



2ND
IMCEET
2024



**2nd International Multidisciplinary
Conference on Emerging Trends in
Engineering Technology**

(2ndIMCEET-2024)

Sponsors



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**2nd International Multi disciplinary
Conference on Emerging Trends in
Engineering Technology**

(2nd IMCEET-2024)

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Conference Proceedings

Organized By:

**The Benazir Bhutto Shaheed University of Technology
and Skill Development Khairpur Mirs, 66020, Sindh, Pakistan**

Sponsored By:

Sindh HEC

In-Collaboration with:

**MUET, SZAB Campus
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**2nd International Multidisciplinary Conference on Emerging Trends in
Engineering Technology-2024 (2nd IMCEET-2024)**



2nd International Multidisciplinary Conference on Emerging Trends in Engineering
Technology-2024
(2nd IMCEET-2024)

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Organized by:

The Benazir Bhutto Shaheed University of Technology and
Skill Development, Khairpur Mirs

In collaboration with:

MUET, SZAB Campus Khairpur Mirs

Sponsored by:

Sindh Higher Education Commission, Government of Sindh

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Prof. Dr. Hyder Abbas Musavi
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Dr. Sadam Hussain Jakhrani
Dr. Asim Ali Abro
Engr. Jawad Akhter Siddiqui
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INTERNATIONAL KEYNOTE SPEAKERS

<i>Sr. No.</i>	<i>Name</i>	<i>Designation</i>	<i>Title of Talk</i>	<i>Photo</i>
1	Prof. Ir. Dr. Erwan bin Sulaiman erwan@uthm.edu.my	Professor at faculty of Electrical and Electronic Engineering, University. University Tun Hussein Onn Malaysia (UTHM).	Innovation of Flux Switching Machine: Design Variation Review	
2	Prof. Dr. Fayyaz Ali Memon f.a.memon@exeter.ac.uk	Professor in Water Engineering University of Exeter, UK	Muti scale modelling of water-energy and food nexus	
3	Dr. Arslan Ahmed arslan.ahmed@namrc.co.uk arslan.ahmed90@gmail.com	Senior Research Engineer (Sensors & Instrumentation) Nuclear Advanced Manufacturing Research Center University of Sheffield, UK	Space Weather Effects on Satellite-based Navigation Systems	
4	Dr. Sunny Katyara sunny.katyara@imr.ie	CTO & Co-Founder Indus Brain	The Rising Trend of Mass Customization and Personalization	
5	Dr. Muhammad Waqas soomro.waqas@yahoo.com	Postdoc researcher at the Yangtze River Delta Research Institute of University of Electronic Science & Technology of China (Huzhou)	Innovative Interlayer Designs for Improved Polysulfide Management and Self-Discharge Prevention in Li-S Batteries	
6	Prof. Ir. Ts. Dr. Mohd Haziman Wan Ibrahim CENG haziman@uthm.edu.my	Faculty of Civil Engineering & Built Environment, Universiti Tun Hussein Onn Malaysia	Properties of Brickwork Under Aggressive Environment	
7	Dr. Sallahuddin Panhwar panhwarsallahudin@yahoo.com	Postdoctoral Researcher at Gazi University Ankara, Turkey	Fabrication of an Impedimetric Biosensor Based on Co-polymer for the Detection of E. coli K12 in Water	



NATIONAL KEYNOTE SPEAKERS

Sr. No.	Name	Designation	Title of Talk	Photo
1	Prof. Dr. Habib-ur-Rehman Mughal mughalhabib@uet.edu.pk	Professor, University of Engineering and Technology, Lahore	Development of 10 kW Francis Turbine Generator at KSK, UET, Lahore	
2	Prof. Dr. Ali Asghar Memon ali.asghar@faculty.muett.edu.pk	Professor, Electrical Engineering at Mehran University of Engineering & Technology Jamshoro, Sindh, Pakistan	Smart Electrical Machine, Operating in All Modes	
3	Prof. Dr.-Ing. Syed Mushahid Hussain Hashmi camd@neduet.edu.pk	Professor / Chairman Department of Automotive & Marine Engineering, NEDUET	Emerging and Disruptive Trends in Automotive Technology	
4	Engr. Dr. Munsif Ali Jatoi jatoi.neuroscientist@gmail.com	Associate Professor at Salim Habib University, Karachi, Sindh, Pakistan	Statistical Measures Based Understanding of Brain Networks	
5	Prof. Dr. Abdul Qayoom Jakhra aqbaloch@quest.edu.pk aqunimas@hotmail.com	Director, Postgraduate Studies, QUEST, Nawabshah	Water Resources Availability and Shortfall in Pakistan and its Possible Solutions	
6	Dr. Ghulam Yasin Shaikh yasinshaikh2001@yahoo.com	Professor, Department of Industrial Management, MUET Jamshoro	Designing of conceptual framework to support AMT system in manufacturing industries of Sindh, Pakistan	
7	Dr. Sajid Hussain Siyal sajid.hussain@duet.edu.pk	Chairman, Department of Metallurgy and Materials Engineering, Dawood University of Engineering and Technology, Karachi	Design and Development of Organic-Inorganic Based Electrolyte by Using the UV Method for Energy Storage Devices (Lithium-Ion Batteries)	



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8	Dr. Tahir Ali Akbar drtahir@cuiatd.edu.pk	Chairman Civil Engineering–All Campuses, COMSATS University Islamabad	GIS & Remote Sensing Applications in Civil Engineering	
9	Dr. Imdadullah Thaheem imdadthaheem@bbsutsd.edu.pk	Director, ORIC BBSUTSD, Khairpur Mirs	High active Spinel CoFe ₂ O ₄ - Er _{0.4} Bi _{1.6} O ₃ composite based cathode Oxygen Electrode for Reversible Solid Oxide Cells	
10	Dr. Samina Rajper samina.rajper@salu.edu.pk	Professor, Computer Science, Director Oric, Focal Person Pmydp – SALU	Transformative Potential of Digital Safe Spaces for Women's Empowerment	
11	Dr. Afaq Manzoor Soomro afaque.manzoor@iba-suk.edu.pk	Assistant Professor in the Electrical Engineering Department at Sukkur IBA University	Role of Novel Materials in The Design of Wearable Flexible Sensors	



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Design and Assessment of Photovoltaic Power Generation Potential in Pakistan's South Punjab

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Electricity shortage	Electricity demand is rising steadily in today's contemporary world. No one in today's world can imagine a world without energy. An essential component of the modern lifestyle is electricity. The majority of the electricity produced in the globe today comes from hydropower or traditional thermal sources. Renewable energy supplies are becoming more and more important as global worries about carbon dioxide emissions and other issues develop, especially wind power and solar cells, are increasingly being recommended for the production of electricity. Among all renewable energy sources, photovoltaic cells are the most affordable and are widely installable in densely populated regions. Pakistan is at a prime position on the solar horizon to capture solar energy. Research is now being done to calculate performance ratio and construct a utility grid tie 204 kW _p DC/ 175 kW _p AC photovoltaic proposed system utilizing PVSyst software. Assessment of solar Irradiation through direct and diffuse on collector plane of photovoltaic cell and total losses of system are calculated. Performance ratios are recorded at a minimum of 78.8% in May and a maximum of 89.3% in January, overall average performance is reported at 82.5% yearly.
Grid connected Solar system	
Power Inverter	
Photovoltaic cell	
Power Generation	
PVSyst	
Renewable Energy	
Solar Irradiation	
Performance Analysis	

1. Introduction

Renewable power generation is producing clean and green energy through Solar, Wind, Magneto hydro dynamic (MHD), and various other non-conventional energy resources. MHD and wind have several restrictions, such as being hard to install everywhere like solar power generation and to provide pollution-free electricity [1]. A solar power generating system primarily comprises of a suitable model of solar cell, a photovoltaic array, a battery to store additional energy, and electrical components. If loads

require direct current (DC) power, an independent photovoltaic system is suited to save conversion losses. Photovoltaic cells generate DC electricity, which is converted by an efficient inverter and injected into a grid via a grid-tied system. Overall, there are two types of system to collect power from solar cell one with batteries another with grid tie inverter system [2]. Without storing energy in batteries and injecting it directly into the distribution system without encountering



transmission losses, distributed power generation close to city centers plays a vital part in meeting customers' everyday needs. Like traditional power plants that use coal, oil, and gas as a fuel, solar and wind power generating has no operating costs [3]. Open circuit voltage (V_{oc}), short circuit current (I_{sc}), and solar cell efficiency in converting solar energy into electrical energy are the key solar power generation factors. Whereas

local climatic factors like year-round sun exposure, temperature, and alter with the cell type model effect solar cell efficiency and its performance [4,5]. Solar power generation must be used if it is not sent directly to the grid because storing solar energy requires the use of batteries, which are expensive today and have a high potential for energy loss. Therefore, sending solar energy directly to

Table 1 Input data through Metenorm-8.1 of Geographic site

Month	Direct irradiation (kWh/m ² /day)	Diffuse irradiation (kWh/m ² /day)	Direct irradiation (kWh/m ² /month)	Diffuse irradiation (kWh/m ² /month)	Temp (°C)	Wind Velocity (m/sec)	Relative Humidity (%)
Jan	2.61	1.58	81.0	48.9	12.2	0.70	72.9
Feb	3.81	1.86	106.6	52.1	16.2	1.20	65.8
Mar	4.67	2.41	144.8	74.6	22.8	1.59	57.3
Apr	5.56	2.84	166.8	85.2	27.7	2.01	44.9
May	6.20	3.20	192.2	99.3	34.7	2.40	34.4
Jun	6.01	3.62	180.4	108.5	35.2	3.00	45.6
Jul	5.53	3.49	171.4	108.3	34.6	2.91	58.1
Aug	5.36	3.23	166.1	100.1	33.1	2.79	63.7
Sep	5.18	2.74	155.4	82.3	30.9	2.10	64.0
Oct	4.41	2.31	127.4	71.6	27.0	1.10	56.6
Nov	3.02	1.62	90.6	48.6	19.4	0.60	65.6
Dec	2.54	1.44	78.8	44.6	14.0	0.50	71.4
Yearly	4.55	2.53	1661.4	924.1	25.6	1.7	58.4

grid-connected systems is the most practical and profitable option. [6,7] Solar cell power generation changes during the day depending on a variety of parameters, including the inclined plane of the solar cell and the kind of battery bank used in stand-alone solar power generation [8]. Numerous tools and software programs are available for the analysis and sizing of both standalone and grid-connected solar systems. System designers and installers size the PV system using simpler tools and simulation software. Researchers and engineers often employ more sophisticated simulation tools for optimization. The three types of software tools used in solar systems are feasibility analysis, system sizing, and simulation for specific

location [9,10]. PVSyst is a specific simulation-based software program for the design of Photovoltaic systems. It incorporates support for Photovoltaic system pre-feasibility, sizing, and simulation. After the researcher and engineers identify the location and loads, The program then determines the size of the solar system automatically after users choose the various parts from a product database [11-14]. The most recent version of PVSyst, version 7.4.0, is used in this study to perform the simulations. In Pakistan's south Punjab area, performance ratio and efficiency are measured for photovoltaic systems that are connected to the grid. Tables and graphs are used to describe the findings, which indicate that south Punjab has a lot of potential for

producing solar electricity.

2. Geographic parameters of proposed Photovoltaic system site

Solar cell positioned at the proper angle to harvest maximum photovoltaic energy; geographic location is crucial. The planned PV location is in Multan, Pakistan's South Punjab region, which is located at Latitude 30.20° N, Longitude 71.48° E, and Altitude 125m. In Table 01 meteorological information for this specific location is displayed above.



Fig. 1. Tilt angle of proposed system

3. Grid Tie Photovoltaic System

The 204 kW_p DC/ 175 kW_p AC grid tie inverter system is made to calculate the solar power generation based on the sun's annual irradiation. Solar cells are arranged in an array to create power in DC form, which is then transformed into AC form by a highly effective inverter and fed into the utility grid. Figure 02 below depicts a grid-tied photovoltaic system.

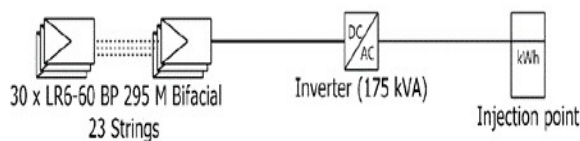


Fig. 2. Grid Tie Inverter Photovoltaic System

4. Photovoltaic System input Parameters

Grid connected photovoltaic system is consist on Photovoltaic array, Inverter, and PV module. The key factors affecting photovoltaic module selection are the solar cell's type, efficiency, and price. All of these photovoltaic qualities are largely dependent on the kind of module used,

such as perovskite solar cells or monocrystalline, polycrystalline, amorphous, with monofacial or bifacial technology. Bifacial Longi solar cells were chosen for the present photovoltaic system design in Pakistan's south-punjab area since numerous module types of solar cells are now accessible with a variety of attributes in the PVSyst software. Since, each bifacial Longi solar cell has a capacity of 295 W_p, there are 690 photovoltaic modules needed to provide the nominal 175 kWAC of AC power after losses. One inverter is all that is needed for an optimal conversion of 175 kWAC from these solar cells, which cover an area of 1144 m². Table 02, which provides information of the related specification of photovoltaic system for optimum conditions and the conversion of AC power to DC through efficient inverter, is provided below.

Table 2 Defined PV system data

Sr. No.	PV system	Technology
1	Module type	Longi Solar
2	PV Array Nominal Power	204 kW _p
3	Number of PV Modules	690 units
4	Module Area (Collector)	1144 m ²
5	Number of Inverters	01
6	Nominal PV Power (Unit)	295 W _p
8	Nominal AC Power	175 kWAC

5. RESULTS

This section presents the findings for the energy feeding to the grid and the performance ratio for the solar radiation available throughout various months at the chosen site in the form of tables and graphs, for the design and analysis of the suggested solar system using the PVSyst software for the specified input parameters. The total performance ratio of the suggested system and the energy injected into the grid for the available solar irradiations from direct and diffuse sun rays is shown in Table 03 above.



2nd International Multidisciplinary Conference on Emerging Trends in Engineering Technology-2024 (2nd IMCEET-2024)

Table 3. Performance Ratio and Injected energy into Grid

Months	GlobHor (kWh/m ²)	DiffHor (kWh/m ²)	TAmb (°C)	GlobInc (kWh/m ²)	GlobEff (kWh/m ²)	E-Array (kWh)	E-Grid (kWh)	Performance Ratio (%)
Jan	81.0	48.9	12.18	100.3	98.3	18561	18219	0.893
Feb	106.6	52.1	16.18	128.3	126.1	23015	22586	0.865
Mar	144.8	74.6	22.75	160.9	158.1	27931	27412	0.837
Apr	166.8	85.2	27.74	173.5	170.4	29307	28753	0.814
May	192.2	99.3	34.71	189.4	186.0	30971	30376	0.788
Jun	180.4	108.5	35.17	174.2	171.1	28719	28174	0.794
Jul	171.4	108.3	34.57	166.5	163.2	27748	27238	0.804
Aug	166.1	100.1	33.06	168.7	165.6	28136	27600	0.804
Sep	155.4	82.3	30.94	167.9	165.0	28191	27660	0.809
Oct	127.4	71.6	27.02	146.9	144.5	25279	24801	0.829
Nov	90.6	48.6	19.42	112.9	110.8	20134	19770	0.860
Dec	78.8	44.6	13.95	100.7	98.8	18448	18108	0.883
Year	1661.4	924.1	25.69	1790.1	1758.0	306440	300697	0.825

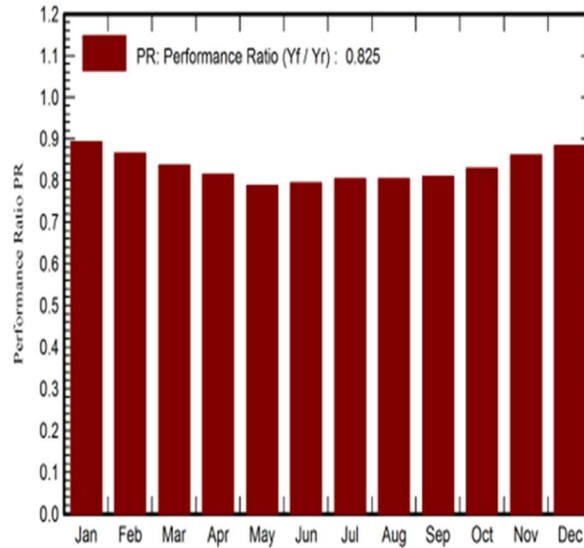


Fig. 3. Performance ratio of 204 kW_p PV system



5.1 Performance Ratio and useful energy

Solar radiation from all sunbeams that directly reach a solar collector plane or that are indirectly collected after reflecting off the earth's surface and all other nearby objects. The bifacial technology of this solar cell longi, which makes it more advanced and effective at collecting sunlight from both facing the ground and from behind the collector surface of the solar cell, is another key benefit. This solar system's performance ratio, which is around 82.5% for a 204 kW_p DC system, is enormous and noteworthy. Any solar system's performance ratio is determined by dividing the useable energy of the inverter output in AC form after all losses by the total nominal installed power and incident energy. The photovoltaic system generates 4.05 kWh/kW_p/day of useable energy overall, with an overall performance ratio of 82.5%. Figure 04 displays useful energy, while Figure 03 displays a performance ratio graph for the entire year. May has the lowest performance ratio at 78.8%, and December and January have the highest performance ratios at 88.3% and 89.3%, respectively. Figure 05 depicts the whole system losses, and the incident sun rays on the collector plane result in a 17.81% power conversion efficiency for the proposed photovoltaic system. After inverter losses, there is still 300697 kWh of potential energy injected into the utility company, but 5743 kWh of that energy is lost during inverter losses and power conversion.

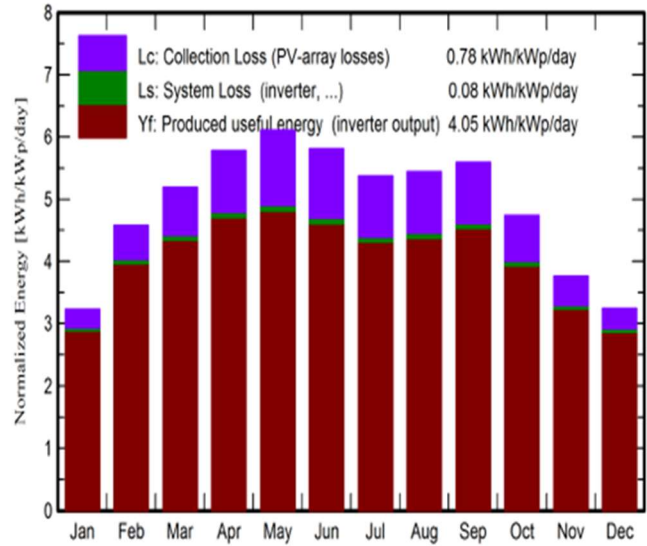


Fig. 4. Useful energy of Photovoltaic system

Figure 06 depicts the overall irradiance, power Conversion efficiency, and grid feeding for one day. As the collector's effective radiation is, 1758 kWh/m² and the PV conversion efficiency is 17.18% for bifacial longi solar cells, the overall loss diagram for the collector area of solar cells is 1144m², and varied losses have an impact on the performance of photovoltaic systems. The photovoltaic system generates 300697 kWh of useful energy after losses from the inverter, cell conversion, cell production, losses from temperatures, and irradiance losses. Figure 05 of the photovoltaic system depicts all losses.

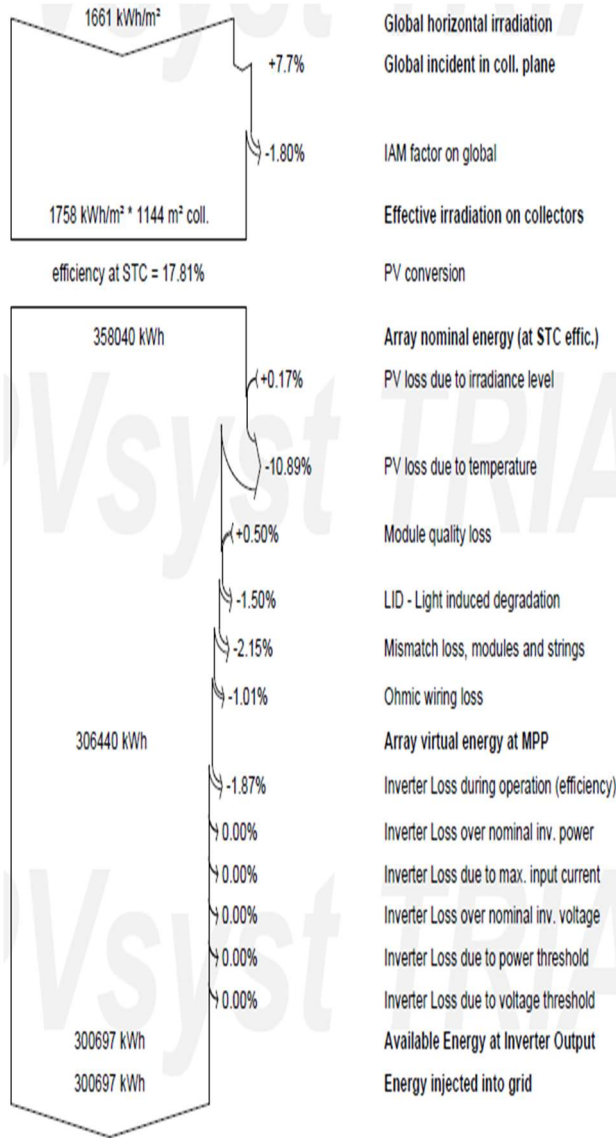


Fig. 5. Loss Diagram

5.2 Daily Input/output data

Energy injected into grid depends on the solar irradiation on collector plane so by increasing the value of globally incident irradiation on collector plane (kWh/m²) on x-axis also increases energy generation through proposed PV system. Daily input of solar irradiation on collector plane of solar cell throughout the year and variations come in the energy generation and energy injected into grid also varies on y-axis depending on the sun irradiations.

Daily input and output are illustrated in Fig. 6, for proposed geographical location in Multan, South Punjab. Along with the daily energy injected into the

grid (kWh/day) on y-axis and total solar radiation on the collection plane on x-axis. In Fig. 6 that describe the daily energy input output diagram of proposed system, it's clear from the figure mostly dots are concentrated above the 600 kWh/day energy injected into grid per day. Overall view of this figure shows that maximum energy injection into grid per day is above 600 kWh/day and below 1200 kWh/day, and proposed PV system can inject 600 kWh/day for maximum days throughout the year.

Fig. 6 also shows the input radiations of sun throughout the year and output in the form of energy generation and injection into the grid tie system in kWh/day. Mostly dotted concentration is above 600 kWh/day and below 1200 kWh/day.

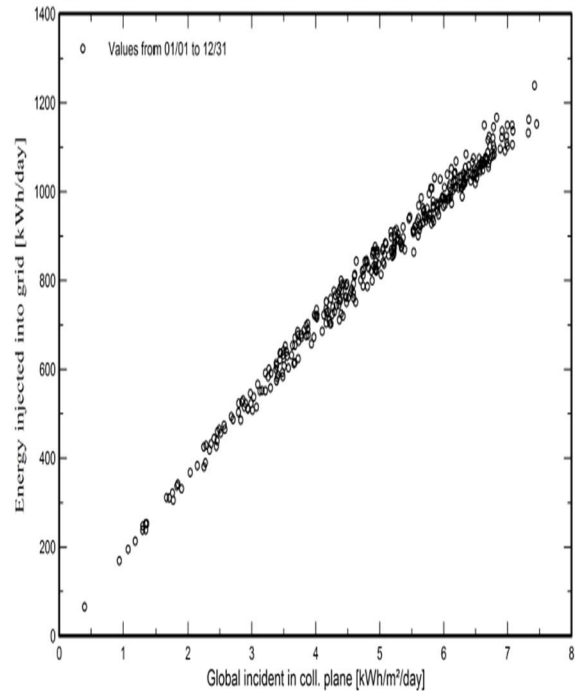


Fig. 6. Daily Input /Output of proposed system

Equation 01 shows that the efficiency of solar cell is the ratio of NPP and the P_{in} is the input of irradiance of sun on collector plane of proposed solar cell. P_{max} given in equation describe the total output of photovoltaic cell depends on important factors like Fill Factor (FF), Open circuit voltage (V_{oc}), I_{sc} is denoted short circuit current density for the proposed photovoltaic system as shown in Equation 02. Where in Equation 04 (V_{oc}) also temperature dependent and in Equation 01 P_{in} is the solar irradiance on



solar cell for proposed location if P_{in} increases then η decreases and effect also increases on NPP.

$$\eta = \frac{P_{max}}{P_{in}} \quad (01)$$

$$P_{max} = FF \cdot V_{oc} \cdot I_{sc} \quad (02)$$

$$\eta = \frac{FF \cdot V_{oc} \cdot I_{sc}}{P_{in}} \quad (03)$$

$$V_{oc} = \frac{kT}{q} \ln \left(\frac{I_{sc}}{I_0} \right) \quad (04)$$

5.2 Power Injected into Grid

Injected power into grid system given on x-axis in kW system, and energy injected into y-axis in MWh on average annually given in Fig. 7. Energy injected into grid 10 MWh when power is 120 kW.

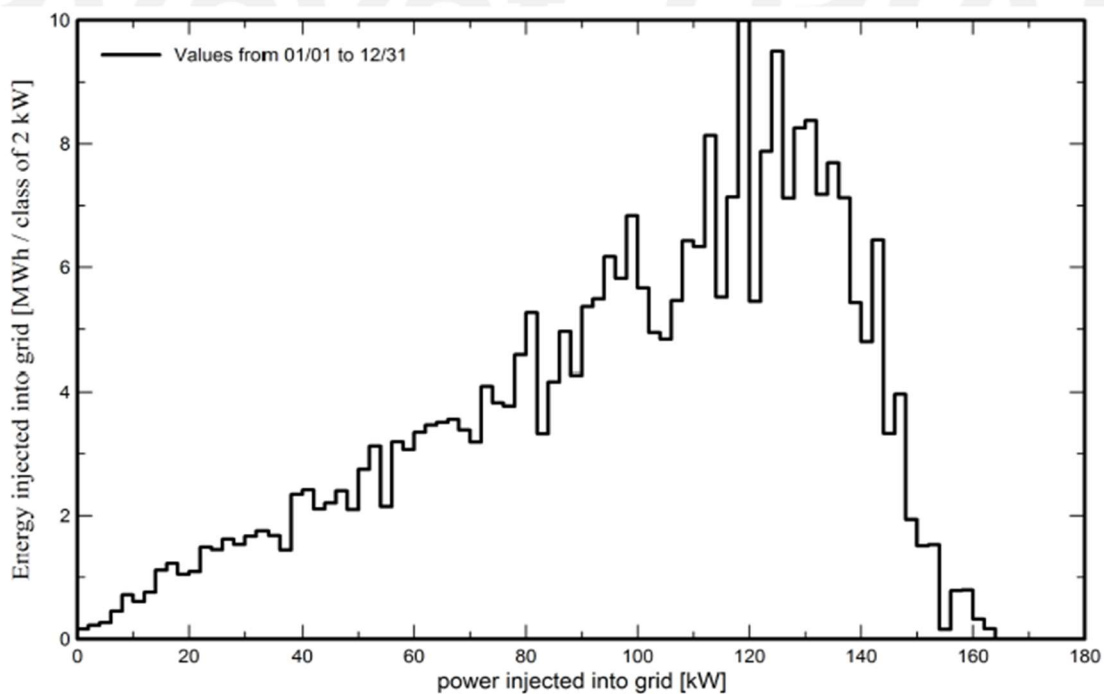


Fig. 7. Power and Energy injected into Grid

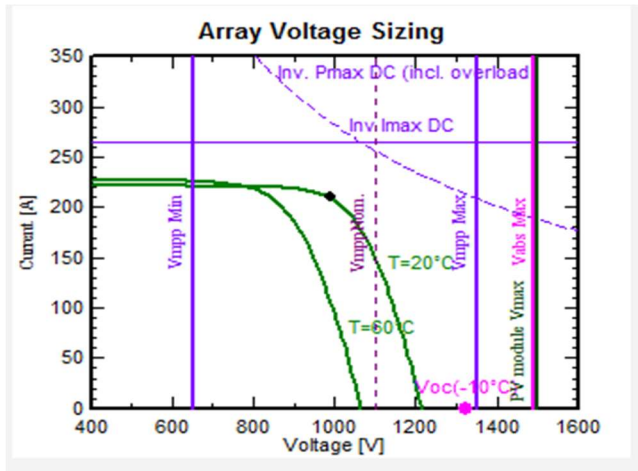


Fig. 8. Array voltage sizing

The suggested design of the overall system shows an array with a voltage generated that is in the optimal range for both voltage and current. The voltage curve of the array is also in the ideal condition to create power, with current being less than 250A and voltage being less than 1100V, as shown in Figure 8.

6. Conclusion

Current research is studied for a 204 kW_p DC/ 175 kW_p AC grid connected photovoltaic system in Multan South Punjab areas of Pakistan with



geographic coordinates Latitude 30.20° N and Longitude 71.48° E. The best choice for a photovoltaic system design is a generic made 175 kWAC inverter and a generic manufactured bifacial Longi solar cell with fixed tilt angle of 30°. The planned solar system's performance ratios are recorded at a low of 78.8% in May and a maximum of 89.3% in January, overall average performance is reported at 82.5% annually according to PVSyst simulation findings. With a PV conversion efficiency of 17.18% for the available solar radiations on the collector plane, 300.6 MWh of clean, green energy is accessible annually and added to grid tie system. The least amount of electrical power that the has added to the system proposed photovoltaic system design is 18.1 MWh in December for the minimum recorded sun irradiation of 78.8 kWh/m², and 30.3 MWh in May for the maximum recorded solar irradiation of 192.2 kWh/m². Overall findings through PVSyst simulation indicate that solar modules work well when there is good radiation hitting the collector plane, but excessively hot weather from June to September also reduces performance ratio and energy production from photovoltaic system.

7. Reference

- [1] M. M. Khan, M. A. Shafi, and Z. Riaz, "Design and development of Magneto hydro dynamic generation," *Int. Journal of Scientific and Engg. Research (IJSER)*, vol. 7, no. 12, 2016.
- [2] M. M. Khan, M. A. Shafi, and N. Khan, "Development of Prototype model of Grid Tie Inverter (Grid Synchronization and Load Sharing)," *Int. Journal of Engg. and Advanced Tech. (IJEAT)*, vol. 05, no. 05, 2016.
- [3] M. Khan, M. A. Shafi, B. Akram, M. Tariq, R. Sarmad, H. Muqheet, and B. Soucase, "Financial Analysis of Photovoltaic-Wind Cogeneration for a Remote Village in Gwadar-Pakistan," *Southern Journal of Research*, vol. 2(1), 2022.
- [4] M. A. Shafi, S. Bibi, M. M. Khan, H. Sikandar, F. Javed, H. Ullah, L. Khan, and B. M. Soucase, "A numerical simulation for efficiency enhancement of CZTS based thin film solar cell using SCAPS-1D," *East European journal of Physics*, vol. 5, no. 5, 2022.
- [5] M. A. Shafi, M. M. Khan, S. Bibi, M. Y. Shafi, N. Rabbani, H. Ullah, L. Khan, and B. M. Soucase, "Effect of parasitic parameters and environmental conditions on IV and PV characteristics of 1D5P model solar pv cell using LTSPICE-IV," *East European journal of Physics*, vol. 5, no. 5, 2022.
- [6] M. M. Khan, M. A. Shafi, and M. Khosa, "An Analysis of Stochastic Wind Power, Approach for Economic Load Dispatch Optimization Using Genetic Algorithm," *Southern Journal of Engg. & Tech*, vol. 01, no. 02, 2023.
- [7] T. M. Iftakhar Uddin, M. A. Saad, H. Al. Bustam, and M. Z. Mahbub, "Computational Modeling of a Grid Connected System Using PVSyst Software," *International Journal of Scientific & Engg Research*, vol. 3, no. 2, 2012.
- [8] H. Al. Bustam, M. Z. Mahbub, M. M. S. Shahriar, T. M. Iftakhar Uddin, and M. A. Saad, "Analysis of a Standalone Photovoltaic Power Generation System Using PVSyst Software," *Global Journals Inc. (USA)*, vol. 12, no. 4, 2012.
- [9] C. P. Kandasamy, P. Prabu, and K. Niruba, "Solar Potential Assessment Using PVSyst Software," in *second International Conference on Green Computing, Communication and Conservation of Energy*, 2013, p.11.
- [10] M. M. Khan, S. Ahmad, A. Raza, H. Sikandar, R. G. Hassan, and M. A. Shafi, "Performance analysis of PVSyst based Grid connected Photovoltaic systems in Pakistan compared to SAARC Countries," *Mehran University Research Journal of Engg. and Tech. (MURJET)*, Vol. 43(2), 2024.
- [11] M. M. Khan, S. Ahmad, S. Jabbar, S. Baloch, M. A. Shafi, R. Nazeer, and J. Faiz, "Simulation design of Grid Tied Photovoltaic (PV) system of a 1.05 kWp DC for a geographical location of Tandojam Sindh," in *1st Int. conference on women development*, 2023, p. 4.
- [12] M. M. Khan, S. Ahmad, H. Sikandar, B. Akram, A. Raza, R. G. Hassan, M. Hussain, "Designing and Performance analysis of Photovoltaic system using PVSyst Software: A geographical location of Pakistan," *TechXchange Int. Conference*, 2024, p.1.
- [13] M. M. Khan, S. Ahmad, A. Raza, R. G. Hassan, U. Tariq, H. Sikandar, M. A. Shafi, "Optimized Photovoltaic System Using PV Syst Software for Residential Building Energy in Multan," *Southern Journal of Engg. & Tech.*, vol. 2, no. 1, 2024.
- [14] M. M. Khan, B. Akram, M. A. Shafi, S. Jabbar, J. Faiz, and R. Nazeer, "Design and Simulation of Photovoltaic power park for evacuating Sindh Solar Potential using HVDC Transmission system," in *thirteen Int. Mechanical Engg Conference*, 2024, p.5.



Effects of Noise Pollution and Its Influence on Roadside of People and Business Community in Northern Part of Nawabshah, Pakistan.

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KEYWORDS

Noise Pollution
Northern part of city
Nawabshah
Noise Meter
Housing and Urban
Development (HUD)

ABSTRACT

The research looked at the amount of noise pollution and the issues associated with noise pollution in light of its negative outcomes on people's quality of life in the Northern area of Nawabshah of district Shaheed Banazirabad-Pakistan. Noise pollution levels checked out by keeping view of different recommendations from United States of America under the Department of Housing and Urban Development (HUD) for noise level in living domain, the noise level was obviously objectionable. Highest noise level of (68.8 dBA) recorded in between 1:10-1:40 pm, at 4:10 to 4:40pm noise level was recorded (61.51 dBA), the lowest value (57.04 dBA) at 9:00 to 9:30 pm. During morning hours March saw the maximum noise level of 73.57 dBA, while the November evening hours had the bottom noise level of 57.11 dBA.

At Qazi Ahmed Mor and regal chowk, which is close to hospital road, the noise level was measured within the allowed limit for a safe environment. Noise level during the month of May, June, July, August, October & November as well as in the evening time throughout year was acceptable normally & it was totally unacceptable in January, February, March, April, September and December.

Health issues that are concerned with noise pollution includes decrease in hearing capacity, listening barriers, irritation, sleeping disturbances, melancholy as well as mental collapse. Problems were found quite more in quantity during the age limit of 20-40 years and the most frequent reported problems like, annoyance and listening capacity problem. A growing percentage of respondents under older age group domain reported experiencing despair, insomnia, and the deafening impact. The effects of deafness on those older than 60 years of age were substantially more common.

1. Introduction

Noise pollution is the disturbing noise with harmful impact on the activity of human or animal life. The source of outdoor noise worldwide is mainly caused by machines and transportation systems, motor vehicles engines & trains. Many cities of world are most affected from Noise pollution. The known worldwide outdoor source of noise is transportation system and industrial machinery. These are the cities in world with the worst noise pollution. Delhi was the second worst city for noise pollution, followed by Cairo, Mumbai, Istanbul and Beijing. Barcelona, one of only two European cities to feature in the worst 7th, while capital cities Mexico City, Paris at 8th and 9th position respectively. The top

five quietest cities were all in Europe: Zurich, Vienna, Oslo, Munich and Stockholm.

Pakistan is also worst effected from Noise pollution. No express provision has been made for the ban and control of noise pollution in the constitution of Pakistan, in 1973, noise free environment has been regarded a Fundamental Right of every citizen of Pakistan. The scientific and technological advancements bring unforeseen problems in their wake. Although, the automobiles, aircrafts, machines, tools, gas turbines and compressors all are useful in themselves but also associate innumerable calamities (Molesworth et al., 2013).



Noise is unpleasant and annoying sound and mans' susceptibility to this element may vary for intensity (Bond, 1996), sensibility and age (Chien and Shih, 2007); and it can be categorized as occupational Noise and community noise (Gangwar *et al.*, 2006). Noise revelation in an industrial work place is termed as community noise, environmental noise or domestic noise (Garg *et al.*, 2007; Jamrah *et al.*, 2006). Among sources of community noise, the transportation system has the dominating role compared to other causes such as road, air and rail, construction activities, use of home appliances and activities in the neighbours (Dev and Singh, 2011). Transpiration noise is a key problem in the cities of the world today (Martin *et al.*, 2006). The motorcycles can generally produce noise level in the range of 72-85 dB but can reach as high as 120 dBA immediately behind the cycles as against the noise level range of 65-75 dB in case of car (Williams and McCrae, 1995; Tang and Tong, 2004; Dev and Singh, 2011). The railway noise that puts direct impacts on residential communities; the primary source includes the whistling noise of locomotives. The noise of diesel locomotives and wheel/rail noise as well. The impact of noise pollution by trains is at optimum level in those areas where railway tracks pass through residential areas (Mikael Ogren, 2006).

There was no legislation in Pakistan to deal with noise

Objectives:

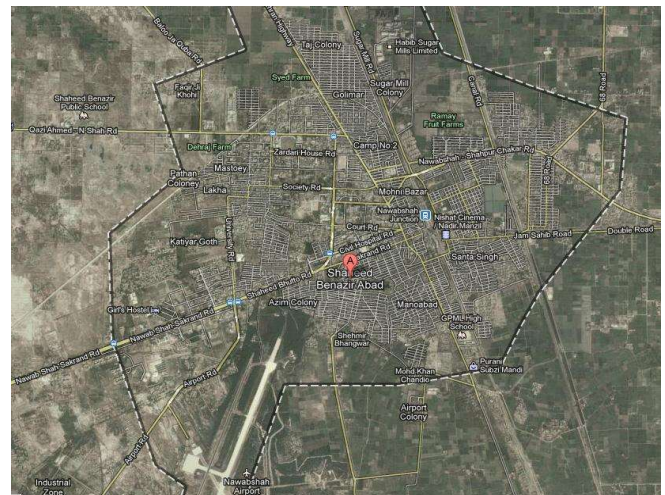
1. To measure traffic noise using digital sound level meter and compare the observed level with the recommended level.
2. To assess possible impact of traffic noise on roadside resident's traders through interviews.
3. To suggest the suitable strategy to mitigate the traffic noise pollution under prevailing environment.

2. System Description

In order to evaluate noise pollution and its possible effects on the roadside residents and traders in Nawabshah city, the study was carried out during the year 2015. The traffic noise was evaluated using digital sound level meter and observed levels were compared with the permissible limits of United States Department of Housing and Urban Development (HUD). The traffic flow intensity on per hour basis was also recorded at the certain points of study.

coming from railway engines, Aircrafts, airport, industrial or construction activities. Public complaints on noise pollution were often received in the federal and provincial environmental protection agencies, but in the absence of national standards for noise, these agencies were handicapped to take any legal action. Most of the civil airports lay in heavily population areas in Pakistan and no such precautionary measures had been taken. The situation gets alarming with increase in traffic density on city roads, particularly in Karachi.

As population increases the requirements for the goods, services and transportation also increase. Everyone requires transportation to move from one place to another place to fulfill their different needs and requirements. Therefore, each year there is an increase in the number of vehicles in Nawabshah city, which has certainly caused traffic noise pollution problems to the city dwellers. The population of poorly maintained vehicles is also growing which intensify the situation significantly. Thus, the pollution is one of the major environmental problems of Nawabshah city adversely affects its citizens. Keeping the above facts in view, the study was carried out to evaluate noise pollution and its possible effects on the roadside residents and traders in Nawabshah city. The study results will provide guideline for future planning in the study area by controlling noise pollution in the environment.



Nawabshah City

The traffic noise levels of trains and vehicles passing through Nawabshah city were measured by digital sound level meter at ten sites in decibel (dB). The noise produced by the horn, the engine and wheels of each train was measured separately. The traffic density was analyzed by counting the number of vehicles crossing the each survey site per hour and the data were analyzed



statistically.

The data were collected using survey method, and in addition to monitoring the noise pollution level at ten different sites in the residential/commercial areas and at railway station of Nawabshah. The following sites were surveyed to examine the level and impact of noise pollution:

Survey Sites

1. **Qazi Ahmed Mor**
2. **Regal chowk**
3. **Sanghar Naka**
4. **Taj colony chowk**
5. **Settlers along the railway track**

Related aspects covered

1. Individual vehicle noise level
2. Traffic flow density at each site
3. Noise level in peak hours of traffic flow
4. Public opinion survey

Measurement of noise pollution

Noise pollution refers to any unpleasant, damaging or irritating noise that has the potential to harm people, wildlife or the environment. The decibel (dB) is the main unit used to measure the intensity or loudness of sounds. A sound can also be measured by its pitch, which is the frequency of sound vibrations per second. For example, a low pitch produced by a deep voice, makes fewer vibrations per second than a high voice. Sounds with higher pitch, such as a cry or sound from a violin, have a high rate of vibrations. Sound is usually recorded with a microphone. However, in a sound level meter, a sound sensor is used. Sound sensors work like microphones but are much more accurate.

Decibel (dB): The SI (International System of Units) unit of measure of sound intensity. The response of a

sound sensor to a nearby sound is approximately proportional to the sound pressure, which is the air pressure produced by the propagating sound. For example, if we talk with a piece of paper placed just in front of our mouth, the resulting air pressure causes the paper to move. A similar observation can be made by feeling vibrations from a loud speaker. After evaluating the selected sites initially, the situation was further confirmed and for confirmation,

Selecting sites for monitoring noise and traffic pollution in Nawabshah city urban area, involves several considerations: Like High Traffic Density, Residential Areas, where Schools are in maximum quantity, Commercial Centres: Historical Data: By considering these factors, authorities can establish an effective network of monitoring stations to assess and mitigate noise and traffic pollution in Nawabshah city.

the noise level was continuously evaluated for 15 days. Special attention was paid in the selection process of measuring points for (1) total of measuring stations that settled in research area must be divided in homogeneous form and (2) measuring station must be settled and installed in adjacent of the main streets. Noise monitoring process at any point must be in operation more than two weeks (for the average noise during weekdays), and the data and information was collected continuously. The method adopted by Nasiri *et al.* (2008) was followed for selection of noise pollution measuring points and collection of the data. To evaluate the impact of traffic noise on roadside residents and traders will be interviewed for confirming the noise related diseases. At the end of thesis work, I will suggest the suitable strategy to mitigate noise pollution under prevailing environment.

Experimental Procedure

The instruments for field measurements were comprised of precision grade sound level meter (PCE 318) ½- inch condenser microphone and ⅓- octave filter with frequency range and measuring level range of 31.5Hz– 8 KHz and 35-130dB, respectively. The instruments were adjusted by the internal sound level calibrator before measurement at the site.



The observations in relation to noise measurement were made at the specified locations. The instrument was operated comfortably in hand with the microphone

Locations	Timings			
	8:0-8:30am	1:0-1:30pm	4:0-4:30pm	8:30-9:0pm
1. Qazi Ahmed Mor	57.80 _I	57.82 ^I	55.68 _G	53.19 _G
2. Regal chowk	65.87 _H	66.31 _H	61.70 _F	57.44 ^E
3. Sanghar Naka	67.89 _F	68.35 ^F	62.93 _D	56.08 ^F
3. Taj colony chowk	69.27 _E	69.74 ^E	62.36 _E	58.93 _C
05. Settlers along the railway track	69.97 _D	70.45 _D	62.45 _E	58.57 _C
Mean	68.36_A	68.83_A	61.57_B	57.04_C

pointed at the suspected source of noise at about one meter distance from any reflecting object. L_{Ai} (A-Weighted Instant Sound Pressure Level) measurement was made at 30-second intervals for 30 minutes, giving 60-meter readings at each location in sample. This process of observations was performed at 8:00-8:30 am (morning), 1:00-1:30 pm (afternoon), 4:0-4:30 pm (evening) and 8:30-9:00 pm (night). The readings

obtained from this process, commonly used community noise assessment quantities like exceedance percentiles L_{10} , and L_{90} , the A-weighted equivalent sound pressure level, L_A , the day-time average sound level, L_D , the day-night average sound level, L_{DN} , the noise pollution level, L_{NP} and the traffic noise index, TNI were computed. The data in relation to noise levels collected from different locations were tabulated and examined critically in accordance with the recommendations of United States Department of Housing and Urban Development (HUD) for noise levels in residential areas. The following are the HUD described standards for noise pollution for the residential areas in view of the human health protection.

Table 1 Noise Level at Different hours of the day at various locations of Nawabshah City.

1. Clearly acceptable ≤ 49 dB (A)
2. Normally acceptable ≤ 62 dB (A)
3. Normally unacceptable ≤ 76 dB (A)
4. Clearly unacceptable > 76 dB (A)

In view of the above HUD standards, the results were described and accordingly the recommendations were developed.

3. Results

The study was carried out during 2015 (from January 2015 to December 2015) to evaluate noise pollution and its possible effects on the roadside residents and traders in Nawabshah city. The data in relation to noise pollution levels were examined critically in accordance with the recommendations of United States Department of Housing and Urban Development (HUD) for noise levels in residential areas. According to HUD, the noise pollution level ≤ 49 dB (A) is described as clearly acceptable, ≤ 62 dB (A) normally acceptable, ≤ 76 dB (A) normally unacceptable and > 76 dB (A) clearly unacceptable. Results contains the statistically analysed data in relation to location-wise noise pollution, monthly noise pollution level for the year 2015, morning and evening noise pollution, noise pollution at different timings in the morning and in the evening.

Noise Level at different Timings of day

Statistically, the level of noise pollution varied significantly ($P < 0.05$) at different timings of the day. The acoustic pollution because of intense commercial activities and due to heavy traffic in areas surrounded by roads was recorded at different locations of



Nawabshah city District Benazirabad in morning and evening hours. The data (Table-1) showed that on average the maximum noise pollution (68.83 dBA) was recorded in the afternoon at 1:00-1:30 pm, Khaskheli, Abid Ali, et al. closely followed by early morning hours of 8:0-8:30 am when the level of noise pollution was 68.36 dBA. The noise pollution pressure reduced to 61.57 dBA in early evening hours at 4:0-4:30 pm and further decreased to 57.04 dBA in the late evening hours at 8:0-8:30 pm. Regardless of the location of the city, 8:0-8:30 am or 1:0-1:30 pm were the hours of intense traffic and commercial activities and hence the noise pressure was severe during these hours of the day. Generally, these morning hours of 8:0-8:30 am is the timing when the school/college going children approach to their institutions; while 1:0-1:30 pm hours is the timing of their return to homes. The location \times timing interaction showed that there was severe level of noise pollution (85.15 or 84.58 dBA) at Purani Sabzi Mandi Road at 1:0-1:30 pm and 8:0-8:30 am, respectively; while the lowest level of noise pollution (48.50 dBA) was recorded at Doctors' colony near hospital road at 8:0-8:30 pm hours. As suggested by the United States Department of Housing and Urban Development (HUD) for noise levels in residential areas, the average noise level recorded at 8:00-8:30 am and 1:0-1:30 pm was in the range of normally unacceptable level; while in the evening time the noise level was in the range of normal acceptable level. The statistical analysis suggested that there was similarity ($P>0.05$) in the level of noise pollution in the morning (8:0-8:30 am) and in the afternoon hours (1:0-1:30 pm); while differences were highly significant ($P<0.05$) when level of noise was compared with evening hours (4:0-4:30 pm and (8:0-8:30 pm).

Morning and evening comparison of noise level

There was significant ($P<0.05$) difference in the level of noise pollution in the morning and evening hours in Nawabshah city ($F=42054.3$, $df=479$) and locations ($F=18109.2$, $df=479$). The noise pollution at certain locations of the city was recorded and compared for morning and evening noise level.

The results in Table-2 showed that in the morning hours the noise level was significantly higher (68.60 dBA) as compared to evening hours (59.31 dBA). In the morning and evening hours, the noise level at Purani Sabzi Mandi was 84.86 and 64.34 dBA, followed by; Naya Naka (74.36 and 61.97 dBA), Golwala Complex Chowk (71.28 and 61.05 dBA); the areas along the railway track (70.21 and 60.51 dBA); Taj Colony Chowk (69.51 and 60.65 dBA); Sanghar Naka (68.12 and 59.51 dBA); Shaheed Chowk (67.44 and 60.38 dBA); Regal Chowk (66.09 and 59.57 dBA); while the morning and evening

hours noise level was at the lower side at Qazi Ahmed Mor (57.81 and 54.44 dBA) and lowest morning and evening noise level (56.26 and 50.63 dBA) was recorded in Doctors' colony near hospital road, respectively.

There was direct association of morning hours' noise level with the evening hours noise level at different locations of the city. As recommended by HUD for noise levels in residential areas, the average noise level recorded in the morning hours was in the range of normally unacceptable level; while in the evening time the noise level was in the range of normal acceptable level.

As per HUD recommendations, the noise level in the morning hours and afternoon at Purani Sabzi Mandi (84.86 dBA), and Naya Naka (74.36 dBA) was clearly unacceptable level, while noise level at Golwala Complex Chowk (71.28 dBA); areas along the railway track (70.21 dBA); Taj Colony Chowk (69.51 dBA); Sanghar Naka (68.12 dBA); Shaheed Chowk (67.44 dBA); Regal Chowk (66.09 dBA) was in the range normally unacceptable level. However, morning hours noise level at Qazi Ahmed Mor (57.81 dBA) and Doctors' colony near hospital road (56.26 dBA) was in the safe range of normally acceptable.

4. Conclusion

With reference to United States Department of Housing and Urban Development (HUD) for noise levels in residential areas, the noise level at 8:00-8:30 am and 1:0-1:30 pm was unacceptable level. The recorded noise in Nawabshah in the evening time was in the range of normally acceptable level. There was similarity ($P>0.05$) in the level of noise in the morning (8:0-8:30 am) and in the afternoon hours (1:0-1:30 pm). The differences were highly significant ($P<0.05$) when level of noise was compared with evening hours (4:0-4:30 pm and (8:0-8:30 pm). The noise level recorded at Purani Sabzi Mandi and Naya Naka was clearly unacceptable as suggested by HUD. The noise level at Golwala Complex Chowk, areas along the railway track, Taj Colony Chowk, Sanghar Naka, Shaheed Chowk, Regal Chowk was in the range of normally unacceptable level. The noise level at Qazi Ahmed Mor and Doctors' colony near hospital road was in the safe range of normally acceptable. Considering HUD baseline for residential areas, the noise level in the months of May, June, July, August, October and November was normally acceptable while normally unacceptable in January, February, March, April, September and December.

The noise level was in similarity ($P>0.05$) during December and February, August and October, June and July and varied significantly ($P<0.05$) when these groups of months were compared with each other or



with the remaining months of the year. The higher noise level in the morning and afternoon hours was because of extra vehicles carrying school going children and carrying the school children back to home in the afternoon timing. The health-related problems associated with noise pollution include hearing capacity problem, interference with communication, annoyance, disturbed sleep, deafness and mental breakdown.

The problems were more in the age group of 20-40 years of age and most reported occurrence of annoyance and hearing problem. The noise effect was not similar in various age groups of people living in the study areas.

The people of growing age can bear brunt of excessive noise. The rising proportion of the respondent people in older age groups acknowledged sleeplessness, deafening effect and depression. The incidence was much higher for deafness effects on people aging more than 60 years.

Recommendations

1. Heavy vehicles/machinery and noisy vehicles should not be given entry into the city
2. Vehicle fitness system may be strictly implemented and vehicles with high noisy and smoke may be restricted.
3. Without fitness certificate, no vehicle should be allowed to enter the city
4. The routes of heavy traffic coming through the city may be changed.
5. Mass transit system may be initiated in the city so that light vehicle movement is reduced.
6. Encroachment along the railway track may be removed
7. The establishment of schools/educational institutions should be restricted upto the main/wide roads and establishment of such institutions must not be allowed in thick population areas of the city

5. Reference

- [1] Agarwal, S. and B.L. Swami. 2009. Noise annoyance under interrupted traffic flow condition for Jaipur City, International Journal of Applied Science and Engineering, 7(2): 159-168.
- [2] Anomohanran, O. 2013. Evaluation of environmental noise pollution in Abuja, the capital city of Nigeria Ochuko Anomohanran Physics Department, Delta State University, Abraka, Delta State, Nigeria. IJRRAS, 14 (2): 470-476.
- [03] Barreiro, J., M. Sanchez and M.V. Grau. 2005. How much are people willing to pay for silence? A contingent valuation study. Applied Economics, 37 (11): 217-226.
- [04] Dev, P. and V. Singh. 2011. Environmental noise pollution monitoring and impacts on human health in Dehradun city, Uttarakhand, India. Civil and Environmental Research, 1 (1) : 32-40.
- [05] EEA, 2012. Good practice guide on noise exposure and potential health effects. European Environmental Association Technical report / No 11/2012, published on October 2012.
- [06] Erdogan, E. and M. Yazgan. 2009. Landscaping in reducing traffic noise problem in cities: Ankara case, African Journal of Agric. Res., 4(10): 1015-1022.
- [07] Determination of ambient noise levels in the main commercial area of Cape Coast (2011), Ghana, Research Journal of Environmental and Earth Sciences 3(6): 637-644.
- [8] Hammer, M.S., T.K. Swinburn and R.L. Neitzel. 2014. Environmental Noise Pollution in the United States: Developing an Effective Public Health Response. Environ Health Perspectives, 122 (2) : 88-94.
- [9] Khaskheli, Abid Ali, et al. "Emission and Noise Characteristics of a Diesel Engine Fuelled with Diesel-Chicken Oil Biodiesel Blends." Engineering, Technology & Applied Science Research 10.2 (2020): 5387-5391.
- [10] Molesworth, B.R., M. Burgess and B. Gunnell. 2013. Using the effect of alcohol as a comparison to illustrate the detrimental effects of noise on performance. Noise & Health, 15 : 367-373.
- [11] Olayinka, O.S. 2015. Effective Noise Control Measures and Sustainable Development in Nigeria. Science and Education Publishing, 1 (1) : 96-107.



Assessment of Chemical Properties of Groundwater Quality of Larkana City

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ABSTRACT

Groundwater is the most important source of drinking water in the Sindh Province of Pakistan. However, the quality of this crucial element of life is deteriorating day by day throughout Pakistan, particularly in its Sindh province. Thus the study was carried out to determine the chemical contamination in the groundwater of the Larkana city of Sindh province. A total of 40 samples were collected randomly from various locations in Larkana city. The chemical parameters like pH, Calcium, Magnesium, Total hardness (TH), Arsenic, Chloride, Sodium, Iron, Nitrites, and Nitrates were determined in the laboratory and were compared with WHO permissible limits. The results revealed that 26% of samples had chloride beyond the permissible limit, and 32% of samples had a concentration of Total Hardness (TH) above the desirable limits. Moreover, 6%, 23%, 29%, 92%, and 80%, of samples had a concentration of Nitrates, Nitrites, Sulfate, calcium, and magnesium respectively beyond the permissible limit. However, the concentration of pH, Iron, Sodium, and Arsenic in groundwater was found within the permissible limit.

1. Introduction

Groundwater is the most common source of drinking water in the Sindh province of Pakistan. About 70-80% population in Sindh province relies on groundwater resources in order to meet their drinking and other domestic needs [1]. However, this important source of drinking water has been contaminated by various factors including natural and anthropogenic activities [2]. Water is contaminated by factors such as overpopulation, urbanization, climate change; percolation of solid waste leachate to groundwater, mixing of untreated domestic and industrial wastewater with natural streams, etc. [3]. Although groundwater

contamination is a matter of grave concern for the whole of Pakistan, groundwater quality in Sindh province is declining due to the unavailability of waste water treatment units; failure of sewerage systems; frequent floods; and overuse of agricultural excessive use of fertilizers for crops, over abstraction of aquifers, and other anthropogenic activities. Studies have revealed that the mixing of sewage with streams and the percolation of sewage from standing ponds to groundwater is the main cause of poor water quality in the Sindh province of Pakistan [4]. It has also been found that the chemical characteristics of groundwater have drastically changed in the Sindh province of



Pakistan in the last two decades. Water in Sindh is found to have higher concentrations of EC, TDS, TH, Cl, As, and other heavy metals. That’s why the availability of safe drinking for residents of Sindh province is shrinking every year [6]. In this regard, this study was proposed to check the chemical characteristics of groundwater of Larkana city because in Larkana there is no other source of drinking than groundwater. Although many scholars already have done thorough research on the groundwater quality of Larkana, none have done detailed research on Larkana city. Previous research has been done on rural areas of Taluka Larkana, Ratodero, Dokri, and other parts, but an analysis of the water quality of the central part of Larkana including urban areas of district Larkana, was missing. Therefore, in this research fitness of drinking water in urban areas has been proposed to be studies.

2. Information about Larkana City

Larkana is located in the North-Western part of the Sindh province of Pakistan as shown in Fig.1. According to census 2023, the population of Larkana city is about 1,784,453. Moreover, Larkana is one of the largest districts of Sindh province and is located on the right bank of the Indus River. This city is also famous due to having historical archaeological site the “Meon Jo Daro” located in Larkana. People in Larkana completely count on groundwater and citizens are compelled to drink poor water in the most part of Larkana. The reason behind this compulsion is that there is no other economical source of drinking water in Larkana nor the government is providing water through any subsidized water supply schemes in any part of Larkana. Secondly, due to the unavailability of any source of treatment of water, people find groundwater more suitable for drinking than rain or river water. The depth of the Water table in Larkana City varies from 50 feet to 110 feet. The depth of the water table depends upon the intensity of aquifers being recharged, therefore, in the western, southern, and northern parts of Larkana, the average depth of the water table is 100 feet, while in the eastern part of Larkana, the average depth of water table is 50 feet due to being nearer to the river that keeps aquifer filled every time. Studies have found that western, southern, and northern parts of Taluka Larkana are completely contaminated and water is not suit for drinking [7]. Water at the eastern part of Larkana is suitable because it is nearer to the river and the river keeps aquifers recharged throughout the year and reduces the chances of wastewater percolating into the groundwater. However, the eastern part of Larkana needs an extensive analysis of Arsenic contamination, because Arsenic is usually found in the river water.

3. Methodology

In this study chemical parameters of drinking water such as pH, Calcium, Magnesium, Total hardness (TH), Chloride, Sodium, Iron, Nitrites, and Nitrates, were determined in each sample of groundwater to know the status of groundwater quality in Larkana city.

For analysis of groundwater samples total of forty (40) water samples were collected from different locations such as Ahsan Colony, Sachal Colony, QUEST student’s hostel, etc. within Larkana city. Samples were collected in a half-litre water bottle purchased from the water treatment plant in Hyderabad and bottles were used that were never used before. Samples were taken from hand pumps, taps, and electric motors. It is important to note that the pump was allowed to discharge water for a minute and the hand pump for each sample was purged before collection of samples. This was done to remove water available in the suction pipe and to collect fresh groundwater samples. Bottles were washed with the same water, the sample of which was being collected. This was done in order to avoid any external source of contamination in water. Later on, Samples were gathered, labelled with a proper code, and sealed before taking to the laboratory. All 40 samples were tested for pH, Calcium, Magnesium, Total hardness (TH), Chloride, Sodium, Iron, Nitrites, Sulfate, and Nitrates, which were determined in the laboratory at the University of Larkano.

For checking the pH value of water pH meter was used and for other parameters required methodology was used. The detailed process of testing is shown in Table

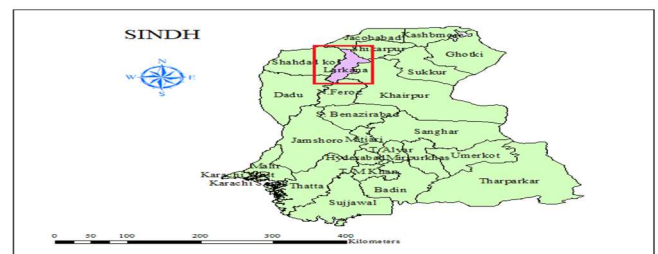


Fig.2 Location of Larkana in Sindh

1. Table.1 Water testing methods

Parameters	Test method/Instrument
Calcium (mg/l)	3500-Ca-D, Standard method (1992)
Chlorides (mg/l)	Titration, Standard Method (1992)
Hardness (mg/l)	EDTA Titration, Standard Method (1992)
Magnesium (mg/l)	2340-C, Standard Method (1992)
pH at 25°C	pH Meter, Hanna Instrument, Model 8519, Italy
Nitrate, Nitrite	NO ₂ Testing Kit



Tests for each sample were done following all standard methods. The results of each parameter of each sample were noted and compared with the permissible values recommended by the WHO, NEQS, and water quality standard developed by SEPA.

4. Results and discussion

Results of individual parameters such as pH, Calcium, Magnesium, Total hardness (TH), Chloride, Sodium, Iron, Nitrites, Sulfate, and Nitrates were determined and matched with the recommended values of the WHO, NEQS, and SEPA (Sindh Environmental Protection Agency). It should be noted that the recommended values of NEQS and SEPA are a reflection of the recommended values of the WHO. Therefore, the results of all samples were compared to the recommended values of the WHO and that was considered a benchmark for knowing the overall quality of groundwater in Larkana city. The results of each parameter are discussed below.

3.1 pH

pH is the most important chemical parameter of drinking water. pH indicates an alkalinity and acidity in water. The higher the value of pH more acidic water. A higher pH value makes water bitter in taste and unsuitable for drinking. On the other lower the value of pH more will be alkalinity in water. The WHO has recommended that for water to be safe, water should be neither extremely acidic nor alkaline. That's why WHO has recommended that for safe drinking water value of pH in water should be between 6.5 and 8.5. When water samples in Larkana city were analyzed for pH, evaluation of pH concentration in drinking water disclosed that the pH value in samples was between 7.1 to 8.2. None of the samples collected from Larkana exhibited higher concentration pH. All samples were found to have pH concentrations within the allowable limit of the WHO, NEQS, and SEPA.

3.2 Calcium (Ca)

Calcium is an important water quality. This water quality parameter indicates hardness in water. The higher the concentration of Calcium in water higher the hardness in water. Such as hardness in seawater is higher than in portable water that's why the concentration of Calcium in seawater is about 400 ppm while in portable water should be of lesser value. According to the WHO in portable water, the concentration of Calcium should not exceed 75 ppm. When the water samples collected from Larkana city were assessed, results represented

that the concentration of Calcium in the water of Larkana city varies between 44 ppm and 167 ppm. It also disclosed that the value of calcium is higher in almost 36 groundwater samples. A higher concentration of calcium was found in samples collected from QUEST Boy's Hostel, Sachal Colony, and Ahsan Colony. It is important to note that people in these three areas have been borrowing water from nearby areas for a year because they have noticed a continuous change taste of water.

3.3 Magnesium (Mg)

Magnesium also contributes to hardness in water. However, calcium is responsible for temporary hardness and Magnesium is responsible for permanent hardness. The WHO has recommended that in order to have safe consumption of water, the concentration of Magnesium in drinking water should not exceed 50 ppm. Here, in this study when samples were tested for the concentration of Magnesium following standard methods, the results revealed that the value of magnesium in samples ranged between 30 ppm and 188 ppm. A higher value of magnesium was found in the water samples from Ahsan colony and the Police Training School (PTS) site of Larkana. Overall, the analysis revealed that thirty-two (32) samples fell in the poor category due to having a concentration of Magnesium beyond permissible limits suggested by the WHO.

3.4 Chloride (Cl)

Chloride contributes to a change in the taste of water. Chloride value was found between 150- 890 ppm. However, the WHO has suggested that in safe portable water, the value of Chloride should be below 250 ppm. Here in this case percolation of untreated domestic waste water can be the reason behind the higher value of chloride in groundwater samples. The highest value of Chloride was found in samples collected from Ahsan Colony, Sachal Colony, and Police Training School (PTS) of Larkana. Overall, ten (10) samples were found to be unfit for drinking due to Chloride.

3.5 Total Hardness (TH)

Total Hardness (TH) in water is due to higher concentrations of Calcium, Magnesium, and chloride. Total Hardness in water causes nuisance, abdominal issues, and gastric pain. The WHO has fixed 500 ppm as a recommended value for Total Hardness for potable water. Although the most desirable value for hardness in water is between 75 ppm and 300 ppm, WHO recommended 500 ppm as the ultimate value because beyond this value water will be extremely unsuitable for



drinking purposes. Here analysis of groundwater samples of Larkana city revealed that the value of Total hardness in groundwater samples ranged between 400 ppm and 2100 ppm. An extreme value of Total Hardness was found in a groundwater sample collected from Ahasan colony Larkana. Similar highest values were found in nearby Ahsan colony as well such as Sasti Basti and Sachal Colony. Overall, the results represented that thirteen samples (13) depicted a concentration of Total Hardness beyond the value recommended by the WHO.

3.6 Nitrate (NO₃) and Nitrites (NO₂)

Nitrate and Nitrites are also important parameters for predicting the overall quality of groundwater. Nitrite and Nitrate both are contributed to water by waste oil and grease etc. Nitrite and Nitrate cause laziness, dizziness, cancer, and other health effects on human beings. The WHO has suggested that in portable water the concentration of Nitrate and Nitrite should not be above 10 ppm and 1 ppm respectively. Assessment of groundwater samples of Larkana City revealed that about three samples possessed a concentration of Nitrate beyond the WHO recommended value and nine samples had Nitrite beyond the WHO suggested value.

3.7 Sulphate (SO₄)

Sulphate in groundwater samples was assessed to know the safe concentration of sulphate in the drinking water of Larkana City. Results of the analysis of each sample for sulphate revealed that the concentration of sulphate in groundwater samples was between 80 ppm to 520 ppm. However, the WHO recommends that water is safe against sulphate concentration if the value of sulphate in water is below 250 ppm. Results of studies further exhibited that about eleven samples were extremely contaminated due to excessive concentration of sulphate. The sample that had a concentration of sulphate beyond permissible limits included samples collected from Ahasn Colony, PTS, QUEST boy's hostel, Sachal Colony, and others.

Overall analysis of groundwater samples based on chemical water quality parameters is shown in Fig.2

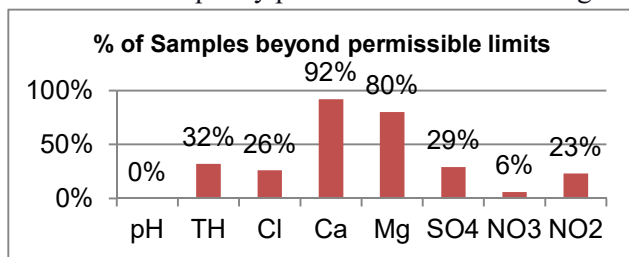


Fig.2 Overall analysis of groundwater samples

5. Conclusion

Water is a crucial source of life. However, this precious element of life is contaminated by various factors such as over abstraction, urbanization etc. Therefore, research works are being to detect suitability of drinking water throughout the world. Sindh province of Pakistan is also grappling with the degrading quality of drinking water. Groundwater is the major source of drinking water in Sindh province, but this source is no more in its pure state. That's why variety research are proposed for checking suitability of groundwater in Sindh province as well. This study was proposed to know true status of groundwater in Larkana city. Forty groundwater samples were randomly collected from random locations from taps, hand pumps, and motor pumps. Each sample was analysed for water quality parameter such as pH, Calcium, Magnesium, Total hardness (TH), Chloride, Sodium, Iron, Nitrites, Sulfate and Nitrates, were analysed. Overall, assessment water samples revealed that the concentration of pH was within the permissible limit. However, 26% of samples had chloride beyond the permissible limit, and 32% of samples had a concentration of Total Hardness (TH) above the desirable limits. Moreover, 6%, 23%, 29%, 92%, and 80%, of samples had a concentration of Nitrates, Nitrites, Sulfate, calcium, and magnesium respectively.

It is recommended that suitable treatment unit for water treatment should be introduced in larkana as soon as possible so that health of citizens should be protected on the priority basis.

6. Reference

- [1] Jamali, M. Z., Khoso, S., Soomro, Z., Sohu, S., & Abro, A. F. (2022). EVALUATING THE SUITABILITY OF GROUNDWATER IN PAKISTAN: AN ANALYSIS OF WATER QUALITY USING SYNTHETIC POLLUTION INDEX (SPI) AND WATER QUALITY INDEX (WQI). *International Journal of Energy, Environment and Economics*, 30(3), 311-328.
- [2] Solangi, G. S., Siyal, A. A., Babar, M. M., & Siyal, P. (2019). Evaluation of drinking water quality using the water quality index (WQI), the synthetic pollution index (SPI) and geospatial tools in Thatta district, Pakistan. *Desalination and Water Treatment*, 160, 202-213.
- [3] Ahmed, S., Jamali, M. Z., Khoso, S., Azeem, F., & Ansari, A. A. (2022). ASSESSMENT OF GROUNDWATER QUALITY IN RURAL AREAS OF TALUKA DOKRI, SINDH, PAKISTAN, THROUGH PHYSICO-CHEMICAL



- ARAMETERS. *International Journal of Energy, Environment and Economics*, 30(3), 211-226.
- [4] Jamali, M. Z., Solangi, G. S., Keerio, M. A., Keerio, J. A., & Bheel, N. (2023). Assessing and mapping the groundwater quality of Taluka Larkana, Sindh, Pakistan, using water quality indices and geospatial tools. *International Journal of Environmental Science and Technology*, 20(8), 8849-8862.
- [5] Jamali, M. Z., Solangi, G. S., & Keerio, M. A. (2020). Assessment of Groundwater Quality of Taluka Larkana, Sindh, Pakistan. *International Journal of Scientific & Engineering Research*, 11(5), 795-797.
- [6] Lanjwani, M. F., Khuhawar, M. Y., & Jahangir Khuhawar, T. M. (2022). Assessment of groundwater quality for drinking and irrigation uses in taluka Ratodero, district Larkana, Sindh, Pakistan. *International Journal of Environmental Analytical Chemistry*, 102(16), 4134-4157.



Effects of Noise Pollution and Its Influence on Roadside of People and Business Community in Southern Part of Nawabshah.

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Vehicles horns
Traffic Congestion
Train Tracks

ABSTRACT

The research in the southern area of Nawabshah identified significant noise pollution issues, surpassing recommended levels set by the Department of Housing and Urban Development (HUD). Peak noise levels reached 68.8 dBA, with morning hours in March recording the highest levels. Naya Naka and Doctors' Colony maintained acceptable noise levels, especially during May to November evenings. Health concerns associated with noise pollution include decreased hearing capacity, irritation, sleep disturbances, and mental health issues, with the most affected age group being 20-40 years. Older individuals, particularly those over 60, experienced more severe effects such as despair and insomnia.

1. Introduction

Noise pollution is the disturbing noise with harmful impact on the activity of human or animal life. The source of outdoor noise worldwide is mainly caused by machines and transportation systems, motor vehicles engines & trains. Many cities of world are most affected from Noise pollution. The known worldwide outdoor source of noise is transportation system and industrial machinery. These are the cities in world with the worst noise pollution. Delhi was the second worst city for noise pollution, followed by Cairo, Mumbai, Istanbul and Beijing. Barcelona, one of only two European cities to feature in the worst 7th, while capital cities Mexico City, Paris at 8th and 9th position respectively. The top five quietest cities were all in Europe: Zurich, Vienna, Oslo, Munich and Stockholm.

Pakistan is also worst effected from Noise pollution. No express provision has been made for the ban and control of noise pollution in the constitution of Pakistan, in 1973, noise free environment has been regarded a Fundamental Right of every citizen of Pakistan. The scientific and technological advancements bring unforeseen problems in their wake. Although, the automobiles, aircrafts, machines, tools, gas turbines and compressors all are useful in themselves but also associate innumerable calamities (Molesworth et al., 2013).

Noise is unpleasant and annoying sound and man's

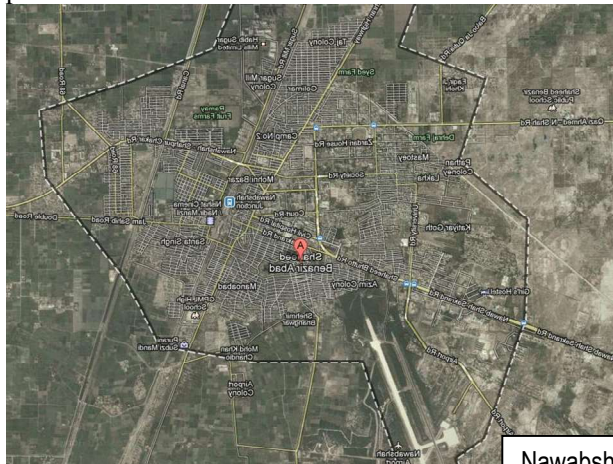
susceptibility to this element may vary for intensity (Bond, 1996), sensibility and age (Chien and Shih, 2007); and it can be categorized as occupational Noise and community noise (Gangwar *et al.*, 2006). Noise revelation in an industrial work place is termed as community noise, environmental noise or domestic noise (Garg *et al.*, 2007; Jamrah *et al.*, 2006). Among sources of community noise, the transportation system has the dominating role compared to other causes such as road, air and rail, construction activities, use of home appliances and activities in the neighbours (Dev and Singh, 2011). Transpiration noise is a key problem in the cities of the world today (Martin *et al.*, 2006). The motorcycles can generally produce noise level in the range of 72-85 dB but can reach as high as 120 dBA immediately behind the cycles as against the noise level range of 65-75 dB in case of car (Williams and McCrae, 1995; Tang and Tong, 2004; Dev and Singh, 2011). The railway noise that puts direct impacts on residential communities; the primary source includes the whistling noise of locomotives. The noise of diesel locomotives and wheel/rail noise as well. The impact of noise pollution by trains is at optimum level in those areas where railway tracks pass through residential areas (Mikael Ogren, 2006).

There was no legislation in Pakistan to deal with noise coming from railway engines, Aircrafts, airport, industrial or construction activities. Public complaints on noise pollution were often received in the federal and provincial environmental protection agencies, but



in the absence of national standards for noise, these agencies were handicapped to take any legal action. Most of the civil airports lay in heavily population areas in Pakistan and no such precautionary measures had been taken. The situation gets alarming with increase in traffic density on city roads, particularly in Karachi.

As population increases the requirements for the goods, services and transportation also increase. Everyone requires transportation to move from one place to another place to fulfill their different needs and requirements. Therefore, each year there is an increase in the number of vehicles in Nawabshah city, which has certainly caused traffic noise pollution problems to the city dwellers. The population of poorly maintained vehicles is also growing which intensify the situation significantly. Thus, the pollution is one of the major environmental problems of Nawabshah city adversely affects its citizens. Keeping the above facts in view, the study was carried out to evaluate noise pollution and its possible effects on the roadside residents and traders in Nawabshah city. The study results will provide guideline for future planning in the study area by controlling noise pollution in the environment.



The traffic noise levels of trains and vehicles passing through Nawabshah city were measured by digital sound level meter at ten sites in decibel (dB). The noise produced by the horn, the engine and wheels of each train was measured separately. The traffic density was analysed by counting the number of vehicles crossing each survey site per hour and the data were analysed statistically. The data were collected using survey method, and in addition to monitoring the noise pollution level at ten different sites in the residential/commercial areas and at railway station of Nawabshah. The following sites were surveyed to examine the level and impact of noise pollution:

Survey sites

6. Naya Naka
7. Doctors' colony near hospital road
8. Shaheed chowk
9. Golwala complex chowk
10. Purani sabzi mandi road

Related aspects covered

5. Individual vehicle noise level
6. Traffic flow density at each site
7. Noise level in peak hours of traffic flow
8. Public opinion survey

Measurement of noise pollution

Noise pollution refers to any unpleasant, damaging or irritating noise that has the potential to harm people, wildlife or the environment. The decibel (dB) is the main unit used to measure the intensity or loudness of sounds. A sound can also be measured by its pitch, which is the frequency of sound vibrations per second. For example, a low pitch produced by a deep voice, makes fewer vibrations per second than a high voice. Sounds with higher pitch, such as a cry or sound from a violin, have a high rate of vibrations. Sound is usually recorded with a microphone. However, in a sound level meter, a sound sensor is used. Sound sensors work like microphones but are much more accurate.

Decibel (dB): The SI (International System of Units) unit of measure of sound intensity. The response of a sound sensor to a nearby sound is approximately proportional to the sound pressure, which is the air pressure produced by the propagating sound. For example, if we talk with a piece of paper placed just in front of our mouth, the resulting air pressure causes the paper to move. A similar observation can be made feeling vibrations from a loud speaker. After evaluating the selected sites initially, the situation was further confirmed and for confirmation, the noise level was continuously evaluated for 15 days. Special attention was paid in the selection process of measuring points for (1) total of measuring stations that settled in research area must be divided in homogeneous form and (2) measuring station must be settled and installed in adjacent of the main streets. Noise monitoring process at any point must be in operation more than two weeks (for the average noise during weekdays), and the data and information was collected continuously. The method adopted by Nasiri *et al.* (2008) was followed for selection of noise pollution measuring points and collection of the data.

To evaluate the impact of traffic noise on roadside residents and traders will be interviewed for confirming the noise related diseases. At the end of



thesis work, I will suggest the suitable strategy to mitigate noise pollution under prevailing environment.

Experimental Procedure

Locations	Timings			
	8:0-8:30a m	1:0-1:30pm	4:0-4:30p m	8:30-9:0pm
1. Naya naka	74.1 1 ^B	74.61 B	63.9 9 ^B	59.95 B
2. Doctors' colony near hospital road	55.8 1 ^J	56.71 J	52.7 7 ^H	48.50 H
3. Shaheed chowk	67.2 1 ^G	67.67 G	62.3 0 ^E	58.46 D
4. Golwala complex chowk	71.0 4 ^C	71.52 C	63.4 1 ^C	58.69 C
5. Purani sabzi mandi road	84.5 8 ^A	85.15 A	68.0 9 ^A	60.59 A
Mean	68.3 6 ^A	68.83 A	61.5 7 ^B	57.04 C

The instruments for field measurements were comprised of precision grade sound level meter (PCE 318) ½- inch condenser microphone and ½- octave filter with frequency range and measuring level range of 31.5Hz–8 KHz and 35-130dB, respectively. The instruments were adjusted by the internal sound level calibrator before measurement at the site.



The observations in relation to noise measurement were made at the specified locations. The instrument was operated comfortably in hand with the microphone pointed at the suspected source of noise at about one meter distance from any reflecting object. L_{Ai} (A-Weighted Instant Sound Pressure Level) measurement was made at 30-second intervals for 30 minutes, giving 60-meter readings at each location in sample. This process of observations was performed at 8:00-8:30 am (morning), 1:00-1:30 pm (afternoon), 4:0-4:30 pm (evening) and 8:30-9:00 pm (night). The readings obtained from this process, commonly used community noise assessment quantities like exceedence percentiles L_{10} , and L_{90} , the A-weighted equivalent sound pressure level, L_{Aeq} , the day-time average sound level, L_D , the day-night average sound level, L_{DN} , the noise pollution level, L_{NP} and the traffic noise index, TNI were computed. The data in relation to noise levels collected from different locations were tabulated and examined critically in accordance with the recommendations of United States Department of Housing and Urban Development (HUD) for noise levels in residential areas. The following are the HUD described standards for noise pollution for the residential areas in view of the human health protection.

Table 1 Noise Level at Different hours of the day at various locations of Nawabshah City.

1. Clearly acceptable ≤ 49 dB (A)
2. Normally acceptable ≤ 62 dB (A)
3. Normally unacceptable ≤ 76 dB (A)
4. Clearly unacceptable > 76 dB (A)



In view of the above HUD standards, the results were described and accordingly the recommendations were developed.

3. Results

The study was carried out during 2015 (from January 2015 to December 2015) to evaluate noise pollution and its possible effects on the roadside residents and traders in Southern Part of Nawabshah city. The data in relation to noise pollution levels were examined critically in accordance with the recommendations of United States Department of Housing and Urban Development (HUD) for noise levels in residential areas. According to HUD, the noise pollution level ≤ 49 dB (A) is described as clearly acceptable, ≤ 62 dB (A) normally acceptable, ≤ 76 dB (A) normally unacceptable and > 76 dB (A) clearly unacceptable. Results contains the statistically analysed data in relation to location-wise noise pollution, monthly noise pollution level for the year 2015, morning and evening noise pollution, noise pollution at different timings in the morning and in the evening.

Noise Level at different Timings of day

Statistically, the level of noise pollution varied significantly ($P < 0.05$) at different timings of the day. The acoustic pollution because of intense commercial activities and due to heavy traffic in areas surrounded by roads was recorded at different locations of Nawabshah city District Benazirabad in morning and evening hours. The data (Table-1) showed that on average the maximum noise pollution (68.83 dBA) was recorded in the afternoon at 1:00-1:30 pm, closely followed by early morning hours of 8:0-8:30 am when the level of noise pollution was 68.36 dBA. The noise pollution pressure reduced to 61.57 dBA in early evening hours at 4:0-4:30 pm and further decreased to 57.04 dBA in the late evening hours at 8:0-8:30 pm. Regardless of the location of the city, 8:0-8:30 am or 1:0-1:30 pm were the hours of intense traffic and commercial activities and hence the noise pressure was severe during these hours of the day. Generally, these morning hours of 8:0-8:30 am is the timing when the school/college going children approach to their institutions; while 1:0-1:30 pm hours is the timing of their return to homes. The location \times timing interaction showed that there was severe level of noise pollution (85.15 or 84.58 dBA) at Purani Sabzi Mandi Road at 1:0-1:30 pm and 8:0-8:30 am, respectively; while the lowest level of noise pollution (48.50 dBA) was recorded at Doctors' colony near hospital road at 8:0-8:30 pm hours. As suggested by the United States Department of Housing and Urban Development (HUD) for noise levels in residential areas, the average noise level recorded at 8:00-8:30 am and 1:0-1:30 pm was in the range of normally unacceptable level; while in the evening time the noise level was in the range of

normal acceptable level. The statistical analysis suggested that there was similarity ($P > 0.05$) in the level of noise pollution in the morning (8:0-8:30 am) and in the afternoon hours (1:0-1:30 pm); while differences were highly significant ($P < 0.05$) when level of noise was compared with evening hours (4:0-4:30 pm and (8:0-8:30 pm).

Morning and evening comparison of noise level

There was significant ($P < 0.05$) difference in the level of noise pollution in the morning and evening hours in Nawabshah city ($F = 42054.3$, $df = 479$) and locations ($F = 18109.2$, $df = 479$). The noise pollution at certain locations of the city was recorded and compared for morning and evening noise level.

The results in Table-2 showed that in the morning hours the noise level was significantly higher (68.60 dBA) as compared to evening hours (59.31 dBA). In the morning and evening hours, the noise level at Purani Sabzi Mandi was 84.86 and 64.34 dBA, followed by; Naya Naka (74.36 and 61.97 dBA), Golwala Complex Chowk (71.28 and 61.05 dBA); the areas along the railway track (70.21 and 60.51 dBA); Taj Colony Chowk (69.51 and 60.65 dBA); Sanghar Naka (68.12 and 59.51 dBA); Shaheed Chowk (67.44 and 60.38 dBA); Regal Chowk (66.09 and 59.57 dBA); while the morning and evening hours noise level was at the lower side at Qazi Ahmed Mor (57.81 and 54.44 dBA) and lowest morning and evening noise level (56.26 and 50.63 dBA) was recorded in Doctors' colony near hospital road, respectively.

There was direct association of morning hours noise level with the evening hours noise level at different locations of the city. As recommended by HUD for noise levels in residential areas, the average noise level recorded in the morning hours was in the range of normally unacceptable level; while in the evening time the noise level was in the range of normal acceptable level.

As per HUD recommendations, the noise level in the morning hours and afternoon at Purani Sabzi Mandi (84.86 dBA), and Naya Naka (74.36 dBA) was clearly unacceptable level, while noise level at Golwala Complex Chowk (71.28 dBA); areas along the railway track (70.21 dBA); Taj Colony Chowk (69.51 dBA); Sanghar Naka (68.12 dBA); Shaheed Chowk (67.44 dBA); Regal Chowk (66.09 dBA) was in the range normally unacceptable level. However, morning hours noise level at Qazi Ahmed Mor (57.81 dBA) and Doctors' colony near hospital road (56.26 dBA) was in the safe range of normally acceptable.

4. Conclusion

In Nawabshah, traffic noise pollution exceeded acceptable levels during morning and afternoon hours, according to HUD guidelines. Areas like Purani Sabzi Mandi and Naya Naka consistently experienced



unacceptable noise levels. Places near Golwala Complex Chowk, railway tracks, and various chowks also faced elevated noise pollution. However, Qazi Ahmed Mor and Doctors' Colony near hospital road maintained safe noise levels. Noise levels varied throughout the year, with May to November generally acceptable and the remaining months unacceptable.

The increase in noise during morning and afternoon hours was attributed to school-related traffic. Health issues associated with noise pollution, such as hearing problems and sleep disturbances, were more prevalent among the 20-40 age group. Older individuals, especially those over 60, experienced heightened effects like sleeplessness and depression due to noise exposure.

Recommendations

8. Heavy vehicles/machinery and noisy vehicles should not be given entry into the city
9. Vehicle fitness system may be strictly implemented and vehicles with high noisy and smoke may be restricted.
10. Without fitness certificate, no vehicle should be allowed to enter the city
11. The routes of heavy traffic coming through the city may be changed.
12. Mass transit system may be initiated in the city so that light vehicle movement is reduced.
13. Encroachment along the railway track may be removed
14. The establishment of schools/educational institutions should be restricted upto the main/wide roads and establishment of such institutions must not be allowed in thick population areas of the city

5. Reference

- [1] Agarwal, S. and B.L. Swami. 2009. Noise annoyance under interrupted traffic flow condition for Jaipur City, International Journal of Applied Science and Engineering, 7(2): 159-168.
- [2] Anomohanran, O. 2013. Evaluation of environmental noise pollution in Abuja, the capital city of Nigeria Ochuko Anomohanran Physics Department, Delta State University, Abraka, Delta State, Nigeria. IJRRAS, 14 (2): 470-476.
- [3] Barreiro, J., M. Sanchez and M.V. Grau. 2005. How much are people willing to pay for silence? A contingent valuation study. Applied Economics, 37 (11) : 217-226.
- [04] Dev, P. and V. Singh. 2011. Environmental noise pollution monitoring and impacts on human health in Dehradun city, Uttarakhand, India. Civil and Environmental Research, 1 (1) : 32-40.
- [05] EEA, 2012. Good practice guide on noise exposure and potential health effects. European Environmental Association Technical report / No 11/2012, published on October 2012.
- [06] Erdogan, E. and M. Yazgan. 2009. Landscaping in reducing traffic noise problem in cities: Ankara case, African Journal of Agric. Res., 4(10): 1015-1022.
- [07] Determination of ambient noise levels in the main commercial area of Cape Coast(2011), Ghana, Research Journal of Environmental and Earth Sciences 3(6): 637-644.
- [8] Hammer, M.S., T.K. Swinburn and R.L. Neitzel. 2014. Environmental Noise Pollution in the United States: Developing an Effective Public Health Response. Environ Health Perspectives, 122 (2) : 88-94.
- [9] Molesworth, B.R., M. Burgess and B. Gunnell. 2013. Using the effect of alcohol as a comparison to illustrate the detrimental effects of noise on performance. Noise & Health, 15 : 367-373.
- [10] Olayinka, O.S. 2015. Effective Noise Control Measures and Sustainable Development in Nigeria. Science and Education Publishing, 1 (1) : 96-107.



Machine Learning-Based Classification of Alzheimer's Disease Using EEG Signal Dataset: A Comparative Study of Feature Extraction and Classification Techniques.

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KEY WORDS

AD disease
Machine learning
classification

ABSTRACT

Alzheimer disorder (AD) is a brain disorder that is regarded as one of the most dangerous diseases. It is a debilitating illness in which a part of the brain that has been affected cannot be restored to its former condition. AD has been diagnosed using a variety of methods, including physiological and neurological examinations, laboratory tests, assessments of mental condition and neurophysiology, and brain scans. Brain scans is considered one of the most accurate and frequently used methods among the earlier ones, but it has several drawbacks. The currently used methods are inefficient, expensive, and time consuming. This study suggests a unique method for diagnosing Alzheimer's disorder using an intelligent healthcare system that uses six antennas put on the head of the individual to record EEG data in order to overcome these challenges. The suggested approach employs an intelligent strategy to efficiently diagnose AD. Automated machine learning and deep learning models are used to determine whether an individual has Alzheimer's disease or not. We use other popular machine learning methods to evaluate how well the suggested prediction model performs in comparison. The proposed classifiers achieved 96.8% accuracy with less computation time which is better than previous approaches.

1. Introduction

An illness of the brain known as Alzheimer's disease that is thought to be extremely dangerous. A neuron that has been harmed by AD cannot recover to its pre-damaged form because it is a degenerative disease. In western nations, it is thought to be the primary cause of dementia. The main cause of AD is the buildup of amyloid protein in the brain, which results in the death of many nerve cells in the brain. The onset of AD is gradual, and the patient is unaware of his condition and whether he has been impacted or not. However, as time goes on, the disease begins to manifest its danger. AD frequently develops in elderly adults beginning at the age of 60 and older. According to the WHO, AD is the sixth most dangerous disease. The US is the country which highly affected by this disease, and as a result, it has a higher fatality rate. Based to a studies created by the World Health Organization (WHO), over 5.8 million individuals have this ailment as of 2020, and if

no measures are done, that number might increase nearly 16 million individuals by the end of 2050. The earliest symptoms of this illness are short-term memory loss, behavioral changes, carelessness, anxiety, depression, speech difficulties and disorientation. A person with this condition experiences symptoms such as shortness of memory, loss of speaking, loss of thinking ability, movement from one location to another, and strange physical conduct at the final stage, which results in death. AD progresses slowly, sometimes taking three to nine years or longer [1, 2]. The four phases of Alzheimer's disease include PR dementia, early stage, middle stage, and advanced stage. Each stage's symptoms are unique from the others [3]. Pre-dementia symptoms include forgetfulness, short-term memory loss, misplacing objects, and mimicking the ageing process. Learning impairment, executive function problems, forgetting



events, bewilderment, and speaking with difficulty are just a few of the early stage symptoms. The symptoms of the middle stage include speech difficulties, loss of control when reading and writing, increased disorientation, difficulty sleeping, and long-term memory deterioration, among other things. The patient's ability to think is compromised in the advanced stages, and these symptoms eventually cause him to death. The patient also has trouble talking, exhibits apathy, and is unable to perform simple tasks on his own. The use of computers in healthcare departments is expanding, and it is now normal practice to report patient data that was formerly gathered using paper-based forms electronically. Because of this, handling unstructured data using database management tools and other traditional methods is difficult and time-consuming. The efficacy and efficiency of medical and healthcare facilities can be increased by using machine learning and data processing technologies and methodologies. The history of the disease, neurological and psychiatric symptoms, and its existence all play a role in the diagnosis of AD. The patient's relatives can be contacted to obtain his medical history, as well as also assess the patient's behavior [4]. When screening and analyzing AD, dietary habits, pharmaceuticals, and other patient nutrients are all taken into consideration. When the recognizable plaques and tangles are visible during a microscopic examination of the brain, Alzheimer's disease can be definitively diagnosed after death. In order to diagnose AD, a number of tests have been carried out, including a physical and neurological examination, which involves the doctor physically examining the patient and evaluating their overall neurological condition. Reflexes, muscle tone, willpower, the capacity to get up from a chair and move around a room, sense of sight and hearing, agility, and balance are all things to take into account throughout the test. During a lab test, medical professionals draw a patient's blood. A doctor can diagnose a thyroid issue or vitamin insufficiency as the cause of the memory loss and frustration through blood testing. Furthermore, a physician can conduct a quick mental status examination or a longer series of tests to ascertain a patient's memory and other cognitive abilities. Longer-form neuropsychological tests can reveal more about mental function when compared to subjects of equivalent age and education. One of the most popular, important, and standard techniques for obtaining visual evidence of brain disorders is brain imaging. MRI and CT scans are two types of brain imaging structures. Positron emission tomography

(PET) allows for the visualization of disease processes. In order to promote accurate and reliable technical assessments for a variety of brain disorders, the research community in the field has focused on the clinical significance of AD and the widely used modern non-invasive imaging techniques. In point of fact, investigators have lately proposed and put into action a variety of machine brain detection (CABD) methods to explore the severity and prevalence of Alzheimer's disease. However, the earlier imaging technique has a significant downside, namely the length of calculation and evaluation. The second argument is that a nation or region with poor economic standing cannot pay the high cost of diagnostic tools. Another factor reducing the effectiveness of the earlier strategies is the need for a skilled radiologist in medical imaging. A report indicates that about 2/3 of the population lacks access to radiologists for disease diagnosis.

In order to address these issues, this study suggests a novel method for the diagnosis of AD that makes use of six antenna placed on the patient's head to record EEG signals. These antennas will record an individual's EEG signal data, and based on that information, it will determine the individual's health status. Different deep learning and machine learning algorithms are used, including logistic regression (LR), random forest (RF), support vector machine (SVM), decision tree (DT). The effectiveness and performance of the suggested computational framework are illustrated by measuring the performance of the used models using a variety of performance evaluation metrics, including accuracy, f1-measure, sensitivity, specificity, ROC curve, and Mathew correlation coefficient (MCC). Rest of the paper is structured as follow. The previous research work is illustrated in section 2, proposed methodology is discussed in section, section 4 discuss the result, and section 5 depicts the conclusion and feature work.

2. Literature review

In the field of medical imaging, early detection of Alzheimer's disease is critical not just for maintaining human cognitive ability, but also for public health. Alzheimer's disease (AD) causes significant issues with human thought, memory, and other everyday activities. To diagnose AD, several methods have been developed that use intelligent approaches such as machine learning, and neural networks techniques that work significantly better than earlier manual approaches. Some of these approaches are shown in table



Table 1. Shows the previous approaches used for ad classification

Authors	Models applied	Contributions	Results	Dataset Used	Dataset	Weak
Hanife GÖKER et al [5]	AdaBoostM1, TB, GB, LB, RB,	Classification	93%	EEG signals	FSU dataset	Accuracy can be improved
Giorgio Biagetti et al.[6]	KNN, DT, SVM, NB	Classification	93%	EEG signals	European Dataset	time complexity used small dataset
R. Swarnalatha[7]	SbRNS	Detection	99.8%	EEG signals	Indian Hospital dataset	Accuracy can be Improved
Bin Jiao et al.[8]	SVM, LDA	classification	70%	EEG signals	ADNI dataset	Accuracy can be Improved
Digambar Puri et al.[9]	SVM, KNN, EBT, DT, NN.	Detection	96.2%	EEG signals	University of Edinburgh dataset	Accuracy can be improved
Xiaocai Shan et al.[10]	ST-GCN	Classification	92.3%	EEG signals	NIHR dataset	Accuracy can be Improved
Andreas Miltiadows et al.[11]	LightGBM, SVM, KNN, MLP, RF	Classification	77%	EEG signals	Open Neuro dataset	Accuracy can be Improved
Vinayak Bairagi[12]	SVM, KNN	Diagnosis	94%	EEG signals	SKN dataset	Used small Dataset
Saman Fouladi[13]	CNN, AE-CNN	Classification	92%	EEG signals	IRCCS CNM dataset	Accuracy can be Improved
Alexandra[14]	Random Forest	Classification	92.5%	EEG signals	Santa Lucia Foundation etc.	Accuracy can be Improved
Gulnaz Ahmed et al.[15]	D-CNN	Classification	99.2%	MRI images	Kaggle dataset	Time complexity
Batzayel et al.[16]	VGG-C, CNN	Prediction	98%	MRI images	Kaggle dataset	Used small Dataset
Waleed Al Shehri[17]	DenseNet-169, ResNet-50	Classification	97%	MRI images	Kaggle dataset	Used small dataset
Nagarathna CR[18]	AD, MCI, CN	Classification	93.3%	MRI images	ADNI dataset	Accuracy can be Improved
Ahila A et al.[19]	CNN	Diagnosis	96%	MRI images	ADNI dataset	Used small dataset
Badia et al.[20]	AlexNet-SVM ResNet-50	Diagnosis	94%	MRI images	Kaggle dataset	Accuracy can be Improved
Sambath Kumar[21]	SVM, KNN	Classification	96%	MR Images	ADNI dataset	Used small dataset
Srividhya et al.[22]	CNN, ResNet-50v2. etc.	Diagnosis	91.8%	MRI images	ADNI dataset	Accuracy can be Improved
Allen J. Chang[23]	CNN	Classification	88.5%	MRI images	ADNI dataset	Accuracy can be improved
Nayef Alqahtani[24]	DBN-MOA	Detection	97.4%	MRI images	ADNI dataset	Accuracy can be Improved

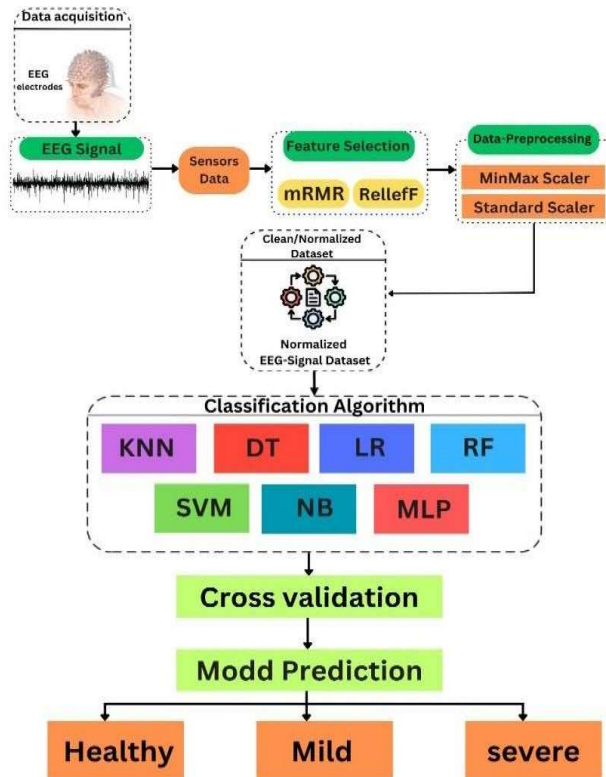
The above mentioned studies has a lot of limitation in term of accuracy and their computation time. In order to fulfill this gap, the proposed approach use a ML based method to classify the Alzheimer disease in an efficient way. Different ML and DL algorithms are employed to determine a human's health issues, such as whether they have Alzheimer's disease.

3. Materials and methods

The proposed experiment aims to develop a classification system for detecting Alzheimer's disease and healthy people. We have used machine Learning techniques to analyze the EEG signals dataset. In addition, we employed algorithms including Relief, and mRMR to choose most important features. Initially, data was collected in that unprocessed form. The data being processed is cleaned of noise using a variety of noise reduction algorithms and the preprocessing procedure methods. Before applying multiple machine learning algorithms to determine a person's health state, the data goes through preprocessing, where it can be purified and normalized. The overall system architecture is shown in figure 1.

3.1 Dataset collection

This study makes use of EEG signal data gathered with the use of numerous electrodes (antenna) put on the heads of people of different ages. A brain computing interface (BCI), which comprises of a helmet with 12 antennae, is used to gather the EEG data.



The patients' skulls are placed over the helmet's imbedded electrodes. The data is then sent to the microprocessor on the rear of the helmet following data gathering. The computer system then receives the EEG signal data and delivers it to a number of machine learning classification models for further processing. There are 450 instances in the collected dataset, including some healthy, some moderate, and some severe cases. The figure 2 shows the dataset's pie chart.

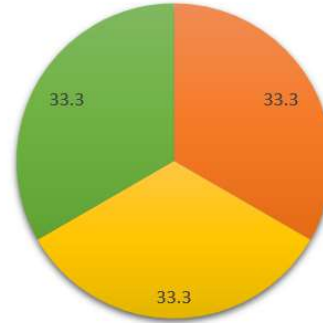


Fig. 2. shows the dataset distribution

3.2 Features selection.

Features extraction minimize the quantity of data in a dataset while keeping the most crucial information [27-29]. It is a crucial stage in machine learning since it enables algorithms to operate just on pertinent data. There are many variables in big data sets. It takes a lot of computing resources to control these variables. Thus, by combining and choosing variables into features, feature extraction aids in the extraction of the best feature from a set of vast data, resulting in a decrease in data volume. The amount of duplicate data in the data collection was reduced using feature extraction without any important or pertinent information being lost.

3.3 Pre-processing

Pre-processing aims to improve data by eliminating unwanted differences or enhancing certain attributes that will aid processing and analysis operations [24-33]. We used a few preprocessing methods to raise the data quality to a respectable degree of accuracy. In order to make the process of identifying tiny differences more straightforward, we used data normalization on our dataset, which is useful for reducing various redundancies from the dataset. Dataset is further subdivided into 70% and 30% ratios for machine learning model training and validation, respectively. As a result, the dataset become ready for training and testing of machine learning models.

3.4 Classification models

The proposed study, use machine learning techniques including Support Vector Machine (SVM), Decision Tree(DT), K-Nearest Neighbor (KNN), Naïve Bayes (NB), Logistic regression (LR), Random Forest (RF), Multi-Layer Perceptron (MLP).

4 Result and discussion

This section of the article discusses the performance of proposed classifier with two different feature selection techniques. Initially we discuss the performance of proposed classifiers with mRMR feature selection approach. Finally, we discuss the performance of proposed classifiers with Releif features selection techniques.

4.1 Performance of all classifiers using mRMR featuresselection approach.

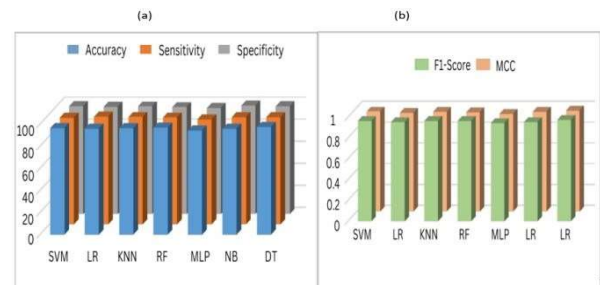
The DT classifier outperformed compared to other classifiers using the 10-fold cross-validation method in all performance evaluation metrics. DT obtained 96.831% accuracy, 96.456% sensitivity, 96.99% specificity, 0.97 F1-Score, and 0.9677 MCC. Similar to NB, NB have a 0.95 F1-Score, 0.9549 MCC, 96.644% sensitivity, 97.33% specificity, and 95.342% accuracy. Numerous experiments using k different numbers, such as K= 3,5,7,9, and 13, were conducted for the KNN classification algorithm. With 95.672% categorization accuracy, 96.735% sensitivity, and 96.95% specificity, an F1- Score of 0.96, and an MCC of 0.9534, KNN beat the competition at k=5. The RF also has 96.148% accuracy, 95.654 sensitivity, 96.199% specificity, 0.96 F1-Score, and 0.9543 MCC. Similarly, LR achieves 0.95F1-Score, 0.9442 MCC, 96.98% sensitivity, 96.51% specificity, and 95.432% accuracy. Similar to this, SVM (L) has 0.96 F1-Score, 0.9576 MCC, 96.034% accuracy, 96.031% sensitivity, 97.22% specificity. MLP achieves 0.94 F1-Score, 0.9354 MCC, 94.561% Sensitivity, and 95.45% Specificity. An actual analysis of the success percentages of all classifiers. The performance of all models using the 10-fold CV-based mRMR feature selection method is shown in table 2. The accuracy, sensitivity and specificity of the proposed classifiers is graphically represented in figure 3(a) while figure 3(b) shows the f1-score and MCC

of the proposed classifiers with mRMR features selection technique. features selection technique.

Fig.3(a) show the accuracy, sensitivity, specificity and Fig 3(b) shows the MCC and f1-score of all classifier using mRMR features selection techniques.

4.2 Performance of all classifiers using the reliefF method

After using reliefF features selection method the DT classifier success rate is still higher than that of the other classifiers. DT has accuracy of 97.855%, sensitivity 98.222%, and specificity of 97.89%, F1-score is 0.98, and MCC is 0.9762. The least accurate model is MLP, which has a 94.210 % success record. The overall performance of the proposed classifiers is shown in table 3.



The accuracy, sensitivity and specificity of the proposed classifiers is graphically represented in figure 4(a) while figure 4(b) shows the f1-score and MCC of the proposed classifiers with relief

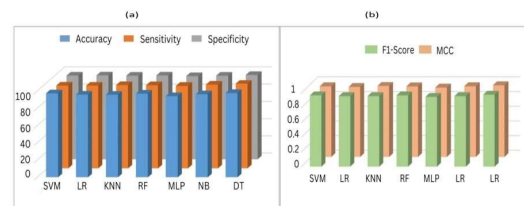


Fig.4(a) show the accuracy, sensitivity, specificity and Fig 4(b) shows the MCC and f1-score of all classifier using relief features selection techniques



Table 2. Proposed methodology result with an evaluation matrix using mrmr technique

<i>Classifier</i>	<i>Accuracy</i>	<i>Sensitivity</i>	<i>Specificity</i>	<i>F1-score</i>	<i>MCC</i>
SVM	96.034	96.031	97.22	0.96	0.9576
LR	95.432	96.98	96.51	0.95	0.9442
KNN	95.672	96.735	96.95	0.96	0.9534
RF	96.274	96.237	96.42	0.96	0.9500
MLP	93.749	94.561	95.45	0.94	0.9354
NB	95.342	96.644	97.63	0.95	0.9549
DT	96.831	96.456	96.99	0.97	0.9677

Table 3. Proposed methodology result with an evaluation matrix using relief technique

<i>Classifier</i>	<i>Accuracy</i>	<i>Sensitivity</i>	<i>Specificity</i>	<i>F1-score</i>	<i>MCC</i>
SVM	97.542	96.031	97.12	0.97	0.9623
LR	96.011	95.98	97.32	0.96	0.9531
KNN	95.875	96.612	96.99	0.96	0.9672
RF	97.143	96.372	97.24	0.97	0.9607
MLP	94.210	95.781	96.56	0.95	0.9451
NB	96.423	97.107	97.013	0.96	0.9631
DT	97.855	98.222	97.89	0.98	0.9762

The RF classifier outperformed all other classification models in terms of ROC curve. Figure 5 shows the ROC curves for the best four classification techniques applied in proposed experiment.

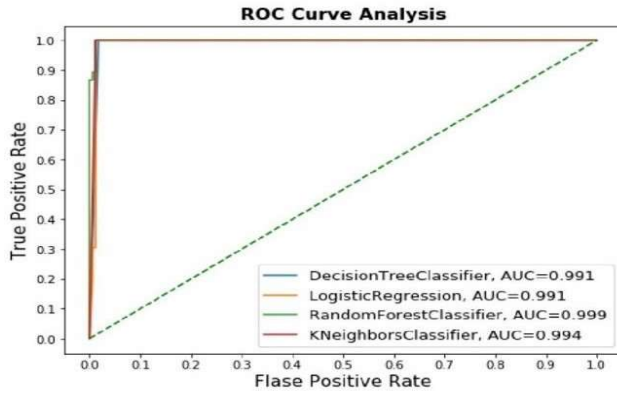


Fig.5 shows the ROC curve for the proposed classifiers.

5 Comparative analysis.

In this section we have compared proposed classifiers result with previous studies. Proposed models achieved better result in performance metrics then previous studies shown in table 4.

Table 4. Comparative analysis

Authors	Models applied	Result S	Dataset	Weakness
[5] Hanife GÖKER	AdaBoostM, 1, TB, GB, LB, RB,	93%	EEG signals	Accuracy can be improved
[6] Giorgio Biagetti et al.	KNN, DT, SVM, NB	93%	EEG signals	time complexity
[8] Bin Jiao et al.	SVM, LDA	70%	EEG signals	Accuracy can be improved
[9] Digambar Puri et al.	SVM, KNN, EBT, DT, NN.	96.2%	EEG signals	Accuracy can be improved
[10] Xiaocai Shan et al.	ST-GCN	92.3%	EEG signals	Accuracy can be improved
Proposed model	KNN,DT,L R,RF,SVM, NB,MLP	96.8%	EEG signals	---

6. Conclusion

This study presents a diagnosis system for AD based on a machine learning model. In proposed study used EEG signals dataset which is collected by using electrodes with six antennas. We used two different features selection techniques and test

the performance of all classifiers. DT classifier achieved highest accuracy, MLP classifier achieved lowest accuracy among all other classifiers with mRMR and reliefF features selection techniques. The time complexity of proposed experiment was less compared to previous approaches. Still there are some limitation in proposed experiment. Firstly, we have use less number of antennas and secondly we have tested the collected dataset with few machine learning models. In future we will use 16 antennas instead of six antennas. Furthermore, we will try more machine learning and deep learning hybrid models to improve the performance of the proposed system.

7. References

- [1] Wang, T., Qiu, R. G., and Yu, M., Predictive modeling of the progression of Alzheimer’s disease with recurrent neural networks. *Sci.Rep.* 8:9161, 2018.
- [2] Haaksm, M. L. et al., Comorbidity and progression of late onset Alzheimer’s disease: A systematic review. *PLoS One* 12(5): e0177044.
- [3] Malik, G. A., and Robertson, N. P., Treatments in Alzheimer’s disease. *J. Neurol.* 264(2):416–418, 2017.
- [4] Neugroschl, J., and Wang, S., Alzheimer’s disease: Diagnosis and treatment across the spectrum of disease severity. *Mt Sinai J. Med.* 78(4):596–612, 2011.
- [5] H. GÖKER, “Detection of alzheimer’s disease from electroencephalography (EEG) signals using MULTITAPER and ensemble learning methods,” *Uludağ University Journal of The Faculty of Engineering*, pp. 141–152, 2023. doi:10.17482/uumfd.1142345
- [6] G. Biagetti, P. Crippa, L. Falaschetti, S. Luzzi, and C. Turchetti, “Classification of alzheimer’s disease from EEG signal using robust- PCA feature extraction,” *Procedia Computer Science*, vol. 192, pp. 3114–3122, 2021.
- [7] R. Swarnalatha, “A greedy optimized intelligent framework for early detection of alzheimer’s disease using EEG Signal,” *Computational Intelligence and Neuroscience*, vol. 2023, pp. 1–10, 2023.
- [8] B. Jiao, R. Li, H. Zhou, K. Qing, H. Liu, H. Pan, Y. Lei, W. Fu, X. Wang, X. Xiao, X. Liu, Q. Yang, X. Liao, Y. Zhou, L. Fang, Y. Dong, Y. Yang, H. Jiang, S. Huang, and L. Shen, “Neural



- biomarker diagnosis and prediction to mild cognitive impairment and alzheimer's disease using EEG Technology," *Alzheimer's Research & Therapy*, vol. 15, no. 1, 2023.
- [9] D. V. Puri, S. Nalbalwar, A. Nandgaonkar, and A. Wagh, "Alzheimer's disease detection from optimal EEG channels and tunable Q-wavelet transform," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 25, no. 3, p. 1420, 2022.
- [10] X. Shan, J. Cao, S. Huo, L. Chen, P. G. Sarrigiannis, and Y. Zhao, "spatial-temporal graph convolutional network for alzheimer classification based on brain functional connectivity imaging of Electroencephalogram," *Human Brain Mapping*, vol. 43, no. 17, pp. 5194–5209, 2022.
- [11] A. Miltiadous et al., "A dataset of scalp EEG recordings of alzheimer's disease, frontotemporal dementia and healthy subjects from routine EEG," *Data*, vol. 8, no. 6, p. 95, 2023. doi:10.3390/data8060095
- [12] V. Bairagi, "EEG signal analysis for early diagnosis of alzheimer disease using spectral and wavelet based features," *International Journal of Information Technology*, vol. 10, no. 3, pp. 403–412, 2018. doi:10.1007/s41870-018-0165-5
- [13] S. Fouladi, A. A. Safaei, N. Mammone, F. Ghaderi, and M. J. Ebadi, "Efficient Deep Neural Networks for classification of alzheimer's disease and mild cognitive impairment from scalp EEG Recordings," *Cognitive Computation*, vol. 14, no. 4, pp. 1247–1268, 2022. doi:10.1007/s12559-022-10033-3
- [14] A.-M. Tăuțan et al., "TMS-EEG perturbation biomarkers for alzheimer's disease patients classification," *Scientific Reports*, vol. 13, no. 1, 2023. doi:10.1038/s41598-022-22978-4
- [15] G. Ahmed, M. J. Er, M. M. Fareed, S. Zikria, S. Mahmood, J. He, M. Asad, S. F. Jilani, and M. Aslam, "Dad-NET: Classification of alzheimer's disease using ADASYN oversampling technique and optimized neural network," *Molecules*, vol. 27, no. 20, p. 7085, 2022.
- [16] B. Tuvshinjargal and H. Hwang, "VGG-C transform model with batch normalization to predict alzheimer's disease through MRI dataset," *Electronics*, vol. 11, no. 16, p. 2601, 2022.
- [17] W. Al Shehri, "Alzheimer's disease diagnosis and classification using Deep Learning Techniques," *PeerJ Computer Science*, vol. 8, 2022.
- [18] C. R. Nagarathna and M. Kusuma, "Classifying the stages of alzheimer's disease by using Multi Layer Feed Forward Neural Network," *Procedia Computer Science*, vol. 218, pp. 1845–1856, 2023.
- [19] A. A. P. M, M. Hamdi, S. Bourouis, K. Rastislav, and F. Mohmed, "Evaluation of neuro images for the diagnosis of alzheimer's disease using Deep Learning Neural Network," *Frontiers in Public Health*, vol. 10, 2022.
- [20] B. A. Mohammed, E. M. Senan, T. H. Rassem, N. M. Makbol, A. A. Alanazi, Z. G. Al-Mekhlafi, T. S. Almurayziq, and F. A. Ghaleb, "Multi-method analysis of medical records and MRI images for early diagnosis of dementia and alzheimer's disease based on Deep Learning and hybrid methods," *Electronics*, vol. 10, no. 22, p. 2860, 2021.
- [21] S. K. Sethuraman et al., "Predicting alzheimer's disease using deep neuro-functional networks with resting-state fmri," *Electronics*, vol. 12, no. 4, p. 1031, 2023. doi:10.3390/electronics12041031
- [22] S. L, S. V, V. Ravi, G. E.A, and S. K.P, "Deep learning-based approach for multi-stage diagnosis of alzheimer's disease," *Multimedia Tools and Applications*, 2023. doi:10.1007/s11042-023-16026-0
- [23] A. J. Chang et al., "MRI-based deep learning can discriminate between temporal lobe epilepsy, alzheimer's disease, and healthy controls," *Communications Medicine*, vol. 3, no. 1, 2023. doi:10.1038/s43856-023-00262-4
- [24] N. Alqahtani et al., "Deep Belief Networks (DBN) with IOT-based alzheimer's disease detection and classification," *Applied Sciences*, vol. 13, no. 13, p. 7833, 2023. doi:10.3390/app13137833
- [25] G. Zaman Khan et al., "Intelligent Systems for early malaria disease detection in patient cells using transfer learning approaches," 2023 4th International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), 2023. doi:10.1109/icomet57998.2023.10099260
- [26] G. Zaman Khan et al., "An efficient deep learning model based diagnosis system for lung cancer disease," 2023 4th International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), 2023. doi:10.1109/icomet57998.2023.10099357
- [27] Gul Zaman Khan and Inam Ullahx, "Efficient technique for monkeypox skin disease classification with clinical data using pre-trained models," *Journal of Innovative Image Processing*, vol. 5, no. 2, pp. 192–213, 2023. doi:10.36548/jiip.2023.2.009
- [28] S. H. Badshah et al., "An efficient classification techniques for brain tumor using features extraction and statistic methods, with machine learning algorithms," *Lecture Notes on Data Engineering and Communications Technologies*, pp. 757–775, 2023. doi:10.1007/978-3-031-24475-9_62
- [29] G. Z. Khan, Ikram Ulhaq, Ihsan Adil, Sajad Ulhaq, and Inam Ullah, "A Privacy-Preserving Based



- Technique for Customer Churn Prediction in Telecom Industry”, VFAST trans. softw. eng., vol. 11, no. 3, pp. 73–80, Sep. 2023.
- [30] A. Bashir, U. Burhan, S. Fouzia, J. Hazrat, and Z. K. Gul, “A supervised classification phenotyping approach using machine learning for patients diagnosed with primary breast cancer,” *i-manager’s Journal on Computer Science*, vol. 11, no. 1, p. 1, 2023. doi:10.26634/jcom.11.1.19374 .
- [31] Spogmay Yousafzai et al. (2023) ‘Improved Neural Network-based system for early and accurate diagnosis of alzheimer disease’, *Journal of Computer Science and Technology Studies*, 5(4), pp. 32–40. doi:10.32996/jcsts.2023.5.4.4.
- [32] Sajad Ulhaq, G. Z. Khan, Imran Ulhaq, I. Ullah, and F. Rabbi, “Epilepsy seizures classification with EEG signals: A machine learning approach,” *Journal of Computer Science and Technology Studies*, vol. 5, no. 3, pp. 25–34, 2023. doi:10.32996/jcsts.2023.5.3.3
- [1] R. Zaman, I. A. Shah, N. Ullah, and G. Z. Khan, “A robust deep learning-based approach for detection of breast cancer from histopathological images,” *The 4th International Electronic Conference on Applied Sciences*, Dec. 2023. doi:10.3390/asec2023-16598



Design of Asphalt Mix Using Postconsumer Recycled Plastic as a Partial Replacement of Filler

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KEYWORDS

Postconsumer Recycled Plastic (PCR)
Polyethylene Terephthalate (PET)
Asphalt Mixtures
Sustainable Approach
Optimum Percentage

ABSTRACT

The use of post-consumer recycled plastic (PCR) in asphalt mixtures has gained noteworthy attention in recent years as a means of reducing plastic waste and improving the mechanical properties of asphalt. This research paper evaluates the performance of asphalt mixes containing PCR specifically Polyethylene Terephthalate (PET) as a partial replacement for aggregates passing through the No. 4 sieve and retained on the 200-micron sieve. The study examines the impact of different percentages of PET (0%, 5%, 10%, 15%, 20% and 25%) on the mechanical properties of the asphalt mixes, including Marshall Stability, flow, air voids, bulk density, and indirect tensile strength. The results show that the addition of PET significantly enhanced the mechanical properties of the asphalt mixes, with the optimum replacement percentage determined to be 13.67%. Furthermore, the mixes containing PET showed enhanced resistance to moisture damage, indicating improved durability.

1. Introduction

Transportation Engineering is a crucial field of engineering concerned with the design, construction, and maintenance of transportation infrastructure such as roads, bridges, highways, and airports. The demand for sustainable and environmentally friendly transportation infrastructure has sparked attention in the application of recycled materials in road construction, especially in asphalt mixes. Asphalt mixes are comprised of aggregates, binder (usually asphalt cement), and additives that provide desirable properties such as strength, durability, and workability. However, the use of conventional aggregate in asphalt mixes has been shown to have several negative impacts on the environment, including resource consumption, habitat destruction, and greenhouse gas emissions. Therefore, finding an alternative to aggregates in asphalt mixes is of greatest importance. One such alternative is the application

of post-consumer recycled plastic as a partial replacement for the conventional aggregates in asphalt mixes [1]. Postconsumer recycled plastic, which is derived from plastic waste generated by households and businesses, is a suitable alternative due to its lightweight, durable and flexible properties.

There are various advantages to producing asphalt using recycled plastic from post-consumer waste. It reduces the vulnerability on non-renewable resources, decreases greenhouse gas emissions and offers a sustainable and is primarily disposed of as solid waste, it is referred to as postconsumer material. One kind of plastic material that comes from plastic waste produced by homes and businesses is postconsumer recycled plastic. One use for recycled plastic from post-consumer waste is in the construction of roads, particularly in asphalt mixtures. Several advantages can arise from partially substituting conventional aggregates in asphalt mixes with post consumer recycled plastic. These advantages include enhanced mechanical qualities and reduced reliance on



limited resources. Nevertheless, there are a few things to take into account when recycling recycled plastic from after-consumption in asphalt mixes. One of the most important factors is the quality of the recycled plastic. Recycled plastic may become unsuitable for use in some applications due to impurities or contaminants that alter its performance and properties. As a result, it's critical to make sure the recycled plastic material is correctly sorted, cleaned, and processed in order for it to fulfill the specifications needed for its intended use.

The kind and size of plastic particles added to the asphalt mix are additional factors to take into account. The particles' composition and compatibility with the asphalt binder must be taken into consideration, and their size should be appropriate for the intended application. Furthermore, to guarantee even dispersion of the plastic particles and avoid segregation, the procedure of combining the recycled plastic with the asphalt binder needs to be closely regulated.

Particularly in the context of road construction, post-consumer recycled plastic offers the potential to offer a long-term solution to the environmental problems associated with plastic waste. To guarantee the efficacy and longevity of the asphalt mixes, it is imperative to take into account variables like material quality, plastic particle size and composition, and mixing technique. We can lessen our environmental impact and promote the creation of long-term infrastructure by doing this.

There are several advantages to using recycled plastic from post-consumer waste in asphalt mixtures. Adding recycled plastic to asphalt mixes is one of the main reasons for doing so. Shredded plastic waste is mixed with asphalt to serve as a binder and enhance the endproduct's functionality. As a result of the plastic's increased flexibility and durability, the asphalt may eventually crack and deform less. This may lead to a resilient road surface that needs less upkeep and fixing. Utilizing recycled plastic also lowers the quantity of virgin materials required to produce asphalt. This is significant because it contributes to energy conservation and lessens the need for non-renewable resources. Furthermore, reducing the amount of trash made of plastic that would otherwise end up in the environment or landfills is possible by incorporating recycled plastic into asphalt mixes. In summary, better road performance, less of an adverse effect on the surroundings and a future that is more sustainable can

result from the use of post-consumer recycled plastic in asphalt mixtures.

Several recent research has looked into the performance of asphalt mixtures using PCR. [4] used Plastic Modified Reclaimed Asphalt Pavement. He added 30% Plastic in that and did different Comprehensive Mechanical Tests and found that it had optimum results at 30%. In another study, [1] investigated the effects of adding different percentages of Acrylonitrile butadiene styrene and Polyethylene Terephthalate in Asphalt Mix. He added 0.5%, 1%, 2%, and 4% of Acrylonitrile butadiene styrene and Polyethylene Terephthalate in Asphalt Mix and after doing different tests like Penetration Test, Viscosity Test, Softening Point Test, Fracture Test, Fatigue and Flexural Stiffness Test, Rutting Resistance Test he found that it has optimum results at 1% for heavy traffic pavements and 2% for Low Traffic Pavements. [5] added different percentages of Recycled polyethylene (rPE) in the Asphalt Mix and investigated various effects. He conducted a Laser Scanning Confocal microscope (LSCM) Test at different percentages of 0%, 1%, 2%, 3%, and 4% and found that 2% has optimum results. Similarly, [6] added 6%-10% of Recycled Plastic Waste and performed a Dry and Wet processed Test and found that at 10% it has optimum results. In another study, [7] investigated the effects of using Plastic waste polyolefins, low density polyethylene, high density polyethylene, and polypropylene with Asphalt Mix. He added percentages of this varying from 1-10% and performed Wet Process Tests, and HighShear Mixing tests. He found that at 4% it has optimum results. used Palm kernel shells (PaKS) and Waste Plastic as partial replacements for aggregate and binder respectively. He added 4% to 7.5% of both materials by weight and performed different tests like Bending Strength Test, Water Susceptibility Test, Rutting, and Cracking Test. After performing these tests he found that it has maximum results at 5.2%. investigated the effects of adding Waste Polyethylene (PE) with Asphalt Mix. He added 5%, 6.1%, and 6.5% of Waste Polyethylene (PE) in the Asphalt Mix and performed various tests like The cyclic compression test and Semi circular bending test. He then found that at 6% it yielded maximum results. investigated the results of including Waste Plastic Bags (WPBs) in Asphalt Mixture. He added various percentages of Waste Plastic Bags (WPBs) ranging from 6-18%. He performed Marshall Mix Design And Indirect Tensile Strength (ITS) Test and



found that it has maximum results at 17% for 9.5 mm, 13% for 12.5 mm, and 7% for 19mm Nominal Maximum Aggregate Size. studied the effects of adding Post Consumer Waste Plastic to Asphalt Mix. He added different % of Post Consumer Waste Plastic varying from 0-10%. He performed different tests like Stiffness Test, Indirect Tensile Strength Test, Rutting test, and Fatigue Test. He found that at 10% of the binder mix it yields maximum results. investigated the performance of an Asphalt Mix containing Low Density Polyethylene. They added Low Density Polyethylene with % of 4, 6, 8, and 10%. They performed Wet Blending Method over a Dry test on Asphalt Mix at different percentages and found that at 5.16% it has optimum results. investigated the effects of adding Waste plastics Polyethylene pellets and Polyethylene shreds to Asphalt Mix. They added 33% of Waste plastics Polyethylene pellets and Polyethylene shreds with Asphalt Mix and performed tests like Differential Scanning Calorimetry (DSC) test, Thermal Gravimetric Analysis test, Fourier Transform Infrared spectroscopy test and Environmental Scanning Electron Microscopy test and found that at 33% it has optimum results. investigated the performance of Asphalt Mix containing Recycled plastic waste (RPW). They investigated the performance at different percentages of 0%, 5%, 10%, and 20%. They performed tests like Rutting Performance Tests, and Fatigue Life Tests and found that at 9.5% of the weight of mineral aggregates, it has optimum results. investigated the effects of adding Low Density Polyethylene in Asphalt Mix. They added 0-1% of Low Density Polyethylene in Asphalt Mix, performed tests like Softening Point Test, Viscosity Test, Ductility Test, Indirect Tensile Strength Test, and Marshall test, and found that at these tests they found that At 3-10% of wt it has Optimum Results.

[8] investigated the performance of Asphalt Mix containing Packaging waste polyethylene (WPE). They added Packaging waste polyethylene (WPE) in Asphalt Mix with a Percentage ranging from 0-10% and performed Wheel Rutting Test, Fatigue Resistance, Marshall Test and found that at 6% it has optimum result. added Low Density Polyethylene (LDPE) in Asphalt Mix at 30% and performed Soundness Test, Impact Value Test, Los Angel's Test, Abrasion Test,

0.5% it has an optimum result. checked the performance of Asphalt Mix by adding Recycled high and low density polyethylene, recycled polypropylene styrene butadiene styrene, and Polybit in percentages ranging from 0-10%. They performed tests like the Performance Grade Test, and Storage Stability Test and found the optimum value at RHDPE content below 4% and RLDPE content below 6%.

[8] added Waste Plastic (Polyethylene) in Asphalt Mix in different percentages to check its performance. They added 4%, 6%, 8%, and 10% of Waste Plastic (Polyethylene) in the Asphalt Mix and performed Marshall Stability Test, Indirect Tensile Strength Test, Resilient Modulus Test, and Dynamic Creep Test. After performing these tests they found that 8% Plastic added is Optimum Value.

[9] checked the performance of the Asphalt Mix containing Polyethylene from Silo Bags and Recycled Polypropylene at percentages of 2%, 4%, and 6%. They conducted Marshall Test, Indirect Tensile Test, Moisture Susceptibility Test, Dynamic Modulus Test, Permanent Deformation Test, and, Creep Compliance Test and found that Optimum Results were found at 2%.

[10] investigated the effects of adding Plastic bottle wastes identified as PET in Asphalt Mix at percentages of 5%, 10%, and 20%. They performed Softening Point Test, Penetration Test, Viscosity Test and Ductility Test and found that at 16.7% it has optimum results.

[11] added Polyethylene (PE) in Asphalt Mix and checked its properties. They added Polyethylene (PE) ranging from 1-10% and performed Viscosity Test, Ductility Test and Softening Point Test. After doing

Marshall Stability Test, Softening Point Test, Penetration Index Test, Ductility Index Test, Flash and Fire Point Test. After performing these tests they found the Optimum value to be at 5-10% of Waste Plastic.

The outcomes of this investigation will offer a thorough comprehension of the functionality of asphalt mixtures that incorporate recycled plastic from post-consumer sources. The findings will help pave the way for the wider adoption of this sustainable material in asphalt production and aid in the creation of more ecologically friendly techniques for building roads [24]. The structure of the paper is as follows: Section 2 covers the details about the technique adopted for

achieving the objective and goals. Section 3 includes the results and discussion, and Section 4 concludes the paper.

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[13] added Low Density Polyethylene (LDPE) in Asphalt Mix at 30% and performed Soundness Test, Impact Value Test, Los Angel’s Test, Abrasion Test, Marshall Stability Test, Softening Point Test, Penetration Index Test, Ductility Index Test, Flash and Fire Point Test. After performing these tests they found the Optimum value to be at 5-10% of Waste Plastic.

The outcomes of this investigation will offer a thorough comprehension of the functionality of asphalt mixtures that incorporate recycled plastic from post-consumer sources. The findings will help pave the way for the wider adoption of this sustainable material in asphalt production and aid in the creation of more ecologically friendly techniques for building roads [24]. The structure of the paper is as follows: Section 2 covers the details about the technique adopted for achieving the objective and goals. Section 3 includes the results and discussion, and Section 4 concludes the paper.

2. Research Methodology

2.1 Introduction

The procedure and approach used during the whole study has been described in this chapter. This test is designed to evaluate the functionality of normal asphalt pavements and modified asphalt pavements in the lab. In this chapter, the several experiments conducted, discussions and the testing procedures followed to attain the purposes of this project are highlighted. The manufacturing processes of mixes were determined from the related lab tests which abide the American Society of Testing Materials (ASTM) and The American Association of State Highway and Transportation Officials (AASHTO) to check materials, mixes parameters to make sure that satisfactory long term

performance from the mixes is achieved.

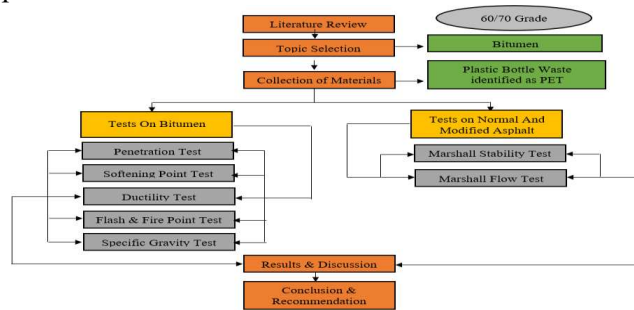


Fig 1. shows the flow chart of research methodology

2.2 Material

2.2.1 Aggregates and (PET)

The crushed aggregates were collected from Kotbanglow Khairpur District of Sindh, Pakistan which were used in this study. The aggregate gradation was selected acc: to the job mix formula during this course of study PET which passes from No 4 sieve and retained on 200 microns was used. The PET is prepared or got by mechanical method (cutting and making into smaller pieces i.e. shredding) at the present temperature from Waste Dump in Khairpur Mir’s, Sindh.

Table 1

Total Aggregates Used For Asphalt Mix Design

Total Aggregate Used For Asphalt Mix Design								
Passing	Retained	Weight Of Aggregate By % Of Bitumen (gm)						
		Job Mix %	4.00%	Polyethylene Terephthalate %				
				5	10	15	20	25
25mm	19.5mm	3.41	40.94	40.9	40.9	40.9	40.9	40.9
19.5mm	12.5mm	11.99	143.90	143.9	143.9	143.9	143.9	143.9
12.5mm	9.5mm	18.83	225.96	226.0	226.0	226.0	226.0	226.0
9.5mm	4.75mm	15.82	189.83	189.8	189.8	189.8	189.8	189.8



4.75m m	2.36m m	14.84	178.1 2	165.6	153.0	140.8	129.3	114.5
2.36m m	300μ m	21.01	252.1 5	246.2	240.2	233.9	228.0	223.0
0.3m m	0.075 μm	5.35	64.14	59.1	54.1	49.1	43.6	39.0
0.075 mm	Pan	4.75	56.95	53.0	49.0	45.0	40.5	37.0
Bitumen			48					
Total Aggregates			1152	1124	1097	1069	1042	1014
Wt. of PET			0	27.6	55.1	82.7	110.0	138.0
Total wt. (No PET)			1200	1172.4	1144.9	1117.3	1090.0	1062.0
Total Wt. of mix			1200	1200.0	1200.0	1200.0	1200.0	1200.0

2.2.2 Asphalt

Bitumen is a viscous product of crude oil distillation. Bitumen is used as a basic binding material in any mix design. The grade of asphalt in this study was 60/70.

Several basic tests were performed at the Highway Engineering Lab at MUET SZAB Campus Khairpur MIR'S.

2.3 Dry Process

The "dry" process uses PET as an reinforcement. Typically, 0% to 25% of the Plastic Bottle Waste is added to the solid asphalt binder in solid form along with the thick aggregate. The dry process can be used to place hot asphalt in a mixture of compact grade, open grade or joint grade. It cannot be used in other asphalt paving applications, such as cold mixing and chip sealing or surface treatment. In the dry process, a little part of fine

Bottle Waste. The Plastic Bottle Waste particles are mixed with the aggregates prior to the inclusion of asphalt cement. The basis of drying process is the use of crushed plastic bottle waste instead of a certain proportion of aggregate and a change in grade.

2.4 Preparation of Marshal Sample

The common process used to incorporate the chosen ingredient into the asphalt mix is dry process. Before bitumen is added in this procedure, the additive is combined with aggregates.

To get a smooth covering of the bitumen over all the aggregates serious care needs to be taken during blending/mixing. until and unless all the plastic bottle waste has not been dispersed thoroughly along with the aggregate there will be no addition of asphalt to the mixer. It is crucial to observe that the addition is evenly distributed and well-mixed to prevent clumping while blending. If clumping happens, it will result in uneven aggregate coating and, in consequence will decrease the ability of the mixture to bear the vertical stresses.

Method:

Marshall Design was used for both the modified and unmodified asphalt concrete mixtures. Using an impact hammer, samples were compressed to a height of roughly 64.5 mm in a mold with a diameter of 101 mm. An illustration of the procedure used to commit HMA mixture samples is provided below:

aggregate (generally it is 1-10% of the mixture's total aggregate) is replaced with granulated or grinded PlasticThe aggregate was graded using the HMA 20 system after being sieved and divided into various sizes. Separate attempts are used to deposit each aggregate size independently. But before they were all proportioned, the aggregates were all dried in an oven.

Each size of aggregate is weighed based on how much of it is in the mix and is then kept in a plastic bag using the HMA 20 gradation. All of the aggregates were dried in an oven set to 100°C before being proportioned.

Each PET is sieved, weighed, and classified into different contents, which are then kept in separate plastic bags.

The necessary quantity of aggregate should be weighed, put in the oven, and heated to 150°C for three hours. The bitumen required for the specimen was heated to a temperature of 120° C for an hour.



Table 2
No of Samples for Bitumen Testing

S. No.	Mix Proportion	% Of Pet	No. Of Samples For Bitumen Testing	No. Of Samples For Stability And Flow Value
1	Tests On Bitumen	00	18 (For Determining Mechanical Properties Of Bitumen)	
2	Control Mix	0.0	18	15 (For Determining Optimum Bitumen Content)
3	Pet	0.0		03
4	Pet	5		03
5	Pet	10		03
6	Pet	15		03
7	Pet	20		03
8	Pet	25		03

The appropriate quantity of PET and filler were added once the aggregates reached the required temperature. They were then combined using a blender machine.

After adding the required quantity of hot bitumen to the aggregate and PET mixer, the mixture was mixed until all of the aggregate and PET had been covered with bitumen.

For the mix to be homogeneous, there shouldn't be any uncoated filler particles that stand out as white dots against the bituminous mix.

In a Marshall mould, the slurry was poured. To prevent the sample and the Marshall mould from sticking together, filter paper was inserted into the base of the mould.

Each side of each sample received 75 compressed strikes.

Before being extruded from the mold, each sample was allowed to cool to room temperature following compaction.

Remove the sample from the Marshall mold with a hydraulic lift and keep it at room temperature for later analysis.

3. Results and Discussions

3.1 Introduction

In this chapter we will be discussing results and findings obtained from the Asphalt Mix containing Postconsumer Recycled Plastic as a partial replacement of filler. This section critically analyzes the empirical findings obtained through experimentation and aims to provide a comprehensive understanding of the impact and effectiveness of incorporating postconsumer recycled plastic in asphalt mixtures. The ensuing discourse explores the implications of these results, drawing connections between observed outcomes and the research objectives, ultimately contributing to the broader discourse on sustainable practices in asphalt engineering.

3.2 Results

Different tests on Bitumen 60/70 grade were performed which are Penetration Test (AASHTO T-49, ASTM D-5), Ductility Test (AASHTO T-51, ASTM D-113), Softening point test (AASHTO T-53, ASTM D-36), Specific gravity test (AASHTO T-288, ASTM D-70), Flash and fire point test (AASHTO T-48, ASTM D-92). Flash and fire point (AASHTO T-48, ASTM D-92).

Table 3

Laboratory Test Result of Bitumen 60/70 Grade

Laboratory Test	Results
Penetration (AASHTO T-49, ASTM D-5)	66
Ductility (AASHTO T-51, ASTM D-113)	140 cm
Softening point (AASHTO T-53, ASTM D-36)	48 °C
Specific gravity (AASHTO T-288, ASTM D-70)	1.030 Kg/cc
Flash and fire point (AASHTO T-48, ASTM D-92) 1) Flash point 2) Fire point	310 °C 368 °C

3.2.1 Optimum Bitumen Content

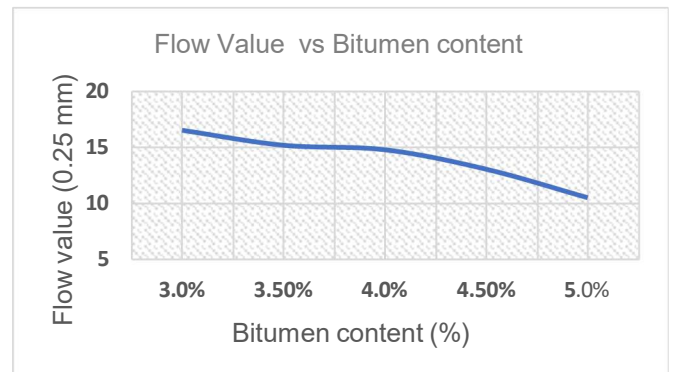
Following steps are followed in order to find the Optimum bitumen content. First we will find the weight of aggregates used with different percentages of bitumen.

At the different percentages of Bitumen values of Gmb, VMA, Pa (% air voids), VFB, Stability Value and Flow Value were obtained which were used to find the Optimum Bitumen Content. Following Table shows results obtained by testing samples for Finding Optimum Bitumen Content.

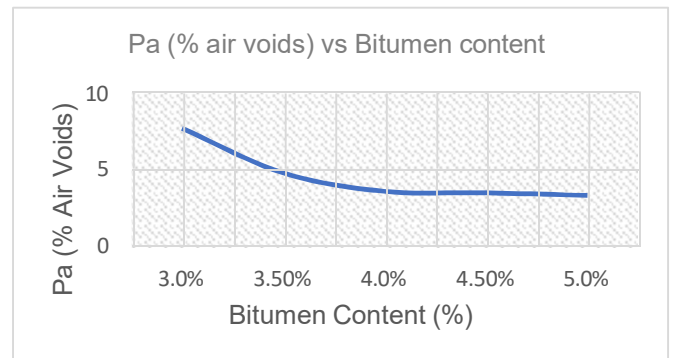
Table 4

Results to Find OBC

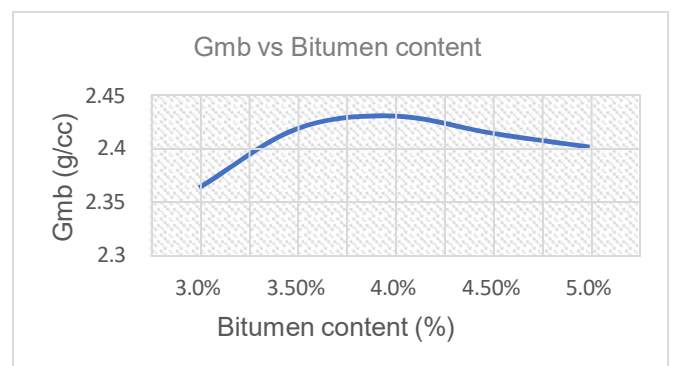
S No	Bitumen Content	Gmb	VMA	Pa (% air voids)	VFB	Stability Value	Flow Value
1	3.0%	2.36	13.66	7.65	43.97	797.62	16.53
2	3.50%	2.41	12.11	4.76	60.66	968.38	15.2
3	4.0%	2.43	12.13	3.57	70.57	988.31	14.8
4	4.50%	2.41	13.16	3.47	73.58	954.37	13.06
5	5.0%	2.40	14.08	3.30	76.56	808.80	10.53



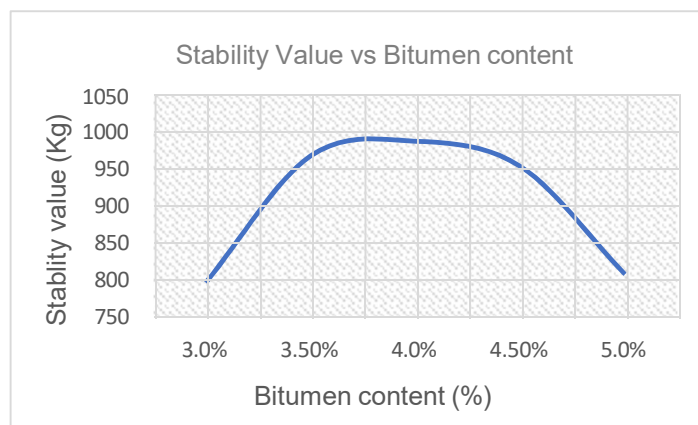
Graph 2. Flow Value vs Bitumen Content



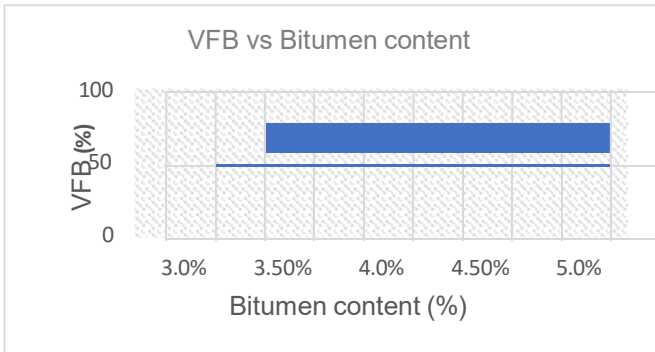
Graph 3. Pa (% air voids) vs Bitumen Content



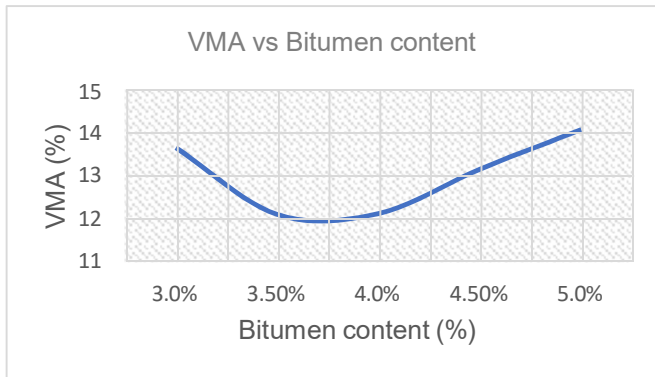
Graph 4. Gmb vs Bitumen Content



Graph 1. Stability Value vs Bitumen Content



Graph 5. VFB vs Bitumen Content



Graph 6. VMA vs Bitumen Content

Optimum Bitumen content

B1=Bitumen content at maximum density (unit weight) = 3.65%

B2= Bitumen content at maximum 4% Air voids = 4.6%

B3= Bitumen content at maximum stability = 3.80%

$$OBC = \left(\frac{B1+B2+B3}{3} \right) = \left(\frac{3.65+4.6+3.80}{3} \right)$$

OBC = 4%

3.2.2 Optimum PET Content

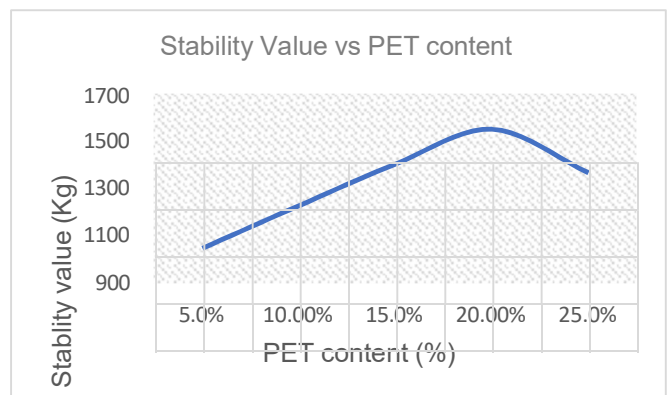
From above results, the OBC was 4%. While making modification in asphalt mixture, the PET was used from 0% to 25% with 5% increment at OBC (4%) using the dry process in mix design.

Table 5

Average Stability from 0% PET to 25% PET

Sample #	% PET	Stability (Kg)	Avg Stability
S-1	0	1552.75	1293.962
S-2		1275.4765	

S-1	5	1053.6545	1046.261
S-2		998.199	
S-3		1086.928	
S-1	10	1275.4765	1227.415
S-2		1186.7477	
S-3		1220.021	
S-1	15	1330.932	1404.873
S-2		1441.843	
S-3		1441.843	
S-1	20	1552.754	1552.754
S-2		1663.665	
S-3		1441.843	
S-1	25	1330.932	1367.902
S-2		1330.932	
S-3		1441.843	



Graph 7. Stability Value vs PET content

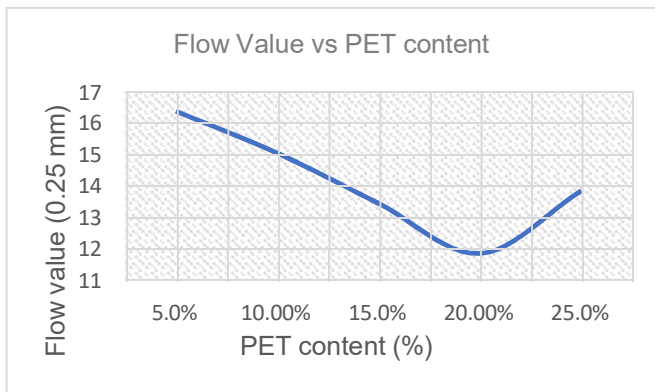
Table 6 Average Flow from 0% PET to 25% PE

Sample #	% PET	Flow (mm)	Avg Flow
S-1	0	17	17.433

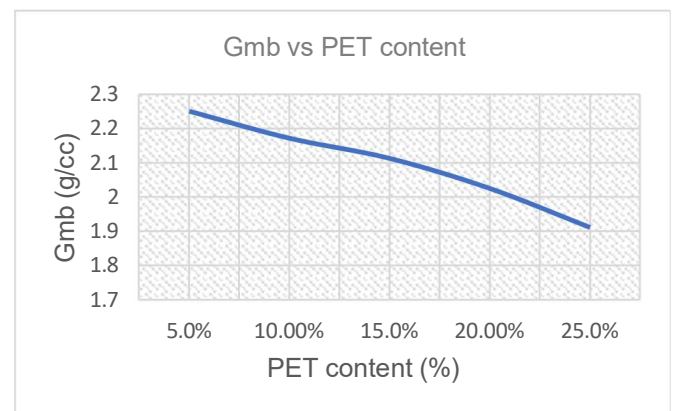


S-2		18.5	
S-3		16.5	
S-1	5	17.2	16.4
S-2		18.8	
S-3		13.2	
S-1	10	18	15.067
S-2		13.2	
S-3		14	
S-1	15	13.2	13.467
S-2		15.2	
S-3		12	
S-1	20	10.8	11.867
S-2		12	
S-3		12.8	
S-1	25	13.6	13.867
S-2		13.6	
S-3		14.4	

S-2		
S-3		
S-1	5	2.253
S-2		
S-3		
S-1	10	2.419
S-2		
S-3		
S-1	15	2.431
S-2		
S-3		
S-1	20	2.415
S-2		
S-3		
S-1	25	2.402
S-2		
S-3		



Graph 8. Flow Value vs PET content



Graph 9. Gmb vs PET content



Table 7

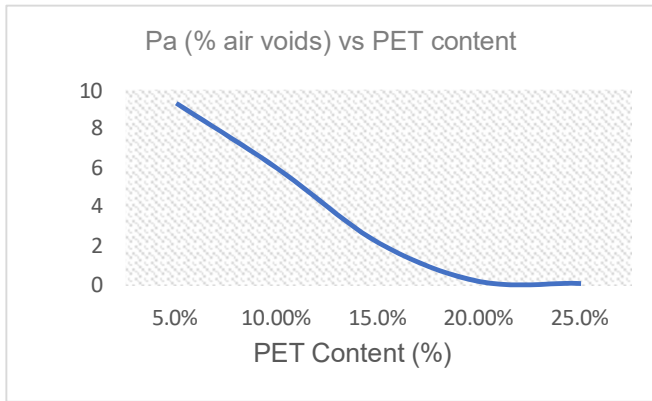
Average Unit Weight (Gmb) from 0% PET to 25% PET

Sample #	% PET	Unit Weight (Gmb)
S-1	0	2.404
S-2	0	2.404
S-3		
S-1		
S-2	5	9.3
S-3		
S-1		
S-2	10	-4.628
S-3		
S-1		
S-2	15	-12.442
S-3		
S-1		
S-2	20	-18.907
S-3		
S-1		
S-2	25	-25.431
S-3		
S-1		

Table 8

Average % Air Voids (Pa) from 0% PET to 25% PET

Sample #	% PET	% Air Voids (Pa)
S-1	0	4.6
S-2	0	4.6
S-3		
S-1		
S-2	5	9.3
S-3		
S-1		
S-2	10	-4.628
S-3		
S-1		
S-2	15	-12.442
S-3		
S-1		
S-2	20	-18.907
S-3		
S-1		
S-2	25	-25.431
S-3		
S-1		



Graph 10. Pa (% air voids) vs PET content

Optimum Polyethylene Terephthalate (PET) content

PET1= Polyethylene Terephthalate content at maximum density (unit weight) = 12%

PET2= Polyethylene Terephthalate content at maximum 4% Air voids = 10%

The research journey embarked upon in the pursuit of the "Design of Asphalt Mix containing Postconsumer Recycled Plastic as a partial replacement of Filler" has yielded significant insights, contributing to the advancement of sustainable road construction practices. This chapter encapsulates the key findings, implications, and future directions emanating from the comprehensive investigation conducted.

The test results showed that Polyethylene Terephthalate (PET) can be conventionally used as a modifier for asphalt mixture.

The investigation focused on elucidating the role of Polyethylene Terephthalate (PET) as a modifier in asphalt mixtures, particularly as a partial replacement of conventional filler. Through a systematic examination involving varied percentages of PET (ranging from 0% to 25%), distinct trends emerged. Notably, an increase in PET content correlated with heightened stability values and diminished flow values. The culmination of these observations pinpointed the optimum efficacy at a 20% PET addition, showcasing a substantial 19.13% improvement over normal asphalt samples.

Furthermore, a nuanced analysis identified that a 13.70% PET addition yielded optimal results, surpassing other percentages by 7.8%. Importantly, the replacement of Polyethylene Terephthalate with filler demonstrated a positive contribution to the

overall performance of asphalt pavements, underscoring the potential of PET as a sustainable modifier in road construction.

The study's findings hold profound implications for sustainable road construction practices. The successful incorporation of Postconsumer Recycled Plastic (PET) into asphalt mixes not only provides an environmentally responsible means of utilizing plastic waste but also enhances the performance characteristics of the resulting pavement. This dual benefit aligns with the growing imperative to adopt eco-friendly materials and technologies in infrastructure development. The economic feasibility of PET-modified asphalt, underscored by optimal performance at the 13.67% PET addition level, adds a pragmatic dimension to its application. Reduced reliance on traditional fillers and the potential for long-term cost savings contribute to the attractiveness of PET-modified asphalt from both an environmental and economic standpoint.

The synthesis of environmental sustainability and economic viability positions PET-modified asphalt as a promising solution for future road construction endeavors. The positive environmental impact stemming from the utilization of recycled plastic is in line with more general sustainability objectives, and the financial viability makes mass adoption more feasible.

In conclusion, the "Design of Asphalt Mix containing Postconsumer Recycled Plastic as a partial substitute for Filler" is a noteworthy advancement in the creation of sustainable infrastructure. The research's conclusions not only add to the body of knowledge but also open the door to real progress in the field of environmentally friendly road building. As society grapples with the imperative of balancing progress with environmental responsibility, the outcomes of this study offer a compelling blueprint for a greener, more sustainable future in the realm of civil engineering and infrastructure development.

1. Reference

- [1] Xuan Lu, D. & Giustozzi, F. (2022) Recycled plastics as synthetic coarse and fine asphalt aggregate. *International Journal of Pavement Engineering*. doi:10.1080/10298436.2022.2068550.
- [2] Sojobi, A.O., Nwobodo, S.E. & Aladegboye, O.J. (2016) Recycling of polyethylene terephthalate (PET) plastic bottle wastes in bituminous asphaltic concrete. *Cogent Engineering*.3(1).



- doi:10.1080/23311916.2015.1133480.
- [3] Martin-Alfonso, J.E., Cuadri, A.A., Torres, J., Hidalgo, M.E. & Partal, P. (2019) Use of plastic wastes from greenhouse in asphalt mixes manufactured by dry process. *Road Materials and Pavement Design*. 20 (sup1), S265–S281. doi:10.1080/14680629.2019.1588776
- [4] Lu, D.X., Enfrin, M., Boom, Y.J. & Giustozzi, F. (2023) Future recyclability of hot mix asphalt containing recycled plastics. *Construction and Building Materials*. 368. doi:10.1016/j.conbuildmat.2023.130396.
- [6] Li, C., Gong, J., Zhao, R., Xi, Z., Wang, Q. & Xie, H. (2022) Laboratory performance of recycled polyethylene modified epoxy asphalt binders. *International Journal of Pavement Engineering*. doi:10.1080/10298436.2022.2101055.
- [7] You, L., Long, Z., You, Z., Ge, D., Yang, X., Xu, F., Hashemi, M. & Diab, A. (2022) Review of recycling waste plastics in asphalt paving materials. *Journal of Traffic and Transportation Engineering (English Edition)*. doi:10.1016/j.jtte.2022.07.002.
- [8] Abdy, C., Zhang, Y., Wang, J., Yang, Y., Artamendi, I. & Allen, B. (2022) Pyrolysis of polyolefin plastic waste and potential applications in asphalt road construction: A technical review. *Resources, Conservation and Recycling*. 180. doi:10.1016/j.resconrec.2022.106213.
- [9] Tagbor, T.A., Mohammed, L., Mohammed, M., Bruce-Mensah, M.M., Tekpetey, S., Armoo, E.A., Adomah, R., Arthur, T.D., Agyenim, F.B., Amoah, J.Y., Laryea, G.N. & Serkan Kirghiz, M. (2022) The utilization of palm kernel shells and waste plastics in asphaltic mix for sustainable pavement construction. *Scientific African*. 16. doi:10.1016/j.sciaf.2022.e01277.
- [10] Rafiq Kakar, M., Mikhailenko, P., Piao, Z. & Poulidakos, L.D. (2022) High and low temperature performance of polyethylene waste plastic modified low noise asphalt mixtures. *Construction and Building Materials*. 348. doi:10.1016/j.conbuildmat.2022.128633.
- [11] Assefa, N. (2021) Evaluation of the effect of recycled waste plastic bags on mechanical properties of hot mix asphalt mixtures for road construction. *Sustainable Environment*. 7 (1). doi:10.1080/27658511.2021.1957649.
- [12] Grady, B.P. (2021) Waste plastics in asphalt concrete: A review. *SPE Polymers*. 2 (1), 4–18. doi:10.1002/pls2.10034.
- [13] Genet, M.B., Sendekie, Z.B. & Jembere, A.L. (2021) Investigation and optimization of waste LDPE plastic as a modifier of asphalt mix for highway asphalt: Case of Ethiopian roads. *Case Studies in Chemical and Environmental Engineering*. 4. doi:10.1016/j.csee.2021.100150.
- [14] Kakar, M.R., Mikhailenko, P., Piao, Z., Bueno, M. & Poulidakos, L. (2021) Analysis of waste polyethylene (PE) and its by-products in asphalt binder. *Construction and Building Materials*. 280. doi:10.1016/j.conbuildmat.2021.122492.
- [15] Dalhat, M.A., Al-Abdul Wahhab, H.I. & Al-Adham, K. (2019) Recycled Plastic Waste Asphalt Concrete via Mineral Aggregate Substitution and Binder Modification. *Journal of Materials in Civil Engineering*. 31 (8). doi:10.1061/(asce)mt.1943-5533.0002744.
- [16] Martin-Alfonso, J.E., Cuadri, A.A., Torres, J., Hidalgo, M.E. & Partal, P. (2019) Use of plastic wastes from greenhouse in asphalt mixes manufactured by dry process. *Road Materials and Pavement Design*. 20 (sup1), S265–S281. doi:10.1080/14680629.2019.1588776.
- [17] Al-Abdul Wahhab, H.I., Dalhat, M.A. & Habib, M.A. (2017) Storage stability and high-temperature performance of asphalt binder modified with recycled plastic. *Road Materials and Pavement Design*. 18 (5), 1117–1134. doi:10.1080/14680629.2016.1207554.
- [18] Abdullah, M.E., Aminah, S., Kader, A., Putra Jaya, R., Yaacob, H., Hassan, N.A., Norazman, C. & Wan, C. (n.d.) *Effect of Waste Plastic as Bitumen Modified in Asphalt Mixture*.



- [19] Angelone, S., Cauhapé Casaux, M., Borghi, M. & Martinez, F.O. (2016) Green pavements: reuse of plastic waste in asphalt mixtures. *Materials and Structures/Materiaux et Constructions*. 49 (5), 1655–1665. doi:10.1617/s11527-015-0602-x.
- [20] Sojobi, A.O., Nwobodo, S.E. & Aladegboye, O.J. (2016) Recycling of polyethylene terephthalate (PET) plastic bottle wastes in bituminous asphaltic concrete. *Cogent Engineering*. 3 (1). doi:10.1080/23311916.2015.1133480.
- [21] Chee, C.Y., Azahari, H. & Rehan, M. (2014) Modification of Bitumen Characteristic by Using Recycled Polyethylene. *Molecular Crystals and Liquid Crystals*. 604 (1), 33–40. doi:10.1080/15421406.2014.967652.
- [22] Fang, C., Li, T., Zhang, Z. & Jing, D. (2008) Modification of asphalt by packaging waste-polyethylene. *Polymer Composites*. 29 (5), 500–505. doi:10.1002/pc.20390.
- [23] Mendes Pontes, A.R. (n.d.) *The forests of Maraca, Northern Brazilian Amazonia: their structure, phenology, fruit assessment and an illustrative guide to their fruit.*



Towards Signal Flow Graph Analysis of Signal Stream Arrival at RAKE Receiver

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KEY WORDS

Fourier Analysis
FFT
DFT
Degree of Complexity
RAKE receivers
Computational Complexity
Multi Path Fading

ABSTRACT

Scientific work on RAKE receivers architecture, design and performance analysis have been done by investigators but the frequency domain analysis of RAKE receivers have not been focused more by the researchers and engineers working in the field of Telecommunications Systems and Internet of Things by considering the parameter of reduction in computational complexity. In this research paper I want to propose an algorithm for reduction in computational complexity of algorithms processed by RAKE receiver and put light on the frequency domain analysis of RAKE receivers input signal stream through Fast Fourier Transforms analysis. The Fast Fourier Transforms are computationally lesser complex having the complexity of $O(n \log n)$ as compared to the Discrete Fourier Transforms and are more effective and applicable computationally. The proposed algorithm will work far better than conventional algorithms designed and implemented before. Also the results will be discussed in more detail for validation of proposed algorithm.

1. Introduction

The RAKE receivers are widely used in telecommunication systems when the engineers and designers try to minimize the effects of multi path fading on the received signals. Generally speaking the telecommunication systems and the branches of telecommunication systems like wireless communication systems, wireless sensor networks, wireless adhoc networks and computer communication networks are composed of transmitters, receivers and line of sight between transmitter side and the receiver side. Scientists have done a lot of work on the transmitter design and the receiver design and the technology continuously evolved in more sophisticated wireless communication networks based transmitters and receivers. The RAKE receivers are one of these advanced developed receivers which not only improve the quality of signal but also enhance the performance of the wireless communication systems [1].

In this research paper, it is necessary for us to introduce the readers about the RAKE receiver design so that a good understanding of the signal reception procedure at the RAKE receiver can be understood and a more thorough work on the proposed algorithm for the signal flow graph analysis of RAKE receivers can be

done. The RAKE receivers are the CDMA spread spectrum based receivers used in wireless communication systems to reduce the effects of multipath signal fading. It is obvious that the signal strength is affected in wireless communication systems when the signals arrive from the transmitter side to the receiver side when the line of sight path from the transmitter side to the receiver side consists of so many paths and the signal received at the receiver from many paths. Due to the traversal of signals from the transmitter to the receiver from many paths, signals suffer fading and the power of the signals at the transmitter side is not the same as the power received at the receiver side. Also because of the inclusion of obstacles between transmitter and the receiver side the signal strength is affected. As a result the quality of the received signal does not belong to the standard benchmarks. To manage such quality and signal strength problems the RAKE receivers were proposed and designed as referred in the papers [2].

2. Literature Review

As far as the receiver design is concerned, the access technology is as important as the architecture and hardware of the receiver design is concerned. The technological evolution of wireless communication



devices started from the early fifty's when the telephonic devices invention was at high peak. The PABX technology and cordless devices invented by the scientists and had been used in everyday life as mentioned in [3].

There are three access technologies which are highly used in communication systems. The first access technology is Frequency Division Multiple Access and the second technology is Time Division Multiple Access and the third technology is Code Division Multiple Access. All of these *technologies* are widely used in wireless communication systems but the involvement of signal fading effects lead the receiver designers towards the utilization of Code Division Multiple Access technology along with RAKE receivers as mentioned in [4].

When the signals are arrived at the receiver side from the transmitter side the signals not only received in the original form, but the signals also contain the noise along with them, so usually the signals are either deformed or the signals are distorted because of the inclusion of noise in the magnitudes as mentioned by the well-known scientist of telecommunication systems Hartley Shannon's as mentioned by him in his early paper [10]. The effects of noise can be eliminated by RAKE receivers when the signal processing technique adopted at the receiver side is in frequency domain.

As we know that the digital signal processing is divided into two types, the first one is in the time domain and the second one is in the frequency domain. RAKE receivers usually work in frequency domain signal processing as referred in [7]

2.1 Fast Fourier Transforms

The Fast Fourier Transforms are also referred as the FFT and usually used in digital signal processing technology when the signals are analysed in the frequency domain. From the computational aspect the FFTs are more computationally implemented as compared with DFTs as referred in [6].

The computational aspect of FFT is important because of the utilization of computers in wireless communication systems which perform high computations. These computers not only perform numeric computing but also enhance the computational power of the signal processing technique as mentioned in [4].

2.2 Discrete Fourier Transforms

The Discrete Fourier Transforms are also referred as the DFT and usually used in digital signal processing

technology when the signals are analysed in the frequency domain when the signals are numerated with discrete values. From the computational aspect the DFTs are less computationally implemented as compared with FFTs. The DFTs are lesser computational because of the lesser usage of computer based communications rather the DFTs involve the discrete value based computations as mentioned in [5].

When we relate DFT and FFT with RAKE receivers we recognize that the FFTs are computationally more implemented and expansive as compared to DFTs as referred in [8].

3. Steps of Research Methodology

The research methodology adopted for proving the results based on Fast Fourier Transform algorithm for reduction of complexity to $n \log n$ parameter is Quantitative. Although in this research paper I have adopted the qualitative research as well but the more focus is on Quantitative research methodology.

3.1 Algorithm

For implementation purpose, first of all I will propose an algorithm for reduction of Computational Complexity to $O(n \log n)$ through Signal Flow Graph Analysis. The steps of the algorithm are given below:

- (a) Initialize the Signal Flow Graph in the algorithm environment
- (b) Initialize the input parameters: $x(0)$, $x(2)$, $x(1)$, $x(3)$
- (c) Initialize the output parameters: $X(0)$, $X(1)$, $X(2)$, $X(3)$
- (d) Initialize cross-sections of input parameters with +1 and -1
- (e) Implement cross-sections of step -d
- (f) Initialize intermediate parameters: +1, +1, +1, -j
- (g) Implement second cross-sections of results of step -e
- (h) Derive the output parameters: $X(0)$, $X(1)$, $X(2)$, $X(3)$

The proposed algorithm when simulated on MATLAB platform produced the required results which were according to our assumptions. The Signal Flow Graph implemented through MATLAB is shown in the figure 1. The last intermediate parameter in the proposed algorithm is of significance since it contains the value -j. and the second stage of the proposed algorithm is dependent upon the intermediate parameters because intermediate parameters are multiplied with outputs

from the first stage.

3.1 Parameters

The proposed algorithm for reduction of Computational Complexity to $O(n \log n)$ through Signal Flow Graph Analysis has been tested on MATLAB software. The input parameters for testing the proposed algorithm for reduction of Computational Complexity to $O(n \log n)$ through Signal Flow Graph Analysis are shown in table 1. The output parameters for testing the proposed algorithm for reduction of Computational Complexity to $O(n \log n)$ through Signal Flow Graph Analysis are shown in table 2.

Table 1

Signal Flow Graph input parameters

Signal Flow Graph input parameters	Value
Module	DSP processor
x(3)	3
x(0)	0
x(2)	2
x(1)	1
Intermediate Parameter P1	+1
Intermediate Parameter P2	+1
Intermediate Parameter P3	+1
Intermediate Parameter P4	-j

Table 2

Signal Flow Graph output parameters

Signal Flow Graph output parameters	Value
Module	DSP processor
X(0)	6
X(1)	-2+2j
X(2)	-2
X(3)	-2-2j

The proposed algorithm can be shown in the form of Signal Flow Graph as depicted in the figure 1. The Signal Flow Graph is based on input parameters and produces output parameters as shown in table 1 and table 2.

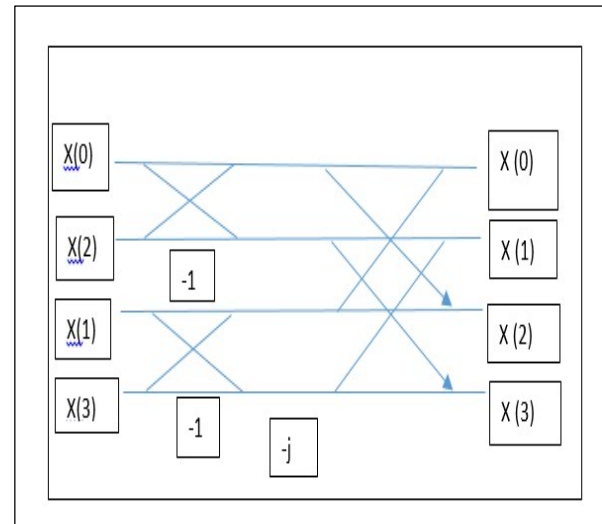


Fig. 1. Signal Flow Graph Analysis of RAKE receivers

The concept of algorithm can be shown in the form of flow chart as depicted in the figure 2. The Signal Flow Graph analysis is based on the computations of Fast Fourier Transforms by the correlators interconnected at the RAKE receiver's modules. The summer works as the integrator which sums the diversified signals processed through correlators at the RAKE receiver and then processed further with weighting coefficients at correlators outputs. The Fast Fourier Transforms are implemented through butterfly algorithm which is 4-point butterfly algorithm with decimation in time.

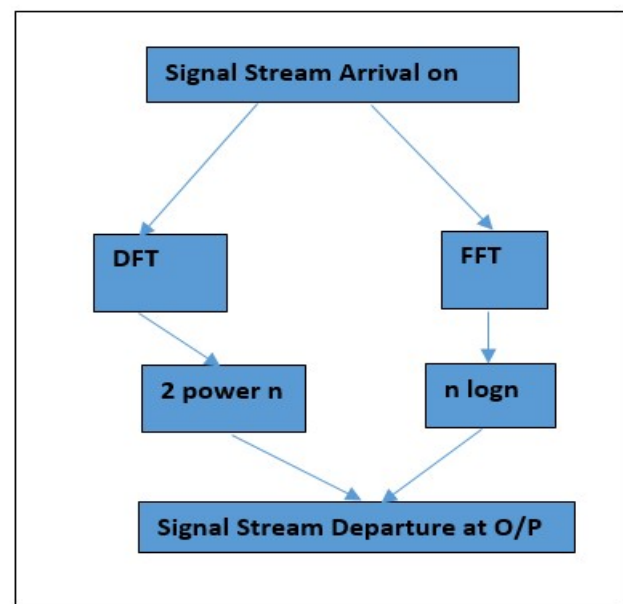


Fig. 2. Flow Chart of Signal Stream Processing at RAKE receiver's inputs



4. Results and Discussion

When we execute the algorithm for Signal Flow Graph analysis of input signal stream, we assume that there are four inputs at the signal stream arrival which are mentioned below:

$$X(n) = \{X(0), X(1), X(2), X(3)\}$$

----- (1)

Such 4 input signal stream is shown in the graph at the output side and the decimal inverted stream is shown in the graph at the input side which are mentioned below:

$$x(n) = \{x(0), x(2), x(1), x(3)\}$$

-- (2)

Such input signal stream is the sample set of the given input signals which can be of any type like impulse signal. The 4 – point butterfly diagram is shown in the figure 1 which depicts the graphical representation of the algorithm proposed in the research paper.

Note that the signals can be of any type real or imaginary, therefore $-j$ is multiplied with the stream arrival at $x(3)$ output. This $-j$ has been derived from the complex identity mentioned below:

$$W_N^k = e^{-j\frac{2\pi k}{N}}$$

----- (3)

When we execute the algorithm on MATLAB, we observe that the algorithm complexity is reduced from 2 raised to power n to $n \log n$.

It has been observed that the Discrete Fourier Transforms are computationally lesser in terms of speed of execution as compared with the Fast Fourier Transforms. The computational efficiency and speed of execution of signal stream arrival at the inputs of RAKE receiver is enhanced n multiplied with $\log n$ times and algorithm complexity is $O(n \log n)$.

4. Conclusion and Future Work

The RAKE receivers are CDMA access technology based receivers which are used in wireless communication systems to reduce the multipath fading effects. The proposed algorithm which uses Signal Flow Graph Analysis for signal processing technique at the RAKE receivers produces the more dynamic and effective results when it use FFT. The simulations and results derived from the proposed algorithm implemented on MATLAB platform reduces the computational complexity of the algorithm up to $O(n \log n)$ and the results are verified in accordance with

our justifications. Also the results obtained from the proposed algorithm are obtained in frequency domain analysis and in complex number form.

The proposed algorithm can be applied to newly wireless communication systems and this algorithm not only improve the outcomes of the digital communications systems receivers but will also enhance the performance of the RAKE receivers when combined with FFT.

The future work of the proposed and implemented research work here is to implement the magnitude plot and the phase plot of the results obtained from the given proposed algorithm. Also with the help of magnitude plot and the phase plot the computational complexity of the proposed algorithm of degree $n \log n$ can be remained up to mark.

The percentage calculation for the signal stream arrival at the inputs of RAKE receivers for the conversion from DFT to FFT is the future work which will be done and published in future research papers.

5. Reference

- [1] Kong, Ning, Thomas Eng, and Laurence B. Milstein. "A selection combining scheme for RAKE receivers." Proceedings of ICUPC'95-4th IEEE International Conference on Universal Personal Communications. IEEE, 1995.
- [2] Cassioli, Dajana, et al. "Low complexity rake receivers in ultra-wideband channels." IEEE Transactions on Wireless Communications 6.4 (2007): 1265-1275.
- [3] Khalaj, BABAK H., A. Paulraj, and T. Kailath. "2D RAKE receivers for CDMA cellular systems." 1994 IEEE GLOBECOM. Communications: The Global Bridge. IEEE, 1994.
- [4] Rovatti, Riccardo, Gianluca Mazzini, and Gianluca Setti. "Enhanced rake receivers for chaos-based DS-CDMA." IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications 48.7 (2001): 818-829.
- [5] Prasad, Ramjee, and Tero Ojanpera. "An overview of CDMA evolution toward wideband CDMA." IEEE communications Surveys 1.1 (1998): 2-29.
- [6] Prasad, Ramjee, and Shinsuke Hara. "An overview of multi-carrier CDMA." Proceedings of ISSSTA'95 International Symposium on Spread Spectrum Techniques and Applications.



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- Vol. 1. IEEE, 1996.
- [7] McCormick, Andrew C., and Emad A. Al-Susa. "Multicarrier CDMA for future generation mobile communication." *Electronics & Communication Engineering Journal* 14.2 (2002): 52-60.
- [8] Gilhousen, Klein S., et al. "On the capacity of a cellular CDMA system." *IEEE transactions on vehicular technology* 40.2 (1991): 303-312.
- [9] Ipatov, Valeri P. *Spread spectrum and CDMA: principles and applications*. John Wiley & Sons, 2005.
- [10] Abu-Rgheff, Mosa Ali. *Introduction to CDMA wireless communications*. Academic Press, 2007.
- [11] Bracewell, Ronald N. "The fourier transform." *Scientific American* 260.6 (1989): 86-95.
- [12] Duhamel, Pierre, and Martin Vetterli. "Fast Fourier transforms: a tutorial review and a state of the art." *Signal processing* 19.4 (1990): 259-299.
- [13] Nussbaumer, Henri J., and Henri J. Nussbaumer. *The fast Fourier transform*. Springer Berlin Heidelberg, 1982.
- [14] Brigham, E. Oran. *The fast Fourier transform and its applications*. Prentice-Hall, Inc., 1988.
- [15] Sifuzzaman, M., M. Rafiq Islam, and Mostafa Z. Ali. "Application of wavelet transform and its advantages compared to Fourier transform." (2009).
- [16] Cochran, William T., et al. "What is the fast Fourier transform?." *Proceedings of the IEEE* 55.10 (1967): 1664-1674.



An Investigation of System Characteristics of RAKE Receivers

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Chip Rate

ABSTRACT

When we discuss the CDMA spread spectrum based systems, the discussion is incomplete without the discussion of RAKE receivers. The RAKE receivers are deployed in Internet of things and clouds most commonly because of the low bit error rate of time shifted multipath signals and lesser fading effects during transmission of multipath signals. In this research paper I will elaborate the system characteristics of RAKE receivers through quantitative analysis of linearity, time invariance, memory less property and causality. This quantitative analysis will be fruitful for adaptation of RAKE receivers in heterogeneous wireless communication networks.

1. Introduction

Today the technology advancement leads towards many new emerging fields which belong to the core Electrical Engineering, Telecommunication Engineering and Computer Systems Engineering. Artificial Intelligence and Machine Learning have completely covered all of the core areas of engineering and overlapped to lead new technology like Wireless Sensor Networks, Wireless Adhoc Networks and Internet of Things. The discussion of Wireless Sensor Networks is incomplete without the discussion of those specific interconnecting devices which can not only perform for signal processing but also communicates with the sensors and actuators of Wireless Sensor Networks as referred in [1].

The interconnecting devices in the new evolving technologies do not become least significant because of the adaptation requirement to the forthcoming technology. The transmitter and receiver designs for Internet of things technology needs to be improved in accordance with the new technological advancements for providing better throughput and larger bandwidth for signals transmission in the form of text, images and videos.

The RAKE receivers are one of these interconnecting device. So many researchers and scientists had worked on RAKE receiver's architecture, design, communication and

functions and a lot of work has been done on it as referred in [2]. But the Digital Signal Processing aspect of the RAKE receiver was not focused more by the researchers.

In this research paper, I have done work on the System Characteristics of RAKE receivers. The System Characteristics of RAKE receivers have not been focused more and this area of research needs more attention by the researchers, scientists and research based students.

The reason for selection of RAKE receiver's topic is the viability of RAKE receivers in new emerging telecommunication systems like Distributed Computing, Internet of things and Cloud Computing. All of these technological arenas include RAKE receivers and RAKE receivers work up to the mark and perform well when deployed in these systems as referred in [3].

The topic selected by me for a thorough review of RAKE receivers, functionality of RAKE receivers and the system characteristics of RAKE receivers is because of many technical reasons. The first reason for selection of RAKE receivers for review and System Characteristics of RAKE receivers is the good response of RAKE receivers toward the reception process of signals as referred in [4]. The ordinary receivers face



difficulty in reception of digital signals and the original signal is received in distorted form, but when RAKE receivers are deployed in the system, signal distortion level is quite reduced as referred in [5]. Also the other problems arise like noise induction during signal transmission from the transmitter side to the receiver side in clouds and Distributed Sensor Networks but when RAKE receivers are deployed in Distributed Sensor Networks, noise induction problem can be eliminated. So many reasons urge engineers and scientists to deploy RAKE receivers in forth coming novel technology like Wireless Sensor Networks, Wireless Adhoc Networks and Distributed Sensor Networks.

2. Literature Review

A lot of articles and research papers discuss RAKE receivers but the System Characteristics of RAKE receivers were not highlighted and elaborated by the researchers. The System Characteristics is the technical nomenclature of Digital Signal Processing field and RAKE receivers belong to the Telecommunication systems field therefore this research paper is a merger of the two mentioned fields namely Digital Signal Processing and Telecommunication Systems in context of RAKE receivers as referred in [10]. First of all I will define "System Characteristics".

The System Characteristics of any system can be defined as the Linearity or Non Linearity, Static or Dynamic and Time Invariant or Time Variant. These System Characteristics are a part of any system and here in this research paper I will discuss RAKE receiver in collaboration with System Characteristics as referred in [6]. The understanding of System Characteristics will be helpful for engineers to properly deploy the RAKE receivers in wireless Sensor Networks and Wireless Adhoc Networks.

The Code Division Multiple Access technology is more favoured and utilized in the industry as compared to Frequency Division Multiple Access technology and Time Division Multiple Access technology. The reason for preference of Code Division Multiple Access technology is the unique selection of users by assigning the codes to individual user in digital cellular networks as referred in [1]. The lesser usage of Frequency Division Multiple Access and Time Division Multiple access is out of the scope of this research paper. The RAKE receivers are Code Division Multiple Access technology based receivers and

work on three correlators. The three correlators work in conjunction with each other to provide the summer the specific signals shifted in time frames. The signals shifted in time frames are referred as time shifted signals and these signals are processed by RAKE receivers as referred in [7].

The RAKE receivers work well on signals in delayed form. Suppose that three signals are received on RAKE receivers with three different delays then the RAKE receiver selects any signal from the three delayed signal and process it with summer. The summer of RAKE receiver works as voter in the receiver system and selects one signal form among the three received signals at the receiver inputs. A specific type of signals is processed by RAKE receiver which are called Multi Path Signals. The RAKE receivers work on Multi Path Faded Signals which are also time shifted. If the signal is not time shifted, it will not be processed by RAKE receiver. Similarly if the signal is not in Multi Path Faded form, it will not be processed by the RAKE receiver.

The RAKE receivers are also referred as "Diversity Based Receivers" in the literature as referred in [5]. The nomenclature for calling RAKE receiver as the "Diversity Based Receiver" was coined because these receivers work and process the signals in delayed form. Each multipath signal has its own delay and the signal selection is done by the summer in RAKE receivers. The time shifted multi path signals are received at the receiver inputs then processed by three correlators and only one time shifted multipath signal is processed through RAKE receiver as referred in [6]. The comparison of delay values of the incoming signals is done with a typical parameter of RAKE receiver. This typical parameter of RAKE receiver is the "Chip Rate". The Chip Rate is compared with delay values and according to the defined algorithm the input time shifted multipath signal is processed through RAKE receiver. The typical parameter that is Chip Rate can vary from one model to another model but it is the standard parameter for delay comparison. [7].

3. Steps of Research Methodology

The research methodology for this review paper is based upon the thorough search and review of the literature for the design of Interconnecting Devices and their adaptation to the newly evolving technology Internet of Things. After reviewing detailed research work from the past work, I analysed that the comparison of RAKE receiver characteristics and the device adaptation with the general system characteristics of the newly evolving networks require that three essential characteristics of the networks need to be discussed in



detail.

Generally either any network based system can contain memory less ness or they contain full memory, similarly the network based systems can be delayed with some time t units or show time variance characteristics and also the network based systems can be either linear or nonlinear. In this research paper the research methodology adopted for investigation is quantitative and the System Characteristics of the RAKE receivers will be investigated and highlighted. In general any system can static or dynamic, Time Variant or Time Invariant and Linear or Non Linear. In this section we will elaborate on the adaptation of the RAKE receivers with the network based systems characteristics and gain an insight of how the RAKE receivers can be used in conjunction with the network based systems.

3.1 Static or Dynamic

Any system can be either static or dynamic. If the system is static then system is referred as memory less whereas if the system is dynamic it is referred as system with memory. Suppose that x (n) is the signal received at the system input and y (n) is the signal received at the system output then consider the following system in equation 1:

$$y(n) = ax(n)$$

-- (1)

The system mentioned in equation 1 is static or memory less system. Consider the following system in equation 2"

$$y(n) = ax(n - 1)$$

-- (2)

The system mentioned in equation 2 is dynamic or system with memory.

Now consider the following equations 3, 4, 5 defined for RAKE receivers

$$y(n) = ax(n - t)$$

-- (3)

$$y(n) = ax(n - 2t)$$

-- (4)

$$y(n) = ax(n - 3t)$$

(5)

We can prove that the RAKE receiver is system with memory or dynamic system.

3.2 Time Variant

Any system can be time variant if it satisfies the following equation 6:

$$y(n - k) \leftrightarrow x(n - k)$$

----- (6)

That is if there is a k unit delay at the input side then there will be k units delay at the output side, then the system will be referred as time variant.

Now considering the RAKE receivers general characteristics, the RAKE receivers are time variant because of the diversification at the input side as well as at the output side. That is the equation 6 is fulfilled for the RAKE receivers as well.

3.3 Linearity

Any system can be referred as linear system if it satisfies the following equation 7:

$$T[a_1x(n) + a_2x(n)] = a_1T\{x(n)\} + a_2T\{x(n)\}$$

----- (7)

The RAKE receiver satisfies the above equation of linearity and it is linear.

4. Results and Discussion

As a result of the review of the System Characteristics of RAKE receivers, I reached towards the identification of the RAKE receiver's functionality and its adaptation with the network based systems and Internet of things technology. The RAKE receivers are system with memory that is dynamic systems, linear systems and time variant systems. The RAKE receivers process delayed time shifted signals therefore it satisfies the system characteristics of dynamic, linear and time variant. The RAKE receivers can work in a good form when these receivers are deployed on Internet of Things based communication networks. The RAKE receivers are dynamic systems and when network based systems work in conjunction with RAKE receivers all of the states of the network are stored in the memory component of RAKE receivers. The RAKE receivers in the interconnected Internet of Things System respond to every type of input signal in a good form. The input signal of today's networks can be of type text, image, audio and video signals and they are processed in good form when flowed and received through RAKE receivers. Also the linearity is fulfilled when the incoming signals are with coefficients and processed



through RAKE receivers in following linearity property.

5. Conclusion and Future Work

It has been concluded from the above discussed investigation of System Characteristics of RAKE receivers that the RAKE receivers are in good form when they run in conjunction with the network based systems and Internet of Things technology. The engineers and scientists should deploy RAKE receivers with Internet of Things based networks to gain the benefits from this device. The RAKE receivers are widely deployed receiver systems and an understanding of the System Characteristics of the RAKE receivers will be very helpful for accurate deployment of the RAKE receivers in Wireless Sensor Networks and Wireless Adhoc Networks. The mathematical equations governing the System Characteristics of the RAKE receivers will help engineers for understanding the signal processing nature of the incoming multipath signals. This understanding of signal processing nature will lead a powerful deployed wireless network in any urban or rural area. Also the actuators and sensors will be more adaptable because of the directed specific digital signals which are in accordance with the requirement of the system and in configuration with the RAKE receiver. The future work in relation with the System Characteristics of the RAKE receivers is the typical parameter understanding of RAKE receiver, typical values from data sheets and necessary workout in comparing the performance of the system device by considering the chip rate. The postgraduate students and researchers may work towards the data sets of the RAKE receivers and comparing their performance. Indeed the Wireless Communication Systems and Wireless Sensor Networks based devices architecture and working is a very hot area of research.

5. Reference

- [1] B Baltzis, Konstantinos. "The rake receiver principle: Past, present and future." *Recent Patents on Electrical & Electronic Engineering (Formerly Recent Patents on Electrical Engineering)* 5.1 (2012): 55-71.
- [2] Win, Moe Z., George Chrisikos, and Nelson R. Sollenberger. "Performance of Rake reception in dense multipath channels: Implications of spreading bandwidth and selection diversity order." *IEEE Journal on Selected Areas in Communications* 18.8 (2000): 1516-1525.
- [3] S. Cassioli, Dajana, et al. "Low complexity rake receivers in ultra-wideband channels." *IEEE Transactions on Wireless Communications* 6.4 (2007): 1265-1275.
- [4] [4] Lenardi, Massimiliano, Abdelkader Medles, and Dirk TM Slock. "Comparison of downlink transmit diversity schemes for RAKE and SINR maximizing receivers." *ICC 2001. IEEE International Conference on Communications. Conference Record (Cat. No. 01CH37240). Vol. 6. IEEE, 2001.*
- [5] [5] Doukeli, Aimilia P., et al. "Increasing the efficiency of rake receivers for ultra-wideband applications." *Wireless Personal Communications* 62 (2012): 715-728.
- [6] [6] Esmailzadeh, Riaz, and Masao Nakagawa. "Pre-RAKE diversity combination for direct sequence spread spectrum mobile communications systems." *IEICE Transactions on Communications* 76.8 (1993): 1008-1015.
- [7] El-Sallabi, Hassan M., Henry L. Bertoni, and Pertti Vainikainen. "Channel characterization for CDMA rake receiver design for urban environment." *2002 IEEE International Conference on Communications. Conference Proceedings. ICC 2002 (Cat. No. 02CH37333). Vol. 2. IEEE, 2002.*
- [8] Baltzis, K. B., and J. N. Sahalos. "On the design of RAKE receivers with non-uniform tap spacing." *Proc. of the 5th International Symposium on Communication Systems, Networks and Digital Signal Processing CSNDSP. 2006.*
- [9] Grob, Urs, et al. "Microcellular direct-sequence spread-spectrum radio system using N-path RAKE receiver." *IEEE Journal on Selected Areas in Communications* 8.5 (1990): 772-780.
- [10] Mun, Cheol, Myung-Sun Choi, and Han-Kyu Park. "Performance of 2-D RAKE receiver in a correlated frequency-selective Nakagami-fading." *IEEE transactions on vehicular technology* 50.5 (2001): 1312-1317.
- [11] Khairnar, Vaibhav, Jitendra Mathur, and Hema Singh. "Design and Performance Analysis of DS-CDMA with Rake and without Rake Receiver Communication System." *International Journal of Emerging Technology and Advanced Engineering, ISSN (2013): 2250-2459.*
- [12] Rovatti, Riccardo, Gianluca Mazzini, and Gianluca Setti. "Enhanced rake receivers for chaos-based DS-CDMA." *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications* 48.7 (2001): 818-829.



Titanium dioxide (TiO₂) and MXene based photocatalyst: a review on state-of-the-art synthesis, characteristics, and phenol photocatalytic degradation.

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KEY WORDS

Photocatalytic degradation
MXene/TiO₂
Phenol
Properties
Synthesis

ABSTRACT

Photocatalytic degradation of phenol is an efficient strategy by employing heterogeneous photocatalysis and has attracted increasing attention. Improving the performance of photocatalyst materials, the composite photocatalyst is considered more advantageous as compared to a single material because of primary limitations such as quick charge recombination, poor spectrum absorption, and a small surface area. Therefore, the coupling of photocatalysts is a more efficient approach than the pristine phase because they influence the interfaces while offering channelized pathways for charge carrier separation, minimizing the impacts of energy losses including recombination and poor spectrum performance. herein, we deliberated the photocatalytic degradation application of composite phase utilization for phenol wastewater treatment based on MXene/TiO₂ material. The review starts with the fundamentals and mechanism of photocatalytic degradation of phenol by composite material. In the mainstream, significant characteristics, manufacturing methods, and optical and electrical properties have been highlighted for pristine phases of TiO₂ and MXene independently. Moreover, the photocatalytic degradation application of MXene/TiO₂ composite for phenol decomposition has been discussed. Different fabrication approaches are adopted for TiO₂ and MXene preparation that have an intense influence on characteristic properties (such as electrical, optical, luminescence, structure, morphology, etc.) and photocatalytic performance. Considerable emphasis is given to MXene/TiO₂ composite for selective photocatalytic degradation phenol from the perspective of surface area, adsorption, porosity, light-harvesting effectiveness, charge carrier formation, separation, migration, and chemical composition. In conclusion, the pristine and composite materials along with their benefitted aspects have been summarized that affect the photocatalytic performance. Finally, potential prospects for improving areas that may best improve photocatalytic degradation performance are suggested. We expect that this review will provide new opportunities to understanding and development of new MXene/TiO₂ with improved photocatalytic degradation performance for new researchers.

. Introduction

The prevalence of organic contaminants in aquatic resources has increased rapidly because of the increasing population and incessant agricultural and industrial expansion. Organic impurities, particularly organic chemicals, pharmaceutical wastes, organic herbicides, and organic pesticides are held responsible for health and ecological disasters due to their poisonous qualities and poor bio-decomposability. Phenol is classified as a major

pollutant since even at low quantities, it is hazardous to people and creatures [1]. Advanced wastewater treatment systems, on the other hand, are prohibitively expensive and usually demand the use of additional chemicals and energy. The use of chemicals for disinfection is commonly employed to provide secure drinking water. During treatment operations, reactions among introduced chemical oxidants like as chlorine and existing organic and inorganic components produce disinfectants. Phenolic compounds are known components of naturally occurring organic



materials. Hypohalous acids such as chlorine, bromine, and iodine may react with phenols via electrophilic aromatic substitution or electron transfer oxidation. As a result, photocatalysis requires careful attention in order to properly destroy these compounds [2].

MXene, being a small bandgap material with high electrical conductivity (which makes it a good electron trap, easily capturing photo-excited electrons and hence speeding the separation and transfer of charge carriers) photocatalytically destroys pollutants in visible light, has been extensively researched for its photocatalytic use [3]. Moreover, titanium dioxide (TiO_2) has been thoroughly researched as an excellent photocatalyst because of its remarkable properties like good redox potential, affordability, chemical stability, nontoxic nature, photo-stability, and enormous use in the removal of organic pollutants but broad bandgap quick recombination of photogenerated charges leads in poor organic pollution reduction performance [4]. As a result, 2D TiO_2 /MXene are promising catalysts with greater separation, broad spectrum activated, and higher photoactivity.

In this review, both the pristine phases of TiO_2 , MXene, and modified MXene/ TiO_2 composite materials has been considered for photocatalytic phenol degradation application. The review starts with the mechanism of the photocatalytic degradation process. In the mainstream, pristine and composite material fundamentals, synthesis approaches, photocatalytic properties, and their degradation application are discussed. The fundamental presents the crystalline and morphological structural understanding of each material. The synthesis approaches such as bottom-up or top-down along with various fabrication techniques (sol-gel, solvothermal, hydrothermal, etc) are provided. Moreover, state-of-the-art TiO_2 /MXene materials characterization provided insights potential strategies of combined structure and interfaces for optimized photocatalytic degradation performances. Finally, the discussion on pristine and hybrid material of TiO_2 and MXene is concluded and perspectives are proposed to enlighten the possible directions of photocatalytic degradation research.

3. Mechanism of photocatalytic degradation

The photodegradation process is a method used to convert organic pollutants into nontoxic intermediates and products. The photocatalytic process of organic pollutants is executed with the help of photocatalyst and irradiation sources having energy $h\nu$. The mechanism is initiated when the photocatalyst (MXene/ TiO_2), substrate molecule (phenol), and light combine in a system which is explained through the given steps:

Step. 1. Light Irradiation over photocatalyst surface: catalyst and light irradiation energy both are prerequisite

components for photocatalytic activity. The surface of the photocatalyst is activated by direct irradiation through the proper light energy [5].

Step. 2. Photoexcitation of electron (e^-) and hole (h^+): irradiation of catalyst surface with proper energy of light results in charge carriers formation such as e^- and h^+ . Through induction of the e^- in the valance band (VB), which jumps to the conduction band (CB) by abandoning h^+ in the VB. The generated e^- - h^+ then takes part in the reduction and oxidation (redox) reactions respectively.

4. General properties of MXene and TiO_2

Complex structures, phases, morphology, and topology are found in photocatalytic materials. Thus, band gap energy, band edges position alignments, absorbance, heterojunction formation, active masses, and defect generations are all suitable characteristics of photocatalytic activity.

4.1 Properties of MXene

MXene, a new two-dimensional (2D) photocatalytic material, has gained considerable attention due to its intriguing properties and excelling in a variety of study domains such as photocatalytic degradation, energy storage, and sensing devices. Because of its uniform planar arrangement, remarkable metal conductivity, surface adaptive chemical characteristics, many derivatives, and great optical and thermal characteristics, MXene has gained growing prominence and preference in photocatalysis [6]. Naguib et al In 2011. The aluminum (Al) atomic layer inside the ternary layered complex Ti_3AlC_2 (MAX) was systematically delaminated with hydrofluoric acid (HF), yielding a 2D Ti_3C_2 material with an architecture similar to graphene. MAX was exposed to a class of organized ternary carbides, nitrides, and carbonitrides with M, A, and X layers. $\text{M}_{n+1}\text{AX}_n$ ($n=1, 2, 3$) is the generic formula, where M denotes transition metals that include Ti, Sr, V, Cr, Ta, Nb, Zr, and Mo. A denotes the major elements of the group Al, Ga, In, Tl, Si, Ge, Sn, and Pb, whereas X denotes carbon (C) or nitrogen (N) as shown in. MXene's architectural structure might be described as $n+1$ layers of transition metal (M) components overlaying n layers of (X) in a $(\text{MX})_n\text{M}$ scheme. MXene is a 2D transition catalyst and due to their unique graphene-like structure, they were known as MXenes [7]. Along with the interesting characteristics of MXene include large surface area, metallic conductivity, biocompatibility, hydrophilicity, as well as a 2D multilayered atomic arrangement with incredibly active surface sites. It is believed that such advantageous features signify him as an environmental remediation agent for pollutant removal. However, after delamination, the MXene chemical structure is best represented as $\text{M}_{n+1}\text{X}_n\text{T}_z$, where T_z represents the functional groups introduced through the etching step. Such terminations are often composed of OH, O, and F



elements, with exchangeable cations such as Li⁺, K⁺ or Mg²⁺. Specifically, Because of their hydrophilic nature and abundance of highly active sites on their outermost layer, MXenes are efficient adsorbents for different molecular or ionic compounds and may thus be employed for pollution treatment or even sensing. The notation Tz or Tx are corresponding to the same surface terminations as 'x' in Tx sometimes propagates confusion thus some research is adopted to represent it as Tz. The presence of surface functional groups is important to the physical/chemical properties of MXene-based materials that may have photocatalytic uses [8].

4.2 Properties of TiO₂

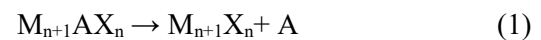
TiO₂ is a crystalline structure of polymorphic material and hence mainly divided into (i) Anatase (ii) Rutile (iii) Brookite (iv) TiO₂-II or srilankite, (v) Cubic fluorite-type, (vi) Pyrite-type, (vii) Monoclinic baddeleyite-type, (viii) Cotunnite-type. Apart from anatase, rutile, and brookite, other types of high-pressure crystalline forms of TiO₂ are obtained and deal with a very critical operation atmosphere and are less photoactive, thus not considered significant polymorphs. Among the active three potential phases of TiO₂ such as anatase, rutile, and brookite, the anatase and rutile have been extensively reported as photocatalysts [9]. In general, anatase-TiO₂ shows maximum photocatalytic efficiency than other phases. The anatase phase having an indirect band gap absorbs a photon and a phonon during the transition from the VB to the CB benefits an improved charge separation and low recombination. However, both rutile and brookite are suggested as semiconductors of direct band gap type. The thermodynamic stability of rutile is high and known as the stable phase of TiO₂, whereas both anatase and brookite are metastable which upon calcination treatment converts into the rutile phase [10].

5. Preparation techniques for MXene and TiO₂

5.1 Preparation of MXene

MXene is a member of the MAX phases, which are a broad set of stacked hexagonal ternary metal carbides and nitrides. MXenes are primarily synthesis by the targeted removal of A elements from the original MAX. In the fabrication of MXene (Ti₃C₂) which is the most investigated phase of MAX, other members of this layered hexagonal family of the first generation of MXenes were all produced by selectively etching the Al layers from different MAX phases (like Ti₂AlC, Nb₂AlC, Nb₄AlC₃, V₂AlC, Ta₄AlC₃, Ti₃Al(C_{0.5}N_{0.5})₂, (Ti_{0.5}V_{0.5})₂AlC, (Ti_{0.5}V_{0.5})₃AlC₂ (Ti_{0.5}Nb_{0.5})₂AlC, (V_{0.5}Cr_{0.5})₃AlC₂) via aqueous HF at room temperature. Following that, the HF etching process is successfully applied to different MAX phases, yielding a plethora of novel MXenes, including Ti₂CTx, Nb₂CTx, V₂CTx, Ti₂NTx, Ti₃C₂Tx, Ti₃CNTx, (Ti_{0.5}Nb_{0.5})₂CTx, V₄C₃Tx, Mo_{4/3}CTx, Nb_{4/3}CTx, W_{4/3}CTx, Nb₄C₃Tx, Ta₄C₃Tx, Mo₂TiC₂Tx, Mo₂Ti₂C₃Tx,

(V_{0.5}Cr_{0.5})₃C₂Tx, and Cr₂TiC₂Tx. Though, because the binding strengths between the various M elements and Al layers change, etching conditions such as acid concentration, temperature, and time have been used as a modification tool for each composition to achieve the conversion. Furthermore, altering the etching conditions is important for achieving high yields and minimizing the breakdown of 2D MXene flakes in acid, since their chemical stability varies depending on the structure and content of the phase. However, other types of fluoride salts and acids, such as KF, CsF, NaF, CaF₂, and [(C₄H₉)₄NF] with HCl or H₂SO₄, have also been used to manufacture MXenes [11]. Deep eutectic solvents (DESS) technique, thermal reduction of MAX phase, and high shear mechanical exfoliation are further innovative synthesis procedures for MXenes. the A element layers of MAX are highly reactive because of their poor attachment to the M-X bonds. As a result, at high temperatures, the MAX phases moderately disintegrate, as demonstrated in the reaction below.



The number of manufactured carbides-assisted MXenes is more than the number of nitrides-assisted MXenes. Implies that may be the preparation of carbide aided MXenes easier than nitrides. Integration energies of Ti_{n+1}N_n are established to be lower as compare to Ti_{n+1}C_n via using density functional theory (DFT), whereas formation energies of Ti_{n+1}N_n from Ti_{n+1}AlN_n are superior to those of Ti_{n+1}C_n from Ti_{n+1}AlC_n. Therefore, the lower integration energy implies lesser structural stability, but the superior formation energy of MXenes from their Al containing MAX phases suggests that Al atoms are more tightly linked in Tin+1AlNn than in Tin+1AlCn, requiring more energy for exfoliation. These two factors combined possibly explain the relative presence of carbides over nitrides MXenes [12].

5.2 Preparation of TiO₂

Generally, the fabrication of TiO₂ can be achieved through a bottom-up technique where all the required precursors are combined and transformed into the desired product. The methods extensively used for the fabrication of nanocomposite material of TiO₂ are precipitation, sol-gel, hydrothermal, solvothermal, hydrolysis, facial synthesis, vapour deposition process, etc. Each of these building processes is distinct for different uses, for example, sol-gel route offers manufacturing of nanomaterials with enhanced physical and chemical characteristics, as well as uniformity. This is a potential synthetic method for producing nano metal oxides with significant porosity and specific surface area. Furthermore, the main reason for metal doping TiO₂ via sol-gel production is (i)



the fabrication good quality NPs of identical size on an industrial scale, (ii) the manufacturing of two or more types of NPs concurrently, which means that alloy products can be generated in a single stage by mixing two or more metal precursors in specific quantities, (iii) lower process temperature, and (iv) substantially homogeneous materials with a quality of more than 99% [13, 14]. Commonly, all these approaches are the combination of two steps; (i) formation of suspension from precursors (titanium tetra isopropoxide (TTIP), titanium (III) chloride ($TiCl_3$), titanium tetrachloride ($TiCl_4$), titanium butoxide ($Ti(OBu)_4$), titanium oxysulfate ($TiOSO_4$), tetrabutylorthotitanate (TBOT) etc) and (ii) product extraction through separation of mother liquid, washing, and drying for resultant solid catalytic material. The preparation of the solid from a homogenized liquid solution resulted in a physical conversion such as evaporation of the solvent, temperature alteration, pH, concentration changes, etc., or chemical intervention like addition of acids or bases, or other chemical agents.

7. Photocatalytic degradation application MXene/ TiO_2 for phenol

Phenolic chemicals are abundant in wastewater generated by the plastic, resin industries, pharmaceutical industry, petroleum refining, paper processing, and carbon liquefaction [15]. The development of TiO_2 on MXene, formation of free active radicals, charge carriers separation and transportation become more effective due to combination of the MXene/ TiO_2 composite structure and the exceptional conductivity of MXene. More importantly, TiO_2 -based nanocomposites along with MXene demonstrated higher photocatalytic activity than pristine TiO_2 , or in composite form for photocatalytic conversion of phenol. However, a very limited number of research have been found on the photocatalytic degradation of phenolic compounds via MXene/ TiO_2 based composite. Peroxymonosulfate (PMS) based AOP were subjected to removal of refractory organic phenol. $CoO@TiO_2/MXene$ (CTM) hybrid composite for effective decomposition of phenol via an incorporated PMS photocatalysis operation. A dual interface charge carrier's migration pathway was created using the proper location and increased appropriateness of the band structure, accelerating the separation of photoinduced charge carriers and providing an acceptable potential difference for redox reaction. More than 96% of the phenol decomposition was observed through 10% CTM/PMS/Vis just in 15min of reaction time. EPR analysis reveals that $SO_4^{\cdot-}$ and super oxide radicals were predominant species that contributed to the catalytic process. [16]. Moreover, the two-dimensional $CdS@Ti_3C_2@TiO_2$ (CTT) hybrid was prepared via facile calcination and hydrothermal method. Based on UV-Visible spectroscopy band gap computation, PL, and photoelectrochemical assessment, the charge sinking

function of Ti_3C_2 was given in this first-time predesigned and three-phase Z-scheme catalyst. Complete elimination of phenol was attained by employing a CTT catalyst after 150min. It has been verified that both superoxide and hydroxyl radicals performed crucial roles in the decontaminants [17].

8. Conclusion

Photocatalytic degradation of phenol and heterostructure composites attracted special attention from researchers because of their improved performance as compared to pure phases. In this review, we have highlighted the different methods that have been adopted for manufacturing, photocatalytic characteristics, and wastewater treatment application for phenol through 2D MXene/ TiO_2 development.

Pure phases or composite photocatalysts are often manufactured by using a bottom-up approach through different processes like exfoliated of MAX phase, sol-gel, hydrothermal, solo-thermal, and so on. Bottom-up is a straightforward approach and requires precursors that add up stepwise for the production of the required catalyst. Moreover, the etching of MAX not only contributes to the production of MXene but as well improves the surface properties which makes him unique and special. The attachment of functional group termination like O, OH, and F participants in its optical and conductivity features. Surface engineering of these functional groups possibly controls according to the importance of application so that it improves the activities' influence. Photocatalytic characteristics and degradation performance of composite depends on the catalytic materials' synthesis process. The combined MXene/ TiO_2 composite typically resulted in distinct physical and chemical characteristics from the original phases and increased photocatalytic performance. Composite photocatalytic properties demonstrated remarkable degradation activity compared to pristine phases because of their advantageous chemical composition, structure, and morphological characteristics. The optimized light harvesting potential, high surface area, visible high absorption, high charge carriers' production, efficient interfacial charge migration, and accessible active sites for surface reactions drive the optimized performance upon MXene/ TiO_2 composite formation in the photocatalytic treatment of phenol contaminants.

9. Prospects

- Fabrication of pristine TiO_2 , MXene, and MXene/ TiO_2 composite with improved performance characteristics through numerous synthesis approaches like hydrothermal, sol-gel, chemical deposition processes, etc. suffers from the complexity of the method, the consumption of unsafe chemicals, and the constraint of large amounts of energy and time. Therefore, (i) much attention is required in the



manufacturing process to overcome the shortcomings. (ii) The use of additional etchants is required since HF is toxic to the human body and the environment, therefore they must be managed with utmost care. As a result, developing new safe or more friendly etchants is a considerably more important investment.

- Because the characteristics and applications of MXenes are heavily dependent on their unique structures and specific synthesis processes, they must be synthesized with high quality and phase purity.
- MXene catalysts like Ti_3C_2 most investigated type but substituted metallic components of M an entirely novel class of excellent photocatalysts may be beneficial for degradation performance.
- A thorough study of numerous aspects, such as electrical structure, composition, surface area, structure of crystals, and morphology for MXene materials is required.
- The degradation application of TiO_2 /MXenes gained deep attention of researchers. Still, a lot of grey areas are there to improve; (i) Fundamentals such as the photocatalytic degradation mechanism of TiO_2 /MXenes are ambiguous since the theoretical knowledge about band energy and redox potential is still not clear. (ii) Many aspects, including electronic structure, electrical modulation, composition, surface area, crystal structure, and morphology for composites, must be thoroughly investigated. (iii) The presence of heterojunction among MXenes/ TiO_2 has been investigated in the photocatalysis process, but the present discussion is insufficient to conclude the flow of charge in TiO_2 and numerous families of MXenes composites, (iv) no discussion has been reported for advanced heterojunctions (indirect Z-scheme, S-scheme, etc.) among MXenes/ TiO_2 composite for photocatalytic degradation processes, which need to be addressed thoroughly.

10. References

- [1] B. P. Kafle, "Chapter 5 - Application of UV-VIS spectrophotometry for chemical analysis," in *Elsevier*, B. P. Kafle Ed.: Elsevier, 2020, pp. 79-145.
- [2] S. Wardhani, D. Purwonugroho, C. W. Fitri, and Y. P. Prananto, "Effect of pH and irradiation time on TiO_2 ," *AIP Conference*, 2018.
- [3] H. Zhang *et al.*, "2D $\alpha-Fe_2O_3$ doped Ti_3C_2 MXene composite with enhanced visible light photocatalytic activity for degradation of Rhodamine B," *Ceram. Int.*, vol. 44, no. 16, pp. 19958-19962, 2018/11/01/ 2018, doi: <https://doi.org/10.1016/j.ceramint.2018.07.262>.
- [4] W. Tang *et al.*, "Complete removal of phenolic contaminants from bismuth-modified TiO_2 single-crystal photocatalysts," *Chinese J. Catal.*, vol. 42, no. 2, pp. 347-355, 2021.
- [5] M. Boroski, A. C. Rodrigues, J. C. Garcia, L. C. Sampaio, J. Nozaki, and N. Hioka, "Combined electrocoagulation and TiO_2 photoassisted treatment applied to wastewater effluents from pharmaceutical and cosmetic industries," *J. Hazard. Mater.*, vol. 162, no. 1, pp. 448-454, 2009.
- [6] Z. You, Y. Liao, X. Li, J. Fan, and Q. Xiang, "State-of-the-art recent progress in MXene-based photocatalysts: a comprehensive review," *Nanoscale*, 10.1039/D1NR02224E vol. 13, no. 21, pp. 9463-9504, 2021, doi: 10.1039/D1NR02224E.
- [7] M. Naguib *et al.*, "Two-dimensional nanocrystals produced by exfoliation of Ti_3AlC_2 ," *Adv Mater*, vol. 23, no. 37, pp. 4248-4253, 2011.
- [8] J. A. Kumar *et al.*, "Methods of synthesis, characteristics, and environmental applications of MXene: A comprehensive review," *Chemosphere*, vol. 286, p. 131607, 2022/01/01/ 2022, doi: <https://doi.org/10.1016/j.chemosphere.2021.131607>.
- [9] D. A. Hanaor and C. C. Sorrell, "Review of the anatase to rutile phase transformation," *J. Mater. Sci.*, vol. 46, no. 4, pp. 855-874, 2011.
- [10] D. K. Muthee and B. F. Dejene, "Effect of annealing temperature on structural, optical, and photocatalytic properties of titanium dioxide nanoparticles," *Heliyon*, vol. 7, no. 6, p. e07269, 2021/06/01/ 2021, doi: <https://doi.org/10.1016/j.heliyon.2021.e07269>.
- [11] M. Naguib, M. W. Barsoum, and Y. Gogotsi, "Ten years of progress in the synthesis and development of MXenes," *Adv Mater*, vol. 33, no. 39, p. 2103393, 2021.
- [12] P. Chakraborty, T. Das, and T. Saha-Dasgupta, "1.15 MXene: A New Trend in 2D Materials Science," *Nanosci. Technol.*, vol. 319, 2019.
- [13] S. I. Mogal, M. Mishra, V. G. Gandhi, and R. J. Tayade, "Metal doped titanium dioxide: synthesis and effect of metal ions on physico-chemical and photocatalytic properties," in *Materials Science Forum*, 2013, 364-378.
- [14] D. Bokov *et al.*, "Nanomaterial by Sol-Gel Method: Synthesis and Application," *Advances in Materials Science and Engineering*, vol. 2021, p. 5102014, 2021/12/24 2021, doi: 10.1155/2021/5102014.
- [15] M. Abatal, I. Anastopoulos, D. A. Giannakoudakis, and M. T. Olguin, "Carbonaceous material obtained from bark biomass as adsorbent of phenolic compounds from aqueous solutions," *J. Environ. Chem. Eng.*, vol. 8, no. 3, p. 103784, 2020/06/01/ 2020, doi: <https://doi.org/10.1016/j.jece.2020.103784>.



- [16] M. Ding *et al.*, "Facile construction of dual heterojunction CoO@ TiO₂/MXene hybrid with efficient and stable catalytic activity for phenol degradation with peroxy monosulfate under visible light irradiation," *J. Hazard. Mater.*, vol. 420, p. 126686, 2021.
- [17] Q. Liu *et al.*, "MXene as a non-metal charge mediator in 2D layered CdS@Ti₃C₂@TiO₂ composites with superior Z-scheme visible light-driven photocatalytic activity," *Environ. Sci. Nano*, 10.1039/C9EN00567F vol. 6, no. 10, pp. 3158-3169, 2019, doi: 10.1039/C9EN00567F
- [15] M. Abatal, I. Anastopoulos, D. A. Giannakoudakis, and M. T. Olguin, "Carbonaceous material obtained from bark biomass as adsorbent of phenolic compounds from aqueous solutions," *J. Environ. Chem. Eng.*, vol. 8, no. 3, p. 103784, 2020/06/01/ 2020, doi: <https://doi.org/10.1016/j.jece.2020.103784>.
- [16] M. Ding *et al.*, "Facile construction of dual heterojunction CoO@ TiO₂/MXene hybrid with efficient and stable catalytic activity for phenol degradation with peroxy monosulfate under visible light irradiation," *J. Hazard. Mater.*, vol. 420, p. 126686, 2021.
- [17] Q. Liu *et al.*, "MXene as a non-metal charge mediator in 2D layered CdS@Ti₃C₂@TiO₂ composites with superior Z-scheme visible light-driven photocatalytic activity," *Environ. Sci. Nano*, 10.1039/C9EN00567F vol. 6, no. 10, pp. 3158-3169, 2019, doi: 10.1039/C9EN00567F



COMPARATIVE STRUCTURAL ANALYSIS OF BUILDING FRAME AND DUAL FRAME SYTEM BY INCORPORATING SHEAR WALL

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KEY WORDS

Finite element method
Earthquake resisting buildings
Shear wall, UBC-97

ABSTRACT

With the time the trend in the buildings changed and people started to move towards the high rise buildings and hence the implementation of performance based engineering philosophies concerning the lateral forces specially, seismic design of civil engineering structures became necessary to be analyzed to make the structure safe and stable. These provision, has led the structural engineers to develop and implement such structural member in the structure which could withstand the lateral or seismic loads. Such as shear wall. Also due to the increasing demand of the earthquake resisting buildings led the engineers to analyze this shear wall in different positions or circumstances. The objective the study is to perform 3D modeling of the building frame and dual frame system and to check the effect of reducing dimensions of building and also to compare the story drift and displacement of models with different positions of shear wall using Uniform Building Code-97. The finite element method is used for simulating the model of Ground plus 7 (G+7) building along with a modeling software ETABS which is used to design and analyze the structure throughout the world. After analyzing it was founded that the shear wall at the core gives the best results.

1. Introduction

The main goal of designing buildings structurally for seismic loading is to provide structural safety in the event of a significant earthquake. Serviceability and the possibility of financial loss, however, are also issues. [10]. It is crucial to ensure adequate lateral stiffness to resist the seismic loads. Other lateral loads such as wind load which depends on the building height, wind flow, surrounding exposure and building shape. It is also significant for multistoried building [1]. When the buildings are tall, the dimensions of other structural members also increases and the beam, column, sizes are quite heavy, and steel required is large. Due to the severe displacement and extreme difficulty in placing and vibrating concrete at these locations, there is a great deal of congestion at their joints. Also the column the of structure only takes the gravity loads and it will not resist the lateral loads so there will be need of the structural walls, commonly known as shear wall in buildings to resist these seismic forces. The shapes of

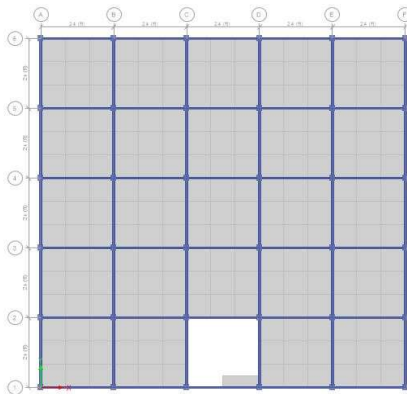
building also effect the result of shear wall. A shear wall is a structural panel that can resist lateral forces acting on it. Shear wall in symmetrical shape give better result than asymmetrical shape as in base shear and story drift. The story drift the rectangular building is less than L shape because of symmetry in rectangular shape [3]. The structural safety is more important that's why dual system is adopted to meet the requirement.

The main objective of the present study is to analyze behavior of the G+7 building frame system and dual frame system by incorporating shear wall and to compare the effect of reducing dimension and area of the steel in building frame and dual frame system with different positions of shear wall.

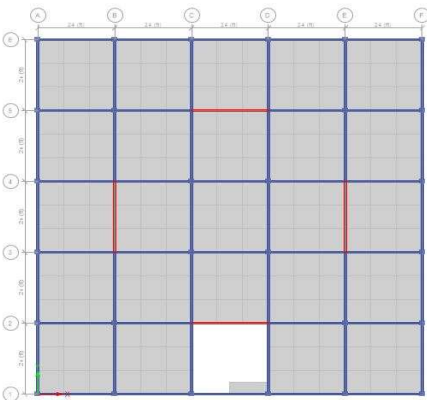
Under the code UBC-97 four models were generated by using ETABS:

PLAN VIEW:

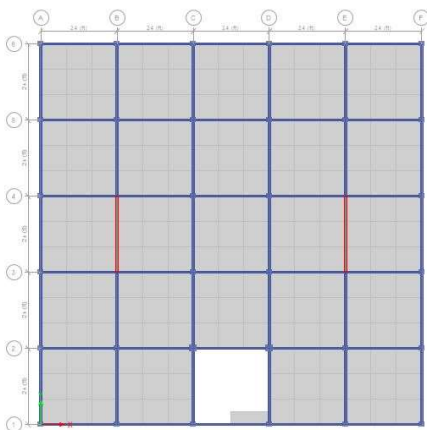
Building frame system:



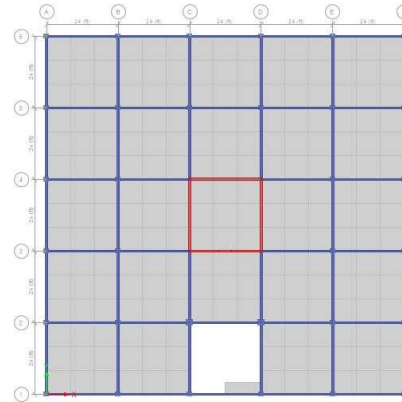
Dual frame system with 4 shear walls;



Dual frame system with 2 shear wall;



Dual frame system with core wall in center;



2. Approaches to Analysis:

Structural analysis helps us to design the structures in such a way that they bear the loads without excess deformation or distress and to avoid from collapse of structure within the specified loading conditions. Additionally it is also very useful to determining the factors of safety in order to increase the capacity of structure to bear the loads beyond expectation. Main approaches analyze are:

- The Elastic theory
- The strength of material approach
- The finite Element method

The Elastic theory: Since stress is proportional to the imposed loads and strain is proportional to the deformation, this suggests that stress and directly proportional which is also given by hook's law;

$$\text{Stress } \sigma = \text{Strain } \epsilon \cdot E$$

The modulus of elasticity E, young's modulus, or the tensile modulus denotes the material stiffness. A material is said to be elastic if it obeys hook's law. This approach is generally present for elastic solid irrespective of its shape. Individual members, such as column, beams, shafts, shelves and plates may be modeled, and solutions are derived from the linear elasticity equations.

Strength of Material Approach: Basically, solid mechanics is the study of load bearing members, in terms of deformations, forces and stability. Generally, there are three scales of length: micro scale, atomic scale and continuum scale. Continuum mechanics approach has been taken in this research. We will be considering the material to be isotropic and homogenous, unless specified. Hence, the properties of material are same when we assume infinitesimal areas and volumes.



Finite Element Methods: It is generally based on the philosophy of building a complex object with simple blocks or dividing a complex object into manageable and small pieces. Some important features are,

- Break structure to pieces (with node),
- Describe the behavior of physical quantities on each element,
- Assemble the elements, and the nodes in order to form an system of equations for the entire structure and solve the system of equations including unknown quantities.

3. Research methodology

The researcher has prepared four models of G+7 stories, one without shear wall (building frame system) and three other models with shear wall (dual system). The building frame system was analyzed and reduced the dimensions of frame sections to get failing dimensions.

Building Characteristics and Material properties;

Table 1

TABLE: Building Characteristics					
Name	Height	Elevation	Master Story	Similar To	Splice Story
	in	In			
STORY8	144	1152	Yes	None	No
STORY7	144	1008	No	STORY8	No
STORY6	144	864	No	STORY8	No
STORY5	144	720	No	STORY8	No
STORY4	144	576	No	STORY8	No
STORY3	144	432	No	STORY8	No
STORY2	144	288	No	STORY8	No
STORY1	144	144	No	STORY8	No
BASE	0	0	No	None	No



Table 2

TABLE: Frame Sections – Summary		
Name	Material	Shape
B8X24	CONC	Concrete Rectangular
B8X27	CONC	Concrete Rectangular
B8X30	CONC	Concrete Rectangular
B8X33	CONC	Concrete Rectangular
C12X12	CONC	Concrete Rectangular
C15X15	CONC	Concrete Rectangular
C15X18	CONC	Concrete Rectangular
C18X18	CONC	Concrete Rectangular
C18X21	CONC	Concrete Rectangular
C21X21	CONC	Concrete Rectangular
C24X27	CONC	Concrete Rectangular

Table 3

TABLE: Material Properties - Summary					
Name	Type	E	v	Unit Weight	Design Strengths
		lb/in ²		lb/ft ³	
A615Gr60	Rebar	2.9E+07	0.3	490	F _y =60000 lb/in ² , F _u =90000 lb/in ²
C4500	Concrete	3823676	0.2	149.9	F _c =4500 lb/in ²
CONC	Concrete	3600000	0.2	149.9	F _c =3000 lb/in ²
OTHER	Other	2.9E+07	0.3	489.02	
STEEL	Steel	2.9E+07	0.3	489.02	F _y =50000 lb/in ² , F _u =65000 lb/in ²

These failing dimensions were used in the dual system models and were analyzed under the UBC-97 code of practice, after that, it was checked for live load, dead load, wind load and earthquake loads. In this work, only the technique of static analysis was used for analysis to check the building against earthquake loads and to find out several other parameters.

4. Results and discussions

After the analysis of different positions of shear wall in the building configuration the total members reduced in the models are given below

Model 2 (64 members)

Model 3 (64 members)

Model 4 (64 members)

Also the comparison in percentage reduction of Story displacement, story drift along with total reduction the area of steel used in the building frame system was carried out. Following tables shows the results; %reduction in story displacement of Dual models compared to Building frame system:



Table 4

MODEL	EQX	EQY
MODEL 2	75.88	71.7
MODEL 3	3.37	70.36
MODEL 4	89.01	85.79

%reduction in story drift of Dual models compared to Building frame system:

Table 5

MODEL	EQX	EQY
MODEL 2	75	72
MODEL 3	11.76	69.89
MODEL 4	89.07	86.02

Table 6

TABLE: Shell Sections – Summary				
Name	Design Type	Element Type	Material	Total Thickness
				in
RW12	Wall	Shell-Thin	4000	12
S5	Slab	Shell-Thin	C3000	5
S6	Slab	Shell-Thin	C3000	6
S7	Slab	Shell-Thin	C3000	6.9996
S8	Slab	Shell-Thin	C3000	8
STAIR8	Slab	Shell-Thin	C3500	8
SW12	Wall	Shell-Thin	C3500	12
SW10	Wall	Shell-Thin	C3500	10
SW9	Wall	Shell-Thin	C3500	9

Table 7

MODELS	% REDUCTION
MODEL2	34.22
MODEL 3	9.85
MODEL 4	29.76

4. Conclusion

ETABS software was utilized to conduct a thorough study and design of building frame systems, with a focus on the Building Frame System and Dual Frame Systems. After careful analysis, it was found that Model 4, which includes the Core wall system, was the most promising option in terms of safety and cost.

When it came to minimizing story drift and displacement, Model 4 with the Core wall performed better in terms of structural integrity than other systems. This displacement decrease indicates improved stability and safety, which are essential components in guaranteeing a structure's resistance to different loading scenarios. In addition to its safety benefits, the Core wall system offers significant economic advantages. Because of its centralized load-bearing design, less material is used overall, which saves real money while building. The technique also uses less steel reinforcement, which reduces the cost of materials even further. It also streamlines the construction process, saving time and labor. Moreover, the long-term financial benefits of the Core wall system arise from its robustness and ease of maintenance. Because of its sturdy design and streamlined construction procedure, the building requires less ongoing maintenance, which lowers operating expenses during its lifetime. Moreover, its resilience to seismic activity and other dangers lowers the possibility of damage, lowering repair costs and boosting its marketability.



5. Reference

- [1] Barua, S., & Sultana, R. (2020). A Study on Influence of Core Wall in Frame Structure Under Seismic Load.
- [2] Chandurkar, P. P., & Pajgade, D. P. (2013). Seismic analysis of RCC building with and without shear wall. *International journal of modern engineering research*, 3(3), 1805-1810.
- [3] Arlekar, J. N., Jain, S. K., & Murty, C. V. R. (1997, November). Seismic response of RC frame buildings with soft first storeys. In *Proceedings of the CBRI Golden Jubilee Conference on Natural Hazards in Urban Habitat* (pp. 10-11).
- [4] Sultan, M. R., & Peera, D. G. (2015). Dynamic analysis of Multi-Storey building for different shapes. *International Journal of Innovative Research in Advanced Engineering (IJIRAE)*, 2.
- [5] Inamdar, V., & Kumar, A. (2014). Pushover Analysis of Complex Steel Frame with Bracing Using Etabs.
- [6] Panchal, D. R., & Marathe, P. M. (2011). Comparative Study of RCC, steel and composite (G+ 30 storey) building. *Nirma University, Ahmedabad, India*.
- [7] Sirisha, D. (2019). Seismic Analysis and Design of Multistoried Building with and without Bracing According to is Code and Euro Code by using ETABS. *International Journal of Engineering Research & Technology*, 8(7).
- [8] Suryawanshi, A. C., & Bogar, V. M. (2019). Seismic Analysis of Building Resting on Sloping Ground with Soil Structure Interaction. *International Research Journal of Engineering and Technology (IRJET) e-ISSN, 2395-0056*.
- [9] Guleria, A. (2014). structural analysis of a multi-storeyed building using ETABS for different plan configurations. *International journal of engineering research and technology*, 3(5), 1481-1485.



Smart Underground Line Fault Locator on Maps Using Arduino GSM and GPS

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KEY WORDS

Underground lines
Underground Cables
Fault diagnosis
Arduino
Global positioning system

ABSTRACT

Underground lines have been an integral part of power transmission and distribution systems. These lines are subject to various faults that reduce their practicality and largely affect the reliability of power transmission. This research proposes an advanced model to detect and locate faults in underground lines. The output is received through a well-integrated circuitry consisting of Arduino, GSM, and GPS. The system sends a real-time data set, including fault type, distance from the substation, and fault location coordinates, to the user's smartphone. The model functions on the principles of Ohm's Law and implements IOT for accessibility. Hence, whenever a fault occurs, the essential data set is available to start the repair process immediately. With this model, reliable power transmission can be ensured through underground lines at minimal repair and maintenance costs. Unlike existing fault tracking methods used for underground cables, this model tends to provide pin-point fault location through an effortless mechanism. Therefore, unnecessary excavations or the use of extra manpower to locate faults will be unneeded. The entire process is digital and single-handedly executable. During initial experimentation, the model was tested with a simulated version that brought the intended results. Later, the research was concluded with a hardware demonstration, which corroborated the applicability of this model. A set of resistors represented underground cables, and the faults were introduced as in practical scenarios. The system responded to a fault and sent over the data set promptly. It was found that the model is feasible for practical use. The objective of increasing the reliability of power transmission through underground lines was well achieved.

1. Introduction

The most crucial aspects of electrical power are transmission and distribution systems that allow its utility. Both systems are required to be efficient and reliable to ensure uninterrupted power supply. For years, these systems have been relying on overhead and underground lines to transmit the power from generation stations all the way to consumers [17]. The transmission lines are susceptible to recurring faults for reasons such as direct contact with the environment. The faults cause a disruption in the power supply, which is undesirable in all circumstances. Therein, the feasibility of overhead lines and underground lines comes into question. In terms of practicality, overhead lines are prone to more faults due to external conditions, i.e., surges, storms, and winds, than

underground lines [16, 4]. Unlike overhead lines that are bare conductors, the underground lines are properly insulated, and the conductor is shielded to withstand electrical, mechanical, and natural stresses. Hence, underground cables are more advantageous compared to overhead lines [16]. The underground cables also have some negatives that limit their overall reliability. These are relatively expensive and require specific infrastructure for installation. Plus, the fault diagnosis and fault tracking processes are very complex. In case of faults, rectification is a procedure that is too demanding [3]. An underground cable is subjected to a variety of faults due to natural phenomena such as corrosion and erosion and external intervention during installation, i.e., civil works. In both cases, the damage to the cable causes faults to occur. The



reasons include conductor blemish, cable cuts, loss of resistance, sheath damage, water treeing, and partial discharges [3, 5]. A fault scenario can make underground cables impractical and have a significant impact on the entire power supply system. Statistical studies have even shown complete distribution network failure due to faults at some points in underground lines [13]. Regarding the feasibility of these lines, the ageing phenomenon is a major concern, but, more or less, the difficulty of fault diagnosis and no accessibility to the lines play a crucial role. Whenever a fault situation arises, the underground cable system fails to ensure continuity of power supply. Although there are various techniques involving hardware equipment and mathematical calculations to track faults. However, they are not very effective. The inceptive underground cable fault tracking method includes bridge approaches based on the fundamentals of Wheatstone Bridge that date back to 1833. For more than a hundred years, the bridge approaches, accompanied by simple mathematical calculations, have been used to localize and track faults in underground cables. Their precision was impeccable even though the measuring instruments (galvanometer, ampere meter, etc.) were not very reliable back then. Today, bridge techniques still play a pivotal role in advanced systems used to locate faults. These bridge approaches are divided into two main methods used for pinpointing faults in underground cables: the Murray Loop Method and the Varley Loop Method [4, 10]. Additionally, a variety of techniques and methods are employed globally to locate faults in underground cables. Most of these methods employ different instruments or specialized equipment to track faults. For instance, Time Domain Reflectometer, a device-based fault tracking method used to track low-resistive faults and intermittent faults in underground cables. It works on the principle of wave propagation. When a low voltage signal is pushed into the line, it travels through the line and reflects back after encountering any impedance change. The TDR (Time-Domain Reflectometer) measures the travel time of the signal, which is then used to estimate the distance to the fault. A short circuit fault causes a negative reflection of the signal, while an open circuit fault causes a positive reflection. Additionally, cable thumping is a commonly used technique for locating faults in underground cables. In this method, high voltage is applied to the faulty cable, creating an arc at the fault point. This arc produces a distinct thumping sound that helps in pinpointing the fault location. The method is not practical for long-distance cables, nor can it detect short circuit faults. Therefore, it is commonly used for short cables that are not prone to short circuit faults. The method also has adverse effects; the provision of high voltages to the cable often causes insulation breakdown. The voltages must be at safe levels; otherwise, the cable will be damaged. Most of these existing fault

tracking techniques fail to provide exact fault location in the first place. The fault locations retrieved from implementing such methods are not accurate; therefore, they require manual exploration in the proposed fault area. It makes the process time-consuming and labour-intensive. For what is at stake, these techniques cannot offer satisfactory results or manifest the required level of efficacy [1,8]. In these conditions, the development of an intelligent system for fault tracking in underground power transmission lines that can provide pin-point fault location was much needed. The advanced system based on efficient gadgetry can help in accurate fault tracking and fault diagnosis in underground lines. It should also provide pin-point fault location with a hundred per cent accuracy. With the system enacted, the manual work for locating faults may be minimal to save time and resources. The system should also be digitally operatable, meeting modern-day standards and offering ease of access to users [1, 10, 11].

2. Methodology and Technique

The way forward for the development of an efficient system to overcome the constraints of fault tracking in underground cables requires an effective blueprint. The pivotal law in electrical engineering, Ohm's Law, became the fundamental of design. When voltage is applied to a faulty line, the resulting current fluctuates based on the fault's distance from the source, leading to a corresponding change in the voltage drop. This variation in voltage drop can be utilized to determine the fault's location, as it indicates a specific distance from the application point of the voltage [4,7]. An Arduino can be used in conjunction with the Global Positioning System (GPS) to determine the distance from the base station to the fault point, providing an accurate fault location. For convenience, this information can be transmitted to the user's smartphone using an integrated Global System for Mobile Communication (GSM) module. Understanding how the system operates with all its components is crucial. The applicability of the system is tested through a hardware model. A series combination of resistors is used to simulate the three phases of an underground line over a given distance. Switches are strategically arranged to create faults in the system. DC voltage is supplied via an AC-to-DC converter to power the setup. When a fault occurs and voltage is applied from the feeder end, the resulting current variation depends on the fault's distance, causing a potential drop across the series resistors. This potential drop is then used to calculate the fault's distance. The fault location is identified by the Global Positioning System (GPS), while the Global System for Mobile Communications (GSM) serves as a communication link between the user and the system [2, 3, 5]. The voltage drop is then converted into distance in kilometres using a mathematical equation-based algorithm. With a distance of the fault point at hand, the

location coordinates are known using application-based software providing online map services.

I. Mathematical Formulae: The distance between the fault point and the base station is calculated as,

$$D = (M * R)/V..... \text{eq: (1)}$$

In this context, D represents the fault distance from the base station to the fault location, M is the corresponding ADC value for the voltages, R is the line resistance, and V is the reference voltage. Additionally, R can be calculated from:

$$R = V/(I + 1).....\text{eq: (2)}$$

Here, I represents the current value, and V denotes the voltage drop measured at the fault point. Equations (1) and (2) are used together to determine the precise distance from the base station to the fault point.

3. Simulation and Results

The development of a simulation model helps to replicate and understand the operation of the proposed hardware prototype. The MATLAB Simulink interface was used to simulate the controller's design and program. The simulation is shown below with its operation:

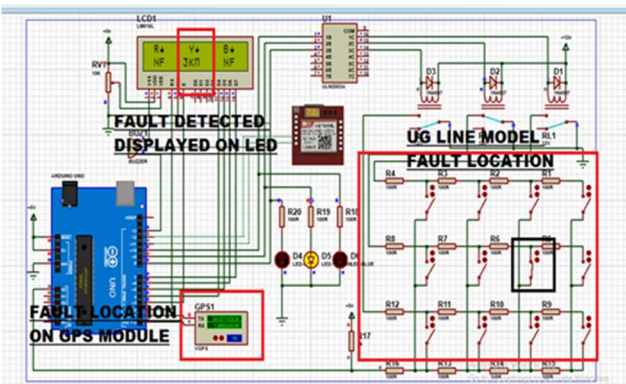


Fig. 1. Simulation Model ((Fault Detected Scenario)

In this case, a short circuit fault is introduced through the set of resistors in the Y PHASE of the cable. The relay detects the abnormal current flow and sends the signal to the controller. The controller identifies the fault and calculates the distance from the base station to the fault point using the algorithm based on Ohm's Law. Simultaneously, the Global Positioning System module (GPS) converts the distance to location coordinates. The data is compiled and sent as information to the user's smartphone through the integrated GSM. The user will get a message on the smartphone, which includes information about the fault and its location in latitude and longitude points. Additionally, the message includes a link to open the fault location on maps for easy and faster access. The user can open the link to identify the exact fault location

and use the information to carry out the rectification process.

Table 1

Results Table

SNO.	TRIGGERED SWITCH	ADC VALUE	VOLTAGE (V)	CURRENT (A)	POSITION (KM)
1.	L1-S1	582	3.224	1.81	2 KM
2.	L2-S2	862	4.285	0.714	2 KM
3.	L1-S4-S5	908	4.44	0.566	4 KM

The readings are taken during the operation of the simulation and corroborated with the results of the hardware model. The voltage drop and current values are across the indicated switches when they are triggered.

4. Hardware Model and Algorithm

The design is implemented in the development of a hardware model for real-time applications. The simulated model is transformed into a hardware prototype. The components are assembled as shown below:

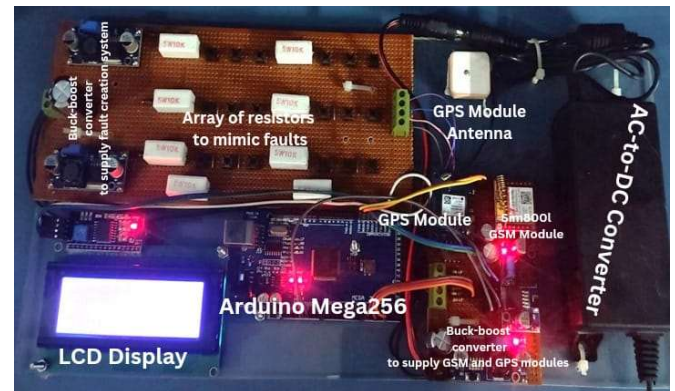


Fig. 2. Hardware Prototype of Proposed Model

I. Normal Operating Condition:

During normal operating conditions, the LCD displays that all three lines, L1, L2, and L3, are 'okay,' and no fault is detected in the system. The fault position is NIL, and the sim8001 GSM module does not send any text message to the user.



Fig. 3. Normal Condition Operation (LCD Output)

If a single line to ground fault is introduced by triggering the switches, for instance, in L1, the LCD displays 'fault at L1-to-G at 2KM'. The coordinates of fault location, including latitude and longitude, are also displayed. The user receives the same data on the smartphone via text message from the sim8001 GSM module integrated with the system.

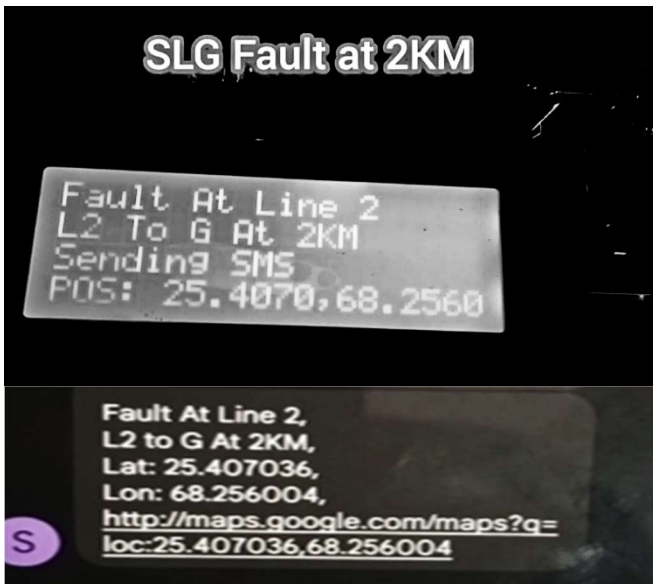


Fig. 4. Fault Condition Operation (LCD Output & SMS)

I. ALGORITHM

Step-by-step Initialization of Algorithm:

- 1) Initialize all input, output, and communication ports; define the time delay, and run the functions for the LCD, ADC, GSM, and GPS.
- 2) Initiate an infinite loop and examine each line for predefined abnormal conditions following a 500ms time delay.
- 3) Read and convert analog data into digital format utilizing the built-in ADC converter. Then, compare the normal and abnormal conditions based on the programmed parameters.
- 4) In case of fault, calculate the distance from the base station to the fault point using preset formulae (Defined in Equation 1 and Equation 2).
- 5) Retrieve signal from GPS and use calculated fault distance to identify fault position in terms of latitude and longitude.
- 6) Display output data on LCD and send the same data set to the user's smartphone (pre-defined) using GSM simultaneously.

- 7) Reinitiate the cycle from step 2 to step 6 for the identification of further faults in the system.

5. Conclusion

The demand for safe power transmission through underground cables is increasing day by day. The underground cables-based power transmission systems are preferred over conventional overhead lines, especially in densely populated areas. In the near future, the overhead lines will become extinct. The proposed research idea can be nurtured and developed to meet the changing dynamics of electrical power transmission through underground cables. It aims to overcome the very basic limitation of the said system. The hardware prototype is a step towards making of a dependable system for fault detection and location in underground cables. It will increase the reliability of underground cables-based power transmission systems, making them more convenient and applicable. In the current century, technological developments are fast-paced, and this research idea and prototype can also become a bedrock for a more advanced-level system in the near future.

6. Acknowledgement

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7. Reference

- [1] M. F. Islam, A. M. T. Oo and S. A. Azad, "Locating underground cable faults: A review and guideline for new development," 2012 22nd Australasian Universities Power Engineering Conference (AUPEC), 2012, pp. 1-5.
- [2] Dhekale, P.M., Bhise, S.S., Deokate, N.R. and Suryawanshi, R.R., 2015. Underground cable fault distance locator. Novateur Publications, International Journal of Innovations in Engineering Research and Technology [ijiert], 2(4).
- [3] Sain, Nikhil Kumar, Rajesh Kajla, and Mr Vikas Kumar. "Underground Cable Fault Distance Conveyed Over GSM." International Organization of Scientific Research Journal of Electrical and Electronics Engineering 11.2 (2016).
- [4] M. R. Hans, S. C. Kor and A. S. Patil, "Identification of underground cable fault location and development," 2017 International Conference on Data Management, Analytics and Innovation (ICDMAI), 2017, pp. 5-8, doi: 10.1109/ICDMAI.2017.8073476.
- [5] N. Sampathraja, Dr. L. Ashok Kumar, K. Vishnu



- Murthy, V. Kirubalakshmi and C. Muthumaniyarasi, Iot Based Underground Cable Fault Detector, International Journal of Mechanical Engineering and Technology 8(8), 2017, pp. 1299–1309.
- [6] Nagendra, V. Surya, et al. "Hardware Implementation of an Underground Cable Fault Detection." International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 5 Issue VII, July 2017.
- [7] G. R. Mirza, A. K. Maheshwari, M. A. Mahar, A. S. Larik and G. H. Talpur, "Design and fabrication of underground fault distance locator using Arduino and GSM," 2017 International Conference on Open-Source Systems & Technologies (ICOSST), 2017, pp. 30-34, doi: 10.1109/ICOSST.2017.8279001.
- [8] R Rengaraj, "Identification and classification of faults in underground cables – A review," 2021 IOP Conf. Ser.: Mater. Sci. Eng. 1166 012018
- [9] Nag, Ankita, et al. "Fault Location in Underground Cable System Using Optimization Technique." 2020 First International Conference on Power, Control and Computing Technologies (ICPC2T). IEEE, 2020.
- [10] Shaikh, Muhammad Suhail, et al. "Analysis of underground cable fault techniques using MATLAB simulation." Sukkur IBA Journal of Computing and Mathematical Sciences 4.1 (2020): 1-10.
- [11] Josephine, M. S., et al. "Intelligent Framework for Underground Cable Fault Detection Based on Embedded Sensor." Renewable Energy with IoT and Biomedical Applications: 117.
- [12] Salimi, Mohd Azmir Mohd, and Azmi Hashim. "Simulation of Underground Cable Fault Detector Using Arduino." Journal of Engineering Technology 9.1 (2021): 86-90.
- [13] Shaalan, Essam M., Sayed A. Ward, and Ahmed Youssef. "Analysis of a Practical Study for Underground Cable Faults Causes." 2021 22nd International Middle East Power Systems Conference (MEPCON). IEEE, 2021.
- [14] Reddy, Peram Chandra Sekhar, and Chilakapati Harini. "Underground Cable Fault Location Detection by Simple Calculations." International Journal of Research in Engineering, Science and Management Volume-3, Issue-3, March-2020.
- [15] Abed, Faisal T., and Haider T. AlRikabi. "Using IoT Applications for Detection and Monitoring of Underground Cable Fault." IOP Conference Series: Materials Science and Engineering. Vol. 1184. No. 1. IOP Publishing, 2021.
- [16] Samuel A. Isaac, Olajube Ayobami, Awelewa Ayokunle "Arduino Microcontroller Based Underground Line Fault Locator" International Journal of Mechanical Engineering and Technology (IJMET) Volume 10, Issue 03, March 2019, pp.890-902.
- [17] H. Al-Khalidi, IETMember, A. Kalam "The Impact of underground Cables on Power Transmission and Distribution Networks" First International Power and Energy Conference PECon 2006 November 28-29, 2006



Investigation of Audio Features for Heart Murmur Detection and Classification

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KEY WORDS

MFCC
LPCC
GTCC
Heart Murmur
Support Vector Machine
Window Size
Feature Order

ABSTRACT

Abnormal heart sounds called heart murmurs, frequently linked to underlying cardiac problems, are a primary global health concern. To be effectively diagnosed and treated, cardiac murmurs must be promptly detected and accurately classified. This study aims to improve heart murmur detection using handcrafted features like Mel-frequency cepstral coefficients (MFCC), Linear prediction coefficients (LPCC), and Gammatone cepstral coefficients (GTCC). This paper is focused on the impact of feature ordering and window size on the overall heart murmur detection performance. The performance of these features is validated by training and testing various Support Vector Machine (SVM) classifier models on the dataset. Experimental results show that features do not show any specific trend on different window sizes, and in the case of feature vectors, MFCC and GTCC performed well at 14, while LPCC showed better results at 20. Further, performance is also evaluated by combining two different features, where MFCC and GTCC showed better results among other combinations.

1. Introduction

Heart Failure, also known as Cardiac Arrest, is one of our society's leading causes of death. The heart defect remains in the victim's body without causing any apparent symptoms, but it does leave certain traces of its presence. One of those heart defects is known as Heart Murmur. Turbulent blood flow, in addition to normal heartbeats, is the factor that causes cardiac murmurs. A cardiac murmur can be harmless (benign) or life-threatening (pathological) depending on a person's age and health. Heart problems such as valvular disorders, valvular regurgitation, intra-cardiac shunt, or aortic stenosis are all signs of pathological murmurs. A heart murmur is present in 10 percent of adults, and 40 to 45 percent of children exhibit a heart murmur [1]. A doctor can prescribe an appropriate treatment plan if life-threatening murmurs are detected early on. However, when murmurs are not diagnosed early enough, they can lead to cardiac failure, resulting in death.

Heart murmur can be detected through auscultation and diagnostic tests. The primary technique for detecting a heart murmur is auscultation or listening to heart sounds using a stethoscope. Medical personnel listen to various chest regions, including the mitral, tricuspid, aortic, and pulmonic zones, to determine the murmur's pitch, timing,

and intensity. To gauge its loudness or intensity, practitioners can categorize it as systolic or diastolic and grade it on a scale from 1 to 6. Diagnostic tests may include echocardiogram (Echo). An Echo is a frequent and effective procedure for detecting heart murmurs. The heart's anatomy and operation are precisely portrayed using sound waves (ultrasound). This examination can demonstrate the heart's chambers, valves, and blood flow, assisting in determining the origin and severity of the murmur. Nowadays, echo machines and stethoscopes are used in hospitals to check for heart murmurs in patients. Patients are directed to hospitals in Pakistan's metropolitan regions since 67.5% of the country's territory is rural, the country's hospitals are underequipped, and the clinicians who operate in those hospitals must gain experience identifying heart murmurs [2]. As a result, the disease's early stages are not readily detected. In this context, developing a quick and effective approach for identifying cardiac murmurs is crucial, which can only be achieved by integrating signal processing methods with machine learning concepts.

Numerous studies have investigated the identification and categorization of heart murmurs by analyzing heart sound signals, specifically Phonocardiogram (PCG) data, acquired via electronic stethoscopes. Different hand-



crafted features played an essential role in detecting and classifying heart murmurs. In [3], MFCC features are extracted to detect disorders, while SVM is a classifier. For training SVM and KNN models, MFCC feature vectors are used in [4] with machine learning-based classifiers for determining and categorizing cardiovascular diseases. In [5], a machine learning-based method is used to identify and classify cardiac murmurs, which improves accuracy by extracting diagnostic features. The methods used in [6] are Empirical wavelet Transform and Shannon energy for segmentation, while SVM and KNN act as a classifier for heart disorders. In [7], 1D-LTP and MFCC features are extracted, and the SVM model is used for classification. MFCC, DWT, and Time-domain features are extracted in [8] and classified through SVM. [9] uses a fusion of GFCC with MFCC and Mel-spectrogram features. These studies are based on hand-crafted feature extraction.

CNN-based feature extraction is also vital in heart sound detection and classification. In [10], different filters are used for noise removal, and CNN is used for classifying heart sounds. The system uses Wavelet transform-based essential features in [11] to classify cardiac auscultation data through CNN. Scalogram and spectrogram-represented models are used for classification in [12]. In [13], three neural networks are trained on two datasets for heart murmur detection. A pre-trained trained CNN-based model, YAMNet, is used in [14] for heart sound classification. A CNN-based model using transfer learning techniques is used to train and classify the dataset [15].

Handcrafted feature extraction is a manual process, while CNN-based feature extraction uses deep learning to learn features from data. CNNs are preferred for computer vision tasks because they can learn expressive and task-specific features from large datasets. Handcrafted features can still be valuable in certain situations, i.e., when data is limited. This study examines how window sizes and feature ordering affect the performance of three handcrafted features (MFCC, LPCC, and GTCC) commonly used in audio and speech processing. Additionally, it emphasizes the advantages of combining various features to shed light on the best feature vector and window length options when the body of current literature lacks specific recommendations.

The rest of the paper is organized as follows. The methodology to assess feature performance is given in Section II, with experimental findings in Section III. The paper is concluded in Section IV.

2. Methodology

This section offers an overview of the training database used in the study, outlines the key features that were analyzed, and presents the process of selecting and classifying these features for heart murmur detection. The schematic depiction of the suggested approach is shown in Figure 1.

2.1 Dataset

A dataset, "CirCor Digiscope PCG dataset from PhysioNet 2022 Challenge," is used in this study. This dataset was compiled from two extensive mass screening campaigns in Northeast Brazil during July-August 2014 and June-July 2015 [16].

It is the most comprehensive collection of heart sound data currently available, encompassing 5,282 recordings from four primary auscultation locations across 1,568 patients. The dataset was meticulously curated, with a medical expert providing manual annotations for 215,780 heart sounds. Each heart murmur was diligently assessed and labeled, considering timing, shape, pitch, and quality factors. Furthermore, the study identified specific regions where the murmurs were most prominently detected and perceived [17]. The 2022 Challenge's training set consists of 60% of the dataset, which is publicly available. The other 40% of the dataset is hidden and will be used for validation and testing.

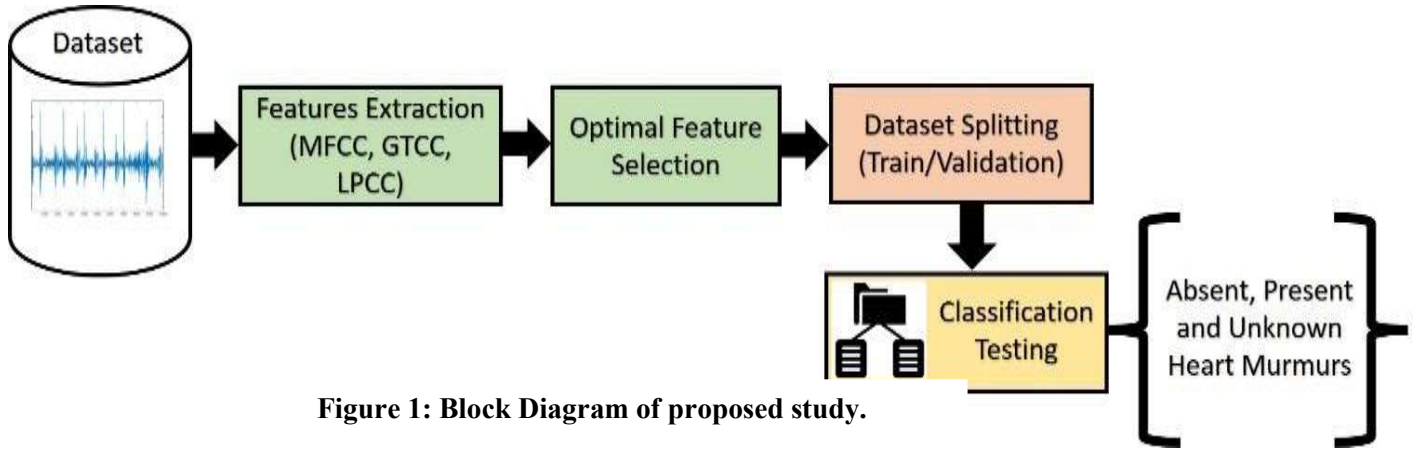


Figure 1: Block Diagram of proposed study.

Table 1. Key Statistics of Dataset

Features	Data Holdout	
	Training (80%)	Testing (20%)
Total Recordings	3163	2119
Recording Per Class	Absent:2391 Present:616 Unknown:159	-
Total Subjects	942	626
Sampling Rate	4000 Hz	4000 Hz
Auscultation location	AV, PV, TV, MV, Phc	AV, PV, MV, TV, Phc
Recording Length	(5-65) seconds	-

The training set comprises 3,163 audio files sampled at 4,000 Hz and taken from 942 patients. These recordings range in length from 5 seconds to 65 seconds. These PCG recordings came from one or more of the four available places on the chest: AV, MV, PV, and TV. The dataset is labelled as Present Murmur, Absent Murmur, and unknown. Table 1 shows the summary of the dataset. This study uses data holdout to train and test the SVM model. The dataset is divided into 80% training and 20% subject-level testing.

2.2 Analyzed Features

Detailed below are the three hand-crafted features which are analyzed and extracted based on feature vector and window size. Figure 2 gives the unified block diagram for extraction of these features.

2.2.1 Mel-Frequency Cepstral Coefficients

Mel-frequency cepstral coefficients (MFCCs) model the human auditory system by characterizing different processes via mathematical representation. MFCCs provide a non-linear approach to capturing sound

frequencies and conveying the comprehensive profile of the spectral envelope [18]. Computed mathematically as,

$$M_n = \sum_{n=0}^c \log(B_c) \cos \left[n \left(c - \frac{1}{2} \right) \frac{\pi}{c} \right] \quad (1)$$

where B_c is the filter bank output, c is the index and M_n is the n^{th} MFCC coefficient.

2.2.2. Linear Predictive Cepstral Coefficients

The method of linear prediction coefficients (LPC) utilizes a linear predictive model to estimate both the magnitude and frequency of residual signals that arise from inverse filtering [19]. LPCs can be computed mathematically through Eq. 2, where n is the index and C_L is the predicted LPC coefficient.

$$C_L = \sum_{l=0}^n a_n C [L - n] \quad (2)$$

2.2.3. Gamma tone Cepstral Coefficients

Gammatone cepstral coefficients (GTCC) are utilized to analyze the spectral response within the cochlea, a critical component of human auditory processing [20]. By modifying the model, GTCC may be used for speech recognition and non-speech audio detection tasks, and it is favored for studies involving emotion and intensity categorization [18]. Eq. 3 shows a mathematical expression of GTCC.

$$G_n = \sqrt{\frac{2}{k}} \sum_{n=0}^k \log(S_k) \cos \left[n \left(k - \frac{1}{2} \right) \frac{\pi}{k} \right] \quad (3)$$

where S_k is the gamma tone filter bank output, k is the number of Gammatone filter coefficients and G_n is the final GTCCs.

care and outcomes. Table II tabulates the utilized performance

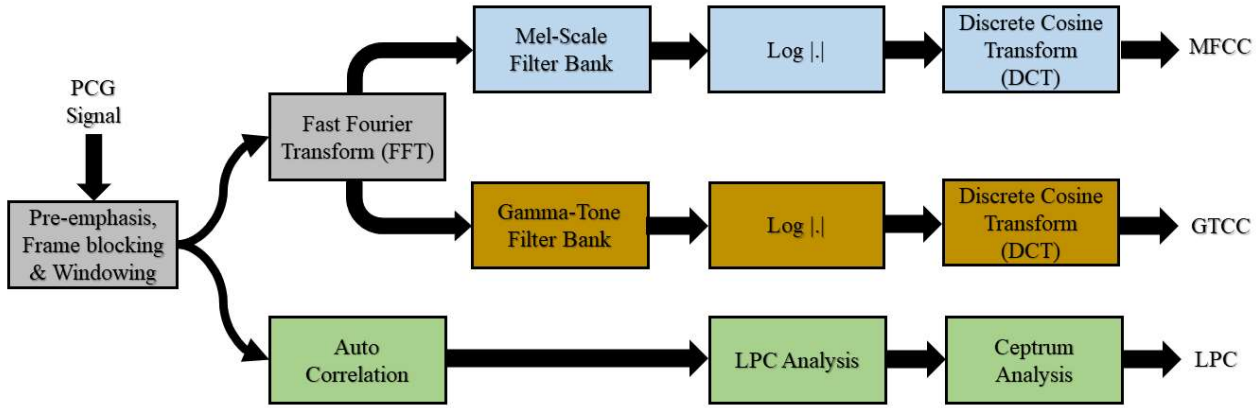


Figure 2: Block diagram exhibiting the MFCC, LPC and GTCC feature extraction process.

Table 2. Performance Metrics

Metrics	Mathematical Expressions
Precision (%)	$P = \left(\frac{TP}{TP + FP} \right) \times 100$
Recall (%)	$R = \left(\frac{TP}{TP + FN} \right) \times 100$
Accuracy (%)	$Acc. = \left(\frac{TP + TN}{TP + FP + TN + FN} \right) \times 100$
F1 Score (%)	$F1 = \left(2 \times \frac{P \times R}{P + R} \right) \times 100$

Table 3. Effect of Window Sizes on Heart Murmur Detection Accuracy

Window Sizes	SVM Kernel	Accuracy (%)		
		MFCC	LPCC	GTCC
5 s	Gaussian	0.76	0.76	0.77
1 s		0.71	0.77	0.74
100 ms		0.70	0.76	0.70
50 ms		0.72	0.76	0.78
25 ms		0.76	0.76	0.77

3. Results and Discussions

3.1 Performance Metrics

Heart murmur detection relies on key metrics such as accuracy, precision, recall, and the F1 score to ensure the effectiveness of detection algorithms. Accuracy measures the correctness of classifications, while precision minimizes false positives, preventing unnecessary medical procedures. Recall ensures genuine heart murmurs are not missed, while the F1 score balances precision and recall, providing a comprehensive assessment of a system's performance. These metrics enable healthcare professionals and developers to fine-tune heart murmur detection systems, balancing accurate identification with minimizing misdiagnosis risk, ultimately improving patient

metrics, where TP is true positive, TN is true negative, FP is false positive, and FN is the false negative value.

3.2 Effect of Window Size and Feature Vector Length

MFCC, LPCC, and GTCC were first investigated separately and then combined to estimate their efficiency for heart murmur detection based on different window sizes and feature vector lengths. SVM models, i.e., Linear, Gaussian, and Polynomial kernels, are evaluated for all these features. Table III shows the result at different window sizes for all three hand-crafted features. Further, the SVM kernel with better accuracy is also mentioned in the table.

For the MFCC, LPCC, and GTCC characteristics, no

apparent trend or pattern was observed when we increased the window size. However, when it comes to

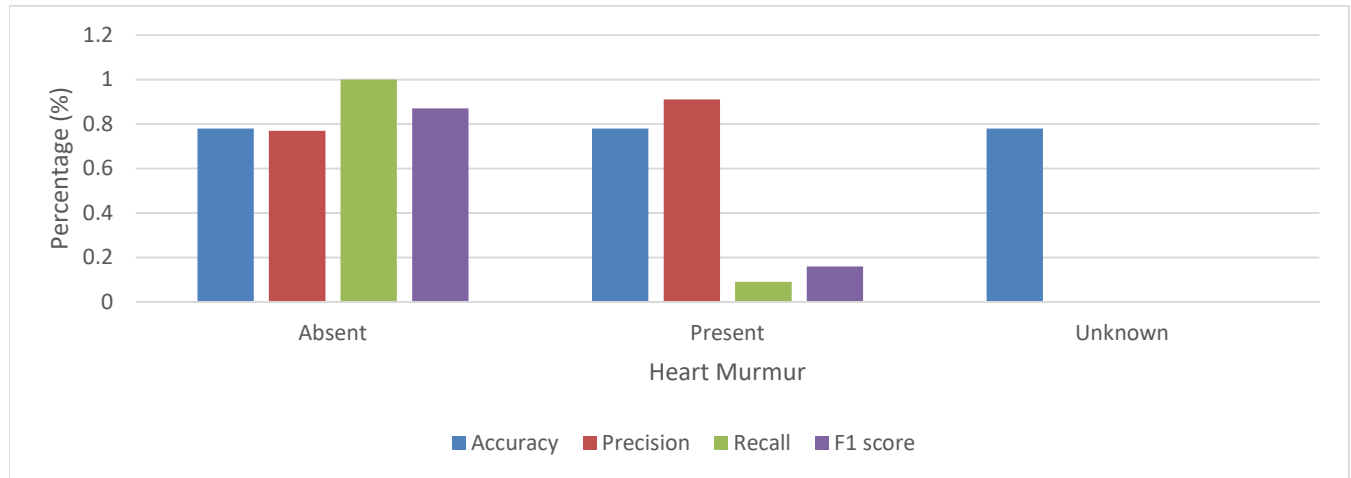


Figure 3: Performance metric values for best performing heart murmur classification model trained on the combinations of MFCC and GTCC features with optimal window size and feature order.

Table 4. Effect of Feature Order on Heart Murmur Detection Accuracy

Feature Order	Accuracy (%)		
	MFCC	LPCC	GTCC
14	0.76	0.77	0.77
20	0.75	0.77	0.76
26	0.75	0.76	0.76
32	0.75	0.76	0.76
40	0.75	0.76	0.76

accurately classifying heart murmurs, we discovered that MFCC gave the best results when the window size was set to 5 seconds and 25 milliseconds. For LPCC, the most accurate results were obtained with a window size of 1 second, and for GTCC, the best accuracy was achieved with a window size of 50 milliseconds. There was no clear trend for the MFCC, LPCC, and GTCC when the feature order was changed. This is evident from Table IV, where the accuracy of heart murmur detection is computed for different feature orders is given. However, the MFCC feature order of 14 showed better accuracy. While GTCC demonstrated its highest accuracy at a feature order of 14, LPCC achieved greater accuracy at feature orders of 14 and 20.

combinations of the extracted features. While testing

Combinations, window size of 1 second is kept fixed for all the features and feature order 14 for MFCC & GTCC and 20 for LPCC is used. The above table shows that the combination of MFCC and GTCC achieved better results than other combinations. Figure 6 depicts the performance metrics, i.e., the accuracy, precision, recall and F1 score of three different classes with the best combination of two different features, i.e., MFCC and GTCC at the window size of 1 second. These results show that the present class has a high precision metric while the absent class has a high recall and F1 score metric.

4. Conclusion

This paper explores three features by varying window sizes and feature vectors, employing different SVM models

Table 5. Effect of Feature Order on Heart Murmur Detection Accuracy

Feature Combination	Window Size	Accuracy (%)
MFCC+LPCC		0.77
MFCC+GTCC	1 sec	0.78
LPCC+GTCC		0.77

Table V shows the classification model results for different



for training and testing. The experimental findings indicated that window size and feature order changes did not show any specific pattern or trend. Notably, the combination of MFCC and GTCC showed superior performance. Our future objective is to explore classifiers other than SVM and incorporate additional handcrafted features in our study.

5. References

- [1] "Heart Murmur: Symptoms & Treatments," University of Utah Health | University of Utah Health, Apr. 06, 2021. <https://healthcare.utah.edu/cardiovascular/conditions/heart-murmur>
- [2] "Pakistan - Rural POPULATION2023 Data 2024 Forecast 1960-2022 Historical." Pakistan - Rural Population - 2023 Data 2024 Forecast 1960-2022. <https://tradingeconomics.com/pakistan/rural-population-percent-of-total-population-wb-data.html>
- [3] Srivastava, Neelesh, Mansi Bhatnagar, Anjali Yadav, Malay Kishore Dutta, and Carlos M. Travieso. "Machine learning based improved automatic diagnosis of cardiac disorder." In Proceedings of the 2nd International Conference on Applications of Intelligent Systems, pp. 1- 8. 2019.
- [4] Ahmad, M. Sheraz, Junaid Mir, Muhammad Obaid Ullah, Muhammad Laiq Ur Rahman Shahid, and Muhammad Adnan Syed. "An efficient heart murmur recognition and cardiovascular disorders classification system." *Australasian physical & engineering sciences in medicine* 42 (2019): 733-743.
- [5] Levin, Alisa D., Anthony Ragazzi, Skyler L. Szot, and Taikang Ning. "A machine learning approach to heart murmur detection and classification." In 2020 13th International Congress on Image and Signal Processing, BioMedical Engineering and Informatics (CISP-BMEI), pp. 521-525. IEEE, 2020.
- [6] Narváez, Pedro, Steven Gutierrez, and Winston S. Percybrooks. "Automatic segmentation and classification of heart sounds using modified empirical wavelet transform and power features." *Applied Sciences* 10, no. 14 (2020): 4791.
- [7] Aziz, Sumair, Muhammad Umar Khan, Majed Alhaisoni, Tallha Akram, and Muhammad Altaf. "Phonocardiogram signal processing for automatic diagnosis of congenital heart disorders through the fusion of temporal and cepstral features." *Sensors* 20, no. 13 (2020): 3790.
- [8] Gündüz, Ali Fatih, and Ali KARCI. "Heart sound classification for murmur abnormality detection using an ensemble approach based on traditional classifiers and feature sets." *Computer Science* 5, no. 1 (2022): 1-13.
- [9] Arora, Shruti, Sushma Jain, and Inderveer Chana. "A fusion framework based on cepstral domain features from phonocardiogram to predict heart health status." *Journal of Mechanics in Medicine and Biology* 21, no. 04 (2021): 2150034.
- [10] Sudarsanan, Sukanya, and J. Aravinth. "Classification of heart murmur using CNN." In 2020 5th International Conference on Communication and Electronics Systems (ICCES), pp. 818-822. IEEE, 2020.
- [11] Petrolis, Robertas, Renata Paukstaitiene, Gabriele Rudokaite, Andrius Macas, Arturas Grigaliunas, and Algimantas Krisciukaitis. "Convolutional Neural Network Approach for Heart Murmur Sound Detection in Auscultation Signals Using Wavelet Transform Based Features." In 2022 Computing in Cardiology (CinC), vol. 498, pp. 1-4. IEEE, 2022.
- [12] S. Z. -e. -Z. Ali, M. O. Ullah and J. Mir, "Classification of Cardiovascular Disease Using 2D-Image Representations of Phonocardiogram Signals," 2022 International Conference on Emerging Technologies in Electronics, Computing and Communication (ICETECC), Jamshoro, Sindh, Pakistan, 2022, pp. 1-6
- [13] Patwa, Ahmed, Muhammad Mahboob Ur Rahman, and Tareq Y. Al-Naffouri. "Heart Murmur and Abnormal PCG Detection via Wavelet Scattering Transform & a 1D-CNN." arXiv preprint arXiv:2303.11423 (2023).
- [14] Maity, Arnab, Akanksha Pathak, and Goutam Saha. "Transfer learning based heart valve disease classification from Phonocardiogram signal." *Biomedical Signal Processing and Control* 85 (2023): 104805.
- [15] Mohammed, Kamel K., Eman I. Abd El-Latif, Noha Emad El-Sayad, Ashraf Darwish, and Aboul Ella Hassanien. "Radio frequency fingerprint-based drone identification and classification using Mel spectrograms and pre-trained YAMNet neural." *Internet of Things* 23 (2023): 100879.
- [16] Reyna, M. A., Kiarashi, Y., Elola, A., Oliveira, J., Renna, F., Gu, A., Perez-Alday, E. A., Sadr, N., Sharma, A., Mattos, S., Coimbra, M. T., Sameni, R., Rad, A. B., Clifford, G. D. (2022). Heart murmur detection from phonocardiogram recordings: The



George B. Moody PhysioNet Challenge 2022.
medRxiv, doi: 10.1101/2022.08.11.22278688

- [17] Oliveira, Jorge, Francesco Renna, Paulo Dias Costa, Marcelo Nogueira, Cristina Oliveira, Carlos Ferreira, Alípio Jorge, et al. "The CirCor DigiScope dataset: from murmur detection to murmur classification." *IEEE Journal of Biomedical and Health Informatics* 26, no. 6 (2021): 2524-2535.
- [18] Alim, Sabur Ajibola, and N. Khair Alang Rashid. *Some commonly used speech feature extraction algorithms*. London, UK: IntechOpen, 2018.
- [19] Itakura, Fumitada. "Line spectrum representation of linear predictor coefficients of speech signals." *The Journal of the Acoustical Society of America* 57, no. S1 (1975): S35-S35.
- [20] Valero, Xavier, and Francesc Alias. "Gammatone cepstral coefficients: Biologically inspired features for non-speech audio classification." *IEEE Transactions on Multimedia* 14, no. 6 (2012): 1684-1689.



Analysis and Design of the Ground Plus Two Storey Building by Using ETABS

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KEY WORDS

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Design
Analysis
G+2 Storey Building

ABSTRACT

Traditionally, the buildings have been designed manually, which was a lengthy process, and the chances of human error were large. With the time, the trend in the buildings changed and people started to move towards high rise buildings. Which made it very difficult to design such high-rise structures by manual methods. Hence, different software were introduced in the market to fill the Gap. ETABS is one of those software, which is used to design any kind of building throughout the world has been taken for analysis and design by using ETABS. In this project, the modeling, analyses and design of the department of Civil Engineering, MUET, SZAB Campus Khairpur Mir's has been done using ETABS (version 9.5). UBC-97 is used, and along with the vertical loads, earthquake loads are also considered in this design for the static analysis. The finite element method is used in this project to simulate the model of building. The building is a G+2 story having classrooms, laboratories (filled with equipment) and offices. It is RC framed structure located in Khairpur Mir's, a district in the Sindh province of Pakistan. In terms of earthquake zones, it is located in Zone 2A(moderate) according to the Building Code of Pakistan (BCP Provisions 2007). The objectives of the study are to perform 3D modeling, structural analysis, check structure against the story drift and design the structure by seismic analyses. 3D model of the building was generated which helped in practicing the usage of ETABS that will prove to an essential skill for getting jobs. The structure was analyzed, and it was found safe against all the load combinations. The structure was checked against story drift and it was found well within the limits. The structure was checked against seismic loadings and it was found safe. Hence, the building is found to be safe against different factors mentioned above. And further study should be conducted to increase the number of stories of the building in order to match the class and laboratory requirements.

1. Introduction

In this project, we are going to model, analyze and design the department of Civil Engineering, MUET, SZAB Campus Khairpur Mir's using ETABS (version 9.5). UBC-97 will be used, and along with the vertical loads, earthquake loads will also be considered in this design for the static analysis. The finite element method will be used

in this project to simulate the model of building. The building is a G+2 story having classrooms, laboratories(filled with equipment) and offices. It is RC framed structure located in Khairpur Mir's, a district in the Sindh province of Pakistan. In terms of earthquake zones, it is located in Zone 2A(moderate) according to the Building Code of Pakistan (BCP- Provisions 2007). There has been a considerable increase in the number of multi-



story buildings throughout the world, thus the effects of lateral loads like earthquake forces are attaining increasing importance and almost every designer is faced with the problem of providing adequate strength against the lateral loads. Occurrence of earthquakes are quite unknown and unpredictable. Educational buildings have also moved to multi-story structures and keeping in view the above fact we have chosen the building of “Department of Civil Engineering, MUET SZAB CAMPUS Khairpur Mir’s” for this study. As the educational building has been chosen for this thesis project, so it is understood that hundreds of persons use it on daily basis, and the thought of their safety (in case of extraordinary circumstances) has motivated this work. Hence, this study views to determine the extent of possible changes in the seismic behavior of “Department of Civil Engineering, Mehran UET, SZAB Campus Khairpur Mir’s”.

1.1 Research Aim And Objectives:

The aim of this research is to do seismic analysis and design of the department of Civil Engineering, Mehran UET, SZAB Campus Khairpur Mir’s. The objectives of our thesis are:

- ❖ To perform 3D modeling of Department of Civil Engineering, Mehran UET SZAB Campus Khairpur Mir’s, Sindh.
- ❖ To perform 3D structural analysis of the building mentioned above.
- ❖ To check building against story-drift.

1.2 Changing Dynamics of Educational Infrastructure

In the beginning, educational buildings were, usually, single-story structures with several classrooms united by a common hallway. As the field of engineering moved further, the design of educational buildings also improved and single and two-story educational buildings started to be constructed on the globe. Commonly, these buildings featured a corridor which passed through the longitudinal axis, and the classrooms were situated on both sides. Today we see, universities on very large areas, these universities have departments of several fields with their 3 own buildings, in addition these universities also gymnasiums, auditoriums, large libraries, beautiful mosques, etc. On the other hand, we also see some universities have only one high rise building.

1.3 Approaches to Analysis of Structures

Main approaches to analysis are as under,

1. The elastic theory approach
2. The strength of materials approach
3. The finite element approach

The first and second kinds of approaches make use of analytic formulation. The third approach is a numerical method to solve differential equations, and is vastly used for structural analysis. These approaches are discussed one-by-one.

1.3.1 Strength of Material Approach:

Basically, solid mechanics is the study of load bearing members, in terms of deformations, forces and stability. Generally, there are three scales of length: micro scale, atomic scale and continuum scale. Continuum mechanics approach has been taken in this book. We will be considering the material to be isotropic and homogenous, unless specified. Hence, the properties of material are same when we assume infinitesimal areas and volumes. The strength of materials methods are present for simple members of the structure, which are subjected to the loadings, such as axially loaded bars, columns, prismatic beams and circular shafts bearing torsion. To analyze the system this approach is used along with statics, which give rise to method of joints for truss analysis and method of sections, moment distribution for small portal frame and rigid frame and cantilever method.

1.3.2 Elastic Methods: The deformation of metals is proportional to the magnitude of imposed loads. Since, stress is proportion to the imposed loads and strain is proportional to the deformation, this suggests that, stress and strain are directly proportional. Which is also given by the hook’s law,

$$\text{Stress } \sigma = E \times \text{Strain } \epsilon$$

The modulus of elasticity E , young’s modulus, or the tensile modulus denotes materials stiffness. A material is said to be elastic if it obeys hook’s law. This approach is generally present for an elastic solid irrespective of its shape. Individual members, such as columns, beams, shafts, shelves and plates may be modeled. And solutions are derived from the linear elasticity equations. This method is used for simple geometry. For complex ones, the methods such as (F-E-M) finite element method are required.

1.3.3 Finite Element Methods: The (F-E-M) Finite Element Method or (F-E-A) Finite Element Analysis is generally based on the philosophy of building a complex object with simple blocks or dividing a complex object into manageable and small pieces. Application of the easy idea, can be found in everyday life and as well as in engineering, everywhere.

- Break structure into pieces (elements with node)
- Describe the behavior of physical quantities on each elements



- Assemble the elements, and the nodes in order to form an system of equations for the entire structure
- Solve that system of equations, involving unknown quantities at the nodes
- Calculate the desired quantities at selected elements.

2. Literature Review

Maruthi T. et al., (2019) [3] have attempted to analyze and design a commercial building using ETABS. Static method is used to carry out analyses and IS 456:2000 is used for the design purpose and guidelines. Apart from ETABS, an attempt has also been made in order to manually design the structural elements. The aim of this research is to perform analysis and design of the structure without witnessing any type of failure. Basically, the objectives of this research were to learn the principles of structures by using IS codes, to manually design structural elements like slab, beam, column and footing and to compare the results obtained from ETABS with a manual method. But, as this is a residential building (G+1) having total height of less than 12 meters, so, there is no need of considering seismic loads. After analyzing and designing the structure manually as well as on the software, it was concluded that, analysis done by the help of ETABS was successfully manually verified as per IS456, i.e. , calculation by ETABS and analysis by manual method gave almost same result and usage of ETABS software minimized the time required for analysis and design of the structure.

Md. Mushtaq and Divya Bharathi., (2016) [4] have studied the effect of lateral loads on axial force, base shear, shear force, maximum story drift, tensile force and moments on G+20 building for four different cases of structural system using ETABS. The four cases of G+20 RCC building construction are with frame (Model-1), with frame and shear wall (Model-2), with frame and shear core (Model-3) and with frame, shear wall and shear core (Model-4). These all models were analyzed for lateral loads and gravity loads. The variation in moments and axial force were linear in all models, whereas the maximum axial force was in model-2 and the maximum moment was in the model-1. Hence, in model-1 the cross-sectional properties of columns and beams were high as compared to the other models. The factors, just as, axial force, shear force, moment, maximum story drift, base shear and tensile force were also higher in model-1 as compared to the other models. Finally, the volume of concrete in model-4 was less as compared to the other models and the optimum design was reached in that case.

Soe Thu Phay and Dr. Kyaw Moe Aung., (2014) [5] has done the analysis and design of RC building with basement and fifteen-stories using ETABS, the analysis is done by response spectrum analysis. Mandalay, a region of

Myanmar, is considered as the area for the design of residential building and the structural system is considered as special moment resisting frame. The structural elements of the building are designed according to ACI-318-99 and load consideration is based on UBC 97. 172ft is the total height of the building. Support conditions are considered as fixed and suitable steel ratio between ρ_{min} and ρ_{max} is chosen. Finally, the columns, beams and slabs are designed. After providing basement wall, story drift was reduced at the base of the building, whereas the required steel increased. In the end, the structural stability was checked, and the structure was safe and adequately designed as the safety factors were within allowable limit.

Ali Khadim Sallal., (2018) [6] has presented the design and analysis of a structure under the effects of wind pressure and earthquake, The structure is a building of (18x18)m² with frame and shear wall, it has eight stories and height of story is taken as 3m. The total height of building is 31m and it is designed to get optimized structure modeled through ETABS. The load, namely, live load, dead load, earthquake load and wind load are acting on the building and reduction factor for live load is taken according to UBC 97, where as load combination is taken according to IS 1893:2002. Resultantly, the obtained values of live load, dead load and floor finished loads by ETABS program were similar to the values calculated manually. The structure was safe and adequate in withstanding the design earthquake loads. And various results like shear force, bending moments and deflection were similar to the value calculated manually.

Nagaratna. S.A. et al., (2019) [7] the analysis and design of commercial building (G+3 hospital building) is discussed in this research paper, particularly the comparison between shear force and bending moment of beams and columns of different spans (large and short) is done. The architectural plan of the building is taken, and the analysis is done accordingly. Beams and columns are analyzed by using the ETABS software and M25 concrete and Fe 415 steel are used as construction material. Design calculations are done with the help of MS excel. The objective of this research paper is structural analysis of multi-storied RCC building using ETABS software. The built-up area of the building is 1262.5m² and the height between the stories is 3m. Resultantly, the member sizes, provided in the building are found to be safe and the different sized members can be adopted at different parts of the building. It was also found that the long beams and columns had large shear force and bending moments.

Thazin T. and Nwe N.W., (2019) [8] have modified the proposed existing structure in TU(MTLA), Meiktila city, Myanmar by comparing its existing design with the new proposed design done by using ETABS. The existing structure is a three storied residential building, which is



generally divided in to five portions and has four expansion joints, in plan the building has a U-shape, therefore it is symmetrical. The structural elements of the building are designed according to the ACI-318-99 code and the loads are considered based on UBC-97. The structural stability is checked in the cases of story drift, overturning effect, resistance to sliding, torsional irregularity and P-delta effect, the structure is found to be safe in all cases except torsional irregularity. The existing proposed building was not designed for the seismic load, as only the wind loads were considered as the lateral loads acting on the structure. Therefore, in this research paper, the structure is analyzed for seismic loads and, in result, two of its columns failed, hence, they were redesigned. Resultantly, the size of columns should be changed to strengthen the structure against torsional irregularity and seismic loads, or other strengthening methods should be used in order to prevent any accident.

Muhaned Abass Mohammed., (2020) [11] performed seismic analysis on symmetrical G+10 storied building using ETABS in B.S and I.S code. It was observed that base reaction, center of mass and rigidity, story stiffness values, frequency and Eigen values were higher in IS code. While the center of mass displacement, diaphragm acceleration values, response spectrum modal information, story max/avg displacement, story drift values, modal period and dynamic load participation ratio, modal direction factor values, shear force and reinforcement values were higher in BS code.

D. Sirisha and M. Divya Tejaswi., (2019) [12] done seismic analysis and design of multistoried building with and without Bracing According to IS Code and Euro Code by using ETABS. It was observed that base shear, lateral displacement and storey drift were reduced as compared to unbraced structure. Displacement and storey shear in euro code for both brace and unbrace system was more than as in IS code. Storey drift was more in first storey, while storey displacement was more for 10 storey in both Euro and IS code.

frequencies. 39 load combinations, which are already defined in the ETABS, will be used to find results, and the load combination which will give highest value of parameters will be chosen.

3.1 Building Characteristics:

In this project we are going to analyze and design the building with following following story data,

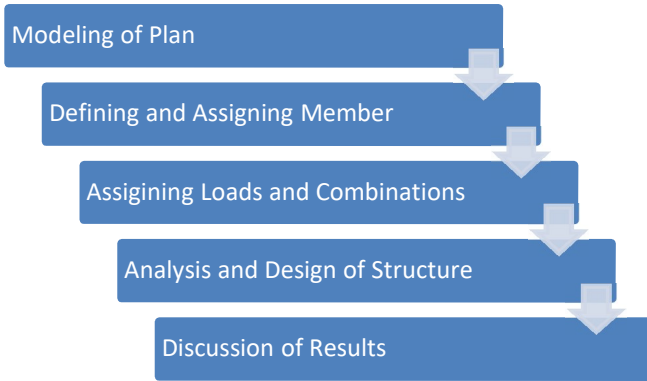
Table 3.1 showing the story data

Story	Height	Elevation	Similar
STAIRCASE ROOF	8.75	47	None
SECOND FLOOR	11.75	38.25	GROUND FLOOR
FIRST FLOOR	12	26.5	GROUND FLOOR
GROUND FLOOR	12	14.5	None
PLINTH	6.5	2.5	GROUND FLOOR
BASE	0	-4	None

Following illustration shows the general image of the Research Flow Chart

3. Methodology

Static analysis will be used for the analysis to check against the earthquake loadings and to find out the dominant



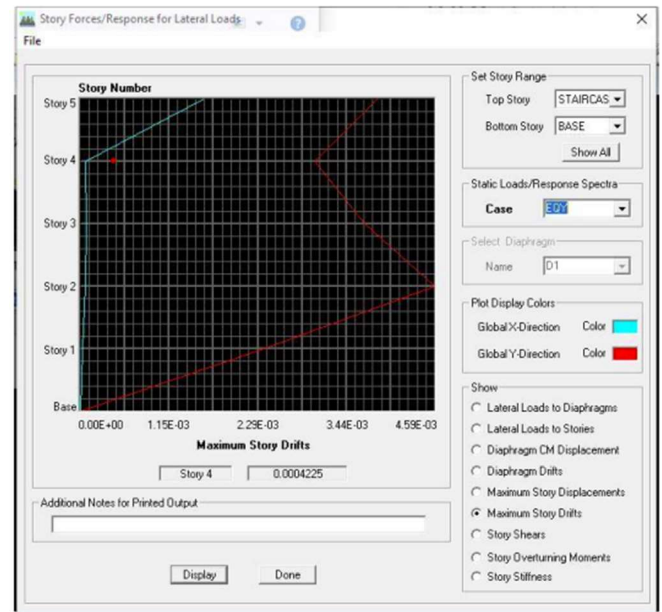
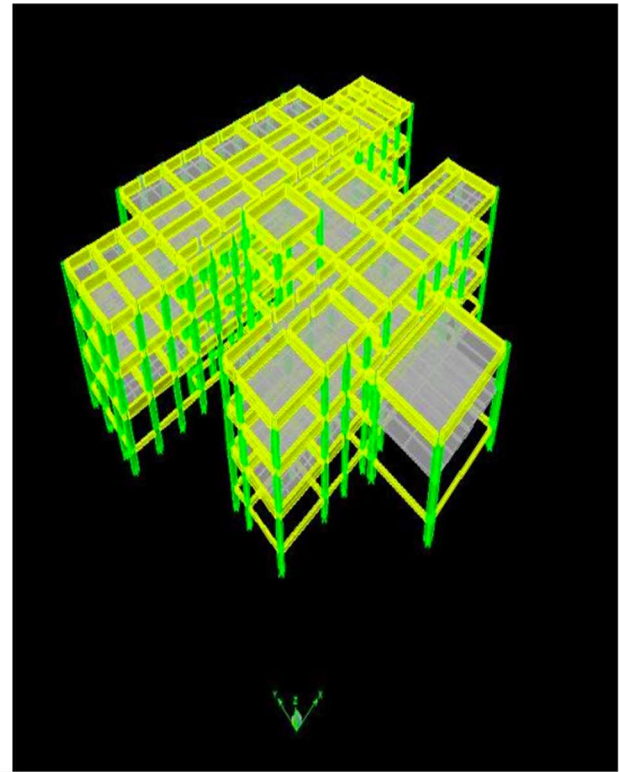
Research Flow Chart

The aforementioned are merely summaries that aim to provide an understanding and elucidation of the methods utilised in the ETABS investigation. One must become extremely familiar with the software through reading and practice before it can be used in practice.

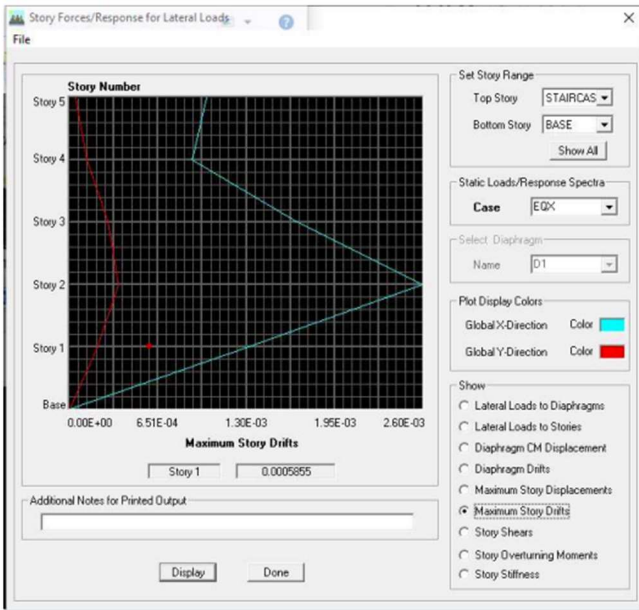
4. Results and Discussions

This section mainly interprets and presents the obtained results from the ETABS after running the analysis. The results obtained from the design check are also presented. The reinforced concrete building frame was subjected to live load, dead load, wind load and earthquake loads. In this chapter, the results are divided into two parts. The first part consists of the results, in which the results will be displayed and tabulated in a simple and clear way. The second part consists of the discussion of the results in accordance with theories and code of practices.

3D MODEL OF THE BUILDING

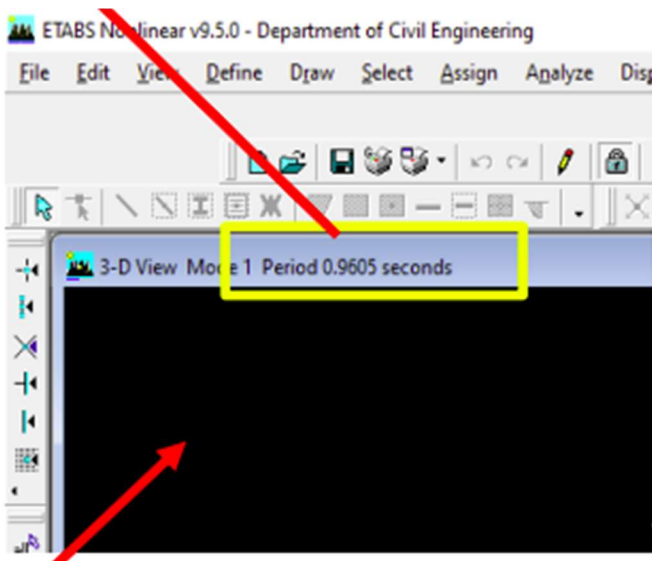


This graph gives the values of maximum story drift for the earthquake load in y-direction (EQY). In this graph, the red line shows the value of maximum story drift in y-direction. Whereas the light blue line shows the value of maximum story drift in the x-direction. Through little focus, it can be found that the drift is highest in the story 2 in the y-direction, its value is 0.00456mm. Note: The values of maximum story drift are in mm.



This graph gives the values of maximum story drift for the earthquake load in x-direction (EQX). In this graph, the red line shows the value of maximum story drift in y-direction. Whereas the light blue line shows the value of maximum story drift in the x-direction. Through little focus, it can be found that the drift is highest in the story 2 in the x-direction, its value is 0.00259mm. Note: The values of maximum story drift are in mm.

According to UBC-97 code, the maximum story drift shall not exceed 0.025 times the story height if the fundamental time period is less than 0.7 second. For structures having a fundamental time period greater than 0.7 second or equal, the maximum story drift shall not exceed 0.02 times the story height. The fundamental time period of the building is 0.9605 seconds.



5.0 Conclusion

The building of the Department of Civil Engineering was analyzed and designed using ETABS, and the objectives of the study were met;

- ❖ 3D model of the building was generated which helped in practicing the usage of ETABS.
- ❖ The structure was analyzed, and it was found safe against all the load combinations.
- ❖ The structure was checked against story drift and it was found well within the limits.
- ❖ The structure was checked against seismic loadings and it was found safe.

Hence, the building is found to be safe against different factors mentioned above. And further study should be conducted to increase the number of stories of the building in order to match the class and laboratory requirements.

5. Reference

- [1] “Three-Dimensional Analysis and Design of Building Systems Tutorial” by Computers and Structures, Inc. Berkeley, California, USA First Edition July 2000.
- [2] “Structures: Pearson new international edition, 7th edition, by Schodek, Daniel; Bechthold, Martin, published by pearson education limited.
- [3] Maruthi T et al., (2019) “analysis and design of commercial building using etabs”, International Journal of Engineering Sciences & Research Technology, ISSN: 2277-9655.
- [4] Md. Mustaq and Divya Bharathi (2016) “Optimized Design of a G+20 Storied Building Using ETABS.” International Journal & Magazine of Engineering, Technology Management and Research, Volume no: 3, Issue no: 10, ISSN NO: 2348-4854.
- [5] Soe Thu Phay and Dr. Kyaw Moe Aung (2014) “Analysis and Design of High-Rise Reinforced Concrete Building with Basement under Seismic Load”, International Journal of Science, Engineering and Technology Research, ISSN 2319-8885 Vol.03, Issue.18.
- [6] Ali Kadhim Sallal, (2018) “Design and analysis ten storied building using ETABS software2016”, International Journal of Research in Advanced Engineering and Technology, ISSN: 2455- 0876, Volume 4; Issue 2.
- [7] Nagaratna. S.A et al., (2019) “Analysis and Design of Multistorey Building (g+3) By Using ETABS



- Software”, International Research Journal of Engineering and Technology, Volume: 06 Issue: 05, p-ISSN: 2395-0072, e-ISSN: 2395-0056.
- [8] Thazin Thein and Nwe Nwe Win (2019) “Structural Modification of Proposed Reinforced Concrete Building” International Journal of Research Publications, Volume-34, Issue-1.
- [9] Rohitkumar B. R. et al., (2017) “Analysis and design of Multi storey Structure Using ETABS”, International Research Journal of Engineering and Technology, e-ISSN: 2395 -0056, p-ISSN: 2395-0072, Volume: 04 Issue: 05
- [10] Rinkesh R Bhandarkar et al., (2017) “Seismic Analysis & Design of Multistory Building Using ETABS”, International Journal of Engineering Development and Research, Volume 5, Issue 2, ISSN: 2321-9939. 75
- [11] Muhaned Abass., (2020) “Seismic Analysis of Structures By ETABS in B.S Code & I.S Code”, International Journal of Engineering Research & Technology, ISSN: 2278-0181, Vol. 9 Issue 03.
- [12] D. Sirisha and M Divya Tejaswi (2019) “Seismic Analysis and Design of Multistoried Building with and without Bracing According to is Code and Euro Code by using ETABS”, International Journal of Engineering Research & Technology, ISSN: 2278-0181, Vol. 8 Issue 09.
- [13] Vijayalaxmi v hadadi et al., (2019) “Seismic Analysis of G+6 Frame Building Using ETABS”, International Research Journal of Engineering and Technology, e-ISSN: 2395-0056, Volume: 06 Issue: 05, p-ISSN: 2395-0072.
- [14] Building code of Pakistan: Seismic Provisions 2007, Ministry of Housing and Works, Government of Pakistan.
- [15] Arthur H. Nilson. “Design of Concrete Structures”. 12th edition. [16] Uniform Building Code, 1997, Volume 2. Structural Engineering Design Provision (1997). [17] U Nyi Hla Nge: Reinforced concrete Design, 1st Edition, Win Toe Aung Offest, Yangon, (2010).



EFFECTS OF THE PARTIAL REPLACEMENT OF COARSE AGGREGATES WITH THE MARBLE AND TILE WASTE ON CONCRETE

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KEY WORDS

Workability
Compressive Strength
Marble Waste
Tile Waste
Replacement

ABSTRACT

Natural resources are being extracted and consumed at faster pace because of the rapid growth in the construction activities. Particularly the usage of natural resources in the shape of coarse aggregate in the concrete. It constitutes 70% of the concrete. The aim of this study was to evaluate the effect of the partial replacement of coarse aggregates with the Marble Waste (MW) and Tile Waste (TW). However, In this study compressive strength of normal cement concrete cubes were compared with the modified concrete cubes containing different percentages of MW and TW i.e, 10%, 20% and 30% respectively by weight of coarse aggregates individually. Next, the MW and TW were combined and coarse aggregate was partially replaced at the rate of 20%, 40% and 60%. The coarse aggregates, MW and TW passing from 19 mm sieve and retaining at 4.75 mm sieve are used. It was observed from the experimental findings that the compressive strength of normal concrete with 1:2:4 ratio was observed as 17 MPa and 19MPa at 7 and 28 days respectively. However, the inclusion of MW and TW increases the compressive strength. The inclusion of MW upto 20% replacement of coarse aggregate gives the better strength results. The inclusion of TW upto 10% gives the better strength results. While the combined replacement of both the waste materials upto 20% gave the best results. Thus, this study recommended using MW and TW as partial replacement of coarse aggregates.

1. Introduction

Concrete is leading material which is extensively used throughout the world and throughout the construction projects be it buildings, roads or dams. It is popular because of it being effective in cost, production is easy anywhere, easily moldable into any shape of desire and its good resistance to environment. Even though it adds to the socio-economic uplifting of a country and its gross domestic product, construction puts stress on the natural resources due to the use of aggregates. Natural resources are continuously

being extracted and consumed. Because resources present in the nature are depleting very rapidly, future generations and the construction industry will lack these materials. Concrete has the ingredients like cement, aggregates and water for the production of concrete [1]. It was also noticed that there is perpetual reduction in the quantity of naturally occurring ingredients used in production of concrete [2]. In the same manner, construction waste material can also be used in the replacement of ingredients of the concrete such as partially replacing fine and coarse aggregate contents. Use of wastes as



coarse replacement produces eco-friendly concrete, hence it can be considered as environmentally sustainable and greatly to reducing the waste being thrown in the open landfill areas and reduction of naturally occurring resources. Considering it, the current study proposes to utilize two different wastes, marble waste and tile waste as partial coarse aggregate replacement in the concrete. One such material is waste, which is generated in large quantities as a by-product of the tile manufacturing process. The production of tiles involves the extraction and consumption of natural resources, such as clay and sand, which contribute to environmental degradation. The waste generated from the tile production process includes offcuts, broken tiles, and unused materials, which are typically disposed of in landfills. This disposal method contributes to the accumulation of waste in the environment, leading to soil and water pollution. Thus, the usage of tile dust waste as a fine aggregate replacement in concrete is an attractive option for reducing the stress on the natural resources.

1.1 MARBLE

Marble is one of the largest part of natural stones, it amounts for more than 50% of natural stones around the Globe [3]. Pakistan also have plenty of marble reservoirs, especially in KPK. Colour of marble is associated with its purity whereas pure limestone transforms into Marble. Marble is used as a decorative material for structures and monuments because of its exquisite appearance. [4]. Marble waste contributes to environmental degradation which is not so easily disposed [5].

1.2 CERAMIC TILE

Tiles are generally created utilizing natural materials that include high proportion of clay minerals. However, benefits of ceramics include its ornamental condition, a great nuisance gets to born from its waste that adversely affect the environment. Ceramic products are being utilized in most of construction projects. [6].

Studies show that over 30% of the material is wasted throughout the ceramic production process, despite the fact that this material can be reused to its full potential [7].

2.0 Literature Review

S.O. Ajamu et al (2018) The compressive strength of TW replaced concrete reduced with the increase in TW content. Whereas, the rates of reduction were considerably low for all the percentage replacements and ages as well. Using up to 100% ceramic tile waste did not produce a weak concrete. [8]Evans Biney et al (2022) This study aimed to determine the suitability of partially replacing crushed granite aggregate with ceramic waste in structural concrete. After experimental methods employed, it was concluded that a maximum content of 20% ceramic waste aggregate replacement in a mix is ideal to produce the required strength and durability of structural concrete. [9]

Bikash Subedi et al (2020) TW have lower specific gravity (SG), higher water absorption (WA) than that of natural aggregate. Up to 30% replacement of natural aggregate by tile aggregate shows better 7 and 28 days compressive strength than that of 0% tile aggregate. [10]Tanweer Ibrahim Adham et al (2017) This research was carried out to study the suitability of replacing crushed marble tiles' waste with coarse aggregate in the concrete mix. In this experimental study, five mixes were casted with C25 grade of concrete. Crushed marble tiles' waste was used to replace the coarse aggregate by (0%, 25%, 50%, 75% and 100%) of weight. The maximum compressive strength was obtained for the mix having 50% of normal coarse aggregate (Basalt) and 50% of crushed marble tiles' waste. [12] A study conducted by Singh et al. (2021) researched the use of marble waste as a partial replacement for coarse aggregate in concrete. The researchers replaced 10%, 20%, and 30% of coarse aggregate with marble waste and came to the concrete made with marble waste had



comparable tensile and compressive strength to that of the control concrete. [13]

Similarly, a study conducted by Arora et al. (2020) researched the use of marble waste as a partial replacement for coarse aggregate in concrete. The researchers replaced 10%, 20%, and 30% of coarse aggregate with marble waste and came to the concrete made with marble waste had comparable tensile and compressive strength to that of the control concrete. [14]

3. Materials and Methodology

3.1 GENERAL

This phase entails discussing the practical and experimental work that needs to be executed in the laboratory.

3.2 WORKING MECHANISM

Mechanism of working is divided into two stages:

- i. Material Testing
- ii. Preparation and Testing of cubes

3.2.1 Material Testing

Determination of the best materials for the preparation of sample using a variety of test methods is included in the section.

3.2.2 Preparation and Testing of Samples

After testing for the physical properties of the materials, the sample preparation takes place. Total of 24 samples of cubes were prepared, 6 at each 7- and 28-days curing. Further Clarification of samples is as; out of 24 samples, 6 cubes of control mix while 6 at each 10%, 20%, and 30% of coarse aggregates by Marble waste and tile waste individually as well as combined.

3.4 CONCRETE MATERIALS

The primary ingredients of concrete are cement, aggregates, and water.

3.4.1 Cement

Ordinary Portland Cement (OPC) of superior quality was used for the experimental investigation. The Portland cement used in the

experiment is produced by "Lucky Cement Factory."

3.4.2 Fine Aggregates

Hill sand that has passed through a 4.75 mm sieve is used to cast every specimen. Aggregates are used in their dry condition and are free from any debris.

3.4.3 Coarse Aggregates

For the preparation of the sample, coarse aggregate that passes through a 19 mm sieve size and is retained on a 4.75 mm sieve is chosen. Aggregates are cleaned of any debris and kept dry for storage.

3.4.4 Marble Waste

Obtained from Marble Factories passing through 19mm and retaining on 4.75mm.

3.4.5 Ceramic Tiles

This study focuses on ceramic tile waste (CTW), which is chosen for sample preparation after passing through a 19 mm sized sieve and being retained on a 4.75 mm sieve. The available debris is taken out of the dry-stored tile waste

Table 3.1 Properties of Marble Waste

Specific gravity (SG)	2.83-2.87
Silicon Percentage	0.3347
Iron Oxide Percentage	0.4093
Calcium Carbonate Percentage	97.782
Bulk density	1.3-1.5gm/cm ³



Table 3.2 Properties of Ceramic Tiles

Description	Test Results
Specific gravity (SG)	1.9
Bulk density	1.1-1.4gm/cm ³
Water Absorption (WA)	12%

3.4.6 Water

Potable water is obtained by MUET SZAB Khairpur Mir's Department of Civil Engineering. Water is utilized with a W/C ratio of 0.5.

3.5 METHODOLOGY

In light of the earlier research, a thorough examination of the compressive strength—a fundamental attribute of hardened concrete made from a mixture of leftover marble and ceramic tile—is conducted in this study.

3.5.1 Concrete Mix Ratio

For this study 1:2:4 ratio was used.

3.5.2 Batching of Concrete

Quantities of materials for Concrete mix can be estimated by following two methods: Batching by volume Batching by weight

3.5.5 Casting

Total 4 number of batches were prepared, every batch contained 6 cubes and in total 4 number of batches. For casting of control specimen weighing method was employed. Before concreting, moulds were oiled all over its interior, in order to make stripping of mould easy.

3.5.6 Age of testing

The samples were tested thoroughly at the curing period of 7 and 28 days to check their strength at different ages.

3.5.7 Testing

3.5.7.1 Specific gravity

Specific gravity it is the ratio of weight of aggregates to the weight of water at the same temperature. The Standards followed for specific gravity for Coarse aggregate is ASTM C-127 and in case of Fine aggregates is ASTM C-128.

3.5.7.2 Water absorption

It is defined as weight of water to weight of aggregates. For Fine aggregates, Coarse aggregates and other materials; standards will be followed are ASTM C-127.

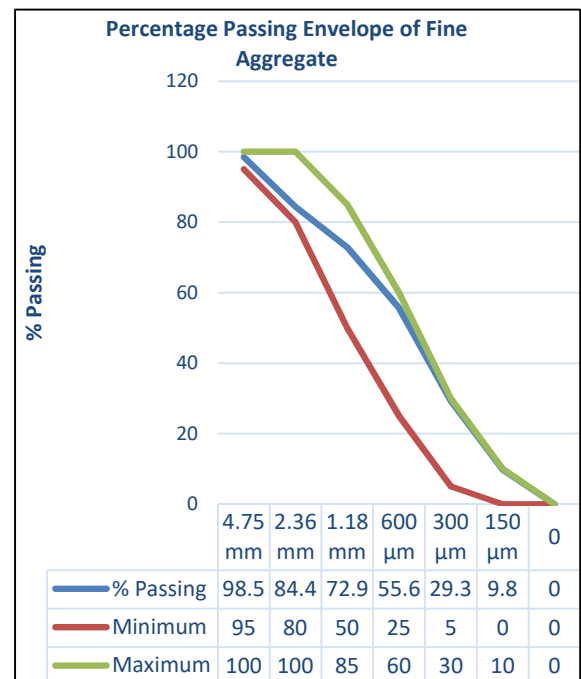
3.5.7.3 Bulk Density of Aggregates

The bulk density or moist density is the total mass of Fine or coarse aggregate per unit of total volume. ASTM C-29 Standard of testing was followed for Bulk unit weight of the materials.

3.5.7.4 Sieve analysis

It is the laboratory test procedure conducted for the grading of materials. This analysis is known as Sieve analysis. While conducting it, Standard ASTM C-33 is followed. Sieve Analysis of the fine aggregates and the coarse aggregates are given below.

Fig 3.1: Particle Size Distribution (PSD) of



Fine Aggregates (Hill Sand)

Fig 3.1: Particle Size Distribution of Coarse Aggregates

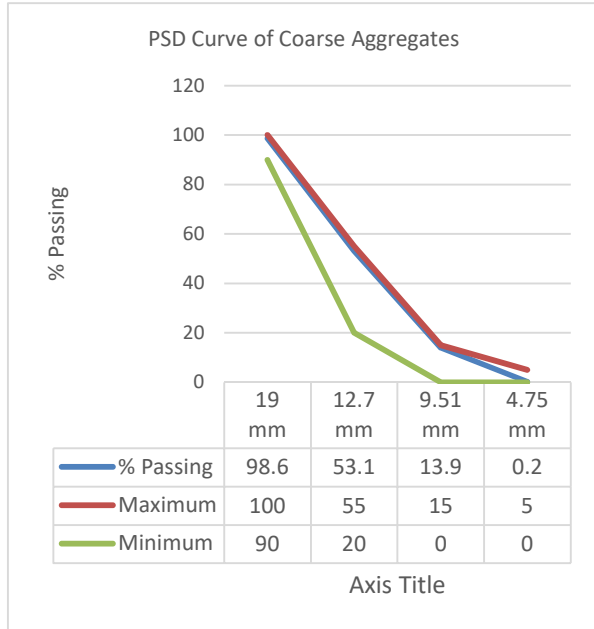


Table 4.1 Compressive Strength Results of Modified Concrete Made with MW Replacement

3.5.7.5 Workability test

4. Results and Discussion

4.1 Compressive Strength Test

The most crucial test to determine whether the material is appropriate is the compression test. Three cubes at each % replacement were casted and cured for two different curing times (7 days and 28 days) in order to measure the compressive strength. The Civil Engineering Materials and Concrete laboratory served as the testing ground. The specifics of the findings and pertinent comments are provided below.

4.2 Results of Compressive Strength Test

The specimen is subjected to a progressive load by the machine. A final Compressive strength value was determined by calculating the average of 3 values at each % replacement.

Past studies on compressive strength of the mix with partial substitution/replacement of MW as well as TW individually had yielded better results by giving increased values of compressive strength [4,6,10]. It was found that up to 20% MW replacement with coarse aggregates that yielded increase in Compressive Strength and that for TW was up to 10%.

Table 4.1 Compressive Strength Results of Modified Concrete Made with MW Replacement

Mix ID	Coarse aggregate %	Replacement %		avg (7 Days) (MPa)	avg (28 Days) (MPa)
		MW	TW		
M0	100	-	-	14	19
M1	90	10	-	15	20.4
M2	80	20	-	17.4	22
M3	70	30	-	14	18

Table 4.1 show the compressive strength test results of the conventional as well as modified concrete with 10%, 20% and 30% replacement if coarse aggregates with the marble waste. It can be observed that concrete strength increases up to the 20% replacement. This can also be seen below in graph

view. Following graph shows the 7 and 28 days strength results of concrete cubes. Vertical figures denote the compressive strength in MPa whereas horizontal line denotes replacement of coarse aggregate with the Marble Waste.

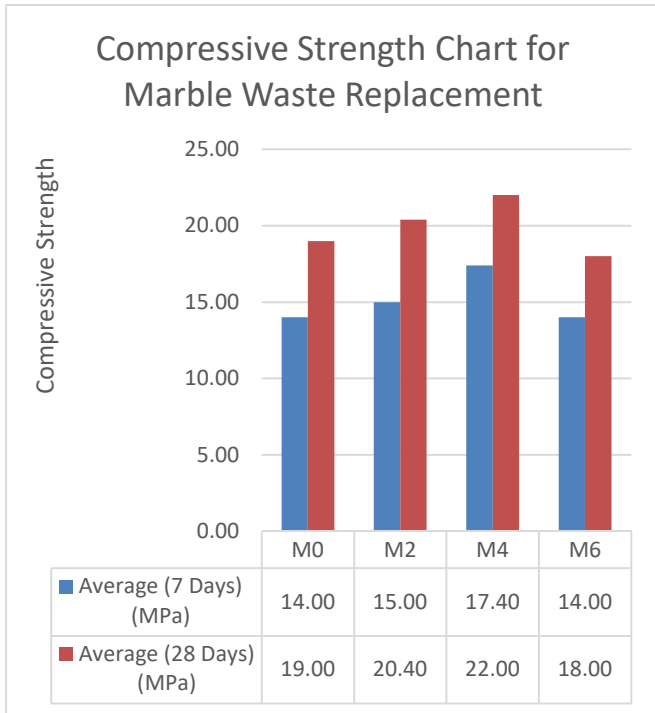
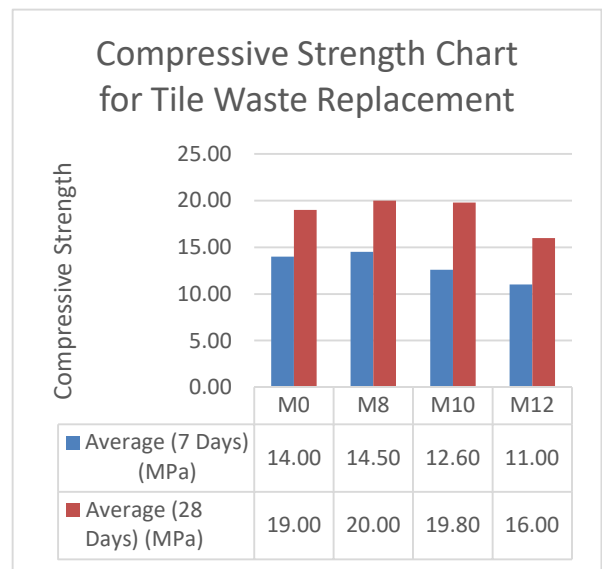


Table 4.2 show the compressive strength test results of the conventional as well as modified concrete with 10%, 20% and 30% replacement if coarse aggregates with the Tile waste. It can be observed that concrete strength increases up to the 10% replacement. This can also be seen below in graph view.

Following graph shows the 7 and 28 days strength results of concrete cubes. Vertical figures denote the compressive strength in MPa whereas horizontal line denotes replacement of coarse aggregate with the Tile Waste.



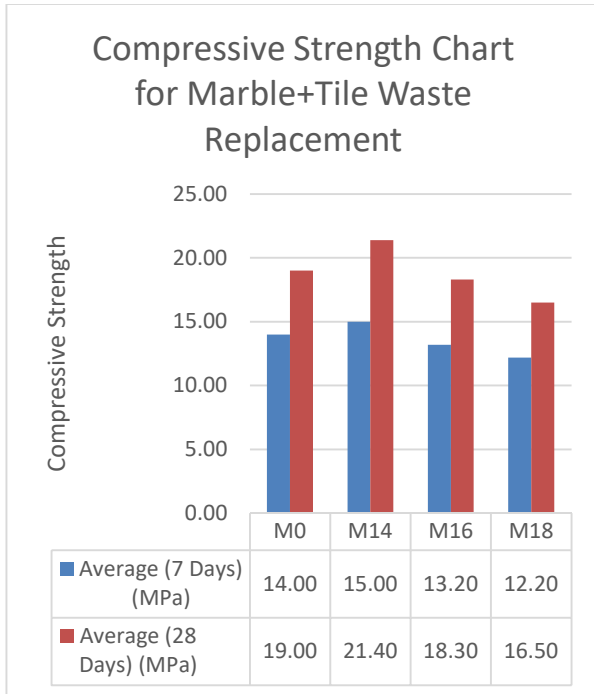
Mix ID	Coarse aggregate %	Replacement %		avg (7 Days) (MPa)	avg (28 Days) (MPa)
		MW	TW		
M0	100	-	-	14	19
M14	80	10	10	15	21.4
M16	60	20	20	13.2	18.3
M18	40	30	30	12.2	16.5

Table 4.2 Compressive Strength Results of Modified Concrete Made with TW Replacement

Table 4.3 Compressive Strength Results of Modified Concrete Made with TW+MW Replacement

Mix ID	Coarse aggregate %	Replacement %		avg (7 Days) (MPa)	avg (28 Days) (MPa)
		MW	TW		
M0	100	-	-	14	19
M4	90	-	10	14.5	20
M5	80	-	20	12.6	19.8
M6	70	-	30	11	16

Table 4.3 show the compressive strength test results of the conventional as well as modified concrete with 10%, 20% and 30% replacement if coarse



Aggregates with the marble + tile waste. It can be observed that concrete strength increases up to the 20% replacement. This can also be seen below in graph view. Following graph shows the 7 and 28 days strength results of concrete cubes. Vertical figures denote the compressive strength in MPa whereas horizontal line denotes replacement of coarse aggregate with the Marble Waste.

4. Conclusion

Regarding this research, the effects of recycling ceramic tiles waste and marble waste on the behavior of concrete were observed and concluding remarks are as follows:

- The Compressive strength of concrete with Marble Waste replacement yields 24% higher compressive strength results against Conventional Concrete at 20% replacement.
- The Compressive strength against compression of concrete with Tile Waste replacement yields 10% higher compressive strength results against Conventional Concrete at 10% replacement
- The Compressive strength against compression of concrete with Marble + Tile Waste replacement yields 7% higher compressive strength results as that of Conventional Concrete at 10% replacement.

5. Reference

- [1] [1] M. Daniyal and S. Ahmad, "Application of Waste Ceramic Tile Aggregates in Concrete," *Int. J. Innov. Res. Sci. Eng. Technol*, vol. 4, no. 1212808–12815, 2015.
- [2] [2] G. C. Ulubeyli and R. Artir, "Properties of Hardened Concrete Produced by Waste Marble."
- [3] [3] N. T. Seghir, M. Mellas, Ł. Sadowski, A. Krolicka, A. Zak, and K. Ostrowski, "The utilization of waste marble dust as a cement replacement in air-cured mortar," *Sustain.*, vol. 11, no. 8, pp.
- [4] [4] A. Ragossnig, "What is the real scope of waste management?," *Waste Manag. Res*, vol. 35, no. 11, pp. 1097–1098, 2017.
- [5] [5] A. K. Thakur, A. Pappu, and V. K. Thakur, "Resource efficiency impact on marble waste recycling towards sustainable green construction materials," *Current Opinion in Green and Sustainable Chemistry*, vol. 13. Elsevier B.V., pp. 91–101, Oct. 2018, doi:
- [6] [6] P. Ramanaidu, P. Murahari Krishna, M. Tech student, and A. Professor, "Partial Replacement of Aggregates with Ceramic Tiles and Rebutted Tyre Waste in Concrete," *Int. J. Eng. Trends Appl.*, vol. 5, no. 3, pp. 71–87, 2018.
- [7] [7] M. Kabir, "An Assessment Of The Properties Of Concrete Made With Ceramic Waste As Aggregate In Partial Fulfillment Of The Requirements For The Award Of A Master Degree In Construction Technology," Ahmadu Bello University, 2016.



[8] [8] Ajamul, S. O., J. R. Oluremi, and E. S. Ogunyemi. "Impact of replacement of coarse aggregates with ceramic tile waste on the strength characteristics of concrete." *Journal of Research Information in Civil Engineering* 15.3 (2018): 2228-2244.

[9] [9] Biney, Evans, et al. "Assessing

structural performance of ceramic waste as partial replacement of coarse aggregate on properties of concrete." *Journal of Engineering Research and Reports* 23.12 (2022): 134-147.

Effects of a Normal Fault Rupture on a Multi-Story Building Resting on Deep Foundation

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KEYWORDS

Fault rupture,
Piled,
ABAQUS,
Raft Foundation,
Storey Drift

ABSTRACT

This study explores the impact of the normal fault rupture on multi-story building supported by the raft foundation using three-dimensional (3D) numerical modeling with ABAQUS software by using finite element method. The investigation employs three-dimensional finite element analysis, simulating a standard break with a 60-degree dip angle and a 60-centimeter length near a 20-story skyscraper on a 4 by 4 piled raft foundation in sand. The raft is a square structure measuring 15 meters in breadth and 1.5 meters in thickness, supported by a series of 4 by 4 piles spaced 3.75 meters apart at the center. The computed results indicate a linear induced settlement in the building. Initially, at fault slip=0 cm, there is minimal differential settlement. However, as fault slip increases, the differential settlement also rises. At a 60-centimeter fault slip, the maximum movement is observed to be 400 mm. The highest lateral deflection occurs at the roof level of the twentieth story. Additionally, the head of P1 pile anticipates the highest negative bending moment of 100 kN-m.

Introduction

A fault is essentially a zone of fractures or a fracture between two blocks of rock. Faults enable movement between these blocks, which can occur rapidly during an earthquake or gradually through processes like creep. The lengths of faults can vary from a few millimeters to kilometers, and throughout the geologic time, most faults have caused repeated displacements. The abrupt slipping of rock a side of the fault relative to other is a characteristic feature during earthquakes. Understanding these geological processes is crucial for making informed decisions about construction in seismically active regions. The rocks' internal strain is what leads to faults. When a formation experiences sufficient stress for a fault to rupture, strain results. The Blue Anchor Fault is depicted in Figure 1 and amply



Figure 1. The Blue Anchor Fault

illustrates how strains can cause surface rupture. Numerous factors, including gravity, drying or wetting conditions, thermal expansion or contraction, and even mantle convection (plate tectonics), can cause stress.

Moreover, figure 2 shows the components of a fault rupture along with proper illustrations and labelling. dip. The three main categories of errors are as follows:

- a) Normal Faults
- b) Reverse Faults
- c) Strike-slip Faults
- d) Oblique Faults

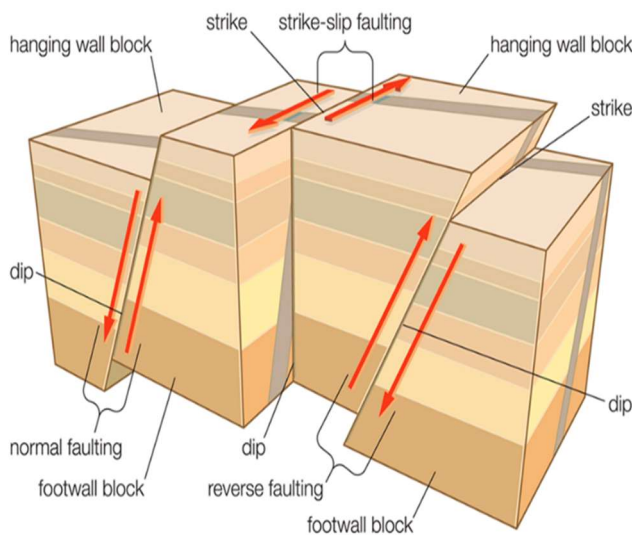


Figure 2. Components of a Fault Rupture

As seen in figure 3(a), normal faults usually occur when hanging wall dips in relation to that of footwall. They are most prevalent where boundaries diverge. These faults are not the most common type; rather, they are "normal" because they obey the fault plane's gravitational pull.

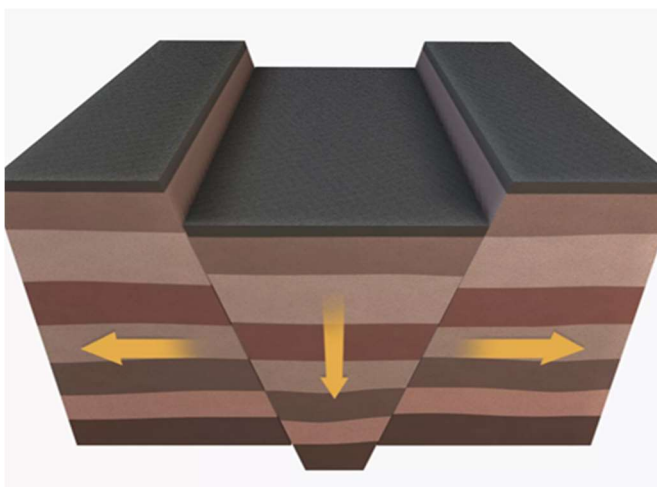


Figure 3(a). Normal Fault Rupture

When the hanging wall moves upward, reverse faults develop. Figure 3(b) illustrates the compressional forces

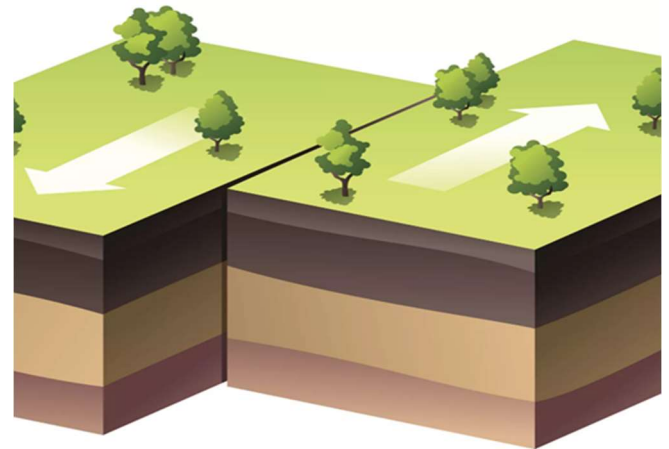


Figure 3(b). Reverse Fault Rupture

that push the sides together to create reverse faults. Around convergent boundaries, they are typical. Since the movement on reverse and normal faults happens along that of dip direction— either down or up, respectively—they are collectively termed to as the dip-slip faults.

Some of the highest mountain ranges throughout the world, such as the Himalayan and the Rocky mountain ranges, are reverse faulting. Walls in strike-slip faults move laterally rather than vertically, as figure 3(c)

illustrates. That is, rather than going up or down the dip, the slip happens along the strike. There are typically no hanging walls or footwalls in these faults because the fault plane is vertical. These faults are usually caused by horizontal or lateral forces that push the sides past one another. There are commonly two types of strike slip faults. This implies that the far side would move



Figure 3(c). Strike-Slip Fault Rupture

to the right or left, depending on where one was standing in relation to the fault trace and looking across it. Left-lateral is the one shown in the picture. Although there are strike-slip faults all over the world, the San Andreas fault is the most well-known. Even though many faults contain elements of both strike-slip and dip-slip, one or the other usually dominates the fault's overall movement. As seen in figure 3, those that suffer from both in significant quantities are referred to as oblique faults (d). Generally speaking, a fault with, say, a 300-meter vertical offset and a 5-meter left-lateral offset would not be classified as an oblique fault. a problem involving both 300 metres.



Figure 3(d). Oblique-Slip Fault Rupture

Understanding the type of fault is crucial because it indicates the kind of tectonic forces operating in a given region. Since many faults exhibit both strike-slip and dip-slip motion, geologists employ more advanced measurements to examine the details of these faults. The complex, time-dependent evolution of friction on a slipping interface behind the rupture front, the radiation of seismic waves, the wear, comminution, and heating of the fault zone material, and other mechanical processes are all involved in earthquake ruptures.

2. Literature Review

Researchers are making efforts to better understand how structures influence a fault's rupture path by incorporating case studies. Unlike designing for shaking, where engineers can use a bracket to establish design forces within a reasonable range of anticipated ground accelerations, estimating structural damage resulting from surface rupture is more complex. The higher number of unknowns in surface rupture necessitates probabilistic analysis as the most effective

method for developing a range of expected displacements. However, actual displacements resulting from surface rupture can significantly differ from predicted values. This highlights the need for continued research and improved methodologies to enhance our understanding of the interaction between fault rupture and structures for more accurate seismic risk assessments. "Mitigation Strategies for Risks Associated with Earthquake Surface Fault Rupture" is a paper published by Bray in 2001, where he reviews the permanent ground displacement caused by fault offset in earthquakes such as Landers, Duzce, Chi-Chi, and Kocaeli. Bray discusses methods to reduce the risk of surface fault rupture, noting instances of reduced cracking in foundation slabs using polyethylene sheeting (Visqueen) as a vapor barrier. The paper suggests post-tensioning slabs and installing soil reinforcement to decrease risks, emphasizing the importance of logical design strategies. In a 2006 paper, Bray and Kelson explore surface fault rupture during the 1906 earthquake along the San Andreas Fault. They discuss how faults' rupture zones can extend several meters, recommending logical design strategies and retrofit techniques to address primary risks. The authors emphasize the need for structures with sufficient strength, ductility, and the ability to adapt to displacement. Bransby et al. investigated the relationship between strip foundations and normal and reverse fault ruptures, finding that foundation performance depends on factors like bearing pressure, soil thickness, raft width, and rigidity. Ahmed et al. used centrifuge tests to evaluate shallow foundations' reactions to reverse faults, concluding that the response is identical to that of normal faults and depends on the relative distance from the fault outcrop. In another study, Bray devised a framework for mitigating the impact of the different types of the fault ruptures on structures, including using compressive material beneath buildings, reinforcing soil, and setting back surface fault ruptures. Gazetas et al. demonstrated the effectiveness of caisson foundations in diverting, bifurcating, and diffusing fault rupture paths through centrifuge tests. Numerical research studies by Baziar et al. showed that using high-strength geogrid to reinforce deeper soil layers near bedrock could minimize differential settlement of foundations. They also demonstrated improved foundation performance by raising the structural load and geogrid depth. To mitigate the impact of an inverse fault rupture on a shallow-foundations, Fadaee et al. suggested erecting a wall of soil bentonite in front of the foundation to redirect fault ruptures away.

3. Methodology

The technique of modeling of multi-storey building resting on a raft foundation response due to fault rupture in finite element method is introduced. This study makes use of the finite element programme ABAQUS (Hibbitt, Karlsson, & Sorensen Inc., 2008). This chapter presents its solution technique. Details of the numerical modelling of the interaction problem between a multi-storey building and a raft foundation are reported, including the types of soil elements used, how initial stresses and boundary conditions were set up, and which

break with a dip angle of 600 degrees near a 20-story skyscraper positioned on a 4x4 piled raft foundation in sand. The general layout of the 20-story building, considering a 60-centimeter fault rupture and piled raft, is depicted in Fig. 1(a). The structure chosen for the study was a concrete, measuring 60 m in height and 15 m in width. Constructed on a square raft with dimensions of 15 m by 15 m and a center-to-center distance of 3.75 m, the building was supported by a series of 4x4 piles, as shown in Fig. 1(b). Each pile had a diameter (d_p) of one meter and a length (L_p) of twenty meters.

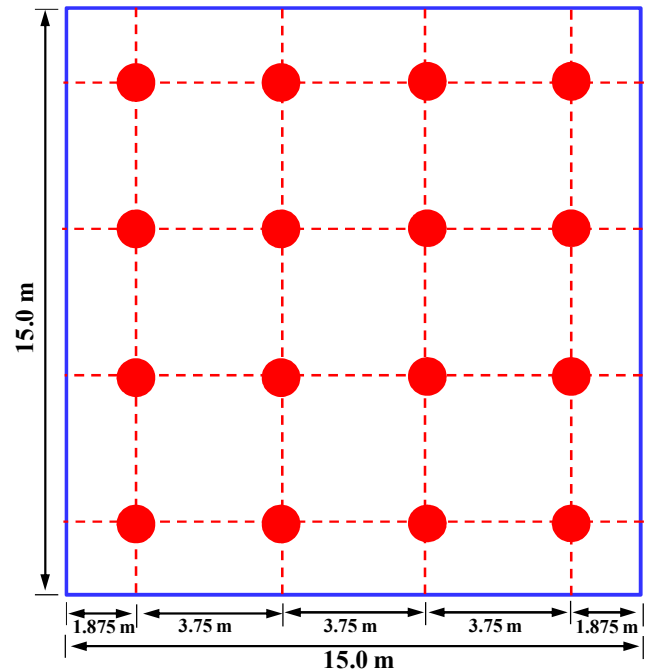
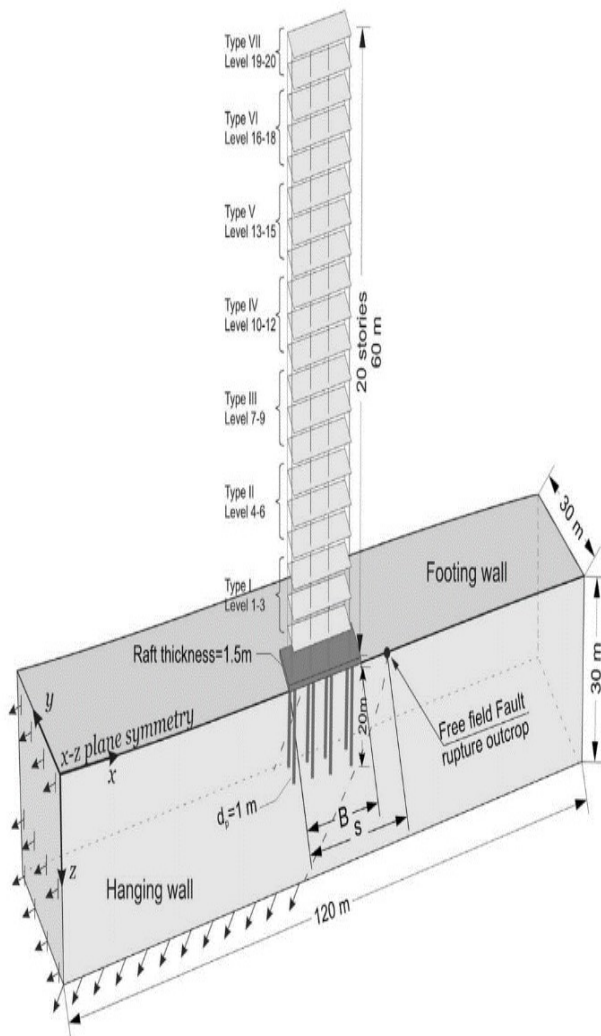


Figure 4 (a) Depicts the General setup of the building, raft foundation with piles (b) Arrangement of Piles in the raft

constitutive models were used for which materials. The constitutive model parameters for concrete and soil are also compiled in this study.

(a)

Three-dimensional finite element analysis was employed to investigate the interaction between excavation and building. The focus was on a standard

3.1 Building Features

These sections were derived from the work of Rasouli and Fatahi [10], who utilized SAP2000 [31] for analysis and design. The creation of these sections followed a standard design process, based on AS3600 [34], AS1170.1 [31], and AS1170.4. Table 1 provides a summary of all sectional details. The members of the concrete were assumed to have a mass density of 2400 kg/m³ and a specific compressive strength (f_c) of 32 MPa. The Elasticity Modulus of the concrete was calculated to be 30.1 GPa.

3.2 Numerical model Characteristics

$c' = 32$ MPa), as derived from Shing and Tanabe's study. The soil, piles, and diaphragm wall were modeled using eight-noded hexahedral brick elements, while props were modeled using two-noded truss elements.

contact technique was utilized [9].

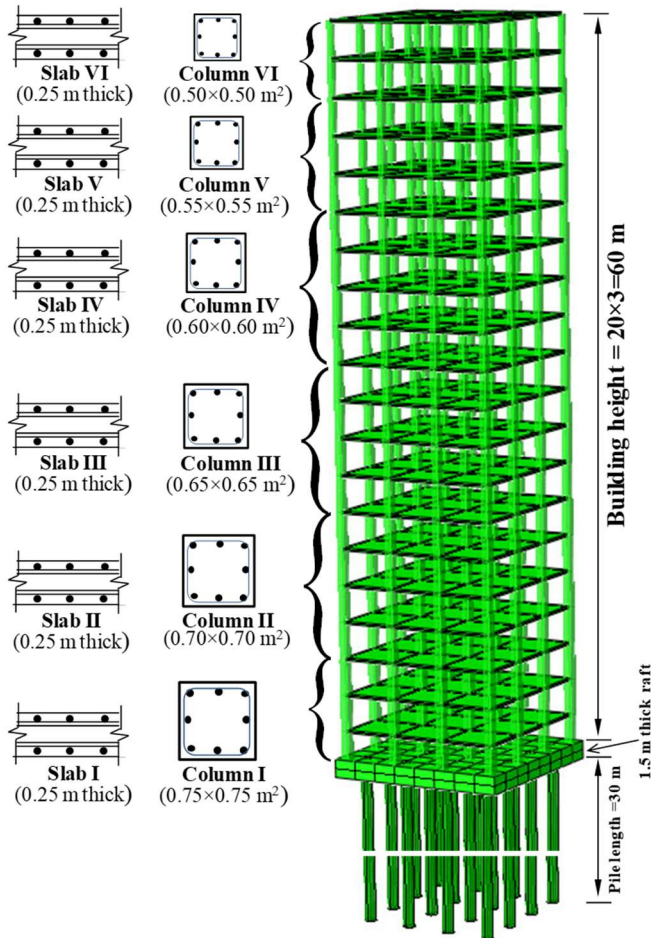


Figure 5

The designed sections of columns and slabs are depicted. This visual representation provides an overview of the structural elements, illustrating the dimensions and configurations of the columns and slabs within the design.

3.3 Soil structure interactions and boundary conditions

In the context of modeling soil-structure interaction (SSI) in the excavation-pile-soil problem, determining the interaction between the pile and the surrounding soil is a crucial component. This is particularly important due to the potential for relative movement between the pile and soil, as well as possible separation between the raft and soil during excavation. The Abaqus software package was employed, and the surface-to-surface

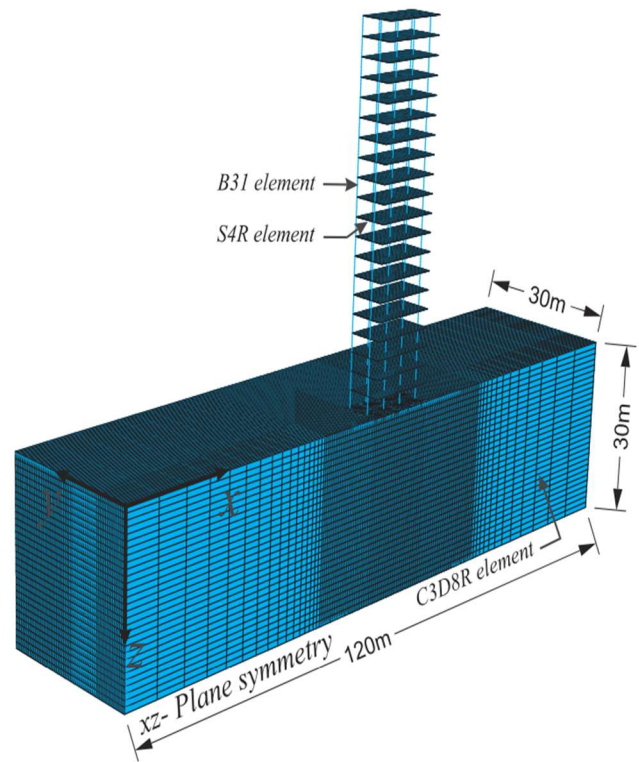


Figure 6

Displays a 3D finite element mesh, providing a visual representation of the model, including the building, raft, and ground. The mesh serves as a detailed computational grid, allowing for the simulation and analysis of structural behaviour within the given model.

Two surfaces which were in contact were designated as the slave and master. For tangential contact, the approach of penalty, while the normal behavior was modeled as hard contact without allowing normal relative displacement between the surrounding soil and the pile. The Coulomb friction law was used to model the interface, requiring input parameters such as the limiting displacement (\lim) and interface friction coefficient (μ). For all analyses, a typical value of 0.35 was used for μ , assuming that a limiting shear displacement of 5 mm would achieve full mobilization of the interface friction, equal to $\mu \times p'$, where p' is the normal effective stress between two contact surfaces.

3.4 Fault Simulation

The bedrock was treated as a rigid boundary in this study, with a focus on understanding the interactive mechanism between the fault rupture and the Fig. 4,

while fault rupturing, the hanging wall, or the moving block, displaced downward parallel to that of dip angle, denoted as ($\alpha = 60^\circ$). It's essential to highlight that the left and bottom boundaries of the hanging block were displaced to simulate fault rupturing and maintain equilibrium.

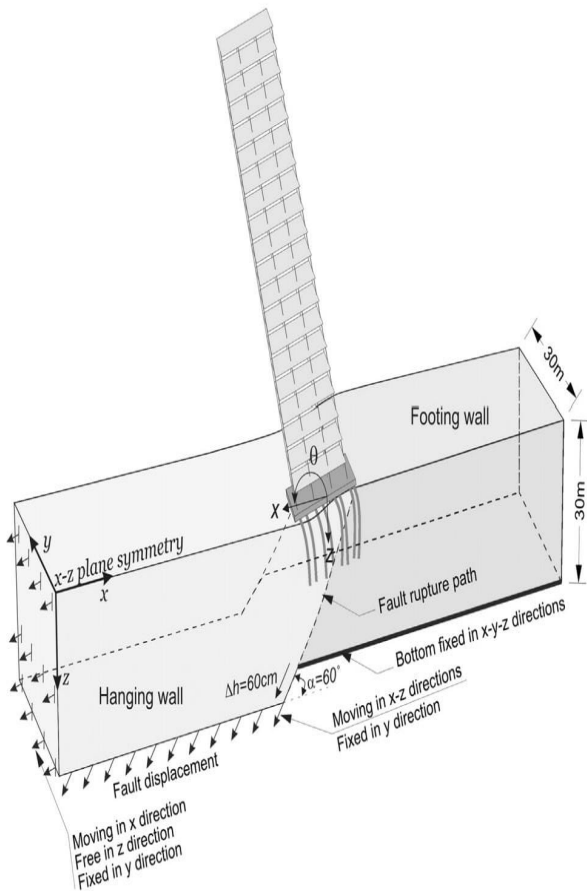


Figure 7

Illustrates a piled raft foundation subjected to the interaction with normal fault rupture. The scenario considers a fault slip of 0.6 m and a dip-slip angle of 60° . The diagram also depicts the boundary conditions during the fault rupturing process.

4.0 Results and Discussions

In this chapter computed results obtained from the numerical modelling is presented, interpreted and discussed.

4.1 Induced Differential Settlement of Piled Raft

An essential consideration is the induced differential settlement in the building. As anticipated, piles closest to the fault slip experience less stress release and greater ground movement during raft foundation fault rupture, resulting in differential settlement in the piles. The piled raft settlements at different positions during various stages of fault slip (i.e., 0 cm, 5 cm, 15 cm, 20 cm up to 60 cm) are depicted in Figure 7.

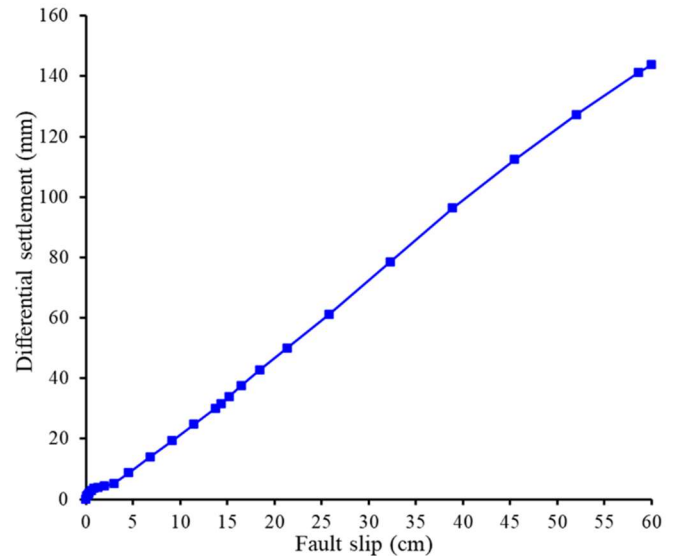


Figure 8: Differential Settlement vs Fault Slip

4.2 Induced Horizontal Movement of Piled Raft

The horizontal movement of the piled raft with varying fault slip stages is depicted in Figure 9. The figure shows that as the fault slip stages (i.e., = 0 cm, 5 cm, 15 cm, 20

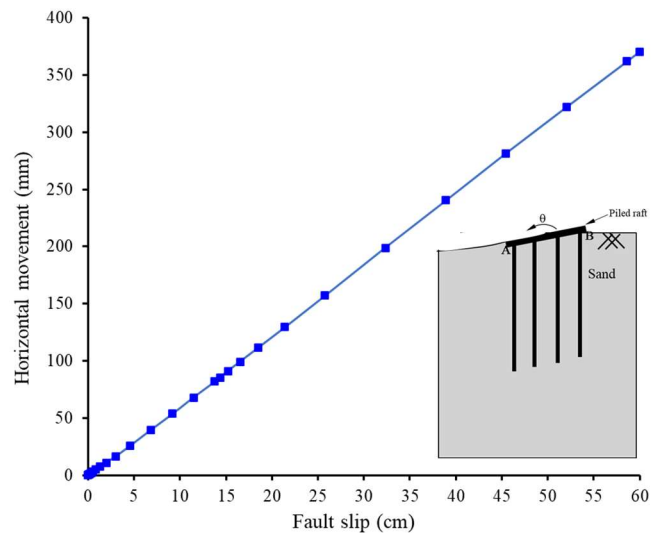


Figure 9 Computed horizontal movement of the piled raft

cm upto 60 cm) increase, so does horizontal movement. It is evident that the building moved in a linear manner. The calculation of negligible horizontal movement was done at the initial fault slip stage, or 0 cm. But as the fault slip continues, the building began to move horizontally. At the 60-centimeter fault slip, the maximum movement was 400 mm.

4.3 Induced Lateral Deflection of The Building

The raft exhibited differential settlement due to the fault rupture, as evidenced by the numerical predictions in the preceding section. Consequently, the 20-story building underwent lateral movement in the direction of the fault rupture. Figure 3 illustrates the induced lateral deflection

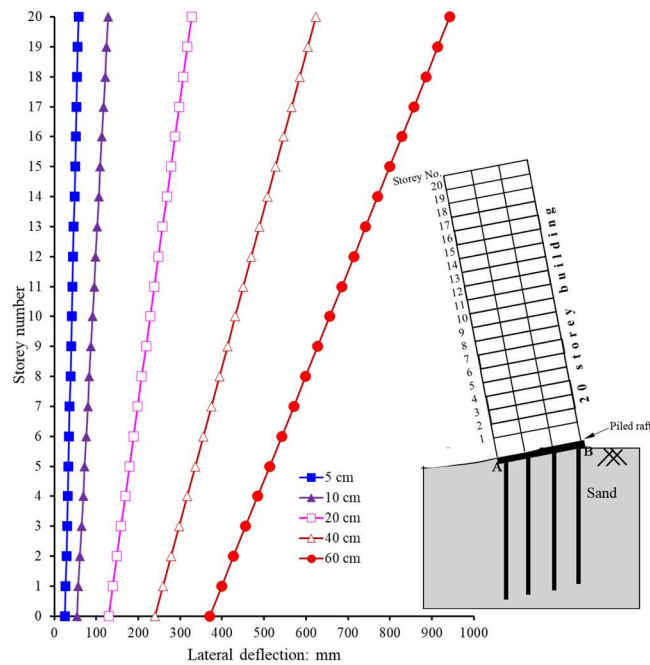


Figure 10 Induced Lateral Movement of the Building

of the building at various magnitudes (i.e., 5 cm, 10 cm, 20 cm, 40 cm, and 60 cm), depicted along each storey. The figure demonstrates an increase in lateral deflection with the building's height. In the initial step, the computation yielded negligible lateral deflection. However, as the fault slip persisted, the building experienced a significant lateral deflection, aligning with the settlement in a piled raft. At the structure's top the greatest lateral deflection was observed—the roof of twentieth (20th) storey. It is depicted in figure 10.

4.4 Inter-Story Drift of Building Sitting

Inter-story drifts, supported by raft foundations and measured at magnitudes of 5cm, 10cm, 20cm, 40cm, and 60cm, are clearly depicted in the figure.

Consequently, at 60 cm, the inter-story drift is 0.3% greater than at 40 cm, where it stands at 0.06%. The normalized differential deflection between two adjacent stories serves to characterize the inter-story drifts in the structure.

The calculated inter-story drift situated on raft foundations during a fault rupture is illustrated in Figure 11.

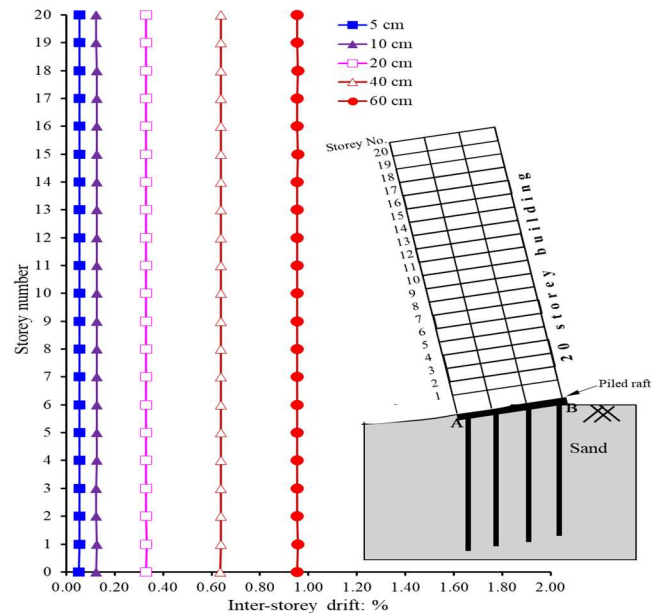


Figure 11 Computed Permanent Inter-Story Drift

4.5 Structural Response of Pile

Examination of bending moments induced by fault rupture in piles is crucial, especially considering that

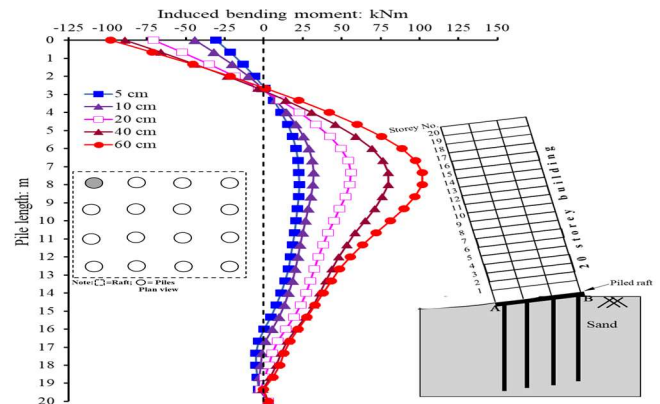


Figure 12. Computed induced bending moment along piles

piles primarily support vertical loads. The fault rupture amplifies the positive induced bending moment. The figure distinctly illustrates that the upper portion, specifically the head of the pile, experiences a negative



bending moment due to the rigid raft connection of the piles. Anticipated at the P1 pile head is the maximum negative moment of 100 kN-m. Counterbalancing this negative moment, a positive moment is generated at the bottom of the pile (where $Z/L_p > 0.2$). Minimal bending moment is observed at the toes of each pile due to their free movement. Notably, when the fault slip exceeds 0.2 m, the increase in bending moments for piles rigidly attached to the raft is marginal.

5. Conclusion

The following deductions can be made in light of the geometries and ground conditions.

- (a) The induced settlement occurred in the building was linear. At the first stage (i.e. fault slip= 0 cm), negligible differential settlement was predicted. However, as fault slip increases, the differential settlement increases.
- (b) Negligible horizontal movement was computed at the first stage of fault slip (i.e., 0 cm). However, as the fault slip continues, the horizontal movement was induced in the building. The maximum movement occurred at the fault slip 60 cm is about 400 mm.
- (c) During the initial stage, a negligible lateral deflection was calculated. However, as the fault slip persisted, a significant lateral deflection was induced in the building. This pattern aligns with the induced settlement in a piled raft.
- (d) Excessive permanent inter-story drifts pose a potential risk of substantial structural distress and increased repair costs. To regulate the performance of various structures, many structural design codes enforce strict limitations on residual drift. According to FEMA273, concrete frame structures must adhere to a maximum allowable permanent inter-story drift, also known as residual drift, limited to 1% to meet the criteria for life safety.
- (e) The anticipated maximum negative bending moment of 100 kN-m was projected at the head of pile P1. To counteract this negative bending moment, a positive bending moment was deliberately induced at the lower portion of the pile, specifically when the ratio of Z (depth) to L_p (pile length) exceeded 0.2. As the pile toes were free to move, minimal bending moment was generated at the toes of each pile. Remarkably, the

bending moments mobilized in the piles, which were firmly connected to the raft, experienced marginal increases when the fault slip exceeded 0.2 m.

5. Reference

- [1] Anastasopoulos, I. and Gazetas, G., 2023. Foundation–structure systems over a rupturing normal fault: Part I. Observations after the Kocaeli 1999 earthquake. *Bulletin of Earthquake Engineering*, 5, pp.253-275.
- [2] Anastasopoulos, I. and Gazetas, G., 2023. Foundation–structure systems over a rupturing normal fault: Part II. Analysis of the Kocaeli case histories. *Bulletin of Earthquake Engineering*, 5, pp.277-301.
- [3] Anastasopoulos, I., Kourkoulis, R., Gazetas, G. and Tsatsis, A., 2023. Interaction of piled foundation with a rupturing normal fault. *Geotechnique*, 63(12), pp.1042-1059.
- [4] Rasouli, H. and Fatahi, B., 2021. A novel cushioned piled raft foundation to protect buildings subjected to normal fault rupture. *Computers and Geotechnics*, 106, pp.228-248.
- [5] Beheshtizadeh, D. and Malekpour, F., 2021. Investigating the Behavior of Underground Structures in the Event of an Earthquake. *International Journal of Civil and Environmental Engineering*, 12(1), pp.24-27.
- [6] Bray, J.D., 2019, January. Developing mitigation measures for the hazards associated with earthquake surface fault rupture. In *Workshop on seismic fault-induced failures—possible remedies for damage to urban facilities*. University of Tokyo Press (pp. 55-79).
- [7] Bransby, M.F., Davies, M.C.R., El Nahas, A. and Nagaoka, S., 2018. Centrifuge modelling of reverse fault–foundation interaction. *Bulletin of Earthquake Engineering*, 6, pp.607-628.
- [8] Loli, M., Bransby, M.F., Anastasopoulos, I. and Gazetas, G., 2018. Interaction of caisson foundations with a seismically rupturing normal fault: centrifuge testing versus numerical simulation. *Geotechnique*, 62(1), pp.29-43.
- [9] Faccioli, E., Anastasopoulos, I., Gazetas, G., Callerio, A. and Paolucci, R., 2018. Fault rupture–foundation interaction: selected case histories. *Bulletin of Earthquake Engineering*, 6, pp.557-583.
- [10] Fadaee, M., Ezzatyazdi, P., Anastasopoulos, I. and Gazetas, G., 2016. Mitigation of reverse faulting



deformation using a soil bentonite wall: Dimensional analysis, parametric study, design implications. *Soil Dynamics and Earthquake Engineering*, 89, pp.248-261.

[11] Gazetas, G., Zarzouras, O., Drosos, V. and Anastasopoulos, I., 2015. Bridge–Pier Caisson foundations subjected to normal and thrust faulting: physical experiments versus numerical analysis. *Meccanica*, 50, pp.341-354.

[12] Zheng, J.J., Abusharar, S.W. and Wang, X.Z., 2008. Three-dimensional nonlinear finite element

modeling of composite foundation formed by CFG–lime piles. *Computers and Geotechnics*, 35(4), pp.637-643.

[13] Liang, F.Y., Chen, L.Z. and Shi, X.G., 2003. Numerical analysis of composite piled raft with cushion subjected to vertical load. *Computers and Geotechnics*, 30(6), pp.443-453.

[14] Davis, E.H. and Poulos, H.G., 1972. The analysis of piled raft systems, *Australian Geomech. Journal* G, 2.



Exploring Trends of Overall Equipment Effectiveness (OEE) Implementation in Manufacturing Organizations

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ABSTRACT

Various productivity measuring tools and techniques are being used nowadays in organizations. The overall equipment effectiveness (OEE) technique is one of them, that identifies the losses and provides insights into the effectiveness of a machine, a process, or a whole system. This paper explores the trends of use of Overall Equipment Effectiveness in manufacturing organizations. Data to use of trend is gathered from a database i.e. Google Scholar. Further, Improvement in the OEE after the use of different tools by organizations to improve the OEE was gathered from different studies and compared with World Class Standards (WCS). It was observed that the trend in the utilization of OEE has increased day by day except in the period of COVID-19 and the recent couple of years. It was observed that most of the studies used a single tool to cope with either availability, performance, or quality which contributed to the improvement of that factor and OEE in general but still lagging the WCS. It is recommended that more tools must be used to meet the WCS of OEE.

1. Introduction

Methods and tools for assessing production efficiency are increasingly being utilized in the industrial sector. Several reasons have contributed to the increased use of these technologies in recent years. It originates mostly from the need to assess progress toward organizational goals and, as a result, identify opportunities for improvement [1]. The Japan Institute of Plant Maintenance (JIPM) introduced Overall Equipment Effectiveness (OEE) as a crucial metric for evaluating equipment performance [2]. The tool OEE is suitable for assessing the effectiveness of the equipment through evaluating the benchmarks. OEE measure is capable of providing information regarding the effectiveness whether it is for single machine or group of interrelated machines [3]. According to [4], OEE frequently serves as a method for enhancing a company's output as it simultaneously targets quality, productivity, and

equipment utilization. It is one of the Key Performance Indicators (KPIs) to measure the productivity of equipment, machines, assembly lines or system. It is a ratio between real and ideal manufacturing [5]. Nakijma in 1988 suggested the use of OEE as a part of total productive maintenance (TPM), the basis for the real-time evaluation of equipment productivity in a manufacturing system [6]. Today, it is increasingly utilized not only within the TPM framework but also as a standalone tool for assessing key performance indicators and driving productivity enhancements. Moreover, nowadays, different initiatives such as TPM (5S, Autonomous maintenance, and kaizen [7]), Lean [8], [9], TPM [2], [10], [11], [12], and CILT [13] are taken for the improvement of processes and OEE is utilized to assess the effectiveness before and after implementation of those techniques or approaches [7]. According to [11], OEE has the potential to assess performance, identify areas for development, and lead the course of improvement.



It is a function of availability, performance rate, and quality rate [7]. OEE measures six (06) losses which are the biggest impediments to the performance of equipment. The measure of OEE highlights the areas for those losses [5]. These losses are related to the parameters (availability, performance rate & quality rate) of the OEE [7]. Initially, the OEE metric focused on six primary loss categories: equipment failures, setup and adjustments, idling and stoppages, reduced speed, process faults, and lower yield. However, more recently, suggestions have emerged to incorporate additional planned downtime factors like preventive maintenance, staff shortages, etc., into the calculation of OEE [14]. The gathering of data encompasses planned and unscheduled stops, set-up times, usage, speed loss, and quality rates. Machine availability, operating efficiency, quality rate, and overall equipment effectiveness (OEE) are assessed using data. A summary of the overall results is provided by the average values of gathered and computed OEE components [14].

In a summary, originally, OEE found application in production, notably within Total Productive Maintenance (TPM), aiding in assessing the overall performance of equipment in manufacturing operations. To meet industry demands, some researchers delved into analysing the productivity of manufacturing line systems or entire factories. Presently, OEE is integrated into improvement methodologies focused on ongoing enhancement, such as lean manufacturing, aimed at boosting productivity through waste reduction. Furthermore, it serves as both a Key Performance Indicator (KPI) and a tool for data collection to gauge the effectiveness and process capability of new process improvement initiative [5].

1.1 Overall Equipment Effectiveness

Thus, the computation of OEE can be expressed as follows:

$$\text{OEE} = \text{Availability} * \text{Performance efficiency} * \text{Quality rate}$$

There is a threshold established for the assessment of OEE. For instance, Nakajima as cited in [15] suggests that under ideal conditions, companies should aim for Availability (A) greater than 90 percent, Performance (P) greater than 95 percent, and Quality (Q) greater than 99 percent. These benchmarks would result in an OEE exceeding 84 percent for top-tier firms, which Nakajima views as a suitable standard for typical manufacturing capabilities. Conversely, [16] argues for a more modest OEE target, suggesting that anything below 0.50 is more realistic. This viewpoint aligns with the range of OEE measurements summarized by [17], where OEE fluctuates between 0.30 and 0.80 [18]. Notwithstanding, only a handful of the industries reach to the utilization of 60% to 90% [19].

1.1.1 Availability

Availability, denoted as "A", can be represented as the proportion of operating time (actual) to loading time. Accordingly:

$$A = \frac{\text{Operating time}}{\text{Loading time}} = \frac{\text{Loading time} - \text{Downtime}}{\text{Loading time}}$$

(i) Where loading time signifies the scheduled duration available per time frame (daily, weekly, or monthly) for production activities, and operating time is derived from subtracting downtime from loading time. Downtime encompasses the total duration during which the system is inactive due to equipment malfunctions, setup/adjustment requirements, changes in dies and other fixtures, etc. Availability can be represented as the ratio of actual operating time to loading time [20].

1.1.2 Performance:

Performance efficiency, labelled as "P", can be approximated as:

$$P = \frac{\text{Net operating time}}{\text{Operating time}} = \frac{\text{Cycle time} * \text{Processed amount}}{\text{Operating time}} \quad \text{(ii)}$$

Where net operating time refers to the time during which equipment operates at its normal pace production pace. To compute net operating time, remove performance time losses from operational time. Performance time losses include both regular production setbacks (decrease in production rate owing to startup, shutdown, and changeover) and exceptional production losses (production rate reductions due to anomalies). The net operating time is calculated by multiplying the processed quantity by the actual cycle time [20].

1.1.3 Quality:

The quality rate, denoted as Q, is defined as:

$$Q = \frac{\text{Processed amount} - \text{Defect amount}}{\text{Processed amount}} \quad \text{(iii)}$$

Where processed amount signifies the quantity of products processed within a given time frame (day, week, or month). The defect amount means the number of products rejected due to quality faults requiring modification/rework/reprocessing or becoming waste [20].

1.2 OEE and six big losses

Manufacturing disruptions can lead to several types of waste and losses. These are characterized as activities that use resources but produce no value. The goal of OEE is to identify such losses. It is a bottom-up method in which an integrated staff works to improve total equipment effectiveness by reducing the six major losses.

1.2.1 Downtime Losses

Breakdown losses include both time and quantity losses due to lower output or damaged products. Set-up and adjustment losses are caused by downtime and faulty items during the transition from one item to the next.



1.2.2 Speed losses.

Idling and small stoppage losses occur when production is halted due to a brief failure or machine idling.

Reduced speed losses are the difference between the equipment's design and actual operating speed.

1.2.3 Quality Losses

Nonconforming output due to any reason may be human or equipment refers to quality losses. From the equipment starts to stabilization there is a loss known as yield loss.

2. Methodology

This study has an objective. The objective is to explore the trend of OEE in practice. To achieve this a systematic approach is adopted to analyse the overall trend in the utilization of Overall Equipment Effectiveness (OEE). Papers selected for the data collection cover various sectors such as automotive, electronics, textile & Pharmaceutical.

2.2 Data Collection

To analyse the trend in the publication the of papers on the OEE, which represents the significance of these tools, an organized approach was selected. Google Scholar website (<https://scholar.google.com>) was used to access the research papers related to OEE. Further, four (4) sequential steps were taken as described below and shown in Fig. 1 (see appendix A).

Step 1: Write the OEE in google scholar bar.

Step 2: Set the range of a single year to access the number of publications in a specific year e.g. 2000 to 2000.

Step 3: Click the search tab.

Step 4: See the result just below the search bar that shows the number of publications on OEE within the range of the provided year.

This four-step procedure was repeated many times for the years 2000 to 2023, to explore the number of publications published in the respective years.

Further to achieve the second objective research papers related to overall equipment effectiveness were searched through Google Scholar & those were selected randomly which consisted of the implementation of various productivity improvement tools that have impacted the OEE. From the selected papers the information like author name, year of publication, country where the studied carried out, type of industry, which tools were implemented & the values of variables i.e., availability, performance, quality, and OEE before & after the tool implementation were extracted.

2.2 Data presentation

A bar graph was generated through MS Excel which depicts the trend of publication on OEE. In the table information is arranged by considering the values of all four parameters i.e. availability, performance, quality, and OEE, before and after the tool implementation, the

improvement & deviation from the world-class standards for each study were calculated further.

3. Results

This section represents the results of the collected secondary data to fulfill the objective of the study.

3.1 Publication Trends in Overall Equipment Effectiveness Research

The trend depicted in Fig. 2 (see Appendix A) showcasing the number of publications on Overall Equipment Effectiveness (OEE) over the past two decades underscores a significant and consistent increase in interest and attention towards this metric.

Over the last two decades, there has been a significant and constant growth in publications on Overall Equipment Effectiveness (OEE). Starting in 2000 with 974 articles, interest in OEE has continuously increased, with a high of 5,880 in 2021. However, in the last couple of years, the number of publications is decreasing. The linear trend line shows that from year 2005 to 2012 the research publications were less than estimated by the linear trend, whereas publications in the years 2017 to 2022 were more than estimated by the linear trend. On the other hand, a two-year moving average line states that publications in all the years are more than the estimated publications except 2023. From the trend, it is obvious that utilization of the OEE metric has become more common among industries in the past couple of decades. OEE is helping industries by assessing the whole production process and improving by evaluating it with world-class standard. In the global competitive environment, OEE is becoming more essential for the industries to survive and grow. This measure ensures maximum availability, and enhancement in the quality & performance rate of the equipment that ultimately gives the competitive edge through reduced price, and customer satisfaction.

3.2 OEE improvement after the implementation of various tools/techniques/approaches.

Furthermore, in the table 1 (see appendix B) there is real time information regarding the overall equipment effectiveness OEE implementation and its contribution to the improvement of the effectiveness of the different organizations. As shown in the table 1, different tools such as theory of constraints, total productive maintenance, lean six sigma, and OEE integrated framework have been implemented in different types of industries resulting in advancement in the parameters availability, performance & quality. Like, a study [7] conducted by Gupta & Garg (2012), concluded that after applying the TPM (specifically, 5S, Autonomous & Kaizen) in automobile manufacturing company there was an improvement in Availability, Performance, Quality & OEE by 5%, 6%, 3%, & 11% respectively, but still there is lack showing the need of further enhancement.



According to [8] carrying out Lean Six Sigma in medium size manufacturing company boosted the parameters i.e. Availability, Quality & OEE by 29%, 1% & 21% respectively. Much improvement is still needed in performance. Investigation made by Anwar & Driss, (2016) in the study [9] showed that Total productive maintenance & lean maintenance practices were executed in a Global Auto company, resulting in Availability, Performance, Quality and OEE upgradation through 4%, 7%, 35 & 9%. Further initiative should be taken especially for performance & availability improvement.

In addition, according to [21] implementation of an integrated OEE framework in the electronics assembly improved the little bit availability by 3%. When compared to world-class standard availability should be enhanced as there is a significant deviation (-10%).

Zhu, (2011) conducted a study in China, where he took some measures to improve the OEE in the electronics manufacturing company. After the execution of such measures, he noticed the boost in the availability, quality & performance by the percentages, 8%, 6% & 3% respectively, Nevertheless, performance has shown more deviation from WCS which means it needs more focus [22]. According to [2], the total productive maintenance initiative in the manufacturing firm led to a significant impact on availability (23%) & performance (12%), even though such improvement yet performance should be upgraded. Researchers conducted the study [10] in the textile mill where they implemented total productive maintenance which made a good improvement in performance (8%) & availability (6%). Availability is surpassing the world-class standard but in performance, there is need a little bit improvement. According to [23] by applying the theory of constraints (TOC) in the Semiconductor package process Availability, Performance & Quality values get improved by 1%, 1% & 2%. There is a significant deviation in the availability that is -29% which means it needs urgent attention. Researchers conducted the study [11] in moulding industry where they implemented total productive maintenance which significantly improved the availability by a percentage of 14. Overall, the industry's performance was excellent but needed to enhance performance rate means an increase in production speed a little bit more to reach world-class standards.

Furthermore, [12] put the total productive maintenance into practice in pharmaceutical company resulted in advancement in the parameter Availability, Performance & Quality by 18%, 12% & 3%. Showing that availability gets more improved as compared to others. It is also clear

that the performance rate is much less than the standard that's 95% by -55%

These improvements highlight the effectiveness of TPM in enhancing operational performance and efficiency in the manufacturing setting. However, deviations from the world-class standard were also evident, suggesting areas for further improvement. Overall, the findings underscore the effectiveness of targeted improvement strategies in enhancing operational performance across diverse industries.

Conclusion

Hence, there is an improvement observed in the processes through the studies conducted by various researchers across different industries. OEE played a very important role in these enhancements by identifying the specific areas and implementation of respective tools such as total productive maintenance, lean manufacturing six sigma etc. All these studies show that overall equipment effectiveness (OEE) is an effective tool for measuring the productivity of the equipment & improving it. As the researchers explored it deeper, they found it an essential tool for operational excellence. It is observed that almost a single tool is implemented to enhance the OEE except for a few studies where two or more than two techniques or tools are used to enhance the effectiveness of the organizations. Nonetheless, all the studies reported an increase in the OEE as a general. It is still hidden how much a single tool or technique contributed to the increase of OEE. That is, how much variation a tool or technique contributed to OEE. It is recommended to use a regression analysis approach to measure that variation in OEE.

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Funding Statement

This work was completed without external funding.

Competing Interests

The authors declare none.

Ethical Standard

This work adheres to ethical guidelines and standards.



APPENDIX A

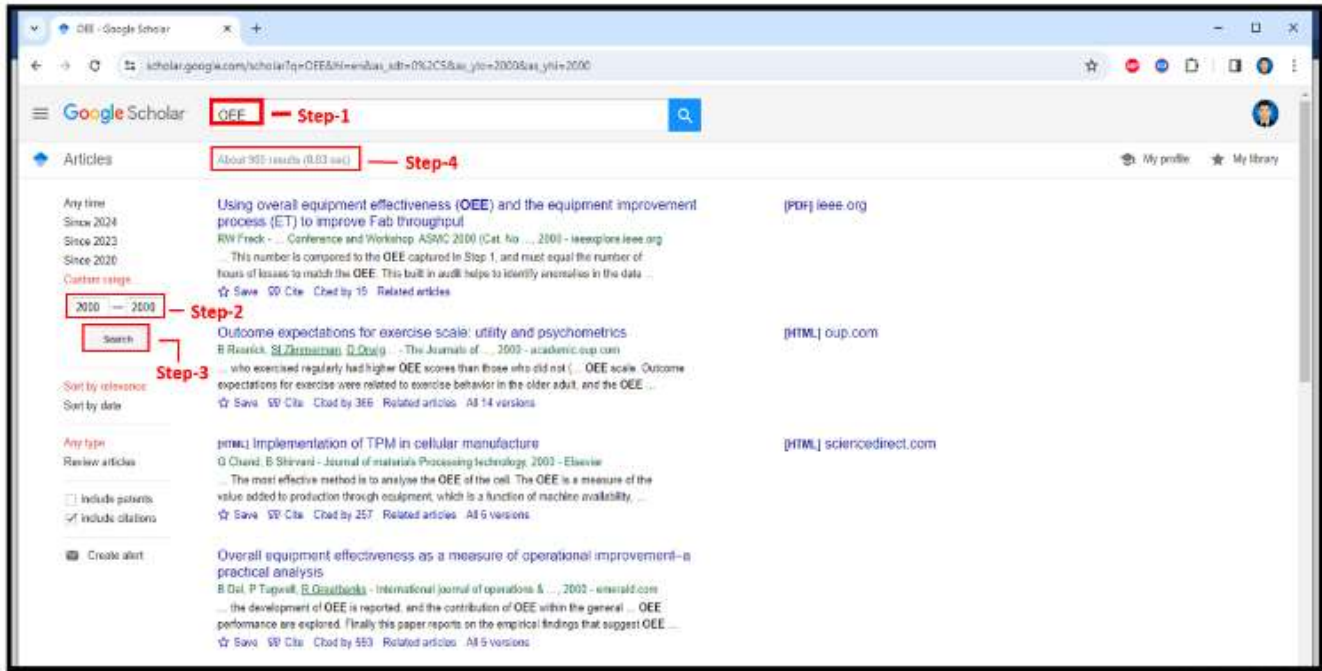


Fig. 1. Steps for the collection of publications data in google scholar.

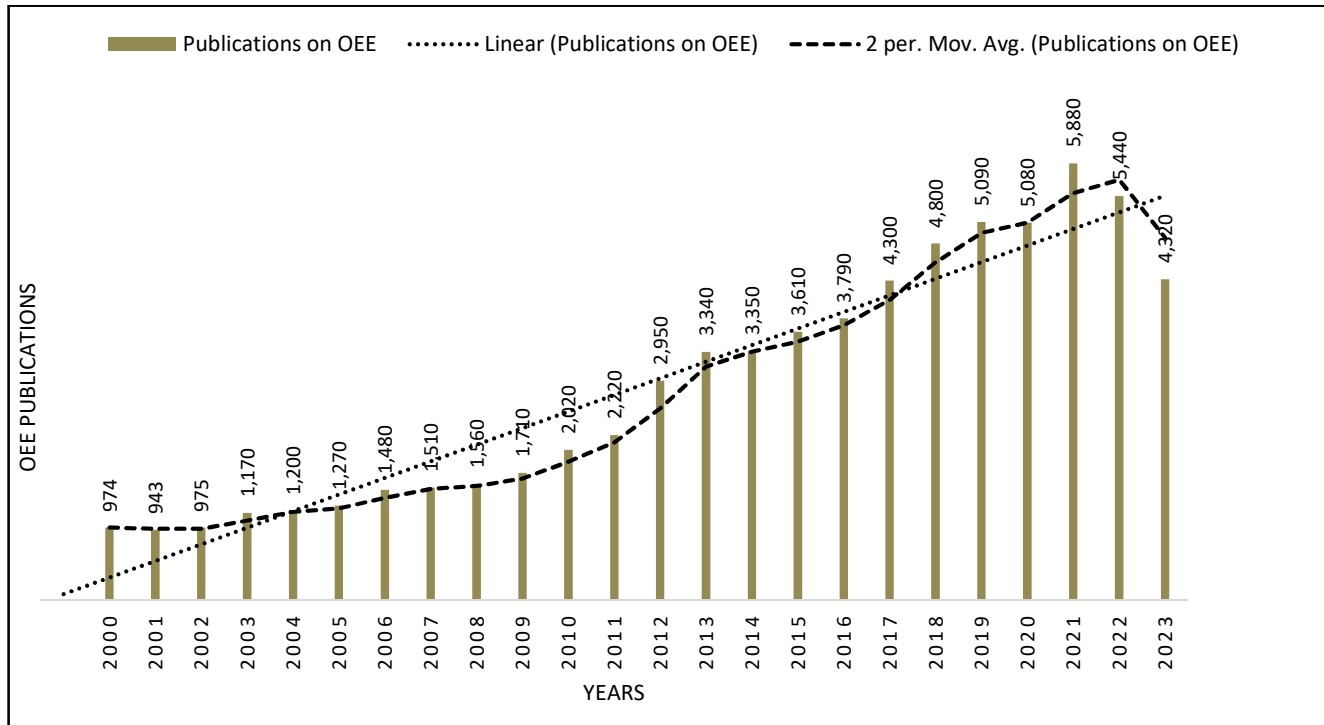


Fig. 2. Publications of OEE as per google scholar database



Appendix B: Table-1 Before and after OEE comparison after implementation of various tools

S. No.	Author, Year & Country	Tool	Industry	Parameters	Before	After	Improve	WCS	Deviation
					Percentage (%)				
1	Gupta & Grag, 2012, India [7]	TPM (5S, Autonomous Maintenance & Kaizen)	Automobile Manufacturing Organization	Availability	80	85	5	90	-5
				Performance	77	83	6	95	-12
				Quality	96	99	3	99	0
2	Chiarini, 2015, Italy [8]	Lean Six Sigma	Medium-sized Italian manufacturing company	OEE	59	70	11	85	-15
				Availability	55	84	29	90	-6
				Performance	74	74	0	95	-21
3	En-Nhaili et al., 2016, Morocco [9]	TPM & lean maintenance actions	Global Auto Interiors Inc.	Quality	98	99	1	99	0
				OEE	40	61	21	85	-24
				Availability	71	75	4	90	-15
4	Cheah et al., 2020, Malaysia [21]	Integrated OEE framework	Electronics Assembly	Performance	66	73	7	95	-22
				Quality	93	96	3	99	-3
				OEE	44	53	9	85	-32
5	Zhu, 2011, China [22]	OEE Improvement Measures	Electronics Manufacturing	Availability	77	80	3	90	-10
				Performance	96	96	0	95	1
				Quality	100	100	0	99	1
6	Jain et al., 2012, India [2]	Total productive maintenance (TPM)	Manufacturing	OEE	73	77	4	85	-8
				Availability	82	90	8	90	0
				Performance	83	86	3	95	-9
7	Ahmed et al., 2018, Bangladesh [9]	Total productive maintenance (TPM)	Akij Textile Mills Limited (ATML)	Quality	90	96	6	99	-3
				OEE	60	75	15	85	-10
				Availability	65	88	23	90	-2
8	Bai et al., 2018, China [23]	Theory of Constraints (TOC)	Semiconductor package process	Performance	73	85	12	95	-10
				Quality	96	98	2	99	-1
				OEE	50	73	23	85	-12
9	Vijayakumar & Gajendran, 2014, India [11]	Total productive maintenance (TPM)	Process Industry of moulding	Availability	91	97	6	90	7
				Performance	84	92	8	95	-3
				Quality	97	99	2	99	0
10	Chikwendu et al., 2020, Nigeria [12]	Total productive maintenance (TPM)	Pharmaceutical company	OEE	75	86	11	85	1
				Availability	60	61	1	90	-29
				Performance	87	88	1	95	-7
				Quality	96	98	2	99	-1
				OEE	50	53	3	85	-32
				Availability	77	91	14	90	1
				Performance	88	92	4	95	-3
				Quality	90	98	8	99	-1
				OEE	61	82	21	85	-3
				Availability	60	78	18	90	-12
				Performance	28	40	12	95	-55
				Quality	96	99	3	99	0
				OEE	16	32	16	85	-53



References:

- [1] F. De Carlo, M. A. Arleo, and M. Tucci, "OEE evaluation of a paced assembly line through different calculation and simulation methods: A case study in the pharmaceutical environment," *International Journal of Engineering Business Management*, vol. 6, no. 1, pp. 1–11, 2014, doi: 10.5772/59158.
- [2] A. Jain, R. Bhatti, H. Singh Deep, and S. Kumar Sharma, "Implementation of TPM for Enhancing OEE of Small Scale Industry," 2012. [Online]. Available: www.irjournals.org
- [3] P. H. Tsarouhas, "Overall equipment effectiveness (OEE) evaluation for an automated ice cream production line: A case study," *International Journal of Productivity and Performance Management*, vol. 69, no. 5, pp. 1009–1032, May 2020, doi: 10.1108/IJPPM-03-2019-0126.
- [4] C. J. Bamber, P. Castka, J. M. Sharp, and Y. Motara, "Cross-functional team working for overall equipment effectiveness (OEE)," *J Qual Maint Eng*, vol. 9, no. 3, pp. 223–238, Sep. 2003, doi: 10.1108/13552510310493684.
- [5] L. del C. N. Corrales, M. P. Lambán, M. E. Hernandez Korner, and J. Royo, "Overall equipment effectiveness: Systematic literature review and overview of different approaches," *Applied Sciences (Switzerland)*, vol. 10, no. 18, MDPI AG, Sep. 01, 2020. doi: 10.3390/APP10186469.
- [6] S. Nakajima, "Introduction to TPM: Total Productive Maintenance.pdf," Productivity Press, Cambridge, p. MA, 1988, doi: http://www.plant-maintenance.com/articles/tpm_intro.shtml.
- [7] A. Kumar Gupta and R. K. Garg, "OEE Improvement by TPM Implementation: A Case Study," 2012. [Online]. Available: www.irjournals.org
- [8] A. Chiarini, "Improvement of OEE performance using a Lean Six Sigma approach: an Italian manufacturing case study," 2015.
- [9] A. En-Nhaili, A. Meddaoui, and D. Bouami, "Effectiveness improvement approach basing on OEE and lean maintenance tools," 2016.
- [10] T. Ahmed, S. Ali, M. Allama, and M. Parvez, "A Total Productive Maintenance (TPM) Approach to Improve Production Efficiency and Development of Loss Structure in a Pharmaceutical Industry," 2010. [Online]. Available: <https://www.researchgate.net/publication/267569800>
- [11] S. R. Vijayakumar and S. Gajendran, "IMPROVEMENT OF OVERALL EQUIPMENT EFFECTIVENESS (OEE) IN INJECTION MOULDING PROCESS INDUSTRY." [Online]. Available: www.iosrjournals.org
- [12] O. C. Chikwendu, A. S. Chima, and M. C. Edith, "The optimization of overall equipment effectiveness factors in a pharmaceutical company," *Heliyon*, vol. 6, no. 4, Apr. 2020, doi: 10.1016/j.heliyon.2020.e03796.
- [13] S. Khan, S. A. Shaikh, M. A. Gopang, and R. Khan, "Impact of Cleaning Inspecting Lubrication & Tightening (CILT) on Overall Equipment Effectiveness for Sustainable Production," *Journal of Sustainable Environmental*, vol. 2, no. 1, pp. 29–37, Jul. 2023, doi: 10.58921/jse.02.01.045.
- [14] T. Ylipää, A. Skoogh, J. Bokrantz, and M. Gopalakrishnan, "Identification of maintenance improvement potential using OEE assessment," *International Journal of Productivity and Performance Management*, vol. 66, no. 1, pp. 126–143, 2017, doi: 10.1108/IJPPM-01-2016-0028.
- [15] A. Raouf, "Improving Capital Productivity through Maintenance," *International Journal of Operations & Production Management*, vol. 14, no. 7, pp. 44–52, Jul. 1994, doi: 10.1108/01443579410062167.
- [16] D. Kotze, "Consistency, accuracy lead to maximum OEE benefits," *TPM Newsletter*, vol. 4, no. 2, 1993.
- [17] J. Ericson, "Disruption Analysis - An Important Tool in Lean Production," Lund University, 1997.
- [18] P. Jonsson and M. Lesshammar, "Evaluation and improvement of manufacturing performance measurement systems - The role of OEE," *International Journal of Operations and Production Management*, vol. 19, no. 1, pp. 55–78, 1999. doi: 10.1108/01443579910244223.
- [19] T. Slavina and N. Štefanić, "Facing Challenges of Implementing Total Productive Management and Lean Tools in Manufacturing Enterprises," *Systems*, vol. 12, no. 2, p. 52, Feb. 2024, doi: 10.3390/systems12020052.
- [20] P. Tsarouhas, "Improving operation of the croissant production line through overall equipment effectiveness (OEE): A case study," *International Journal of Productivity and*



- Performance Management, vol. 68, no. 1, pp. 88–108, Jan. 2019, doi: 10.1108/IJPPM-02-2018-0060.
- [21] C. K. Cheah, J. Prakash, and K. S. Ong, “An integrated OEE framework for structured productivity improvement in a semiconductor manufacturing facility,” *International Journal of Productivity and Performance Management*, vol. 69, no. 5, pp. 1081–1105, May 2020, doi: 10.1108/IJPPM-04-2019-0176.
- [22] X. Zhu, “Analysis and Improvement of Enterprise’s Equipment Effectiveness Based on OEE,” in *International Conference on Electronics, Communications and Control (ICECC)*, Ningbo, China: IEEE, 2011, pp. 1167–1171.
- [23] Z. Q. Bai, Q. Y. Wei, M. Dai, and Z. S. Zhang, “An OEE Improvement Method Based on TOC,” in *25th International Conference on Mechatronics and Machine Vision in Practice*, 2018, pp. 1–6.



Exploring Modern Threats and Trends in Healthcare Cybersecurity: A Systematic Review

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Cyber attack
Cyber crime
Cyber security
Healthcare
Ransomware

ABSTRACT

Amidst the dynamic landscape of healthcare technology, the integration of digital systems presents both opportunities and challenges. While these progressions offer the possibility to improve patient consideration and functional proficiency, they additionally open medical care associations to a variety of network safety dangers. This orderly survey resolves the major problem of network safety inside the medical services area, with a particular spotlight on contemporary patterns and weaknesses, strikingly the unavoidable danger of ransomware assaults. Directing an intensive assessment of scholarly writing recovered from driving data sets like CINAHL, PubMed (MEDLINE), and ProQuest, this examination recognizes and dissects 31 significant articles. The discoveries uncover an unsettling reality: the medical services industry falls behind different areas in executing hearty network safety measures, leaving basic patient information defenseless against double-dealing. In light of the orchestrated bits of knowledge, this survey underlines the critical basic for medical services associations to support their online protection safeguards. Key suggestions incorporate plainly characterizing network safety obligations, laying out thorough conventions for programming updates and information break reaction, taking on cutting edge security innovations like VLANs and cloud-based registering, and giving extensive client preparing. These procedures are fundamental to actually relieve dangers and protect delicate medical care data.

1. Introduction

The Patient Security and Reasonable Consideration Act (ACA) and the Wellbeing Data Innovation for Monetary and Clinical Wellbeing Act (HITECH) are main thrusts of medical services innovation. These regulations are empowering medical care suppliers to illustrate "significant use" by becoming arranged in offering types of assistance [1]. As medical care associations make the progress to an electronically based framework many are left defenseless against cybercrime. The rise of cybercrime started in the last part of the 1970s as the PC data innovation (IT) industry was creating at a quick speed [2]. This started as spam and later transformed into infections and malware. To keep

away from the break of medical services information, the Health care coverage Versatility and Responsibility Demonstration of 1996 (HIPAA) acquainted specialized and actual shields with intensely scramble delicate data which is impermeable by cybercriminals [3]. Actual shields incorporate workstation use and security, gadget and media controls, and office access controls. Specialized shields incorporate a remarkable client distinguishing proof number, crisis access technique, programmed logoff, encryption and unscrambling As the medical care industry keeps on developing, cybercriminals are tracking down ways of breaking these shields. The reception of medical services innovation is a significant endeavor that requires an enormous



measure of arranging and time for execution. The product ought to be update constantly to stay up with cybercriminals' developments and their double-dealing of openings in security because of the product's execution. "Associations are burning through billions on undertakings to turn out to be more coordinated, yet they're not investing the energy or cash on refreshing programming," as per [4]. An illustration of a new danger: ransomware. Ransomware invades networks and scrambles records to obstruct access. Then the documents are delivered. The technique isn't new. Dr. Joseph Popp made the thought in 1989. Popp utilized code to target scientists who were keen on basic exploration on Procured Immunodeficiency Syndrome(AIDS) [6]. Specialists captured him. In any case, his code brought about numerous subordinates that structure the premise of many cybercriminals' systems. Ransomware shows how programmers pinpoint and exploit the shortcomings in 21st century data innovation (IT) foundation [6]. After a payoff was paid to return Hollywood Presbyterian Clinical Center in Los Angeles, California's records, it was uncovered that they were requested to make an installment from \$17,000 to get a decoding key to reestablish the framework [5]. This sum does exclude the 10 days of lost income while the clinic's framework was debilitated or the catastrophe for its standing in safeguarding patient information [5]. To keep wellbeing data secure, medical care suppliers need to adjust as fast as the dangers do. Almost 90% of medical care suppliers say they've encountered an information break over the most recent two years [5]. Starting around 2010, digital assaults have expanded by 125% and are currently the main source of wellbeing information security breaks [5]. As innovation is continuously advancing this audit tries to expand upon the writing in the at present immature region. This orderly writing survey is an update to an audit named "Digital Dangers to Wellbeing Data Frameworks: An Efficient Audit" distributed in January, 2016 [7]. The reason for this methodical survey is to distinguish network safety patterns including late dangers like ransomware, and its connection to the medical services industry through scholarly writing.

2. Literature Review

The combination of clinical benefits development gathering and online security has emerged as a vital place of combination in the rapid environment of contemporary clinical benefits. With regulative

undertakings like the Patient Security and Sensible Thought Act (ACA) and the Prosperity Information Development for Monetary and Clinical Prosperity Act (HITECH) driving clinical consideration providers toward digitalization, the subsequent troubles and shortcomings require a thorough appraisal of existing composition. The development of advanced risks in the clinical consideration region can be followed back to the last piece of the 1970s, creating from fundamental spam to state of the art diseases and malware. The appeal of prosperity data to cybercriminals begins from its lavishness, integrating both individual and money related nuances. Disregarding the request for regulatory measures like the Medical care Minimization and Obligation Act (HIPAA), cybercriminals determinedly recognize approaches to exploiting deficiencies in physical and specific safeguards. The blend of clinical consideration development, but exceptional, accomplishes inconvenient hardships. Affiliations that energetically placed assets into blend regularly ignore the fundamental piece of standard programming invigorates, inciting shortcoming to creating advanced risks. The striking event including ransomware at a California facility is an unquestionable indication of the potential results, as affiliations face money related setbacks as well as stain their standing concerning patient data security. While affiliations attempt to safeguard against advanced risks, composing features the significance of evidently portrayed network wellbeing commitments, strong programming overhaul frameworks, the utilization of VLANs and de-approval, cloud-based handling, and exhaustive client planning. These frameworks, though fruitful, require advancing thought and hypothesis to acclimate to the reliably changing risk scene. The urgency of this calculated composing overview lies in its update to a past work disseminated in 2016. This overview means to recognize and assess late organization wellbeing designs, with a specific focus on ransom ware, investigating their repercussions for the clinical consideration region. With generally 90% of clinical consideration providers experiencing data breaks over the latest two years and a 125 percent flood in computerized attacks starting around 2010, obviously a proactive method for managing network wellbeing is basic.

3. Methods

1. Development of Review Structure and Criteria for Selection:

The team structured their systematic assessment based

on the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). To be considered for this assessment, articles needed to have been released within the past decade and must be accessible in full-text format through databases like PubMed (MEDLINE), CINAHL, or ProQuest. Furthermore, the publication needed to be recognized as a peer-reviewed or academic journal.

2. Sources of Information:

To collate relevant literature on cybersecurity and its recent developments, the team looked into three distinct databases. These included the Cumulative Index of Nursing and Allied Health Literature (CINAHL) and PubMed (MEDLINE complete) through EBSCO Host, alongside Nursing and Allied Health Source provided by ProQuest. A consistent search parameter was applied across these platforms, encompassing the terms (Cybersecurity AND Healthcare) OR Ransomware, as showcased in Fig. 1.

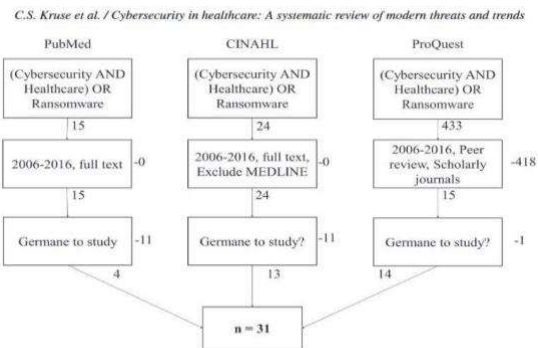


Fig. 1. Literature search process with inclusion and exclusion criteria.

3. Process of Searching:

Encountering initial setbacks during the literature search phase, the team eventually overcame these through the application of Boolean operators and a process of trial and improvement. Despite employing the same search criteria across the board, PubMed and CINAHL returned minimal results. ProQuest, on the other hand, yielded more substantial findings upon applying filters - specifically those for peer-reviewed and academic journals. A minimum of three researchers independently scrutinized the gathered literature, summarizing their findings. Acceptance of literature into the study was contingent upon its relevance, decided through a rejection process if a

consensus of irrelevance was reached by at least two team members.

4. Selection of Studies:

Out of the 472 articles uncovered using the cybersecurity OR ransomware search terms, many pertained to news pieces due to the novelty of ransomware, in contrast to the journal-oriented nature of cybersecurity literature. Ultimately, 31 articles made it to the final selection. Gathering Data and Merging Findings: Through multiple consensus meetings, the reviewers discussed their findings and progress. Initially, applying filters left them with 54 articles. These were then distributed evenly for review, ensuring each piece was analyzed by at least a pair of reviewers. Disagreements were resolved in a “why” session, where each reviewer justified their stance until a mutual decision was reached, narrowing down the selection to 31 articles for final analysis. The same collaborative method was employed for detailed article analysis, with discrepancies also addressed in consensus meetings.

5. Bias and its Implications:

Given the relatively recent emergence of ransomware within the healthcare sector, there's a scarcity of studies conducted through randomized control trials. This scarcity likely introduces a publication bias, thus limiting the scope of data available for a comprehensive analysis.

4. Discussion

Summary of evidence: The issue of cyber attacks has been acknowledged by the U.S. government, leading to new security requirements under HIPAA and the HITECH act. These changes compel healthcare entities to enhance their cybersecurity practices. The HITECH act has updated HIPAA’s security rule to ensure that healthcare organizations have updated policies to combat data breaches. Healthcare entities are now adopting various techniques to counter cyber threats, such as defining cybersecurity duties for employees, upgrading software procedures, implementing VLAN, deauthentication, creating breach plans, utilizing cloud computing, and training employees to be vigilant about cybersecurity. The most emphasized security measure in the literature is effective employee training, as most security breaches are a result of employee actions like accessing malicious files.

Limitations: Researchers encountered several



limitations during the study. Firstly, due to the novelty of ransomware, there were limited academic articles addressing the topic, leading to constrained search results. Furthermore, network safety, particularly in medical care, is a tremendous subject, making it trying to precisely recognize all outer and inner dangers and patterns. In conclusion, the review zeroed in fundamentally on the American medical services framework, consolidating just English articles applicable to the U.S. wellbeing framework.

Conclusion: The healthcare industry faces digital dangers essentially because of fast mechanical progressions and developing government approaches. As medical care IT framework wrestles with new innovations and security conventions, it turns into an ideal objective for clinical data burglary. While progress has been made by security firms and the public authority to diminish digital assaults' pervasiveness, the medical care area slacks in protecting basic information contrasted with different businesses. Reliable variety to creating network security perils like ransomware is imperative to shield clinical consideration development and patient information protection from unapproved access. Put assets into staying aware of and ensuring clinical benefits advancement security.

5. Conclusion

The deliberate survey shows a security weakness in the medical care area, particularly concerning arising dangers like ransomware. Dissecting 31 articles features the business' lacking safety efforts contrasted with different areas. To handle this issue, medical services foundations should speedily appoint online protection jobs, lay out conventions for programming updates and information break reactions, use estimates like VLANs and deauthentication, and embrace secure cloud-based processing. Similarly basic is giving client preparing to distinguish and forestall malignant code associations. Given the medical care area's powerlessness to clinical information burglary and its lacking information assurance framework, vital interests in assets and time are fundamental. Safeguarding medical care innovation and saving patient data secrecy require an exhaustive system to limit unapproved access. The discoveries underline the need for medical care associations to focus

on network safety rehearses lined up with industry guidelines to shield the honesty and security of clinical information.

6. References

- [1] Centers for Medicare & Medicaid Services [Internet]. Electronic health records (EHR) incentive programs Baltimore, MD: CMS; 2016. URL:<https://www.cms.gov/RegulationsandGuidance/Legislation/EHRIncentivePrograms/index.html?redirect=/ehrincentiveprograms>. Accessed: 2016-08-09. (Archived by WebCite R© at <http://www.webcitation.org/6je8QNlo0>).
- [2] CW Jobs [Internet]. London, UK: 2016. Cyber crime timeline; URL:<http://www.cwjobs.co.uk/careers-advice/it-glossary/cyber-crime-timeline>. Accessed: 2016-08-09. (Archived by WebCite R© at <http://www.webcitation.org/6je8V9cyI>).
- [3] U.S. Department of Health and Human Services. Security standards: technical safeguards [Internet]. Baltimore,MD:CMS;URL:<http://www.hhs.gov/sites/default/files/ocr/privacy/hipaa/administrative/securityrule/techsafeguards.pdf>. Accessed: 2016-08-09. (Archived by WebCite R© at <http://www.webcitation.org/6je8cfMpZ>).
- [4] U.S. Department of Health and Human Services. Fact sheet: ransomware and HIPAA [Internet]. Baltimore, MD: CMS;URL:<http://www.hhs.gov/sites/default/files/RansomwareFactSheet.pdf>. Accessed: 2016-08-09. (Archived by Web Cite R© at <http://www.webcitation.org/6je8iBYI5>).



Development of a Cost-Effective Dynamometer using PLC

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KEY WORDS

Dynamometer
Programmable Logic Control
Human Machine Interface
Winproladder
Load Cell
Encoder

ABSTRACT

Induction motors are widely utilized due to their simple and robust design, cost-effectiveness, and high reliability. With a broad power range and efficient operation, they offer self-starting capability and compatibility with the standard power grid, making them the preferred choice for various applications. However, these motors must be tested before any application to assess performance parameters such as speed (rpm), torque, and power. The development of a dynamometer is very beneficial for testing purposes, but traditional testing methods are often expensive and not affordable for many users. This research describes how a "Cost-Effective Dynamometer" can effectively test such parameters at a reasonable cost. The dynamometer operates with a PLC, analog modules, communication buses, and a Human Machine Interface (HMI). The components used are affordable yet effective. The encoder and load cell measure the speed and torque of the motor being evaluated, respectively. The results of these findings are displayed on an HMI. This project also aligns with the Sustainable Development Goals (SDGs), particularly goals number 8 (decent work and economic growth) and number 9 (industry, innovation, and infrastructure).

1. Introduction

In this era, the industrial sector occupies a large area and extensively uses electric motors. The industry's most popular motor by far is the AC induction motor. It is widely used due to its low purchase cost, durable design, and low maintenance requirements. AC induction motors accelerate high load inertia more rapidly and efficiently and are more dependable than synchronous motors under transient load conditions. These motors can drive pumps, fans, compressors, and conveyors by transforming electrical energy into mechanical energy. Testing and assessing the Capabilities of motors is crucial to ensure they perform at peak levels. One of the most widely used tools for testing and evaluating the performance of induction motors is the dynamometer. A dynamometer is a device used to measure the output of

engines, motors, and other machines. It can measure force, torque, and power output, test and calibrate equipment, troubleshoot problems, and optimize performance. This research aims to design and develop a cost-effective dynamometer system for induction motors using a Fatek PLC as the control system. The system will be designed to provide accurate measurements of motor performance,

Including torque and speed, while being easy to use and cost-effective compared to traditional dynamometer systems. The research will begin with a review of existing induction motor dynamometer systems, followed by a detailed explanation of the components and architecture of the proposed system. The design and implementation of the Fatek PLC-based control system will then be presented, along with experimental results demonstrating the accuracy and cost-effectiveness of the system. The data obtained will



be used to evaluate the performance of the motor, including its efficiency, power, and starting and running characteristics. The findings of this research will provide crucial Perspectives into the performance of induction motors and help optimize their efficiency and reliability. The findings will be helpful for engineers, manufacturers, and researchers in the field of induction motor technology. Additionally, it will aid in the design, testing, and optimization of induction motor systems, which is crucial for industries that rely heavily on these motors.

2. Literature Survey

The relevant literature on different approaches and practices in this field has been carefully studied and reviewed. Worldwide, much research has been done on the cost-effectiveness of dynamometers using PLC but not in Pakistan. Three Cornell University students designed a PIC32 MCU-based electric motor dynamometer to measure torque, efficiency, and power of small electric motors, but special mounting and connection considerations are required for MCUs to withstand industrial environment shock and vibration [4]. Design and development of the main engine's load characteristics, alongside PLC-compatible implementation, utilizing a water brake as a generator, in which SIEMENS PLC is used as a microcontroller which is expensive as compared to FATEK PLC, and SIEMENS sensor modules are not readily available in Pakistan's market [5]. One research had also been done in the US by the university "University of Arkansas" to design and Implement a Small Electric Motor Dynamometer for Mechanical Engineering Undergraduate Laboratory with Computer Automated Measurement and Control as a microcontroller. But PCs cannot protect the control code and execution activities from outside influences [6]. In India, research has been held for the performance Investigation of PLC Hardware for a Portable Two-Wheeler Dynamometer Test rig. Mitsubishi FX series PLCs are used as an operating unit, but compared to our proposed solution, it is expensive and does not easily avail their compatible modules and sensors [7]. Another research has been done on how to build a PID-based dynamometer; in this research, a propositional-integral-derivative control logic algorithm is used to tackle the industrial environment. The most popular control algorithm used in industry is PID

control, which is widely utilized in industrial control but has no customization option for additional usability that plays a vital role in increasing overall industry efficiency [8]. In China, Beihang University designed and simulated an electrical dynamometer utilizing a high-performance DTC induction motor on the basis of driver space vector modulation (SVM) technique. However, this dynamometer is designed to measure torque and stator current ripples only [9]. A dedicated setup for testing and analyzing electric motor performance at the University of Debrecen's Faculty of Engineering, is designed for testing prototype racing cars' motor efficiencies to improve their active duty. This project is PC based system. PCs cannot protect the control code and execution activities from outside influences [10].

3. About Dynamometer

The cost of dynamometer systems varies widely depending on the size and type of operation. Generally, larger systems are more expensive, ranging from a few thousand to several thousand dollars. The cost of operation also varies depending on the type of operation, as well as the frequency of use. Generally, larger systems require more frequent maintenance and calibration, which can increase the cost of operation. Safety considerations should also be considered when assessing dynamometers' cost-effectiveness. Most dynamometers come with safety features that help to reduce the risk of injury or damage to the equipment. These features include emergency shut-off switches, overload protection, and special guards. Several engine development operations, including the calibration of engine management controllers, thorough analyses of combustion behaviour, and tribology, can be performed on dynamometers as part of a testbed. Dynamometer for measuring hand strength testing considerations should also be considered when assessing dynamometers' cost-effectiveness. Most dynamometers come with safety features that help to reduce the risk of injury or damage to the equipment. These features include emergency shut-off switches, overload protection, and special guards. Several engine development operations, including the calibration of engine management controllers, thorough analyses of combustion behaviour, and tribology, can be performed on dynamometers as part of a testbed. Dynamometer for measuring hand strength testing the strength of your grip



Hand-held dynamometers, as they are known in medicine, are applied for initial and ongoing evaluation of hand function and strength in patients with hand damage. Athletes, patients, and workers undergo strength assessments using force dynamometers, which measure their back, grip, arm, and leg strength in rehabilitation, kinesiology, and ergonomics to assess physical status, performance, and task demands. In conclusion, dynamometers' cost-effectiveness depends on various factors, including the size and type of system, the cost of operation and maintenance, the accuracy and reliability of the system, and the safety considerations associated with its use. Generally, larger systems are more expensive but provide more accurate and reliable results. Additionally, safety features should be considered to reduce the risk of injury or damage to the equipment. The project fulfils maximum SDGs to make it economical, safe and environment friendly. This research achieves two sustainable development goals, including decent work & economic growth and industry, innovation & infrastructure.

A list of motor dynamometers manufacturers companies is listed shown in Table 1 [11].

Table 1 List of Motor Dynamometer Manufacturer Companies.

Companies	Country	Website
Application Systems	India	www.applicationsystem.net
AEP Transducers	Italy	www.aep.it
Adoorwin Industrial Limited	China	www.adoorwin.com
Hwanwoong Mechatronics Co., Ltd.	Korea	www.dytek.co.kr
Weinlich GmbH & Co. KG	Germany	www.weinlich.de

Since there is no dynamometer production in Pakistan, all enterprises must import expensive dynamometers, including import duty expenses. The proposed project is an essential step to ease dynamometers' availability and repair services; it is also economically effective.

4. Design Methodology

The following steps shows how to develop a cost-effective dynamometer to get the following results:

- First, we conducted a literature review on the project to determine how much work is involved and how it may be completed. We read nearly seven research articles for this, and we gained a lot of knowledge.
- After that, a list of the equipment required for this study is designed. Then decide which of the equipment options is best for our project.
- An analogue sensor load cell of 100kg by Tin Hang Technology Limited, YH-T7E communication port, the incremental encoder of 500 pulses per revolution by Hubner Berlin Encoders, 7-inch HMI by Weintek, PLC

microcontroller by Fatek FBs20MAT2-AC, dc generator by Siemens, FBs-CB25 and RS-232 communication cable.

- are selected. These selected components are shown in Figure 1.



Figure 1. Selected Components

- The software which is selected to program our PLC is win-pro-ladder version 51.52.0.0.
 - The accuracy and reliability of dynamometers also play an essential role in their cost-effectiveness. Generally, higher-end systems provide more accurate and reliable results. This is due to the use of more advanced sensors, as well as the use of more sophisticated software. After selecting sensors, the next step is calibrating sensors by connecting them with PLC.

4.1 Torque from the Load Cell and YH-T7E

In this section, measurement is performed to calculate torque.

- The data transferred from the load cell through YH-T7E is in ASCII.
- First, with the help of ladder logic, this serial data is converted into floating form.
- This data is the weight of the rotating motor produced by the moment arm on disc attached on the load cell.
- The weight is converted into force by this calculation.

$$F = m \times a \quad 4.1$$

$$F = w \times g \quad 4.2$$

- Torque is derived from exerted force and moment arm by equation 4.3.

$$T = F \times l \quad 4.3$$

4.2 Revolutions Per Minute from the Encoder

In this section, measurement is performed to find the motor's RPMs under test from PPR.

PPR is specified on the encoder.

To achieve real-time RPM, average data values are arranged according to the revolution in data per second.

Set two values as CV and PV. Initially, set the previous value to zero.

RPM is obtained from scaling through ladder logic code steps.

[6] Simulation and Results

5.1 Results for Load Cell

The results on the status page are shown in Figure 2. This status page shows all converted results from ASCII data to decimal data obtained from load cell. The communication setup involves the transmission of data via the RS232 serial communication port. The YH-t7E device is connected to a programmable logic controller (PLC) through the FBs-CB25 expansion module. This communication link facilitates the exchange of information between the YH-t7E and the PLC, allowing for seamless integration and control. The RS232 protocol serves as the communication medium, ensuring reliable data transfer between the devices.



Ref. No.	Status	Data	Ref. No.	Status	Data	Ref. No.	Status	Data
R200	Decimal	48	R220	Hexdecimal	0100H			
R201	Decimal	49	R221	Decimal	0			
R202	Decimal	50	R222	Decimal	100			
R203	Decimal	0	R223	Decimal	0			
R204	Decimal	55	R224	Decimal	0			
R400	Decimal	18	R109	String	'a'			
			R110	String	'0'			
			R111	String	'6'			
DR252	Floating	18.759998	R112	String	'7'			
			R113	String	'.'			
			R114	String	'2'			
			R115	String	'1'			
M4	Enable	ON	R116	Decimal	48			
DR282	Floating	18.759998	R1012	Decimal	0			
DR284	Floating	187.59998						

Figure 2. Results of load cell on the status page

5.1 Results for Encoder

The result is shown in register DR112, Figure 3.

Ref. No.	Status	Data	Ref. No.	Status	Data
DR102	Floating	-84335	R4096	Decimal	-19008
DR104	Floating	-83081			
DR106	Floating	-1254			
DR108	Floating	-12540	DR112	Floating	-1504.7999
DR110	Floating	-25.08			
DR112	Floating	-1504.7999	DR98	Decimal	-945506432

Figure 3. Results of encoder on the status page

6. Conclusion

In conclusion, this Research has been successful in addressing the construction of a low-cost dynamometer that uses a PLC as its primary control system. The dynamometer system provides dependable and precise data-collecting capabilities by integrating a load cell for torque measurement and an encoder for RPM measurement. The current system represents a considerable breakthrough in terms of accessibility and functionality, notwithstanding the possibility of implementing changeable test circumstances in the future. Utilizing a PLC allows for easy integration and scalability for possible industrial applications in addition to accurate control and monitoring of the dynamometer. The system's usefulness in monitoring and analysing the performance traits of various motors is demonstrated by the findings. The cost-effective technique presented in

this thesis advances dynamometer technology and may be used by researchers, engineers, and businesses engaged in motor testing and analysis.

7. Reference

- [1] M. H. Rashid, Power electronics handbook: devices, circuits, and applications. Burlington, Ma: Butterworth-Heinemann, 2011.
- [2] "Dynamometer," Wikipedia[Online] Available at: <https://en.wikipedia.org/wiki/Dynamometer> (Accessed: 12 April 2023).
- [3] S. Hamada, T. Takahashi, N. Kezuka, M. Kouketsu and S. Ishigaki, "Inverter Drive of Dynamometers for Automotive Evaluation System," in 2018 International Power Electronics Conference, Niigata, Japan, 2018, pp. 227-232.
- [4] E. Y. Shi Aasta Gandhi, & Kowin and E. Y. Shi Aasta Gandhi, & Kowin, "Build a Motor Dynamometer," Aug. 01, 2021. <https://circuitcellar.com/research-design-hub/projects/build-a-motor-dynamometer/>
- [5] M. Markert, H. Schmidt and M. F. R. Ardyatama, "Development of Load Characteristic of Main Engine and Its PLC Compatible Preparation in Cooperation with Water Brake as Generator," in International Journal of Marine Engineering Innovation and Research, Vol. 1, no. 4, pp. 284-294, sept. 2017.
- [6] A. Farley, "Design and Implementation of a Small Electric Motor Dynamometer for Mechanical Engineering Undergraduate Laboratory," M.Sc. thesis, Dept. Mech. Eng., Univ. of Arkansas, Fayetteville, US, 2012.S. Maniar, A. Umbarkar and O. Morbale, "Performance Investigation of PLC Hardware for Portable Two-Wheeler Dynamometer Test Rig," in IOP Conf. Series: Materials Science and Engineering, India, 2021, pp. 1-11.
- [7] P. Kulkarni and C. Kadu, "PID based Dynamometer used in engine test", International Journal of Scientific & Engineering



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- Research, Vol. 6, 7, pp. 343-349, July 2015.
- [8] Cheng-li, Yan-Zhong and Liang-Wei, “Design and simulation of electrical dynamometer using improved DTC induction motor driver,” Journal of Central South University, Vol. 24, 6, pp. 1360-1368, 2017.
- [9] G. A. Sziki, A. Szanto, J. Kiss, G. Juhasz and E. Adamko, “Measurement System for the Experimental Study and Testing of Electric Motors at the Faculty of Engineering, University of Debrecen,” Journal of Appl. Sci., Vol. 12, 19, pp. 1-50, 2022.
- [10] “Dynamometer manufacturing countries,” Listcompany.net [Online]. Available: https://www.listcompany.org/Aep_Transducers_Info.html.



An In-Depth Analysis of Cross-site Scripting (XSS): Threats, Mechanisms, and Mitigation Strategies

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ABSTRACT

Cross-site Scripting (XSS) presents a significant security threat in the realm of web applications, posing risks to both data integrity and user privacy. This paper delves into the intricacies of XSS attacks, elucidating their methodologies and far-reaching implications within the cybersecurity domain. Through a meticulous literature review and case analysis, the paper sheds light on the multifaceted impact of XSS, emphasizing the urgent need for robust defence mechanisms against these exploits. The primary objective of this research is to offer a comprehensive examination of XSS, covering its diverse types, attack vectors, and preventive measures. The document is structured as follows: an extensive review of existing literature to contextualize XSS within the cybersecurity landscape, a detailed exploration of XSS types and associated attack vectors, and a conclusive section that synthesizes crucial findings and provides actionable recommendations for mitigating XSS vulnerabilities in web applications.

Introduction

Cross-site Scripting (XSS) is a serious issue in the field of cybersecurity, where individuals attack websites with the intention of injecting malicious scripts into them. Despite its long existence, web application security has not been able to overcome XSS threats completely, necessitating the need to delve deeply into it. The purpose of this paper is to examine how XSS attacks work, establish their effects and suggest appropriate ways to counter them. In recent years, XSS has become an important aspect of web security with increasing reliance on web-based services by businesses. It creates doubts in users' minds and disturbs data integrity making it a difficult challenge within web application security itself.

What is Cross-site scripting?

When we talk about Cross-scripting, also called XSS, it's a serious web security issue. Attackers can trick a user's actions with a software tool. This opens up a way for them to get around set safety features measures that should limit harmful acts between websites. XSS bugs often lets bad guys wear a user's "mask." They can do what the user does and even sneak into and grab the user's important stuff, like their session cookies. XSS

breakdown comes in two flavours: one that sticks around (persistent) and one that doesn't (non-persistent) [1]. These types can be found in two places: the usual server-side code problems (traditional) and in code on the user's end (DOM-based).

In web applications, non-persistent XSS vulnerabilities could let harmful sites attack users while logged in. This type of cross-site scripting flaw is basic among web threats. These weaknesses surface when data is transferred by a web user, typically through HTTP query parameters like HTML form submission. They hit directly when the server-side of a web app composes a page and shows it to a client without appropriate cleaning. HTML documents have a flat, serial layout that blends control instructions, formatting, and content. Dangerous lines can be crossed when non-checked user data finds its place on the final page without suitable HTML coding, resulting in markup injection. [5] Persistent XSS vulnerabilities stand out. They're worse than others. An attacker's harmful script runs even when there's no initial intention to personally target victims or send them to another website. The code spreads, especially across social network accounts. It forms what you may call a client-side- worm.

When do cross-site scripting attacks occur?

- 1) Online apps often get shady data, usually through a web request.
- 2) That data is popped into content for users, without a malware- scan first

Bad stuff online can come in many forms. It's often coded in JavaScript, but you can also find it in HTML, Flash, or other languages that computers use. The aim? To get your private info. They might want to snatch your cookies or session details. Or maybe redirect you to a site they control. That's not all. They might even use your computer to pull off their dirty tricks, all while pretending to be a trustworthy site!

How JavaScript Can Be Used For Attacks.

JavaScript that is deemed risky has the same page privileges. This includes seeing the user's cookies. Cookies usually contain session tokens. If a harmful player snags a user's session cookie, they can pretend to be them. They can even perform actions as the user. Worse yet, they can view the user's private info.

JavaScript lets you alter the browser's DOM without limitations. But, it's possible only on pages where JavaScript is enabled.

Using the XMLHttpRequest object, JavaScript can send HTTP requests with unique content anywhere.

Modern browsers' JavaScript can tap into HTML5 APIs. So, it can get user's location, webcam, microphone, even certain system files. While most APIs ask for user's permission, tricksters can bypass it through social engineering.

When blended with manipulative tactics, it gives bad actors the tools to perform complicated attacks. They can grab cookies, plant trojans, record keystrokes, trick people, and steal identities.

Types of xss attacks

1. Reflected XSS Attacks

A "reflected attack" happens when a script is sent to the web server. It then bounces back and appears in things like an error message or search result. This message is partly or wholly made up of the sent script [3]. The victims of these attacks usually find out through email or a different website. The bad code gets sent to a website that's vulnerable. Then, it sends the attack to the user's browser. This happens when the user is tricked into

clicking on a harmful link, filling out a specific form, or visiting a rogue website. The browser runs the code since it thinks it's from a "trusted" server.

2. Stored XSS Attacks

Stored attacks occur when the malicious script sneaks into the server and stays there for good. This can happen in databases, message boards, visitor logs, even in the comment box and others. The victim unknowingly asks for this 'poisoned' data and the server, not knowing better, sends it back. This type of attack goes by other names too. Some call it persistent or even Type II XSS.

3. DOM Based XSS

As a type of XSS attack, DOM-Based XSS is carried out

```
<html>
<h1>Most recent comment</h1>
<script>maliciousCode(); </script>
</html>
```

FIGURE 3. Modified HTML code.

by manipulating the DOM "environment" in the victim's browser that was created by the original client-side script to include the attack payload. The repercussions of this action are that the client-side code will behave in an "unexpected" manner even though the page itself (the HTTP response) does not change due to this malicious modification of the DOM environment. This is distinct from other types of XSS attacks (stored or reflected) where the attack payload appears on the response page due to server-side vulnerabilities.

How cross-site scripting works? — Review

The attacker's payload, or malicious code, is placed on a webpage. When the victim visits the webpage, the malicious JavaScript code initializes the attack which runs in the victim's browser. The victim visits the website with the malicious code. The attacker phishes or socially engineers the victim to get them to visit the malicious URL. As shown in Figure 1, the attack is

```
"<script>maliciousCode();</script>"
```

FIGURE 1. A vulnerable comment section.

performed with these specific lines of code entered into the website's input area.

FIGURE 2. Shows the most recent remark on a webpage, which would be the script tag now embedded into the

webpage.

```
print "<html>"
print "<h1>Most recent comment</h1>"
print database.latestComment
print "</html>"
```

FIGURE 2. Snippet of a server-side pseudocode.

```
</script>
```

FIGURE 4. Client-side script.

You'll note that our script above is simply writing out the very latest comment into an HTML page after being retrieved from the database. We assume that the comment is just text; there are no HTML elements or other codes in the printed comment. Of course, the above approach is susceptible to XSS, as malicious payload could be posted in the comment by an attacker.

Now, whenever a user views the webpage, the web server sends out the following HTML your way:

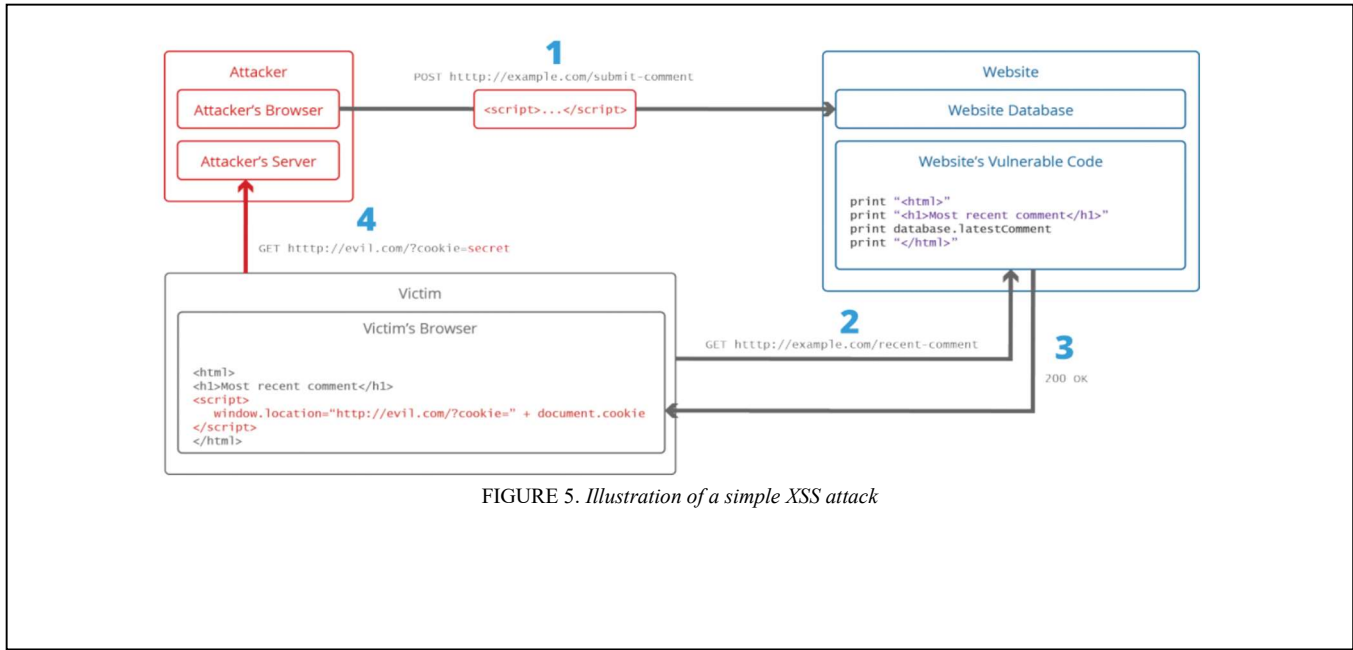
The malicious script the attacker has included in the

webpage is now executed when your browser loads the page, and you are none the wiser nor capable of ending it.

How XSS is Used by Attackers to Steal Cookies

XSS in general is a very typical scam for cookie theft - the attacker, with the help of XSS, defines the document.cookie string, which includes the victim's login cookie. This enables the attacker to impersonate the victim. The attacker can later easily get the cookie to their server in any number of ways - for example, one such variant of client-side script might be: FIGURE: 5 shows a step-by-step breakdown of a simple XSS attack.

By submitting a susceptible form containing malicious JavaScript code, the attacker inserts a payload into the website's database.



The victim requests for a webpage via the web server. The web server offers the webpage containing the attacker's payload as HTML body to the user's browser. The user's browser then executes the malevolent scripting that is part of its HTML page running, transmitting this victim's cookie back to attacker's server.

From there, all he needs to do is wait for the HTTP request coming towards his own server and get at victim's cookie while using hijacked cookie for impersonation.

XSS Attack Repercussions

The result is always the same whether stored or reflected XSS attack (or DOM-based). But, how its payload gets



to the server differs. Do not trust a read-only or brochureware web page that it is safe from dangerous reflective XSS attacks. In case of cross-site scripting (XSS), this may mean anything from minor inconvenience to hijacking one's account. The trickiest XSS hacks can allow an attacker to take charge of an account, and using the user's session cookie, hijack their session. Other malicious attacks include trojan horse software installation, end-user file disclosure, user redirection to other sites or changing website content (content spoofing).

Real-World Examples

A XSS vulnerability could be exploited by a hacker to alter dosing information on a pharmaceutical website, possibly resulting in drug overdose, or to modify press releases or news items that change a company's share price or consumer confidence. Some actual cases can be used as examples of just how important XSS attacks are. For example, stored cross-site scripting attack (XSS) led to user data compromise and loss of trust on social media platforms. There is an XSS vulnerability in the web client for WhatsApp discovered by a security researcher. The attacker could send a well-crafted message containing malicious code. Upon receiving the message via the web client, the code executed [4]. In another instance, one popular online store was hacked resulting in significant financial losses and damage to its reputation.

Cross-site scripting Attack Vectors

Any of the XSS attack vectors given below can be used by an attacker to bypass security on a web page or web application.

The `<script>` tag is a straightforward and effective way of carrying out the XSS payload. JavaScript code may be placed inside a `<script>` element or referenced from another location.

JavaScript events are inherent within several tags in JavaScript, for instance `onload` and `onerror`. This is one of the most popular vectors for XSS attacks.

In body tag, for example, we can insert an XSS payload using event attributes or other less conspicuous properties like `background`.

Some browsers also execute JavaScript that is included in the `img` attributes.

Using `<iframe>` tag, you can incorporate another HTML page into a current one. However, even if JavaScript was included in an `IFrame`, it would not be able to access DOM of its parent page due to Content Security Policy enforced by browser. However, `IFrames` continue to be

a good way for executing phishing attacks.

`<input>` Tag—It is probable that changing the input tag in some browsers would cause a script to be embedded once type property is `image`

`<link>` Tag—Scripts can be used with the link tag which is generally used to provide links to external stylesheets.

`<div>` Tag—The `div` element acts like both the `table` and `td` tags as it can define a background and contains a script.

`<object>` Tag—The object tag allows inclusion of scripts from an external website.

Cross-site scripting mitigation strategies — Methodologies

Stopping cross-site scripting, or XSS, isn't easy. How well you can stop it depends on the kind of programming you're using, how you use user input, and the specific kind of XSS problem you're dealing with. But, there are some broad tips to help keep your web stuff safe. A great resource is the OWASP XSS Prevention Cheat Sheet which talks about the main ways to protect against XSS. Another helpful tool is the OWASP ESAPI project. They've made a bunch of security tools in different coding languages, including ways to check and keep bits of code safe so people can't mess with them or put in harmful XSS codes. Plus, for learning how to deal with data correctly and understand more about XSS, the OWASP WebGoat Project has some training that's worth checking out.

How to Recognize the Vulnerabilities

Checking the code for any security issues and finding ways someone could enter unwanted data through a web request into the website's display are the best methods to spot weak spots. Remember, harmful JavaScript can sneak in through many different parts of a website. While they have their limits, programs like Nessus or Nikto can help check a site for these weak spots. Often, if there's one security hole found on a website, there might be more.

General Strategies to Mitigate XSS

Keeping Your Online Application Safe: Making sure your online app is secure is super important. Everyone who works on it - like your coders, QA team, DevOps folks, and system admins - needs to know about the dangers of XSS (that means cross-site scripting) and get the right security training

Don't Just Trust What Users Type In: Always be cautious with the stuff users put into your app. If their input ends up on your webpage, it could cause trouble



because of XSS. Treat everything users enter, even if they're logged in or part of your team, as if it could be risky.

Be Smart with User Input: Depending on how you're using what users' input, you might need to "escape" or encode it to keep things safe. If you have to do this, try using libraries that already exist for this job. But if you can't find one that fits, you might need to create your own.

Clean Up HTML: Sometimes, you can't just escape or encrypt what users enter, especially when you need to allow some HTML. In these cases, use a library that's been checked out and trusted to clean up the HTML. Make sure the library works with the coding language you're using.

Protect Cookies With the HTTPOnly Flag: This trick stops those sneaky XSS attacks from getting to your cookies through JavaScript on the client side.

Set Up Content Security Policies: Content Security Policies, or CSPs, are like setting rules for your app that say which dynamic resources are okay to use. These policies are set in the HTTP response header to help stop XSS vulnerabilities from causing problems.

Check often: Your team or outside tools can accidentally add XSS (cross-site scripting) risks. Make it a habit to use a tool that finds web app weaknesses often.

XSS attack prevention mechanisms

Taking a deeper look into how XSS (cross-site scripting) attacks happen, we find many different tactics and methods being used. The most effective way to stop these attacks is through filtering and escaping [12]. Basically, defending against XSS attacks usually involves two main approaches.

- 1) Validate input on arrival.
- 2) Encode data for output.

Validate input on arrival / Filtering.

The only and, possibly, the most truthful technique of doing away with cross-web page scripting vulnerabilities is to send all input via a clear out. A filter could dispose of hazardous keywords like the <script> detail, JavaScript instructions, CSS patterns, and HTML markups containing occasion handlers. Many internet builders construct their personal XSS screening methods. They generally write server-aspect code (in PHP, ASP, or another web-enabled programming language) that looks for keywords and replaces them

with empty strings. Although this tactic is not intrinsically unfavourable, hackers regularly have greater revel in than web page builders and might frequently get beyond easy filters via leveraging strategies such as hex encoding, Unicode man or woman variations, line breaks, and null characters in strings. All these tactics ought to be addressed, that is why it's miles pleasant to use a library that has been tried and tested with the aid of the community.

Whitelisting vs Blacklisting

Input validation must regularly hire whitelists in place of blacklists. Instead of generating a listing of all volatile protocols (e.G., JavaScript, facts), develop a list of safe protocols (e.G., HTTP, HTTPS) and limit everything else. This guarantees that your safety does now not smash whilst new unstable protocols seem, and it makes it less prone to attacks that try to conceal erroneous information to keep away from a blacklist.

Filtering strategies have an unintentional effect of putting off legitimate textual content as it consists of banned terms. Any article, for instance, could be incomplete if the web server just erased all HTML markup. Texts consisting of <script> and alert("") are tough to encompass. If you need to maintain the original information (and its formatting) as intact as possible, loosen your filters and rent HTML, Script, and CSS escape strategies.

Encode data on output / Escaping.

Avoiding XSS attacks primarily involves escaping. By

```
<a href="#" onclick="x='This string needs  
two layers of escaping'">test</a>
```

FIGURE 8. Two layers of escaping.

deciding on to get away, you are basically informing the net browser that the facts you are transmitting desires to be handled as data and not processed otherwise. The sufferer is unaffected due to the fact, if the script is efficaciously escaped, the browser won't run it. Hazardous characters in HTML can be escaped by way of making use of HTML entities which includes the &# sequence followed by the character code. Before writing any user-controllable statistics to a page, encoding should be entire for the reason that type of encoding required relies upon on the situation. For instance, values in an HTML context require a one-of-a-kind sort of escaping than values in a JavaScript string.

In an HTML environment, non-whitelisted values need

to be transformed to HTML entities.:

- `<` converts to: `<`;
- `>` converts to: `>`;

In the

FIGURE 6. Escaping in HTML context.

JavaScript string context, non-alphanumeric values have to be Unicode-escaped.:

- `<` converts to: `\u003c`
- `>` converts to: `\u003e`

FIGURE 7. Escaping in JavaScript context.

include person enter into an event handler, as an instance, you need to don't forget each the HTML and JavaScript contexts. Thus, the enter ought to first be Unicode-escaped before being HTML-encoded.

Escaping HTML is simple. To maintain online utility safety, you should also escape JavaScript code, Cascading Style Sheets, and, in some situations, XML facts. There are numerous dangers if you attempt to accomplish all the fleeing on your very own. Here is where an get away library is available in on hand.

When to perform escaping?

You cannot just break out the whole lot; else, your scripts and HTML markup would fail, rendering your page useless. There are various regions to your website that ought to be correctly escaped.

HTML Escaping: When untrusted data is positioned among HTML opening and remaining tags, use HTML escaping.

JavaScript Escaping: When untrusted statistics is injected into considered one of your scripts, or whilst

FIGURE 10. Untrusted

```
<div style="background-image: If this data is untrusted, it must be CSS-escaped.">
```

data that can be CSS escaped.

doubtlessly malicious JavaScript is delivered, use JavaScript escaping. This applies to all event handlers, including onmouseover and onload, in addition to specific HTML homes such as style.

CSS Escaping: When untrustworthy information is injected into your CSS styles, utilize CSS escaping. A script can be smuggled into your website whilst you operate a number of inline CSS styles. Allowing "safe" HTML Although it is most efficient to keep away from permitting customers to enter HTML markup, there are

times when it's far required for business. For example, a weblog website might also permit comments to be made using a tiny quantity of HTML. The standard technique is to try and filter JavaScript and potentially harmful tags. You can strive to perform this with a whitelist of safe tags and houses., however it's far very hard to put into effect this securely due to differences in browser parsing engines.Client-Side XSS prevention: Using a JavaScript library like DOMPurify. The trade approach involves filtering and encoding in the consumer's browser. Users can supply markdown material and feature it transformed into HTML the usage of other libraries.

Prevention of DOM Based XSS

```
<body onload="If this data is untrusted, it must be JavaScript-escaped.">  
<script>alert('If this data is untrusted, it must be JavaScript-escaped.')</script>
```

FIGURE 9. Untrusted data that can be JavaScript-escaped.

It is especially frequent when packages use wellknown JavaScript function calls like record.BaseURI to construct a phase of the web page with out sanitization [11]. The number one rule for stopping DOM XSS is to sanitize any untrusted facts, even supposing it is most effective utilized in patron-facet scripts. If you should use person enter to your page, only accomplish that in

```
$title = sanitize_text_field( $_POST['title'] );  
update_post_meta( $post->ID, 'title', $title );
```

FIGURE 11. Sanitizing the data

the text context, never as HTML tags or some other ability code. Use report.InnerText and record.TextContent instead of strategies together with report.InnerHTML. If viable, avoid the usage of user enter, specifically if it impacts DOM additives like file.Url, file.Region, or record.Referrer. Also, the use of JavaScript methods like eval() in a extensive manner is fallacious since it permits a textual content to be parsed as JavaScript code, which can be dangerous. It is important to recollect that DOM XSS and other sorts of XSS aren't at the same time specific. Your software may be prone to both pondered/saved and DOM XSS. The right information is that you ought to be capable of avoid any XSS vulnerabilities if user enter is treated successfully at the fundamental level.

Prevent XSS using a template engine

Modern websites often use server-side template engines, which include Twig and Freemarker, to incorporate dynamic content into HTML. Usually, they provide their



very own ways of escaping. Other template engines, like React and Jinja, avoid maximum instances of XSS via default escaping dynamic content. It is suggested to carefully look at an engine's or framework's get away capabilities before figuring out whether to apply them.

Server-side XSS prevention: On the server aspect, you can accomplish sure degrees of protection with the aid of the use of HTTP headers. Some browsers provide this method of shielding against XSS attacks. When the browser detects an XSS attack, it executes a couple of protection measures depending at the parameters inside the reaction header. This defence method prevents the web application from loading insecure sections containing the XSS attack script. As previously indicated, HTTP headers may be used to construct server-aspect security; but, programmatic protection is also a opportunity. Using the computer language PHP, that's used for WordPress improvement, it makes feel to sanitize statistics, specifically that generated by way of input fields. Because PHP is displayed at the server-facet, the data to be communicated may be sanitized earlier than it is added. An input containing a malicious script can be defused using the code shown in FIGURE 11. Mitigating XSS Using Content Security Policy

The content protection policy (CSP) [9] serves because the final layer of protection towards cross-website scripting. If your XSS safety fails, you could use CSP to restriction an attacker's moves. A Content Protection Policy (CSP) offers a further layer of protection for a web software, protective it from injection threats like XSS. It lets in you to restrict the browser, and as a result the internet utility, to handiest load scripts from depended on assets.

CSP lets in you to manipulate numerous settings, inclusive of whether outside scripts may be loaded and whether or not inline scripts are done. To use CSP, encompass your policy in an HTTP response header referred to as Content-Security-Policy. Typically, a server administrator releases a listing of domains, or

best the server's own, as a honest source. If you desire to load only scripts from your personal domain, it looks as if this: This also can be precise as an HTML meta tag

This tenet states that assets including pix and scripts should be loaded from the equal origin as the primaryweb page. As a end result, despite the fact that an attacker injects an XSS payload effectively, they

can most effective access assets from the contemporary starting place. This drastically reduces the possibility of an attacker exploiting the XSS vulnerability. If you require outside sources to load, be sure the scripts you allow do now not allow an attacker to make the most your internet site. If you whitelist positive websites, any script from those sites may be loaded through an attacker. Try to host sources to your own domain wherever feasible. Discussion We have looked at numerous assault vectors, maximum considerably the ones that result from person inputs which have no longer been nicely sanitized in locations like remarks, URLs, and shape fields. Attackers may additionally use these vulnerabilities as access factors to insert malicious scripts, which would possibly bring about the theft of consultation tokens, cookies, or redirection to dangerous websites. Cross-site scripting (XSS) attacks are available numerous types: DOM-primarily based, contemplated (non-chronic), and saved (everlasting), each with precise dangers. One of the main problems with internet utility security is vulnerabilities. Our exploration delves into proposed methodologies for mitigating XSS vulnerabilities, recognizing that every assault type carries particular traits traumatic particular countermeasures.

Gurvinder Kaur [13] tackles the challenges posed by means of go-website online scripting (XSS) attacks, offering a streamlined -tier technique. The first tier makes a speciality of detecting each persistent and non-persistent XSS attacks in the MVC2 architecture of the server. The controller, responsible for dealing with client requests, scans parameters for capability XSS threats by matching them against predefined units of expressions. Any recognized attack results in an instantaneous redirection of the client returned to the originating web page, stopping the malicious request from progressing past the controller.

The second tier entails deploying a compact JavaScript code, called the DOM assault detector script, that's blanketed with every server reaction and achieved at the customer side. This script objectives to prevent DOM-based XSS attacks, enhancing the general protection of the gadget. Although the

```
Content-Security-Policy: default-src 'self'
```

FIGURE 12. CSP Header

proposed approach claims to be complete in its

```
<meta http-equiv="Content-Security-Policy" content="default-src 'self'; script-src 'self'">
```

FIGURE 13. HTML Version Of The Header



potential to stumble on all varieties of XSS attacks, it is critical to note potential alternate-offs. While it does not require extra infrastructure or depend on a complicated framework, there's a overall performance overhead associated with a reaction put off.

In essence, Kaur's method offers a balanced solution for XSS safety, leveraging server-facet detection and purchaser-side prevention. The performance of the technique need to be weighed against the slight delay added and the absence of a want for extra infrastructure or complex frameworks.

CONCLUSION

The XSS assault sticks out as one of the maximum common threats to internet packages, capable of exposing touchy person or company profile facts. This paper aimed to clarify XSS attacks, categorize their kinds, and determine prevention strategies alongside their limitations. A two-tier technique is then introduced and verified to be a greater powerful approach.

Despite the sizable adoption of net services throughout various industries for their benefits at the World Wide Web, a regarding trend persists. Many entities, to reduce expenses, forget the safety of the web sites they set up. This not only jeopardizes user protection but additionally poses dangers to the corporations themselves. The incidence of internet applications necessitates the established order of a robust and comprehensive framework for stopping XSS assaults and different critical threats to internet software protection.

REFERENCES

1. Rodriguez G.E.; Torres J.G.; Flores P, Benavides D.E., "Cross-site scripting (XSS) attacks and mitigation: A survey," Computer Networks 2020.
2. Cross Site Scripting:
<https://www.acunetix.com/websitesecurity/cross-site-scripting/>
3. "OWASP's XSS (Cross Site Scripting) Prevention Cheat Sheet"
<https://owasp.org/www-community/attacks/xss/>
4. Land2Cyber. (2023, OCT. 20). Real-world examples of XSS attacks and how they were executed [Online]. Available: <https://medium.com/@Land2Cyber/real-world-examples-of-xss-attacks-and-how-they-were-executed-531e0e33e85b>

5. Al-Khurafi O.B.; Al-Ahmad M.A. Survey of web application vulnerability attacks. 2015 4th International Conference on Advanced Computer Science Applications and Technologies (ACSAT). IEEE, 2015.
6. OWASP's XSS (Cross Site Scripting) Prevention Cheat Sheet
https://cheatsheetseries.owasp.org/cheatsheets/Cross_Site_Scripting_Prevention_Cheat_Sheet.html
7. OWASP Enterprise Security API (ESAPI)
<https://owasp.org/www-project-enterprise-security-api/>
8. OWASP WebGoat;
<https://owasp.org/www-project-webgoat/>
9. Mozilla Developer Network; "Content Security Policy (CSP)"
<https://developer.mozilla.org/en-US/docs/Web/HTTP/CSP>
10. Mozilla Developer Network; "Comparison of HTML parsers"
https://en.wikipedia.org/wiki/Comparison_of_HTML_parsers
11. Acunetix; How to prevent DOM based Cross Site Scripting
<https://www.acunetix.com/blog/web-security-zone/how-to-prevent-dom-based-cross-site-scripting/>



Social Media Crisis Communication: Exploring its Influence on Organizational Reputation beyond Breaches

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KEY WORDS

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ABSTRACT

Social media platforms play a crucial role in modern communication but also pose risks like data breaches and privacy concerns. This research examines crisis communication strategies in the wake of such breaches, emphasizing their impact on organizational reputation and user privacy. Exploring transparent incident explanations and admission of responsibility as effective crisis responses, the study highlights communication's pivotal role in mitigating fallout. Consumer concerns drive demand for research on ethical business practices and responsible platform design. The influence of social media on consumer behaviour and the aftermath of brand apologies are examined, shedding light on reputation management complexities. Coping responses to post-breach stress and notable incidents on platforms like LinkedIn are also discussed. Through social media analytics, the research evaluates breaches' repercussions on Information Security Reputation, offering insights for post-breach interventions. This research provides a nuanced understanding of social media breach challenges, stressing proactive crisis communication and ethical considerations for preserving

1. Introduction

In the digital age, social media has seamlessly woven itself into the fabric of our daily lives, transforming communication, interaction, and even consumer behaviour. [2] [3] [7] Platforms like Facebook, Twitter, Instagram, and Snapchat boast millions of users globally, not only reshaping our social landscape but also revolutionizing the way we make purchasing decisions. As these platforms become influential tools for marketers, this study endeavours to scrutinize the profound impact of social media on the intricate process of consumer purchase decision-making. However, the increasing dominance of social media is not without its challenges. The documentary "The Social Dilemma" [4] sparks crucial conversations about algorithms, addiction, and privacy, revealing consumer anxieties over data manipulation and prompting discussions on issues

ranging from censorship to the historical manipulation of knowledge. Furthermore, the integration of social media into business operations exposes a heightened risk of data breaches, as cyber threats evolve and target vulnerabilities.[1] This paper delves into the fallout of such breaches, exemplified by the Facebook data breach, [2] [3] examining the implications for user privacy and the potential exploitation of leaked data by cybercriminals. The exploration extends to recent incidents involving a massive database of WhatsApp user mobile numbers, underlining the urgency of understanding the evolving landscape of social media-related cyber threats and its broader ramifications for user data protection. [1]

1. Literature Review:

In recent years, the rise in data breaches and unauthorized access to user information, particularly



affecting major tech companies like Meta, has drawn significant criticism. The section reviews current literature on data breaches, incidents of scraping, and the protective measures implemented by companies to secure user information. Additionally, it delves into the role of hacking communities in facilitating the sale of such datasets, examining potential motives behind cybercriminal activities. [7] The impact of data algorithms on digital advertising efficacy has generated conflicting study results. Regulatory challenges due to jurisdictional differences make privacy protection in digital information difficult. The historical difficulties in controlling and modifying information, often illustrated by frequent references to books, highlight the complexity of the issue. The Persuasion Knowledge Model suggests that consumers desire tools to identify manipulation in social situations, enabling them to craft more persuasive responses. [4] An overview of previous studies on how social media affects consumer behavior is given in the literature review. The assessment focuses on the elements that affect customers' decisions to buy as well as the ways in which social media can affect these decisions. The best social media channels for swaying customers' decisions to buy are also listed in the review. [5] Significant hazards arise from data breaches caused by cyber-attacks like ransomware and phishing, which can result in identity fraud worldwide. Companies that use social media in particular are more likely to be targeted, which jeopardizes their reputation and sense of trust. The chances of a social media data breach have increased due to remote labor during COVID-19. Platform susceptibility is highlighted in a LinkedIn case study, underscoring the necessity for improved

Cybersecurity precautions. [1] The section reviews past data breaches on Facebook, with a focus on the 2019 vulnerability enabling the scraping of millions of phone numbers. It examines Facebook's responses to previous breaches, detailing measures to address vulnerabilities and safeguard user data. The literature review extends to a broader exploration of social media data breaches and their consequential impacts. [2] The study examined penitential apologies in social accounts, relying on user recall. It investigated the timing of responses for trust repair, recognizing the dynamic nature of trust. The research also explored the impact of civility or incivility on trust dynamics after penitential accounts. [3] Global privacy concerns related to data breaches result in 500-charge FTC settlements for companies (like Exactis and Vizio). Their market value and consumer spending decline as a result of the financial and reputational expenses they incur. Reactions differ according to accountability and affect sectors such as drugs, healthcare, and finance. [8] The literature review provides context for the LinkedIn data breach. - It explains why LinkedIn was hacked and the importance of the stolen data. [6] The study expands on prior research by emphasizing the role that crisis communication plays in handling reputational issues that arise from data breaches. It assesses the efficacy of a number of tactics, such as thorough policies, in-depth incident reports, acceptance of blame, denial, self-disclosure, and the use of social media in organizational responses. [12] The literature analysis highlights the gravity of events like Vizio and Exactis and looks into worldwide challenges of social media trust and privacy following data breaches. Prominent incidents,



Paper Name	Year Of Publication	Author Name	Objectives
The Rise of Social Media Data Breaches	Apr. 28, 2021.	A. McConnell	To review significant hazards arise from data breaches caused by cyber attacks
533 million Facebook users' phone numbers and personal data have been leaked online[6]	April three, 2021	A. Holmes	To review past data breaches on Facebook, with a focus on the 2019 vulnerability enabling the scraping of millions of phone numbers
Effect of penitence on social media trust and privacy concerns: The case of Facebook[19]	2020	Ayaburi, E.W.; Treku	To explore the impact of civility or incivility on trust dynamics after penitential accounts.
The dilemma of social media algorithms and analytics[1]	5 November 2020	Maria Petrescu1 · Anjala S. Krishen2	The impact of data algorithms on digital advertising
A Social Network Analysis (SNA) Study On Data Breach Concerns Over Social Media[2]	2019	Naga Vemprala the University of Texas at San Antonio, Glenn Dietrich the University of Texas at San Antonio	overview of previous studies on how social media affects consumer behaviour
Vulnerability in massive API scraping: 2021 LinkedIn data breach[23]	January 2021	B. Gibson, T. Spencer, D. Lewis, and S. Bhunia	To review context for the LinkedIn data breach
WhatsApp Data Leak: Massive Database of User Numbers for Sale	Nov. 15, 2023	J. Lapienytė	To view data breaches, incidents of scraping, and the protective measures implemented by companies
Data Breaches and Effective Crisis Communication: A Comparative Analysis of Corporate Reputational Crises[17]	August,2021	Kuipers S. and Schonheit M	To research emphasizing roles that crisis communication plays in handling reputational issues that arise from data breaches.

Like the data leak on LinkedIn, underline how crucial crisis communication plans are. The review establishes links between these occurrences and more general themes, such as the influence of social media on consumer behaviour, privacy issues, and digital advertising. It talks about the widespread dangers of cyber-attacks during the COVID-19 epidemic and criticizes big tech firms for leaking customer data, like Meta. The integrative methodology used combines formal methods, quantitative analysis, empirical testing, and qualitative insights to create a comprehensive understanding.

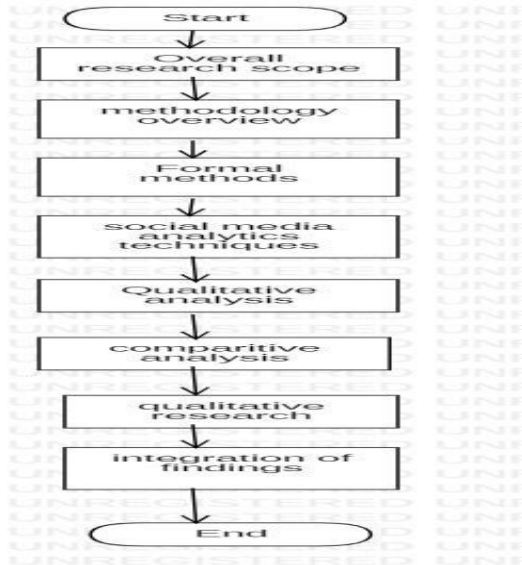
3. Methodology:

The research employs a comprehensive methodology to investigate social media applications, data breaches, and organizational responses. The approach combines

formal methods tools, social media analytical techniques, and qualitative research. Formal methods, utilizing predicate logic and Yices, address permission-delegation threats and verify security policies in social networks. Social media analytical techniques examine data breaches through Twitter postings, analyzing incidents like those at Home Depot, JPMorgan Chase, and the LinkedIn breach.[4] [6] A quantitative analysis involves an experimental survey with 230 respondents, employing multivariate regression analysis for hypotheses testing. Comparative analysis assesses organizational responses to data breaches, considering crisis communication strategies' impact on reputational recovery. Semantic analysis of Twitter messages discussing "The Social Dilemma" extracts themes related to tech companies, data manipulation, algorithms, and censorship. [4] Additionally, qualitative



research gathers insights into consumer purchase decisions made through social media, conducting in-depth interviews and analyzing data thematically. [5] This integrative methodology provides a holistic understanding, incorporating empirical testing, formal tools, quantitative analysis, and qualitative insights.



EMBED StaticMetafile

4. Discussion

This amalgamation of research papers offers a nuanced understanding of the evolving challenges within the realm of social media. Key themes include Cybersecurity strategies, crisis communication, algorithmic concerns, and user behaviour. [1] [4] [11]

The discussions on LinkedIn, [6] Facebook, [2] [3] and WhatsApp [7] data breaches underscore the pressing need for robust security measures, urging companies to enforce terms of service to deter malicious activities. Crisis communication emerges as a linchpin in mitigating reputational damage, emphasizing transparent strategies like selfdisclosure.

Algorithmic debates shed light on user reactions and the call for ethical platform design. The studies advocate for collaborative research to balance freedom of speech with responsible platform algorithms. Consumer behavior insights reveal the power of social influence, trust-building, and information dissemination through social media platforms.

Trust and privacy dynamics on Facebook highlight the pivotal role of organizational integrity. Contrary to expectations, privacy concerns do not significantly contribute to trust repair, showcasing the intricate factors influencing user trust in the social media landscape. [10] [11]

A psychological perspective explores coping responses post-data breach, emphasizing the impact of stress and social contract violation. [8] Technical vulnerabilities are dissected in the LinkedIn data breach study, advocating for enhanced defence strategies. [6]

Formal methodologies to address unintentional privacy breaches and the exploration of social media reputation on Twitter contribute to the broader understanding of social media risks. Negative sentiments in tweets attributing responsibility for data breaches underline the public perception of organizational responsibility. [11]

In synthesis, these papers collectively emphasize the need for a holistic approach, combining technical defences, ethical considerations, crisis communication, and a nuanced understanding of user behaviour. The findings underscore the everevolving nature of social media risks, calling for continuous research and adaptability in navigating this dynamic landscape.

Case of Facebook data breach:

Characters in the Case Scenario:

Mark Zuckerberg: Facebook CEO

David: Facebook user worries about hacking incident.

Sarah: A Facebook user whose private information was compromised.

Scene -1: Apology from Mark Zuckerberg.

He addresses the users in a Facebook video. He sincerely apologizes from everyone who has affected by the data breach. Also Mark said that we take full responsibility for what happened.

Scene -2: Initial Reactions.

Sarah reads news about the apology from Facebook CEO on information leakage.

Sarah (thinking): I cannot believe that this happened.

Scene -3: Sarah and David Discussion.

David talks with Sarah about the data breach news and apology from Facebook. He said what you think about it. Sarah says that I am not sure whether I can forgive them quickly. Then David said I understand you are upset. But Facebook is a big organization and these things happen sometimes.

Scene -4: Reaction of the company

Sarah receives news notification about the massive data leakage from Facebook which exposes phone numbers, names, locations and other sensitive information of millions of users. Sarah (thinking):This is unbelievable. How can they be so irresponsible? David: It affecting millions of people. Now what you are going to do?

David and Sarah observing live Facebook feed where Mark Zuckerberg addresses “We understand the seriousness of this case and apologize deeply to everyone who affected by the data leak. We are investigating the incident and taking steps to improve



the security and privacy measures.”

Scene-5: Privacy Measures and User Reactions.

Few weeks later, Sarah still using Facebook but she is now more cautious about what information she shares and thinking I will just have to be more careful about what I post.

Talk Points:

How well Facebook apology does help users rebuilding the trust? What step can Facebook take to improve its security protocols and prevent more data leakages? How can users protect their personal information on social media platforms?

Results

- Most hypotheses involving behavioural integrity were supported.
- Perceived persuasiveness of the apology positively impacts perception of behavioural integrity.
- Persuasiveness of the apology is not related to privacy concerns perception.
- Behavioural integrity is negatively associated with social media users' privacy concerns. [10] - Behavioural integrity has a significant effect on trust in affiliate social media services.
- Stress and perceptions of social contract violation impact outcome variables.
- Differences in consumer coping behaviour's based on data types (PII vs. NPPII).
- Industry clusters vary in levels of stress and social contract violation. [8]
- Actions businesses can take to reduce negative consumer responses. [11] [8]
- No significant differences in effects of stress and social contract based on switching cost. [8]
- Analysis of the LinkedIn data breach in 2021 [6]
- Adversary used LinkedIn's API to scrape massive amount of personal information [6]
- Super-list of data created and sold maliciously [10]
- 90% of users' data exposed - Social engineering attacks launched on targeted users [3] [5]
- Defence strategies proposed: proper authentication, limiting data scraping, anomaly detection [6]

Conclusion

In conclusion, these diverse research studies collectively emphasize the multifaceted challenges and implications of social media-related issues, ranging from Cybersecurity incidents to data breaches and consumer behaviour. The proposed unique approach employing formal methods and logical reasoning offers a systematic means to address transitivity permission-delegation threats and unintentional privacy breaches in social networks. The examination of data breaches' dynamics underscores the critical dimensions of organizational Information Security Reputation (ISR), urging the importance of managing social media reputation and post-data breach interventions. The second-hand smartphone market emerges as a significant risk, particularly concerning privacy breaches from social media applications, calling for data sanitization features to safeguard user information. LinkedIn's security breach serves as a stark reminder of the need for robust authentication and defence strategies against data scraping. Consumer coping mechanisms in the face of stress and social contract violation, as well as the persuasive impact of apologies on trust repair in the aftermath of data breaches highlight the intricate relationship between user sentiments and organizational responses. The overarching theme points to the pivotal role of social media in influencing consumer decisions, necessitating ongoing research, collaboration among stakeholders, and ethical considerations for platform design. Moreover, the studies stress the importance of organizational responses, including consistent compensation, apology, and rectification strategies, in enhancing reputational recovery from data breaches. In light of these conclusions, the research underscores the urgency for Cybersecurity awareness, employee training, and technological measures to mitigate risks in the ever-evolving landscape of social media-related challenges.

Reference

[1] A. McConnell, "The Rise of Social Media Data Breaches," *Cybersecurity Content Specialist*, Apr. 28, 2021.[Online]Available:HYPERLINK "https://netacea.com/blog/the-rise-of-social-media-data-breaches/" <https://netacea.com/blog/the-rise-of-social-media-data-breaches/>.

[2] A. Holmes, "533 million Facebook users' phone numbers and personal data have been leaked online," *Business Insider*, Apr. 3, 2021, 7:41 PM GMT+5. [Online] Available: HYPERLINK "https://www.businessinsider.com/stolendata-of-



- 533-million-facebook-users-leaked-online-2021-4"
<https://www.businessinsider.com/stolen-data-of-533million-facebook-users-leaked-online-2021-4>.
- [3] Ayaburi, E.W.; Treku, D.N. Effect of penitence on social media trust and privacy concerns: The case of Facebook.
Int. J. Inf. Manag. 2020, 50, 171–181. [CrossRef]
- [4] Maria Petrescu¹ · Anjala S. Krishen², “The dilemma of social media algorithms and analytics” Accepted: 27 October
2020 / Published online: 5 November 2020 © Springer Nature Limited 2020. Available: HYPERLINK
"https://link.springer.com/article/10.57/s41270-020-00094-4"
<https://link.springer.com/article/10.57/s41270-02000094-4>.
- [5] Naga Vemprala the University of Texas at San Antonio, Glenn Dietrich the University of Texas at San Antonio, “A Social Network Analysis (SNA) Study On Data Breach Concerns Over Social Media” [2019]. Available: HYPERLINK "https://aisel.aisnet.org/hicss-52/st/cyber_threat_intelligence/8/"
https://aisel.aisnet.org/hicss52/st/cyber_threat_intelligence/8/. [6] B. Gibson, T. Spencer, D. Lewis, and S. Bhunia, “Vulnerability in massive API scraping: 2021 LinkedIn data breach,” in Proceedings of the International Conference on Computational Science and Computational Intelligence (CSCI), pp. 777–782, IEEE, New York, NY, USA, January 2021.
- [7] J. Lapienyte, "WhatsApp Data Leak: Massive Database of User Numbers for Sale," Cyber news, Nov. 15, 2023, 12:53 PM. [Online]. Available: HYPERLINK
"https://cybernews.com/news/whatsapp-data-leak/" <https://cybernews.com/news/whatsapp-data-leak/>.
- [8] Labrecque, L. I., Markos, E., Swani, K., & Pena, P. (2021). When data security goes wrong: Examining the impact of stress, social contract violation, and data type on consumer coping responses following a data breach. Journal of Business Research, 135, 559–571. HYPERLINK
"https://doi.org/10.1016/j.jbusres.2021.06.054"
- <https://doi.org/10.1016/j.jbusres.2021.06.054>
- [9] Nestor-catano, Software Engineering “A Logical Framework for Verifying Privacy Breaches of Social Networks.”
09 Jun 2018. HYPERLINK "https://typeset.io/papers/a-logical-framework-for-verifying-privacy-breaches-of-social-2xu74vln3u" <https://typeset.io/papers/a-logical-framework-for-verifying-privacy-breaches-of-social2xu74vln3u>.
- [10] Oussama Benrhouma, Ali Alzahrani, Ahmad B.Alkhodre, Abdullah Namoun, “To sell, or not to sell: social media data-breach in second-hand Android Devices” 19-Aug-2021. HYPERLINK
"https://typeset.io/papers/to-sell-or-not-to-sell-social-media-data-breach-in-second-180x327b4w"
<https://typeset.io/papers/to-sell-or-not-to-sell-socialmedia-data-breach-in-second-180x327b4w>.
- [11] Romilla Syed, Gurpreet Dhillon, “Dynamics of Data Breaches in Online Social Networks: Understanding Threats to Organizational Information Security Reputation.” 01 Jan 2015. HYPERLINK
"https://typeset.io/papers/dynamics-ofdata-breaches-in-online-social-networks-1n9s62vhtp"
<https://typeset.io/papers/dynamics-of-data-breaches-inonline-social-networks-1n9s62vhtp>.
- Kuipers S. and Schonheit M., “Data Breaches and Effective Crisis Communication: A Comparative Analysis of Corporate Reputational Crises,” Corporate Reputation Review, vol.25, pp: 176–197, August 2021. HYPERLINK
"https://doi.org/10.1057/s41299-021-00121-9" <https://doi.org/10.1057/s41299-021-00121-9>.



Machine Learning for Heart Attack Prediction: A Comparative Analysis

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KEYWORDS	ABSTRACT
<p>Machine Learning</p> <p>Logistic Regression</p> <p>Heart Attack</p> <p>Chest Pain</p> <p>Decision Tree</p> <p>Random Forest</p> <p>Nearest Neighbour</p>	<p>This comprehensive analysis uses machine learning algorithms on a dataset that includes a range of contributing factors for the prediction of heart attacks. Utilizing the force of relationship grids and the scikit-learn system, this study distinguishes the chest pain type as the most compelling variable, explaining its principal role in foreseeing coronary episodes. The assessment gives out six grouping models, going from decision trees to logistic techniques. Surprisingly, logistic regression comes out on top in terms of accuracy, recall, precision, and F1-score metrics. This analysis not only stresses the meaning of powerful component determination in refining perceptive models but additionally highlights the ground-breaking capability of machine learning in lifting symptomatic exactness for heart illnesses. The recognizable proof of chest pain as a key indicator gives significant experiences to medical care experts as well as reaffirms the clinical importance of this side effect in early determination. By and large, this study lays out the convincing capability of machine learning for upgrading the symptomatic scene of heart illnesses, working with convenient treatment mediations, and working on tolerant results.</p>

1. Introduction

Heart disease is a common disease which is considered as a global health issue [1]. It is a chronic disease which requires extensive treatment. It creates interruptions in blood vessels and coronary heart, which can result in heart attacks, strokes, heart failure, and many other disorders. Diagnosing of heart attack in patient is a significant task for medical professionals, and paramedics [2]. It needs a comprehensive study of symptoms as well as physical examination by considering factors such as diabetes, smoking, age, gender and some other relevant. If diagnosing on the basis of symptoms is predicted accurate, it can help to avoid cardiac events. Machine learning is a very helpful tool for accurate prediction of cardiac events in patients [3].

Classification is widely used technique of Machine learning for prediction of a specific output on the basis of provided input data. Classification techniques are useful for predicting heart attacks in patients. Classification models use the patient data for prediction, which contains the factors that can lead to a heart attack. To enhance the accuracy of classification process, it is essential to execute proper variable processing. The

correlation plays a significant role by defining the interdependency between the variable that contributing the effectiveness of classification system [4]. The correlation matrix provides the supplementary information that enhances the precision of predictions. The use of the Scikit-learn library module in this view is impressive, showing that it's got the best rating because of all its features. In my view, the effects of different analyses carried out on all variables have been achieved in terms of ratings [5].

This research seeks to assess and evaluate systems studying classification fashions, which include decision trees, logistic regression, naïve bayes, k-nearest neighbor, support vector machines, and random forests. The assessment is executed using a cardiac attack dataset acquired from the Kaggle internet site. The dataset has two categorization classes: one and 0. Here, 1 represents a wonderful case, indicating a patient who has had a heart attack, and zero represents a terrible example, displaying that the patient has now not had a heart assault.

In the process of determining the optimal model, the focus lies on achieving the highest prediction accuracy.



This accuracy is gauged through the mean of cross-validation, a reliable method for estimating the performance of machine learning models. The comparative analysis aims to identify which classification model demonstrates the most favorable prediction accuracy for the given heart attack dataset.

This paper presents a comprehensive exploration of machine learning applications for predicting heart attacks using a diverse array of algorithms and a dataset encompassing various contributing factors. The paper identifies chest pain type as the most influential variable in predicting heart attacks and evaluates eleven classification models, ranging from decision trees to ensemble methods. The paper demonstrates that logistic regression emerges as the standout performer, achieving superior accuracy, recall, precision, and F1-score metrics. The paper not only emphasizes the significance of robust feature selection in refining predictive models but also underscores the transformative potential of machine learning in elevating diagnostic accuracy for heart diseases.

2. Theory

In this investigation, diverse classification models have been employed, each characterized by unique methodologies for making predictions. A comprehensive elucidation of each classification model utilized in this study will be appended to the theoretical section. The detailed explanations will provide insight into the underlying principles, algorithms, and mechanisms of prediction associated with each model, offering a thorough understanding of their respective approaches within the context of the research on heart attack prediction.

2.1 Logistic Regression

Logistic regression is a kind of machine learning set of rules that is used for class tasks, wherein the intention is to decide if an instance belongs to a positive elegance or no longer [6]. That is a statistical method that analyzes how the established binary variables are inspired by the set of impartial variables.

2.2 K-Nearest Neighbours

Nearest Neighbour is a simple system-study technique that could handle each classification and regression duty [7]. It relies on the proximity of fact points to estimate the label or value of a new fact factor.

2.3 Support Vector Machine

SVM is a supervised learning method that can do both classification and regression. Though we use the term regression difficulties, it's far more desirable for categorization [8]. The number one aim of the SVM

technique is to find the first-rate hyperplane in an N-dimensional space that could break up facts into wonderful training inside the characteristic space. The hyperplane aims to maximize the distance among the closest points of various instructions.

2.4 Naive Bayes

Naive Bayes classifiers are a fixed set of type methods based totally on Bayes' Theorem [9]. It isn't always a single algorithm; alternatively, it is a family of algorithms that all observe the same concept, specifically that every pair of characteristics being classified is impartial to one another [10].

2.5 Decision Tree

The decision-tree set of rules falls under the area of supervised learning algorithms. It supports both non-stop and specific output variables. A decision tree is a tree-like shape that depicts a sequence of options and their capabilities and outcomes [11]. Every node within the tree symbolizes a choice, just as every department displays the end result of that decision. The tree's leaves mirror final choices or forecasts.

2.6 Random Forest

A random forest is made up of numerous randomly generated choice trees. There are types of randomness embedded in the trees [12]. First, every tree is created using a random sampling of the original facts. Second, for every tree node, a random series of traits is selected to offer the most useful breakup.

3. Methodology

3.1 Data Collection

The research data for this study was acquired from the Kaggle website, specifically utilizing a publicly available heart attack classification dataset accessible at <https://www.kaggle.com>. This dataset comprises 14 variables [14], encompassing both categorical and numeric types, with one of them serving as the output variable, denoted by values 0 or 1. In this context, a value of 1 represents an individual with a heart attack, while a value of 0 indicates the absence of a heart attack. The dataset encompasses a total of 296 data points.

3.2 Dataset Evaluation

When evaluating an ownership dataset, the closeness of variables is determined using a correlation matrix. The purpose of the matrix is to reveal the direction and intensity of correlations between variables. Finding the variables that affect a person's chance of having a heart attack can be helpful. To determine the impact of these factors on the prediction of a heart attack, further analysis of the correlation matrix is conducted using the variable

with the greatest characteristics. The ability to carefully investigate factors and their function in predicting heart health is provided by this sequence technique.

3.3 Data Evaluation

The measurement findings of the confusion matrix, which are displayed in Fig. 1, will also be used to assess the test outcomes in this investigation. It is occasionally referred to as the error matrix in machine learning. The confusion matrix is a type of matrix used to show the performance of a classification model. It is often displayed in tabular form [15]. This table makes it easier to identify the mistakes that happen when forecasts are made. Based on both real and predicted data, each cell in the table represents one of several potential forecasts. For instance, a cell denoting the quantity of false negative (FN) data—data that, in reality, has a right value—is produced by the model's incorrect predictions.

You may also utilize the confusion matrix to calculate the accuracy, recall, precision, and f1-score values.

	Predicted 0	Predicted 1
Actual 0	TN	FP
Actual 1	FN	TP

Fig. 1. Confusion Matrix

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

True Positive (TP) and True Negative (TN) addition is used to calculate accuracy, which is then divided by the total number of potential values. The accuracy value represents the quantity of data that was correctly anticipated.

$$Precision = \frac{TP}{TP + FP}$$

The quantity of data that is deemed positive (TP + FP) divided by the number of correct positive predictions (TP) yields the precision.

$$Recall = \frac{TP}{TP + FN}$$

Recall, as opposed to accuracy, determines the proportion of accurate positive predictions (TP) to all true positive data (TP + FN).

$$F1 - score = \frac{2(Recall * Precision)}{(Recall + Precision)}$$

F1-score: It is the harmonic mean of precision and recall, providing a balance between the two metrics. It is especially useful when there is an uneven class distribution.

4. Results and Analysis

4.1 Variable correlation in the dataset

Random forest (RF) is a collection of decision tree classifiers that work collectively to categorize data with the aid of assessing many outputs simultaneously while ensuring independence [12]. Random forest classification is more powerful than single-selection tree classification. This improvement is attributed to the fact that every decision tree in a random forest produces random predictions with variable mistakes. The Random Forest model's ensemble structure significantly minimizes the likelihood of incorrect classifications outweighing correct ones. This ensemble method improves the overall robustness and accuracy of the classification process.

In the context of the current dataset, the numerical features, namely major vessels, maximum heart rate achieved, and ST depression, exhibit reasonably fair correlations with the target variable as shown in Fig. 2. The correlation coefficients for these features are 0.36, 0.4, and 0.27, respectively. These coefficients help to identify variables that may play an important role in predicting the target variable, in this case, the likelihood of a heart attack, by providing insight into the strength and direction of the relationships.

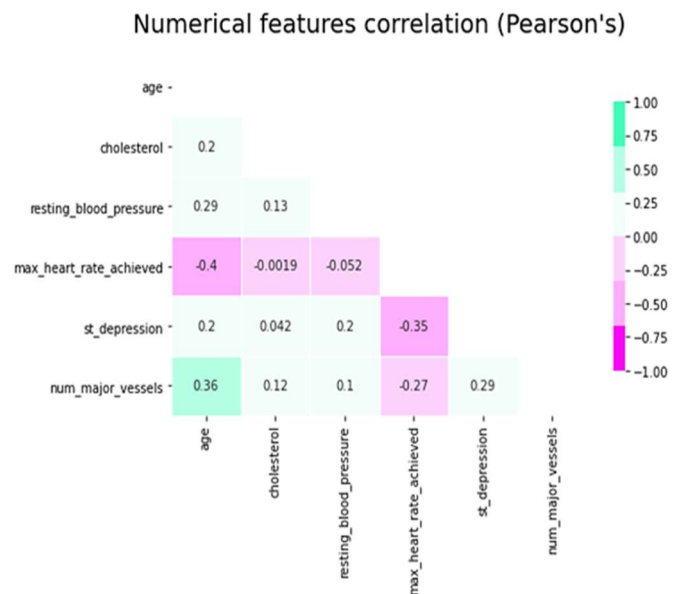


Fig. 2. Numerical Features Correlation Matrix

In terms of categorical features as shown in Fig. 3, all major features are related to target variables for chest

pain, large vessels, thalassemia, and exercise induced angina. A high correlation coefficient of 0.5 to 0.55 is observed between chest pain and thalassemia. These correlation values demonstrate that the risk of a heart attack is closely related with these specific features. It is significant to recognize the risk factors for heart attack by understanding these correlation coefficients.

False negatives (FN) are occasions in which the model mistakenly forecasts occurrences as negative when they are really positive; there are three such misclassifications. True positives (TP) are cases that were properly predicted to belong to the positive class, and the logistic classifier recognized 32 of them.

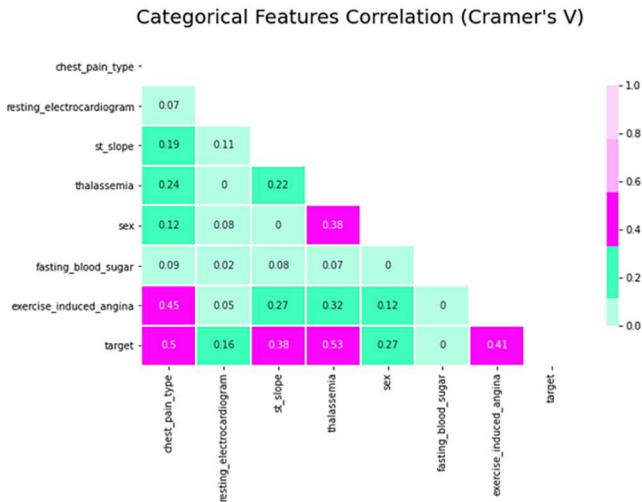


Fig. 3. Categorical Feature Correlation matrix

4.2 Analysis of classification models

In addition to accuracy, F1 score, recall, and precision for any classification model, a complete analysis of the confusion matrix and its associated metrics is provided by the results of these tests. Particular characteristics of the confusion are used to evaluate each model in terms of strengths and weaknesses of various approaches for prediction of heart attack from study data.

The confusion matrix results gives complex understanding of each classification model is capable in terms of real positive, true negative, false positive and false negative values. The researchers are able to identify the predictive capacity, specific strength or weakness by analysing the accuracy, F1 scores, recall rate and precision. Such a comparison analysis may help identify the optimal classification model for predicting heart attacks based on the particular characteristics and requirements of the data in this study.

4.2.1 Logistic Regression

The confusion matrix shown in Fig. 4 summarizes the outcomes of the logistic classifier's predictions. A true negative (TN) happens when the model properly detects cases that do not belong to the positive class, as it did in this case, with 32 such accurate predictions. False positive (FP) predictions, in which the model wrongly labels cases as positive when they are actually negative, account for seven incidents.

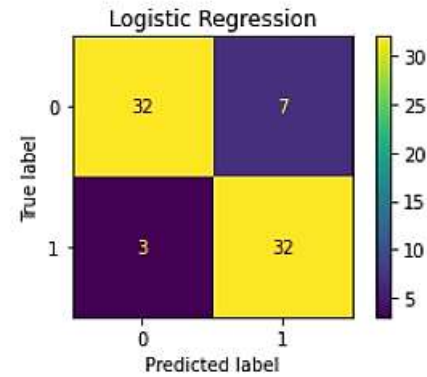


Fig. 4. Logistic Regression Confusion matrix

4.2.2 K-Nearest Neighbours

Fig. 5 represents the confusion matrix for the KNN classifier model. It shows that the true negative outcomes are 30, false positive 9, false negative 24, and true positive 11.

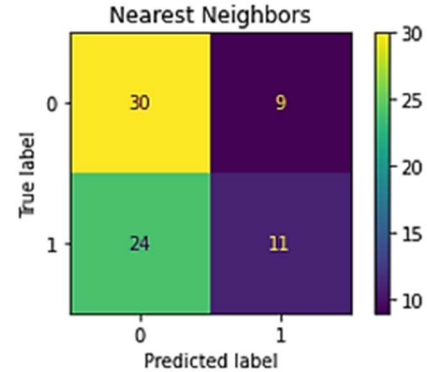


Fig. 5. KNN Confusion matrix

4.2.3 Support Vector Machine

Fig. 6 shows the confusion matrix for the support vector model. It shows that the true negative outcomes are 17, false positive 22, false negative 4 and true positive 11.

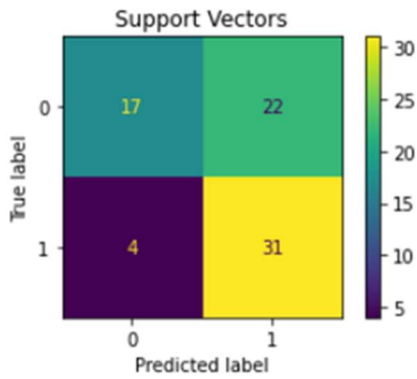


Fig. 6. Support Vectors Confusion matrix

The confusion matrix for random forest is represented in Fig. 9, which shows that the true negative outcomes are 33, false positive 6, false negative 6 and true positive 29.

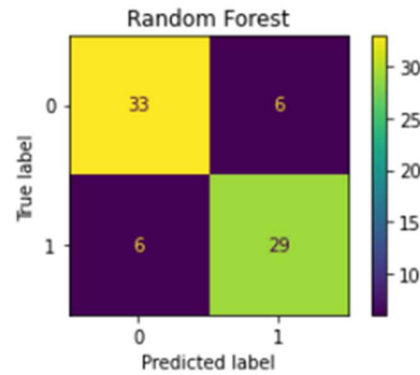


Fig. 9. Random Forest Confusion matrix

4.2.4 Naive Bayes

Fig. 7 demonstrates the confusion matrix for the Naïve Bayes which shows that true negative outcomes are 31, false positive 8, false negative 8 and true positive 30.

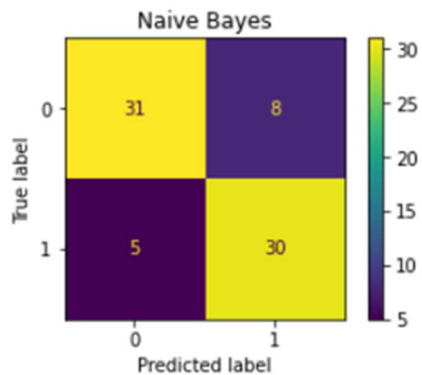


Fig. 7. Naïve Bayes Confusion matrix

The bar chart in Fig. 10 vividly illustrates the accuracy values derived from the confusion matrix for each classification model, offering a succinct and visually compelling summary of their predictive performances. Remarkably, the Nearest Neighbour and Support Vector models exhibit accuracies below the 70% threshold, suggesting a comparatively diminished predictive capability. In contrast, the Logistic Regression, Random Forest, Decision Tree, and Naïve Bayes models showcase accuracies surpassing the 70% mark, indicating more robust predictive capabilities.

4.2.5 Decision Tree

Fig. 8 Shows the confusion matrix for decision tree classifier, which shows that the true negative outcomes are 32, false positive 7, false negative 6 and true positive 29.

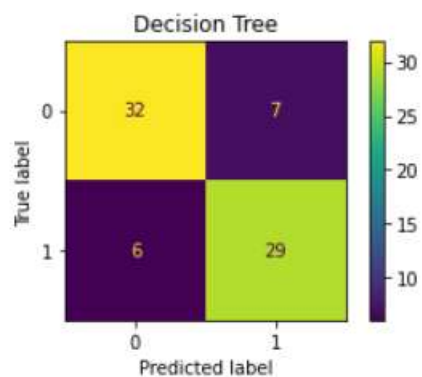


Fig. 8. Decision Tree Confusion matrix

4.2.6 Random Forest

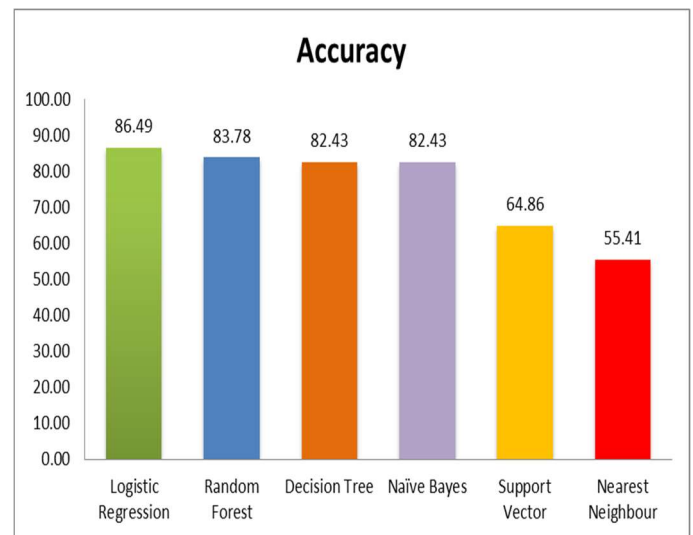


Fig. 10. Models Accuracy

It is seen from Fig. 10 that Logistic Regression performed well, with the highest accuracy of 86.49% among all the models. This visual representation not only emphasizes the superior performance of Logistic Regression but also provides a comparative analysis of the efficiency of other models. This visual representation shows a clear and concise overview of the relative performance of each classification model, assisting in

the selection of the most effective model for predicting heart attacks based on the dataset under consideration.

The graph shown in Fig. 11 represents the comparison of recall scores of classifier models. Analysis shows that the Nearest Neighbour secured 0.31, naïve bayes 0.83, random forest 0.83, and logistic regression led with a 0.91 score. Notably, Nearest Neighbour achieves the lowest recall value, while Logistic Regression achieves the highest among all classifiers, as illustrated in Fig. 11.

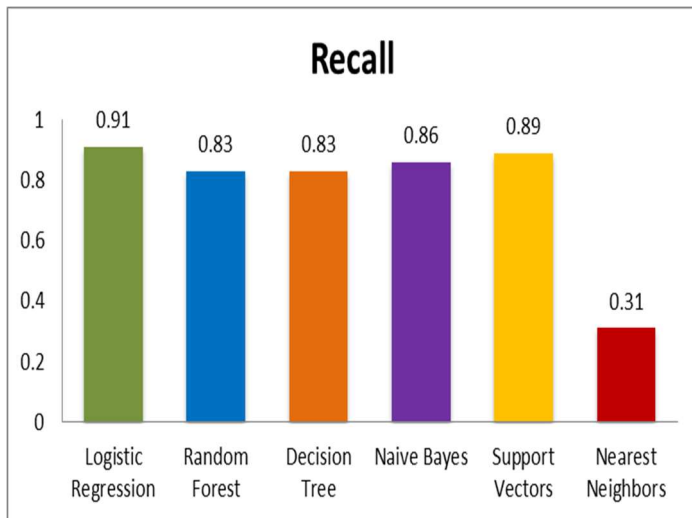


Fig. 11. Comparison of Recall function

The figure displays the precision scores for various classifiers. Support Vector and Nearest Neighbour exhibit the lowest values at 0.58 and 0.55, respectively. In contrast, Naïve Bayes, Decision Tree, Random Forest, and Logistic Regression achieve higher values, surpassing 0.7. Notably, among all classifiers, Random Forest attains the highest precision at 0.83, with Logistic Regression closely trailing at 0.82, signifying their superior precision performance in comparison to other models.

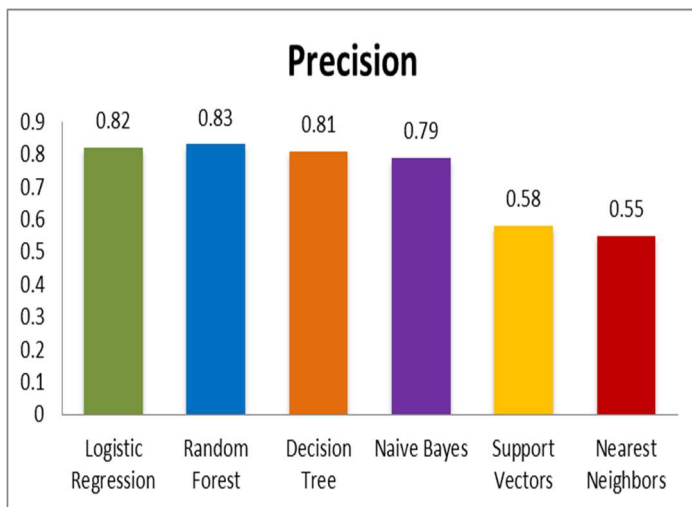


Fig. 12. Precision of Models

Fig. 13 illustrates the comparison of F1-scores for classifier models. Analysis shows that the nearest neighbour has the lowest score with 0.4, and logistic regression achieved the highest score of 0.86. This visualization demonstrates that logistic regression’s performance is better in terms of F1-score as compared to other models.

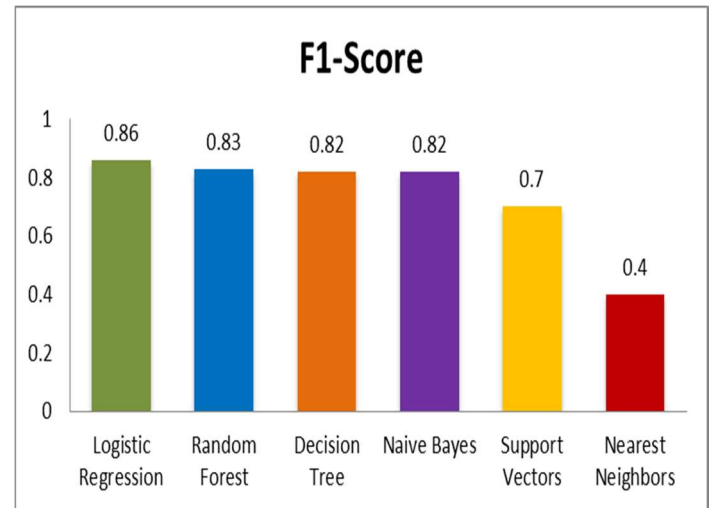


Fig. 13. Comparison of F1-score

Table 1 shows the comparative analysis of key performance indicators of classifiers including accuracy, recall, precision, and F1 score. It shows that the logistic regression is better to other model in terms of different aspects. On careful analysis of all results it shows that Logistic regression is more suitable and precise for the prediction of a heart attack. This also shows that the logistic regression model is robust and provides valuable information to researchers and healthcare professionals.

Table 1

Comparison of models performance

Classifier	Accuracy	Recall	Precision	F1-Score
Logistic Regression	86.49	0.91	0.82	0.86
Random Forest	83.78	0.83	0.83	0.83
Decision Tree	82.43	0.83	0.81	0.82
Naive Bayes	82.43	0.86	0.79	0.82
Support Vectors	64.86	0.89	0.58	0.7
Nearest Neighbors	55.41	0.31	0.55	0.4

5. Conclusion

The key objective of this research is to analysis the efficiency of machine learning classification models on data to find the influence of different factor in heart



attack including the assessment of efficiency of models. Also analysis the significant associations of database variable that are linked with the prediction of heart attack. The correlation matrix demonstrate that the features which are most important for predicting a heart attack were thalassemia, at peak heart rate, and chest pain type.

In terms of model performance, the accuracy results show that logistic regression model is better than others. It achieves the highest recall, precision, accuracy, and F1-score values, reaching 91%, 82%, 86.49%, and 86%, respectively. These findings suggest that the logistic regression model is particularly effective in accurately predicting heart attacks based on the given dataset, demonstrating a high level of both sensitivity and precision.

5. Reference

- [1] W. Nugraha, "Prediksi penyakit jantung cardiovascular menggunakan model algoritma klasifikasi," *Jurnal Manajemen dan Informatika*, vol. 9, 2021.
- [2] A. Rajkumar and G. S. Reena, "Diagnosis of heart disease using datamining algorithm," *Global Journal of Computer Science and Technology*, vol. 10, 2010.
- [3] M. H. A. Yazid, M. S. Talib, and M. H. Satria, "Heart disease classification framework using fuzzy and flower pollination neural network," *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 8, 2019. DOI:10.30534/ijatcse/2019/2181.62019. DOI:10.30534/ijatcse/2019/2181.62019
- [4] V. P. Andreev, G. Liu, J. Zee, L. Henn, G. E. Flores, and R. M. Merion, "Clustering of the structures by using "snakes--dragons" approach, or correlation matrix as a signal," *PLoS ONE*, vol. 14, 2019. DOI:10.1371/journal.pone.0223267.
- [5] T. Desyani, A. Saifudin, and Y. Yulianti, "Feature selection based on naive bayes for caesarean section prediction," vol. 879, 2020. DOI:10.1088/1757-899X/879/1/012091. ISSN 1757899X
- [6] "Logistic regression," pp. 209–212, Mar. 2008. [Online]. Available: <https://doi.org/10.46692/9781847423399.014>
- [7] P. Cunningham and S. J. Delany, "K-nearest neighbour classifiers-a tutorial," 2021.
- [8] N. Guenther and M. Schonlau, "Support vector machines," *The Stata Journal: Promoting communications on statistics and Stata*, vol. 16, no. 4, pp. 917–937, Dec. 2016. DOI:10.1177/1536867x1601600407.
- [9] H. Chen, S. Hu, R. Hua, and X. Zhao, "Improved naive bayes classification algorithm for traffic risk management," *Eurasip Journal on Advances in Signal Processing*, vol. 2021, 2021. DOI:10.1186/s13634-021-00742-6.
- [10] L. K. Foo, S. L. Chua, and N. Ibrahim, "Attribute weighted naive bayes classifier," *Computers, Materials and Continua*, vol. 71, 2022. DOI:10.32604/cmc.2022.022011.
- [11] T. A. Assegie and P. S. Nair, "Handwritten digits recognition with decision tree classification: A machine learning approach," *International Journal of Electrical and Computer Engineering*, vol. 9, 2019. DOI:10.11591/ijece.v9i5.pp4446-4451.
- [12] J. Hatwell, M. M. Gaber, and R. M. A. Azad, "Chirps: Explaining random forest classification," *Artificial Intelligence Review*, vol. 53, 2020. DOI:10.1007/s10462-020-09833-6.
- [13] H. Jiang, Z. He, G. Ye, and H. Zhang, "Network intrusion detection based on pso-xgboost model," *IEEE Access*, vol. 8, 2020. DOI:10.1109/ACCESS.2020.2982418.
- [14] N. Khoiruzzaman, R. D. Ramadhani, and A. Junaidi, "Hasil klasifikasi algoritma backpropagation dan k-nearest neighbor pada cardiovascular disease," *Journal of Dinda : Data Science, Information Technology, and Data Analytics*, vol. 1, 2021. DOI:10.20895/dinda.v1i1.141.
- [15] A. Sharma, "Confusion matrix in machine learning," *Www.Geeksforgeeks.Org*, 2018. [Online]. Available: <https://www.geeksforgeeks.org/confusion-matrix-machine-learning/>
- [16] M. H. Widiyanto, A. A. S. Gunawan, Y. Heryadi, and W. Budiharto, "Evaluation of machine learning on smart home data for prediction of electrical energy consumption," in *2023 International Conference on Computer Science, Information Technology and Engineering (ICCoSITE)*, 2023. DOI:10.1109/ICCoSITE57641.2023.10127700 pp. 434–439.
- [17] Rahu, M.A., et al. (2023). Towards Desig of



- Internet of Things and Machine Learning-Enabled Frameworks for Analysis and prediction of Water Quality, IEEE Access, Vol.11, pp 101055-101086, doi: 10.1109/ACCESS.2023.3315649
- [18] Rahu, M.A et al (2024), An IoT and machine learning solutions for monitoring agricultural water quality: a robust framework, Mehran University research journal of Engineering and Technology, Vol.43. No.1, pp 192-205, doi: 10.22581/muet1982.2401.2806
- [19] Jatoi, G.M et al (2023), Water Quality Monitoring in Agriculture: Applications, Challenges and Future Prospectus with IoT and Machine Learning, Journal of Applied Engineering and Technology, Vol.7, No. 2, pp 46-54, doi: 10.55447/jaet.07.02.131
- [20] Das, B., Ali, S. M., Shaikh, M. Z., Chandio, A. F., Rahu, M. A., Pabani, J. K., & Khalil, M. U. R. (2023, January). Linear Regression Based Crop Suggestive System for Local Pakistani Farmers. In 2023 Global Conference on Wireless and Optical Technologies (GCWOT) (pp. 1-6). IEEE.
- [21] Mushtaque Ahmed Rahu , Muhammad Mujtaba Shaikh , Sarang Karim , Abdul Fattah Chandio , Safia Amir Dahri , Sarfraz Ahmed Soomro , Sayed Mazhar Ali, “IoT and machine learning solutions for monitoring agricultural water quality: a robust framework,” Mehran University Research Journal of Engineering and Technology, vol. 43 (1), 2024, 192-205. Doi: <https://doi.org/10.22581/muet1982.2401.2806>
- [22] Sayed Mazhar Ali, Bhagwan Das, Dileep Kumar, “Machine Learning based Crop Recommendation System for Local Farmers of Pakistan,” Rivista Geintec Gestao, Inovacoa e Tecnologias, Vol. 11 (4), 2021, pp 5735-5746.
- [23] Sayed Mazhar Ali, Mushtaque Ahmed Rahu, Sarang Karim, Ghulam Murtaza Jatoi, Asim Sattar, “Internet of Things (IoT), Applications and Challenges: A Comprehensive Review,” Journal of Innovative Intelligent Computing and Emerging Technologies (JIICET) Vol. 1 (1), 2024, pp 20-27
- [24] Mushtaque Ahmed Rahu, Sarang Karim, Sayed Mazhar Ali, Ghullam Murtaza Jatoi, Najamu Din Sohu, “Integration of Wireless Sensor Networks, Internet of Things, Artificial Intelligence, and Deep Learning in Smart Agriculture: A Comprehensive Survey,” Journal of Innovative Intelligent Computing and Emerging Technologies (JIICET) Vol. 1 (1), 2024, pp 8-19.
- [25] Mushtaque Ahmed Rahu, Abdul Fattah Chandio, Sayed Mazhar Ali, “Machine Learning Overview in Agriculture,” Journal of Applied Engineering and Technology JAET, Vol 6 (1), 2022, pp 28-39.
- [26] Ghullam Murtaza Jatoi, Mushtaque Ahmed Rahu, Sarang Karim, Sayed Mazhar Ali, Najamu Din Sohu, “Water Quality Monitoring in Agriculture: Applications, Challenges and Future Prospectus with IoT and Machine Learning,” Journal of Applied Engineering and Technology JAET, Vol.7 (2), 2023, pp 46-54.
- [27] Lata Bai Gokalani, Bhagwan Das, Dilip Kumar Ramnani, and Mazhar Ali Shah, “House Price Prediction of Real-Time Data (DHA Defence) Karachi using Machine Learning,” Sir Syed University Research Journal of Engineering & Technology, Vol. 12 (2), 2022, pp 75-80, Doi: <https://doi.org/10.33317/ssurj.504>



Design and Development of DCS for Production Unit

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KEYWORDS

PLC: Programmable logic controller

RTU: Remote terminal unit

HMI: Human machine interface

RS-485 communication

Winproladder

Easy builder pro

ABSTRACT

In this study, the industries or production facilities operated manually, lacking real-time machine controls or data systems. A Distributed Control System (DCS) was designed and developed for a production unit using Fatek Programmable Logic Controllers (PLCs) and the RS-485 Modbus communication protocol. The primary objective of this research was to enhance the automation and control capabilities of the production unit, thereby increasing productivity and operational efficiency. Fatek PLCs are central to the production unit, serving as the brain of the operation by executing predefined control logic. These programmable logic controllers seamlessly interface with various sensors and actuators, ensuring smooth machine functionality. During the design phase, a meticulous process identified the control requirements, which were then translated into detailed functional specifications. To facilitate communication between the dispersed PLCs and the central control station, the RS-485 Modbus protocol is employed. In this master-slave setup, the Fatek PLCs operate as slave devices, while the central control station acts as the master. Suitable data structures and protocols are established to ensure seamless data exchange and synchronization between the central control station and the distributed PLCs.

1. Introduction

A computer-based network called a distributed control system (DCS) is used to supervise and manage a plant's operations and control, which may involve many control loops. Even though the RTUs are located at various locations across the system, there's a central control room where operators can monitor and manage everything. By centralizing control operations close to the plant, DCS improves reliability and lowers costs while allowing for remote monitoring and supervision. It is crucial for process management and control in the industrial industries. Effective process management is made possible by DCS's networking characteristics, which can handle both discrete and analog signals for inputs and outputs [1]. RTUs, or Remote Terminal Units, are small computers or microprocessors designed to control equipment from remote locations. It connects various hardware parts to industrial control systems' distributed control systems (DCS). This device is known by several names besides RTU, including remote telecontrol unit and remote telemetry device. Like RTUs and PLCs, these intelligent controllers can efficiently manage all machine

functions. Acting as communication hubs, RTUs receive user commands and use them to automatically control the machine. They can communicate via Ethernet or serial protocols (RS-485/232) depending on the setup and requirements, showcasing their flexibility [2]. Secure data interchange between industrial automation systems is facilitated by OPC, an open platform communication standard. Improved communication makes it possible to gather and analyze data from various industrial processes, which boosts productivity, responsiveness, and well-informed decision-making [3]. A daisy chain connection between the master and slave devices is required for RS-485 Modbus to function as a single master multiple slave protocol. For communication purposes, a unique ID is given to every slave. Along the chain, the master sends messages with the relevant slave ID in order to communicate with a specific slave. The slave receives the message directed to it, interprets it, and replies by sending a message back to the master via the chain [3].

2. Literature Survey

To gain an understanding of the architecture and operation of distributed control systems, we reviewed



various research publications and industry standards, are essential to the manufacturing industry because they monitor and control a range of processes. Ivan Castillo, Thomas F. Edgar in 2009 introduced the paper about the main advantages of using an industrial distributed control system (DCS) to supervise distillation column operations in a laboratory for undergraduate unit operations are discussed in this research. DCS systems are popular and efficient for handling the complex procedures involved in regulating several parameters and control loops in distillation columns [3]. Advances in Distributed Control Systems (DCS), which are extensively utilized for industrial process control, were discussed in a 2011 conference paper. The paper aimed to develop a new generation of DCS, referred to as DCS of systems, based on a service-oriented architecture. These systems are crucial for ensuring reliable and safe operations across various industries, including the electric and petrochemical sectors [4]. A traditional SCADA system places more emphasis on data acquisition than does the DCS system, which stresses a viewpoint that is process-oriented. SCADA systems are built to operate consistently over erratic connections, guaranteeing a cache of collected data. DCS systems, on the other hand, can access data sources instantly, allowing for real-time updates. Whereas DCS systems usually work in a sequential fashion, SCADA systems are generally event-driven. This distinction affects the creation of alarms, which for SCADA and DCS are triggered by events and process state changes, respectively [5]. When the paper was published in 2019, it presented the novel idea of using PLC controllers in a distributed control system (DCS). It examined the structure, requirements, costs associated with installation, and functionality of commercial DCS setups in comparison to those based on PLC logic controllers. The features, engineering design, and configuration of DCS systems using PLC controllers were covered in detail. A special focus was placed on matching up specific system components with the appropriate layers in the design framework [6]. In 2020 Failure Impact Analyzing of a Chemical Plant based on its DCS Data Set was studied. The method for evaluating the effect of anomalous components on the operational state of a framework activity is presented in this study. One of the main challenges is figuring out the fault score for each sensor's matching components in the DCS dataset. With its representation as a two-dimensional matrix with m rows (sampling periods) and n columns (sampling points), the DCS dataset, which is made up of monitoring data, may be understood as a big

collection of variables throughout time. As a result, fault score sequencing is necessary for system fault detection. Conventional simulation with the Tennessee Eastman process is used to validate this approach [7].

3. Design Methodology

Constructing a reliable industrial automation control system often involves utilizing RS-485, a trusted option for connecting multiple devices or nodes. The RS-485 master-slave concept can be applied to develop such a system in the following systematic manner: First, identify the functions and features your system requires. This will guide the design process. Designing a well-balanced Distributed Control System (DCS) network involves several key steps. First, determine the number of devices (sensors, controllers, etc.) that need to communicate. Next, identify the specific data flows required for proper system functionality. Critical considerations include data transmission speed, reliability, and latency to ensure real-time operation and acceptable delays. The chosen network topology, influenced by these factors, could be a master-slave design for simplicity or a multi-drop design for flexibility. By carefully evaluating device numbers, data needs, and performance requirements, you can select the optimal network topology for your DCS. After designing the network plan, the next step is selecting hardware components like microcontrollers or PLCs to handle logic and decision-making. RS-485 transceivers are crucial for translating electrical signals into a format suitable for network transmission, considering factors such as power consumption, noise immunity, and voltage requirements. Communication between devices is facilitated by protocols like Modbus, which define message formats, device identification, and error-checking methods. In this setup, Modbus will orchestrate communication between master and slave devices within the DCS network. Creating a functional DCS network involves two crucial phases: developing the hardware and software for both master and slave nodes. The master node, known as the conductor, features an RS-485 transceiver, microprocessor, and customized software. It assumes the role of initiating communication, controlling network traffic, communicating with slaves, and exchanging commands and data. Similarly designed but with responsive firmware, slave nodes

provide information, execute received commands, and respond to queries from the master. This coordinated hardware and software setup in both master and slave nodes establishes a reliable communication system for the DCS network. Ensuring reliable communication within the DCS network goes beyond hardware and software. It's crucial to integrate error detection and recovery techniques from the chosen communication protocol, such as Modbus, directly into the firmware of slave nodes. Thorough testing before deployment is essential to uncover any potential flaws. This includes simulating both normal operations and various failure scenarios to verify data integrity and ensure compliance with relevant standards. Once hardware is correctly installed and configured, communication between master and slave nodes is validated throughout the deployment phase. Lastly, a maintenance schedule must be established to monitor the system, promptly address issues as they arise, and regularly apply upgrades and updates to maintain optimal performance. The review emphasizes the importance of ongoing monitoring and enhancement of the DCS network. Regular performance assessments are recommended, along with necessary adjustments to optimize its functionality [8]. Figure 1 illustrates the typical design.

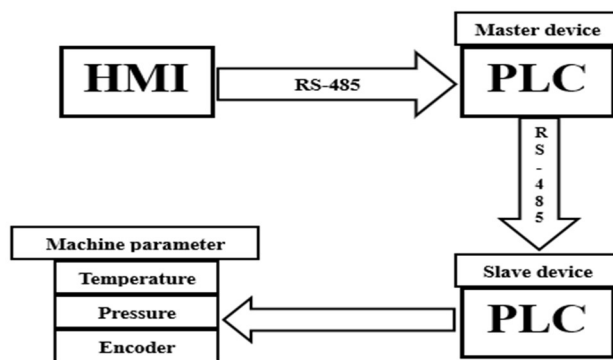


Figure 1. Typical Design of DCS

The suggestion of proposed DCS design hinges on its ability to reliably transport data. This critical aspect is now under scrutiny as we assess the data delivery performance of the RS-485 Modbus communication protocol chosen for the system. This evaluation involves ensuring seamless integration of controllers and other components. Utilizing WinProLadder software tailored for Fatek PLCs, we simulate these conditions. Our objective through these tests is to confirm the system's dependability and efficiency in transmitting data.

4. Simulation Setup

Win-Pro Ladder is a software tool designed for creating ladder logic programs used in industrial automation with programmable logic controllers (PLCs). Its popularity stems from its user-friendly interface, which eliminates the complexity of traditional coding. Through a graphical interface, Win-Pro Ladder allows programmers to easily construct and manage programs by dragging and dropping pre-defined logic components and symbols onto a visual canvas. Easy Builder Pro software is utilized to develop HMI (human-machine interface) programs for industrial automation systems. These programs create graphical interfaces that allow monitoring and management of diverse processes and equipment, including PLCs and other automation devices. The simulation setup includes three controllers, each equipped with specific boards or modules placed randomly within an industrial setting. Connect the twisted pair cable to each controller as instructed. Each controller must be configured individually according to the machine's specifications. This involves setting parameters such as parity, stop bits, data bits, and baud rate for each controller. Additionally, establishing the communication protocol, slave and master station numbers, and ensuring consistency in system characteristics based on their respective roles is crucial. The RS-485 module indicates the beginning of communication. The master device's Modbus function includes error indicators for monitoring communication errors. All controllers should share the same station number and adhere to the specified communication protocol and system characteristics based on their positions. The master device controls every slave device, as illustrated in Figure 2, with a master Modbus table established for coordination.

Seq.	Command	Slave	Master Data	Slave Data	Data Size	
0	Read	2	R0	<	400001	1
1	Read	2	R1	<	400002	1
2	Read	2	R2	<	400003	1
3	Read	2	R3	<	400004	1
4	Read	2	R4	<	400005	1
5	Read	2	R5	<	400006	1
6	Write	2	R6	->	400001	1
7	Write	2	R7	->	400002	1
8	Write	2	R8	->	400003	1
9	Write	2	R9	->	400004	1
10	Write	2	R10	->	400005	1
11	Write	2	R11	->	400006	1
12	Read	2	Y0	<	000001	1
13	Read	2	Y1	<	000002	1
14	Read	2	Y2	<	000003	1
15	Read	2	Y3	<	000004	1
16	Read	2	Y4	<	000005	1
17	Read	2	Y5	<	000006	1
18	Read	2	R90	<	400091	1

Figure 2. Master modbus table for coordination

4.1 Master Slave Concept

According to this theory, each communication begins with a single device acting as the master, which not only initiates but also manages the data flow. Other devices, known as slaves, follow the master's instructions and respond to its requests. The slaves transmit their data and instructions to the master device, which in turn processes commands and returns data to them [9]. This master-slave architecture ensures that all devices in the network adhere to a unified set of rules, establishing a clear communication hierarchy.

4.2 Program for Slave PLC

The code has been developed for a slave Programmable Logic Controller (PLC) used in a prototype traffic light simulation. Figures 3, 4, and 5 depict the code, hardware setup, and HMI design respectively, illustrating the control and emulation of traffic light behaviour.

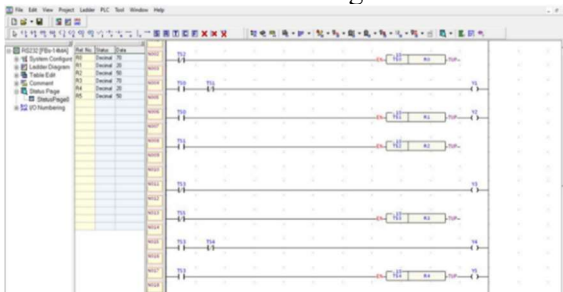


Figure 3. Code for traffic lights

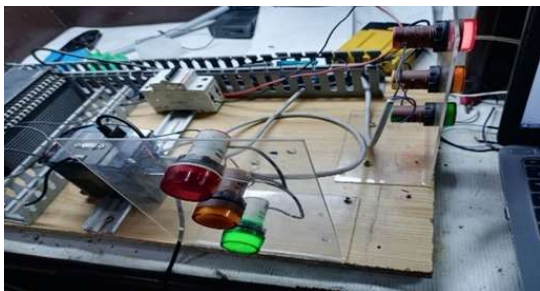


Figure 4. Hardware implementation of traffic light

This method ensures system effectiveness through comprehensive testing and refinement of the master-slave code concept before deployment.

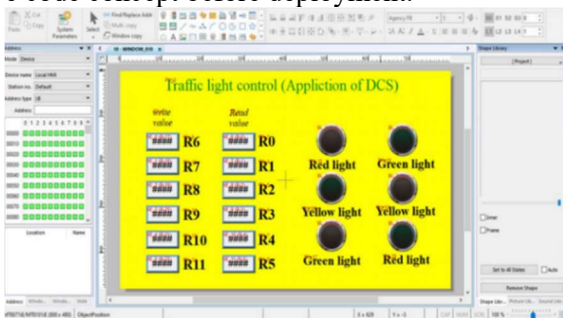


Figure 5. Design for HMI

5. Simulation Results and Discussion

The status page offers real-time feedback on the performance of the traffic light simulation, serving as an interface or monitoring tool. Figure 6 graphically presents the data received from the slave PLC, illustrating its role in displaying simulation results.

Ref. No.	Status	Data	Ref. No.	Status	Data	Ref. No.	Status	Data
Y0	Enable	ON						
Y1	Enable	ON						
Y2	Enable	OFF						
Y3	Enable	OFF						
R0	Decimal	12						
R1	Decimal	1796						
D10	Decimal	34						
D11	Decimal	45						

Figure 6. Slave PLC results

By visually inspecting master data, operators and engineers can swiftly assess the efficiency and performance of the traffic light management system. Adjustments can be implemented from a centralized control unit, as depicted in Figure 7.

Ref. No.	Status	Data
R0	Decimal	70
R1	Decimal	20
R2	Decimal	50
R3	Decimal	70
R4	Decimal	20
R5	Decimal	50
R6	Decimal	70
R7	Decimal	20
R8	Decimal	50
R9	Decimal	70
R10	Decimal	20
R11	Decimal	50

Figure 7. Master PLC results

6. Conclusion

This project utilizes a master-slave PLC configuration for communication. The HMI serves as the controller, directing commands to the master PLC. The master PLC then retrieves a value from its memory register and transmits it to a slave PLC. Upon receiving the value, the slave PLC adjusts it according to instructions from the master. This bidirectional communication is facilitated using the Modbus protocol over RS-485. In this master-slave setup, one PLC acts as the master, while others function as slaves. The RS-485 interface enables the master PLC to connect with multiple slave PLCs. The slave PLCs respond to requests from the master, execute commands, process data, and report back to the master. Meanwhile, the master initiates all communications and manages the data flow.

7. Reference

[1] "Distributed Control System," *Wikipedia*, Sep. 15, 2020. <https://en.wikipedia.org/>



- wiki/Distributed_control_system (accessed Jan. 15, 2024).
- [2] "Remote terminal unit," *Wikipedia*, Apr. 01, 2021. https://en.wikipedia.org/wiki/Remote_terminal_unit (accessed Dec 25, 2023).
- [3] I. Castillo and T. F. Edgar, "Using a distributed control system (DCS) for distillation column control in an undergraduate unit operations laboratory," in *Proceedings of the 2009 American Control Conference*, St. Louis, MO, USA, 2009, pp. 1025-1030.
- [4] L. Na and T. Jingjing, "DCS system function testing and safety evaluation," in *Proceedings of the 2008 3rd IEEE Conference on Industrial Electronics and Applications*, Singapore, 2008, pp. 1561-1565.
- [5] S. Karnouskos and A. W. Colombo, "Architecting the next generation of service-based SCADA/DCS system of systems," in *Proceedings of the IECON 2011-37th Annual Conference of the IEEE Industrial Electronics Society*, Melbourne, VIC, Australia, 2011, pp. 1522-1527.
- [6] A. Hulewicz, Z. Krawiecki, and K. Dziarski, "Distributed control system DCS using a PLC controller," in *ITM Web of Conferences*, Poznan, Poland, 2019, vol. 28, pp. 1-8.
- [7] K. Sun and Q. Chen, "Failure Impact Analyzing of a Chemical Plant based on its DCS Data Set," in *2020 11th International Conference on Prognostics and System Health Management (PHM-2020 Jinan)*, IEEE, 2020.
- [8] B. Li et al. "Distribution Control of Energy-Storage Systems for Voltage Regulation in Distribution Network with High PV Penetration," in *2018 UKACC 12th International Conference on Control*, Sheffield, UK, 2018, pp. 169-173.
- [9] P. Martí, et al., "Real Time Scheduling Methods Requirements in Distributed Control Systems," *IFAC Proceedings Volumes*, vol. 33, no. 7, pp. 95-102, 2000.



Enhancing Cybersecurity Through Honeypot-Based Intrusion Detection and Prevention Systems

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(IDS/IPS)

Network security

ABSTRACT

With the escalating threat landscape in the digital sphere, safeguarding sensitive information stands paramount for individuals and enterprises alike. Traditional security measures like encryption, firewalls, and authorization protocols have been pivotal, yet evolving cyber threats necessitate more proactive approaches. This paper advocates the adoption of honeypot-based Intrusion Detection and Prevention Systems (IDPS) as a robust defense mechanism. By leveraging the amalgamation of diverse honeypot types, this proposed system offers real-time analysis capabilities, bolstering its efficacy and cost-effectiveness. Furthermore, the utilization of virtualization technology streamlines setup and management processes, enhancing operational efficiency. In an era where network-connected devices proliferate, the risk of cyberattacks looms larger. Honeypots, acting as decoy traps, emerge as indispensable assets in fortifying cybersecurity postures. This study delves into the intersection of cybersecurity, encompassing facets such as machine learning, cyber threats, and the pivotal role of honeypots. Empirical evidence underscores the pivotal role of honeypots in thwarting unauthorized access attempts, providing invaluable insights into attack origins and methodologies. Thus, advocating for the integration of honeypot-based IDPS emerges as a proactive strategy in the relentless pursuit of fortifying digital defenses against evolving cyber threats.

1. Introduction

To safeguard information, various hardware devices and software tools are used. IT managers must design and implement suitable security solutions to maintain integrity. Technological advancements have led to an increase in attacks on information systems, recorded in attack databases. Intrusion Detection Systems (IDS) analyze and monitor these databases, helping computer systems detect potential threats.[2-3]While IDS focus on analysis and monitoring, Intrusion Prevention Systems (IPS) are designed to detect and prevent malicious attacks in real-time.They are positioned on network segments to monitor traffic for known attack signatures. This study

proposes a honeypot-based approach for real-time intrusion detection and prevention. The developed honeypot server application, combined with IDS, offers an effective detection level by merging the advantages of low and high interaction honeypots.[3]This hybrid honeypot system aims to reduce security costs in enterprise networks, minimize false positives in anomaly-based IDS, and adapt to zero-day security vulnerabilities. The system provides real-time visualization of network traffic, similar to global live attack maps, offering alive attack map for a campus network. This allows for the detection of new attacks not in signature databases, facilitating updates.The developed system, a honeypot-based Intrusion Detection and Prevention System (IDPS), visually represents both

internal and external attacks on a corporate network in real-time. This novel approach fills a gap in existing institutional systems, making it an effective solution for enhancing network security.[5]

2. Literature Review

In the quickly changing technological landscape of today, cybersecurity is a crucial concern because of the development of digital dangers that make it difficult to protect sensitive data [1]. Information systems have been protected in large part by the use of conventional security

management procedures, particularly in light of the constantly expanding cyber threat landscape. The body of research backs up the idea that honeypots are useful instruments for spotting and stopping illegal access attempts. They also serve as decoy traps, which serve to expose and deflect potential attackers [4]. The developed system's low- interaction honeypot strategy reduces security threats in LAN zones, which lowers the risk associated with the present IDSs and honeypots' view evaluation of findings. Techniques for centralized control were suggested. The goal of this study is to reduce the costs associated with placement, setup, and maintenance, especially for enterprise campus networks. The IDS, monitor, and honeypot server applications are logically isolated through the use of virtualization technologies, lowering the chance of a breach [5]. The idea that this kind of logical isolation improves the system's overall security is supported by the literature. The purpose of the honeypot server module, which has components for attack attraction, configuration, and IDS communications, is to lure and catch possible attackers on the network by fabricating computer profiles. Low- interaction honeypots are crucial for flexible monitoring and system architecture.

3. Methodology

A honeypot-based attack detection and prevention design has been built as part of our application development to monitor enterprise network traffic and analyze it to prevent harmful actions. The fundamental elements of this developed application can be divided into three categories: "the honeypot server application," which can mimic trap systems; "the monitor application," which can display animations detected from the honeypot communication server and configure the honeypot server application; and "the IDS application," which is a server application that receives packets from the honeypot server via trapping and forwards them to the monitor. Recognizing a honeypot in a LAN zone is known to pose serious security threats [17, 18]. Thus, in the executed program, the Honeypot's attack attraction component is designed to be low-interaction. It has been intended for external software to supply the data gathering and data analysis components of honeypots, similar to those in high interaction systems. As a result, the hybrid honeypot offers flexible monitoring and more appropriate disclosure of system architecture in detail. The current study suggests

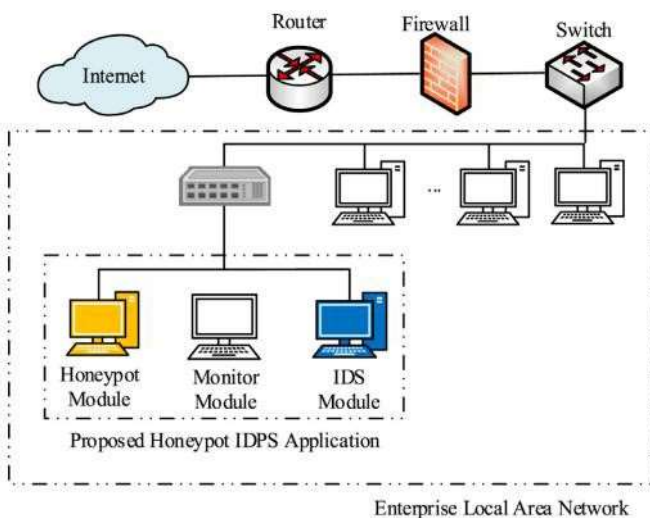


Fig. 1. Localization of developed honeypot IDPS on LAN.

mechanisms like firewalls, encryption, and authorization procedures [2]. But in order to mitigate potential dangers, creative and proactive ways are needed given the increasing sophistication of cyberthreats. In order to provide some protection against malicious activity, intrusion detection and prevention systems, or IDS and IPS, have proven crucial in the analysis and monitoring of databases for potential threats [2–3]. Although the primary objective of these systems is to detect and avert assaults, the incorporation of honeypots into cybersecurity tactics offers an extra safeguard. As fictitious decoy devices, honeypots draw in and capture any invaders, offering useful information about the methods and sources of attacks [4]. The study's suggested Honeypot-Based Intrusion Detection and Prevention System (IDPS) makes use of the combination of several honeypot kinds to provide a real- time analysis feature that improves the system's effectiveness and affordability [3]. The incorporation of virtualization technology enhances operational efficiency by optimizing setup and



a novel centralized control technique to lower placement, setup, and maintenance expenses. The honeyddisclosure, according to the study. The suggested protocol technique's illustration of the communication protocols between the IDS application and the honeypot server application shows an organized method for productive cooperation [5]. By doing this, the honeypot system's capacity to receive instructions from the IDS program is guaranteed, which improves its flexibility and response to new threats. application attack attractiveness component has been applied to the minimum contact honeypot design. To effectively gather data, capture network packets, and a central control management has been suggested to analyze data in a more error-free setting. The components for data analysis and acquisition are added to the IDS application for this purpose. By having many honeypots running on the network, centralized monitoring is made possible, speeding up and simplifying the processing. The IDS, monitor, and honeypot server apps have been logically isolated from one another and made available for physical machine operation thanks to virtualization technologies. This reduces the danger in the event that the intruder compromises the honeypot that has trapped it. The system configuration modifies the way certain virtual networks are configured in relation to the IDS and honeypot applications. The network communication of honeypot apps will therefore maintain separation from the actual network. The honeypot IDPS application's network placement is depicted in Fig. 1. Fig. 2 depicts a broad diagram of the suggested honeypot IDPS design. The honeypot server application is implemented in the C# programming language to ensure the integrity of the executed application. The Mono Project is a cross-platform framework that is utilized with the Linux operating system. Internet technology. This will allow the Linux server program to run the honeypot server application. The honey application is likewise carried out utilizing the same development platform for the assault attraction component.

Honeypot server Module

The low-interaction attack attraction component, setup component, and IDS communications component make up the three parts of the honeypot server program. Component for attack attraction: The honeyd application has equipped this low involvement honeypot

with the ability to attract attacks. This particular section has a device that has the ability to draw intruders. Part of the configuration: This component allows for the configuration of both the attack attractiveness component of the honeyd apps and the IDS. Component of IDS communications: The honeypot server module is provided by this component in order for it to interact with the IDS module. By using network monitoring components at the second layer, low- interaction honeypots are able to create fictitious computer profiles on the network. Furthermore, they react to ARP requests that arrive at a detected network layer-2 address of the honeypot IP addresses. Because of this, even though they are not physically present on the network, they can create a false computer profile. In this manner, they can create traps with multiple fictitious IP addresses on the network using a honeypot application that operates on a virtual device. Additionally, they can use a number of scripts to replicate other layer packets. Because of this, the hacker believes the phony machine with an IP address to be authentic. The scripts employed by honeypots to respond to specific application layer protocols are designed in a manner that mimics software vulnerability diagnosis. When the trespasser thinks a honeypot is a genuine computer The target system's probe detects the vulnerabilities as of right now. These flaws are used to trick an intruder into falling straight into the trap system by sending them phishing emails. In plain English, the intruder becomes stuck in the honeycomb. It is also feasible to mask the genuine systems that are in operation in this way. Since there won't be any genuine information, the network trap is unexpected when non-malicious individuals connect to these trap IP addresses in honeypot simulation services. As a result, all requests sent to the IP addresses of the computers that the honeypot mimics on the network are designated as attacks. Consequently, information about attack packets is obtained from the honeypots in order to identify novel attack techniques (zero-day attacks). These log files, retained in order to be examined. Furthermore, the data can be obtained by reviewing the logs that were maintained on the vulnerabilities on the corporate network. Nonetheless, the firewall can stop the invaders that are captured in real time within the honeypots. The packets that arrive at the honeypots provide important details regarding the actions of the

intruders. Malicious attacks are simpler to keep an eye on since a real-time interface allows for the monitoring of intruder activity. The traffic in honeypots with the source and target locations combined have been shown as an animation in this investigation using the monitor program. Additionally, the honeypot server application can be used to configure the honeyd program so that it operates on it. To achieve this, a unique Python script .has beendevloped, enabling communication between the apps running on honeypot servers and honeyd. The IDS application and the honeypot server application receive the directives, which are then sent to the honeyd application via a Python script. In a similar vein, information regarding the status of honeypots at now can be obtained by means of a mediator script. It gives the system manager access to the status of the operational honeypots by sending the data to the intrusion detection system. Additionally, it protects against any system faults by notifying inaccurate or flawed honeypot configurations. To get the necessary results, it can operate on a single operating system with several honeyd application interfaces.

honeypot is gathered by the honeypot server application from the honeyd apps that operate on the honeypot server. After that, it awaits instructions from the IDS. The IDS program can send the following instructions to the honeypot server:

To activate the spyhole.

To put an end to the honeypot.

To build a fresh honeypot.

Both removing and configuring the existing honeypot are priorities. To include fresh and distinct trails (fingerprint-signature).to include fresh scripts that let honeypots mimic authentic services. Figure 3 illustrates the protocol method that is used to communicate between the honeypot server and the IDS application. The honeypot application lacks a visible Windows-based interface because it is a console application. Therefore, there is no direct contact between it and the user. It can only communicate with the IDS program.

4. Discussion

Honeypots are essentially decoy systems or resources that are set up within a network to lure in potential attackers. They're designed to mimic legitimate systems and services, making them appear enticing to malicious actors seeking to exploit vulnerabilities or launch attacks. When attackers interact with a honeypot, their actions are closely monitored and analyzed, providing valuable insight into their tactics, techniques, and procedures. One of the primary purposes of honeypots is to gather intelligence about emerging or uncommon threats that may not be detected by traditional security measures. By acting as bait, honeypots attract attackers who may be attempting to exploit vulnerabilities that are not yet widely known or understood. This allows security teams to proactively identify and mitigate potential risks before they can cause significant harm to the network or its users. Additionally, honeypots serve as a means of detecting malicious activities on the network by capturing and analyzing the behavior of attackers. This can include activities such as scanning for vulnerable systems, attempting to exploit known vulnerabilities, or launching malware attacks. By

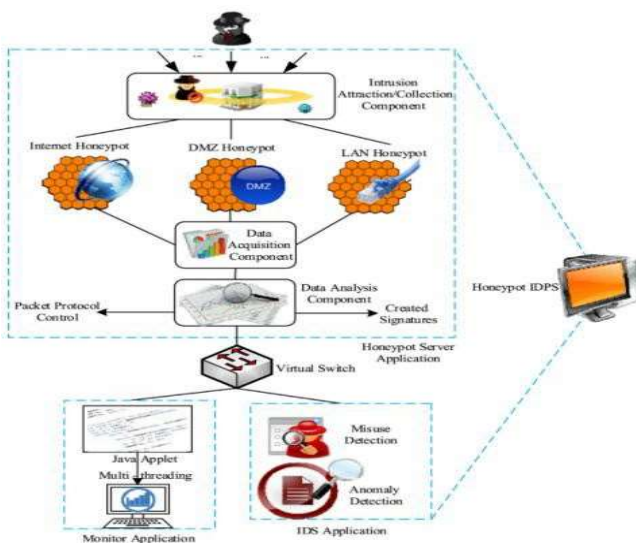


Fig. 2. Proposed honeypot IDPS.

To facilitate communication between the IDS application and the honeypot server apps, a unique protocol has been established. The IDS program opens a TCP connection with the honeypot server to begin the protocol. As a result, information on the status of every

monitoring these activities, security teams can gain valuable insights into the tactics and tools used by attackers, enabling them to better defend against future threats. Moreover, honeypots play a crucial role in discovering new attack types and methods, including zero-day exploits. Because honeypots are intentionally exposed to potential attackers, they provide an opportunity to observe and analyze previously unseen attack techniques in a controlled environment. This allows security researchers to develop countermeasures and defenses to protect against these emerging threats. [1] This paper discusses the use of honeypots as a security tool. It mentions that honeypots can block unauthorized access and provide insights into attacks. The researchers found that honeypots are becoming more important in cybersecurity. The paper highlights the need to improve honeypot services and detect honeypot servers. Comparative studies of different methods are presented in figure 1 and 2. [2]

5. Conclusion

Using Intrusion Detection and Prevention Systems (IDPS) with honeypot architecture is a viable way to strengthen cybersecurity defences against growing cyberthreats. The significance of proactive tactics is emphasised in this study in light of the always changing cyber threat environment. Through the combination of several kinds of honeypots and virtualization technology, the suggested system provides real-time analysis capabilities, operational effectiveness, and affordability.

The study's conclusions emphasise the important role that honeypots play as decoy traps, offering priceless knowledge into attack sources, techniques, and new dangers. It provides actual proof of the effectiveness of honeypots in identifying malicious activity on network-connected devices and repelling unauthorised access attempts. The low-interaction honeypot technique also simplifies system architecture disclosure while lowering security threats in local area networks (LANs). In addition, the article suggests a new centralised control method to reduce setup, placement, and maintenance expenses, especially in business campus networks. Through the use of virtualization technologies, the logical isolation of IDS, monitor, and honeypot server applications improves overall system security by

lowering the possibility of breaches. The productive

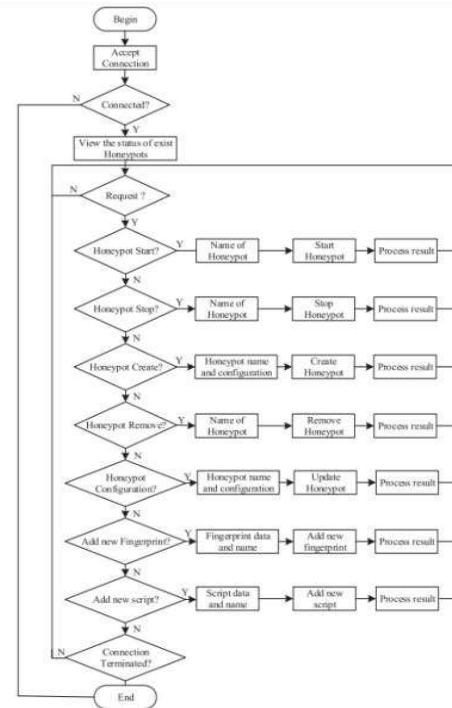


Fig. 3. Flowchart of communication rules between IDS and honeypot server.

collaboration between the IDS application and the honeypot server application is ensured by the communication protocol, which also improves the system's adaptability and reactivity to emerging threats. All things considered, this study adds to the increasing amount of data demonstrating the effectiveness of honeypot-based IDPS as a preventative cybersecurity tool to strengthen digital defences against changing cyberthreats.

6. Reference

[1] B. I. Australia, "INFOGRAPHIC: everything that happens online in 60 seconds," Business Insider. [Online]. Available: <http://www.businessinsider.com/infographic-what-happens-online-in-60-seconds-2015-5>. [Accessed: 04-Apr2018].

[2] Pirounias S, Mermigas D, Patsakis C. The relation between information security events and firm market value, empirical evidence on recent disclosures: an extension of the GLZ study. *Inf Secur Appl* 2014;19:257–71. <https://doi.org/10.1016/j.jisa.2014.07.001>.



- [3] Pfleeger CP. The fundamentals of information security. IEEE Softw 1997;14:15–16. 60
<https://doi.org/10.1109/52.566419>.
- [4] Safa NS, Maple C, Watson T, Von Solms R. Motivation and opportunity based model to reduce information security insider threats in organisations. J Inf Secur Appl 2018. <https://doi.org/10.1016/j.jisa.2017.11.001>.
- [5] Bouabdellah M, Kaabouch N, El Bouanani F, Ben-Azza H. Network layer attacks and countermeasures in cognitive radio networks: a survey. J Inf Secur Appl 2018;38:40–9. <https://doi.org/10.1016/j.jisa.2017.11.010>.
- [6] Joshi C, Singh UK. Information security risks management framework – a step towards mitigating security risks in university network. J Inf Secur Appl 2017;35:128–37.
<https://doi.org/10.1016/j.jisa.2017.06.006>.
- [7] Li S, Rieck K, Woodward A. Special issue on threat detection, analysis and defense. J Inf Secur Appl 2014;19:163–4.
<https://doi.org/10.1016/j.jisa.2014.08.001>.
- [8] Fussell RS. Protecting information security availability via self-adapting intelligent agents. In: MILCOM 2005 - 2005 IEEE military communications conference, 5; 2005. p. 2977–82.
<https://doi.org/10.1109/MILCOM.2005.1606116>.
- [9] Shamala P, Ahmad R, Zolait A, Sedek M. Integrating information quality dimensions into information security risk management (ISRM). J Inf Secur Appl 2017;36:1–0.
<https://doi.org/10.1016/j.jisa.2017.07.004>.
- [10] Marcinkowski SJ, Stanton JM. Motivational aspects of information security policies. In: IEEE international conference on systems, man and cybernetics, 2003,3; 2003. p. 2527–32.
<https://doi.org/10.1109/ICSMC.2003.1244263>.
- [11] Campbell S. Supporting digital signatures in mobile environments. In: WET ICE 2003. Proceedings. Twelfth IEEE international workshops on enabling technologies: infrastructure for collaborative enterprises, 2003; 2003. p.238–42.
<https://doi.org/10.1109/ENABL.2003.1231414>.
- [12] Vieira TPB, Tenório DF, da Costa JPCL, de Freitas EP, Galdo GD, de Sousa Júnior RT. Model order selection and eigen similarity based framework for detection and identification of network attacks. J Netw Comput Appl 2017;90:26–



Stone Columns: A Paradigm Shift in Ground Stabilization Techniques

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KEY WORDS

Soil Stabilization
Stone Columns
Soft Soil
Ground Improvement

ABSTRACT

Various methodologies exist within the realm of geotechnical engineering to improve ground conditions. One extensively employed technique is the stone column method, designed to augment soil bearing capacity and mitigate both total and differential settlement in structures erected on soft soil. By incorporating stone columns into the soft soil, their inherent high permeability is harnessed to amplify load-bearing capabilities and diminish soil settlement. Furthermore, these columns serve a dual purpose as vertical drains, expediting the consolidation process. The focal point of this paper is to furnish a short review of ground improvement strategies, with a specific focus on the utilization of stone columns and an assessment of their efficacy as a ground improvement technique.

1. Introduction

For construction projects soft soil is one of the most challenging task for an engineer because, soft soil exhibits low bearing capacity, higher compressibility and permeability, and insufficient strength. Several techniques are available for soil stabilization, including compaction, Grouting, soil replacement, deep soil mixing, stone columns, lime stabilization, and more. It is essential to have a thorough understanding of ground improvement before employing any of these methods. Among these methods, stone columns have emerged as a widely adopted solution to improve the soil stability and reduce the settlement issues. Beginning in France in the 1830s, this method gained popularity in the 1950s, particularly throughout Europe. Stone column is a technique of introducing columns of compacted stone into the soil, this method aims to improve the mechanical property of a soil, improving load-bearing capacity and minimizing settlement. They are also known as granular piles. They are cost effective as compared to steel or concrete piles and environmentally friendly. The key factor affecting the necessary ground improvement solutions primarily include type of soil, ground profile, area of site, and the design loads [1]. Mechanical

properties of stone, cohesion of surrounded soil greatly affect the capacity of granular piles [2]. The aggregates should be compacted such that to achieve desired strength [3].

2. Installation methods

Stone column installation method depends mainly on availability of equipment. Two different methods are discussed in this section

2.1 Vibro-Replacement Method

This method involves the insertion of a vibrating probe (Vibro-float) into weak or compressible soils to create holes, followed by the injection of crushed stone or granular material into these holes. As the probe is withdrawn, the granular material is compacted, displacing and densifying the surrounding soil to form granular piles. In vibro-replacement method granular piles are constructed in a regular pattern by simply substituting the soil with aggregates. Holes is created using vibratory probe, with the help of water jet, as shown in Figure 2. High speed and large depths are the advantages of this method [4], [5].

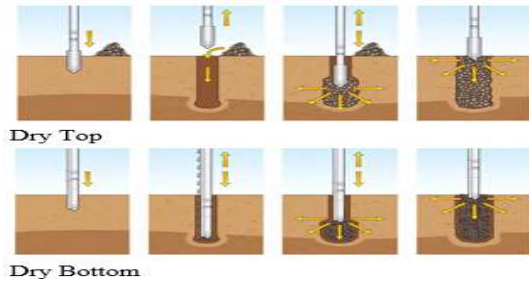


Fig. 1 Dry Vibro Replacement Method

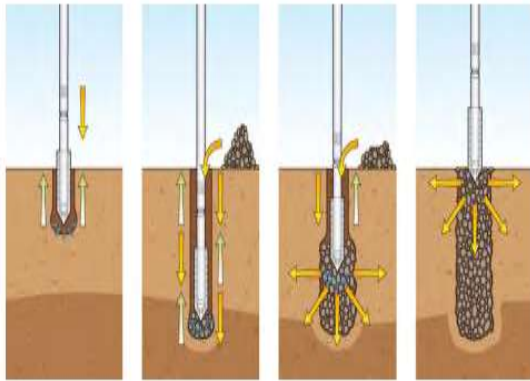


Fig. 2 Wet Vibro Replacement Method

2.2 Vibro composer Method

When the ground water level is high then, vibro-replacement method is not suitable. In this case another method by the name vibro composer method is used. At this method a column of diameter ranges from 600 to 800 mm can be constructed effectively. In the technique casing pipe is inserted to the required depth with the help of vibratory hammer at the top of the casing pipe, in order to perform granular compaction, as seen in picture 3.

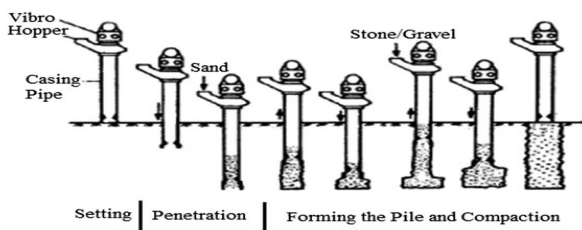


Fig. 3 Vibro Composer Method [6]

3. Applications

In the field of geotechnical engineering granular piles are used for soil improvement in the regions with soft clay or loose sands. In order to avoid landslides, it helps to stabilise embankments and slopes, lessen the danger of uneven settlement, increase the load-bearing capacity,

and limit movement below the footings. They mitigate liquefaction risks by increasing soil density and strength preventing the accumulation of high pore pressure, creating a drainage pathway for excess water.

4. Design parameters

Various design parameters should be considered while designing the stone column for ground improvement. Some key design parameters include:

4.1 Column Diameter

The bore hole's diameter is always larger than the casing diameter while constructing a stone column, because of the lateral displacement produced by vibration. In case of vibro-float method, granular piles diameters normally range from 600 mm in stiff clays to 1100 mm in soft clays. Wet construction results in larger diameters compared to dry methods [7]. In the rammed process, stone column diameters vary between 400 to 750 mm [6]. Essentially, the diameter of the hole is affected by lateral displacement caused by vibration or ramming, and it varies depending on the specific soil conditions and construction method.

Han's [8] findings in 2015 revealed that for ordinary stone columns, typical diameters ranged from 0.6 to 1.2 m, while for encased stone columns, diameters typically fell between 0.7 and 0.9 m. It was observed that smaller diameters of encased stone columns transferred more stress from the loaded foundation compared to larger diameters, likely due to the higher confining stresses they mobilize, as noted by [9-10]. Mohamed et al.'s [11]. research confirmed that smaller diameters of encased stone columns notably enhance the bearing capacity of soft clay soil compared to larger diameters. He found that the bearing capacity ratio increased significantly by 232% and 187% for stone columns with diameters of 400 mm and 600 mm, respectively. This highlights the effectiveness of smaller diameters in improving soil stability and load-bearing capacity. The findings underscore the importance of considering column diameter when designing ground improvement techniques for soft clay soils. Such insights offer valuable guidance for optimizing construction strategies in geotechnical engineering projects.

4.2 Spacing between stone columns

It's important to highlight that the settlement value is significantly influenced by the diameter (D_c) and spacing (S_c) of stone columns. A larger diameter, coupled with reduced spacing, notably diminishes

settlement [12]. The determination of stone column spacing is influenced by factors such as design load, the extent of improvement needed, ensuring a dependable foundation, considerations of soil tolerance, the installation process, and site conditions for construction. When we want to construct isolated footings, then closer spacing between the column is effective, while in case of constructing raft, larger spacing is preferred. Generally, spacing of 2-3D is considered as optimum spacing between the columns [13].

4.3 Pattern

Although installing stone columns in a quadrangle's arrangement is a possible alternative, a triangular design is the most effective and desirable pattern since it guarantees one of the most densely packed arrangements of stones within the column in a given space, as seen in Figure 4. [14]. A circle of equal area can be used to represent the tributary area quite effectively. In the case of an equilateral triangular arrangement of stone columns, the nominal circumference (D_e) is $1.05S$, where S is spacing between granular piles. While in case of a square grid configuration, the equivalent circle's diameter is $1.13S$.

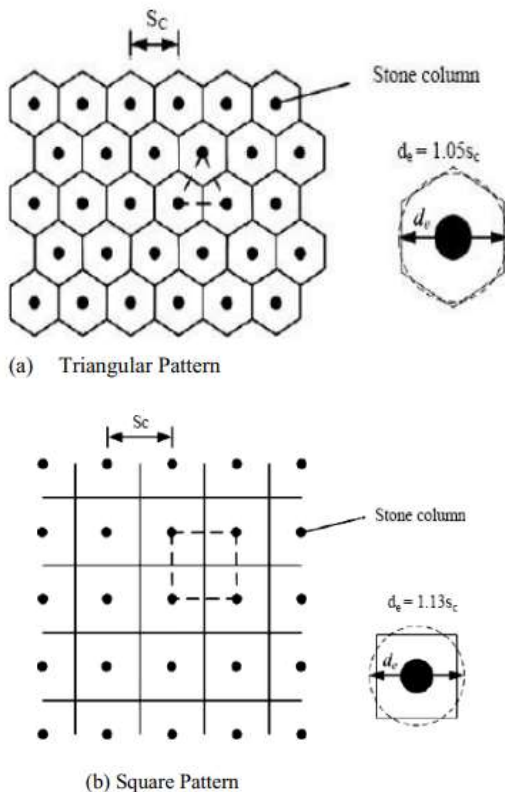


Fig. 4 Plan view showing square and triangular

arrangements of granular piles [14].

4.4 Area Replacement Ratio

Now the area replacement ratio (a_s) is one of the important parameters involve in the overall capacity of granular piles. It might be simply defined as the ratio of the area contributed by stone column to total tributary area (area of the unit cell). Mathematically it can be written as

$$a_s = A_s / A_t$$

Research studies state that the effectiveness of the enhanced soil layer is significantly impacted by this parameter. According to Shahu et al. [15], when we increase the area replacement ratio, the bearing capacity factor also increases, hence greater chance of removing weak soil and relacing it by aggregates. According to a numerical analysis by Debbabi et al. [16], there was a significant decrease in settlement when the area replacement ratio was raised. They came to the conclusion that the settlement declined by seventeen percent when the area replacement ratio varied from twelve to eighteen percent, while it dropped by almost fourteen percent when the area replacement ratio increased from eight to twelve percent.

Al-Waily's [17] conducted an extensive experimental study to find the effect of area replacement ratio on bearing capacity factor in 2012. It was found that the installation of granular piles with area replacement ratios of 0.042, 0.099, 0.333, and 0.563 resulted in respective enhancements in bearing capacity ratios of 1.16, 1.29, 1.64, and 2.29. Similarly, another researcher Ng [18] conducted numerical study and concluded that 0.25 is an effective area replacement ratio in case of end-bearing piles, while for floating granular piles it came out to be 0.45. Additionally, Kumar et al. [19] advised utilizing a ratio exceeding 30% to prevent embankment instability and recommended ratios between 60% and 80% for bridge abutment foundation piles.

A researcher conducted model tests and came to a conclusion that granular piles are only effective if their area replacement ratio is 0.25 or more, below 0.25 there is no considerable effect on the soil's bearing capability [14]. Later on, his results were verified by Fattah and Majeed [20], using finite element modelling. According to Barksdale and Bachus [21], an area replacement ratio of more than 35–40% was not economically viable, and less than 10% was not effective in improving soil bearing capacity.



5. Failure modes

Constructing stone column whether it is end bearing granular pile or floating granular pile, it is essential for an engineer to know about its failure mechanics. It is very essential to understand the variety of failure mechanisms that stone columns might experience in order to optimise their applicability. A stone column can fail in four different ways: i.e. (i) General shear failure (ii) Local shear failure (iii) Bulging failure and (iv) Sliding Failure. Bulging is often a significant factor influencing stone column failure, particularly when the column length exceeds 2-3 times its diameter. The elements that determine the types of failure include the kind of stone column (free-floating or end-bearing), the type of force applied to the column, and the soil's passive pressure [22].

6. Conclusion

Now adays stone columns are extensively used as a ground improvement method in soft cohesive soil. This technique has proven successful in providing support for isolated footings, large raft foundations, and embankments. Particularly in soft clays, the implementation of granular piles has demonstrated notable enhancements in load-bearing capacity while significantly reducing settlement. Due to their granular and well-drained nature, these columns expedite consolidation settlement and minimize post-construction settling.

7. Reference

- [1] Choobbasti, A. Zahmatkesh, and R. Noorzad, "Performance of stone columns in soft clay: numerical evaluation," *Geotech. Geol. Eng.*, vol. 29, pp. 675–684, 2011.
- [2] S. Malarvizhi and K. Ilamparuthi, "Load versus settlement of clay bed stabilized with stone and reinforced stone columns," presented at the 3rd Asian regional conference on geosynthetics, 2004, pp. 322–329.
- [3] M. Dheerendra Babu, S. Nayak, and R. Shivashankar, "A critical review of construction, analysis and behaviour of stone columns," *Geotech. Geol. Eng.*, vol. 31, pp. 1–22, 2013.
- [4] D. Sayar and M. Khalilpasha, "Soil improvement using vibro replacement technique," *Adv. Environ. Biol.*, pp. 658–662, 2012.
- [5] H. J. Priebe, "The design of vibro replacement," *Ground Eng.*, vol. 28, no. 10, p. 31, 1995.
- [6] M. Dheerendra Babu, S. Nayak, and R. Shivashankar, "A critical review of construction, analysis and behaviour of stone columns," *Geotech. Geol. Eng.*, vol. 31, pp. 1–22, 2013.
- [7] M. Mokhtari and B. Kalantari, "Soft Soil Stabilization using Stone Column--A Review," *Electron. J. Geotech. Eng.*, vol. 17, pp. 1459–1466, 2012.
- [8] J. Han, "Principles and Practice of Ground Improvement", Wiley, United States of America, 2015.
- [9] Y. Tandel, C. Solanki and A. Desai, "Laboratory experimental analysis on encapsulated stone column", *Arch Civ Eng* 59(3):359–379, 2013. <https://doi.org/10.2478/ace-2013-0020>
- [10] N. Al Obaidy, "Treatment of Collapsible Soil using Encased Stone Columns", PhD Thesis, The University of Birmingham, Birmingham, 2017.
- [11] M. Mohamed, M. Sakr and W. Azzam, "Geotechnical behaviour of encased stone columns in soft clay soil", *Innov Infrastruct Solut* 8(2):80, 2023. <https://doi.org/10.1007/s41062-023-01044-6>
- [12] J. Shahu, M. Madhav, and S. Hayashi, "Analysis of soft ground-granular pile-granular mat system," *Comput. Geotech.*, vol. 27, no. 1, pp. 45–62, 2000.
- [13] IS:15284-2003 Indian standard code of practice for design and construction for ground improvement-guidelines. Part 1: Stone columns, India.
- [14] S. Murugesan and K. Rajagopal, "Model tests on geosynthetic-encased stone columns," *Geosynth. Int.*, vol. 14, no. 6, pp. 346–354, 2007.
- [15] J. Shahu, M. Madhav, S. Hayash, "Analysis of soft ground granular pile-granular mat system", *Computer Geotech* 27(1):45–62, 2000.
- [16] I. Debbabi, R. Saddek, A. Rashid, A. Muhammed Numerical modelling of encased stone columns supporting embankments on sabkha soil. *Civ Eng J* 6(8):1539–1608, 2020. <https://doi.org/10.28991/cej-2020-03091569>
- [17] Al-Waily "Effect of area replacement ratio on bearing capacity of soil treated with stone column", *J Kerbala Univ* 10(4):280–290, 2012.
- [18] K. Ng, "Numerical study on bearing capacity of single stone column", *Int J Geoeng* 9(9):1–10. 2018 <https://doi.org/10.1186/s40703-018-0077-z>



2nd International Multidisciplinary Conference on Emerging Trends in Engineering Technology-2024 (2nd IMCEET-2024)



- [19] N. Kumar, R. Kumar, B. Nirola and A. Jaiswal, “Numerical analysis of a dual-layer geosynthetic encased stone column installed in soft soil”, *Adv Civ Eng* 2023:1–12, 2023. <https://doi.org/10.1155/2023/5039439>
- [20] M. Fattah and Q. Majeed, “Finite element analysis of geogrid encased stone columns”, *Geotech Geol Eng* 30:713–726. 2012. <https://doi.org/10.1007/s10706-011-9488-8>
- [21] R. Barksdale and R. Bachus, Design and construction of Stone Columns. Technical Report, Federal Highway Administration, Washington, 1983.
- [22] R. Ghanti and A. Kashliwal, “Ground Improvement Techniques—with a focussed study on stone columns,” *Dura Build Care PVT LTD* Retrieved January, vol. 30, p. 2013.



Analysis of Drinking water Quality of Larkana City (Urban Areas)

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Groundwater, Physicochemical characteristics,
Drinking Water,
Larkana, Sindh

ABSTRACT

Water is the most important source of life. However, due to various anthropogenic activities, water is no longer pure and drinkable. Pakistan is a country that is facing an acute shortage of safe water, and safe water drinking resources in Sindh, which is the second largest province of Pakistan, are depleting day by day. Therefore, a research study was carried out to determine the Physico-Biological properties of groundwater of Larkana city of Sindh province of Pakistan, where groundwater is the only source of drinking. For this purpose, a total of 40 samples were randomly collected from various locations in Larkana city, and the Physico-Biological parameters like Color, Odor, Taste, Turbidity, Total Solids (TS), Electrical Conductivity (EC), and Faecal Coliform and E-Coli were determined in the laboratory and were compared with WHO permissible limits. The results revealed that all of the samples were colorless with no turbidity, but 20% of the samples had having odor of sewage water. Moreover, 20% of samples had having slightly bitter taste, particularly the samples collected from Ahsan Colony, Sachal Colony, and QUEST hostel. Moreover, 92% of samples had values of Total Solids and EC beyond permissible limits. Further, most of the samples were found to have no presence of E. coli, but 8% of samples were found to have faecal Coliform present.

1. Introduction

Groundwater is the most used source of drinking water in the Sindh province of Pakistan. This is the single source of drinking water that is readily available to every resident of Sindh province of Pakistan. However, this important source of drinking has emerged as the main cause of diseases in the Sindh province of Pakistan. This

source of water is degraded by the overuse of aquifers, excessive application of agricultural fertilizers for crops, dumping of solid waste, discharge of untreated sewage into natural streams, and natural factors related to climate change. The mixing of fecal waste with water is also extremely detrimental to human health and is one of the major causes of water quality deterioration. Although water supply schemes have been introduced in



the various parts of Sindh province of Pakistan such as Karachi, Sukkur, Hyderabad, and Jacobabad, almost 80% of the population in the Sindh province extract groundwater for their daily consumption [1]. Groundwater in the Sindh province of Pakistan is not only used for drinking but also for irrigation and other domestic purposes as well. Groundwater in Sindh province is available in the forms of unconfined aquifers and confined aquifers. People in Sindh province abstract water for their daily use through open-dug wells, with the help of electric pumps, and hand pumps as well. Even in the parts of Sindh province where water supply schemes are working to provide safe water to the consumers, yet population in various rural parts of these districts rely on the groundwater. This is because either water supply schemes are also not sufficient to provide the required quantity of water to the whole population residing in urban and rural parts of Sindh province or using water supply schemes is neither economical for rural populations nor for water supply companies.

Studies have found that access to safe drinking water for the people of the Sindh province of Pakistan is declining day by day. It has also been found that about 7-8% of the population in the rural parts of Sindh province of Pakistan has easy access to safe drinking water, and the remaining population of the province about 92% drink unhealthy and unhygienic water [2]. Moreover, it also confirmed with the help of research works that about 50% of diseases in Sindh province are associated with poor water quality [3]. The common diseases that are attributed to the degraded quality of drinking water in the Sindh province of Pakistan include Hepatitis, Cholera, diarrhea, Gastro, Kidney diseases, etc. Aljazeera in 2022 reported that after the flood hit various parts of Sindh, a variety of diseases such as gastro, diarrhea, abdominal issues, and other waterborne diseases erupted in the Sindh province of Pakistan. All diseases were attributed to the consumption of poor-quality drinking water.

Therefore, various scholars have started working on the assessment of the groundwater quality in the Sindh province of Pakistan. In order to facilitate scholars for their research, the government of Sindh also has established water testing laboratories under the umbrella of PCRWR which is the research council in water resources in Pakistan. Hence, this study was proposed to detect the suitability of groundwater in Larkana city of Sindh province of Pakistan for drinking purposes.

Larkana shown in Fig.1 is located on the right bank of

the Indus River. It has a total population of 17.84 million. It is located between earth coordinates 27° 33' 50.3748" N and 68° 12' 54.4824" E. Water for irrigation to Larkana city is supplied by Canal that has been provided only for growing the rice crop and that canal flows through the heart of the city. Moreover, this canal oftakes from the Sukkur barrage constructed on the Indus River at Sukkur. The crops that are commonly grown in Larkana include Mustard, Rice, and Wheat.

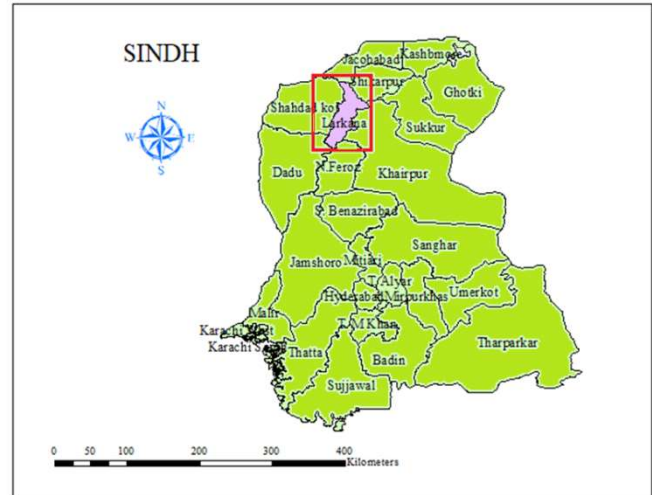


Fig.1 Location of Larkana in Sindh Province

The source of drinking water in Larkana city is only the groundwater. No water supply schemes have been introduced in Larkana yet. People of Larkana City either are compelled to drink poor groundwater for their survival or borrow water from other sources that are suitable for consumption. Jamali et al. 2022 [4] revealed while analyzing the quality of groundwater in the UC Ratokot of Larkana that water was extremely contaminated for drinking purposes and people used to borrow water from specified hand pumps where water was found sweaty in taste and did not pose any threat to human health. Lanjwani et al. 2022 [5] also have found that the groundwater in nearby areas of Larkana is contaminated but people take water from other sources for their daily consumption. Although Non-governmental organizations (NGOs) are facilitating people in taking safe water to their doors, not all the parts of Larkana are covered by the NGOs. On the other hand, solarized water purification units are also provided in a limited number of villages, but no monitoring of such units is done by any executive authorities. For instance, Ahmed et al. 2022 [6] reported that in a few villages it had been three to five years since people were drinking water from the solarized water treatment units, but



residents said that no officials from the government or NGOs looked after these units after installment. That ultimately means people are drinking the same contaminated groundwater not the treated water.

Therefore, this study was an effort to assess the suitability of the groundwater of Larkana City so that the safety of the public can be ensured.

2. Methodology

For the assessment of groundwater samples of Larkana city, a total of forty (15) groundwater samples were collected from Larkana city. Samples were collected in 250 ml plastic water bottles. The samples were given proper labeling and codes so that analysis based on the location of samples should be made properly. Each groundwater sample was analyzed for water quality parameters such as pH, Total dissolved solids (TDS), Electrical conductivity (EC), color, taste, odor, E-Coli, and fecal Coliform. The E-Coli and Faecal Coliforms were also assessed because studies have revealed that in Larkana city the major cause of groundwater contamination is the mixing of fecal waste and animal waste with the groundwater [7].

Testing of samples was done in the water testing Laboratory of Rohri. The pH and Total dissolved solids were determined by using a TDS meter as well. The concentration of EC was determined by using Equation 1.

$$EC = \frac{TDS}{0.646} \quad \text{Equation (1)}$$

The equation has been used by many scholars such as Solangi et al. 2019 [8], etc. Moreover, E-Coli and fecal coliform were measured by using the Membrane Filtration Technique at the Rohri water testing laboratory. However, physical parameters of drinking water quality such as color, odor, and taste were measured on the site by sensory technique. The Color was checked by the naked eye, the smell was determined by the nose, and while taste was checked by the tongue on the site. Once the results were obtained the analysis of results was made by comparing obtained values of each parameter with the WHO guidelines. The WHO recommended values are followed in the whole of Pakistan for the detection of the suitability of drinking water. Moreover, the recommendations of other statutory bodies in Pakistan such as PEPA, NEQS, etc. also follow the recommendation of the WHO.

The detailed methodology and suitable methods for the assessment of various water quality parameters are listed in Tabl.1.

Tabl.1 Methods of testing of groundwater samples

Parameters	Test method/Instrument
TDS (mg/l)	TDS Meter
EC (mg/l)	Equation (1)
Color	Sensory
Odor)	Sensory
Taste	Sensory
pH at 25°C	pH Meter, Hanna Instrument, Model 8519, Italy
Faecal Coliform and E-Coli	Membrane Filtration Technique

3. Result and Discussion

Groundwater samples were properly analyzed for water quality parameter and their observed values were matched with the recommended values of the WHO. The results of each parameter such as pH, Total dissolved solids (TDS), Electrical conductivity (EC), color, taste, odor, E-Coli, and fecal Coliform is individually discussed below.

3.1 pH

The pH indicates the measurement of acidity and alkalinity in water. The value of pH in the drinking water ranges between 0 and 14. Water is considered extremely acidic if its value touches 14 and water is extremely alkaline if it has zero concentration of pH, however, 7 is marked as neutral water. The WHO recommends that the water should neither be extremely acidic nor extremely acidic. Thus, the WHO suggests that the value of the pH in water should be between 6.5 to 8.5. Upon analysis of drinking water samples collected from groundwater resources of Larkana City, it was observed that the value of the concentration of pH in drinking water samples ranged from 6.8 to 8.1. Furthermore, it was also found that none of the samples exhibited pH levels exceeding the permissible limits, indicating that the water is not at risk from pH-related issues.



3.2 Total dissolved solid (TDS)

The concentration Total Solids (TDS) is the measurement of the total quantity of organic and inorganic impurities dissolved in water. The WHO says the TDS makes water unsuitable for drinking if its concentration in water goes beyond 1000 ppm. The analysis of groundwater samples disclosed that the value of TDS in Larkana City was between 560 ppm to 2100 ppm. The peak concentration of TDS in drinking water was found in the groundwater samples obtained from Mahdi Colony, Sachal Colony, and samples from the QUEST University campus, etc. Overall, 36 samples had a value of TDS beyond permissible limits. Deterioration of groundwater quality based on the TDS may be due to the percolation of salts from dumping sites, and water-logged soil.

3.3 Electrical Conductivity (EC)

Electrical Conductivity is also the measurement of solids and salts in drinking water. The higher concentration of Electrical Conductivity makes water saline in taste. The salinity is also measured from the values of Electrical Conductivity. The WHO has recommended that in suitable drinking water, the concentration of Electrical Conductivity should not be higher than 400 micro-simen per centimeter. When the groundwater samples for Electrical Conductivity were analyzed the results exhibited that the water in Larkana City is also vulnerable to Electrical Conductivity. The concentration of Electrical Conductivity in samples was found between 856 micro-simen per centimeter and 3255 micro-simen per centimeter. The highest value of EC was found in the samples collected from Mahdi Colony, Khohra Complex, Ahsan phase-II colony, etc. Overall, 36 samples had a value of EC beyond permissible limits

3.4 E-Coli and Faecal Coliform

E-Coli is also a group of fecal coliform. Faecal Coliform in water is the presence of human and animal waste in drinking water. This is the most dangerous water quality parameter. The kidney, liver, and abdominal diseases are attributed to the presence of fecal coliform in drinking water. This dangerous parameter is imparted in water by the mixing of sewage with groundwater or surface water. The WHO has recommended that the fecal coliform and E-Coli in drinking water should be zero. When groundwater samples were analyzed for E-Coli and fecal

coliform, it was found that samples did not exhibit the presence of E-Coli, however, three samples were found to have a concentration of fecal beyond the permissible limit. The three samples which exhibited the presence of fecal coliform were collected from Yar Muhammad Colony, Mumtaz Colony, and Mahdi Colony.

3.4 Color, odor and taste

The Portable water does not have any shape or odor and is sweaty in taste. Each sample for taste, odor, and color was tested by tongue, nose, and eye. The sensory evaluation of groundwater samples, that covered analysis of color, taste, and odor, the results demonstrated that all samples were colorless. However, eight samples presented that taste that was a bitter taste and a sewage-like odor as well. Particularly, the samples gathered from Ahsan-I, Ahsan-II, Mahdi Colony, Sachal Colony, Yaar Muhammad Colony, Mumtaz Colony, Larkana Coach Stand, and Noor Colony displayed a slightly saline and bitter taste, accompanied by an unpleasant odor.

Overall, the results of groundwater samples based on the physical-biological analysis of groundwater samples is shown in Fig.1

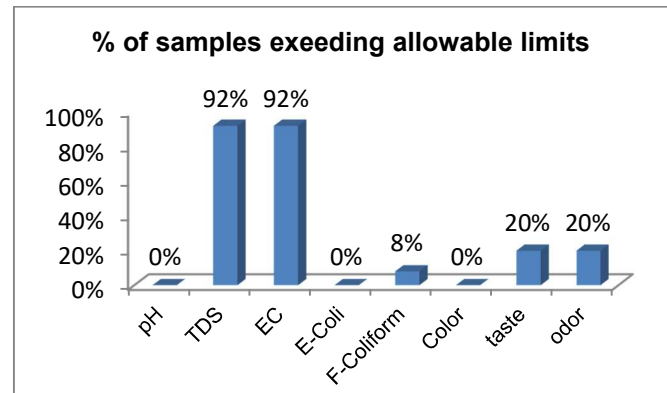


Fig.2 Overall, results of groundwater samples

4. Conclusion

Groundwater quality assessment has become a very important trend of research nowadays. This is because groundwater quality is on the verge of complete deterioration. The reasons behind the degrading quality of groundwater are natural and anthropogenic as well, but anthropogenic reasons are the major cause of poor groundwater quality. Groundwater is the single source



of drinking water in Larkana City the residents of Larkana city rely on, that's why residents of Larkana City are extremely affected by the deteriorating groundwater quality. This study, therefore, was carried out to find the suitability of groundwater focusing on the physical and biological properties of groundwater. The evaluation of groundwater samples divulged that the groundwater is extremely contaminated and its contamination is truly represented by its color, taste, odor, TDS, EC, and fecal coliform. The results of the analysis of forty groundwater samples revealed that although samples were colorless with no turbidity, 20% of the samples exhibited the odor of sewage water. Moreover, 20% of samples exhibited a slightly bitter taste, particularly the samples collected from Ahsan Colony, Mahdi Colony, Sachal Colony, and QUEST campus Larkana. Moreover, 92% of samples had values of Total Solids and EC beyond permissible limits. Further, none of the samples had a concentration of e-Coli above allowable limits, but 8% of samples were found to have fecal Coliform beyond suggested values.

Overall, water was not suitable in many parts of Larkana city. Extensive research on the groundwater of Larkana city is also recommended in which application of mathematical models such as WQI should be made.

5. Reference

- [1] Samtio, M. S., Jahangir, T. M., Mastoi, A. S., Lanjwani, M. F., Rajper, R. H., Lashari, R. A., ... & Noonari, M. W. (2023). Impact of rock-water interaction on hydrogeochemical characteristics of groundwater: Using multivariate statistical, water quality index and irrigation indices of chachro sub-district, thar desert, sindh, Pakistan. *Groundwater for Sustainable Development*, 20, 100878.
- [2] Jamali, M. Z., Solangi, G. S., Keerio, M. A., Keerio, J. A., & Bheel, N. (2023). Assessing and mapping the groundwater quality of Taluka Larkana, Sindh, Pakistan, using water quality indices and geospatial tools. *International Journal of Environmental Science and Technology*, 20(8), 8849-8862.
- [3] Qamar, K., Nchasi, G., Mirha, H. T., Siddiqui, J. A., Jahangir, K., Shaeen, S. K., ... & Essar, M. Y. (2022). Water sanitation problem in Pakistan: A review on disease prevalence, strategies for treatment and prevention. *Annals of Medicine and Surgery*, 104709.
- [4] Jamali, M. Z., Khoso, S., Soomro, Z., Sohu, S., & Abro, A. F. (2022). EVALUATING THE SUITABILITY OF GROUNDWATER IN PAKISTAN: AN ANALYSIS OF WATER QUALITY USING SYNTHETIC POLLUTION INDEX (SPI) AND WATER QUALITY INDEX (WQI). *International Journal of Energy, Environment and Economics*, 30(3), 311-328.
- [5] Lanjwani, M. F., Khuhawar, M. Y., & Jahangir Khuhawar, T. M. (2022). Assessment of groundwater quality for drinking and irrigation uses in taluka Ratodero, district Larkana, Sindh, Pakistan. *International Journal of Environmental Analytical Chemistry*, 102(16), 4134-4157.
- [6] Ahmed, S., Jamali, M. Z., Khoso, S., Azeem, F., & Ansari, A. A. (2022). ASSESSMENT OF GROUNDWATER QUALITY IN RURAL



AREAS OF TALUKA DOKRI, SINDH,
PAKISTAN, THROUGH
PHYSICOCHEMICAL

PARAMETERS. *International Journal of
Energy, Environment and Economics*, 30(3),
211-226.

- [7] Jamali, M. Z., Solangi, G. S., & Keerio, M. A. (2020). Assessment of Groundwater Quality of Taluka Larkana, Sindh, Pakistan. *International Journal of Scientific & Engineering Research*, 11(5), 795-797.
- [8] Solangi, G. S., Siyal, A. A., Babar, M. M., & Siyal, P. (2019). Evaluation of drinking water quality using the water quality index (WQI), the synthetic pollution index (SPI) and geospatial tools in Thatta district, Pakistan. *Desalination and Water Treatment*, 160, 202-213.



Evaluation of effect of Clay-water on the Physico-Chemical Properties of Drinking water

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KEY WORDS

Clay-Water Cooler,
Physicochemical parameters,
water treatment, safe drinking
water.

ABSTRACT

The issue of degradation of drinking water quality has become a problem of great concern in Pakistan, and especially availability of water treatment facilities in the Sindh province of Pakistan is almost negligible, particularly in rural areas. And, the public has been using traditional methods to reduce the concentration of physico-chemical parameters in drinking water. Therefore this study was carried out to analyze the impact of a Clay-water cooler on physico-chemical parameters of drinking water. Analysis revealed that samples remained colorless, with the passage of time odor of water changed to a clayey odor; Turbidity increased with the passage of time and temperature decreased; the pH value of water increased initially and crossed the allowable limit but with time it was observed that pH of water decreased came under the limit; the concentration of EC, Cl, Ca, Total Hardness and TDS decreased for first 12 hours, but increased with increase in storage time. The value of Magnesium increased as storage time increased. Overall, it was disclosed that a Clay-water cooler has a positive impact on the quality of drinking water particularly if water is stored in a clay-water cooler for a time not longer than 8 hours.

1. Introduction

The quality of drinking water whether it is in form of surface water or groundwater is getting deteriorated drastically with the passage of time. There are many reasons behind the degradation of drinking water quality. The causes of bad water quality are associated with the natural phenomenon as well as the anthropogenic activities. The natural causes include geological changes of layers, climate change, shortage of rainfall, acidic rainfall, etc. However, the anthropogenic reasons include over abstraction of water,

urbanization, over population, disposal of untreated domestic and industrial sewage into streams, dumping of solid waste, overuse of agricultural fertilizers, etc. The issue of poor quality of drinking water is not only limited to the developing countries but developed countries are also grappling with the availability of safe drinking water as well. It is also investigated that about 20 billion people around the world are facing scarcity of safe and suitable drinking water, and almost 50-60% diseases in the world are the waterborne diseases [1]. It is further evaluated through research that after 2025 almost 50% population of the world will face scarcity of suitable



drinking water.

Pakistan is also one of the countries that are coping with the shortage of portable water. Research has revealed that only 30-40% people in Pakistan drink good drinking water, rest of people either struggle with the availability of water or consume poor drinking water [3]. That's the reason that in Pakistan abdominal diseases such as Gastro, diarrhoea, and other diseases such as cholera, malaria, typhoid, etc. are common owing to extremely contaminated drinking water [4]. In the most parts of Pakistan particularly rural areas, residents are using unfit drinking water. This unhealthy water is not only affecting the economy of Pakistan but also increasing the patients of chronic diseases in Pakistan. The UNICEF and government authorities of Pakistan have confirmed that in the last ten years the patients of waterborne diseases have increased excessively [5, 6]. The PCRWR (Pakistan Centre for Reclamation of Water Resources) have also confirmed that almost 60% drinking water in Pakistan is not fit for drinking. The major cause of the water pollution in Pakistan is the mixing of sewage with the surface water and ground water [7]. Therefore, scholars have been recommending that the government should immediately take remedial measures in order assure the supply of safe drinking water to the population of Pakistan.

However, neither it is feasible nor economical to provide treated water supply schemes everywhere. It also depends upon the source of water as well. For instance in the Tharparkar district of Sindh province of Pakistan, neither dam can be constructed because there is complete desert that does not allow rain water to move from one point to another nor the lined canal is constructed there by government. In such circumstances, residents are reluctantly drinking water from dug wells and aquifers, which are not safe for drinking due to variety of chemical and physical impurities. On the other hand, various cities only have accessibility to groundwater for their domestic uses, but, groundwater also exhibit variety of contamination. Therefore, the need of economical and locally available technique of water purification is the need of time in many countries in the world including Pakistan.

Clay water coolers locally known as (Dilla or Matt) are commonly used in the rural areas of Pakistan. Most of population in the rural areas use clay water coolers due to being cheaply available everywhere. Besides that many think that these clay water coolers may have negative or positive impact on the many water quality

parameters. Thus, in order to assess the change in the properties of drinking water this study was proposed. And, frequent change in various parameters was assessed in the laboratory.

2. Materials and Methods

2.1 Materials

For assessing the effect of clay water cooler on the quality of drinking water, three clay water coolers shown Fig.1 with proper cap and tap were purchased from the Larkana city and were brought the Laboratory of the University of Larkano.



Fig.1 the Clay Water Cooler

2.2 Methods

For determining the change in the quality of drinking water the water quality parameters such as pH, Total Dissolved Solids (TDS), taste, odor, Total Hardness (TH), Chloride (Cl), Magnesium (Mg), and Calcium (Ca). The samples were collected from the electric motor of the University of Larkano. All tests were done following the standard laboratory methods. The water quality parameters were firstly checked before filling the clay water coolers so that the results could be matched with the forthcoming results. The clay water coolers were first properly washed and then filled with the same water and placed in the laboratory of the University of Larkano. Later on, the clay water coolers were left for three, eight, twelve, and fourteen hours. Firstly after three hours samples were collected from each Clay water Cooler and testing was done; samples were again collected after eight hours; twelve hours and lastly the samples from each Clay water cooler collected after fourteen hours and the concentration each parameter was determined. It should be noted that three samples of 250 ml were collected from three Clay water coolers and



testing was done systematically. And, in the end all results were compared with the values of each parameter determined before filling the clay water cooler.

3. Results and Discussion

The results of the various water quality parameters such as pH, Total Dissolved Solids (TDS), taste, odor, Total Hardness (TH), Chloride (Cl), Magnesium (Mg) and Calcium (Ca), were determined initially before filling of clay water cooler, and after three, eight, twelve, and fourteen hours. The results of each parameter were compared with results after the three, eight, twelve, and fourteen hours. The effect of clay water cooler on the properties of drinking water is discussed below.

3.1 Taste and odor

Taste and odor of drinking water samples were assessed initially and after three, eight, twelve and fourteen hours of storage in the Clay Water Coolers. When initially samples were assessed, samples did not have any color or odor and even after three, eight, twelve, and fourteen hours of storage in Clay water cooler, the water did not exhibit change in taste. However, the odor of water slightly changed with passage of time and exhibited muddy odor.

3.2 pH

pH is a chemical drinking water quality parameter. The WHO recommends that the pH in the drinking water should not exceed 8.5 neither should be lesser than 6.5. When the drinking water samples were initially tested for the pH the value of pH was found 8.3, and when the pH value of water stored three hours in the clay water was checked it displayed the value of 8.6 on the pH meter. However, the value started decreasing after the storage of eight hours. The value of pH after eight hours storage was found 8.1, after twelve hours it was 7.9 and after fourteen hours it was 7.85. Thus, results displayed reduction in the pH value with the increase in storage time. The results are displayed in Fig.2.

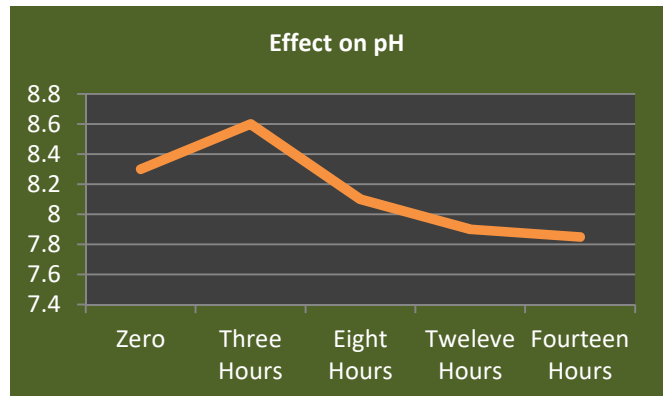


Fig.2 Effect of Clay water cooler on the pH

3.3 Total Dissolved Solids (TDS) and Electrical Conductivity (EC)

Total dissolved Solids (TDS) is one of the important parameters of drinking water. The TDS in the drinking water samples were checked by using TDS meter. The results revealed that initially the value of TDS was found as 1210 ppm. However, after the storage of three hours in Clay water cooler it reduced to 1200 ppm, later on after eight hours it showed further decline in its values from 1200 ppm to 1189 ppm, and after twelve hours it reduced to 1185 ppm. However, it displayed an increase in the concentration of TDS after fourteen hours. The value after fourteen hours was recorded as 1191 ppm. The results are displayed in Fig.3

The electrical Conductivity of water followed the same pattern. Initially the value of EC was recorded as 1875 $\mu\text{S}/\text{cm}$, after three, eight, twelve, and fourteen hours it was recorded as 1860 $\mu\text{S}/\text{cm}$, 1857 $\mu\text{S}/\text{cm}$, 1843 $\mu\text{S}/\text{cm}$, 1837 $\mu\text{S}/\text{cm}$, and 1846 $\mu\text{S}/\text{cm}$ respectively. The detailed results are displayed in Fig.4.

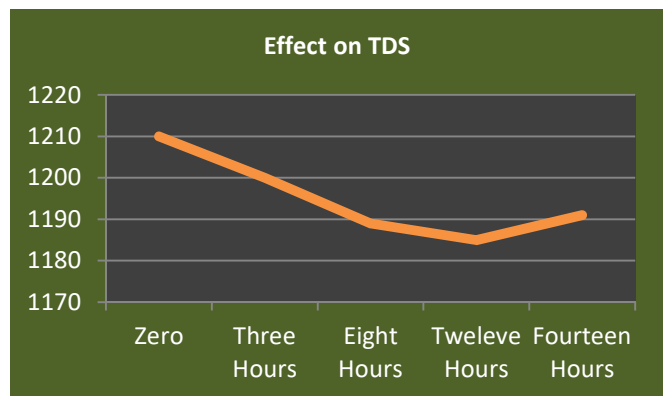


Fig.3 Effect of Clay water cooler on the TDS

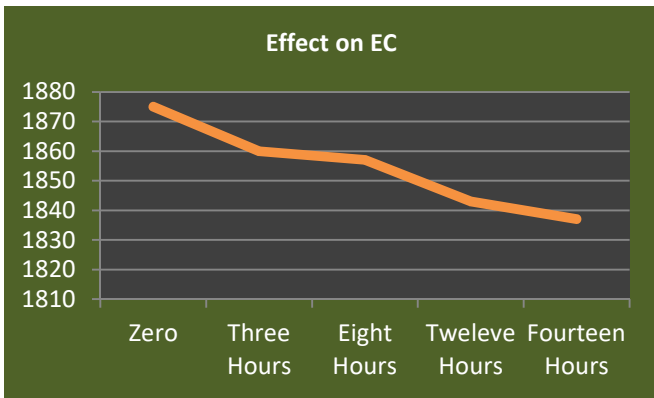


Fig.4 Effect of Clay water cooler on the TDS

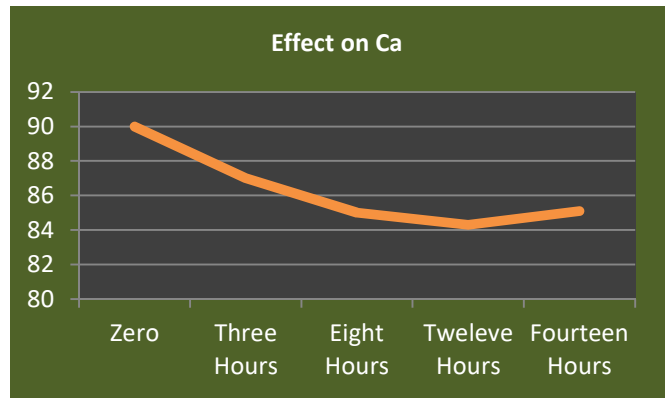


Fig.6 Effect of Clay water cooler on the Ca

3.4 Total Hardness (TH)

Similar pattern of testing as done for TDS, EC, Colr, and odor was followed for the Total Hardness. When the samples were checked initially, after three hours, eight hours, twelve, and fourteen hours, the value of TH was recorded as 1440 ppm, 1439 ppm, 1435 ppm, 1430 ppm, and 1436 ppm respectively. It also revealed that there is a positive impact on the total hardness of drinking water if water is stored for up to twelve hours, however, later it starts increasing as shown in Fig.5.

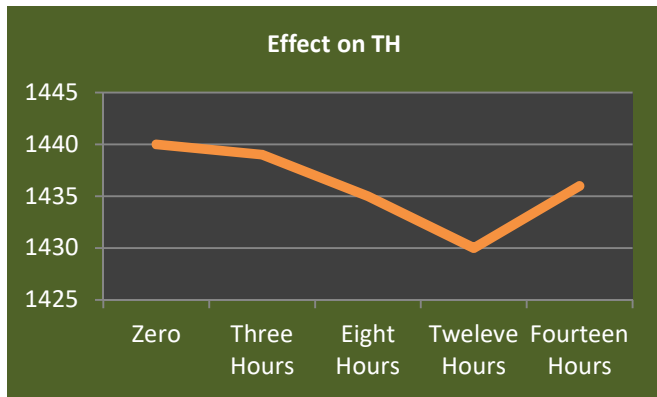


Fig.5 Effect of Clay water cooler on the TH

3.5 Calcium (Ca) and Magnesium (Mg)

Calcium and Magnesium are another important elements of drinking water. These two parameters contribute to total hardness in the water. When the concentration of calcium was tested initially its value was observed as 90 ppm. However, when water was stored in the Clay Water cooler and samples were taken for testing after three, eight, twelve, and fourteen hours, the results revealed that the value of calcium reduced from 90 ppm to 87 ppm after three hours, after eight hours it reduced to 85 ppm, 84.3 ppm and 85.1 ppm after twelve and fourteen hours respectively. The details are shown in Fig.6.

However, when magnesium in the water samples were tested as shown in Fig.7, initially the value of Magnesium was observed as 71.2 ppm. When water samples were tested after three, eight, twelve, and fourteen hours the values of magnesium were observed as 72 ppm, 73.3 ppm, 74.86 ppm, and 75 ppm respectively.

In nutshell, the values of Calcium kept decreasing for the first twelve hours while values of Magnesium kept increasing throughout period.

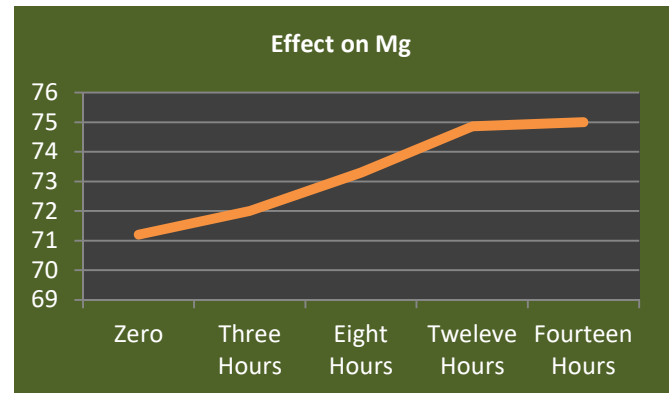


Fig.7 Effect of Clay water cooler on the Mg

4. Conclusion

Water is the most crucial source of life. However, this important element of life is on the verge of deterioration due to various anthropogenic and natural causes that have been making quality of water unsuitable for drinking. The major causes behind the shrinking quantity of safe drinking water are the mixing of industrial and domestic sewage with groundwater and surface water, shortage of rainfall, percolation of dangerous leachate to groundwater, and disposal sites of solid waste. Therefore, it has become important to introduce efficient and economical water treatment



methods in Pakistan and other countries. Keeping this view in mind this effort was made to assess changes in the quality of drinking water when it is stored in the Clay water Cooler. The Clay water cooler is the most commonly used cooler for storing water particularly in rural areas of Pakistan. When the effect of clay water cooler on the quality of water was assessed the results revealed that there is a slight positive change in the various water quality parameters such as Calcium, Total hardness, Total dissolved solids, and pH if water is stored in the caly water cooler for the time not more than twelve hours. However, it was reported that the reduction in values of such parameters was not as reasonable as required, but, they are recommended when water is slightly contaminated and in such cases water can be made good for drinking by the use of Clay Water Coolers.

5. Reference

- [[1] Onda K, LoBuglio J, Bartram J (2012) Global access to safe water: accounting for water quality and the resulting impact on MDG progress. *Int J Environ Res Public Health* 9(3):880–894
- [2] Jamali, M. Z., Solangi, G. S., Keerio, M. A., Keerio, J. A., & Bheel, N. (2023). Assessing and mapping the groundwater quality of Taluka Larkana, Sindh, Pakistan, using water quality indices and geospatial tools. *International Journal of Environmental Science and Technology*, 20(8), 8849-8862.
- [3] Singh, K. R., Dutta, R., Kalamdhad, A. S., Kumar, B. (2020), “Review of existing heavy metal contamination indices and development of an entropy-based improved indexing approach.” *Environment, Development and Sustainability*, 22, 7847-7864.
- [4] Jamali, M. Z., Khoso, S., Soomro, Z., Sohu, S., & Abro, A. F. (2022). EVALUATING THE SUITABILITY OF GROUNDWATER IN PAKISTAN: AN ANALYSIS OF WATER QUALITY USING SYNTHETIC POLLUTION INDEX (SPI) AND WATER QUALITY INDEX (WQI). *International Journal of Energy, Environment and Economics*, 30(3), 311-328.
- [5] Ahmed, A., Noonari, T. M., Magsi, H., & Mahar, A. (2013). Risk assessment of total and faecal coliform bacteria from drinking water supply of Badin city, Pakistan. *Journal of Environmental Professionals Sri Lanka*, 2(1), 52-64.
- [6] Ahmed, S., Jamali, M. Z., Khoso, S., Azeem, F., & Ansari, A. A. (2022). ASSESSMENT OF GROUNDWATER QUALITY IN RURAL AREAS OF TALUKA DOKRI, SINDH, PAKISTAN, THROUGH PHYSICOCHEMICAL ARAMETERS. *International Journal of Energy, Environment and Economics*, 30(3), 211-226.
- [7] Jamali, M. Z., Solangi, G. S., & Keerio, M. A. (2020). Assessment of Groundwater Quality of Taluka Larkana, Sindh, Pakistan. *International Journal of Scientific & Engineering Research*, 11(5), 795-797.



Design and Development of Synchronous Reluctance Machine for Industrial application

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KEY WORDS

Synchronous reluctance motor
permanent magnets
flux barriers,
stator winding,
rotor design,
Motor Solve software, torque
ripple,
average torque,
finite element method (FEM),

ABSTRACT

This paper presents a comprehensive study on the design and development of a 3kW synchronous reluctance motor tailored specifically for industrial applications. The motor architecture comprises a stator featuring 2 poles and 24 slots, akin to an induction motor configuration. A key focus of this investigation is the rectification of inefficiencies inherent in conventional synchronous reluctance motor designs, particularly those arising from rotor windings, which inherently compromise overall performance metrics. In this study, we introduce a novel rotor design for synchronous reluctance motors (SynRM) aimed at enhancing motor efficiency. Utilize copper windings in the rotor, resulting in significant losses and reduced efficiency. Our research addresses this limitation by introducing flux barriers and flux carriers in the rotor construction. The absence of rotor windings in this design eliminates losses of over 30%, leading to a significant improvement in overall motor efficiency. Employing advanced methodologies, this study leverages insights gleaned from the finite element method (FEM) coupled with Motor Solve software to meticulously analyze the motor's electromagnetic behavior. This analysis serves as a pivotal foundation for informed design decisions aimed at bolstering motor efficiency. These simulations provide quantitative insights into performance enhancements, crucial for gauging the efficacy of design modifications. The resultant synchronous reluctance machine showcases considerable promise for industrial applications, underpinned by a robust foundation of both simulation and empirical validation. Noteworthy advantages include superior thermal performance and steadfast, constant-speed operation. This research marks a significant stride forward in advancing synchronous reluctance motor technology, underscoring its viability and efficacy within Industrial domains.

1. Introduction

For modern mechatronic systems, synchronous reluctance motors (SynRM) provide a compelling potential as electromechanical energy converters [1-4]. Their simplicity in rotor design, Among their key selling

qualities are their low moment of inertia, absence of windings, and permanent magnets on the rotor. SynRM meet strict energy efficiency criteria by minimising bearing assembly temperatures, reducing stator winding overheating, and exhibiting excellent

efficiency by doing away with rotor windings [5]. Moreover, optimal compatibility with induction motor manufacturing processes is emphasized in the SynRM design. Even though synchronous reluctance motors' idea and working principles have been known since the early 20th century [6, 7], their widespread use didn't take off until the development of power electronics at the end of the century. In 2012, ABB, a pioneer in the SynRM industry, unveiled a product range with capacities ranging from 17kW to 350kW [8–10]. According to ABB, losses may be reduced by 10 to 20% in drive systems that use SynRM as opposed to those that use an induction motor of the same size and adhere to strict energy efficiency regulations. Retaining the same energy efficiency class allows the motor's total size to be reduced by one axis height step. Notwithstanding these achievements, the lack of mass manufacturing prevents SynRM from being widely used in Russian developments. Comprehensive theoretical study and experimental data comparing SynRM with other motor types, such as induction motors, synchronous motors with permanent magnets, and switching reluctance motors, are required for the successful integration of this novel motor type into a variety of systems. The development and experimental study findings on a 3kW rated power synchronous reluctance motor are presented in this work. This study attempts to clarify the properties and functionality of SynRM by theoretical analysis and experimental validation, offering important insights for its possible applications in diverse system.



Figure 1. Synchronous reluctance motor general view of the constructions



Fig.2. Synchronous reluctance motor rotor

1.1 Problem Statement

The prevalent adoption of permanent magnet machinery within industrial sectors faces significant obstacles due to the high procurement costs and intricate logistics associated with their supply chain management. Furthermore, the environmental repercussions, particularly pertaining to recycling complexities contributing to global warming, have accentuated the necessity for alternative approaches. Consequently, there is an escalating emphasis on non-permanent magnet technologies, exemplified by synchronous reluctance machines, as promising substitutes. Nevertheless, the tailored design and development of synchronous reluctance machines tailored specifically for industrial contexts remains largely unexplored. Hence, this research endeavors to bridge this gap by concentrating on the optimization of synchronous reluctance machine designs for industrial applications, with the aim of furnishing a financially viable and ecologically sustainable alternative to permanent magnet machinery. The main objective of research as given below

1. Design and develop a 3kW synchronous reluctance motor for industrial use.
2. Address inefficiencies in conventional designs, particularly in rotor windings.
3. Introduce a novel rotor design with flux barriers and flux carriers.
4. Utilize advanced methodologies like finite element analysis with Motor Solve software.
5. Quantify performance enhancements crucial for informed design decisions.



2. Methodology

The design process begins with a comprehensive analysis of the motor's specifications, including the stator geometry and rotor configuration [11-12]. Leveraging insights from the finite element method (FEM) and Motor Solve software, intricate details of the motor's electromagnetic behavior are meticulously studied to inform the design decisions aimed at enhancing motor efficiency. A key focus of the methodology involves the introduction of novel winding configurations and the meticulous design of rotor flux barriers and flux carriers. These design elements are refined through iterative simulations, utilizing advanced optimization techniques such as particle swarm optimization (PSO) to achieve robust performance under varying operating conditions. Practical testing plays a crucial role in validating the effectiveness of the proposed design. Experimental setups are utilized to compare different winding gauge sizes, identifying the optimal wire size for improved speed performance. Through extensive simulations and practical testing, various machine parameters are evaluated to ensure alignment with the targeted industrial application requirements. The methodology presented in this study integrates theoretical analysis, computational modelling, and experimental validation to provide a comprehensive understanding of the design and development process of SynRM for industrial applications [13-14]. By leveraging advanced simulation tools and practical experimentation, the proposed methodology facilitates the realization of a high-performance synchronous reluctance motor optimized for industrial use we consider the specification of our motor prototype design as below.

2.1 Prototype Design

In this research the specifications of a synchronous reluctance machine designed for industrial applications, featuring a three-phase configuration with 380 volts supply voltage and 800 RPM synchronous speed, exhibiting a 5% slip. It highlights essential dimensions, including a 125 mm outer diameter, 1 mm air gap thickness, and a 70 mm stack height, alongside details of the rotor, which comprises 16 round bars with inner and outer diameters of 33 mm and 66 mm, respectively. The stator is described as a square type with 3 phases, 4 poles,

and 24 slots, with dimensions of 68 mm inner diameter and 125 mm outer diameter. In this research the coil cross-section placement method, stator end winding specifications, and housing design with a 5.56 mm thickness and specified emissivity values for effective thermal management. Thermal analysis results are provided, indicating total losses of 0.747 kW, distributed among various components such as winding, rotor cage, and iron losses. Overall, the paper offers valuable insights into the design and development of a synchronous reluctance machine optimized for industrial use, focusing on performance, efficiency, and thermal considerations.

2.2 Synchronous Reluctance Motor Design Issues

Synchronous reluctance motors (SynRM) are designed using three main categories of parameters, each of which has a major influence on the motor's performance and efficiency.

2.1.1 Design Parameters of Stator Geometry:

This category includes the stator's basic dimensions, such as the number of slots, poles, outer and inner diameters, and other geometric features. These factors mostly determine the stator's overall design and size, impacting things like torque generation and magnetic flux distribution.

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2.1.2 Target Variables:

The motor's intended performance measurements are represented by the goal variables in the third category. These factors include things like speed characteristics, torque production, and efficiency. In order to satisfy the particular needs of industrial applications, it is essential to optimize the design with regard to these target characteristics. The overall motor characteristics in the context of SynRM design are mostly determined by the stator geometry parameters. But the main factor influencing performance variations among different motor types is the rotor structure. It is noteworthy that the transversally laminated kind of stator structure is comparable to other machine types, such induction

machines, highlighting the critical role rotor design plays in improving SynRM performance. Reluctance rotors within stators from already existing induction manufacturing lines are a useful construction method for SynRM. To obtain the best possible motor performance, this method makes use of easily available components and the unique features of synchronous reluctance technology.

2.2 Design Specifications of SynRM Rating

Here are the below tables shows the characteristics of the suggested synchronous reluctance motor.

Table 1 Rotor Parameter

S.No	Name Of Parameter	Measurement In Cm	Measurement In mm
1	Slot Depth	0.93cm	9mm
2	No: of Bars	16cm	-
3	Tooth Width	0.384 cm	3.84 mm
4	Inner Diameter	3.3 cm	33 mm
5	Outer Diameter	6.5cm	6.5mm
6	Tang Angle	2.76cm	-

Table 2 Stator Parameter

S.N O	Name Of Parameter	Measurement In Cm	Measurement In mm
1.	Slot Depth	1.8cm	18mm
2.	Slot Opening	0.15cm	1.5mm
3.	Tooth Opening Thickness	0.24cm	2.4mm
4.	Inner Diameter	6.8cm	68mm
5.	Outer Diameter	12.5cm	125mm
6.	Stack Height	7cm	70mm
7.	NO: of poles	4	
8.	NO: of slots	24	
9.	NO: of Phase	3	
10.	Voltage	340	
11	Speed of RPM	1450	
12	Slip	5%	
13	Tooth Width Thickness	5mm	

3. Simulation And Experiential Results

In an effort to maximize the synchronous reluctance motor's (SynRM) performance, a systematic approach was adopted by inputting specific design variables into Simcenter Motor Solve software. This sophisticated tool enabled comprehensive analysis and simulation of the motor's behaviour under various operating conditions. The following design variables were meticulously selected and inputted into the software to facilitate the design and optimization process. These results are obtained after we put following design variable in Simcenter Motor Solve software.

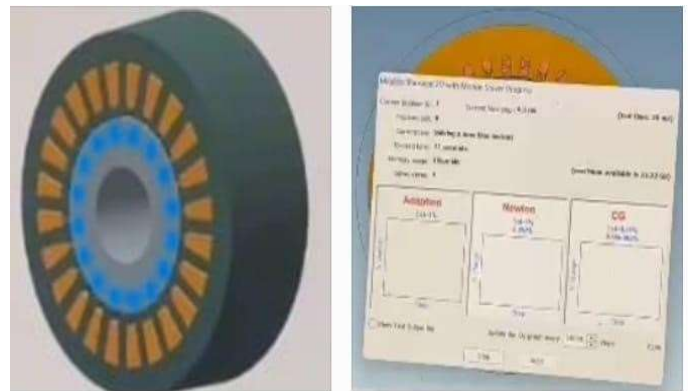


Fig.3. Simulation of Motor

Figure 3 illustrates the Simulation of Motor, wherein a fundamental simulation was conducted for our research to achieve the desired outcome.

3.1 Graphical Analysis of Results obtained on Motor Solve Software.

In this section, we present a graphical examination of the results obtained through Motor Solve software. Graphical analysis offers a visual representation of various performance metrics, providing deeper insights into the behavior and characteristics of the motor under study. Through the visualization of key parameters and their relationships, we aim to elucidate the performance trends and identify potential areas for optimization and improvement.

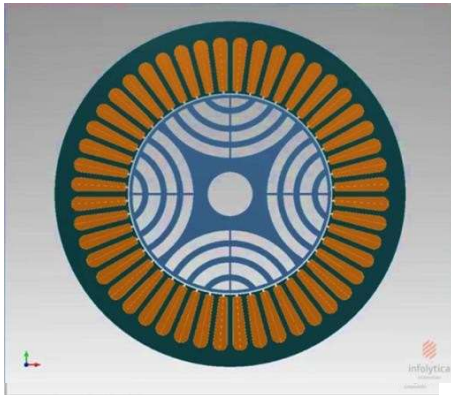


Fig.4. Synchronous Reluctance motor

Figure 4 presents a visual depiction of the synchronous reluctance motor, illustrating its complete structure and arrangement. It offers a graphical representation of the motor's design, highlighting the relative positioning of its essential components. This figure serves as a valuable tool to showcase the motor's overall appearance and layout.

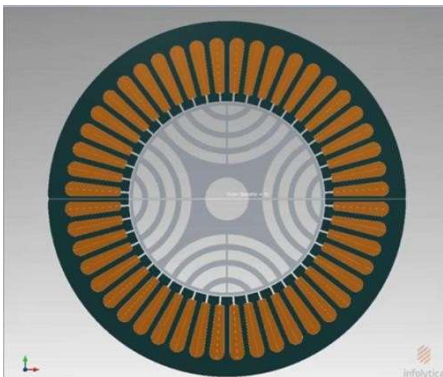


Fig.5. The stator part of synchronous reluctance motor

The stationary portion of the synchronous reluctance motor is emphasized in the stator section of Figure 5. This component comprises carefully arranged windings that play a crucial role in its operation. The figure is particularly useful for demonstrating the stator design and highlighting its significant features that impact the motor's performance.

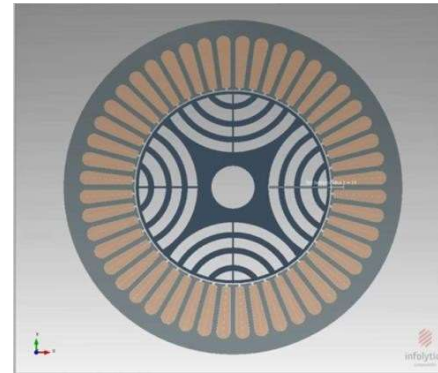


Fig.6. The Rotor part of synchronous reluctance motor

Figure 6 visually captures the rotating component responsible for generating torque within the motor. It serves as a valuable resource for showcasing the design of the rotor, encompassing its shape, construction, and any notable features that contribute to the motor's efficiency or overall performance. As we know about reference current that it is a stable source of current it does not fluctuate with the temperature, supply voltage or loads. As we see in graph that current line is in pair with reference current line so we don't have any problems regarding current drops during working.

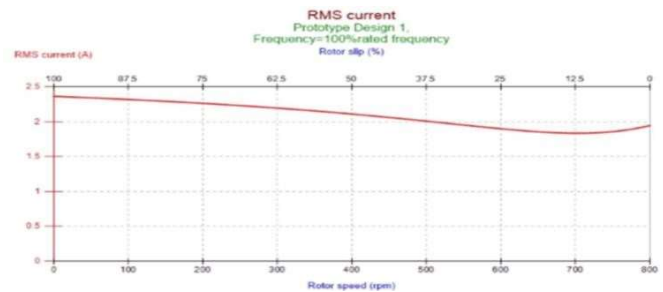


Fig.7. Current Characteristics of Motor

As we know about reference current that it is a stable source of current it does not fluctuate with the temperature, supply voltage or loads. As we see in graph that current line is in pair with reference current line so we don't have any problems regarding current drops during working.

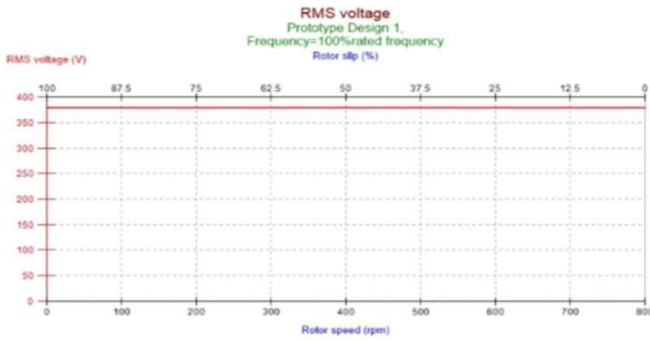


Fig.8. Voltage Characteristics of motor

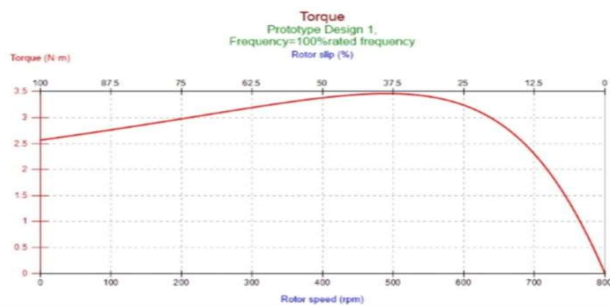


Fig.9. Torque Characteristics of motor

The synchronous reluctance machines with or without ferrite permanent magnets are source of constant power to speed ratio. It can be used in smaller applications to bigger industrial applications i.e. Traction applications. As it is observed that the torque is relatively constant with small and negligible changes

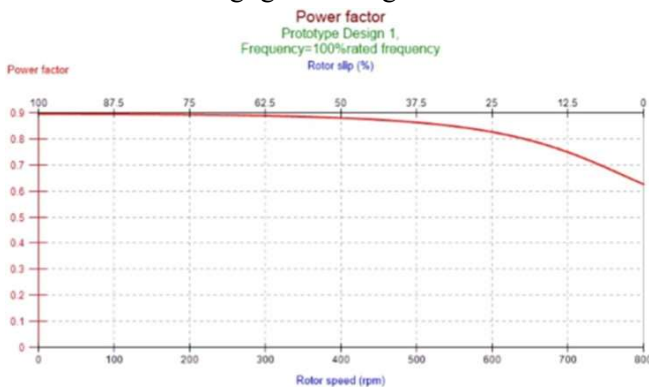


Fig.10. Power factor prototype design, frequency 100 rated

There is no issue regarding flux linkage with current. As the electric current i.e. the flow of charges is in line with the magnetic flux line caused by reluctance. The motor will be good candidate of delivering constant speed and torque.

3.3 Hardware Result

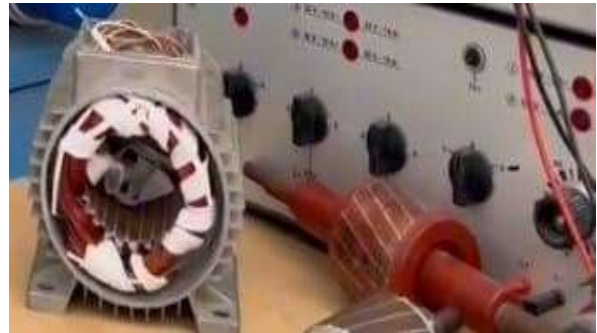


Fig.11. Hardware Induction Motor

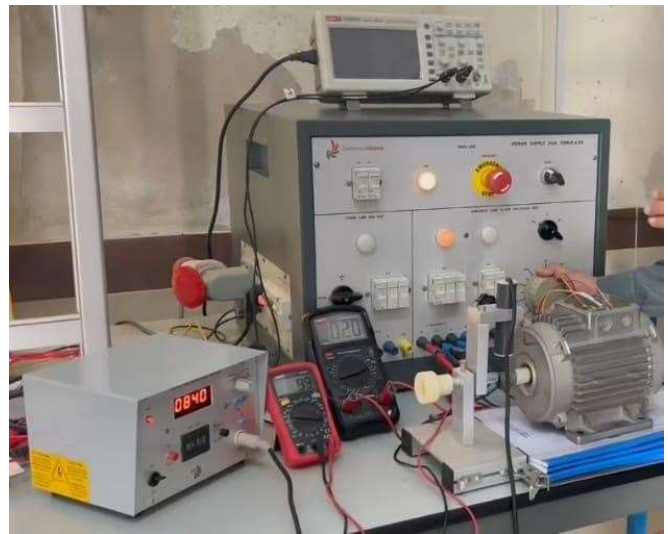


Fig.12. setup of for hardware experiment

Figure 13 shows all the experimental setup component which used in our research. By these components we compare the results of voltage current and RPM with our software result.



Table 3 Result When Winding gage is 26

S.No	Voltage	Current	RPM
1	300	2.33mA	422
2	350	2.7 mA	485
3	410	3.04 mA	720

Table 4 Result when Winding gage is 27

From table 4 and table 5 we conclude that when we increase the winding gage there is changing in RPM which increases and result the overall output of motor hence efficiency increases.

3.3 Result and Discussion

In this study, we introduce a novel rotor design for synchronous reluctance motors (SynRM) aimed at enhancing motor efficiency. Traditional SynRM designs, resembling those of induction motors, utilize copper windings in the rotor, resulting in significant losses and reduced efficiency. Our research addresses this limitation by introducing flux barriers and flux carriers in the rotor construction. The absence of rotor windings in this design eliminates losses of over 30%, leading to a significant improvement in overall motor efficiency. The flux barriers, which create empty spaces to impede the passage of magnetic lines of force, and flux carriers, resembling laminations made of magnetic materials, allow for efficient rotation of the rotor using magnetic flux. This design innovation enables the motor to operate at synchronous speed by aligning the magnetic forces of the stator with those of the rotor. Comparative analysis with previous studies highlights the inefficiencies associated with rotor windings in traditional SynRM designs. By replacing copper windings with flux barriers and carriers, our study demonstrates a substantial improvement in motor efficiency. Practical testing further validates the efficacy of this novel rotor configuration, providing empirical evidence of its effectiveness in industrial applications. This technological advancement not only overcomes the limitations of conventional SynRM designs but also opens avenues for further enhancements in motor efficiency and performance in

industrial settings.

4. Conclusion

In conclusion, this paper introduces a groundbreaking advancement in synchronous reluctance motor (SynRM) technology tailored for industrial applications, presenting a novel rotor configuration aimed at significantly enhancing motor efficiency. By addressing the inefficiencies inherent in traditional SynRM designs, particularly those stemming from copper windings in the rotor, our study introduces the use of flux barriers and flux carriers to eliminate losses and boost overall performance. Comparative analysis

S.No	Voltage	Current	RPM
1	250	0.09 mA	1480
2	350	0.15 mA	1720
3	380	0.18 mA	1820

highlights the superiority of our design innovation in terms of efficiency and performance, validated through empirical testing in industrial settings. Leveraging advanced methodologies such as finite element analysis and Motor Solve software, we establish a

robust foundation for informed design decisions, resulting in a synchronous reluctance machine with superior thermal performance and constant-speed operation. This research not only overcomes existing limitations but also paves the way for further advancements in SynRM technology, solidifying its position as a leading solution for industrial motor applications.

5. References

[1] P. Matyska, "Advantages of Synchronous Reluctance Motors," Transactions on Electrical Engineering, vol. 3, no. 2, 2014, pp. 44-47.

[2] S.A. Zhuravlev, A.M. Zaitsev, A.V. Zakharov, "Development and research of synchronous reluctance electric motors characteristics," Proceedings of the XVI International Conference "Electromechanical, Electrotechnology, Electrotechnical Materials and Components," Moscow, "Znak," 2016, pp. 100-103.



- [3] N. Bianchi, S. Bolognani, E. Carraro, M. Castiello, E. Fornasiero, "Electric Vehicle Traction based on Synchronous Reluctance Motors," *IEEE Transactions on Industry Applications*, vol. 52, no. 6, 2016, pp. 4762-4769. DOI 10.1109/TIA.2016.2599850.
- [4] T. Miller, A. Hutton, C. Cossar, D. Staton, "Design of a synchronous reluctance motor drive," *IEEE Transactions on Industry Applications*, vol. 27, issue 4, July-Aug. 1991, pp. 741-749.
- [5] D. Dorrell, "A Review of the Methods for Improving the Efficiency of Drive Motors to Meet IE4 Efficiency Standards," in *Journal of Power Electronics*, vol. 14, no. 5, pp. 842-851, September 2014. <http://dx.doi.org/10.6113/JPE.2014.14.5.842>.
- [6] J. K. Kostko, "Polyphase reaction synchronous motors," *Journal Amer. Inst. Electrical Engineers*, vol. 42, 1923, pp. 1162-1168.
- [7] P. Lawrenson, L. Agu, "Theory and performance of polyphase reluctance machines," *Proceedings of the Institution of Electrical Engineers, IEEE*, vol. 111, no. 8, 1964, pp. 1435-1445. Low voltage IE4 synchronous reluctance motor and drive package for pump and fan applications. A 9AKK105828 EN 06-2013. ABB Motors and Generators. 2013, 47 p.
- [8] A. Vagati, A. Canova, M. Chiampi, M. Pastorelli, M. Repetto, "Design Refinement of Synchronous Reluctance Motors Through Finite-Element Analysis," *IEEE Transactions on industry applications*, vol. 36, no. 4, 2000, pp. 1094-1102.
- [9] A.V. Zakharov. "The prospects of technical applications synchronous motors with anisotropic magnetic conductivity of the rotor," *Proceedings of International scientific-technical conference "State and prospects of development of Electrotechnology"* (XVIII Benrdosovsky reading), Ivanovo, 2015, pp. 124-127.
- [10] F.A. Gelver, N.V. Belousova, V.F. Samoseyko, "The reactive electromechanical converter with anisotropic magnetic conductance of the rotor," *Proceedings of the VIII international (XIX Russian) conference on the automatic electric drive*, 2014, vol. 1, pp. 394-398.
- [11] L.N. Makarov, A.V. Zakharov. "The main directions of improvement of low-voltage electric motors," *Proceedings of the Academy of Electrotechnical Sciences of the Russian Federation*, 2016, Issue 18, pp. 72-80.
- [12] A.V. Zakharov, L.N. Makarov, S.V. Skitovich, "New directions of research of the JSC "NIPTIEM" in the AC electrical machines," *Proceedings of "Actual problems of electromechanics and Electrotechnology, APEET-2017"*. Ekaterinburg: FGAOU VPO, Ural Federal University, 2017, pp. 91-94.
- [13] F. Cupertino, G. Pellegrino, C. Gerada, "Design of Synchronous Reluctance Motors with Multi-Objective Optimization Algorithms," in *Industry Applications, IEEE Transactions on*, vol. 50, no. 6, pp. 3617-3627, November-December 2014.



Revolutionizing Air Quality Forecasting: Releasing the Power of Functional Data Analysis and Machine Learning on Extensive Environmental Datasets

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KEYWORDS

Functional data analysis
Air quality
Time series
Predictive modelling

ABSTRACT

The impacts of air pollution are not limited to respiratory and heart diseases; they also affect neurological health and well-being. This necessitates AI to predict air quality, providing accurate real-time pollution data. This study deviates from statistical approaches, employing functional data analysis to examine a large dataset that includes hourly updates from several sensors across various chemicals over an entire year. Complex pollution patterns such as carbon monoxide, nitrogen oxides, and benzene can be identified using this method. To transform the time series into an analytical form that allows for a more in-depth analysis of climate trends, the method requires meticulous data preparation. By utilizing a combination of non-parametric methods and functional linear models, this study enhances its estimates' accuracy and scope. Ultimately, the findings also validate these models, indicating how functional data analysis can guide overall health strategies and environmental surveillance. This research is a significant milestone in environmental data analysis as it contributes to large-scale sustainable environment management.

1. Introduction

FDA considers information focuses parts of persistent capabilities, rather than solitary events. This specific perspective shows remarkable capability in time series analysis, uncovering primary and utilitarian examples that are habitually overlooked by regular methodologies. The FDA's strength lies in its ability to portray complex information connections in a nuanced way. This gives a more comprehensive and nitty gritty understanding of observed peculiarities. Basic to natural examination, specifically air quality observation and the executives, is the precise expectation of time series [1]. Because of industrialization and urbanization hardships, air quality principles support is an urgent and general wellbeing crisis. Basic to natural examination, explicitly air quality

and time series prediction [2]. Because of industrialization and respiratory issues, it stresses the criticality of defining and timely contamination expectations. Forecasts of this nature are vital in working with brief general wellbeing warnings and educating the public regarding the importance of persevering through ecological approaches and precautions [3].

This work deals with application of Functional Data Analysis (FDA) on air quality data with special attention paid to the state-of-art techniques applied to large data set from UCI Machine Learning Repository. The dataset is one-year long and contains hourly readings from many chemical sensors and a vast number of air pollutants, and, therefore, it is suitable for FDA [4]. The objective of the manuscript is to apply FDA on air quality data using complex methods that have been applied to a large



dataset from the UCI Machine Learning Repository. The FDA will be most helped by this year’s data set which has hourly measurements from several chemical sensors and a variety of air pollutants.

Based on the literature review, it can be expected that the presence of FDA in this context will create an important change in the environment. Thus changes may be made to the ecological and general wellbeing drives more suited to tackle fundamental urban problems. The key goal is to demonstrate the adequacy of complex measurable strategies, like those used by the FDA, in translating mind-boggling natural information. Thus, this will result in a greater level of education and dynamic work in the areas of general well-being and ecological administration.

2. Related Work

This study evaluates the viability of Computational Liquid Elements (CFD) models and advanced learning methods in estimating airborne poison spread in metropolitan conditions. It features CFD's precision in catching complex, meter-scale peculiarities yet recognizes its limitations due to critical computational demands forecasting [5]. The examination then, at that point, distinguishes the multiResUnet advanced learning design as unrivaled in execution. It conveys close continuous expectations with satisfactory exactness on key air quality measurements, essentially dominating the computational time expected for customary CFD models [6].

Machine learning techniques for air quality forecasting in industrial and urban regions, where pollution from transportation and fuel use poses a significant risk [7]. It examines the impact of multidimensional factors on air quality. It discusses the recent shift towards big data applications, fueled by environmental sensing networks.

Table 1. Summary of the different variants of each model tested in this study

Models	Min filters	Losses
FCN	1 - 2 - 4 - 8	J3D - bce - mse
PSPNet	8 - 16	J3D - bce - mse
linkNet	8 - 16 - 32	J3D - bce - mse
SegNet	8 - 16 - 32	J3D - bce - mse

multiResUnet	8 - 16 - 32	J3D - bce - mse
Unet	8 - 16 - 32	J3D - bce - mse

In a comprehensive table synthesizing key studies that utilize big data methodologies for air quality analysis, a variety of approaches and objectives are presented. This reflects a global concern for air quality monitoring. [8] Employed deep data analytics to forecast ozone levels, utilizing cross-correlation analysis of readings from multiple stations in Gauteng, South Africa. Data was sourced from IoT-transmitted monitoring station datasets. [9] Predicted air quality indices up to 48 hours in advance at Chinese monitoring stations by integrating temporal linear regression with neural networks. This was done using current meteorological data and air quality indices.

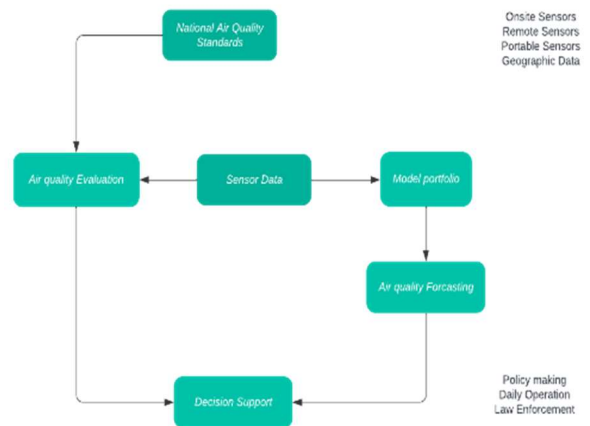


Fig 8. Big data based decision support for air quality

[10] Identified regional pollution sources in the Western USA using statistical analysis of sensor and satellite data. This targeted particulates, smoke, and haze with data from the Terra satellite's Moderate Resolution Imaging Spectroradiometer. [11] Focused on air quality assessment in Shenzhen, China. Sparse spatial-temporal data from limited monitoring stations was used to estimate urban air quality, incorporating meteorological and traffic data into visualized air quality maps.



Table 2. Synthesis of Studies Employing Big Data Approaches for Air Quality Analysis

Ref	Objective and Field of Inquiry	Methodology	Locale	Variables	Data Origin
[8]	Employing big data analytics to forecast ground-level Ozone concentrations	Correlation analysis between station readings and spatial interstation correlations	Gauteng province, South Africa	Ozone	Multi-year datasets from monitoring stations, relayed via IoT
[9]	Prediction of air quality indices for up to 48 hours at monitoring stations using data-driven techniques	Temporal linear regression and neural networks for local and global air quality factors	China	Meteorological conditions, weather predictions	Real-time monitoring station forecasts for up to 48 hours
[10]	Identifying regional contributors to air pollution through sensor and satellite imagery	Statistical evaluation and remote sensing data analysis	Western USA	Particulates, smoke, haze	Data from the Terra satellite's Moderate Resolution Imaging Spectro radiometer
[11]	Assessing air quality in urban areas with sparse spatial-temporal data	Estimation of air quality using a limited number of monitoring points	Shenzhen, China	Weather patterns and vehicular traffic	Visualization of air quality maps from Shenzhen data
[12]	Creating a novel method for using surveillance cameras to track PM10 fluctuation patterns	Utilizing Dust Trak meters for PM10 analysis and regression for algorithm calibration	In-house laboratory	PM10 levels and atmospheric reflectance	IP network cameras as proxy sensors for air quality assessment

Lastly, [12] developed an innovative application of surveillance cameras to monitor PM10 concentration patterns. This application employs Dust Trak meters and regression algorithms for calibration in a lab setting, with IP network cameras serving as air quality monitoring sensors [13]. This table encapsulates the diverse and technologically advanced efforts being made in air quality analysis. It reflects a blend of traditional data sources with cutting-edge big data techniques to combat air pollution globally.

The related work presents a detailed evaluation of Computational Fluid Dynamics (CFD) and deep learning methods for modeling air pollutant dispersion in urban settings [14]. While CFD offers precise simulations at micro-scale, its computational intensity limits its practical application. The study identifies the multiResUnet architecture as a standout deep learning model. It delivers accurate predictions on critical air quality measures in a fraction of the time required by CFD models [15]. This advancement in prediction

models has significant implications for real-time air quality monitoring, providing a faster, more efficient means to manage urban air pollution.

In addition, the work encompasses a review of big data approaches to air quality monitoring. Several studies, such as those by [8] and [9], have applied extensive data analytics and machine learning models like ANNs and GAs to forecast air quality, leveraging extensive datasets and IoT technology. Engel et al. Have utilized remote sensing for pinpointing pollution sources, while [11]. A number of studies have been conducted to estimate air quality in data-sparse regions through available monitoring stations. [12] Novel use of surveillance cameras for PM10 tracking highlights innovative sensor-based environmental monitoring.

These studies collectively demonstrate a shift towards integrating big data and machine learning to enhance air quality forecasting accuracy and timeliness. This convergence of technologies paves the way for developing advanced predictive tools, crucial for environmental management in smart cities and industrial regions.

3. Dataset Gathering

This study employs a dataset from the UCI Machine Learning Repository, a premier source for datasets in machine learning and data mining, specifically curated for air quality monitoring [2]. This dataset, one of the most comprehensive available for public research, includes hourly measurements from five metal oxide chemical sensors targeting various pollutants. It spans from March 2004 to February 2005. It captures pollutants like CO, NMHC, Benzene, NO_x, and NO₂, along with key environmental factors such as temperature and humidity. This offers a detailed view of the pollution context [3].

This data set is based on the sensor information of air quality control. Despite the fact that sensors are important for the continuous data acquisition, they also have problems such as mind float. This is when the characteristics of the objective variable are likely to vary in the long-term position especially in relation to the operation of a sensor and natural conditions [16]. Also, sensor sensitivity could be influenced by external factors and hence may lead to information distortion. In dealing with these issues, proper planning and assessment of these difficulties is crucial for dataset effectiveness [17]. Functional data analysis approaches such as the Air Quality dataset from the UCI Repository enables both potential and difficulties of analysing air pollutants' behaviours.

4. Methodology

The work portrays a novel methodology for analyzing and breaking down air quality data that consolidates Functional Data Analysis (FDA) with deep learning. The method comprises a few basic advances. More details for methodology understanding we have explained it in Fig 2.

4.1 Data Pre processing

The primary stage requires thorough data planning, which is essential for data quality and consistency. Missing qualities in the Air Quality dataset, set apart as -200, are filled in by straight addition, guaranteeing data progression and citation [18]. Moreover, normalizing sensor values is essential for consistency, preparing for reliable analysis.

4.2 Functional Data Representation

Our strategy transforms time series data into a functional structure utilizing basis functions like splines and Fourier [19]. This process captures both linear and non-linear trends, offering a comprehensive view of dataset dynamics.

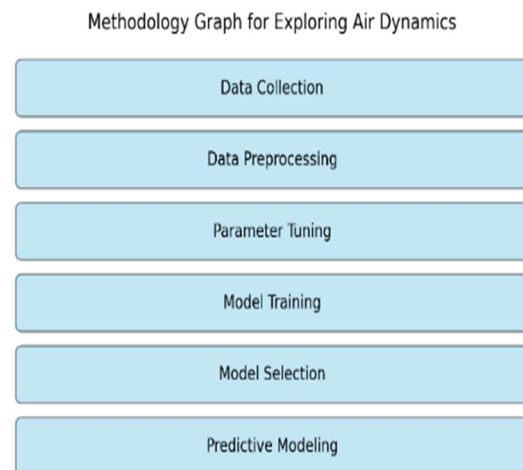


Fig 9. Methodology of Exploring Air Dynamics

4.3 Predictive Modelling

We employ FDA methods, particularly functional linear models and non-parametric approaches, to model temporal dependencies and complex patterns in air quality data. The choice of model depends on the specific pollutant and the data's characteristics, aiming to optimize predictive performance.

4.4 Python libraries and Tools

The study leverages various Python libraries such as numpy, Pandas, scikit-fda, matplotlib, seaborn, and scikit-learn. These tools are essential for efficient data handling, transformation, and application of FDA techniques, ensuring robust and scalable analysis.

4.5 Modelling Training Selection

Model training involves applying functional linear and non-parametric models to the dataset. The process includes splitting the data into training and testing sets and using cross-validation techniques to ensure model robustness [20]. The model demonstrating the most accurate performance in terms of prediction accuracy and generalization is selected for air quality prediction.

4.6 Parameter Tuning

Handling artificial models entails the setting of certain parameters which affect the model's overall performance. Grid search and Random search is employed to optimize the level of model complexity and the level of forecast accuracy [21]. The last models are fine-tuned with the modified parameters to enhance the capability of the models' prediction skills. Thus, this procedure presents another guideline for predictive modelling in the context of environmental data analysis [7].

5. Results and Comparison Analysis

This segment focuses on the outcomes of the deep learning models in the time series prediction of air quality data.

5.1 Performance Model

Different models are used including Multi-Layer Perceptions (MLPs), Convolutional Neural Networks (CNNs), and Long-Short-Term Memory (LSTMs). A model's performance is evaluated based on the training and validation loss where more emphasis is given to the learning rate and the model's capability to learn from the data. MLP is a good learner but it is prone to over fit the data. However, CNNs are more flexible in applying the learned knowledge to different scenarios; on the other hand, LSTMs reveal a steady, and balanced learning process.

5.2 Comparison with Non-FDA Methods

This paper presents the results of the comparison between FDA-based deep learning models and conventional methods like ARIMA to show the

effectiveness of the proposed approach. In the case of time series prediction, FDA methods are more efficient in capturing the features of the patterns.

5.3 Insights and Findings

The analysis of loss curves reveals key insights into model behaviours, such as overfitting and under fitting tendencies. The best-performing model is identified based on the lowest validation loss. Additionally, a qualitative analysis compares actual and forecasted 'T' and 'RH' values providing a tangible assessment of the models' forecasting accuracy.

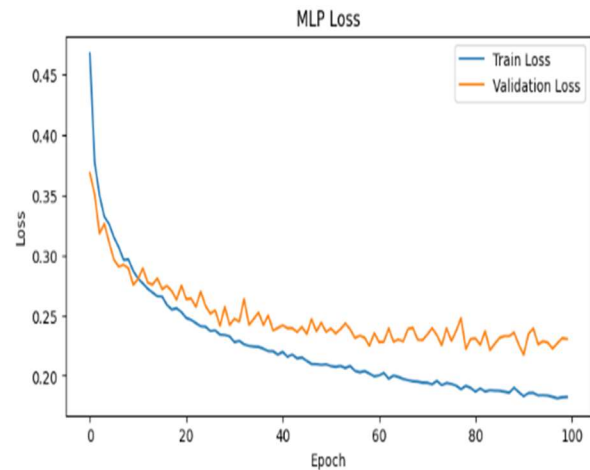


Figure 10. Training and validation loss of MLP model with FDA Method.

In Fig 3, it is observe that training and validation loss of the MLP model applying the FDA method. The x-axis represents the number of epochs, while the y-axis denotes the loss value. Both training and validation loss metrics are shown. Initially, the training loss decreases sharply, suggesting that the model is quickly learning from the training dataset. As the epochs increase, the rate of decrease in training loss slows down, indicating that the model begins to converge.

The validation loss, on the other hand, follows a similar downward trend, which implies that the model is generalizing well and not overfitting to the training data. However, there are some fluctuations in the validation loss, which could be indicative of the model's response to the complexity of the validation data it encounters during learning.

It is noteworthy that the validation loss remains consistently higher than the training loss throughout the training process, which is a typical observation as the model is always trained directly on the training data but only indirectly optimized for the validation data through generalization.

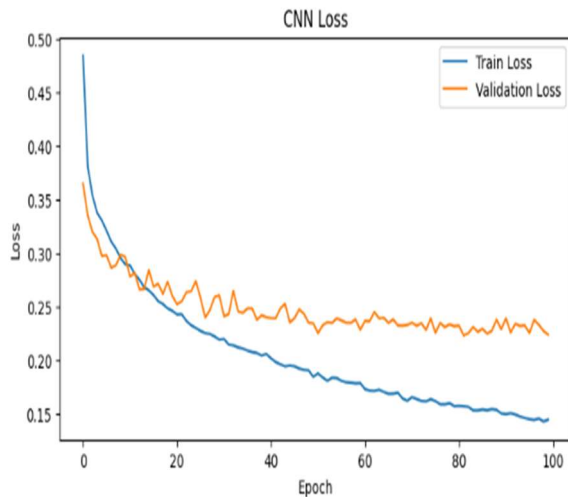


Fig 11. Training and validation loss of CNN model with FDA Method

Fig 4, presents the training and validation loss for a CNN model trained with the FDA Method. The x-axis enumerates the training epochs, and the y-axis represents the loss. Two curves are depicted: the blue curve indicates the training loss, and the orange curve represents the validation loss. Initially, the training loss decreases rapidly, suggesting that the model is learning effectively from the training data. As training progresses, the decrease in training loss slows, indicating that the model is starting to converge.

The validation loss depicted by the orange curve also decreases, but less steeply compared to the training loss, and it shows more volatility. This pattern is expected as the validation dataset is not used for training and therefore provides an independent assessment of model performance. The fact that the validation loss does not increase significantly over time is an indicator that the model is not overfitting and is generalizing well to unseen data. By the end of the 100 epochs, both loss curves have plateaued, suggesting that further training might not result in significant improvements without modifications to the model or training procedure.

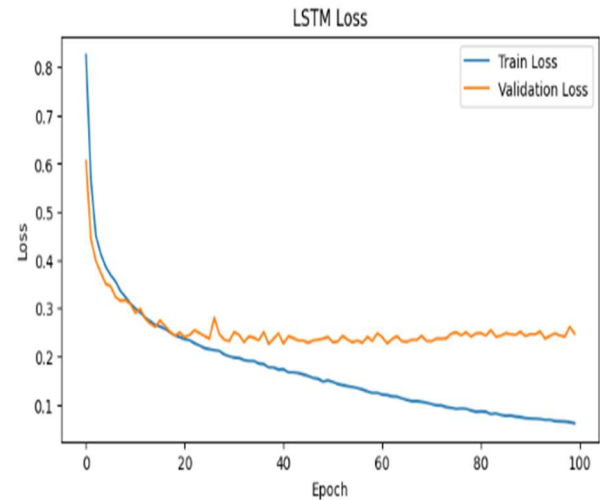


Fig 12. Training and validation loss of LSTM model with FDA Method

Fig 5 below, demonstrates the training and validation loss in an LSTM model that the FDA Method was used on. On the x-axis, the epochs of training are indicated while the y-axis gives the corresponding loss value. The training loss is shown in blue colour and validation loss is in orange colour. In particular, training loss is reduced at the beginning of training, this means that the model quickly learns new examples and improves its ability to fit them. Over the epochs, this loss gradually flattens which is normal as the algorithm tries to converge to the minimum in the loss function.

As in the case of the training loss, the validation loss decreases from 0.1740 to 0.1186 though the curve is not as steep. This trend is typical for validation loss as it shows model's ability to perform on new data that it has not seen before. By analysing the validation loss curve it can be noticed that it is not extremely oscillatory and it is decreasing without large oscillations, and it gradually approaches the training loss curve, which indicates that the model is not overfitting, and it has good generalisation capabilities. At the end of the training, both losses are getting to certain levels and neither of them reduces more; hence, the model works at its optimum level in its current architecture and optimum hyper parameters.

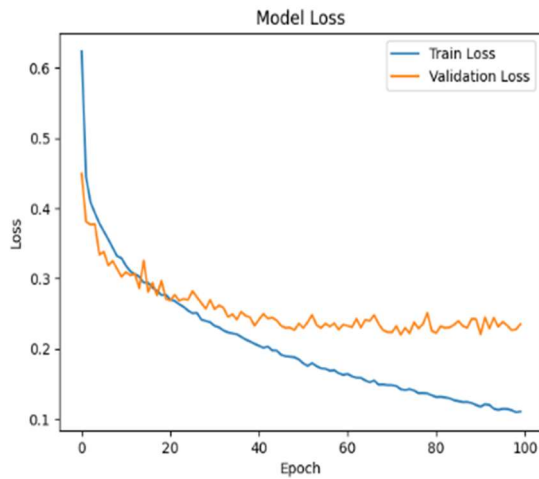


Fig 13. Training and validation loss of Conv LSTM model with Non-FDA Method

Fig 6 shows the training and validation loss for 100 epochs with the help of proposed Conv LSTM model using Non FDA Method. Epoch number is placed on the x-axis, which as a metric shows how many times the learning algorithm has been through the entire training dataset. The y-axis represents the loss, which is another measure that estimates the gap between the output and the targets where lesser the value better is the model.

The training loss shown with the help of the blue line starts initially at a high level and is decreasing steeply which emphasizes the fact that the model is learning from the training data. This means that as the epochs increase, the training loss continues to reduce at a diminishing rate, meaning that the model's performance is going up but soon, the optimization function will fold; this suggests that the model will not be able to learn as well as earlier epochs.

Meanwhile, the validation loss, shown in orange, follows a similar downward trajectory, which is desirable as it indicates that the model is generalizing well to data it has not seen during training. However, the validation loss exhibits some variability, which is common in the training process, and could be due to the model encountering various complexities within the validation data. The convergence of the training and validation loss curves towards the end of the training suggests that the model has reached a stable state with consistent performance on both training and unseen data.

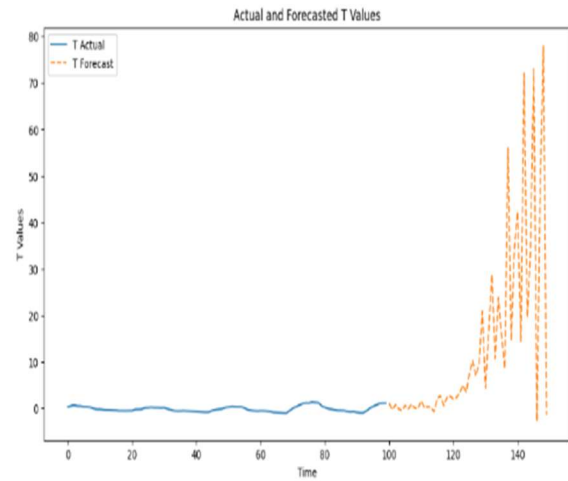


Fig 14. Actual and Forecasting graph of T Value Using LSTM.

Fig 7, compares the actual and forecasted T values generated by an LSTM model. The x-axis represents the time steps of the dataset, while the y-axis shows the magnitude of the T value. The solid blue line denotes the actual T values observed in the dataset, serving as a ground truth against which the model's predictions are compared.

The dashed orange line represents the T values as forecasted by the LSTM model. Initially, the model's predictions closely track the actual values, indicating a high degree of accuracy in the model's forecasts. However, as time progresses, particularly after the 100th time step, the forecasted values diverge significantly from the actual values, displaying an increasing trend with considerable volatility.

This divergence may suggest that the LSTM model, while initially capturing the underlying pattern of the T variable, starts to lose predictive accuracy over time. The reason for this could be an inherent limitation in the model's structure, a change in the underlying data patterns that the model fails to adapt to, or perhaps overfitting to the training data, resulting in poor generalization to later points in the time series.

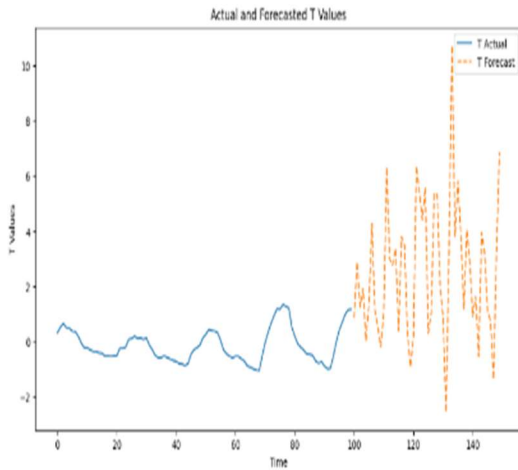


Fig 15. Actual and Forecasting graph of T Value Using MLP

Fig.8, portrays the performance of an MLP in forecasting a time series variable denoted as 'T'. The x-axis corresponds to discrete time steps in the observed period, while the y-axis measures the T values. The solid blue line illustrates the actual T values, providing a reference for evaluating the MLP's forecasting ability.

In contrast, the dashed orange line represents the forecasted T values as produced by the MLP. At the outset, up to around time step 100, the forecast does not appear to closely align with the actual values, indicating potential issues in the model's ability to understand and predict the underlying patterns in the data. Post time step 100, the forecasted values exhibit a pronounced oscillatory pattern with significant amplitude, diverging further from the actual values. This could be indicative of model overfitting, where the model has learned the noise in the training data rather than the true underlying trends, or it could suggest that the MLP lacks the necessary complexity or has not been adequately trained to capture the dynamics of the time series effectively.

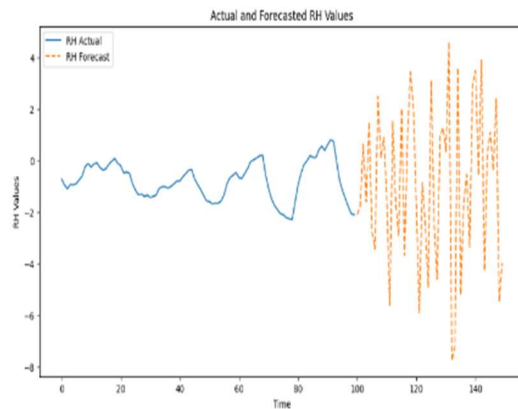


Fig 16. Actual and Forecasting graph of RH Value Using MLP

Figure 9, illustrates the actual and forecasted RH

values obtained through an MLP model. The x-axis labels the sequential time steps, while the y-axis quantifies the RH values. The actual RH values are traced by the solid blue line, and they exhibit a somewhat periodic behaviour over time, which is typical for environmental data like humidity levels.

The forecasted RH values are depicted by the dashed orange line. Initially, the forecasted values show a reasonable approximation of the actual RH, indicating that the MLP model has captured some of the patterns in the data. However, beyond approximately the 100th time step, the forecasted values start to diverge dramatically from the actual ones, showing extreme fluctuations. This erratic behaviour suggests that the MLP might be overfitting to the training data or it may not have the predictive capacity to handle the complexity of the data beyond a certain point in time. It might also indicate that the model has not been trained for sufficient epochs, or the architecture needs to be revisited for improved prediction of long-term trends.

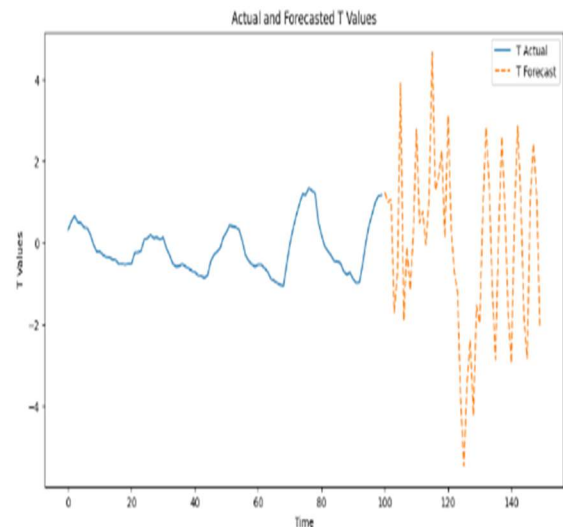


Fig 17. Actual and Forecasting graph of T Value Using CNN

The comparison of actual T values with the forecast ones that obtained using CNN is illustrated in the Fig. 10. Hence, the axes have been described whereby the x-axis depicts the time steps and the y-axis portraying the T values. Actual values are depicted with a solid blue colour and they look like fluctuating which is expected in any time series data that might depict a variety of natural phenomenon such as temperature, stocks or any measurable phenomenon at a particular time.

The forecasted values are depicted by the dashed orange line, and they look like they mimic the behaviour of the actual values, meaning that the CNN has managed to learn the patterns of the given time series. After 100 time steps the actual and forecasted values demonstrate

high fluctuations and do not have a constant trend, in addition the upper and lower borders also do not have constant width and increase in the next step. This could suggest that while the CNN has captured the near dependencies within the time series quite well it fails to do so in the longer time horizon possibly due to over training of the model or insufficient context information to learn longer sequences. The increasing divergence might also imply that CNN is not the best suited architecture to capture the process that generation the time series.

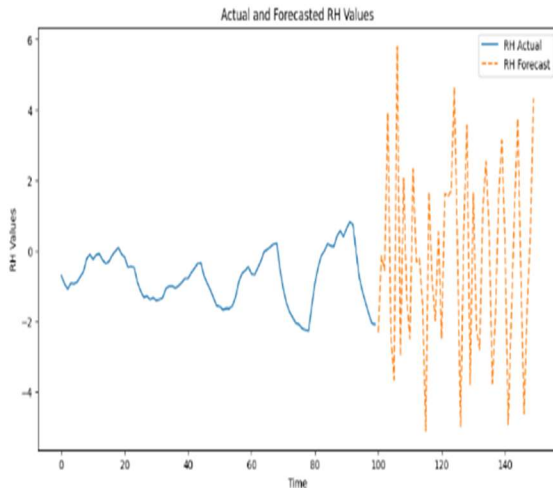


Fig 18. Actual and Forecasting graph of RH Value Using CNN

Fig 11, illustrates the actual and forecasted RH values over time, as predicted by a CNN. On the x-axis, we have the time steps of the dataset, and on the y-axis, we have the RH values. The solid blue line represents the actual RH values, which fluctuate over time, showing the natural variability in humidity levels.

Initially, up to around the 100th time step, the forecasted values appear to closely follow the actual RH levels, suggesting that the CNN has effectively learned the patterns within the historical data. However, post this point, the forecasted values start to exhibit a pattern of high volatility, with pronounced spikes and troughs. This could indicate that the CNN is less effective at making long-term forecasts, or it could be reacting to noise in the training data rather than the underlying signal. The increasing divergence between the actual and forecasted values could also suggest that the model's architecture or the training process may need to be refined to improve its long-term forecasting capability.

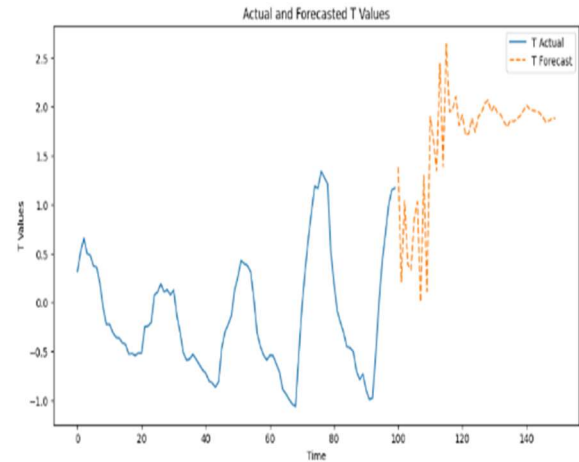


Fig 19. Actual and Forecasting graph of T Value Using Conv LSTM

Figure 12 presents the changes of the actual and expected T values in time using Conv LSTM model. The horizontal axis shows the time steps, wherein T is on the vertical axis. Three of the quantities are given by the blue solid line which oscillates greatly and this can be associated with the fact that real time series data are usually characterized by high variability due to various underlying processes.

The broken orange line depicts the T value forecasted by the Conv LSTM. Though, at the onset, the Conv LSTM model appears to track the trend and the oscillations of the actual data as evident from the fact that it follows the actual data in such an environment up to the 100th time step. Nevertheless, after certain moment of time, the values of the forecast start to deviate noticeably from the actual ones. The forecasted line tends to fluctuate, indicating a lower degree of prediction in the model. This may happen because the model cannot remember long-term structures or alterations in the process of data generation beyond what has been observed in the training set. It can also be a sign that the model is, in fact, overly fitting to the training dataset and cannot generalize well on new unseen data.

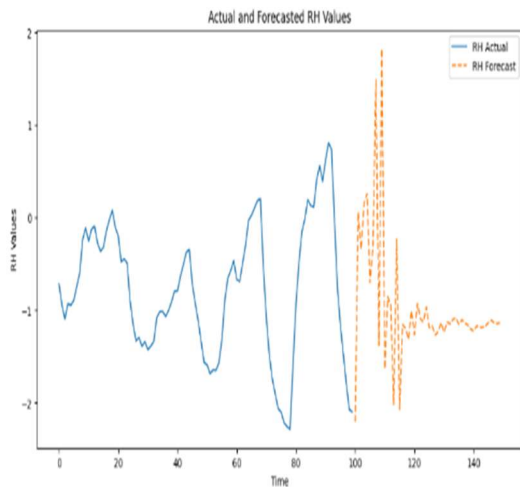


Fig 20. Actual and Forecasting graph of RH Value Using Conv LSTM

Fig 13 signifies the comparison of the RH values with the actual and predicted values by Conv LSTM model. On the x-axis there are the time steps of the observation period and on the y-axis there are the RH values. The RH actual values are illustrated with a blue line and we can observe oscillations over time, which typical for environmental data such as humidity.

As for the Conv LSTM model, the values calculated are the forecasted RH as presented by the dashed orange line. First, the fitted model looks plotted seems to be a good fit to the actual RH data as evidenced by initial congruence with actual RH values. Nevertheless, the forecasted values begin to shift rather dramatically after the 100th time step and show a heightened fluctuation and difference from the real values. This pattern could suggest several potential issues: the model could be learning only the features of the training data and could not be showcasing good generality when tested with new data or perhaps the Conv LSTM structure is not able to capture the long term relations in the time series data. It might also mean that the fundamental relationships in the dataset have shifted and the model has not learned to recognize.

Besides illustrating the effectiveness of the used models, this study also explores the peculiarities of deep learning application for analysing the environmental time series.

5.4 Comparison Analysis

Table.3 comparison of Mean Squared Error (MSE) values across four distinct neural network models, each representing a unique approach to machine learning tasks. The models under comparison include the Convolutional LSTM (Conv-LSTM), Multi-Layer Perceptron (MLP), Convolutional Neural Network (CNN), and LSTM Variant.

(CNN), and a variant of LSTM. The Conv-LSTM, combining the spatial feature extraction capabilities of CNNs with the temporal data processing strength of LSTMs, registers an MSE of 0.252984. This is marginally higher compared to the other models, suggesting a slightly less accurate performance in the specific context of this evaluation. The MLP, a foundational neural network structure characterized by multiple layers of perceptron's, shows an improved MSE of 0.24189. This indicates its effective performance, although it doesn't utilize the more complex convolutional or recurrent layers found in other models.

Table 3. Comparison of Mean Squared Error (MSE) for Different Models

Model	Mean Squared Error (MSE)
Convolutional LSTM (Conv-LSTM)	0.252984
Multi-Layer Perceptron (MLP)	0.24189
Convolutional Neural Network (CNN)	0.227212
LSTM Variant	0.22789

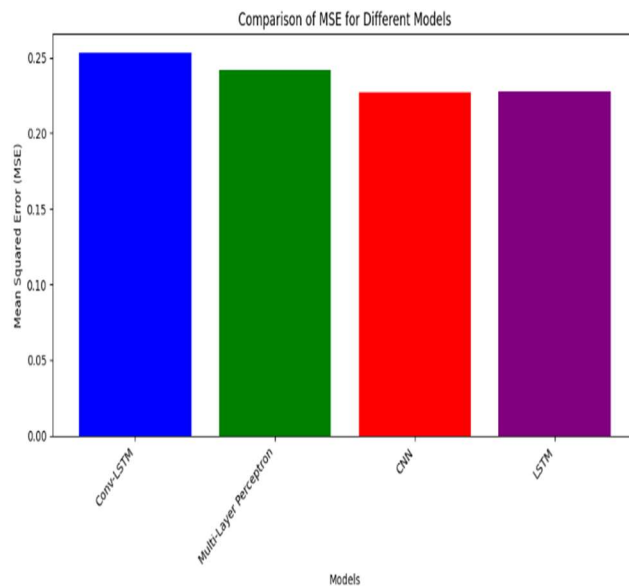


Figure 21. MSE Comparisons of Models

Significantly, the CNN and LSTM Variant exhibit the lowest MSE values, 0.227212 and 0.22789 respectively. The CNN, renowned for its proficiency in handling grid-like data structures such as images, demonstrates its robustness in predictive accuracy. Meanwhile, the LSTM Variant, tailored for sequential data processing and capturing long-term dependencies, shows a comparably high level of accuracy.



Various research efforts employing machine learning models to predict air quality across different regions. One study investigated the real-time monitoring of air quality and the prediction of peak nitrogen dioxide (NO₂) levels using artificial neural networks (ANN) in Athens, Greece, utilizing data from local air quality operational centres. Another research combined genetic algorithms with ANNs (GA-ANN) to select a subset of predictive factors for air quality in Tianjin, China, focusing on sulphur dioxide (SO₂) and NO₂, using historical air quality and meteorological data.

A different approach introduced a random forest model to predict urban air quality, specifically PM_{2.5} concentration levels, in Shenyang, China. This method incorporated a range of data including meteorology, road information, traffic status, and points of interest distribution. In contrast, another study implemented decision tree models to predict carbon dioxide (CO₂) levels within smart environment testbeds in Tokyo and Kyoto, indicative of overall air quality.

Further, a study carried out in Macau Peninsula, China used an LSSVM model to devise an early warning system for air quality. Applying meteorology and pollution data, according to which the level of temperature reflects the level of NO₂, this method covers the distribution of health advisories on daily basis. Another study by researchers in Beijing presented an independent study in which the authors developed a spatiotemporal deep learning (STDL) method using a deep belief network for air quality prediction. Particularly, this method aims to measure PM_{2.5} levelling on an hourly basis and based on the data obtained from twelve air quality control stations for two consecutive years. Every of these works contributes to the growing body of literature on prediction of air quality where machine learning has numerous applications in environmental science.

6. Challenges and Limitations

To assess the level of relevance and limitations of this research, this study highlights the major limitations necessary for contextualizing the results.

6.1 Sensor Limitations

One of the major issues is that sensor data collecting is minimally done. All of these are capable of distorting the readings to a certain degree, decreasing the quality of the datasets collected and, as a result, decreasing the efficiency of the artificial neural network prediction model due to environmental factors, blurring of the sensors, and hardware issues. Thus, calibration and pre-processing data are vital in lowering outcomes since they minimize the impact of errors. . Thus, it stresses that the

regular maintenance and checking the reliability of the data sensed by sensors overcome these drawbacks.

6.2 FDA Limitations

Despite having more strength for the complicated data, Functional Data Analysis (FDA) has inherent breakpoints. The listed suspicion of data progression in FDA may not tally with real situations that depict abrupt shifts or gaps, which may lead to model under fitting and wrong depiction. The review includes the importance of selecting the right premise capabilities and the challenges associated with analysing the functional data of the higher layer. So, future research should focus on the approaches concerning the choice of premise capability and regularization methods in order to improve the FDA models interpretability and accuracy.

Such difficulties underline the importance of the cautious approach to the methods of data collecting and analysing, revealing the trends for the further studies and developments in the field.

7. Conclusion and Future

This work introduces a new approach to predict air quality changes by combining FDA with deep learning procedures. Our findings show that integrating FDA with neural networks such as MLP, CNN and LSTM bases itself on the recognition and analysis of transient patterns in air quality data. FDA transforms individual data into a continuing functional image and allows models to utilize unique fleeting characteristic optimally. This combination of strategies worked effectively with the complex time series datasets with LSTM substantially precise with rehashed forecasts. Even with common issues such as sensor inaccuracies and the FDA's inherent constraints, the check demonstrated the models' remarkable proficiency at forecasting. The presented results highlight that the integration of FDA with deep learning can be a promising strategy in the field of environmental data analysis and forecasting. The results obtained show that FDA, in conjunction with deep learning, can serve as a competent analysis and prediction tool for environmental data. Future studies should focus on refining the sensor accuracy, exploring other complex FDA methods, and enhancing the interpretability of the model. This work lays the groundwork for further research and essentially contributes to the field of predicting the quality of the atmosphere.



7.1 Future Work

The study has found a good application of FDA in time series prediction and there are lot of opportunities for further research can be derived from this. One major area of focus is the development of adaptive basis functions aimed at capturing generic of time series data; more so the non-stationarity issue. It can significantly enhance flexibility and accuracy of FDA models subjected to a tremendous fluctuating dynamic environment. Another aspect, crucial to the developments is improvement of sensor calibration processes. To achieve data dependability, necessary actions have to be taken in order to refine calibration, as the accuracy of models in prediction relies heavily on the data gathered from sensors in complex environment. Further participation and research is needed to move forward the area of regularization techniques. Such procedures are rudimentary in fighting over-fitting while at the same time providing strong assurances of model flexibility, thus providing for versatility and reliability in environmental data analysis. Another interesting area is the exploration of hybrid modelling frameworks that integrate FDA, an analytical toolbox with FDA properties, with traditional time series forecasting techniques. They hold in them the potential for providing more accurate and precise estimations using efficiency and the best approaches from both worlds to handle large datasets. Finally, we believe that succeeding in engaging with realistic and complex FDA models the capabilities of sound conceivability are absolutely essential. The added benefits should consequently concentrate on enhancing the understand ability and use of these models by the professionals and managers. This would make it easier to manage the complex measurable methodologies into practical applications, addressing the realism of environment observing or dynamic systems. These planned review fields anticipate engaging with the FDA's ability to dissect time series data, committed to supporting environmental observing and primary sweeping direction.

5. Reference

- [1] S. Goyal and R. Sharma, "Prediction of the concentrations of pm2.5 and nox using machine learning-based models," *Journal Name*, 2023.
- [2] W. Breed, "Social control in the newsroom: A functional analysis," *Social forces*, pp. 326–335, 1955.
- [3] L. Holl, M. Hilgarth, A. J. Geissler, J. Behr, and R. F. Vogel, "Prediction " of in situ metabolism of photobacteria in modified atmosphere packaged poultry meat using metatranscriptomic data," *Microbiological research*, vol. 222, pp. 52–59, 2019.
- [4] E. Ahmadi Basiri, S. M. Taghavi-Shahri, B. Mahaki, and H. Amini, "Functional kriging for spatiotemporal modeling of nitrogen dioxide in a middle eastern megacity," *Atmosphere*, vol. 13, no. 7, p. 1095, 2022.
- [5] F. Kleinert et al., "Forecasting air pollution on the time horizon of several days," *Journal Name*, 2022.
- [6] X. Jurado, N. Reiminger, M. Benmoussa, J. Vazquez, and C. Wemmert, "Deep learning methods evaluation to predict air quality based on computational fluid dynamics," *Expert Systems with Applications*, vol. 203, p. 117294, 2022.
- [7] M. Mendez ' et al., "Machine learning algorithms to forecast air quality: A global perspective with relevance to low-resource settings," *Artificial Intelligence Review*, 2023.
- [8] T. M. Chiwewe and J. Ditsela, "Machine learning based estimation of ozone using spatio-temporal data from air quality monitoring stations," in *2016 IEEE 14th International Conference on Industrial Informatics (INDIN)*. IEEE, 2016, pp. 58–63.
- [9] Y. Zheng, X. Yi, M. Li, R. Li, Z. Shan, E. Chang, and T. Li, "Forecasting fine-grained air quality based on big data," in *Proceedings of the 21th ACM SIGKDD international conference on knowledge discovery and data mining*, 2015, pp. 2267–2276.
- [10] J. A. Engel-Cox, C. H. Holloman, B. W. Coutant, and R. M. Hoff, "Qualitative and quantitative evaluation of modis satellite sensor data for regional and urban scale air quality," *Atmospheric environment*, vol. 38, no. 16, pp. 2495–2509, 2004.
- [11] J. Y. Zhu, C. Sun, and V. O. Li, "Granger-causality-based air quality estimation with spatio-temporal (st) heterogeneous big data," in *2015 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS)*. IEEE, 2015, pp. 612–617
- [12]] C. Wong, M. MatJafri, K. Abdullah, H. Lim, and K. Low, "Temporal air quality monitoring using surveillance camera," in *2007 IEEE International Geoscience and Remote Sensing*



- Symposium. IEEE, 2007, pp. 2864–2868.
- [13] F. Maduri et al., “Air quality forecasting using machine learning: Lightgbm, gbm and random forest models,” *Journal Name*, 2023.
- [14] “Air quality prediction using machine learning algorithm,” in *IEEE Conference*, 2023.
- [15] “Improving 3-day deterministic air pollution forecasts using machine learning algorithms,” *Atmospheric Chemistry and Physics Discussions (ACPD)*, 2023.
- [16] N. S. Gupta et al., “Prediction of air quality index using machine learning techniques: A comparative analysis,” *Hindawi*, 2023.
- [17] P. Laj, J. Klausen, M. Bilde, C. Plass-Duelmer, G. Pappalardo, C. Clerbaux, U. Baltensperger, J. Hjorth, D. Simpson, S. Reimann et al., “Measuring atmospheric composition change,” *Atmospheric environment*, vol. 43, no. 33, pp. 5351–5414, 2009.
- [18] “Air quality prediction by machine learning,” *ResearchGate*, 2023.
- [19] T. Somasekhar, “Survey on air pollution in india: Insights, predictions, and mixed gas analysis for an improved future,” *Journal Name*, 2023.
- [20] “Air pollution prediction using machine learning,” in *IEEE Conference*, 2023.
- [21] “Air quality forecasting using machine learning: A global perspective,” *ResearchGate*, 2023.



AI-Enhanced Secure Multi-Party Computation via Secret Sharing: Advancements and Application

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ABSTRACT

Secure Multi-Party Computation (SMPC) enables multiple parties to collaboratively determine a function's outputs while preserving its privacy. Recent AI developments have dramatically increased SMPC protocols' efficiency, scalability, and security. The interaction between SMPC and Artificial Intelligence (AI) techniques is the focus of this paper. Our proposed scheme uses machine learning algorithms for shared distribution, performs minimal communication overhead and enhances computation. AI additionally chooses standards and adjusts their configuration, ensuring privacy and application requirements. Our experiments based on real-world applications demonstrate that AI-enhanced SMPC is capable of supporting advanced data analysis and machine learning operations. The complexities of scalability to a large number of participants and adversarial threats are demonstrated with the help of real-world examples. The purpose of this research is to investigate the revolutionary possibilities of privacy-preserving technology in highly confidential group situations. Finally, our paper shows SMPC and artificial intelligence are able to support each other by the integration of their respective technologies.

1. Introduction

Due to the fact that in current and especially future scenarios communication takes place at high rates and data is transmitted at high rates as well, it is imperative that such environments are secure and privacy-preserving. Given that data transactions are becoming more voluminous and shifting at a faster pace, the number of persons who fall prey to security and privacy violations also increases. High-rate communications allow real-time data exchange and work as effective tools for improving efficiency and productivity, but at the same time, they are followed by a range of threats. These are the some flaws in implementing a security system, cyber attackers can easily hijack those processes and intercept the information being conveyed and perform complex attacks. Hence, security strategies such as encryption top-notch, multi-factor authentication, and

secure communication should be adopted to ensure that the data is secure and does not fall into the wrong hands. Also, technologies for private data processing as homomorphic encryption, and Secure Multi-Party Computation allow for data manipulation and analysis without unveiling the information. These technologies guarantee that the input information is secure even when being processed, hence avoiding the undesirable outcomes of data leakage. While digital communication grows sophisticated, the demand for safer methods of computing environments will be paramount, and hence, the need for constant developments in secure frameworks and PETS to counter future threats. [1]. in recent years, data hacks, privacy breaches, and cyber threats are on the rise; therefore, information security is more crucial than ever. Among the approaches prospective for the resolution of those challenges, Secure Multi-Party Computation (SMPC) is one of the



most effective. SMPC enables multiple entities to perform functions on their data inputs in a combined manner while preserving the data's confidentiality. This cryptographic framework allows the data of every party to be kept secure since only the result of the computation is disclosed and not each input used in the computation. In SMPC, several techniques like secret sharing, homomorphic encryption, and zero knowledge proofs are used and hence, it offers strong security against adversaries. This is especially the case with applications that involve data sensitiveness such as research, monetary and health related applications among others. Specifically, SMPC reduces the consequences of threats based on data leakage and cyber-attacks, as well as helps to develop trust relationships between parties that need to exchange information that may be valuable to third parties. Thus, the expansion of SMPC and other cryptographic solutions will be imperative in the future as the digital environment becomes increasingly threatened by various cyber threats [2]. While ensuring the privacy of personal data. SMPC technology ensures that neither party knows all or nothing about the transaction. This ensures that all individuals have control over their own data. Thanks to this feature, a more efficient approach to data protection and collaboration is provided. The applications of SMPC are vast: from conducting medical research to issues in the financial sector to assessing risk without revealing specific patient information. With the increasing use of decentralized networks and distributed systems, SMPC enables secure interoperability while maintaining confidentiality and privacy. When we address the complexities of the digital age with SMPC embedded in our technology infrastructure, we can revolutionize our technology. The digital age holds great promise for achieving a balance between innovation and security [3].

Due to the need to protect the data that ought to be shared as well as protecting the type of data to be shared, Secure Multi-Party Computation (SMPC) protocols incorporate what is commonly referred to as traditional forms of cryptography as a mean of sharing confidential data. These protocols are formulated so as to guarantee that each party's contribution is kept private while the global computation is done concurrently. Nevertheless, several critical challenges have been noted which affects the usage of SMPC, and which includes; Complexity of data and length of calculation. These problems are observed more frequently when working with large physical databases or performing complex practical calculations.

Another major source of difficulty associated with SMPC is the fact that the various constituents that comprise it are forced to undertake significant

communication. Every of the participants has to exchange a significant amount of information to perform the computations securely. However, extensive communication is necessary for self-organizing to function properly, which, in addition to compounding the complexity of the protocol, greatly influences the speed of calculations. When the data size and the number of participants increase, the amount of information that have to be transferred increases exponentially, thus, diminishing the rate of the entire process.

This is an issue because the calculations in SMPC are slow and this becomes worse when real time calculations are needed. This particular disadvantage can be critical when multiple inputs or calculations have to be made in real time because it involves a lot of communication. Due to this, it becomes difficult when integrating the SMPC in (Applications where a timely response is important). For instance, in real time applications such as financial trading where transactions must be effected in a millisecond, then the delays that are brought about by SMPC could be unmanageable.

In response to these challenges, there are efforts being made where analysts have tried to work on the different ways of improving on the enhancement of SMPC protocols. Another strategy is trying to come up with enhanced cryptography that minimizes the amount of sending and receiving information between the members. This is another strategy which can be implemented is optimization of the communications that are likely to reduce some delays and increase the throughput. Also, enhancement in the hardware like the inclusion of special processors that are most appropriate for the mathematical operation used in cryptographic computations can also solve the general performance problem often linked to SMPC.

However, as it was discussed in the previous section, the discussed Secure Multi-Party Computation (SMPC) method is considerate efficient in the case, when multiple inputs have to be protected from unauthorized access. This method is especially useful in situations where different individuals need to come together to perform a computation on a number while at the same time, none of the involved parties should have access to the data of the other party. Such joint computations are realized through the SMPC that employs keys to encrypt the inputs of each participant, yet the final computation result is made available to all parties.

Healthcare is one area of prominent usage of SMPC. This field involves collective or combined data analysis of different patients among various health entities like hospitals, research institutions, and clinics among others. For instance, they may conduct research on the



same disease to find better treatment technique or to study the pattern of the illness. What SMPC allows other such organizations to do is to conduct joint analysis on such cases without revealing the identity of the patient involved. Both institutions can feed their data into the computation process while the patients' relevant information is not disclosed to the other institutions. This is to bar any violation of privacy laws such as the HIPAA as the patients' information is required for the collaborative research deemed crucial for attainment of health objectives.

Likewise, in the cases of secure cyber control, SMPC can open up the possibilities of secure sharing of materials and data among various organizations for their mutual benefit. The threats in the domain of cybersecurity are getting more numerous and complex, which means that multiple actors should work to identify the main adversities and prevent them. SMPC protocols can also be used by different organizations to exchange threat intelligence information; this data set can then be combined in the different organizations in order to enable better threat identification and response. For instance, many firms require to exchange data about identified viruses or phishing attempts. With SMPC, they are able to do so without risking divulgence of unique security measures, weaknesses or any other strategic organizational information. It also improves the security paradigm of all the participating partners while at the same time preserving the identity of all the organizations' information.

In both the medical and computer security the effectiveness of using SMPC is the ability to make efficient decisions promptly. However, when it comes to the amount of data that is communicated during its collaborative computation, it is self-evident that it is not easy and there lies the fact that different SMPC protocols have been developed to ensure that these computations are done efficiently and in the shortest time possible. Experts are still working to discover better cryptographic techniques and ways of communication for increasing the efficiency of SMPC, which opens up its relevance for use with time-sensitive applications. In recent years, artificial intelligence research has produced interesting solutions to the problem of solving sequential problems, thus revealing the full potential of SMPC and allowing it to be used effectively. It should be noted that researchers have tried to improve the calculation method using SMPC in the SMPC protocol to improve the separation process, protocol selection and storage method. Specific examples of good machine learning algorithms come from eliminating communication overhead, simplifying computation, and programming protocols that require different protocols. In this context,

the new in the field of large data storage and large data storage, as well as benchmarks, real-time computing among the pioneers of SMPC. Throughout the work, it aims to explore the interaction between secure multimedia computing (SMPC) and artificial intelligence (AI), particularly to the extent that physical computing is possible, and how AI techniques can be incorporated into distributed computing. Cryptography ... the importance of increasing stability and security. In order to highlight revolutionary possibilities in both SMPC and secret distribution, we are examining the theoretical underpinnings of both SMPC and secret distribution from a theoretical perspective. Our aim is to incorporate AI-enriched SMPC into real-world applications and real-world action results in order to achieve real-world benefits. As part of our efforts, we are focusing more on securing the data and focusing on feature-preserving machine learning projects as well as collaborating on decision-making processes. Our goal in this field of research is to highlight the importance of finding innovative solutions to new challenges in the field of forensic security and shared computing and to highlight the importance of pioneering new solutions.

Our aim is to demonstrate the transformative potential of SMPC by imbuing it with term intelligence in order to facilitate secured and feature-preserving computations through the application of secure and feature-preserving algorithms. Moreover, we discuss the trends as well as the opportunities associated with term-intelligence and SMPC to point the way for future investigation and practical applications related to how they go together and how they influence one another.

2. Related Work

Over the last few years, the literature has reported increased interest in integrating SMPC with AI, which has resulted in extensive and diverse works that investigate different aspects of this conceptual composite. This integration of SMPC with AI has led to inspiring a lot of interest and has fostered a very active line of research. Researchers are creating as well as exploring content that focuses on the interdependence of the two domains, indicating a spectrum of research interest in the improvement of both domains.

The term intelligence presents one of the primary foci, with its integration to SMPC. Terminology intelligence that is, extraction and analysis of terms and their concepts in certain contexts contribute to enhancing the efficiency of the application of artificial intelligence. When integrated with SMPC, term intelligence can improve on the handling and processing of intelligence information in AI systems securely. This synergy enables the investigator to deal with problems linked



with data confidentiality and security while at the same time utilizing AI's potential in data evaluation and comprehension.

It is possible to focus on the intersection of the two in terms of its approaches, conceptualizations, and types of initiatives. For example, current studies look into the ways in which the efficiency of SMPC protocols can be enhanced in order to allow AI to operate on the encrypted data without the need for decryption. This is especially true in situations where the information which is involved requires high levels of protection like in health or in financial sectors. The use of SMPC in AI systems ensures precise computation of complex values on data that require protection of the individual entries.

In addition, the approach of researching this area includes the formulation of research materials that makes it possible to analyse SMPC from different perspectives. There are studies as to how one can modify an existing SMPC protocol, or otherwise improve the design of extant SMPCs to be more accommodating of AI procedures. This includes coming up with new cryptographic techniques that would enhance the efficiency in SMPC while at the same time strengthening on the security measures put in place. Furthermore, the emphasis is placed on the possibilities of term intelligence enhancement and the development of SMPC methods as the two intersect.

Current studies in this field are providing them with a foundation for the next advancements in safe and private AI solutions. Thus, analysing the relationship between SMPC and term intelligence, researchers hope to overcome current challenges and advance toward better solutions for collaborative and secure computing. This combined approach has the potential to create major advancements in both the AI front and the cryptographic techniques, and therefore improve the efficiency and the protection of data-oriented services.

There has been a growing interest among researchers to develop efficient protocols and cryptographic principles for enabling secure computations between many individuals in the field of secure multiparty computation (SMPC). It is a major principle of SMPC that, in addition to keeping computation information secret, it also provides optimal information for those who are establishing official computational protocols so that they can provide optimal service. Protocols for official computations are based on traditional methods such as Yao's garbled [4] circuits and privacy object schemes, which have been around for years. These laws hide things and only those who have the right keys can use them. In recent years, technology has been developed to distribute. Recently, research efforts have

been applied to various areas such as protocol optimization, window encryption, and peer optimization. To keep people safe, Windows encryption can be used as a computer protocol for public computers with highly sensitive information. Homomorphic encryption allows third parties to encrypt transmissions without the knowledge of the sending computers.

One of the best ways to increase the efficiency and usability of SMPC processes is to implement artificial intelligence (AI). Much research has been done using machine learning techniques to improve security software, such as the selection of protocols, types of deployments, and security operation evaluations. Theodoropoulos et al [5] and Shen et al [6] suggest that neural networks and optimization algorithms can improve the performance of safety algorithms. These areas are the subject of numerous studies to show that useful parameters can be calculated in these areas with good performance.

It also helps in improving the safety of calculations for the field of machine learning during this integration. The sole idea of these systems remains in selection of the particular protocol which offers higher performance, increased security, and better options for data exchange without overcoming the main principles of computation. Such as, through SMPC and other realization approaches, the model training at the same time can learn from distributed datasets and also prevent the leakage of dataset's information. It not only increases the accuracy of calculations in various fields but also improves the coordination process of acquired data among organizations, including research centres and commercial companies. The investigations in these secure protocols enhance computing performances in important application domains, and thus open up a space for developing safer and more reliable ML methods. In addition, it provides a solid basis for the future utilization of sound calculating techniques for achieving organisational success meaning it is well positioned in the context of the ongoing advancement of data-protection-compliant approaches in artificial intelligence and machine learning. Experts globally have explored several ways of applying AI from the simple statistical analysis to the modern methodologies of ML. For instance, a study by Zhang et al. [7] established that voice intelligence offered an immense prospect in the medical field by analysing information on diseases with a view of improving, diagnosing, facilitating comprehensive and early treatments to safeguard patient safety. Also, further work by Song et al [8], has shown that networking benefit from the application of linguistic intelligence. Their research demonstrates how these techniques help improve the trust of users in secure



privacy-preserving systems for secure and confidential business transactions. These developments articulate the significance of AI in enhancing data analysis and information sharing while ensuring high privacy levels leading to increased confidence and increased utilization of AI technologies by different fields.

Many studies in different parts of the world have shown that end-to-end monitoring methods are effective for computer security in different locations. In such situations it is important to protect and secure important information. The word "wisdom" can be described as one that bestows many blessings, and these words show their effectiveness in everyday situations where they are used. Therefore, a new system of intelligence can provide reliable life relationships and is an effective and efficient way to cope with a challenging world where everything is constantly changing.

Despite significant improvements in language skills, there are still many challenges to participating in the SMPC protocol. There are many things that make the mind hard. The importance of questions, the need to build trust and the risk of attacks from external enemies. This paper describes a number of cases where large-scale computational complexity and scaling problems occur with more and more data sets, and the cases have non-consistency problems. Furthermore, it is necessary to maintain a fiduciary duty, as the participants must rely on each other in order to do their part properly without being retaliated against by their counterparts. It is also worth noting that there is also a risk of the possibility of adversarial attacks and malicious functionality, such as the contamination of data or the inversion of models. A cryptographic solution, a machine learning solution, as well as the security of a systemic approach can be found to solve these problems. The existence of these problems highlights the need for further research and development in the field of semantically skewed computation, in order to resolve these issues. SMPC protocols require more research and development in order to improve term intelligence techniques in the SMPC protocols so that their use at a global level can be made possible and to make the use of SMPC protocols possible in the future.

Altogether, the present offering can be viewed as a useful compile for those who work in the field of SMPC and manage term intelligence as it may help better understand the ways of relationship between them. Deriving from the foregoing section, these resources have been instrumental in the making of significant part in feature-preserving computation. These researches have investigated prior findings and outlined new opportunities and directions to improve secure and collaborative computing with the imputation of recent

issues. They help in creating sustainable methods that ensure that the privacy and, at the same time, security of data is upheld while allowing computations and sharing. Thus, the connection of SMPC and term intelligence which both focus on constructing practical secure computational systems creates new possibilities of implementation into various areas such as healthcare, finance, and distributed systems to improve the dependability and efficiency of the secure computing approach.

In this regard, it is pertinent to note that the term intelligence techniques have been reported to play a very significant role in the enhancement and optimization of the Secure Multi-Party Computation (SMPC) protocols. These techniques improve the operations of SMPC in protecting data computation and communication operations that transpire amid the partner nodes' collaborative efforts. Despite the fact that these developments present some difficulties, their application is useful for uneven and cooperative computing in a vast amount of disciplines. From these achievements, our research entails evident advantages not only in the improvement of the secure computing but also in the prospect of broad innovation area of study and research.

Other techniques used in the determination of Terms include the development of protocols of Term intelligence integrated with SMPC, which makes it possible to provide data privacy and security while at the same time computing efficiency is maintained. This is especially valid when the information is highly secure, in industries including medical and financial departments. For example, these techniques can be employed in the medical field to safely analyse patients' information and provide appropriate diagnoses as well as remedies and prescriptions without compromising the data. Likewise in finance, secure computation can assist in achieving confidential financial calculations and financial transactions, hence, the privacy, of vital financial information is preserved.

The integration of term intelligence with SMPC has also changed secure computing by enhancing its possibilities. It has created the basis for wide and parallel computing applications which are in a position to perform computations on big data safely. This provides opportunities in numerous sectors and facilities new trends of study and implementation. For instance, in social sciences, there is an opportunity to improve research cooperation in secure sharing and computation of data while, at the same time, safeguard participants' information. In the case of distributed systems, these appearing advancements can enhance the security and the rate of data handling with different nodes in the

network.

Moreover, these developments are flexible since they can be implemented in different industries apart from health and economy. These advancements can be useful in any developing domain that requires safe and swift numerical processing of the information. This includes sectors like cybersecurity where security of information from being hacked or improperly accessed is imperative, and government and policy making where secure data analysis should be nurtured to enhance on policy making.

Thus, the research and development of term intelligence and SMPC techniques produces innovative processes of scalable and collaborative computing applications. These innovations extend not only the protection of information and optimization of cop. Documents calculations but also opens a new level of opportunity to create solutions that help to overcome difficult challenges of different areas of human activity. What these technologies are shaping themselves into is that these will have higher usage and prominence as more of an enabler of easing life as we know, providing safety and bridging the connection.

3. Major Contributions

- Designing cryptographic distribution schemes to incorporate semantic intelligence techniques for secure multiparty computation (SMPC).
- Testing the efficacy of machine learning algorithms in improving the allocation of shares, protocol selection and cost of secure collaboration in collaborative computing.
- Assess real-world applications of multiparty computation based on semantic intelligence, such as data security analysis, privacy-preserving machine learning, and collaborative decision-making in the health and finance industries.
- We present a theoretical discussion of SMPC and cryptographic distribution, explaining the interaction of these forces with the term intelligibility.
- A better understanding of the challenges and opportunities associated with combining SMPC with semantic intelligence will enable further research and practical actions to be taken.
- Analyses recent developments in feature-secure computation and synthesizes current SMPC products and terminology.

4. Proposed Model

Using Shamir's Secret Sharing Scheme, the SMPC model is integrated into Shamir's scheme for improving artificial intelligence and increasing security. In the case of P_1, P_2, \dots, P_n participants, where each n participant has a private entry x_i . As part of Shamir's Secret Sharing, in order to generate a portion s_i of the input x_i each participant P_i generates a polynomial interpolation over the threshold t at which the input x_i can be generated. In order to safely calculate the interaction $f(X)$ on distributed shares, an SMPC protocol is employed, as well as ensuring the characteristic of the interaction is preserved. A critical interaction is employed to reduce mixing parameters $J(\theta)$ as part of an optimization experiment to improve various aspects of the calculation process; a text representation of the (AI) is introduced. As part of the AI model, we optimize the distribution of share among the participants (θ_d), we select and customize the protocol (θ_p), and we estimate the interaction cost accurately (θ_f). This minimizes the overhead of transaction processing and computations while maintaining the level of safety that needs to be maintained. In order to ensure accuracy, the final result $f(X)$ is constructed by the participants using their shares at the end of the calculation, after which error correction techniques are used to ensure accuracy. In order to evaluate the robustness of a model, a security analysis needs to be conducted on it. Performance, transient load, as well as security criteria are evaluated in the process of performing a performance analysis. There are several features in this model that make it a robust solution for secure computing, helping organizations to improve security practices and to collaborate in a seamless way. More details of proposed model is explained in Fig .1.

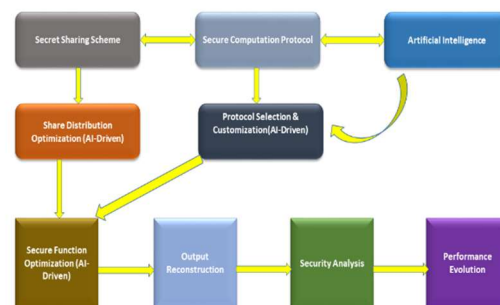


Fig 22. Proposed Model

5. Adversary Model

Looking at the more specific field of computation that utilizes SMPC together with AI, there are several likely

actions that adversaries can take to threaten the safety and security of the computation in question. Some of its capabilities are, wiretapping, message interception, participating as a member, and using complex cryptographic analyses. The purpose of such adversarial actions is to obtain and compromise information pertaining to inputs, alter computations, and deceive the results. Eavesdropping as a type of attack involves passive concealment where the attacker listens and records information that does not in any way change the content being transmitted or the pace at which it is passed. On the other hand, capturing or manipulating messages, or changing the parameters of communication can be formally defined as active interference in which the intruders intentionally tamper the information being transmitted with the possibility of jeopardizing the credibility of the computation. One of the major risks is the collusion that might occur among the participants to provide a threat that is capable of threatening the confidentiality as well as the accuracy of the data processed. Additionally, cryptographic attacks that involve breaking the cryptography system by attacking the algorithm or the protocol underpin SMPC system security. In order to manage these threats and make the SMPC process more reliable actualization of the following protective measures is mandatory. Transmission and storage security uses encryption as a core notion because even if the data is intercepted, it cannot be understood by anyone who does not have a specialized access. Identification routines also check that all the participants are permitted to be involved in the computational process. Traditional Simple cryptography methods scatter the secret information among the parties, where it is impossible to make a complete information profile without a minimum number of people involved making it hard for colluding parties to gain full info. Thus, protocol authentication helps guarantee that the computation shall follow the set protocols in a bid to avoid unfaithful computation to the system. When these measures are adopted, it is easy to enhance the security, privacy, and confidentiality of the SMPC process, thus reducing the impact of all the adversarial strategies. To describe the opponent model and the related response measures in more detail, it is suggested to refer to Fig. 2, which shows the possible threats and protective actions.

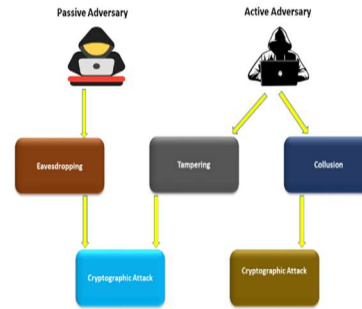


Fig 23. Adversary Model

6. Proposed Scheme

Our scheme based on following steps;

6.1 Secret Sharing Scheme (Shamir's Secret Sharing)

Using Shamir's secret system, each participant P_i creates a share of the private entry $\frac{x_i}{s_i}$ that is associated with their personal entry. The secret sharing scheme of Shamir entails a process whereby each participant, P_i , creates the part of its private entries, x_i , which is known as s_i . Polynomial interpolation is employed in this case, based on a threshold t in order to reach the target. There is a method in which participant P_i receives a share from a very small pool of participants, which is only for members in that group. In this case, the share is only available to the participants that are in that group. While maintaining specificity and reducing transition burdens, this reduces computational complexity and reduces transition burden. In addition, total secret sharing scheme can be calculate with following formula;

$$s_i = (x_i, t) \quad (1)$$

6.2 Secure Multi-Party Computation Protocol

- A SMPC protocol is used between the parties in order to jointly calculate the function $f(X)$ over a distributed share of the result.
- With the help of the protocol, involved parties can collaborate on computing $f(X)$ without their private inputs $SMPC(f(X))$ being revealed to each other.

6.3 AI Optimization Function

- It is presented here a function designed to optimize different aspects of the computation process based on AI, called $AI(X)$.
- The AI model determines the most efficient variables θ with a view to minimizing the

- Objective measure, $J(\theta)$, in order to preserve privacy while maximizing computational efficiency.

$$\theta^* = \operatorname{argmin}_{\theta} J(\theta) \quad (2)$$

6.4 Share Distribution Optimization

- In order to minimize the communication overhead and computational complexity, the AI model optimizes the share distribution among the parties.
- To minimize the number of shares required to perform computation, it would be beneficial for us to learn how to calculate optimal parameters with θ_d . It is also necessary to ensure that the function's result was accurately reconstructed by re-executing the function.

Additionally, we have also proposed algorithm 1.

Algorithm 1 Secure Multi-Party Computation using Shamir's Secret Sharing Scheme

Require: Number of parties N , Threshold parameter T

Ensure: Secure computation performed without revealing individual shares

1: *GenerateShares:*

2: **for** i **from** 1 **to** N **do**

3: Generate private input x_i for party i

4: Generate shares for party i using Shamir's Secret Sharing Scheme:

5: $shares[i] \leftarrow \text{generateShare}(x_i, T)$

6: **end for**

7: *SecureComputation:*

8: **for** i **from** 1 **to** N **do**

9: Transmit share $shares[i]$ securely to all parties

10: **end for**

11: Perform secure computation using shares

12: **return** Secure computation performed

7. Simulation and Results

The experiments in this table. 1. Associated with a set of shares specified by a threshold value example

Table 4. Experiential Data Analysis Parameters

Share	Threshold	Total Communication Cost	Computational Efficiency	Privacy Metric	Preservation
5	3	500	10	0.95	
5	3	600	12	0.93	
5	3	550	11	0.94	
5	3	520	9	0.96	
5	3	580	13	0.92	

a value of 3 and a specified number of shares specified by a number in this example, 5 shares. According to shamir secret sharing scheme, these parameters are the key components that are used in the proposed scheme as a key component. In this sense, they contribute greatly to the assurance of the scheme's security and efficiency as they determine the minimum number of shares required to reset the secret.

shares and thresholds. In all experiments, the share and threshold values are set the same. For example, where share is defined as the total number of shares required to reconstruct the secret, the threshold value is set at three. By securing the advice lion's secrets with these parameters, a reliable and efficient way to share the computation load can be achieved while securing the advice lion's secrets.

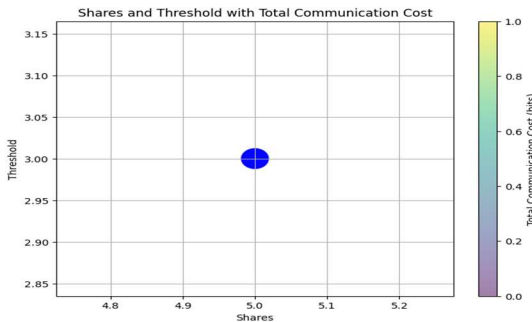


Fig 24. Shares and Threshold with Total Communication Cost

There are two variables involved in the experiment:

Fig 3 shows, there are several different ways that a total communication cost can be used to help we assess how much practical information is gained during an experiment. Depending on the experiment, the number of bits can range between five hundred and five hundred forty-eight, but it is very variable. In the communications industry, this metric is used to reflect efficiency, as lower costs are associated with lower overheads and more efficient data transfer processes.

Fig 4 shows, as a measure of a computation's performance, you may ask how long it can take to perform a computation safely. As a result of our experiments, the launch times vary from nine to thirteen

seconds, indicating different levels of computational efficiency. A lower value indicates a faster computation, which has a significant impact on total performance, since it is the most significant factor.

Fig 5 shows, there is no doubt that our internal information security is of the utmost importance when it comes to Confidentiality Maintenance Standards. The value ranges anywhere between zero and twenty one, and a higher value predicts a stronger level of privacy. Defining the extent to which effective secrets can be disclosed without authorization is the purpose of this standard.

Obviously, the results of these studies are attributed to communications, computational efficiency, and privacy trade-offs, all of which have been claimed to be important. In addition, they provide feedback on the performance of the claim and future developments.

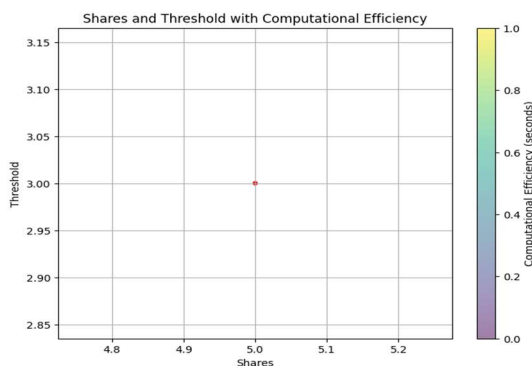


Fig 25. Shares and Threshold with Computational Efficiency

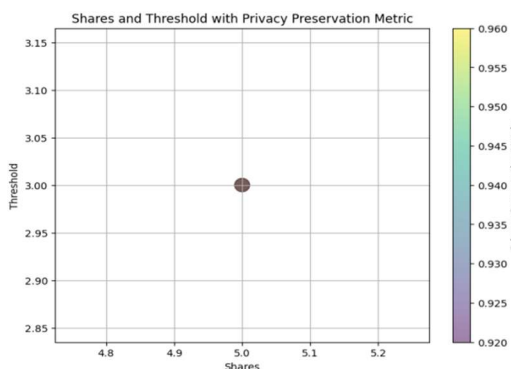


Fig 26. Shares and Threshold with Privacy Preservation Metric

8. Security Analysis

8.1 Eavesdropping Resistance

In order to protect the transmission of messages exchanged between parties, the system uses strong encryption techniques, regardless of whether or not

eavesdropping is present. By encrypting communication channels, obscuring and analysing systems, encryption helps to reduce the risk that sensitive information will be infiltrated into the wrong hands.

8.2 Tamper Resistance

In order to identify messages and to reject messages that contradict each other, strong authentication mechanisms are implemented. It is important that the integrity of the exchanged messages is ensured by means of digital signatures and message authentication codes. The use of a system like this prevents adversaries from scraping messages in any way or adding content that could be malicious.

8.3 Collusion Resistance

It is our goal to minimize concurrency attacks by using consensus cryptographic techniques, to ensure that no minimum number of lions is compromised as a result of concurrency attacks. As a means of maintaining the confidentiality of the integrated cycle or impact analysis or computation process, it is necessary for the data to be encrypted.

8.4 Cryptographic Attacks Resistance

Cryptography Integration Analysis Once the system is installed, the system undergoes ongoing testing and analysis to identify any security vulnerabilities or flaws.

9. Conclusion and Future Work

Finally, the proposed system provides a solution for multi-partition computing (SMPC) in complex environments using Shimmer secret partitioning strategy, registration method and authentication method. Over time, other types of accounts will gain more privacy, reliability, and security. Covers a wide range of adversary threats while providing adequate protection against intrusions and intrusions, intrusions, and systemic and covert attacks. In security testing, the system demonstrated the strength and effectiveness of protecting confidential information. By employing a distributed encryption and decryption approach, the system significantly reduces the risk of vulnerabilities and unauthorized access. The authentication method cannot contain fraudulent activities, but the ordinary method and account verification method provide guarantee for system security. These products are suitable for use in critical situations around the world, such as healthcare, finance and distribution networks.

Although the proposed system is strong But there are many ways of work and future research to improve the security, performance and use of the process, using rapid analysis and methods of restoring security and truth to



the system of different levels. Setup - View updated settings. System performance and scalability, such as methods similar to distributed computing this can provide the opportunity to handle Sensitive data, etc., can have many types of use due to their different lifespans and uses. Finally, it is important to continue to pursue the research and development of encryption because of the risks of analysis. It can ensure the future vision of the system and develop flexible behaviour.

10. Reference

- [1] Ali, S., Wang, J., & Leung, V. C. M. (2023). Defensive strategies against PCC attacks based on ideal (t, n) -secret sharing scheme. *Journal of King Saud University-Computer and Information Sciences*, 35(9), 101784.
- [2] Bellini, A., Bellini, E., Bertini, M., Almhaithawi, D., & Cuomo, S. (2023, July). Multi-party Computation for Privacy and Security in Machine Learning: a Practical Review. In *2023 IEEE International Conference on Cyber Security and Resilience (CSR)* (pp. 174-179). IEEE.
- [3] Ahmed, S., & Khan, M. (2023). Securing the Internet of Things (IoT): A comprehensive study on the intersection of cybersecurity, privacy, and connectivity in the IoT ecosystem. *AI, IoT and the Fourth Industrial Revolution Review*, 13(9), 1-17.
- [4] Jafargholi, Z., & Wicks, D. (2016, October). Adaptive security of Yao's garbled circuits. In *Theory of Cryptography Conference* (pp. 433-458). Berlin, Heidelberg: Springer Berlin Heidelberg.
- [5] Theodoropoulos, P., Spandonidis, C. C., & Fassois, S. (2022). Use of Convolutional Neural Networks for vessel performance optimization and safety enhancement. *Ocean Engineering*, 248, 110771.
- [6] Shen, T., Nagai, Y., & Gao, C. (2020). Design of building construction safety prediction model based on optimized BP neural network algorithm. *Soft Computing*, 24, 7839-7850.
- [7] Zhang, J., Wu, J., Qiu, Y., Song, A., Li, W., Li, X., & Liu, Y. (2023). Intelligent speech technologies for transcription, disease diagnosis, and medical equipment interactive control in smart hospitals: A review. *Computers in Biology and Medicine*, 106517.
- [8] Song, M., Xing, X., Duan, Y., Cohen, J., & Mou, J. (2022). Will artificial intelligence replace human customer service? The impact of communication quality and privacy risks on adoption intention. *Journal of Retailing and Consumer Services*, 66, 102900.



Enhancing Hydrofoil Energy Harvesting Performance through Slot Integration: An Experimental Study

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KEY WORDS

Energy Harvesting
Wake Piezoelectric
eel Water tunnel
Flapping traces
Dominant Frequency
Hydrofoils

ABSTRACT

An experimental study was proposed and designed for micro energy harvesting from the wake of streamline body (NACA 0012) with addition of introducing three different configurations of slots. The hydrofoils were placed at three different angles of attack, $\alpha = 0^\circ, 4^\circ,$ and 8° in the closed- circuit water tunnel in a uniform flow with piezoelectric eel placed in the wake. The response (power output) of the piezoelectric eel and instantaneous data was collected through LabView, and flapping footage of the eel was captured through high-speed camera for a time span of 120 sec each. The flapping traces and dominant frequency are post processed by MATLAB. The Amplitude to Length (A/L) ratios, frequencies, and power output for all configurations were determined. It has been found that hydrofoils are also suitable for energy harvesting through piezoelectric eel from their wake's contrary to bluff bodies.

1. Introduction

Excess energy derived from renewable sources is obtained from natural and consistent flows of energy present in the immediate environment surrounding us. In the current study an experimental study was performed to capture the ambient energy present in naturally occurring flows. By placing a bluff body in flowing fluid results in vortex formations which in turn cause oscillations in the body that is converted into meaningful form of energy. Some transduction methodologies like piezoelectric, electrostatic and electromagnetism are applied for converting mechanical energy to electrical energy. Here piezoelectric transduction (PVDF eel) will be used

that will convert strains produced by fluid structure interaction in the wake into electric current.

The concept of utilizing hydrofoils for energy generation was initially introduced by McKinny et al. [1]. They conducted research, on the viability and practicality of employing oscillating foils, for energy harvesting purposes.

Using single degree of freedom plunge can harness the power but the results of Yining et al. [2] proved that the double degree freedom of plunge flutter based aeroelastic can harness more power than single degree of freedom plunge. Numerical simulations on a flapping hydrofoil arrangement

developed by Zhou et al. [3] found that the heave force is the key driver of power generation. Energy extraction efficiency was enhanced by making modifications to flap lengths and angle of deflection amplitude, with even greater improvements obtained by reducing the gap width. Notably, compared to traditional hydrofoil-based energy harvesting technologies, the proposed design revealed a significant increase in energy extraction efficiency by up to 23.5%. An investigative study was done by Song et al. [4] to find the impact of water flow-induced vibrations on two piezoelectric energy harvesters. They examined the performance link between upstream and downstream harvesters, utilizing theoretical and experimental approaches. By optimizing the setup, the total output power was increased, showcasing significant improvement over using a single piezoelectric energy harvester. In the investigation of symmetric airfoil wakes, Yerusevych et al. [5] established that the Strouhal number of vortex shedding in wake can notably rise at lower Reynolds numbers. This phenomenon is attributed to the separation bubble existence, which exerts considerable impact on the stability of subsequent shear layer. Sidaard et al. [6] investigated the effect of a free shear layer on harvesting energy. They found that placing PVDF material in the wake of an airfoil allows for energy harvesting. Efficiency of energy harvesting varies with varying angle of attack (α) and downstream distance. Increasing the downstream distance leads to a greater oscillation of the PVDF material, indicating increased energy harvesting potential.

The experimental study was conducted by Banafi et al. [7] on wake development behind airfoil NACA0012 and the effect of angle of attack on wake characteristics. The findings show that for a specific α , the velocity deficit and width of wake decrease by moving downstream, indicating the wake diminishes. With increasing the angle of attack, the wake becomes more asymmetric and shifted, hence the velocity defect increases, and the recovery rate decreases. Sidaard et al. [8] performed the study to observe the aerodynamic effects of chordwise slots on a NACA 0012 airfoil. Three configurations were evaluated. The total drag of the slotted airfoils was similar to the baseline airfoil. The slots increased interaction between the tip vortex and wake shear layer, inhibiting vortex development. Analogous to

this study, slots were introduced with different configurations on the NACA 0012 surfaces for energy harvesting. This investigative study proposes a novel approach for harvesting ambient energy by combining hydrodynamics and piezoelectric technology. By customizing the streamlined body and calculated placement of the piezoelectric eel, this study seeks to convert the fluid-induced mechanical energy within the wake region into electrical power output that would be harvested for various applications.

2. Experimental Setup

2.1 3D Modelling and Manufacturing

Computer Aided Drafting, CAD, modelling software was used to create a 3D model of NACA 0012 hydrofoil followed by introduction of different slots on it. The coordinates for NACA 0012 were obtained from *airfoiltools.com*. The 2D coordinate model obtained was transformed to a 3D shape with a chord length of 10.16 cm and span length of 20.32 cm having an aspect ratio (AR=2). Shan et al. [9] mentioned that mean separation zone of NACA 0012 spans between $x/c = 0.19-0.68$ corresponding to separation and attachment mean points. Then slots were introduced according to the aforementioned ranges at different positions making 3 configuration of slots and 1 base hydrofoil, all utilizing the NACA 0012 profile as shown in Fig.1.

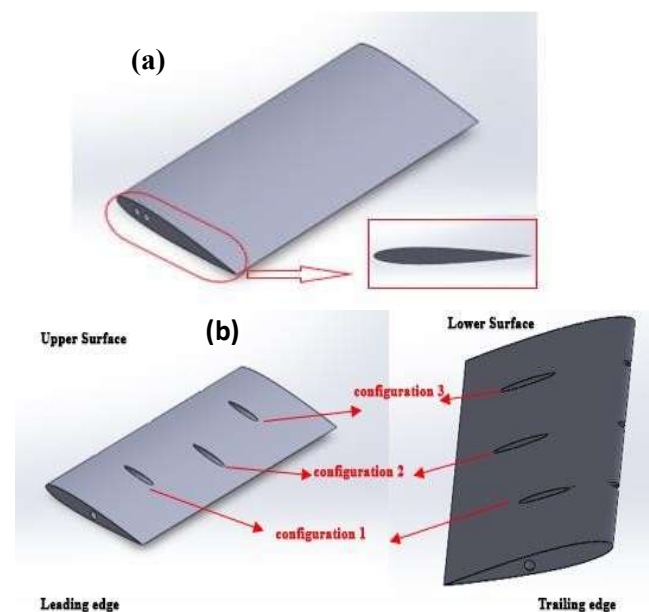


Fig. 1. 3D Models (a) base profile (b) slots configuration on hydrofoil

Table 1. Configurations and slots positions

Configuration	Slots	Positions
0	0	Plane surfaces
1	1	Near leading edge on both sides
2	1	Near trailing edge on both sides
3	1	Near leading and trailing edge on both sides

The hydrofoils were 3D printed with Creality 3Dprinter. Polyethylene terephthalate glycol (PETG) was used as the printing material. For a smoother surface finish, the hydrofoils were sanded with grits ranging from 320 to 2000, finished with the coat of paint.

2.1.1 EEL

The Eel is an energy harvester that utilizes a long strip of piezoelectric polymers that oscillate/flap in fluid flows like swimming eel. Eel specification is provided in Table.2 [10] and Fig.2 shows the piezoelectric eel. The electric power generated by oscillating eel in water flow is given by the equation proposed by G W Taylor et al. [11].

$$P = \frac{\eta_1 \eta_2 \eta_3 \rho A U^3}{2} \quad (1)$$

Where η_1 is hydrodynamic efficiency, η_2 piezoelectric eel efficiency, η_3 efficiency of circuit, ρ is water density, A is eel cross sectional area, U is the flow velocity.



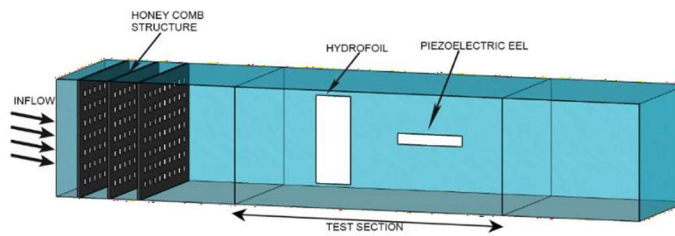
Fig. 2. Piezoelectric eel

Table 2. EEL Specifications

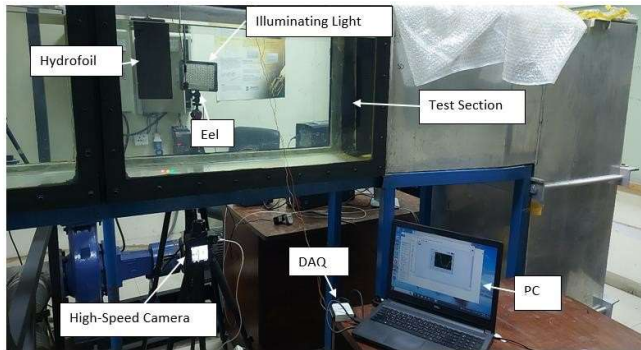
Parameters	Values
Active Length	60mm
Total Length	70mm
Width	16mm
Material	Polyvinylidene fluoride (PVDF)
Young's Modulus	$2-4 \times 10^9 \frac{N}{m^2}$
Density	1.78 kg/m^3
Relative permittivity	12
Output voltage	0.01-10 V
Operational temperature	32 -160 °F
k_{31}	12
d_{31}	$23 \times 10^{-12} \frac{C}{N}$
Capacitance	1.44 pF/cm ²
g_{31}	$216 \times 10^{-3} \frac{Vm}{N}$

2.3. Water tunnel

Experimentation was conducted in a water tunnel facility located within the flow visualization lab at the School of Mechanical and Manufacturing Engineering (SMME) National University of Science and Technology (NUST) [12]. The test section flow velocity, U , was fixed at 0.22m/s using Variable Frequency Drive (VFD) motor, (corresponding Reynolds number, $Re = 25000$). Fig. 3(a) shows the mechanism and schematic diagram of the water tunnel while Fig. 3(b) shows the experimental setup in the flow visualization lab.



(a)



(b)

Fig. 3. (a) Schematic of Experimental setup
(b) Experimental setup

Table 3. Parameters of Setup

Parameter	Value
Fluid	Water
Fluid Density	998 kgm ⁻³
Fluid's Velocity	0.22ms ⁻¹
Reynolds number	25000

The hydrofoil NACA 0012 along with 3 different types of slot configurations were placed within tunnel test section by securing one by one in a traverse for experimentation. The PVDF eel was positioned beyond the trailing edge of the hydrofoil with one end affixed and the second end free for oscillation as shown in Fig. 3(a-b). The α was set through use of two protractors fitted with traverse and hydrofoil. The flow velocity and the Re number were kept constant for all the experimental runs. For capturing the flapping motion of the eel, a high-speed Sony RX-IV camera was utilized. Image processing

techniques built within

MATLAB were then utilized to assess the footage to grasp information such as flapping area, normalized frequency, and amplitude. The footage was processed frame by frame and generated amalgamated flapping images and associated excel files containing data of instantaneous motion of piezoelectric eel. Fast Fourier Transform (FFT) was used to determine peak oscillating amplitude and dominant frequency. The output terminals of the piezoelectric eel were linked to the Data Acquisition card (DAQ NI-6009) of National Instruments to collect output signals generated by the flapping motion of the eel. The signal data was then processed by using LabView by utilizing the Virtual Interface

(VI) (utilizing standard NI DAQmx library). The VI was used to collect, save, and display data in real time during the experimental runs.

3. Results

For testing, the hydrofoil was placed in a water tunnel with the flow properties as stated in table 3. Hydrofoil angle of attack α is varied at 0°, 4° and 8°. At each angle of attack the piezoelectric eel placed behind in the wake region was placed at different position from trailing edge $x/c=0.5-2.5$ with an increment of 0.5 to collect and record the eel response at every arrangement.

3.1. NACA 0012 Hydrofoil (plain profile)

The schematic arrangement of hydrofoil and PVDF is shown in Fig. 4.

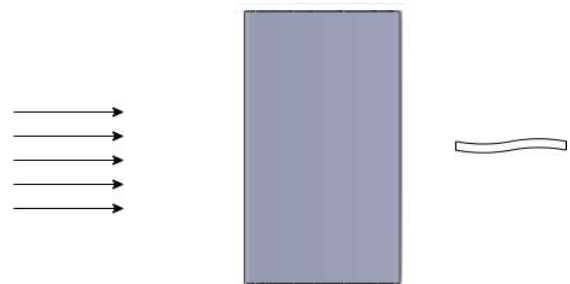
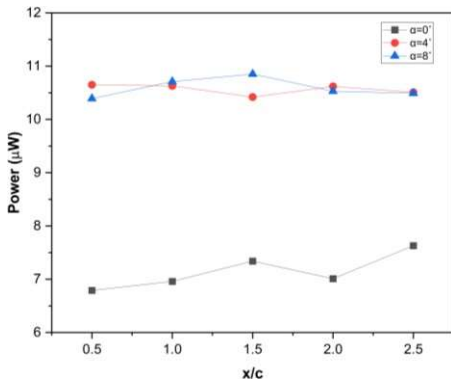
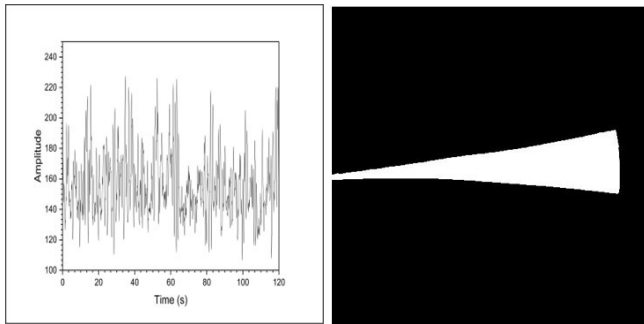


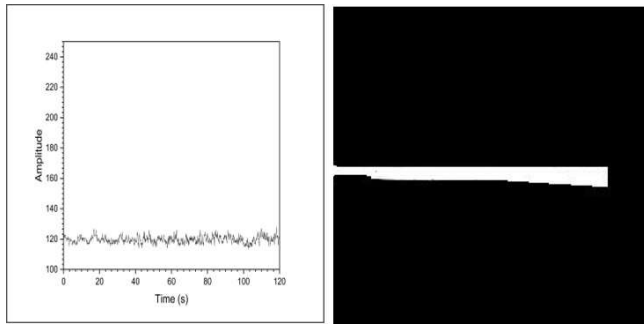
Fig. 4. Schematic arrangement of plane profile



(a)



(b)



(c)

Fig. 5. (a) Harvested Power output (b) Amplitude history and traces of maximum power output. At $\alpha = 0^\circ$, $x/c = 0.5$
(c) Amplitude history and traces of minimum power output. At $\alpha = 8^\circ$, $x/c = 1.5$.

As hydrofoil is at 0° the wake behind was not so turbulent so minimum energy was harvested. While at $\alpha = 8^\circ$ the maximum power output equaled $10.85 \mu W$ of piezoelectric eel was obtained in wake region of $x/c = 1.5$ as shown in Fig. 5(a). The corresponding amplitude history and amplitude traces are shown in Fig. 5(b). Hydrofoil placed at $\alpha = 0^\circ$ and eel placed in the wake region where $x/c = 0.5$ the minimum power output of $6.76 \mu W$ was obtained as shown in Fig 8. The corresponding amplitude history and amplitude traces are shown in Fig. 5(c).

3.1. Hydrofoil Configuration 1

The slots were introduced on the upper and lower surface to disturb the boundary layer, effects of which would propagate in the wake downstream.

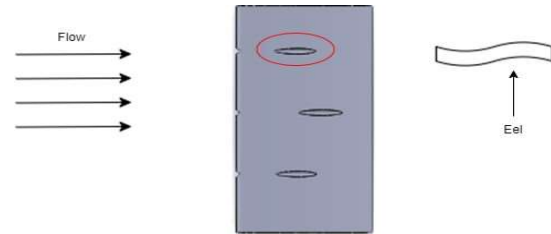
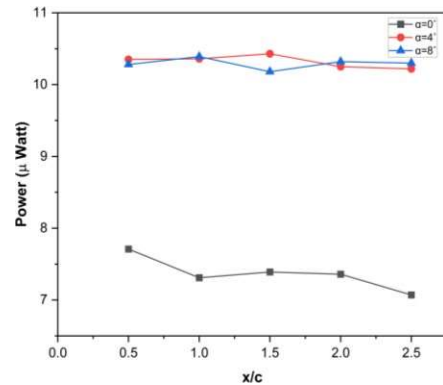
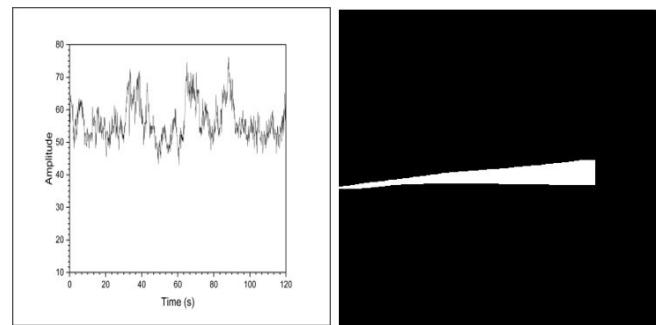


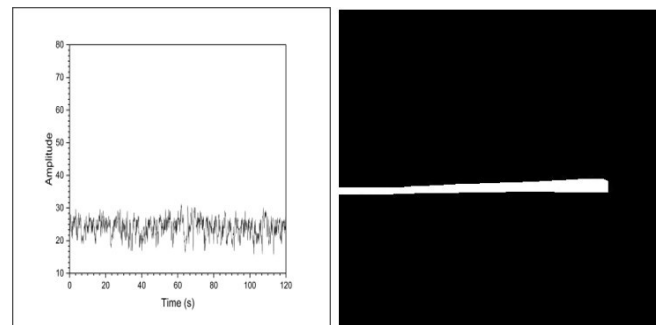
Fig. 6. Schematic Configuration



(a)



(b)



(c)

Fig. 7. (a) Harvested power output (b) Amplitude history and traces of maximum power output. At $\alpha = 0^\circ$, $x/c = 2.5$
(c) Amplitude history and traces of minimum power output.

In the wake region at a downstream distance, from trailing edge, of $x/c = 1.5$ and $\alpha = 4^\circ$, the maximum energy of $10.43\mu\text{W}$ was recorded. The minimum power output of $7.07\mu\text{W}$ at $\alpha = 0^\circ$ at a downstream distance $x/c = 2.5$ was obtained, as shown in Fig. 7(a).

3.1. Hydrofoil Configuration 2

In configuration 2, the slots are placed starting from the leading edge and end near the trailing edge on both sides of hydrofoil surface. This was done to assess the impact of turbulent boundary layer near trailing edge on wake behavior.

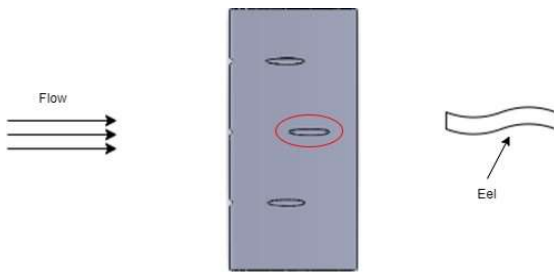
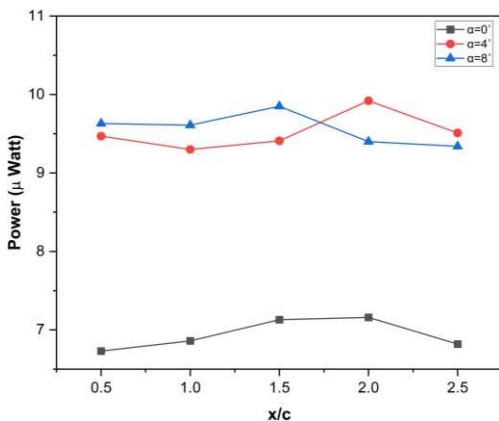
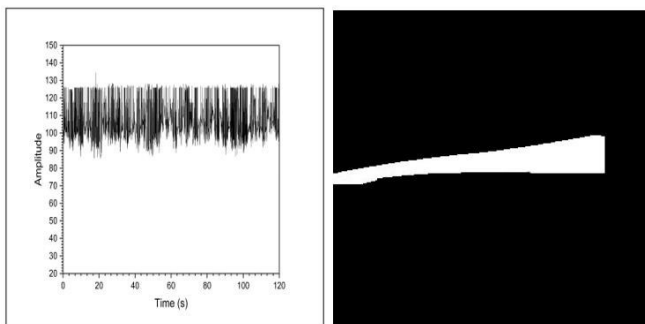


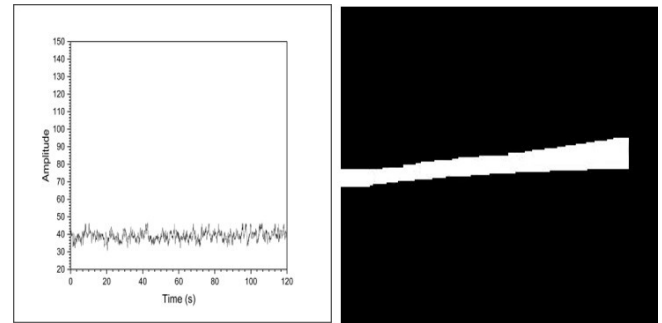
Fig. 8. Schematic arrangement



(a)



(b)



(c)

Fig. 9. (a) Harvested Power output (b) Amplitude history and traces of maximum power output. At $\alpha = 0^\circ$, $x/c = 0.5$ (c) Amplitude history and traces of minimum power output. At $\alpha = 4^\circ$, $x/c = 2$

Minimum power output of $6.73\mu\text{W}$ was recorded at hydrofoil position $\alpha = 0^\circ$ at eel position of $x/c = 0.5$ in wake region. Maximum power output of $9.92\mu\text{W}$ with hydrofoil oriented at $\alpha = 4^\circ$, to the flow, with eel located at $x/c = 2$ within the wake region, as shown in Fig. 9(a).

3.2. Hydrofoil Configuration 3

The third configuration of slots in the hydrofoil starts from leading edge and ends near the trailing edge of surface while other side emerge out near the leading edge, disturbing the boundary layer at two distinct positions simultaneously on opposite surfaces.

The schematic arrangement is shown in Fig. 10.

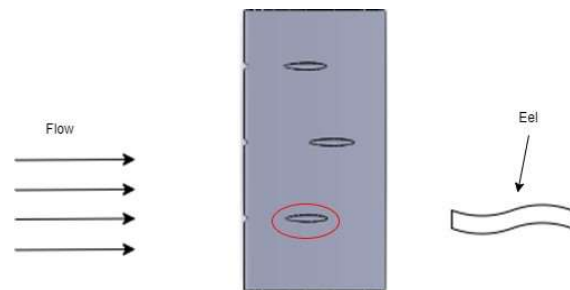
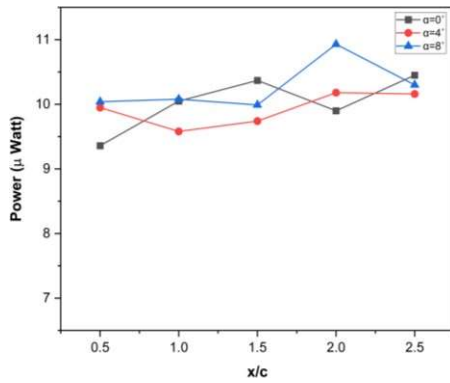
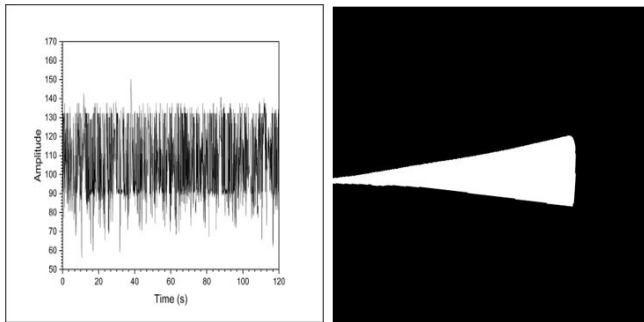


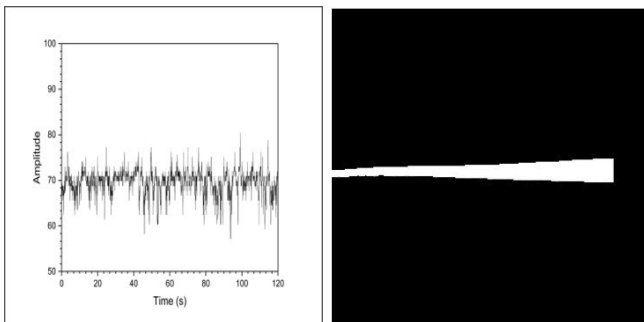
Fig. 10. Schematic Configuration



(a)



(b)



(c)

Fig. 11. (a) Harvested Power output (b) Amplitude history and traces of maximum power output. At $\alpha=0^\circ, x/c=0.5$
(c) Amplitude history and traces of minimum power output. At $\alpha=8^\circ, x/c=2$

The maximum power output equals $10.92 \mu\text{W}$ in hydrofoil arrangement at $\alpha=8^\circ$ with eel position in wake region $x/c=2$ with corresponding amplitude history and amplitude traces is shown in Fig. 11(a-b-c).

1. Conclusion

Experimental study was conducted for harvesting energy from the wake of streamlined bodies. Energy harvested by the original profile and various slotted configurations were studied. These arrangements

were aimed to influence the boundary layer on the hydrofoil when it is placed in a fluid flow.

Each hydrofoil arrangement was placed in laminar flow to create turbulence in the downstream flow due to pressure gradient produced between the free shear layers that causes the vorticity which induces the oscillation in the eel due to its interaction resulting in energy harvest also increase in wake width improves eel oscillation resulting in considerable energy harvest.

Configuration of slots pair near the leading and trailing edges at hydrofoil (configuration 1, configuration 2 and base hydrofoil) without slots at α

$=0^\circ$ has overall low energy output in comparison with Hydrofoil configuration 3, (slot pair placed at different positions on opposite sides).

The overall energy harvest at $\alpha=4^\circ$ was nearly equal to $10 \mu\text{W}$ for all configurations when the eel was placed at $x/c=2$, measured from the trailing edge of the hydrofoil.

Hydrofoil placed at $\alpha=8^\circ$ the energy harvest of all slot's configuration was above $10 \mu\text{W}$ except hydrofoil configuration near leading edge slots (Hydrofoil config 2) harvest that was below $10 \mu\text{W}$.

Hydrofoil configuration 3 is the more advisable and suitable in all these configurations for harvesting energy by using piezoelectric eel from their wake based on results obtained.

Summarizing, the body shape and modification are very crucial for the wake enhancement along with downstream distance x/c , selection of eel and flow condition to harvest maximum energy from the natural flow through the fluid structure interaction.

2. Future Recommendation

1. Further research is needed on streamline bodies modification to enhance wake to robustly increase frequency and amplitude of the eel as these parameters directly relate to the eels' power output.
2. Further experimentation and study can be performed by placing the base hydrofoil (NACA 0012) in reverse orientation to the flow for wake study and associated energy harvesting. Streamline bodies for micro energy harvesting can be a more optimal solution than bluff bodies as bluff



bodies create a blockage to the flow that does not happen in streamline body's case.

5. Reference

- [1] W. Mckinney and J. Delauriert, "The Wingmill: An Oscillating-Wing Windmill," vol. 5, no. 2, 1981.
- [2] A. Da Ronch, Y. Wu, D. Li, and J. Xiang, "Piezoaeroelastic energy harvesting based on an airfoil with double plunge degrees of freedom: Modeling and numerical analysis," *J. Fluids Struct.*, vol. 74, pp. 111–129, 2017, doi: 10.1016/j.jfluidstructs.2017.06.009.
- [3] D. Zhou, Y. Cao, and X. Sun, "Numerical study on energy-extraction performance of a flapping hydrofoil with a trailing-edge flap," *Ocean Eng.*, vol. 224, no. December 2020, p. 108756, 2021, doi: 10.1016/j.oceaneng.2021.108756.
- [4] R. Song, C. Hou, C. Yang, X. Yang, Q. Guo, and X. Shan, "Modeling, validation, and performance of two tandem cylinder piezoelectric energy harvesters in water flow," *Micromachines*, vol. 12, no. 8, 2021, doi: 10.3390/mi12080872.
- [5] S. Yarusevych, P. E. Sullivan, and J. G. Kawall, "Coherent structures in an airfoil boundary layer and wake at low Reynolds numbers," *Phys. Fluids*, vol. 18, no. 4, 2006, doi: 10.1063/1.2187069.
- [6] S. Gunasekaran, G. Ross, and D. Curry, "Effect of flexible inverted PVDF in free shear layer wake," *AIAA Scitech 2019 Forum*, no. 2019, doi: 10.2514/6.2019-1338.
- [7] M. B. Mehdi Banafi, "An Experimental research on wake behind airfoil Naca0012 under various angles," *Int. J. Theor. Appl. Mech.*, vol. 2, pp. 164–170, 2017.
- [8] S. Gunasekaran and T. Gerham, "Effect of chordwise slots on aerodynamic efficiency and wingtip vortex," *AIAA J.*, vol. 56, no. 12, pp. 4752–4767, 2018, doi: 10.2514/1.J057073.
- [9] H. Shan, L. Jiang, and C. Liu, "Direct numerical simulation of flow separation around a NACA 0012 airfoil," *Comput. Fluids*, vol. 34, no. 9, pp. 1096–1114, 2005, doi: 10.1016/j.compfluid.2004.09.003.
- [10] S. I. Electrodes, "DT Series Elements with Lead Attachment Piezoelectric film sensor DT Series Elements with Lead Attachment," *Measurement*, pp. 1–2, 2009.
- [11] G. W. Taylor, J. R. Burns, S. M. Kammann, W. B. Powers, and T. R. Welsh, "The energy harvesting Eel: A small subsurface ocean/river power generator," *IEEE J. Ocean. Eng.*, vol. 26, no. 4, pp. 539–547, 2001, doi: 10.1109/48.972090.
- [12] M. Saeed, E. Uddin, A. Mubashar, S. U. Zahir, and A. A. Zaidi, "Design and development of low-speed water tunnel," *Proc. 2018 15th Int. Bhurban Conf. Appl. Sci. Technol. IBCAST 2018*, vol. 2018-Janua, no. February 2020, pp. 614–619, 2018, doi:



Mitigating Phishing and Social Engineering Ransomware Threats in Bioinformatics: Strategies for Education and Awareness

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Bioinformatics
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ABSTRACT

Phishing and social engineering attacks, along with ransomware, have become an unforeseen obstacle in the quickly developing field of bioinformatics, putting confidential information at risk and interfering with research procedures. As the bioinformatics landscape continues to change, addressing cybersecurity vulnerabilities becomes a critical concern. Similarly, even the most knowledgeable experts in the given area may fall prey to such cyber dangers. Social engineering and phishing are the types of attacks that exploit people's weaknesses, thus a comprehensive approach by integrating technical fixes, awareness and education campaigns aimed at fighting cyber threats should be embraced. In this case, bioinformatics experts can traverse the digital sphere with resolve and get rid of bad data and maintain the integrity of the domain of science as they grow a responsible community. As a result of the systematic review we conducted, from the 551 studies we found, 20 that met the eligibility criteria were chosen for further analysis. This analysis of literature concentrated on the defence's biotechnology against ransoming crooks' constantly morphing strategy. The report went over a couple of things, like the increased complexness of encryption algorithms, and the RaaS (ransomware-as-a-service) model. This study offers a new toolkit focused on campaigns to sensitize the public and educate them to address the threats and dangers presented by ransomware. The physicists of bioinformatics are equipped to withstand the digital world with staunchness and see to securing the non-negotiables essential data safeguard and the limited but fundamental research activities by developing an elaborate culture of cybersecurity awareness.

1. Introduction

In recent decades, the advancement of bioinformatics contributed significantly to research through the changing of strategies by which biologists deal with data to achieve significant results in the fields of genomics, personalized medicine, and agriculture. Also, the digital space opens the door to an assimilated scientific research and medical innovation that never has been discovered

all the time, and even, at the same time, it exposes the effects of threats that never has been imagined all the time. The ransomware attackers and social engineering are among the two most efficacious cyber tools for disrupting key genetic information safety [1]. Phishing is the richest and most complex method used by the biologists to extract the sensitive data from the humans. On these sites, for those who read the messages, they can be sometimes misleading, and titles



misappropriated as authentic messages. Stealing data and arriving at a conclusion that it will be possible to make the data unusable by applying a reliable encryption algorithm is one of the methods that the ransomware tries to take an advantage of the human weaknesses and persuade the victim to pay a ransom in order to make the data decrypted. The convergence of the devastating threats exhibits a multifaceted as well as a tough nut to crack a problem and therefore we need the concerted effort of the bioinformatics community to highlight the risk “as the first step.” After that, educational programs must follow [2]. Bioinformatics which is a rapidly growing area as an integral part of science, needs to be highly protected and maintained to secure digital platforms that support scientific research, medical diagnostics, and agricultural acceleration. This article investigates complex environments of cybersecurity risks where bioinformatics meets, identifies the most common ways for data leaks, and offers practical strategies to minimize the risks of ransomware and phishing attacks. Through recognizing the various challenge positions arising the risks, the community of bioinformatics will develop an environment which is both resilient and vigilant, thus making sure that the projects are successful in the long run [3].

2. Related Work

The research field of bioinformatics cybersecurity is of great interest as more scholars and experts focus on different facets of emerging security issues and potential preventive interventions. It also include the publications below which do a summarized review of the topic by studying ransomware, phishing, social engineering, and cybersecurity education programme in bioinformatics [7]. The paper provides a brief overview of malware, however, it specifies the ransomware, and enlists the many types it possesses and their impacts. It allows for understanding the ransomware development and evasion techniques, that is perfect basis for development of DNAact-Ran. To find ransomware, the research hereby proposes a Digital DNA Sequencing Engine which harnesses the use of innovative design design limits and k-mer frequency vectors. Through the examination of a dataset, the DNAact-Run has shown its capabilities of being accurate and effective in predict and detecting the ransomware. This can efficiently aid in the cybersecurity measures [8].

The paper considers various cyber security hurdles in bioinformatics. It provides a comprehensive case study of various types of threats like the phishing and ransomware, with the intention to enrich the knowledge of the bioinformatics experts on threats and how they respond when it comes to protecting sensitive biological data [9]. The survey below is dedicated to email-based threats in bioinformatics in general sense, particularly, phishing attacks against bioinformatics experts. It shows the methods used by attackers to get to the subject, it tries bring to light community flaws by making recommendations on more secure email systems [10]. This paper will discuss the case of ransomware in the context of bioinformatics. It finds motives and results of such assaults presenting possible outlook for bioinformatics society. The research seeks to enrich the knowledge on ransomware threats and the appropriate response measures [11]. The present study concentrates on the human aspect found in the social engineering attacks in the field of bioinformatics. It investigates the psychological and behavioural factors that contribute to the case of social engineering approaches and provides shopping lists on how bioinformatics professionals can be resilient [12]. The realm of cybersecurity education is discussed in this survey as it showcases the lags in awareness among bioinformatics professionals. This paper purposefully focuses on the identification of knowledge areas that need to be powerfully reinforced within the bioinformatics community in order to spark relevant educational initiatives [13]. Implementing user-oriented methodology, this essay performs the behavioural study of the people who are pursued by phishing attacks in bio informative. Using the study findings, a comprehensive user perspective on anti-phishing measure on bioinformatics will be developed [14]. This study emphasizes training in cybersecurity, and it presents a template for educating bioinformatics professionals. Which is based on the practices that are running right now and it proposes future directions for the development of the comprehensive and effective cybersecurity educational programs that address the needs of the bioinformatics community. [15].



L.Re f	Scope of Work	Technique	Gap	Limitation
[8]	Cybersecurity threats in bioinformatics	Survey analysis	Cybersecurity awareness and proposing educational initiatives	Limited focus on specific malware types and detection methods
[9]	Email-based phishing attacks on bioinformatics professionals	Survey and pattern analysis	Lack of emphasis on preventive measures and training for individuals targeted by phishing	Limited exploration of advanced phishing techniques and their count
[10]	Trends and patterns in ransomware attacks in bioinformatics	Analysis of ransomware incidents	Insufficient exploration of the human factor in ransomware attacks	Limited discussion on strategies for ransomware incident response
[11]	Comparative analysis of defensive strategies against phishing	Comparative analysis of defensive measures	Lack of focus on specific vulnerabilities within healthcare-oriented bioinformatics	Limited discussion on the integration of defensive strategies with healthcare systems
[12]	Behavioral analysis of social engineering tactics in bioinformatics	Behavioral analysis	Limited insights into emerging social engineering tactics and their impact on bioinformatics	Scope restricted to behavioral analysis, overlooking technical aspects of social engineering attacks
[13]	Identification of educational gaps in cybersecurity awareness	Survey and analysis of educational programs	Limited exploration of the effectiveness of existing educational initiatives	Reliance on self-reported data for educational program evaluation
[14]	Comparative analysis of defensive strategies against phishing	Comparative analysis of defensive measures	Lack of focus on specific vulnerabilities within healthcare-oriented bioinformatics	Limited discussion on the integration of defensive strategies with healthcare system
[15]	Preparedness of genomic data centers against	Case study and incident analysis	Limited coverage of preventive measures,	Narrow focus on genomic data centers, may not

	ransomware attacks		with a focus on incident response	generalize to broader bioinformatics infrastructure
[16]	Behavioral analysis of individuals targeted by phishing attacks	Behavioral analysis and user-centric approach	Limited exploration of evolving phishing tactics and their impact on user behaviour	Relies on self-reported data for understanding user behaviour and may lack real-world validation
[17]	Framework for bioinformatics cybersecurity training	Proposal of a comprehensive training framework	Lack of empirical validation of the proposed framework	Theoretical approach without practical implementation and validation

3. Methodology

In conducting our study, we adopted a comprehensive review methodology, gathering data from diverse sources such as IEEE Xplore, Scopus, and Google Scholar. Our search query, skilfully crafted as "Bioinformatics," "Ransomware," and "Social Engineering," served as an effective guide in pinpointing relevant literature. Within this structured framework, we formulated specific research questions that facilitated the extraction of key objectives from the pertinent literature. The figure 1 shows the methodology which opt in this paper.

4. The Threat Landscape:

In bioinformatics, phishing attacks often aim to attack researchers, physicians, and institutions that deal with health-related genetic or genomics data, which is also very sensitive. Unlike the technical ransomware which relies on exploiting computer vulnerabilities to gain unauthorised access and endanger the data integrity, the social engineering ransomware explores any human susceptibility. Analyzing and studying the complexities of such risks is one substantial part for creating successful mitigation strategies.

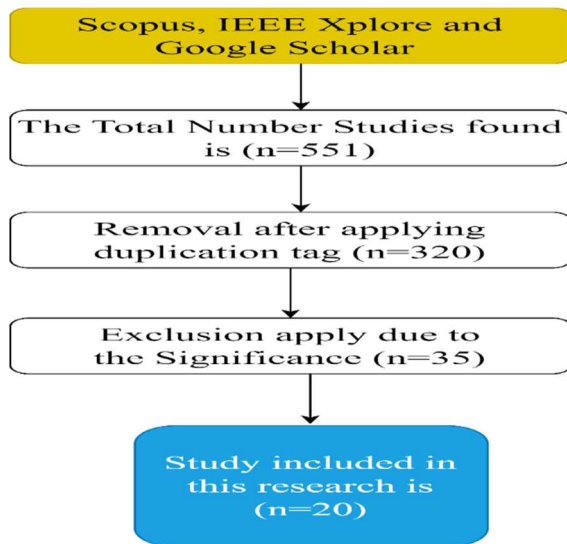


Figure 1. Methodology

4.1 Phishing Attacks in Bioinformatics:

Targets: By including the terms such as academics, clinical area, and organisations processing genetic, genomic, and healthcare data, it becomes clear which group is at risk. The pruning campaigns are developed to use the credibility and access permissions of bioinformatics professionals who deal with highly important and sensitive data [16].

Risk to Data Integrity: Attacks like phishing have remained notorious for misleading users into providing their login passwords or important information like financial details to them. The bioinformatics context could also include phishing attacks which breaks into databases that contain genetic data and are very sensitive [17]

4.2 Social Engineering Ransomware:

Exploiting Human Vulnerabilities: This part of the conversation will be focused on the human factor of cyber protection. Psychological attack exploiting the weak points of people in the area of biotechnology is a common feature of social engineering ransomware. During these raids, the criminals use ingenious administrative techniques like impersonation or trust-based figures to validate their illegal trespasses [18].

Unauthorized Access and Data Compromise:

Contrary to the ordinary ransomware that may either employ exploitation or social engineering, this one relies on an individual to cause a breach of security. Now the

attacker has been in the system, and he/she initiate to encrypt the valuables data point that will make the legal user unable to decrypt it. Such attack opens to the loses of the important bioinformatics data by hacking or data permanent damage [19].

4.3 Cruciality of Understanding Threat Intricacies:

Tailored Mitigation Strategies: It focuses on the significance of being in the know of the main natures of these risks. Generally, the most inventive phishing and social engineering ransomware are the most elaborate, and they normally grow more sophisticated and complex. Standards or common cybersecurity strategies cannot be effective in handling such sophisticated cyber-attacks [5].

Risk Mitigation: Through the in-depth knowledge of the use of bioinformatics tools in hacker attacks, specialized mitigation tools are developed. To have these defences against phishing reinforced, the initiatives might involve particular educational programs, better spam filters, and user-awareness campaigns. For social engineering ransomware technical constraints and letting the users to recognize the deceitful actions is the key [6].

4. Common Attack Vectors in Bioinformatics:

a. Email-Based Phishing: Spam messages that are sent from accounts that appear to belong to reputable organizations, are often employed by phishers to lure recipients to visit harmful sites or disclose personal information.

b. Spear Phishing: Specifying certain members of the bioinformatics community who personally can be employed for the specific purpose of maximising the possibilities of success.

c. Malicious Attachments: Generally, ransomware attacks are performed via indirect vectors that trigger after the victim opens or clicks the infected files or attachments.

d. Impersonation: Social engineering is a tricky approach that always attempts to impersonate as a trustworthy authority in order to induce individuals voluntarily disclose personal data.

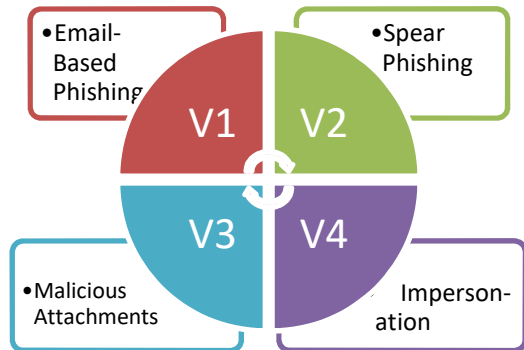


Figure 2. Infection Vektor Scale

5. Mitigation Strategies

We pinpointed the useful methods to protect ourselves from almost all perils once we analysed many of the researches. As shown on Figure 3, these findings of the survey are divided into 20 researched papers that will be used for the analysis later. It is quite evident that performing these steps with the urgency required in the industry are the necessary factors for the execution of the mitigation plan.

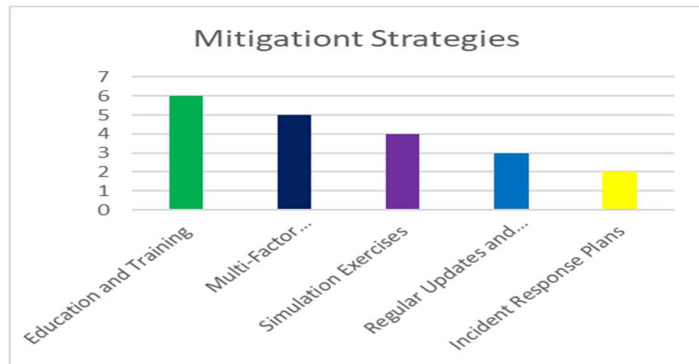


Figure 3. Mitigation Measures

6. Conclusion

We have carefully outlined a range of mitigation techniques in this paper with the goal of protecting data from future attacks. Because bioinformatics is a dynamic field, our safeguards for sensitive data must constantly change. To effectively counteract the threats posed by ransomware and phishing emails, the bioinformatics community must unite behind a common initiative that includes raising awareness and providing thorough education. Through proactive measure implementation, the development of a cybersecurity-focused culture, and ongoing threat monitoring, the bioinformatics

community is well-positioned to fortify its defences and guarantee the unwavering integrity and confidentiality of vital biological data. In conclusion, the proactive implementation of these tactics creates a strong defence in the rapidly developing field of bioinformatics against changing cyberthreats.

5. Reference

- [1] Kathryn, K, Millett., Eduardo, dos, Santos., Piers, Dominic, Millett. (2019). Cyber-Biosecurity Risk Perceptions in the Biotech Sector. *Frontiers in Bioengineering and Biotechnology*, 7:136-. doi: 10.3389/FBIOE.2019.00136
- [2] Adrie, Bekker. (2022). Strategic Analysis of Cyberbiosecurity in 2022: How to Defend Biotech and Healthcare Sector from Cyber Treats. doi: 10.36227/techriv.20485929
- [3] Dr., Alex, Roney, Mathew., Hannah, Alex. (2022). Cyberbiosecurity as the Foremost Biological Weapon to the Digital World. *International research journal of innovations in engineering and technology*, 06(02):75-79. doi: 10.47001/irjiet/2022.602013
- [4] Tao, Tao., Yuan, Chen., Bijing, Liu., Xueqi, Jin., Mingyuan, Yan., Shouling, Ji. (2018). Security Analysis of Bioinformatics WEB Application. 383-397. doi: 10.1007/978-3-030-16946-6_30
- [5] Xavier-Lewis, Palmer., Lucas, Potter., Saltuk, Bugra, Karahan. (2022). Exploration on APTs in Biocybersecurity and Cyberbiosecurity. *Proceedings of the ... international conference on information warfare and security*, 17(1):532-535. doi: 10.34190/iccws.17.1.67
- [6] Randall, S., Murch., William, K., So., Wallace, G., Buchholz., Sanjay, Raman., Jean, Peccoud. (2018). Cyberbiosecurity: An Emerging New Discipline to Help Safeguard the Bioeconomy.. *Frontiers in Bioengineering and Biotechnology*, 6:39-39. doi: 10.3389/FBIOE.2018.00039
- [7] Ingrida, Domarkienė., Laima, Ambrozaitytė., Linas, Bukauskas., Tautvydas, Rančelis., Stefan, Sütterlin., Benjamin, James, Knox., Kaie, Maennel., Olaf, Maennel., Karen, Parish., Ricardo, G., Lugo., Agnė, Brilingaitė. (2021). *CyberGenomics: Application of Behavioral Genetics in Cybersecurity.. Systems Research*



- and Behavioral Science, 11(11):152-. doi: 10.3390/BS11110152
- [8] Khan, F., Ncube, C., Ramasamy, L. K., Kadry, S., & Nam, Y. (2020). A digital DNA sequencing engine for ransomware detection using machine learning. *IEEE Access*, 8, 119710-119719.
- [9] Reddy, B. V., Krishna, G. J., Ravi, V., & Dasgupta, D. (2021). Machine learning and feature selection based ransomware detection using hexacodes. In *Evolution in Computational Intelligence: Frontiers in Intelligent Computing: Theory and Applications (FICTA 2020)*, Volume 1 (pp. 583-597). Springer Singapore.
- [10] Bat-Erdene, M., Park, H., Li, H., Lee, H., & Choi, M. S. (2017). Entropy analysis to classify unknown packing algorithms for malware detection. *International Journal of Information Security*, 16, 227-248.
- [11] Manas, Kumar, Yogi., D, Aiswarya. (2023). A Comprehensive Review -Application of Bio-inspired Algorithms for Cyber Threat Intelligence Framework. 2(1):101-111. doi: 10.36548/rrj.2023.1.08
- [12] Wadho, S. A., Yichiet, A., Lee, G. M., Kang, L. C., Akbar, R., & Kumar, R. (2023, October). Impact of Cyber Insurances on Ransomware. In *2023 IEEE 8th International Conference on Engineering Technologies and Applied Sciences (ICETAS)* (pp. 1-6). IEEE.
- [13] Simon, A., Levin. (2023). Challenges in cybersecurity: Lessons from biological defense systems. *Mathematical biosciences*, 362:109024-109024. doi: 10.1016/j.mbs.2023.109024
- [14] Bayan, Hassan, Banimfreg. (2023). A comprehensive review and conceptual framework for cloud computing adoption in bioinformatics. *Healthcare analytics*, 3:100190-100190. doi: 10.1016/j.health.2023.100190
- [15] (2023). Challenges in Cybersecurity: Lessons from Biological Defense Systems. *Social Science Research Network*, doi: 10.2139/ssrn.4342051
- [16] Adrie, Bekker. (2022). Strategical Analysis of Cyberbiosecurity in 2022: How to Defend Biotech and Healthcare Sector from Cyber Treats. doi: 10.36227/techrxiv.20485929
- [17] Adrie, Bekker. (2022). Strategical Analysis of Cyberbiosecurity in 2022: How to Defend Biotech and Healthcare Sector from Cyber Treats. doi: 10.36227/techrxiv.20485929.v1
- [18] Xavier-Lewis, Palmer., Lucas, Potter., Saltuk, Bugra, Karahan. (2022). Exploration on APTs in Biocybersecurity and Cyberbiosecurity. *Proceedings of the ... international conference on information warfare and security*, 17(1):532-535. doi: 10.34190/iccws.17.1.67
- [19] Lucy, L., Thomson. (2022). Privacy and security challenges in bioinformatics. doi: 10.4337/9781839105951.00021
- [20] Haris, Smajlovic., Ariya, Shajji., Bonnie, Berger., Hyunghoon, Cho., Ibrahim, Numanagić. (2022). Sequire: a high-performance framework for rapid development of secure bioinformatics pipelines. 164-165. doi: 10.1109/IPDPSW55747.2022.00040



Photocatalytic degradation of pesticide from agriculture wastewater supported by $\text{Ti}_3\text{AlC}_2\text{-MAX/TiO}_2$ composite

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KEYWORDS

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Wastewater
LAMBDA-CYHALOTHRIN
Pesticide

ABSTRACT

Pesticide incorporation for high-yield production is the most hazardous substance that spoils the natural environment. Photocatalytic degradation has attracted considerable attention on account of its more feasible and higher rate of decomposition of pesticides. Several photocatalysts such as ZnO, WO_3 , g- C_3N_4 , TiO_2 , CdS, etc. are employed for the photocatalytic degradation of pesticides. Among these, the Titanium dioxide (TiO_2) photocatalyst is commonly employed due to its nontoxic nature, low price, and high stability. However, its performance is still low because of poor spectrum absorption and fast charge recombination, therefore the efficiency may be enhanced by coupling with a highly conducting material such as the MAX phase. In this study, we have investigated the synergistic influence of Ti_3AlC_2 MAX/ TiO_2 on photocatalytic removal of pesticides (LAMBDA-CYHALOTHRIN). Different percentages of the MAX phase are added to the TiO_2 and obtain an optimum proportion of composite material. The maximum photocatalytic performance was demonstrated by TiO_2 coupled with 15% Ti_3AlC_2 MAX with more than 90% degradation. This eco-friendly technique offers a long-term and affordable plan for reducing pesticide pollution in agricultural wastewater, helping protect ecosystems and public health.

1. Introduction

Pakistan is among the world's top agricultural countries that produce a huge quantity of wheat, cotton, sugarcane, mango, dates, and rice [1]. The pesticides used for agriculture are very large amounts in Pakistan, especially they are used in Baluchistan. The problem of wastewater from the agriculture sector is big in Baluchistan. Pakistan has been shown to have high pesticide usage relative to worldwide with an alarming rise over the last two decades, hence, water pollution is increasing day by day. The use of pesticides is dangerous and is used in agricultural areas, of Baluchistan as a result of its low cost and easy accessibility. They can include herbicides & fungicides that are highly toxic and unhealthy for both human and aquatic life. Organic compounds are toxic and harmful to health and enter to skin with fat tissue.

This wastewater disturbs the circulatory system, and it causes health issues after some time. It has been observed that the intake of pesticides may cause diseases including cancer, neurological, and pulmonary disease. Different treatment methods such as adsorption, membrane, ozonation, chlorination, the Fenton process, advanced oxidation process, and photocatalytic degradation have been adopted to deal with such wastewater resources but among all these photocatalytic degradation is highly valued [2-7]. TiO_2 has been thoroughly researched as an excellent photocatalyst because of its remarkable properties like good redox potential, affordability, chemical stability, nontoxic nature, photo-stability, and enormous use in the removal of organic pollutants but broad bandgap quick recombination of photogenerated charges leads in poor organic pollution reduction performance [8-



11]. Since the unveiling of graphene, two-dimensional (2D) photocatalysts have piqued the curiosity of many researchers. Because of the decrease in dimension and size, 2D materials have demonstrated several novel features [12-16]. With remarkable breakthroughs in synthetic methods, several 2D materials besides graphene have been successfully synthesized. Among them is a recently identified large group of 2D early transition metal carbides and nitrides group known as MAX [17-19]. Being a small bandgap material with high electrical conductivity (which makes it a good electron trap, easily capturing photo-excited electrons and hence speeding the separation and transfer of charge carriers) photocatalytically destroys pollutants in visible light, has been extensively researched for its photocatalytic use [20-24]. As a result, TiO₂/MXene are promising composite catalysts with greater separation, broad spectrum activated, and higher photoactivity.

The focus of this work is to synthesize and characterize photocatalyst independent phases of TiO₂ and Ti₃AlC₂ (MAX) powders and their composite TiO₂/Ti₃AlC₂. Furthermore, In this work, we probed the nature of the Photo activity of specified pesticides (CHLORPYRIFOS, and LAMBDA CYHALOTHRIN) by utilizing the photocatalyst and photoreactor. Various analytical approaches have been utilized for the characterization and evaluation of photocatalysts and photocatalytic degradation results respectively. We suggest that the obtained composite materials of porous 2D layered Ti₃AlC₂ and TiO₂ with stable structure, improved conductivity, and expanded visible spectrum photocatalytic activity have excellent application prospects in organic wastewater treatment.

2. Materials and method

Aldrich, Merck, and deionized water were used in all experiments a complete process mechanism is obtained through a systematic approach as displayed in Fig. 1(a).

2.1 preparation of composite

The synthesis of TiO₂/Ti₃AlC₂ composites with varying percentages of Ti₃AlC₂ was obtained with step-by-step operation. The experimental procedures for the synthesis and characterization of the composites are described in detail, including the materials, synthesis process, and drying procedure. To prepare the composite phase of Ti₃AlC₂/TiO₂. 0.1g of TiO₂ with 50 ml of ethanol were combined in a container. Stir the mixture continuously to ensure uniform dispersion. Arrange separate beakers

for different composite percentages, take a constant amount of 0.15g of TiO₂, and transfer it to separate beakers. Labelled these beakers as TCT5, TCT10, TCT15, TCT20, and TCT25, representing composites with 5%, 10%, 15%, 20%, and 25% max phase of TiO₂/Ti₃AlC₂, respectively. Then we added the appropriate amount of Ti₃AlC₂ on the desired composite percentage (0.0075g of Ti₃AlC₂ in 5% of TCT5, 0.015g of Ti₃AlC₂ in 10% of TCT10, 0.0225g of Ti₃AlC₂ in 15% of TCT15, 0.03g of Ti₃AlC₂ in 20% of TCT20, and 0.0375g of Ti₃AlC₂ in 25% marked as TCT25). Ensured proper mixing by stirring continuously and stirring each solution in the beakers for two hours to achieve thorough dispersion of Ti₃AlC₂ within the TiO₂/ethanol solution. After stirring, transferred all the solutions to the containers and placed them in an oven for 24 hours. Set the oven temperature to a level suitable for the complete drying of the solutions.

2.2 Characterization

The catalyst was exposed to X-ray diffraction (XRD) to determine its crystalline structure. An X-ray diffractometer using (Cu-K radiation, = 0.154178 nm) was utilized, and it operated at 30 mA, 40 kV, and 30 mA with a scanning rate of 1.2 /min. The morphological analysis was accomplished through field emission scanning electron microscopy (FESEM HITACHI HT 7700). The light-harvesting abilities of TiO₂, Max Ti₃AlC₂, and Max phase of Ti₃AlC₂/TiO₂ composite were evaluated A beam of light with a range of wavelengths typically between 190 and 800 nanometres is passed across a sample during UV-visible spectroscopy. Certain wavelengths of light are absorbed by the sample, and the transmitted or reflected light is then measured. The resulting spectrum gives details about the sample's transmission or absorption of light at various wavelengths. The visual absorbance strength of the photocatalyst sample of TiO₂, Max Ti₃AlC₂, and Max phase of TiO₂/ Ti₃AlC₂ was calculated from a double beam UV Visible Spectrometer by using a UV-visible diffuse spectrometer.

2.3 Photocatalytic degradation process

To begin the experiment, a beaker with a volume of 250 ml and a diameter of 2.5 inches (6.35 cm) is used to set up the beaker. A magnetic stirrer that has a diameter of one inch is used for continuous mixing of solution. A tube with a diameter of 0.75 inches is inserted into the beaker, and an HID light with a power of 55 watts and an H4-2800k specification is placed inside the tube as

illustrated in Fig. 1(b). Next, the max phase of the catalyst is added to the mixture. The mixture is continuously stirred for 4 hours and 30 minutes. Upon starting the stirring process, the photo activity test of the prepared solution is initiated. The first sample is collected after 30 minutes of stirring. Upon starting the stirring process, the photo activity test of the prepared solution is initiated. The first sample is collected after 30 minutes of stirring. Following the collection of the first sample, the photo light is turned on for 4 hours. After 1 hour and 30 minutes of light exposure, the second sample is taken. The third sample is collected after 2 hours and 30 minutes, the fourth sample after 3 hours and 30 minutes, and finally, the fifth and last sample is collected after 4 hours and 30 minutes. A syringe filter is used to treat the samples and filter out any contaminants. After being filtered, the samples are introduced to a UV-visible spectrometer where the absorption at various wavelengths is measured. Using software like Origin, the collected data is analyzed and a graph showing the quantity of pesticide breakdown in the water is shown. By examining the absorption values acquired from the spectrometer readings, this experiment tries to determine the catalyst's efficiency in photocatalytic degradation.

the black line shows the concentration of TiO_2 which has higher intensity than Ti_3AlC_2 . Upon comparison the appearance of Ti_3AlC_2 MAX with characteristic peaks was very similar to the diffraction peaks of Huang et al., [25]. The XRD of the Ti_3AlC_2 phase is found at 9.4° , 19° , 34° , 35.9° , 38.9° , 41.7° , 48.4° and 60° ascribed to the (002), (004), (101), (103), (104), (105), (107) and (110) planes [26]. The diffraction peaks with crystal planes are obtained at 25° , 38.6° , 48° , 53° , 55° , 62° , 68.8° , 70° , and 75° accredited to the (101), (112), (200), (105), (211), (204), (116), (220), and (215) for TiO_2 anatase [27]. Whereas, the presence of various percentages of MAX phase in TiO_2 material resulted in the formation of low-angle surfaces and seems preserved simultaneously throughout the samples. Inferring that the $\text{TiO}_2/\text{Ti}_3\text{AlC}_2$ composite material is manufactured through the hydrothermal oxidation procedure.

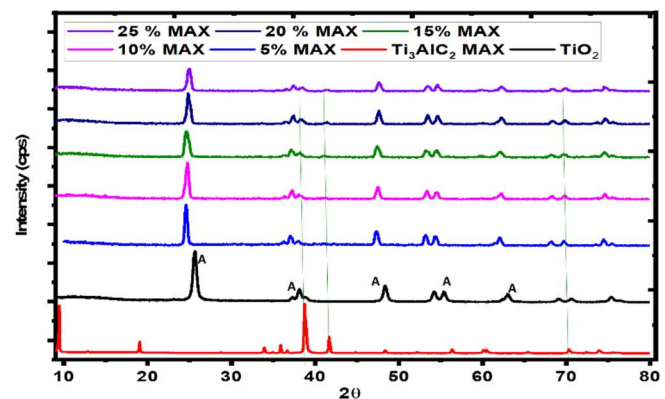


Fig. 2. XRD analysis of TiO_2 , Ti_3AlC_2 , and max phase of $\text{TiO}_2/\text{Ti}_3\text{AlC}_2$

3.2 Field emission scanning electron microscopy analysis

Field Emission Scanning Electron Microscopy, or FESEM specifies the main knowledge about the morphology and makeup of materials. The images (Fig. 3.1 (a-c)) presented the morphology of TiO_2 , Max Ti_3AlC_2 , and Max phase of $\text{TiO}_2/\text{Ti}_3\text{AlC}_2$ composite respectively. Pure TiO_2 granted similar and uniform spherical nanoparticles or powder-like morphology [28]. Max Ti_3AlC_2 is a thick and bulky layer structure involving dense, smooth, and compacted sheets with fine interlayer spacing fully accompanying each one by metallic assembling [29]. The composite phase of $\text{TiO}_2/\text{Ti}_3\text{AlC}_2$ illustrations has supported the MAX phase with the dissemination of TiO_2 nanoparticles on the surface and in between interlayered fine spaces. The SEM images obtained for TiO_2 , Ti_3AlC_2 MAX, and $\text{TiO}_2/\text{Ti}_3\text{AlC}_2$ MAX are in correspondence with the

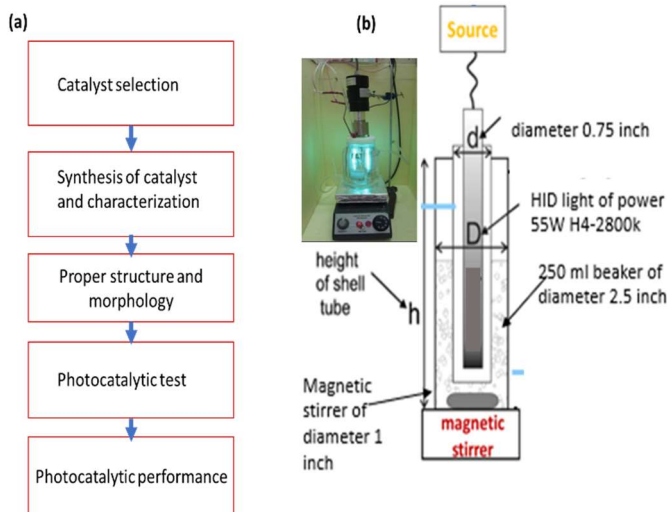


Fig. 1. (a) Step-by-step methodology for photocatalytic degradation of pollutants. (b) Schematics of the experimental setup; (inside) lab setup.

3. Results and discussion

3.1 X-ray diffraction

The X-ray diffraction (XRD) results of the analysis are shown in Fig. 2. The red line shows the higher concentration of Ti_3Al_2 , Ti_3AlC_2 has low intensity while

XRD analysis. Also, TiO₂ and Ti₃AlC₂ MAX are mixed through simple stirring and therefore, have no possibility of the formation of any third material. Moreover, the same morphology has been observed for TiO₂, Ti₃AlC₂ MAX, and TiO₂/Ti₃AlC₂ MAX in the literature discussed by our group [30].

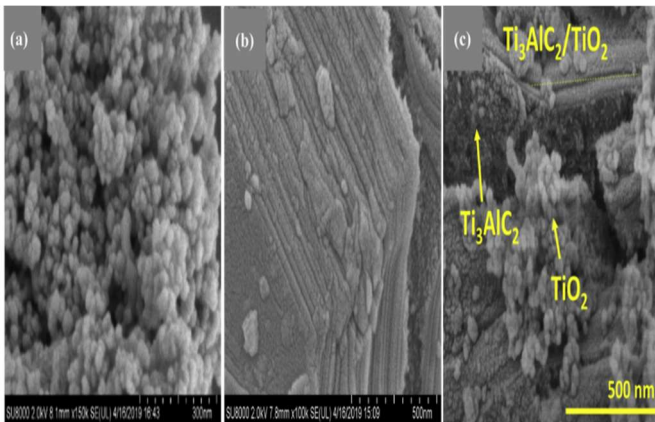


Fig. 3. FESEM analysis of (a) TiO₂, (b) Max Ti₃AlC₂, and (c) Ti₃AlC₂/TiO₂

3.3 UV-Visible spectroscopy analysis

The UV-Vis of pristine and composite samples are determined to study the optical properties of photo-materials. The optical property and absorption bands belonging to TiO₂, Max Ti₃AlC₂, and Max phase of Ti₃AlC₂/TiO₂ are acquired using UV-vis spectra, and results obtained are exhibited in Fig. 4. A flat absorption profile of Ti₃AlC₂ was revealed in the UV-Vis result which might be because of the metallic nature of MAX phase [30]. While TiO₂ displayed an absorption edge at 400 nm [31]. The Ti₃AlC₂/TiO₂ composite presented an absorption edge at around 445 nm. This was also because TiO₂ was uniformly distributed over the 3D Ti₃AlC₂ layered structure, as revealed by FESEM analysis, and visible light absorption may be instigated by the MAX changing the light-harvesting morphology of TiO₂.

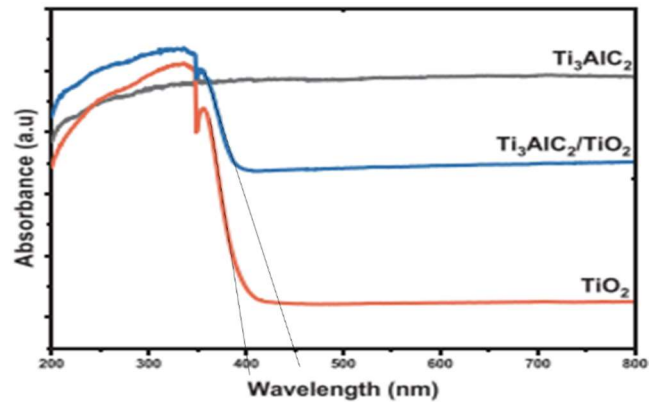


Fig. 4. UV-visible analysis of TiO₂, Ti₃AlC₂, and Ti₃AlC₂/TiO₂

3.4 Photocatalytic degradation of pesticide by using TiO₂, and TiO₂/Ti₃AlC₂

The pesticide LAMBDA-CYHALOTHRIN photocatalytic degradation with a synthesized catalyst was tested under UV-Vis light radiation and the results are shown in Fig. 5. The mixture of 0.4 g/200 mL catalyst and pesticides was mechanically agitated for 30 min in dark condition to obtain the adsorption stability between pesticides and the catalyst. In the persuasion of decomposition of pesticide, the process starts under the illumination of the samples for 4 h 30 min. The process involves exposing pesticide-contaminated water to these photocatalysts, which absorb photons from a light source to generate electron-hole pairs. The generated electrons and holes take part in the redox reaction to produce hydroxyl radicals. The hydroxyl radicals are very reactive species that initiate oxidation processes that break down the pesticide molecules. As a result, the pesticides are converted into simpler and less toxic intermediate products, ultimately transforming into harmless carbon dioxide, water, and other mineral byproducts. It was observed that the photocatalytic degradation of pesticide varies with the addition of different mass percentages of MAX phase to TiO₂ and the order of performance noticed as given 15% Ti₃AlC₂ MAX > 20% Ti₃AlC₂ MAX > 25% Ti₃AlC₂ MAX > 10% Ti₃AlC₂ MAX > 5% Ti₃AlC₂ MAX > pure TiO₂.

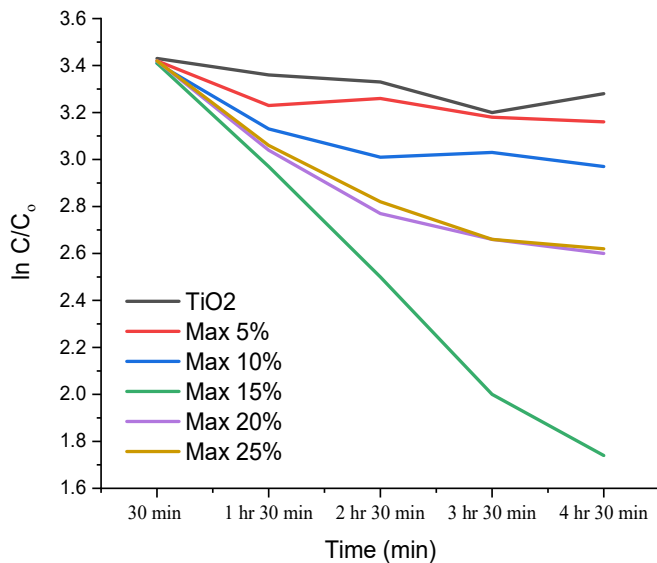


Fig. 5. Photocatalytic degradation of pesticide LAMBDA-CYHALOTHRIN

4. Conclusion

In summary, a hydrothermal approach is employed for the fabrication of the composite phase of MAX-Ti₃AlC₂/TiO₂. The addition of Ti₃AlC₂ improved the spectrum edge absorption of TiO₂ nanoparticles and increased its light harvesting from the visible light spectrum. The TiO₂ uniformly distributed on Ti₃AlC₂ material surface resulted in the integration of semiconducting properties. When Ti₃AlC₂ was combined with TiO₂, the composite development resulted in the improved photocatalytic performance of both the pristine phase of TiO₂ and MAX for degradation of pesticide. Among various composite samples, the 15% proportion of the MAX phase in TiO₂ demonstrated maximum degradation results. The study findings demonstrate that photocatalytic degradation effectively removes pesticides from agriculture wastewater and Ti₃AlC₂/TiO₂ is an encouraging photocatalyst material for wastewater.

5. Reference

- [1] M. I. Qureshi, U. Awan, Z. Arshad, A. M. Rasli, K. Zaman, and F. Khan, "Dynamic linkages among energy consumption, air pollution, greenhouse gas emissions and agricultural production in Pakistan: sustainable agriculture key to policy success," *Natural Hazards*, vol. 84, pp. 367-381, 2016.
- [2] S. H. H. Al-Taai, "Water pollution Its causes and effects," in *IOP Conference Series: Earth and Environmental Science*, 2021, vol. 790, no. 1: IOP Publishing, p. 012026.
- [3] M. Daud *et al.*, "Drinking water quality status and contamination in Pakistan," *BioMed research international*, vol. 2017, 2017.
- [4] S. Kanwa *et al.*, "Water pollution in Balochistan province of Pakistan," *International Journal of Engineering and Applied Sciences*, vol. 2, no. 6, p. 257885, 2015.
- [5] M. V. Shankar, S. Anandan, N. Venkatachalam, B. Arabindoo, and V. Murugesan, "Novel thin-film reactor for photocatalytic degradation of pesticides in an aqueous solution," *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology*, vol. 79, no. 11, pp. 1279-1285, 2004.
- [6] S. H. Khan and B. Pathak, "Zinc oxide based photocatalytic degradation of persistent pesticides: A comprehensive review," *Environmental Nanotechnology, Monitoring & Management*, vol. 13, p. 100290, 2020.
- [7] D. Vaya and P. K. Surolia, "Semiconductor based photocatalytic degradation of pesticides: An overview," *Environmental Technology & Innovation*, vol. 20, p. 101128, 2020.
- [8] W. Tang *et al.*, "Complete removal of phenolic contaminants from bismuth-modified TiO₂ single-crystal photocatalysts," *Chinese J. Catal.*, vol. 42, no. 2, pp. 347-355, 2021.
- [9] N. Verma, T. S. Chundawat, H. Chandra, and D. Vaya, "An efficient time reductive photocatalytic degradation of carcinogenic dyes by TiO₂-GO nanocomposite," *Mater. Res. Bull.*, vol. 158, p. 112043, 2023.
- [10] X. Zhang *et al.*, "Highly efficient visible-light-driven photocatalytic degradation of gaseous toluene by rutile-anatase TiO₂@MIL-101 composite with two heterojunctions," *J. Environ. Sci.*, vol. 134, pp. 21-33, 2023.
- [11] M. B. K. Suhan, S. B. Shuchi, M. R. Al-Mamun, H. Roy, and M. S. Islam, "Enhanced UV light-driven photocatalytic degradation of methyl orange using MoO₃/WO₃-fluorinated TiO₂ nanocomposites," *Environ. Nanotechnol. Monit. Manag.*, vol. 19, p. 100768, 2023.
- [12] S. M. Kozlov, F. Viñes, and A. Görling, "Bandgap Engineering of Graphene by Physisorbed Adsorbates," *Adv Mater*, vol. 23, no. 22-23, pp. 2638-2643, 2011.
- [13] J. Kim, L. J. Cote, F. Kim, W. Yuan, K. R. Shull, and J. Huang, "Graphene oxide sheets at interfaces," *J. Am. Chem. Soc.*, vol. 132, no. 23, pp. 8180-8186, 2010.
- [14] Y. Si and E. T. Samulski, "Synthesis of water soluble graphene," *Nano Lett.*, vol. 8, no. 6, pp. 1679-1682, 2008.



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- [15] O. C. Compton and S. T. Nguyen, "Graphene Oxide, Highly Reduced Graphene Oxide, and Graphene: Versatile Building Blocks for Carbon-Based Materials," *Small*, vol. 6, no. 6, pp. 711-723, 2010.
- [16] D. R. Dreyer, A. D. Todd, and C. W. Bielawski, "Harnessing the chemistry of graphene oxide," *Chem. Soc. Rev.*, vol. 43, no. 15, pp. 5288-5301, 2014.
- [17] A. A. Khan and M. Tahir, "Well-designed 2D/2D Ti₃C₂TA/R MXene coupled g-C₃N₄ heterojunction with in-situ growth of anatase/rutile TiO₂ nucleates to boost photocatalytic dry-reforming of methane (DRM) for syngas production under visible light," *Appl. Catal. B: Environ.*, vol. 285, p. 119777, 2021.
- [18] Z. Chen, Y. Ma, W. Chen, Y. Tang, L. Li, and J. Wang, "Enhanced photocatalytic degradation of ciprofloxacin by heterostructured BiOCl/Ti₃C₂Tx MXene nanocomposites," *J. Alloys Compd.*, vol. 950, p. 169797, 2023.
- [19] X. Meng *et al.*, "Recent developments and perspectives of MXene-Based heterostructures in photocatalysis," *Chemosphere*, p. 139550, 2023.
- [20] H. Zhang *et al.*, "2D a-Fe₂O₃ doped Ti₃C₂ MXene composite with enhanced visible light photocatalytic activity for degradation of Rhodamine B," *Ceram. Int.*, vol. 44, no. 16, pp. 19958-19962, 2018.
- [21] C. Cui *et al.*, "Bi₂WO₆/Nb₂CTx MXene hybrid nanosheets with enhanced visible-light-driven photocatalytic activity for organic pollutants degradation," *Appl. Surf. Sci.*, vol. 505, p. 144595, 2020.
- [22] Z. Zhang, Z. Pan, Y. Guo, P. K. Wong, X. Zhou, and R. Bai, "In-situ growth of all-solid Z-scheme heterojunction photocatalyst of Bi₇O₉I₃/g-C₃N₄ and high efficient degradation of antibiotic under visible light," *Appl. Catal. B: Environ.*, vol. 261, p. 118212, 2020.
- [23] Q. Huang, Y. Liu, T. Cai, and X. Xia, "Simultaneous removal of heavy metal ions and organic pollutant by BiOBr/Ti₃C₂ nanocomposite," *J. Photochem. Photobiol., A*, vol. 375, pp. 201-208, 2019.
- [24] M. Hou, Y. Deng, and S. Yao, "Spatial Agglomeration Pattern and Driving Factors of Grain Production in China since the Reform and Opening Up," *Land*, vol. 10, no. 1, p. 10, 2021.
- [25] H. Huang *et al.*, "One-step in-situ preparation of N-doped TiO₂@C derived from Ti₃C₂ MXene for enhanced visible-light driven photodegradation," *Applied Catalysis B: Environmental*, vol. 251, pp. 154-161, 2019.
- [26] M. Tahir, "Enhanced photocatalytic CO₂ reduction to fuels through bireforming of methane over structured 3D MAX Ti₃AlC₂/TiO₂ heterojunction in a monolith photoreactor," *Journal of CO₂ Utilization*, vol. 38, pp. 99-112, 2020.
- [27] H. Mao and A. Rasheed, "Facile synthesis of porous Mn₂TiO₄/TiO₂ composites for high performance supercapacitors," *Materials Letters*, vol. 215, pp. 114-117, 2018.
- [28] Z. Xiu *et al.*, "Recent advances in Ti³⁺ self-doped nanostructured TiO₂ visible light photocatalysts for environmental and energy applications," *Chemical Engineering Journal*, vol. 382, p. 123011, 2020.
- [29] Z. Miao, G. Wang, X. Zhang, and X. Dong, "Oxygen vacancies modified TiO₂/Ti₃C₂ derived from MXenes for enhanced photocatalytic degradation of organic pollutants: The crucial role of oxygen vacancy to schottky junction," *Applied Surface Science*, vol. 528, p. 146929, 2020.
- [30] A. A. Khan, M. Tahir, and Z. Y. Zakaria, "Synergistic effect of anatase/rutile TiO₂ with exfoliated Ti₃C₂TR MXene multilayers composite for enhanced CO₂ photoreduction via dry and bi-reforming of methane under UV-visible light," *Journal of Environmental Chemical Engineering*, vol. 9, no. 3, p. 105244, 2021.
- [31] A. Venkatesan *et al.*, "Study of synergistic effect of cobalt and carbon codoped with TiO₂ photocatalyst for visible light induced degradation of phenol," *Chemosphere*, vol. 305, p. 135333, 2022.



Converting Waste Heat from Motorbike Silencers Using Thermoelectric Generators into Usable Electricity

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Exhaust Silencer,
Sustainable Transportation

A B S T R A C T

Internal combustion engines, a mainstay of transportation, suffer from significant energy losses, with 30-40% of generated energy dissipating as waste heat in the exhaust and silencers. This study explores the potential of recovering this lost thermal energy and transforming it into usable electricity using Peltier modules, a type of thermoelectric generator (TEG).

Ten commercially available TEC1-12706 Peltier modules (40mm x 40mm) were connected electrically in series and thermally in parallel, and mounted directly onto the silencer of a Honda CD 70 (2005 model) motorbike. This simple and adaptable arrangement harnesses the waste heat from the engine to generate electricity. While no dedicated cooling mechanism was employed for the hot side, the other side of the modules was exposed to the ambient environment. Experimental results showed a maximum power output of 1.23 W at a silencer temperature of 92°C. The findings confirm a direct relationship between temperature difference and voltage output, with 5.37 V achieved at 92°C.

Peltier modules offer a promising solution for converting waste heat into usable electric power. This research paves the way for developing more efficient TEG systems for motorbikes. Future work will focus on optimizing module configuration and heat management to improve power generation. Additionally, exploring the integration of this system with the existing motorbike battery could potentially lead to increased fuel efficiency and reduced environmental impact.

This study highlights the potential of TEG technology for waste heat recovery in motorbikes, promoting environmental sustainability by harnessing a currently underutilized energy source.

1. Introduction

The modern transportation sector, a critical component of global society, faces mounting challenges related to energy efficiency and environmental impact. Internal combustion engines, despite their established power and reliability, are inherently inefficient. A significant portion of their energy output, estimated between 30-40%, dissipates as waste heat primarily emitted through

the exhaust system and silencers. This wasted thermal energy represents a missed opportunity for improved fuel economy and reduced dependence on fossil fuels. This study addresses this challenge by exploring the potential of thermoelectric generators (TEGs), also known as Peltier modules, to recover waste heat from motorbike silencers and convert it into usable electricity. TEGs function based on the Seebeck Effect, a principle that directly converts temperature differences into



electricity. By strategically attaching TEGs to the hot motorbike silencers and exploiting the temperature gradient between the exhaust and a cooler heat sink (e.g., ambient air), electricity can be generated from this waste heat.

The research focuses on developing and implementing a TEG system specifically designed for motorbike silencers. The achievable power output under various conditions was investigated, and the relationship between temperature difference and electricity generation was analyzed. Additionally, the simplicity and adaptability of this approach for wider application within the transportation industry were explored.

This study aims to demonstrate the feasibility of using TEGs to harvest waste heat in motorbikes, leading to significant energy conservation, reduced fuel consumption, and a more sustainable transportation future. This approach leverages existing exhaust systems and readily available TEGs, offering a practical solution for environmental sustainability.

2. Literature Review

Comparison of Studies on TEG Applications for Waste Heat Recovery

S. #	Study	Application	Key Findings	Comparison to Current Study
1	(Mr.P.Tamil arasu1, S.Nishanth2, M.A.Srigow tham2, 2023)	Vehicle silencer	Up to 1.25 W generated	Similar application, but focuses on motorbikes and explores series connection for voltage increase.
2	(Perdana and Kusuma, 2023)	Patrol boat exhaust	Series circuit: 12.85 V, 5.88 W; Parallel circuit: 1.5 V, 1.44 W	Highlights importance of circuit configuration for power output. Current study utilizes series connection.
3	(Gurjar and Agade, 2021)	Car engine	Effective at high exhaust temperatures (up to 400°C)	This study focuses on car engines, which have higher waste heat compared to motorbikes.
4	(Naibaho and Tamba, 2021)	Motorcycle exhaust (phone charging)	2.17 V (boosted to 4.58 V), identified measurement error	Similar application, but current study investigates power output without boosting and explores series connection for voltage increase.
5	(Rizal, Lubis and Amin, 2021)	Motorcycle exhaust (phone charger)	4.47 V at 4000 RPM, even at idle	Similar application, current study explores series connection and impact on voltage.

6	(Kumar, 2020)	Motorcycle silencer	1.58 V (details lacking)	Similar application, current study provides details on TEG configuration, power output, and series connection for voltage increase.
7	(Mirmanto, Tira and Pabriansyah, 2020)	Motorcycle exhaust	Series circuit (1600 rpm): 3.3 V; Parallel circuit (higher rpm): 0.133 W	Similar application, reinforces importance of circuit configuration. Current study utilizes series connection.
8	(Hidayanti, Wati and Miftahudin, 2020)	Motorcycle exhaust	4.2 V (ΔT 57°C), successfully charged devices at 5.2 V	Similar application, current study explores impact of series connection on voltage and investigates power output at higher temperature difference.
9	(Jadhav and Sidhu, 2017)	Motorcycle exhaust	ΔT 83.2°C, 12 V at 6000 rpm	Similar application, current study explores series connection for voltage increase and focuses on power output at lower engine speeds.
10	(Kamelia, Faroqi and Muajjanisan, 2016)	Motorcycle exhaust	ΔT 560.9°C, 2.89 V (boosted to 12.8 V)	Similar application achieved higher ΔT due to potentially higher exhaust temperatures in their study. Current study explores impact of series connection on voltage at lower ΔT .

This review of relevant studies on TEG applications for waste heat recovery highlights several key findings:

- TEGs have the potential to generate electricity from waste heat in various vehicles, including motorbikes, patrol boats, and cars. Studies have reported power outputs ranging from 1.25 W to 5.88 W, depending on factors like TEG configuration, application, and exhaust temperature.
- Circuit configuration plays a significant role in optimizing TEG output. Series connections tend to generate higher voltage, while parallel connections may provide higher power at specific operating conditions.
- Exhaust temperature is another crucial factor. Studies focusing on car engines, which have higher exhaust temperatures compared to motorbikes, achieved greater temperature differences (ΔT).

The current study builds upon this existing knowledge by investigating the feasibility of using TEGs for waste heat recovery in motorbikes with a focus on two key aspects:

1. *Series Connection for Combined Voltage and Power Improvement:* While several studies explored series



connections for increased voltage, this study analyzes its impact on both voltage and power output. This combined analysis provides a more comprehensive understanding of the series configuration's effectiveness in a motorbike setting.

2. *Power Generation at Lower Temperature Differences*: Compared to some studies that achieved high ΔT (e.g., Kamelia et al. 2016), this research investigates power generation at lower ΔT values typically encountered in motorbike exhausts. This approach assesses the practicality of TEGs in real-world motorbike conditions.

By focusing on series connection and analyzing its impact on both voltage and power at lower ΔT , this study aims to contribute to the development of efficient TEG systems for waste heat recovery in motorbikes, potentially leading to improved fuel efficiency and a more sustainable transportation future.

3. Problem Statement

Internal combustion engines are the most widely used transportation systems, but they have a significant drawback: they waste up to 40% of the energy they generate as heat, primarily through the exhaust system and silencers. This wasted thermal energy represents a missed opportunity to improve fuel efficiency and reduce dependence on fossil fuels.

Thermoelectric generators (TEGs) have the potential to capture waste heat from motorbike silencers and convert it into usable electricity, according to existing research highlighted in the literature review. Although studies have demonstrated varying degrees of success, with power outputs ranging from 0.469 W to 12.8 W and voltage generation from 1.5 V to 12.8 V, these findings suggest that TEG technology is feasible but has limitations.

The main challenge is to optimize the TEG system design for motorbike silencers to achieve a balance between several aspects, such as maximizing the amount of electricity generated from the waste heat to provide a practical benefit for motorbikes, ensuring the TEG system is affordable to implement and maintain for widespread adoption, designing a system that can be easily integrated with existing motorbike exhaust infrastructure without requiring significant modifications, and constructing a TEG system that can withstand the harsh operating environment of motorbikes, including vibrations, heat fluctuations, and weather conditions.

Addressing these challenges is crucial to unlocking the full potential of TEG technology for waste heat recovery in motorbikes. By optimizing TEG configuration, exploring advanced materials, and integrating the system with onboard electronics, we can create a solution that contributes to a more sustainable and fuel-efficient transportation future.

4. Methodology

This study investigates the effectiveness of TEGs in capturing waste heat from motorbike silencers and converting it into usable electricity. The methodology focuses on optimizing a TEG system specifically designed for motorbike applications. Here's a breakdown of the key steps:

1. TEG Selection and Configuration:

Commercially available TEG modules were chosen based on their compatibility with motorbike exhaust temperatures and size constraints. The selection criteria considered factors like maximum operating temperature, number of couples (p-n junctions), and footprint to ensure efficient heat transfer from the silencer and minimize wasted space.

The chosen TEGs were connected electrically in series (Eqn. 1) to achieve a higher output voltage (V_{out}) as the voltage generated by individual TEGs is typically low.

$$\text{Eqn. 1:} \quad V_{out} = \sum V_i$$

(where V_i represents the voltage of each individual TEG module in the series connection)

2. Experimental Setup:

A test motorbike was chosen, and the TEG modules were securely attached directly to the silencer surface. Thermal paste was applied between the TEG modules and the silencer to improve thermal contact and minimize heat transfer resistance.

Electrical connections were established for measuring voltage (V) and current (I) output of the TEGs using a voltmeter and ammeter, respectively. Data acquisition equipment (e.g., data logger) was employed to record these measurements continuously.

A thermocouple sensor was attached to the silencer surface near the TEGs to monitor the exhaust gas temperature (T_h) continuously.

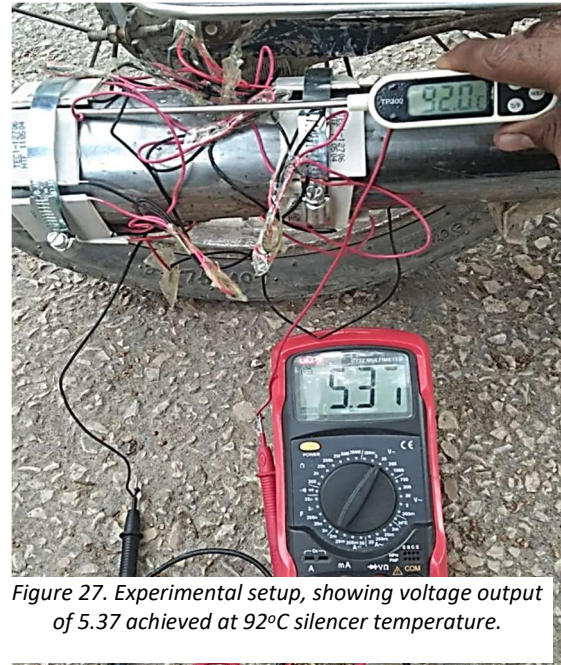
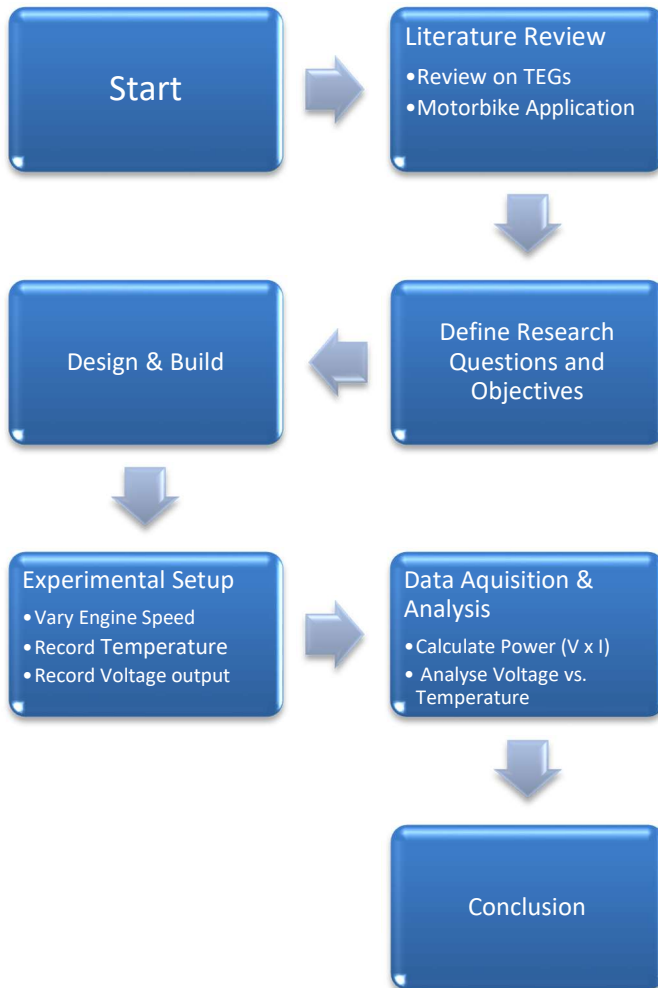


Figure 27. Experimental setup, showing voltage output of 5.37 achieved at 92°C silencer temperature.



3. Performance Evaluation:

The motorbike engine was operated under various conditions, including different engine speeds (RPM) and varying loads (e.g., idling, constant speed, acceleration).

At each operating condition, the voltage (V), current (I), and silencer temperature (T_h) were recorded. The power output (P) of the TEG system was calculated using Eqn. 2:

$$\text{Eqn. 2:} \quad P = V \times I$$

The relationship between power output, engine speed, and silencer temperature was analyzed to understand the impact of operating conditions on TEG performance.

4. System Optimization:

Based on the experimental results, the effectiveness of the TEG system design was evaluated. Factors like the number of TEGs used, their arrangement (series vs. additional series/parallel combinations), and potential heat sink optimization for the cold side of the TEGs were considered for improvement.

5. Results and Discussion

This part of the report outlines the significant discoveries obtained from the experimental exploration of the TEG system for collecting waste heat from motorbike silencers. The outcomes concentrate on the association between temperature difference and voltage output while considering the constraints recognized during the experiment.

Regarding Voltage Output and Temperature Difference, the voltage output of the TEG system rose proportionally with the temperature difference between the hot and cold sides, as depicted in Slide 1. This trend is consistent with the fundamental principle of thermoelectric generation,



where a greater temperature gradient leads to a higher voltage output. During the experimental study, the ambient air temperature was found to be 20 °C, whereas the silencer temperature was noted to be increasing with higher RPM. According to the data, there is a clear correlation between the temperature difference and voltage output. The findings revealed a voltage output of 0.71 volt at a temperature difference of 2.3°C and a voltage output of 5.37 volts at a temperature difference of 72°C. This discovery indicates that it is crucial to maximize the temperature difference across the TEGs for optimal voltage generation.

Table 01. Voltage Output and Difference of Silencer Temperature

Temp. of Heat Source	Temp. of Heat Sink	Difference in Temp.	Voltage
T_h (C)	T_c (C)	dT	Volt
22.3	20	2.3	0.71
24.9	20	4.9	0.81
26	20	6	0.84
26.5	20	6.5	0.86
27.8	20	7.8	0.9
30.6	20	10.6	1.37
30.8	20	10.8	1.41
32.7	20	12.7	1.75
35.8	20	15.8	2.09
38.6	20	18.6	2.42
38.6	20	18.6	2.42
41.3	20	21.3	2.48
42.6	20	22.6	2.47
43.7	20	23.7	3
51.9	20	31.9	4.23
57.5	20	37.5	4.56
72.8	20	52.8	4.93
86.8	20	66.8	5
90.3	20	70.3	5.17
92	20	72	5.37

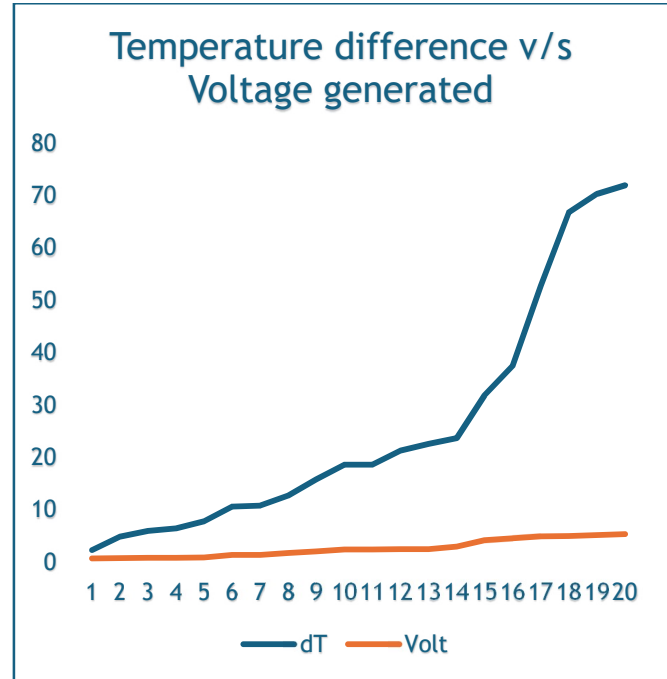


Fig. 02 Temperature difference v/s Voltage generated.

6. Limitations and Discussion

The experiment conducted showed a maximum temperature of 92°C, which is lower than what some previous studies have reported. This could be due to factors such as the operating conditions of the engine, silencer design, or the placement of TEGs. Although this research proves that TEGs can be used for waste heat recovery and voltage generation, further optimization is required to achieve higher temperature ranges, which are typically observed in motorbike exhaust systems.

The performance of the TEG system can be influenced by engine speed and load, which were not measured in this study. Therefore, it is important to consider their potential impact on temperature difference and voltage output in future research.

The durability of TEGs in the harsh environment of motorbikes, with vibrations and temperature fluctuations, requires further investigation. Besides, the practicality of integrating the TEG system with existing motorbike electronics needs to be addressed to assess its feasibility for practical applications.

7. Future Work

Efforts for future research will concentrate on improving the TEG system design to attain higher temperature differences. This may involve examining techniques to enhance heat transfer between the silencer and the TEGs



or exploring the usage of sophisticated TEG materials with higher efficiency at lower temperature ranges. Moreover, incorporating the TEG system with onboard motorbike batteries to power low-voltage electronics is a promising avenue for further exploration. By addressing the limitations and including these areas for future work, TEG technology can become a feasible solution for waste heat recovery and low-voltage power generation in motorbikes, contributing to a more sustainable transportation future.

8. References

- [1] Gurjar, N. and Agade, P.K. (2021) 'Study of Waste Heat Recovery in the Form of Electricity from Engine Exhaust', (2), pp. 898–901.
- [2] Hidayanti, F., Wati, E.K. and Miftahudin, M.F. (2020) 'Design of energy harvesters on motorcycle exhaust using thermoelectric generator for power supply electronic device', *International Journal of Renewable Energy Research*, 10(1), pp. 251–259. doi:10.20508/ijrer.v10i1.10446.g7864.
- [3] Jadhav, M.G. and Sidhu, J.S. (2017) 'Design and Fabrication of Silencer Waste Heat Power Generation System Using Thermo-Electric Generator', *International Journal of Advanced Mechanical Engineering*, 7(1), pp. 1–14. Available at: <http://www.ripublication.com>.
- [4] Kamelia, L., Faroqi, A. and Muajjanisan, A.A. (2016) 'The Conversion of Waste Heat From Motorcycle Into Small Power Plant', *OIDA International Journal of Sustainable Development*, 9(1), pp. 79–84. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2734295.
- [5] Kumar, P. (2020) 'Thermoelectric Power Generation By Bike Silencer', *International Research Journal of Engineering and Technology* [Preprint]. Available at: www.irjet.net.
- [6] Mirmanto, M., Tira, H.S. and Pabriansyah, A. (2020) 'Effect of motorcycle exhaust pipe temperature and electrical circuit on harvested dc power from thermoelectric generators', *Dinamika Teknik Mesin*, 10(1), p. 41. doi:10.29303/dtm.v10i1.319.
- [7] Mr.P.Tamilarasu1, S.Nishanth2, M.A.Srigowtham2, A.T. (2023) 'SILENCER BASED POWER GENERATION using Peltier Plate', 12(1), pp. 2907–2911. doi:10.31838/ecb/2023.12.s1-B.291.
- [8] Naibaho, E. and Tamba, T. (2021) 'Utilization of Produced Heat in Motorcycle Exhaust as a Mobile Battery Charger Using Thermoelectric Seebeck Generator', *Journal of Technomaterial Physics*, 3(2), pp. 101–108. doi:10.32734/jotp.v3i2.5570.
- [9] Perdana, Y.S. and Kusuma, C. (2023) 'Development of Thermoelectric Generator for Energy Saving Device Using Exhaust Waste Heat in Patrol Boat', *International Journal of Marine Engineering Innovation and Research*, 8(3), pp. 391–398. doi:10.12962/j25481479.v8i3.16249.
- [10] Rizal, T.A., Lubis, K.H. and Amin, M. (2021) 'Experimental Research on Utilization of Motorcycle Exhaust Heat Using Thermoelectric Generator (TEG) For Mobile Phone Chargers', *Proceedings of the 2nd International Conference on Science, Technology, and Modern Society (ICSTMS 2020)*, 576(Icstms 2020), pp. 244–247. doi:10.2991/assehr.k.210909.054.



Recognition of Vitiligo Skin Lesion through Neural Network and KNN

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Machine learning
K-Nearest Neighbour
Neural Network
Automatic recognition
Clustering.

ABSTRACT

Vitiligo affects up to 2% of the world's population, impacting children and adults' quality of life. It has characteristics with other skin problems, such as low contrast and uneven skin lesions. However, the size of the lesion makes it challenging to get dermoscopy photographs under controlled lighting settings. This paper seeks to present a technique for dividing skin lesions into segments using a clustering algorithm, followed by automated identification using KNN and NN on the gathered information. There were 18 patients who had been diagnosed with the non-segmental kind of vitiligo. A dataset of 285 photos was first acquired, and eventually expanded to 500 images through the process of image augmentation. The achieved accuracy for KNN is 81.9% (k=1), 78.7% (k=2), and 74.7% for NN. The technology might help doctors and researchers diagnose and track vitiligo. It can simplify the analysis of vast amounts of skin lesion photos and improve diagnosis and therapy by automating segmentation and identification.

1. Introduction

Skin illnesses are among the most prevalent infections among humans. Due to the deformity and accompanying difficulties, skin diseases create a great deal of difficulty for their victims. Every year, millions of individuals suffer from a variety of skin problems [1]. Due to the range of their visual characteristics, diagnosing skin illnesses might need a high degree of knowledge. Considering that human judgment is sometimes subjective and difficult to reproduce, a computer-assisted diagnostic method should be explored for more objective and trustworthy diagnosis [1, 2].

Vitiligo, a prevalent skin condition characterized by depigmentation, affects approximately 0.5-2% of the global population [3]. Vitiligo is frequently disregarded as a cosmetic issue, despite its potential to cause severe psychological distress and significantly impact everyday functioning [4, 5]. Vitiligo is a condition characterized by depigmentation in certain areas of the skin. Vitiligo often begins to appear in individuals during their mid-

twenties, however it can develop at any stage of life. Over time, it gradually develops and leads to larger areas of skin losing pigmentation [6]. Certain persons with vitiligo may encounter depigmented patches that impact their scalp or body hair. Vitiligo is commonly seen as an autoimmune disorder. Autoimmune illnesses occur when the immune system attacks the body's own tissues and organs. In individuals with vitiligo, the immune system appears to attack the melanocytes, which are the pigment cells in the skin [7]. Approximately 15 to 25% of individuals with vitiligo also experience at least one other autoimmune disorder, such as autoimmune thyroid disease, rheumatoid arthritis, type 1 diabetes, psoriasis, and so on. Research has shown that variations in many other genes also contribute to the likelihood of developing vitiligo [8]. Many of these genes are also implicated in immunological function or melanocyte biology, and alterations in each are anticipated to have a minimal impact on vitiligo susceptibility. Certain genetic variants that are connected to a higher likelihood of developing vitiligo have also been found to be related



with a greater susceptibility to other autoimmune illnesses. The specific circumstances that trigger the immune system to attack the melanocytes in the skin are currently not understood [9]. Research suggests that individuals with the condition may experience an abnormal immune response to melanocytes that have been subjected to stress from factors like chemicals or UV radiation. Furthermore, the melanocytes of individuals with vitiligo may exhibit heightened sensitivity to stress compared to the general population, rendering them more susceptible to immune attacks. The condition is believed to be primarily influenced by a combination of genetic and environmental variables, however the specific details of these causes remain largely unidentified [8-10].

A dermatologist has recognized numerous types of vitiligo. The most common kind of vitiligo is generalized vitiligo (also known as non-segmental vitiligo), which includes the loss of pigment (depigmentation) in areas of skin across the body [11]. Depigmentation commonly affects the face, scalp, and areas surrounding body openings such as the mouth and genitals. Occasionally, pigment can be depleted in mucosal membranes, such as the lips. Hypopigmentation is prevalent in places that experience frequent rubbing, pressure, or other forms of disruption, such as the hands, arms, and regions where bones are close to the surface of the skin (bony prominences). Segmental vitiligo is a different kind of vitiligo that is identified by smaller patches of depigmented skin. These patches appear in an uninterrupted area on one side of the body (figure 1). This subtype occurs in around 10% of afflicted persons. Vitiligo has attracted significant interest as a major skin ailment within the field of pigmented skin disorders research. In addition to sharing some characteristics with other skin diseases, such as low contrast and irregular skin lesions, obtaining dermoscopy photographs for examination under controlled lighting settings might be challenging due to the large size of the lesion. Numerous other pigmented skin illnesses, such as melanoma, have similar problematic characteristics. As a result, the technology for analyzing generalized RGB photographs obtained in natural daylight has now become a critical clinical necessity for assessing these illnesses [13, 14].

While there are no standardized clinical assessment techniques for pigmented skin disorders, the majority of techniques often use the width of the skin lesion as a crucial signal. Numerous semi-objective evaluation techniques often use the "Rule of Nines" for assessing vitiligo. The rule of nines is used to determine the extent to which an extension is involved. The intensity of

illness is quantified using five phases of disease density [15]. According to the Vitiligo European Task Force (VETF), an evaluation method for vitiligo predicated on changes in the size of the lesion over time as well as its stage and progression has been developed. The size of the lesion, phase, and progression of the disease are all taken into account, and the size of the lesion is measured in palm units [16]. Moreover, like VETF, the Extensibility and severity of vitiligo are combined in the Vitiligo Extent Tensity Index (VETI) rating [17]. When assessing the extent of the lesion, these approaches shown in table 1 depend on visual evaluation and involve some level of subjective interference. Lately, academics have been exploring new ways of assessing the size of an area, such as point-counting and planimetry [18], and digitization [19], which needless human participation. They are, nevertheless, less feasible for use in clinical settings since they need specialized equipment and software, as well as expensive operation. For example, a transparent film must be placed over the skin lesion, the lesion border must be manually defined, and the size must be estimated by counting the number of points on the grid or by utilizing CAD software, for example. In real-world therapeutic settings, this may be inconvenient and even unpleasant. Segmenting the lesion automatically and precisely is thus a vital strategy for objectively measuring its size. However, the problem is that for training classifiers, several dermatological pictures have been labeled with category categories that may be utilized as a guide. As a result of skin disease photographs' fussy border and uneven area, pixel-level annotation might take a long time. This means that many high-quality photos are squandered and cannot be utilized to train the segmentation models that depend on robust (pixel-level) supervision [18-20].

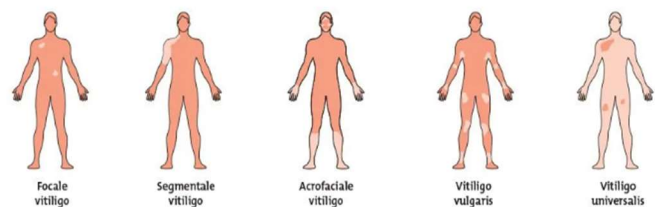


Fig. 1. Varieties of vitiligo are determined by the number of lesions and their location on the body [21].

Table I

Vitiligo measurement instruments [22].

Instrument	Description	Reference
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Vitiligo Life Quality Index (VLQI)	A set of 25 questions evaluating the effect of vitiligo on the patient's life (skin types II to IV).	[23]
Vitiligo Impact Scale-22 (VIS-22)	A set of 22 questions analyzing the effect of vitiligo on the patient's daily life.	[24]
VitiQoL	A set of sixteen questions examining the influence of vitiligo on a patient's mental and emotional health, as well as their lifestyle habits during the last month.	[25]
Vitiligo Noticeability Scale (VNS)	Patient rates the noticeability of vitiligo posttreatment compared with pre-treatment (score 1 to 5).	[26]
Self-assessed Vitiligo Area Scoring Index (SAVASI)	The patient indicates the body parts affected by vitiligo and assesses the number of hand units affected per body part and the extent of depigmentation within.	[27]
Vitiligo Area Scoring Index (VASI)	Assesses the degree of depigmentation across five distinct and mutually exclusive body areas.	[28]
Vitiligo European Task Force Assessment (VETF)	Determines the degree, stage, and dissemination of disease.	[29]
Vitiligo Extent Score (VES)	Measures the total vitiligo involvement (extent) of the body by separating it into 19 distinct locations.	[30]

2. Literature Review

The systematic review contained 10 research papers that were examined and selected based on certain eligibility criteria, including inclusion and exclusion criteria. These publications focused on evaluations related to the diagnosis of vitiligo. The study investigations have shown that Machine Learning (ML) approaches and algorithms are more successful than traditional and

conventional ways in evaluating and identifying vitiligo. Based on the main purpose of this systematic review and the related inquiries and examinations, it can be inferred that machine and deep learning approaches, such as Convolutional Neural Networks (CNN) and Artificial Neural Network (ANN), are more effective. In 2012 the findings of a structural evaluation were outlined and objectively understood, evaluating some significance structures in patients with all forms of Vitiligo, the measuring properties of the clinician, patient and observer performance.[31]. Various measurement instruments such as the European Task Force (ETF) test Vitiligo have been tested. [32].On calculating error, the VETF score was assessed. No interpretability details was found, since there were no records of small significant improvements or slight significant differences. The above has also tested a rather well-known Vitiligo Rating Index (VASI) [16]. The current state-of - the-art computerized diagnostic systems[33] can achieve very good performance in certain skin cancers, such as melanoma, by integrating them with some popular classification tools (such as CNN and ANN).

Out of all the studies Cazzaniga et al. in [34] has reported all the three things i.e accuracy sensitivity and specificity that are the requirement of good machine learning reporting. We can analyze that from table 2 that most of the papers fail to reports all the outcomes measurements that are considered desirable in machine learning. Aydin et al. in 2007 [18] uses a technique that is not a machine learning technique but depicted a good result. In 2007 Surface areas of 31 vitiligo lesions were calculated by five volunteers using point counting and optical planimetry. Twice with an interval of two weeks, three independent observers checked the areas mentioned with the point counting method. Any single observer using digital planimetry has calculated the same lesions. An inter and intra-observer interaction test was used to compare the estimation results of three observers. For all measurements, there was significant inter-and intra - observer consensus. Every observer's observations of the point counting and the digital planimetry tool also had a major similarity. There were no major differences in surface results obtained by the two methods ($p > 0.05$). The dot counting method can be used to measure the area of the vitiligo as simple and reliable method.

Similarly, Anthal et al. in 2017 [35] used the LVQ neural network which also seems very promising in terms of accuracy because its reporting accuracy is 92%. The vector quantification of learning is a type of neuronal network that uses a clustering and classification



combination. The LVQ Neural Network involves three layers: input, hidden, and output, clusters between the input and hidden layer, and classifications are extended from the secret to the output layer. In this case, a neural network with learning vector quantization classifies a Vitiligo image as an infection in the affected region vs the uninfluenced environment. The LVQ neural network is remarkably well-implemented with a 92.22% exactness and 0.810 kappa value which is remarkable for the approach being proposed.

2.1. Gaps Found in literature Review

Some of the studies also reported limitations for example in [34] it was an important step, with numerous equilibrium predictor sub - sets leading to various solutions. A broader collection of Vitiligo lesions characteristics and treatments will help to find a much more predictive model of excimer laser treatment. Assets were the maximum in [23]. Of longer training time we would like to have access to the resources. We do wish to produce new samples using a generative opposing network to improve our results. Regarding the limitations of this systematic review, it is undeniable that there is a reduced number of included papers. Furthermore, only publications published in English were chosen, thus excluding research from non-English speaking nations and reducing the applicability of the findings. Furthermore, it is quite likely that the search technique employed for this study may have overlooked any pertinent research, as the systematic review did not include articles published in fraudulent journals or conferences.

Table 2

Summary of screened studies.

Ref ere nce	ML Algorithm / Technique	Dataset source	Data set Size	Accur acy / P- value/ JI	Sens itivity	Spec ificit y
[18]	Point Counting; Digital Planimetr y Technique s (superv- -ised)	vitiligo lesions of five volunte er	n = 31	p – value < 0.05	NA	NA

[34]	ANN (discrimi- -native and regression network) (superv- -ised)	120 patients	n = 325	Ac = 85.85 %	88.9 4 %	80.9 5 %
[37]	ANN (ICA, FCM, MLP) (superv- -ised)	Patients (18 and 55 years)	NA	NA	Vary betw een 96% to 100 % in 20 test for all three meth ods.	Vary betw een 47% to 100 % in 20 test for all three meth ods.
[38]	k mean clustering (un- supervised)	NA	NA	Ac = 59%	NA	NA
[39]	computeri zed digital imaging analysis system (un- supervised)	56 patients above 15 (29 women, 27 men)	NA	P = 0.053	NA	NA
[40]	CNN	Vit2019 (80% patients, 20% Internet e.g., Google Images DERM 101)	n = 2000	Ac = 75.8	66.1	76.3

[35]	LVQ neural network (supervised)	Inter net	NA	Ac = 92.22 %	NA	NA
[41]	CNN with SVM (supervised)	NA	n = 996	Ac = 91%	NA	NA
[36]	U-Net-based CNN (supervised)	Patients (no. of patients NA)	n = 308	JI = 73.6 %	NA	NA
[42]	KL divergence based agglomerative clustering (unsupervised)	35 patients (15 female, 20 male)	n = 52	p – value < 0.05	NA	NA

was then expanded to include a volume of 500 images through the process of image augmentation. Because the skin lesion regions are also surrounded by obvious treatment or any other colored residues, which may have major detrimental impacts on the training phase and excessive exudate, which results in the absence of the condition's surface look and texture, the data cleaning process is also accomplished. All of these factors contribute to the fact that the data cleaning process is successful. Images of excellent image quality, with a simple background that draws attention to the distinctive skin lesions, as shown in figure 2. Whereas in figure 3, the process of collection of Vitiligo images has been demonstrated. After the skin lesion has been chosen, the images were captured in three settings with 2 months gap in between.



Fig 2. A collection of non-segmental vitiligo images of upper and lower extremities from 18 Subjects.

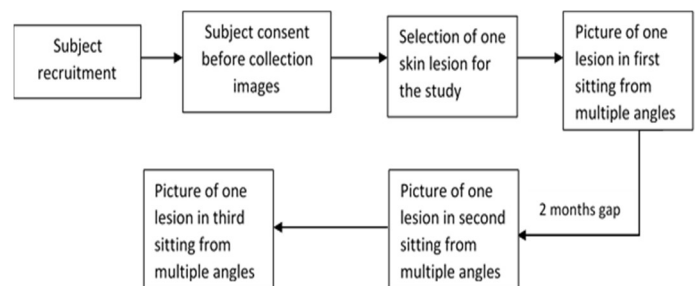


Fig. 3. Method of collection of images.

3. Materials and Methods

3.1. Dataset Collection

Ethical approval for the gathering of the dataset was granted by the Ethical Review Committee (ERC) of Ziauddin University in Pakistan, and prior informed permission was obtained from each subject. The collection of the dataset included a total of 18 subjects who were diagnosed with a non-segmental type of vitiligo (table 3). These subjects ranged in age from 11 years old to 60 years old and were male or female. Only lesions that were found on the upper and lower limbs (hands and legs) have been incorporated in the dataset. This was done after taking into account ethical considerations and identification difficulties. All of the clinical photographs were shot by the author [NM] in the clinical environment of the Department of Dermatology at the Jinnah Postgraduate Medical Centre (JPMC) under normal lighting circumstances using the rear camera of an iPhone. It was possible to acquire a complete dataset consisting of 285 photographs, which

Table 3

Details of the subjects recruited for the study.

Subject No.	Gender	Age yrs.	Mode of treatment
Subject 1	F	45 yrs.	Creams
Subject 2	F	60 yrs.	Creams
Subject 3	M	32 yrs.	Creams
Subject 4	F	28 yrs.	Phototherapy treatment and cream
Subject 5	F	26 yrs.	Phototherapy treatment
Subject 6	M	73 yrs.	Creams
Subject 7	F	12 yrs.	Phototherapy treatment
Subject 8	F	16 yrs.	Phototherapy treatment
Subject 9	M	25 yrs.	Phototherapy treatment and cream
Subject 10	M	31 yrs.	Creams
Subject 11	F	18 yrs.	Creams
Subject 12	F	19 yrs.	Creams
Subject 13	M	17 yrs.	Creams
Subject 14	F	20 yrs.	Creams
Subject 15	M	72 yrs.	Phototherapy treatment and cream
Subject 16	M	12 yrs.	Phototherapy treatment and cream
Subject 17	F	15 yrs.	Phototherapy treatment and cream
Subject 18	M	10 yrs.	Creams

3.2. Data Augmentation

Through the utilization of data augmentation techniques, it is technically feasible to purposefully increase the size of an already existing dataset. For the purpose of addressing data scarcity and diversity concerns, natural language processing (NLP) models and computer vision models employ data augmentation methodologies. According to the information presented in [43], Tanner and Wong et al. were the first to propose data augmentation as a means of simplifying and expanding the availability of simulation. It's possible

that data enrichment strategies might be beneficial to machine learning models. For the purpose of an image classification task, a number of studies have demonstrated that a machine learning model that included image augmentation outperformed a machine learning model that did not incorporate augmentation. This was the case in terms of training loss (i.e., the penalty for making an incorrect prediction) and accuracy, as well as validation loss and accuracy [44]. Augmentation techniques like cropping, flipping, and rotation are used in the proposed methodology as seen in figure 4 to eliminate the insufficient data diversity and to challenge the algorithm.

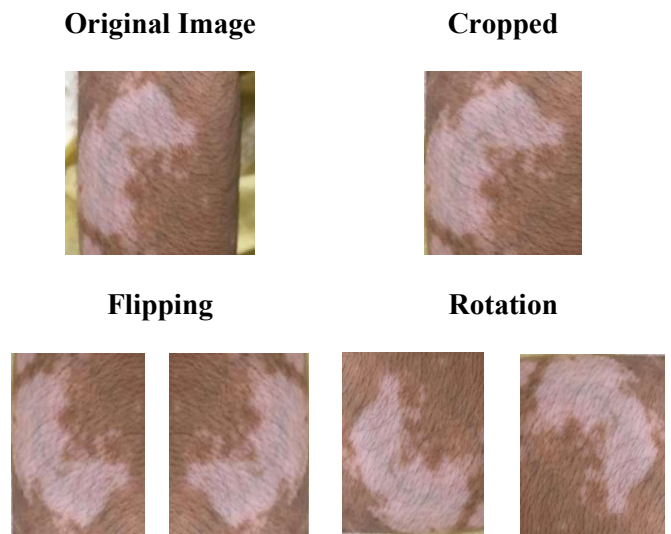


Fig. 4. Demonstration of no. of images increases after applying data augmentation.

3.3. Image Processing

A series of image processing operations performed on an RGB image to enhance its suitability for feature extraction and classification.

1. Creating a mask threshold RGB image using a color Thresholder.
2. Thresholding the RGB image using the color Thresholder App, resulting in a binary mask (BW) and a composite image (maskedRGBImage) that shows the original RGB image values under the mask.
3. Converting the RGB image to a chosen color space.
4. Defining thresholds for channel 1 based on histogram settings.



5. Defining thresholds for channel 2 based on histogram settings.
6. Defining thresholds for channel 3 based on histogram settings.
7. Creating a mask based on the chosen histogram thresholds.
8. Applying the mask to the RGB image using logical operations.
9. Initializing an output masked image based on the input image.
10. Setting background pixels to zero where the mask is false.

$m_{i(t)}, m_{j(t)} = \text{means}$.

The new mean is calculated and used to update the clusters as follows:

$$m_{i(t+1)} = \frac{1}{|S_{i(t)}|} \sum_{x_j \in S_{i(t)}} X_j \quad (2)$$

Where $m_{i(t+1)}$ = updated mean.

In this investigation, two clusters are selected since segmentation is necessary to differentiate between pixels that have lesions and those that do not. The K-means clustering approach may produce an image with pixels that are grouped together in clusters. Therefore, the resulting image is transformed into a binary representation where only pixels corresponding to lesions and a few additional pixels are present.

4.2. Color-Based Image Segmentation

The L*a*b color space is initially converted from the RGB image. To obtain grayscale photos with clearer distinctions between mole and skin pixels, one can strategically overlay the individual channels of the L*a*b color space. Segmenting the lesion from an RGB image based on intensity becomes difficult. The lesions exhibit a noticeable disparity in hue compared to the adjacent pixels in the photographs, as previously shown. A color image is formed by combining the gray values from the R, G, and B channels. While it is possible to utilize individual RGB channels for color analysis, it would be impractical to handle all three channels separately. The RGB image is converted to the L*a*b color space to enhance the visibility of color variations that exist between the mole and the lesion, while ensuring computational efficiency is maintained. By subtracting the data of the brightness channel from that of the a* or b* channels, a new grayscale image is generated that effectively differentiates between the skin and the lesion [53].

Step 1: Read the image. Read in hestain, which is an image of skin stained with vitiligo. This staining method helps dermatologists distinguish different skin types.

Step 2: Using 'rgb2lab', convert an image from RGB to L*a*b* color space. The L*a*b* space is composed of three layers: a luminosity layer 'L*', a chromaticity layer 'a*' showing the color's red-green axis location, and a chromaticity layer 'b*' indicating the color's blue-yellow axis location. The 'a*' and 'b*' layers include all of the color information. The Euclidean distance metric is used to determine the difference between the two colors [46, 53].

3.4. Splitting of Dataset

Training (70%) and testing (the other 30%) were separated once the data was cleaned (table 4). Data from 70% of each class was utilized for training, while data from 30% of each class was tested.

Table 4.

No. Of training and testing images.

S. No	Classes	No. of Training Images	No. of Testing Images
1.	Health images	200	200
2.	Lesion images	400	100
	Total	600	300

4. Feature Extraction

4.1. K-Mean Clustering

A clustering approach is employed to detect lesions in the resampled image from the preceding section. This segmentation technique utilizes K-means clustering as its grouping algorithm, depending on color. To lower the cluster sum of squares, all pixels in the picture are initially assigned to a cluster, and then the cluster pixels are updated based on the new mean for each cluster. The below equation is utilized to assign a pixel to a certain cluster [45];

$$S_{i(t)} = \{ x_p : \| x_p - m_{i(t)} \|^2 \leq \| x_p - m_{j(t)} \|^2 \forall j, 1 \leq j \leq k \} \quad (1)$$

Where x_p = observation,

$S^{(t)}$ = Cluster,

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (3)$$

Step 3: Utilize K-Means Clustering to Characterize the Colors in 'a*b*' Space. The 'a*b*' color space contains all of your object's color information, which means that each pixel has a 'a*' and 'b*' value. To utilize 'imsegkmeans', convert the data to a single data type. Imsegkmeans provides an index, or label, corresponding to a cluster for each item in your input. All pixels in a picture should be labelled.

Step 4: Develop images that Segment the H&E Image by Color.

Step 5: Nuclei should be segmented. The blue items are included in Cluster 3. Take note of the contrast between dark and bright blue things. Using the 'L*' layer in the L*a*b* color space, you can distinguish dark blue from light blue. The nuclei of the cells exhibit a dark blue color. Each color has its own brightness value stored in the "L*" layer. Extraction and thresholding of the brightness values of pixels in this cluster using 'imbinarize' with a global threshold. The indices of pixels with light skin may be derived using the mask is light blue. Take a mask of blue items, mask3, and remove the pixels of light skin from the mask by copying and pasting. Make use of the new mask to alter the original picture and then show the result.

5. Classifiers

5.1. Neural Networks

A neural network, commonly referred to as an artificial neural network, is a flexible system that acquires knowledge by utilizing interconnected nodes or neurons organized in layers. Neural networks can acquire the ability to recognize patterns, classify data, and make predictions about future occurrences through the process of learning from data. Neural networks are highly suitable for representing complex relationships and are extensively employed in speech, vision, and control systems to identify patterns and classify signals. Neural networks may be utilized for both supervised learning, which includes classification and regression, as well as unsupervised learning, which involves pattern recognition and clustering. The model parameters are obtained by assigning weights to the neural network through a process of "learning" on training data. This is often done by reducing prediction error through the optimization of weights [47].

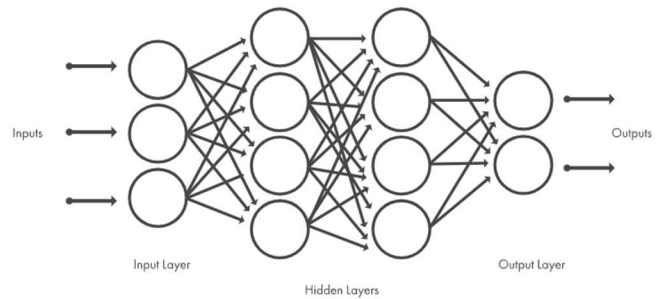


Fig. 5. Concept of layers in neural network [47].

The hidden layer possesses the ability to transform the input into the desired output. Comprehending the concealed layer necessitates familiarity with weights, bias, and functions for activation. Weight plays a crucial role in determining how an input affects the output. This is analogous to the slope in linear regression, where the weight is multiplied by the input to contribute to the formation of the output. Output is in this form:

$$Y = f(x) = \sum x_i w_i \quad (4)$$

Where i is the index of number of neurons. It is not similar to the multiple regression model as the multiple regression model's index refers to the number of variables [47, 48].

Bias might be likened to the residual error that is introduced in a linear equation. The extra parameter is utilized to modify the output in conjunction with the weighted sum of the inputs to the neuron.

$$\text{Output} = \text{sum}(\text{weights} * \text{inputs}) + \text{bias} \quad (5)$$

An activation function is applied to this output, and the function is termed activation function. As can be seen in figure 6, the output of the neurons in the layer below the current one serves as the input for the layer that comes after it [49].

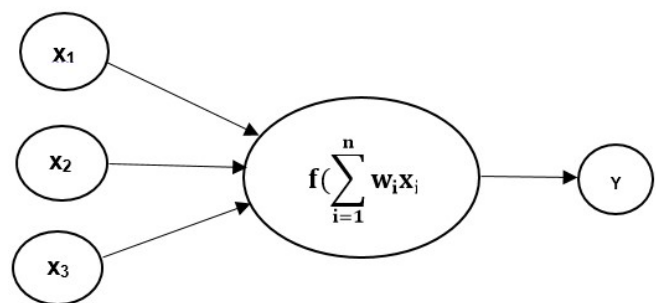


Fig. 6. Activation function.

5.2. *K*-Nearest Neighbor

KNN, short for *K* Nearest Neighbors, is a well recognized classification method in the industry due to its simplicity and high accuracy. *K*-nearest neighbors (KNN) is a straightforward technique that saves all current instances and categorizes new instances by using a similarity metric, such as distance functions. KNN has been utilized as a non-parametric approach in statistical estimates and pattern identification. The system categorizes comparable values that appear in close proximity. In the KNN model, *K* represents the quantity of closest neighbors. The number of neighbors is the primary determinant in making a decision. Typically, when there are 2 classes, the value of *K* is chosen to be an odd integer [50]. First, we locate the point that is closest to *P* and then assign the label of the nearest point to *P*. Next, we identify the *k* nearest points to *P* and subsequently categorize the points based on the majority votes of its *K* neighbors. Each item casts a vote for its respective class, and the prediction is determined by the class with the highest number of votes. In order to locate the nearest comparable points, we employ distance measures such as Euclidean distance, Hamming distance, Manhattan distance, and Minkowski distance to calculate the distance between points [51]. The Euclidean approach has been opted for in the current research. The Euclidean distance formula is as follows:

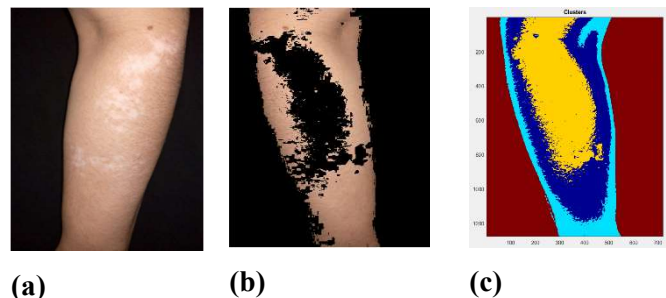
$$D = \sqrt{\sum_{i=1}^k (x_i - y_i)^2} \quad (6)$$

The selection of the number of neighbors (*K*) in the *K*-nearest neighbors (KNN) algorithm is a crucial hyperparameter throughout the model construction process. *K* may be seen as an independent variable that has control on the prediction model. Optimizing the value for *K* is most effectively achieved by initially examining the data. Typically, a higher value of *K* provides greater precision by minimizing total noise, however there is never absolute assurance. Cross-validation is a method used to estimate an optimal *K* value by retroactively validating it using an independent dataset. Traditionally, the most suitable value for *K* in most datasets has ranged from 1 to 10 [52]. That yields much superior outcomes compared to 1NN (with *K*=1). Typically, an odd number is selected when the total number of classes is an even number. In addition, we evaluate the model's performance by creating it with various values of *K*.

6. Results

The project was developed and evaluated using a machine equipped with a 2GHz CPU, 4GB RAM, and a 64-bit operating system utilizing MATLAB R2018b. The average computing time required to segment the lesion from the photos using this technique is 3.15 seconds. The calculation time of the recommended technique in constructing a system for identifying skin disorders using image processing technologies is a significant and valuable addition. The method of feature extraction is discussed in section 3.2 (figure 7). The segmented nuclei in numeric from the image matrix used for the classification and these results are also published in the IEEE conference by the same author (N.M) [53]. The training and testing data are divided into 70% and 30% respectively.

Distance from the image centre eliminates false positives. After then, the final lesion centroid is in a specific zone around that location in the photo. Clustering produces some false-positive pixels. Noisy pixels may be caused by skin hair and uneven illumination. Hair-related products are smaller than mole-related ones. Area-based thresholding eliminates them. A hole filling operation is performed on the resulting picture to improve segmentation accuracy and ensure that the image centroid is only on the image that will be calculated to pick the mole from all segmented objects. Eliminating false positives requires finding each item's centroid. All photographs analyzed show the lesion centrally. Thus, the binary image's final lesion was chosen by distance. Estimated distance separates each object's centroid from the image center. Only items within an allowed range are moles.



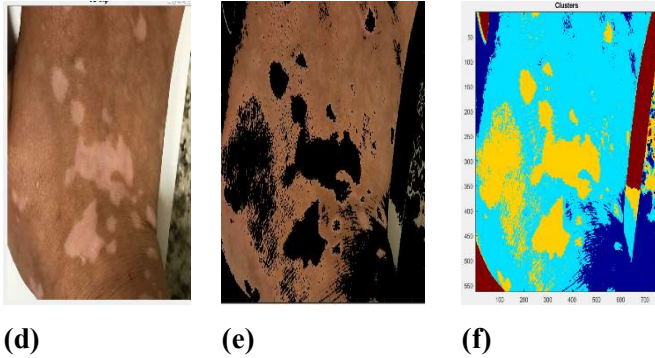
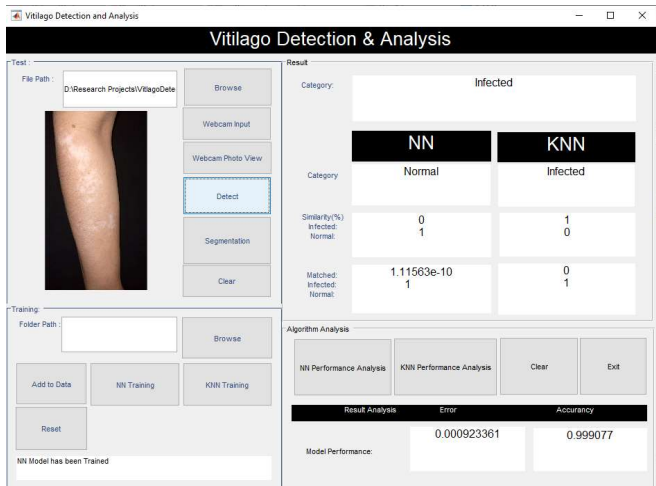


Fig. 7 (a-f). Results of feature extraction [53].

Figure 8a is the snapshot of GUI made in MATLAB for the current research. The proposed system is tested for the skin lesion of subject 1. Figure 8b shows that KNN detects the skin lesion and model performance accuracy is 99% when K=1 while NN fails to detect the vitiligo lesion hence the accuracy is 53.2% in figure 8c. This represents the model accuracy of NN that it's a weak and needs more data and training as compared to KNN which has presented the highest accuracy throughout the testing. Table 5 shows the accuracy of all 18 subjects at all three stages of capturing images of skin lesions. This table shows the results of the testing of the algorithms individually for each subject. Whereas, figure 9 (a-c) shows the confusion matrix when the algorithm were tested on whole dataset at once and figure 10 shows the ROC's of all the testing.



(a)

Result Analysis	Error	Accuracy
Model Performance:	0.000923361	0.999077

(b)

Result Analysis	Error	Accuracy
Model Performance:	0.467221	0.532779

(c)

Fig 8. (a) MATLAB GUI of the project, (b) kNN individual subject model performance, and (c) NN individual subject model performance.

Table 5.

Model performance of all 18 subjects tested from the gui in figure 8 at all three stages.

	NN			KNN when K = 1			KNN when K = 2		
	St ag e 1	Sta ge 2	Sta ge 3	Sta ge 1	Sta ge 2	Sta ge 3	Sta ge 1	Sta ge 2	Sta ge 3
1	I	I	I	I	I	I	I	I	I
2	I	I	I	I	I	I	I	I	I
3	NI	NI	NI	I	I	I	I	I	I
4	I	I	NI	I	I	NI	NI	I	NI
5	NI	NI	NI	I	I	I	I	I	I
6	I	I	I	I	I	I	NI	I	I
7	I	NI	NI	I	I	I	NI	I	NI
8	I	I	I	I	I	NI	I	I	NI
9	NI	NI	NI	I	I	I	I	I	I
10	I	NI	NI	I	I	I	I	I	I
11	NI	NI	NI	NI	NI	NI	NI	NI	NI
12	I	I	NI	I	I	I	I	I	I
13	I	I	I	I	I	I	I	NI	I
14	NI	I	NI	I	I	I	I	I	I
15	NI	NI	NI	I	I	I	I	I	NI
16	NI	NI	NI	I	I	I	I	I	I
17	I	I	I	NI	NI	NI	NI	NI	NI
18	I	I	I	I	I	I	I	I	I

276 42.5%	59 9.1%	82.4% 17.6%
60 9.2%	254 39.1%	80.9% 19.1%
82.1% 17.9%	81.2% 18.8%	81.7% 18.3%

(a) K = 1

442 40.8%	108 10.0%	80.4% 19.6%
123 11.4%	410 37.9%	76.9% 23.1%
78.2% 21.8%	79.2% 20.8%	78.7% 21.3%

(b) K = 2

89 41.0%	19 8.8%	82.4% 17.6%
36 16.6%	73 33.6%	67.0% 33.0%
71.2% 28.8%	79.3% 20.7%	74.7% 25.3%

(c) NN

Figure 9. (a) kNN (when k=1) overall performance confusion matrix (b) kNN (when k=2) overall performance confusion matrix, and (c) NN overall performance confusion matrix.

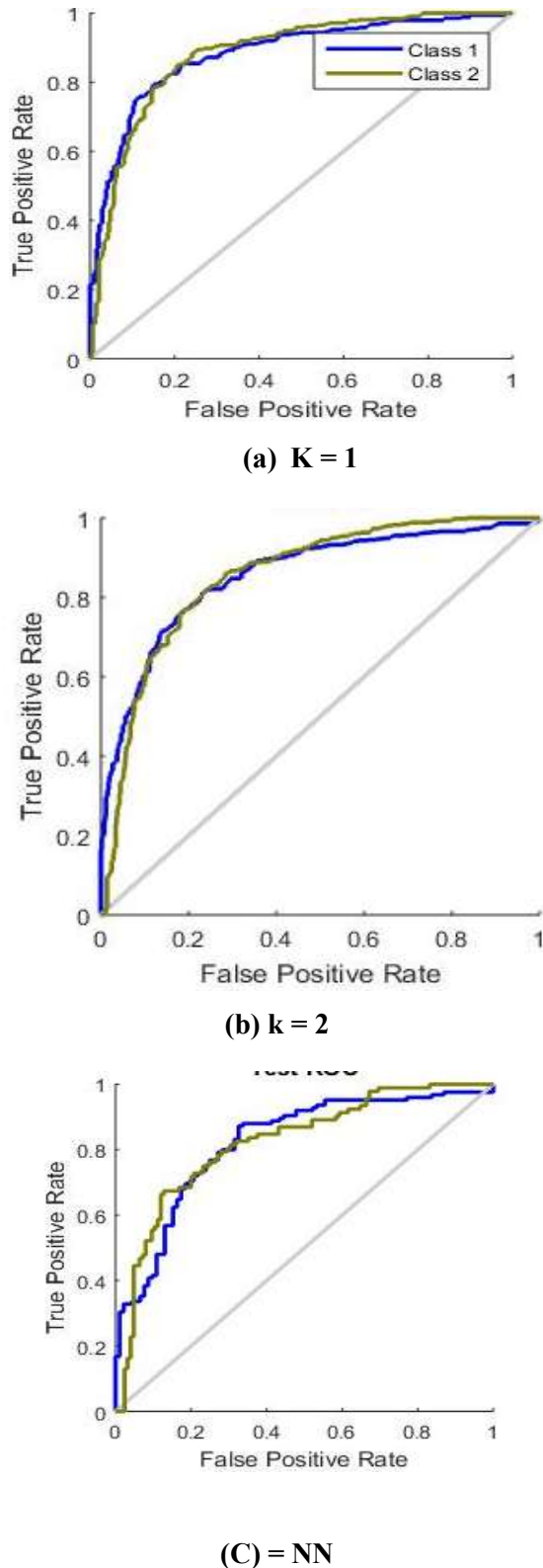


Figure 10. (a) kNN (when $k=1$) overall performance ROC (b) kNN (when $k=2$) overall performance ROC, and (c) NN overall performance ROC.

7. Discussion and Limitations

Similar approach of feature extraction method was opted by Gupta et al. in [42] but the researchers opted for Bregman divergence based agglomerative clustering method and in the propose method, k-means clustering method is used. A number of skin disorders can only be diagnosed with any degree of certainty by the use of quantitative and objective examination of skin lesions. We initially measured data from individuals with vitiligo or melasma skin lesions to ensure our approach was applicable to clinical settings, and then we measured parameters from a group of healthy people to verify our results. The system's overarching goal guided the decision to focus on these particular disorders for analysis. Dermatologists can readily diagnose these conditions based on visible symptoms and the known variability in their underlying parameters (melanin) [54].

One of the key contributions of this study was the utilization of data augmentation techniques to increase the diversity and size of the dataset. By applying cropping, flipping, and rotation operations to the original images, we were able to generate a larger dataset that better captured the variations in vitiligo lesions. This augmentation process helped improve the generalization capability of the machine learning model and contributed to its enhanced performance. In the preprocessing stage, we employed various image processing operations to enhance the suitability of the RGB images for feature extraction and classification. The color thresholding technique played a crucial role in creating a binary mask and composite image that highlighted the vitiligo lesions. By transforming the RGB images into the Lab color space, we were able to achieve better differentiation between the lesion and surrounding skin pixels. This preprocessing step proved to be effective in isolating the vitiligo lesions and reducing the influence of irrelevant information in the images.

To determine how long patients treated with excimer laser for vitiligo using an incremental dosage method would need to undergo the process of repigmentation before reaching a certain degree of improvement. To create a mathematical model using the results of a recent randomized clinical study, it was required to first hypothesize a linear connection between time and repigmentation rate. Furthermore, additional factors had to be replicated because of the necessity to address lesion-intrinsic aspects including location and size. The final testing revealed this restriction to be problematic after we normalized performance measures for patient



membership using a regularization strategy meant to enhance generalization capacity [34]. We are aware that there are several significant drawbacks to the proposed research. To begin, we assumed that the rate of repigmentation was about linear. For our randomized experiment to establish this premise, it would need to last longer than our 12-week study. Secondly, since we are using data from a randomized experiment to choose which variables to use, our selection of which factors to evaluate may be arbitrary. In the end, we got the training of neural networks by using a variety of random beginning weights. However, we obtained more than one optimum result, suggesting that the neural network issue has more than one spatial solution. The selecting process has similar issues. This was a crucial stage, and various solutions may be reached by selecting from among several subsets of optimum predictors [55, 56]. The development of a more accurate prediction model for vitiligo treatment may depend on the availability of a bigger database detailing the characteristics of vitiligo lesions and their responses to excimer laser therapy.

In most cases of vitiligo, repigmentation after therapy is slow and gradual [57]. Having a formula that can anticipate how well a patient would respond clinically would be a huge help in managing people with vitiligo. Unfortunately, there hasn't been any effort at formally developing a prediction rule for vitiligo, and only a small number of research have evaluated the characteristics linked with clinical response [58, 37]. Our research sheds light on the challenges of clinical prediction in vitiligo and suggests a method for estimating the number of excimer laser treatments needed to achieve repigmentation.

It is crucial to recognize that other methods, particularly image segmentation approaches based on deep learning also have potential. KNN and NN algorithms were chosen by the author [NN] due to their fundamental character in computer vision and machine learning. KNN is a straightforward and intuitive algorithm for calculating the distances between data points, making it suitable for classification tasks. NN, on the other hand, is a flexible method capable of discovering intricate patterns and relationships within the data. Notably, however, deep learning-based image segmentation techniques, such as Convolutional Neural Networks (CNNs), have attracted a great deal of interest and demonstrated extraordinary performance in a variety of computer vision tasks, including medical image analysis. These methods utilize the power of deep neural networks to automatically learn and extract relevant features from input data, resulting in highly accurate

segmentation results.

However, it is important to acknowledge the limitations of this study. Firstly, the dataset size was relatively small, which may affect the generalizability of the developed model. To address this limitation, future work should focus on expanding the dataset to include a larger number of samples, as well as a wider range of vitiligo lesion types. This would enhance the model's ability to accurately detect and classify different variations of vitiligo. Another limitation is the reliance on images captured under controlled lighting conditions using a specific camera. Real-world scenarios often involve varying lighting conditions and different camera types, which may impact the performance of the system. Further evaluation and optimization of the system's performance in such real-world conditions are necessary to ensure its practicality and effectiveness in a clinical setting.

8. Conclusion

In the process of identifying skin growths through the utilization of image preparation procedures, one of the most important challenges is the accurate segmentation of the skin lesion. It is possible to segment images of skin lesions by the use of a procedure that is completely automated. When the channels of the L^*a^*b color space are strategically mixed, it is much simpler to understand the differences between skin lesions and the background. Using the centroid of each item, any false positives that are still present are removed. The fact that the proposed technique produced accurate results that were satisfactory is a clear indication of the potential of this method. It takes an average of 3.15 seconds for this method to segment the lesion from the pictures. This method has the potential to be applied for specific real-time applications in the segmentation of skin lesions from digital images.

9. Future Recommendation

Future research in skin lesion segmentation could explore the potential of deep learning-based methods, particularly CNNs, as they have shown promising results in segmenting complex and diverse image datasets. The integration of large annotated datasets and advanced network architectures could further enhance the accuracy and robustness of the segmentation process.

Also to add saliency-based costs to the framework so that we can find stable regions and keep them from merging in the future. On a more general clinical level, we'd like to look into ways to automatically identify the stages of VETF depigmentation, so that the whole



pipeline can be automated with as little user input as possible.

10. Ethics Approval and Consent to Participate

This study is ethically approved by Ethics Review Committee (ERC), Ziauddin University, Pakistan. The ethical approval no. is 3260221NMBME.

11. Consent For Publication

Informed consent was taken from every person who contributed to this study.

12. Availability Of Data and Material

The details of the data and material are available within this article.

13. Funding

None.

14. Conflict Of Interest

The authors declare no conflict of interest, financial or otherwise.

15. Acknowledgment

Declared none.

16. Reference

- [1] G. K. Jana, A. Gupta, A. Das, R. Tripathy, and P. Sahoo, "Herbal treatment to skin diseases: A global approach," *Drug Invention Today*, vol. 2, no. 8, pp. 381–384, 2010.
- [2] J. Arroyo and B. Zapirain, "Computer Vision Techniques for the Diagnosis of Skin Cancer," in *Series in BioEngineering*, J. Scharcanski and M. E. Celebi, Eds. Springer, 2014, pp. 139–192.
- [3] C. Bergqvist and K. Ezzedine, "Vitiligo: A review," *Dermatology*, vol. 236, no. 6, pp. 571–592, 2020.
- [4] "Vitiligo," *Medlineplus.gov*. [Online]. Available: <https://medlineplus.gov/genetics/condition/vitiligo/>. [Accessed: 19-Nov-2022].
- [5] M. L. Frisoli, K. Essien, and J. E. Harris, "Vitiligo: Mechanisms of pathogenesis and treatment," *Annu. Rev. Immunol.*, vol. 38, no. 1, pp. 621–648, 2020.
- [6] R. Zubair and I. H. Hamzavi, "Phototherapy for vitiligo," *Dermatol. Clin.*, vol. 38, no. 1, pp. 55–62, 2020.
- [7] T. Searle, F. Al-Niaimi, and F. R. Ali, "Vitiligo: an update on systemic treatments," *Clin. Exp. Dermatol.*, vol. 46, no. 2, pp. 248–258, 2021.
- [8] A. F. Nahhas, T. L. Braunberger, and I. H. Hamzavi, "Update on the management of vitiligo," *Skin Therapy Lett.*, vol. 24, no. 3, pp. 1–6, 2019.
- [9] E. L. Katz and J. E. Harris, "Translational research in vitiligo," *Front. Immunol.*, vol. 12, p. 624517, 2021.
- [10] V. M. Sheth, R. Rithe, A. G. Pandya, and A. Chandrakasan, "A pilot study to determine vitiligo target size using a computer-based image analysis program," *J. Am. Acad. Dermatol.*, vol. 73, no. 2, pp. 342–345, 2015.
- [11] "Different types of Vitiligo," *Vitiligo Support International*, 11-May-2019. [Online]. Available: <https://vitiligosupport.org/different-types-of-vitiligo/>. [Accessed: 19-Nov-2022].
- [12] "Vitiligo Types," *Globalvitiligofoundation.org*. [Online]. Available: <https://globalvitiligofoundation.org/types-of-vitiligo/>. [Accessed: 19-Nov-2022].
- [13] Z. Bian, S. Xia, C. Xia, and M. Shao, "REMOVED: VitSeg: Weakly supervised vitiligo segmentation in skin image," *Comput. Med. Imaging Graph.*, vol. 85, no. 101779, p. 101779, 2020.
- [14] Q. Abbas, I. F. Garcia, M. Emre Celebi, W. Ahmad, and Q. Mushtaq, "A perceptually oriented method for contrast enhancement and segmentation of dermoscopy images," *Skin Res. Technol.*, vol. 19, no. 1, pp. e490-7, 2013.
- [15] D. J. Gawkrödger, "Vitiligo: concise evidence based guidelines on diagnosis and management," *Postgrad. Med. J.*, vol. 86, no. 1018, pp. 466–471, 2010.
- [16] A. Taïeb, M. Picardo, and VETF Members, "The definition and assessment of vitiligo: a consensus report of the Vitiligo European Task Force," *Pigment Cell Res.*, vol. 20, no. 1, pp. 27–35, 2007.
- [17] A. Feily, "Vitiligo Extent Tensity Index (VETI) score: a new definition, assessment and treatment evaluation criteria in vitiligo," *Dermatol. Pract. Concept.*, vol. 4, no. 4, pp. 81–84, 2014.



- [18] F. Aydin, N. Senturk, B. Sahin, Y. Bek, E. P. Yuksel, and A. Y. Turanli, "A practical method for the estimation of vitiligo surface area: a comparison between the point counting and digital planimetry techniques," *Eur. J. Dermatol.*, vol. 17, no. 1, pp. 30–32, 2007.
- [19] G. Verma, S. R. Varkhande, H. K. Kar, and R. Rani, "Evaluation of repigmentation with cultured melanocyte transplantation (CMT) compared with non-cultured epidermal cell transplantation in vitiligo at 12th week reveals better repigmentation with CMT," *J. Invest. Dermatol.*, vol. 135, no. 10, pp. 2533–2535, 2015.
- [20] "What you need to know about vitiligo," The Vitiligo Society, 03-May-2020. [Online]. Available: <https://vitigosociety.org/about-vitiligo/>. [Accessed: 19-Nov-2022].
- [21] "Vitiligo treatment in Faridabad," Kdcclinic.com. [Online]. Available: <https://kdcclinic.com/services/vitiligo-treatment>. [Accessed: 30-Jun-2023].
- [22] A. Şenol, A. D. Yücelten, and P. Ay, "Development of a quality of life scale for vitiligo," *Dermatology*, vol. 226, no. 2, pp. 185–190, 2013.
- [23] V. Gupta, V. Sreenivas, M. Mehta, B. K. Khaitan, and M. Ramam, "Measurement properties of the Vitiligo Impact Scale-22 (VIS-22), a vitiligo specific quality-of-life instrument," *Br J Dermatol*, vol. 171, pp. 1084–1090, 2014.
- [24] V. Gupta, V. Sreenivas, M. Mehta, B. K. Khaitan, and M. Ramam, "Measurement properties of the Vitiligo Impact Scale-22 (VIS-22), a vitiligo specific quality-of-life instrument," *Br J Dermatol*, vol. 171, pp. 1084–1090, 2014.
- [25] E. Lilly et al., "Development and validation of a vitiligo-specific quality-of-life instrument (VitiQoL)," *J. Am. Acad. Dermatol.*, vol. 69, no. 1, pp. e11-8, 2013.
- [26] J. M. Batchelor, W. Tan, S. Tour, A. Yong, A. A. Montgomery, and K. S. Thomas, "Validation of the Vitiligo Noticeability Scale: a patient-reported outcome measure of vitiligo treatment success," *Br. J. Dermatol.*, vol. 174, no. 2, pp. 386–394, 2016.
- [27] L. Komen, G. E. van der Kraaij, J. P. W. van der Veen, M. A. de Rie, and A. Wolkerstorfer, "The validity, reliability and acceptability of the SAVASI; a new self-assessment score in vitiligo," *J. Eur. Acad. Dermatol. Venereol.*, vol. 29, no. 11, pp. 2145–2151, 2015.
- [28] I. Hamzavi, H. Jain, D. Mclean, J. Shapiro, H. Zeng, and H. Lui, "Parametric modelling of narrowband UV-B phototherapy for vitiligo using a novel quantitative tool: the Vitiligo Area Scoring Index," *Arch Dermatol*, vol. 140, pp. 677–683, 2004.
- [29] L. Komen, V. da Graça, A. Wolkerstorfer, M. A. de Rie, C. B. Terwee, and J. P. W. van der Veen, "Vitiligo Area Scoring Index and Vitiligo European Task Force assessment: reliable and responsive instruments to measure the degree of depigmentation in vitiligo," *Br. J. Dermatol.*, vol. 172, no. 2, pp. 437–443, 2015.
- [30] N. van Geel et al., "Development and validation of the Vitiligo Extent Score (VES): An international collaborative initiative," *J. Invest. Dermatol.*, vol. 136, no. 5, pp. 978–984, 2016.
- [31] C. Vrijman et al., "Measurement properties of outcome measures for vitiligo. A systematic review: A systematic review," *Arch. Dermatol.*, vol. 148, no. 11, pp. 1302–1309, 2012.
- [32] I. Hamzavi, H. Jain, D. McLean, J. Shapiro, H. Zeng, and H. Lui, "Parametric modeling of narrowband UV-B phototherapy for vitiligo using a novel quantitative tool: the Vitiligo Area Scoring Index: The vitiligo area scoring index," *Arch. Dermatol.*, vol. 140, no. 6, pp. 677–683, 2004.
- [33] A. S´aez, B. Acha, and C. Serrano, "Computer Vision Techniques for the Diagnosis of Skin Cancer," in *Series in BioEngineering*, J. Scharcanski and M. E. Celebi, Eds. Springer, 2014, pp. 23–48.
- [34] S. Cazzaniga, F. Sassi, S. R. Mercuri, and L. Naldi, "Prediction of clinical response to excimer laser treatment in vitiligo by using neural network models," *Dermatology*, vol. 219, no. 2, pp. 133–137, 2009.
- [35] J. Anthal, A. Upadhyay, and A. Gupta, "Detection of vitiligo skin disease using LVQ neural network," in *2017 International Conference on Current Trends in Computer*,



- Electrical, Electronics and Communication (CTCEEC), 2017.
- [36] M. Low, V. Huang, and P. Raina, "Automating vitiligo skin lesion segmentation using convolutional neural networks," in 2020 IEEE 17th International Symposium on Biomedical Imaging (ISBI), 2020.
- [37] J. F. Chica, S. Zaputt, J. Encalada, C. Salamea, and M. Montalvo, "Objective assessment of skin repigmentation using a multilayer perceptron," *J. Med. Signals Sens.*, vol. 9, no. 2, pp. 88–99, 2019.
- [38] E. E. Kislal and C. L. Halasz, "Software for quantifying psoriasis and vitiligo from digital clinical photographs," *J. Dermatolog. Treat.*, vol. 24, no. 2, pp. 107–111, 2013.
- [39] N. Shamsudin, S. H. Hussein, H. Nugroho, and M. H. A. Fadzil, "Objective assessment of vitiligo with a computerised digital imaging analysis system: Vitiligo assessment," *Australas. J. Dermatol.*, vol. 56, no. 4, pp. 285–289, 2015.
- [40] Z. Bian, S. Xia, C. Xia, and M. Shao, "Weakly supervised vitiligo segmentation in skin image through saliency propagation," in 2019 IEEE International Conference on Bioinformatics and Biomedicine (BIBM), 2019.
- [41] T. Gupta, S. Saini, A. Saini, S. Aggarwal, and A. Mittal, "A deep learning framework for recognition of various skin lesions due to diabetes," in 2018 International Conference on Advances in Computing, Communications and Informatics (ICACCI), 2018.
- [42] M. Das Gupta, S. Srinivasa, J. Madhukara, and M. Antony, "KL divergence based agglomerative clustering for automated Vitiligo grading," in 2015 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2015.
- [43] C. Shorten and T. M. Khoshgoftaar, "A survey on image data augmentation for deep learning," *J. Big Data*, vol. 6, no. 1, 2019.
- [44] C. Shorten, T. M. Khoshgoftaar, and B. Furht, "Text Data Augmentation for Deep Learning," *J. Big Data*, vol. 8, no. 1, p. 101, 2021.
- [45] A. Agarwal, A. Issac, M. K. Dutta, K. Riha, and V. Uher, "Automated skin lesion segmentation using KMeans clustering from digital dermoscopic images," in 2017 40th International Conference on Telecommunications and Signal Processing, .
- [46] M. Greenacre, "Euclidean Distance," in *International Encyclopedia of Education*, Elsevier, 2010, pp. 103–111.
- [47] C. M. Shufflebarger, "What is a neural network?," *Ann. Emerg. Med.*, vol. 21, no. 12, pp. 1461–1462, 2021.
- [48] "Pretrained networks for images - MATLAB & Simulink," Mathworks.com. [Online]. Available: https://www.mathworks.com/help/deeplearning/pretrained-networks-for-images.html?s_tid=CRUX_topnav. [Accessed: 28-Jan-2023].
- [49] V. Sharma, "Deep learning model data visualization using Matplotlib," *Pluralsight.com*. [Online]. Available: <https://www.pluralsight.com/guides/data-visualization-deep-learning-model-using-matplotlib>. [Accessed: 28-Jan-2023].
- [50] S. Uddin, I. Haque, H. Lu, M. A. Moni, and E. Gide, "Comparative performance analysis of K-nearest neighbour (KNN) algorithm and its different variants for disease prediction," *Sci. Rep.*, vol. 12, no. 1, p. 6256, 2022.
- [51] H. Saadatfar, S. Khosravi, J. H. Joloudari, A. Mosavi, and S. Shamshirband, "A new K-nearest neighbors classifier for big data based on efficient data pruning," *Mathematics*, vol. 8, no. 2, p. 286, 2020.
- [52] Z. Lubis, P. Sihombing, and H. Mawengkang, "Optimization of K Value at the K-NN algorithm in clustering using the expectation maximization algorithm," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 725, no. 1, p. 012133, 2020.
- [53] N. Mehmood, S. J. Khan, and M. Rashid, "K-means clustering-based color segmentation on vitiligo skin lesion," in 2022 International Conference on Emerging Trends in Smart Technologies (ICETST), 2022.
- [54] R. Jolivot, Y. Benezeth, and F. Marzani, "Skin parameter map retrieval from a dedicated multispectral imaging system applied to dermatology/cosmetology," *Int. J. Biomed. Imaging*, vol. 2013, p. 978289, 2013.
- [55] J. F. Lawless and M. Fredette, "Frequentist prediction intervals and predictive distributions,"



Biometrika, vol. 92, no. 3, pp. 529–542, 2005.

- [56] H. Kwasnicka and K. Michalak, “Correlationbased feature selection strategy in neural classification,” ISDA Proc, vol. 1, pp. 741–746, 2006.
- [57] H. W. Lim and C. L. Hexsel, “Hexsel CL: Vitiligo: to treat or not to treat,” Arch Dermatol, vol. 143, pp. 643–646, 2007.
- [58] E. Nicolaidou, C. Antoniou, J. S. Alexander, and C. Stefanaki, “Katsambas AD: Efficacy, predictors of response, and long-term follow-up in patients with vitiligo treated with narrowband UVB phototherapy,” J Am Acad Dermatol, vol. 56, pp. 274–278, 2007



INVESTIGATION ON PERFORMANCE OF GEOTHERMAL COOLING SYSTEM IN BUILDINGS

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KEY WORDS

Geothermal cooling system
Prototype
Copper pipe
Co-efficient of performance

ABSTRACT

The objective of this research work was to highlight the benefits of adopting geothermal cooling systems in buildings. In this regard, initially a model was created considering the temperatures of local vicinity, which was then turned to a small prototype. This involved a network of copper pipe with carefully selected materials and designed buried in the saturated soil in a small water tank. The literature shows that the soil temperature at a specific depth throughout the year is stable, regardless of external temperature fluctuations, presents a unique opportunity to explore various methods of harnessing ground energy for cooling purposes. Among the various heat transfer mediums available, air is commonly used to extract energy from the ground during the summer season. The research involved evaluating the soil temperatures at a specific depth, selecting appropriate piping materials and configurations, and experimentally determining the coefficient of performance (COP) of the installed system. The developed working prototype was found to achieve an average temperature gradient of 33°C that without the system was above 40°C.

1. Introduction

Due to the environmental concerns associated with fossil fuels, renewable energy sources have gained significant attention from energy policymakers in recent years. These renewable energy sources serve various purposes, including desalination, heating, and electricity generation [1,2]. Among the different types of renewable energy, geothermal energy stands out as one of the most accessible in various regions worldwide. It harnesses the thermal energy stored in the ground and can be utilized as a heat source in heat pumps [3–4]. This not only reduces fuel costs but also lowers greenhouse gas (GHG) emissions.

Geothermal Heat Pumps, also known as Ground Source Heat Pumps (GSHP), essentially consist of a system for exchanging heat with the ground and a heat pump (see

Figure 1). These systems can be designed with either a groundwater-fed system or a ground heat exchanger. The heat is extracted from the ground using methods such as groundwater wells, Borehole Heat Exchangers (BHE), "geo-structures," and horizontal heat exchanger pipes, extending up to 100 meters [5,6]. Extensive theoretical and experimental research has been conducted over the years to establish a solid foundation for evaluating the performance and design of BHE systems [5,7]. Figure 1 illustrates a typical BHE setup. These systems utilize the ground as a heat source in heating mode, with a fluid medium conveying heat from the ground to the heat pump evaporator. In cooling mode, they use the ground as a heat sink. GSHPs currently require 0.22–0.35 kWh of electricity for every kWh of cooling or heating produced, which is 30–50% less than the seasonal energy consumption of air-to-air



heat pumps that rely on the ambient air as a heat sink/source. The use of heat pumps for cooling and heating applications in buildings and other contexts can lead to reduced CO₂ emissions and energy consumption compared to conventional systems, depending on the specific case [8,9]. Additionally, GSHPs, by employing geothermal technology, can reduce emissions of other undesirable gases such as SO₂, H₂S, and NH₃ [10,11]. The Coefficient of Performance (COP) measures the ratio of useful energy output to the electricity input of a heat pump under specified operating conditions. The COP is influenced by several factors, including the temperature of the input water from the ground circuit, which depends on technical parameters and geological conditions. Other variables affecting the COP of a heat pump include the cooling/heating load, the type of building cooling/heating system, and the corresponding resource temperatures. BHEs, operating at depths less than 10 meters, benefit from the earth's consistent temperature over time, with slight increases with depth beneath the surface. As a result, they exhibit superior energy efficiency and performance compared to horizontal earth heat exchangers. Several parameters impact the efficiency and COP of GSHPs, including the temperatures of the heat sink and heat source (which vary by case study), system design, and soil properties affecting heat transfer. For instance, a study by Zhang et al. [12] demonstrated that the COP of a heat pump system can vary within the range of 3.36–5.94 under different operating conditions. Design parameters like BHE design play a critical role in GSHP operation due to their influence on heat transfer [13,14]

2. Geothermal Cooling System

The term "Geothermal" originates from the fusion of "Geo," signifying earth, and "Thermal," representing heat. The earth's heat results from both gravitational compression and the radioactive decay of isotopes. The geothermal system, also referred to as a Geo-exchange system, operates based on the fundamental principle of heat pumps, utilizing the stable temperature of the earth to provide both heating and cooling. Ground loops are employed to establish a connection between the ground and the space to facilitate heating or cooling applications [15]. Additionally, it's worth noting that the temperature of the soil below a certain depth remains consistently stable [16], offering a constant temperature of around 16°C throughout the year at a depth of approximately 6-8 meters. Historically, air conditioning systems were seen as symbols of luxury. However, in today's rapidly evolving world, they have become an essential necessity. The residential and commercial sectors account for more

than 30% of total electricity consumption, with Heating, Ventilation, and Air Conditioning (HVAC) systems responsible for 64% of this consumption. With the ever-increasing demand for HVAC, renewable energy sources have gained prominence, paving the way for the practicality of "Geothermal Heating and Cooling Systems" [15].

3. Simulation and Results

In this research on the performance of a geothermal cooling system, a systematic methodology was followed.

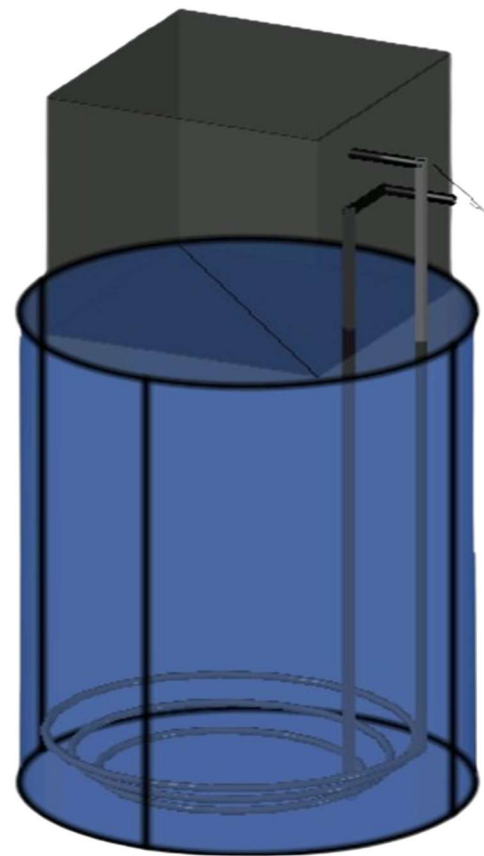


Fig. 1. Design of Geothermal Cooling System



Fig. 2. Water Tank

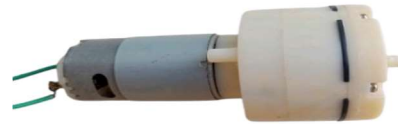


Fig. 5. Compressor



Fig. 6. Lead Acid Battery



Fig. 3. Fiber False Ceiling



Fig. 7. Ice Cubes



Fig. 4. Arrangement of Copper Pipes



Fig. 8. Soil

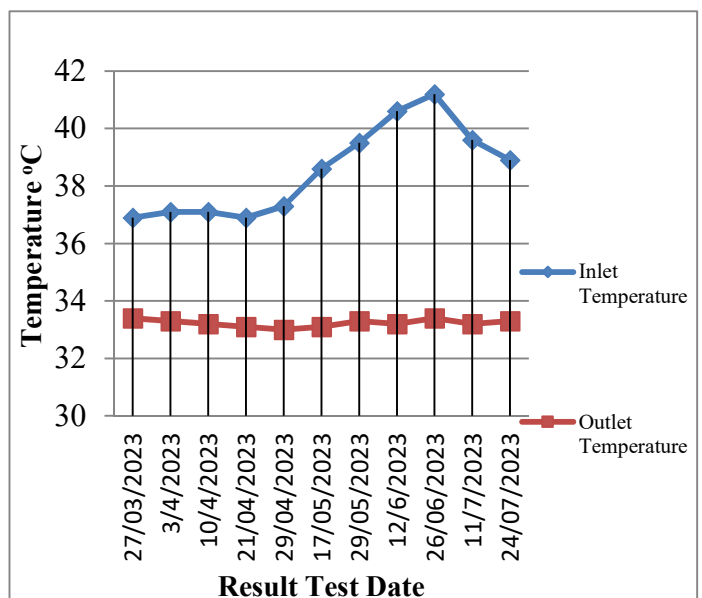


The first step involved the design of the geothermal cooling system using AutoCAD software, which allowed for detailed planning and visualization. Subsequently, a room model measuring (2x2x2)ft was constructed using fiber false ceiling sheets interconnected with nuts and bolts. To simulate the underground soil conditions, soil was placed in two layers at the bottom of the water tank, with the first layer positioned below the copper pipes and the second layer above them. The arrangement of copper pipes was a critical step, where circular copper pipes were stretched vertically and spirally to maximize air circulation. This design included 4.5ft of vertical piping from both sides and a 9ft spiral section, ensuring extended contact between the air and the copper pipes to enhance cooling efficiency. To maintain the desired temperature of 16°C, ice cubes were strategically placed within both layers of soil, creating the necessary conditions to cool the air passing through the copper pipes. For the operational phase, a sheet with inlet and outlet pipe openings was placed over the water tank, and the room model was positioned on top. The copper pipes were connected to inlet and outlet connections, enabling air circulation. Additionally, the inlet was linked to a compressor, which, in turn, was connected to a battery to supply power. This comprehensive methodology allowed for the investigation of the geothermal cooling system's performance under controlled conditions, with careful consideration of each step in the process.



Fig. 9. Working of System

Temperature measurements were conducted at both the inlet and outlet of the heat exchange system to assess the performance of the geothermal system. An initial intake of atmospheric air at 41°C was introduced into the system to evaluate its maximum effectiveness. When this air was forced into the pipe using a compressor, the inlet temperature of the air rose to 41°C. Subsequently, the system efficiently conditioned and cooled the air down to a consistent 33°C temperature. To investigate whether heat was accumulating in the soil surrounding the pipe, the system's inlet was opened to the atmosphere, allowing hot air intake for an 8-hour period from 09:00 AM to 05:00 PM. This test revealed that there was no significant heat buildup around the outer surface of the pipe, demonstrating the effective performance of the selected piping materials, which maintained nearly uniform outlet temperatures throughout the day. The geothermal cooling system, as designed and installed, displayed a notably high coefficient of performance (COP). Results indicated that the temperature at the pipe's outlet would not fall below 33°C, with 33°C being the lowest achievable temperature. On average, a temperature difference of 33°C was consistently achieved by the system. Monthly temperature variations over four months were also monitored using a compressor that drew air from the atmosphere and circulated conditioned air through the copper pipes for space conditioning. Our geothermal system successfully reduced the room temperature from 41°C to a range between 33.1°C and 33.5°C when the compressor was used as a suction device. The greatest temperature drop observed within the tested enclosure was 7°C, with recorded temperatures ranging between 33.1°C and 33.4°C.



Following table figure shows the results of geothermal cooling system, all the results were taken with help of Digital Thermometer.



Fig. 10. Average result

Sr No	Week No.	Reading Date	Reading Time	Temperature °C	
				Inlet	Outlet
01	1 st	27-03-2023	02:26 pm	36.9	33.4
02	2 nd	03-04-2023	02:34 pm	37.1	33.3
03	3 rd	10-04-2023	01:27 pm	36.7	33.2
04	5 th	21-04-2023	02:45 pm	37.1	33.1
05	7 th	29-04-2023	03:14 pm	36.9	33.0
06	09 th	17-05-2023	12:38 pm	37.3	33.1
07	11 th	29-05-2023	12:55 pm	38.6	33.3
08	13 th	12-06-2023	01:16 pm	39.5	33.2
09	15 th	26-06-2023	01:55 pm	40.6	33.4
10	17 th	11-07-2023	01:45 pm	41.2	33.2
11	19 th	24-07-2023	02:08 pm	39.6	33.4

4. Conclusion

The outcomes derived from this experiment were deemed as satisfactory. It has been deduced that in regions where the soil temperature ranges between 16 to 23°C at a depth of 6 meters below the ground surface, the implementation of a geothermal cooling system can yield highly favorable results. The geothermal system installed, along with the chosen piping materials for geothermal air cooling, managed to achieve an exceptionally optimistic coefficient of performance

(COP). An intriguing observation during our experimentation was that we obtained higher outlet temperatures with reduced airflow rates. This can be attributed to the fact that as air moves vertically towards the upper end, it reheats due to the relatively elevated temperature of the surrounding soil adjacent to the piping. To counteract this effect, it's essential to maintain an optimal mass flow rate. Considering all factors, including installation cost, excavation area, and soil characteristics, we opted for copper piping with a horizontal and spiral slinky-type loop configuration. This choice is more efficient and dependable due to its superior rigidity and resistance to chemical corrosion. Furthermore, slinky loops require less space for installation compared to an equivalent length of straight horizontal piping.

5. Reference

- [1] A. K. Jhatial, A. Khatri, S. Ali, and A. A. Babar, "Sol-gel finishing of bamboo fabric with nanoparticles for water repellency, soil release and UV resistant characteristics," *Cellulose*, vol. 26, no. 10, pp. 6365–6378, 2019, doi: 10.1007/s10570-019-02537-3.
- [2] Faegh, M., & Shafii, M.B. (2017). Experimental investigation of a solar still equipped with an external heat storage system using phase change materials and heat pipes, *Desalination*, 409, 128–135. doi:10.1016/j.desal.2017.01.023.
- [3] Arab, M., Soltanieh, M., & Shafii, M.B. (2012). Experimental investigation of extra-long pulsating heat pipe application in solar water heaters, *Experimental Thermal and Fluid Science*, 42, 6–15. doi: 10.1016/j.expthermflusci.2012.03.006. 3.
- [4] Narei, H., Ghasempour, R., & Noorollahi, Y. (2016). The effect of employing nanofluid on reducing the bore length of a vertical groundsource heat pump, *Energy Conversion and Management*, 123, 581–591. doi: 10.1016/j.enconman.2016.06.079.
- [5] Somogyi, V., Sebestyeny, V., & Nagy, G. (2017). Scientific achievements and regulation of shallow geothermal systems in six European countries—A review. *Renewable and Sustainable Energy Reviews*, 68, 934–952.
- [6] Knoblich, K., Sanner, B., & Klugescheid, M. (1993). *Energetische, hydrologische und geologische Untersuchungen zum Entzug von*



- Wärme aus dem Erdreich, Giessener Geologische Schriften, 49, Giessen, 192.
- [7] Sanner, B., Reuss, M., Mands, E., & Muller, J. (2000). Thermal response test. Experiences in Germany, Proceedings Terrastock, Stuttgart, 177–182.
- [8] Man, Y., Yang, H., Diao, N., Liu, J., & Fang, Z. (2010). A new model and analytical solutions for borehole and pile ground heat exchangers, International Journal of Heat and Mass Transfer, 53, 2593–2601.
- [9] Koroneos, C.J., & Nanaki, E.A. (2017). Environmental impact assessment of a ground source heat pump system in Greece, Geothermics, 65, 1–9.
- [10] Lucia, U., Simonetti, M., Chiesa, G., & Grisolia, G. (2017). Ground-source pump system for heating and cooling: Review and thermodynamic approach, Renewable and Sustainable Energy Reviews, 70, 867–874.
- [11] Islam, M.M., Mun, H.S., Bostami, A.B.M.R., Ahmed, S.T., Park, K.J., & Yang, C.J. (2016). Evaluation of a ground source geothermal heat pump to save energy and reduce CO₂ and noxious gas emissions in a pig house, Energy and Buildings, 111, 446–454. 28
- [12] Ahmadi, M.H., Mehrpooya, M., & Pourfayaz, F. (2016). Exergoeconomic analysis and multi objective optimization of performance of a Carbon dioxide power cycle driven by geothermal energy with liquefied natural gas as its heat sink, Energy Conversion and Management, 119, 422–434.
- [13] Zhang, S., Zhang, L., Wei, H., Jing, J., Zhou, X., & Zhang, X. (2016). Field testing and performance analyses of ground source heat pump systems for residential applications in Hot Summer and Cold Winter area in China, Energy and Buildings, 133, 615–627.
- [14] Luo, J., Zhao, H., Jia, J., Xiang, W., Rohn, J., & Blum, P. (2017). Study on operation management of borehole heat exchangers for a large-scale hybrid ground source heat pump system in China, Energy, 123, 340–352.
- [15] Rosen, M.A., & Koochi-Fayegh, S. (2017). Geothermal energy: Sustainable heating and cooling using the ground. John Wiley & Sons Ltd.
- [16] Nimish Dhepe and Raahul Krishna “A Review of the Advancements in Geothermal Heating and Cooling System”, Global Journal of Enterprise Information System. Volume-9, Issue-1, January-March, 2017.



Enhancing Home Security: A Comprehensive Approach through Machine Learning in Smart Homes

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ABSTRACT

In an age marked by technological advancements, smart homes have transformed conventional living style by adding intelligent bias into connected systems. As these smart technologies redefine our lives, the need to secure these environments becomes compulsory. Traditional home security models were somehow effective, but they do not address the evolving nature of modern difficulties, especially with the excess of Internet of Things (IoT) devices. This increasing attack requires measures to protect occupants' privacy. Machine Learning, with its systematic ability and flexibility, appears as a capable tool to enhance the efficiency of home security systems. This research aims to explore the ability of ML in automating sides like intrusion detection, anomaly recognition, and predictive analysis. By using AI capabilities, the goal is to develop security mechanisms that learn and adapt to arising risks over time. In this research, a complete review of ML algorithms suitable for home security is presented. A suggested smart home system with machine learning-driven automation focuses user comfort, energy savings, and security. This study addresses security challenges in smart home automation, particularly through intrusion detection with deep learning, and thus offering a practical and cost-effective approach to improving living quality.

1. Introduction

The concept of a "smart home" is innovative model, transforming traditional living spaces into organised systems of intelligent devices. As the addition of smart technologies continues to improve our daily lives, the importance of security becomes vital. This research paper investigates the home security, specifically focusing on the application of machine learning algorithms to automate security measures in smart homes.

This research explores the capability of machine learning in automating various sides of home security, such as intrusion detection, anomaly recognition, and predictive analysis. By using artificial intelligence, we aim to develop strong and practical security mechanisms that not only respond to known threats but also learn and adapt to emerging risks over time.

The paper examines smart home security, explaining limitations of current systems and demonstrating the need for more intelligent and adaptive

solutions. It presents a comprehensive review of ML algorithms suitable for application in the context of home security, assessing their strengths, weaknesses, and potential use cases.

By exploring, we hope to contribute to the current topic on the intersection of technology and security, offering considerations for how machine learning can play a fundamental role in protecting the security of smart homes. The outcome of this research promises of not only enhances the safety of occupants but also contributes to the evolution of strong and alert smart home systems in the face of ever-evolving security challenges.

2. Literature Review

The merging of artificial intelligence with electronics lead to brings both powerful features and challenges. We are living in an AI growing age where multiple applications including security are improving their automation and efficiency. However, they also



come with various challenges such as worries about data privacy. Thus, a careful evaluation is needed when dealing with such concerns so that there will be smooth integration of AI. The identified areas of impact, specifically in R&D, Manufacturing, and Security, underscore AI's current significance. [1]

A rising concept of effective smart home system can be helpful in addressing security concerns. Smart technologies like IoT and Artificial Intelligence can be added into the system to make it efficient, robust, and secure. You can easily control your system remotely and check it efficiently as well. Deep learning's model Convolutional Neural Network (CNN) accurately finds human movement patterns for intrusion detection and presents a promising solution, particularly in distinguishing between regular occupants and potential intruders. The system not only eases control of home appliances and environmental monitoring but also ensures robust security through IoT camera surveillance. [2]

The smart home system leverages machine learning, employing Decision Tree, K-Nearest Neighbours, and Multilayer Perceptron algorithms to predict and automate user actions, particularly in controlling curtains. The system's three modes cater to manual control, predefined automation, and intelligent, machine learning-driven prediction. Achieving high accuracies around 97%, the Decision Tree classifier was chosen for its versatility in handling varied data types. The system aligns with current IoT and home automation trends, emphasizing user comfort, energy efficiency, and security, with a distinctive focus on innovative curtain control using machine learning. [3]

The effectiveness of home automation can be improved by efficient device management, enabling remote access, perfecting resource use, and strengthening home security. A critical look at various applications highlights potential benefits such as enhanced efficiency, adaptability, and improved security measures. These findings seamlessly align with the broader theme of AI and information security in home automation, emphasizing the crucial intersection of these elements for smart living. [4]

Using supervised machine learning will be helpful in detecting unauthorized IoT devices. Methodology includes data collection, manual labelling, and training classifiers. Findings reveal high accuracy (96%), swift detection, transportability, and resilience to cyber-attacks. Critical analysis notes robustness but suggests exploring diverse devices and real-world

scenarios for practicality. Relevant to the theme, it enhances IoT security in smart homes, offering real-time threat response and applicability to home networks. [5]

The IoT's impact, convenience, and security threats are to be kept in mind while designing the system. The Methodology includes threat identification, data collection, device profiling, and defining security requirements. Findings categorize IoT applications and stress communication model security. Critical analysis notes rapid tech growth and specific threats in WSNs and RFID. [6]

Introducing an IoT-based home security system with efficient appliance control is the main concept in home automation. Findings show rapid responses, real-time data, and secure access. Critical analysis notes concern internet dependency and scalability. It highlights IoT's foundational role and potential integration with AI for enhanced security. [7]

Combining multidimensional chaotic sequences and artificial neural networks for face image recognition is the key to smart home security. The encryption method incorporates wavelet and DCT transformations, using chaotic sequences generated by Henon and Logistic maps. The findings highlight the algorithm's significant encryption effectiveness against various attacks, emphasizing robustness to geometric and light intensity changes. Critical analysis highlights commendable performance, with areas for potential improvement in occlusion attacks. The algorithm's relevance lies in enhancing the security of AI applications, especially in smart home systems employing facial recognition, addressing privacy concerns associated with image recognition in home automation. [8]

The Smart Home Systems (SHS) evolution is all about emphasizing AI's integral role and extending its impact beyond traditional residences. Employing a Systematic Literature Review (SLR), the authors explore construction methods, sensor types, communication protocols, and security measures. Critical analysis evaluates key technological approaches, highlighting challenges. Relevant to the current study, it enriches understanding, guides future research, and aids practitioners in SHS development. [9]

The remote CCTV monitoring is the real-time application of Internet of Things (IoT) technology, specifically using Raspberry Pi. Emphasizing real-time control through a web interface, the system incorporates Motion Eye and a webcam as a sensor, enabling access



via smartphones or laptops. Simulations assess parameters like video resolution and frames per second, revealing their influence on system performance. The results suggest the viability of IoT in CCTV monitoring, with trade-offs noted between video quality and CPU usage. A critical analysis could explore practicality, scalability, cost-effectiveness, and potential security concerns. The study's implications extend to the broader IoT and information security context, relevant to smart homes and AI-driven surveillance systems. [10]

Paper [11] explores IoT's impact on security and privacy, emphasizing the need to integrate virtual and real worlds. It discusses IoT's definition, layers (Perception, Network, Application), and applications like healthcare, smart homes, and community security. Security concerns involve unauthorized access and network congestion, while privacy issues focus on data leakage and protection. The paper [11] concludes by highlighting IoT's transformative potential but stresses the critical need for research in addressing security and privacy challenges for a trusted IoT platform.

Research paper [12] focuses on wireless sensor networks (WSNs) and the challenges they face, highlighting the specific threat of wormhole attacks at the network layer. It addresses WSN challenges such as resource constraints, ad-hoc deployment, and hostile environments. The paper categorizes attacks based on the ISO-OSI model, with a focus on network layer attacks, particularly wormholes. The characteristics and classification of wormhole attacks are discussed, emphasizing their potential for disrupting routing operations. The paper aims to review existing detection techniques for wormhole attacks in the network layer, acknowledging the need for specialized security measures in WSNs.

Paper [13] emphasizes the transformative potential of the Internet of Things (IoT), highlighting its evolution from the Internet and predicting its impact on various aspects of life. It explores IoT applications, from monitoring cattle for agriculture to improving living conditions in impoverished areas. The challenges, including IPv6 deployment, sensor energy, and standards, are acknowledged but considered surmountable. The overall message underscores the pivotal role of IoT in shaping the future, enhancing human lives, and addressing global challenges.

This work introduces a breakthrough in real-time enforcement of privacy policies on streamed video using OpenFace, a correct open-source face recognizer. By combining face recognition with tracking in the

RTFace denaturing pipeline, the system achieves full frame rate speeds while keeping high accuracy. The proposed privacy mediator enables selective denaturing based on policy settings, and the architecture can be deployed at an enterprise scale for privacy aware IoT video analytics. This approach marks a significant step towards addressing privacy concerns in the era of ubiquitous video cameras. [15]

The research explores the feasibility of integrating video surveillance systems with cloud technologies, addressing questions on cost savings, risks, and ethical considerations. Further, it also emphasizes particularly on IP cameras and its related factors like bandwidth, storage, and legal implications. The study considers the impact of cloud reliability, economic goals, compliance, and data security. Additionally, it outlines parameters for assessing storage requirements and provides a cost breakdown for a traditional system. The evolving trend favours IP cameras, yet challenges in bandwidth and storage persist. Overall, the paper highlights the need for careful consideration when implementing video surveillance in a cloud environment. [16]

The conclusions from the research articles indicate that how artificial intelligence (AI) is integrated into electronic systems is driving progress. The essential functions that AI plays in manufacturing, security, and research and development are evident as we move toward an AI-influenced future. These positions provide significant advantages in terms of automation and efficiency.

The investigation of novel smart home systems—which has been documented in several papers—highlights the need to incorporate cutting-edge technology like artificial intelligence (AI) and the Internet of Things (IoT). Notably, separating normal residents from possible intruders using a Convolutional Neural Network (CNN) for intrusion detection offers a viable answer to security challenges. Furthermore, the novel usage of curtain control demonstrates the remarkable accuracy with which machine learning algorithms, such as Decision Tree, K-Nearest Neighbors, and Multilayer Perceptron, can anticipate and automate human behaviours.

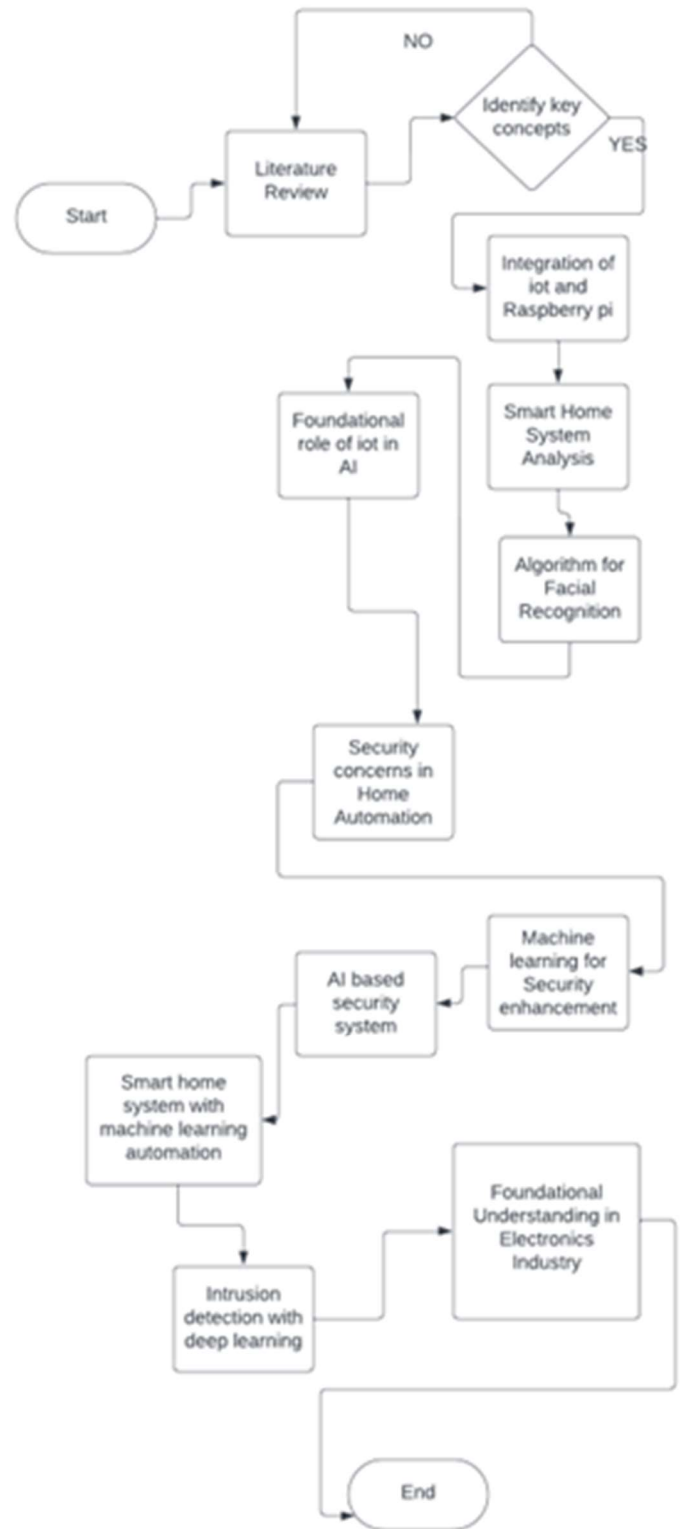
Efforts to enhance home automation, especially in terms of efficient device management and security, align with broader themes of AI and information security in the context of smart living. Supervised machine learning proves instrumental in detecting unauthorized IoT devices, showing high accuracy, swift detection, and



resilience to cyber-attacks.

Overall, these results highlight how AI and IoT are changing several industries, from smart homes to security systems. While highlighting promising advancements, the research also emphasizes the need for a nuanced approach, considering ethical considerations, security implications, and practical feasibility. The insights gained from these diverse studies contribute to a more comprehensive understanding of the evolving landscape shaped by AI and IoT technologies, guiding future developments and ensuring a balanced integration for a smarter and more secure future.

3. Methodology





The method employed in this research encompasses several key steps which are defined as under:

3.1 Start

It is the Beginning the exploration of AI integration in home automation. Initiate the research journey to enhance home automation through AI for information security.

3.2 Literature Review

Comprehensive study of existing research on AI and home automation. Review research papers all the earlier work for foundational insights on AI applications in smart homes.

3.3 Identify Key Concepts

Extracting crucial concepts from literature. Categorize key concepts like AI algorithms, IoT, and security measures from the reviewed papers.

3.4 Integration of IoT and Raspberry Pi

Applying IoT and Raspberry Pi for CCTV monitoring. Explore the integration of IoT and Raspberry Pi for smart security systems, as discussed in the above studies.

3.5 SHS Analysis

In-depth analysis of Smart Home System components. Examine computational methods and technologies in Smart Home Systems, as highlighted in second paper.

3.6 Algorithm for Facial Recognition

Developing an algorithm for secure facial recognition. Create an algorithm, inspired by Paper 3, for facial recognition with robust encryption in smart homes.

3.7 Foundational Role of IoT in AI

Exploring IoT's role in enhancing AI intelligence. Investigate how IoT contributes to AI intelligence, aligning with Paper 4's emphasis on foundational IoT roles.

3.8 Security Concerns in Home Automation

Addressing security concerns in smart home automation. Implement security measures, considering [5] insights on data integrity and confidentiality in smart homes.

3.9 ML for Security Enhancement

Exploring machine learning for enhanced security. Investigate machine learning applications, inspired by Paper 6, to enhance security in smart home ecosystems.

3.10 AI-Based Security Systems

Emphasizing AI-based security for home appliances. Focus on AI-based security systems, as discussed in Paper [7], to manage home appliances for improved security.

3.11 Smart Home System with ML Automation

Highlighting an innovative smart home system. Introduce the proposed system from Paper 8, using machine learning for automation, comfort, and security. This succinct overview highlights the key steps in exploring the integration of AI in home automation for enhanced information security, as inspired by the relevant research papers.

The method progresses from the identification of key aspects through an analysis of smart home systems to a detailed exploration of advanced security measures, underpinned by a foundational understanding of electronics.

5. Discussion

5.1 Our Thought

From our perspective, the incorporation of model Convolutional Neural Network (CNN) highlights a complete approach to security enhancement.

CNN, or Convolutional Neural Network, is a deep learning algorithm specifically designed for image processing and pattern recognition. In the context of the smart home security system, CNN plays a crucial role in distinguishing between regular occupants and potential intruders by analyzing human movement patterns. The CNN model can be trained using a comprehensive dataset consisting of samples of various human postures, ensuring its effectiveness in recognizing distinct motion patterns.

The proposed method of CNN image classification has passed the efficiency and feasibility test which was one of the methods of home security. With a high accuracy rate of approximately 98%, the CNN model proves its capability to find entities efficiently in the home environment with the help of motion patterns. The CNN model has shown a high potential in enhancing the overall security of IoT smart home automation.

The integration of CNN not only helps in the identification and classification of motion patterns but also creates alerts based on detected anomalies. In summary, the incorporation of CNN in the proposed smart home security system is a transformative advancement, promising increased efficiency, and reliability.



5.2 Effectiveness of Machine Learning Algorithms

We believe that integrating machine learning methods, such as convolutional neural networks (CNN), with smart home security has significantly improved home security. With their amazing flexibility to dynamic threats, these algorithms are ideal for tasks like anomaly recognition, predictive analysis, and intrusion detection. Because of their adaptability, smart houses' security is more effective and resilient, which represents a significant breakthrough in the automation of home security systems.

5.3 Comparison with Traditional Security Systems

The improved accuracy, responsiveness, and adaptability of the machine learning-integrated security system would be noticeable when compared to the older, more conventional security system. This comparison highlights how machine learning can revolutionize home security and result in more sophisticated and efficient protection measures.

5.4 Ethical Considerations and Privacy Implications

Implementing ethical considerations to secure user data is crucial to the concept of integrating machine learning in smart homes. The integrity of data and user trust is demonstrated using moral guidelines to reduce potential biases and guarantee safe use. The effectiveness of smart homes greatly depends on striking a balance between security precautions and moral behavior.

5.5 Integration of IoT Devices

In our perspective, the integration of Internet of Things (IoT) devices significantly enhances the overall effectiveness of the security system. Machine learning models, including CNN, play a crucial role in securing the interconnected ecosystem of smart devices. This integration highlights the constructive collaboration between machine learning and IoT technologies, offering a holistic and adaptive approach to home security that sets a benchmark for future developments.

5.6 User Experience and Acceptance

When evaluating the feedback about the user experience with the smart home shows a positive outcome. This automated home security system along with the security, also provides comfort to its users. Understanding user needs and addressing their concerns ensures a flawless integration of security measures into daily life that ultimately fosters a positive relationship between occupants and smart home technologies.

5.7 Practical Implications for Smart Home Ecosystems

The research discoveries show the broader development of smart home ecosystems. The outcomes contribute to the safety, adaptability, and responsiveness of smart home environments. The integration of machine learning in home security will automate security measures and provide a responsive and user-friendly smart home environment.

4. Conclusion

In the concept of smart homes, we are going to integrate machine learning to automate home security which will enhance the overall home environment. The traditional security systems are not effective enough to detect dynamic threats, but machine learning made this detection possible with CNS. This study not only highlights the efficiency of automation algorithms but also emphasizes the importance of technology integration to ensure high home security.

In comparison to old and traditional home security systems, machine machine-learning home security approach has many advanced features including proving accuracy and adaptability. Additionally, the integration of Internet of Things (IoT) devices will further strengthen the home security system with an approach to protect the interconnected smart home ecosystem.

The concept of home security automation is being widely used and adapted by many users, as it not only enhances security but also amplifies the user experience. The above studies contribute greatly to the discussion of the integration of technology and security for the invention of a safe and user-friendly home environment.

In conclusion, this research talks about the new and upcoming era of smart home security with the fusion of machine learning algorithms and user-centric designs. It ensures a safe future with a secure and resilient home ecosystem while considering ethical values as well. .

5. Reference

- [1] S. S. L. Kazi and K. S. L. Kazi, "Electronics with Artificial Intelligence Creating a Smarter Future: A Review", *Journal of Communication Engineering and Its Innovations*, vol. 2023, pp. 38–42, Jan. 2023, doi: 10.46610/jocci.2023.v09i03.005.
- [2] O. Taiwo, A. E. Ezugwu, O. N. Oyelade, and M. S. Almutairi, "Enhanced Intelligent Smart Home



- Control and Security System Based on Deep Learning Model,” *Wireless Communications and Mobile Computing*, vol. 2022, pp. 1–22, Jan. 2022, doi: 10.1155/2022/9307961.
- [3] S. Kumar and M. Abdul Qadeer, “Application of AI in Home Automation,” *International Journal of Engineering and Technology*, vol. 4, no. 6, pp. 803–807, 2012, doi: 10.7763/ijet.2012.v4.488.
- [4] Y. Meidan et al., “Detection of Unauthorized IoT Devices Using Machine Learning Techniques,” *ArXiv (Cornell University)*, Sep. 2017, doi: 10.48550/arXiv.1709.04647
- [5] M. Husamuddin and M. Qayyum, “Internet of Things: A Study on Security and Privacy Threats,” *2017 2nd International Conference on Anti-Cyber Crimes (ICACC)*, Mar. 2017, doi:10.1109/anti-cybercrime.2017.7905270.
- [6] U. Ijaz, U. Ameer, B. ul Islam, A. Ijaz, and W. Aziz, “IOT Based Home Security and Automation System,” *NFC-IEFR Journal of Engineering and Scientific Research*, vol. 4, no. 1, pp. 58–63, Dec. 2016, doi: 10.24081/nijesr.2016.1.0011.
- [7] L. Feng and X. Chen, “Image Recognition and Encryption Algorithm Based on Artificial Neural Network and Multidimensional Chaotic Sequence,” *Computational Intelligence and Neuroscience*, vol. 2022, pp. 1–9, Aug. 2022, doi:10.1155/2022/9576184.
- [8] C. Stolojescu-Crisan, C. Crisan, and B.-P. Butunoi, “An IoT-Based Smart Home Automation System,” *Sensors*, vol. 21, no. 11, p. 3784, May 2021, doi:10.3390/s21113784.
- [9] E. Rohadi et al., “Internet of Things: CCTV Monitoring by Using Raspberry Pi,” *International Conference on Applied Science and Technology (iCAST)*, vol. 2018, Oct. 2018, doi:10.1109/icast1.2018.8751612.
- [10] J. S. Kumar and D. R. Patel, “A Survey on Internet of Things: Security and Privacy Issues,” *International Journal of Computer Applications*, vol. 90, no. 11, pp. 20–26, Mar. 2014, doi:10.5120/15764-4454.
- [11] P. Maidamwar and N. Chavhan, “A Survey on Security Issues to Detect Wormhole Attack in Wireless Sensor Network,” *Zenodo (CERN European Organization for Nuclear Research)*, vol. 2012, Jul. 2018, doi:10.5281/zenodo.1310896.
- [12] D. Evans, “Cisco Internet Business Solutions Group (IBSG) the Internet of Things How the next Evolution of the Internet Is Changing Everything,” Apr. 2011. Available: https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf
- [13] Mischa Dohler “Machine-to-Machine Technologies Vision, Standards and Applications.”
- [14] J. Wang, B. Amos, A. Das, P. Pillai, N. Sadeh, and M. Satyanarayanan, “A Scalable and Privacy-Aware IoT Service for Live Video Analytics,” *ACM SIGMM Conference on Multimedia Systems*, Jun. 2017, doi:10.1145/3083187.3083192.
- [15] D. Neal and S. Rehman, “Video Surveillance in the Cloud”, *International Journal on Cryptography and Information Security*, vol. 2, no. 3, pp. 1–19, Sep. 2012, doi:10.5121/ijcis.2012.2301.



A Comparative Survey of Symmetric and Asymmetric Key Cryptography Algorithms

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KEY WORDS

Cryptography Symmetric
Algorithms Asymmetric
Algorithms Cryptographic
Schemes Network Security
Information Security
Modern Cryptographic
Techniques

ABSTRACT

In today's digital world it is crucial to ensure that sensitive information is securely transmitted and stored. Cryptography, which involves encoding and decoding data plays a role, in protecting against access and tampering. This field encompasses two types of algorithms; symmetric and asymmetric. Symmetric algorithms use a key for both encryption and decryption while asymmetric algorithms rely on a pair of keys – private. The choice of methods depends on factors such as security needs, computational efficiency and the complexities of management. This research paper conducts an analysis of cryptographic techniques specifically focusing on symmetric (DES, 3DES, AES) and asymmetric (RSA, ElGamal, ECC) algorithms. Through a review of existing literature we examine the performance characteristics of these algorithms emphasizing the balance between security and efficiency. Methodologically speaking we delve into the core principles of cryptography involving both asymmetric systems. Our empirical assessments consider factors like encryption/decryption time and key generation time to assess effectiveness. In our discussions we analyse the landscape of techniques by highlighting AES's superior performance over DES in symmetric cryptography. Additionally we note RSA's efficiency in encryption/decryption tasks, within cryptography despite its key generation times compared to ElGamal.

Introduction

In today's interconnected world driven by information the Internet has become a presence playing a role, in areas like online shopping and email communication. However along with its usage comes the looming risk of entry potentially causing significant problems. To address this risk fields like cryptography and network security have emerged as measures.

Cryptography, known as the art of communication dating back to Roman times has evolved into a

complex discipline in modern times. It uses algorithms to convert messages into an unreadable format making them understandable only to the intended recipient. The main objectives of cryptography include ensuring secrecy maintaining data integrity enabling authentication and controlling access. Originating from words meaning "writing" cryptography has diverse applications across various sectors such as securing cash machines, military communications and educational institutions.[1][2]

The broader field of cryptology encompasses both



cryptography and cryptanalysis.

Cryptanalysis involves decoding codes through processes while cryptography focuses on creating and utilizing codes. Encryption and decryption are the techniques, at the heart of methods. Transforming plaintext into a format through a designated key is what encryption entails while decryption on the hand undoes this procedure to unveil the initial message.

Cryptographic systems, which play a role, in ensuring communication involve limited potential plaintexts, cipher texts, keys and algorithms. These systems boost security by utilizing technologies like networks for generating keys. The field of cryptography encompasses components such as public key cryptography hashing algorithms and other elements that contribute to its complexity.[3]This research paper delves into an examination of cryptographic methods focusing on both symmetric and asymmetric algorithms.

Symmetric key cryptography enables communication using a shared key between entities while asymmetric cryptography also referred to as public key cryptography relies on public and private keys for secure communication. Prominent algorithms in these categories include DES (Data Encryption Standard) 3DES (Triple Data Encryption Standard) AES (Advanced Encryption Standard) RSA (Rivest, Shamir and Adleman) ElGamal and ECC (Elliptic Curve Cryptography).

The goal of this paper is to offer a review of schemes by assessing their performance across varying file sizes. The analysis will primarily consider factors such as encryption/decryption duration and key generation time. Each section explores facets of the subject matter leading to a conclusion that outlines potential directions, for future research endeavours.[5]

Literature Review

The landscape of cryptography encompasses a myriad of algorithms, each designed to secure

information through distinctive approaches.

Algorithms such as DES, 3DES, Blowfish, AES, RSA, ElGamal, and Palliser have gained prominence. The challenge, however, lies in identifying the optimal security algorithm that not only ensures high security but also minimizes the time required for key generation, encryption, and decryption processes. The effectiveness of security algorithms is contingent upon weighing the pros and cons of each algorithm, considering specific requirements, and suitability for diverse applications. [3]

Several studies have contributed valuable insights into the performance of cryptographic algorithms. For instance, a comparative evaluation scrutinized the performance of

DES and Blowfish based on parameters like encryption speed, power consumption, and security analysis. Surprisingly, the results favoured Blowfish, highlighting its superior performance over DES and AES. Conversely, another study contradicted this, asserting that AES outperformed Blowfish. In a comprehensive examination of cryptographic algorithms, including AES, DES, 3DES, RC6, Blowfish, and RC2, demonstrated variations in performance based on file type and size.

Notably, DES emerged as faster than 3DES, and Blowfish exhibited optimal performance as packet size increased.

The study delved into how file size affects the performance of algorithms carrying out experiments, on both processors and cloud computing platforms. The findings showed that cloud computing notably boosted the speed of algorithms with AES showing the most improvement for smaller input files. Extending the assessment to hardware setups it was highlighted that encryption time increases as data size grows regardless of the file format. It was observed that 3DES had a throughput compared to AES with variations noted for textfiles and images. [5]

Analysing the specifics of algorithm implementation underscored that DES performed well in hardware



but fell short in software applications. It reiterated the significance of selecting simulators for precise evaluations of AES, DES and Blowfish.

When looking closely at algorithm analyses focusing on memory usage, computation time and output byte parameters for RSA, DES and AES. It became evident that there were disparities in file encryption times between DES and AES. RSA stood out for having the encryption time and consuming an amount of memory. Further exploration, into client server dynamics revealed that RSA outperformed ECC on the client side while ECC excelled in server side performance. The study also introduced WTLS (Wireless Transport Layer Security) for performance assessments. [6][4]

In a comparative evaluation of RSA, ElGamal, and Paillier, analysed parameters like encrypted file size, decrypted file size, encryption time, decryption time and throughput. The findings showed that RSA performed best in encryption time while ElGamal stood out in decryption time. Overall RSA showed performance, across the selected criteria. [1]

Moving beyond analysing algorithms we conducted a study of RSA exploring different key sizes and word lengths. Our research looked into the encryption and decryption procedures, memory requirements and processing times. The findings revealed that RSA performed slower and required memory compared to ECC. When focusing on power usage and efficiency it was concluded that DES outperformed algorithms. [6]

Expanding our discussion to concepts we provided an overview of cryptography's significance, in converting readable data into an unintelligible format. We highlighted the objectives of cryptography such as confidentiality, authentication, data integrity, access control and non-repudiation.

Additionally we delved into terms and historical principles like the Kerckhoffs' principles. [2]

Shifting our attention to algorithms and network security aspects we covered primitives such as block ciphers, stream ciphers, message authentication code algorithms, hash functions and modes of authenticated encryption. We further explained cryptography terms like encryption decryption plaintext ciphertexts keys while categorizing cryptography into key cryptography public/asymmetric key cryptography hash functions/one way encryption/message digests. [3][4]

Finally emphasized the interconnected nature of network security, with cryptography by examining security elements and potential threats.

The conversation touched on active threats, security measures and the significance of data integrity, confidentiality, authenticity and non-repudiation. This analysis lays a groundwork, for grasping the intricacies and subtleties related to encryption methods their assessments of effectiveness and the wider implications of cryptography, in safeguarding information security. [3][6][4]

Methodology

1) Basic terminology of Cryptography: Cryptography is the art of converting information into an unreadable form. This section delves into the principles, including the history of cryptography the difference between text and encrypted text and its vital role in protecting data from unauthorized access or changes. Cryptography goes beyond security; it also plays a role in verifying user identities.

2) Symmetric Key Cryptography: Symmetric key encryption uses a secret key for both encoding and decoding information. In this method parties exchanging messages share the key needed for decryption. While efficient securely transmitting these keys poses a challenge. This encryption technique involves using the key, for both encrypting and decrypting text.

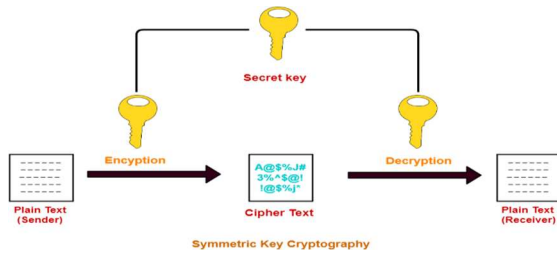


Fig. 1. Depicts a system where a shared secret key is used to encrypt and decrypt messages. Sender encrypts the message with the key, resulting in ciphertext.

The receiver then decrypts the ciphertext back to the original message using the same key.

1) Asymmetric Key Cryptography: Asymmetric key cryptography, or public-key encryption, utilizes distinct keys for encryption (public key) and decryption (private key). The public key can encrypt messages, but only the corresponding private key can decrypt them. The security of this method relies on the mathematical relationship between the keys, making it more secure than symmetric encryption. Common techniques include RSA, DSA, and PKCS.

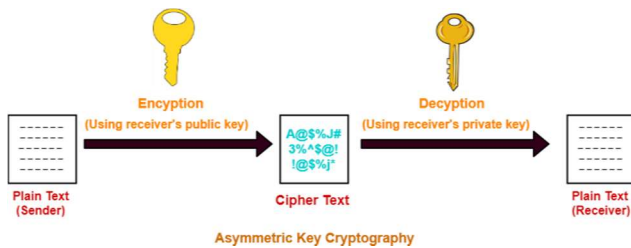


Fig. 2. Depicts a system which uses two keys: a public key and a private key. Sender encrypts a message with the receiver's public key, and only the receiver can decrypt it using their private key.

2) Data Encryption Standard (DES): The Data Encryption Standard (DES) is a symmetric block-cipher algorithm converting 64-bit plaintext blocks to cipher text using 48-bit keys. It serves the dual purpose of encryption and decryption, emphasizing key uniformity.

3) Advanced Encryption Standard (AES): AES, designed to replace DES, operates with 128-bit block length and key sizes of 128, 192, or 256 bits. The number of rounds in the cipher varies with the key length, ensuring a robust encryption standard.

4) Public-Key Cryptography: Public-key cryptography utilizes a pair of unique keys—one public and one private—for encryption and decryption. The sender encrypts the message with the recipient's public key, and only the recipient's private key can decrypt it. This section highlights the asymmetric nature of this cryptography, emphasizing the necessity of a key pair for secure communication.

Discussion

I. State of the art of Cryptography Schemes

A. Symmetric Cryptography

Symmetric cryptography, characterized using a shared key for plaintext-to-ciphertext conversion, plays a pivotal role in modern cryptographic schemes. Examining specific symmetric cryptography schemes:

DES (Data Encryption Standard): Introduced in the early 1970s, DES operates with a 56-bit key and is widely utilized in military, commercial, and communication security applications. Its successor, 3DES, employs a 168-bit key but exhibits slower performance than DES.

AES (Advanced Encryption Standard): An advancement of 3DES, AES, introduced in 1997, distinguishes itself through variable key sizes—128, 192, and 256 bits. Known for encrypting 128-bit blocks, AES finds applications in small devices, monetary transactions, and security systems.

B. Asymmetric Cryptography

Asymmetric cryptography, another crucial category, utilizes two keys—public and private—for encryption and decryption. Key algorithms include:

RSA (Rivest, Shamir and Adleman): Introduced in 1977, RSA plays a vital role in key transfer over insecure channels. With its public and private key pair, RSA provides confidentiality, integrity, authenticity, and non-repudiation.



Widely used in electronic industries for online money transfers. ElGamal: Introduced in 1985, ElGamal serves as an alternative to RSA, leveraging the Diffie-Hellman key exchange. Its applications extend to digital signature generation, particularly in conjunction with the Paillier homomorphic algorithm for semantic security.

ECC (Elliptic Curve Cryptography): Introduced in 1985, ECC operates on elliptic curves, offering encryption, digital signatures, and pseudo-random generation. It stands out for enhanced security with smaller keys. [2][5]

II. Performance Evaluation

A. Experimental Setup

The experimental evaluation of symmetric and asymmetric algorithms involved implementation in Java, utilizing an Intel Pentium processor with 2.34 GHz and 1 GB of memory. Various text file sizes, ranging from 32KB to 280 KB, were employed in the experiments.

B. Experimental Result

The performance evaluation considered encryption time, decryption time, and key generation time for symmetric (DES and AES) and asymmetric (RSA and ElGamal) algorithms. Table I outlines key sizes and their corresponding generation times.

C. Symmetric Cryptography

Examining the encryption and decryption time of symmetric algorithms, the results indicate that AES outperforms DES in both encryption and decryption. As file sizes increase, encryption and decryption times also show an upward trend.

D. Asymmetric Algorithms

The performance of asymmetric algorithms, specifically RSA and ElGamal, was analysed in terms of encryption and decryption time. RSA demonstrated superior performance in both encryption and decryption compared to ElGamal.

E. Symmetric and Asymmetric Algorithms Encryption Time Comparative analysis of DES, AES, RSA, and ElGamal on different file sizes reveals that DES encryption time surpasses other schemes, with RSA exhibiting the least encryption time.

Asymmetric algorithms generally outperform symmetric algorithms in encryption time.

Decryption Time: RSA decryption time outshines DES, AES, and ElGamal. Asymmetric algorithms, particularly RSA, demonstrate efficiency in decryption. Key Generation Time: Symmetric algorithms, like DES can generate keys quickly than RSA, which requires more time due to its longer key size. [8][9][4]

Conclusion

In conclusion, this study confirms the critical role of cryptography in today's world. AES, a type of symmetric algorithm demonstrates efficiency compared to DES. On the other hand RSA, an asymmetric algorithm is effective in encryption and decryption processes despite key generation times. The decision between using asymmetric cryptography depends on needs. These research findings contribute to discussions, on selecting solutions as technology progresses. The changing field of cryptography encourages ongoing exploration to improve data protection methods continuously.

Reference

- [1] Harshraj N. Shinde, Aniruddha S. Raut, Shubham. Vidhale, Rohit V. Sawant, Vijay A. Kotkar "A Review of Various Encryption Techniques" International Journal of Engineering And Computer Science ISSN: 2319-7242, Volume 3, Issue 9, September 2014. Online, https://www.academia.edu/103216172/A_Review_On_Different_Encryption_Techniques_A_Comparative_Study
- [2] Ms. R. Padmalatha "A Study on Network Security and Cryptography". Online, <https://www.researchgate.net/publication/3582>



- 42788_A_Study_on_Network_Security_and_Cryptography
- [3] MohiniChaudhari, Dr. KanakSaxena “Fast and Secure Data Transmission using Symmetric Encryption and Lossless Compression” International Journal of Computer Science and Mobile Computing, ISSN 2320– 088X, Vol. 2, Issue. 2, February 2013. Online, https://www.academia.edu/2580491/Fast_and_secure_data_transmission_using_symmetric_encryption_and_lossless_compression
- [4] Prerna Sharma, Khushboo Yadav, Ankit Kumar Tiwari “A Review Paper on Network Security and Cryptography”. Online, <https://www.wjrr.org/a-review-paper-on-network-security-and-cryptography>
- [5] AL.Jeeva, Dr.V.Palanisamy, K.Kanagaram “Comparative Analysis of Performance Efficiency and Security Measures of Some Encryption Algorithms” International Journal of Engineering Research and Applications (IJERA), ISSN: 2277 128X, Volume 3, Issue 6, June 2013. Online, <https://www.semanticscholar.org/paper/COMPARATIVE-ANALYSIS-OF-PERFORMANCE-EFFICIENCY-AND-Jeeva-Palanisamy/1bbeac3a18d5d1877868f67abfe4d c240d819389>
- [6] D Venkata Vidya Deepthi, B Homer Benny, and K Sreenu1, "Various Ciphers in Classical Cryptography." Journal of Physics: Conference Series, Volume 1228, IOP Publishing Ltd, 28 September 2019. Online, <https://iopscience.iop.org/article/10.1088/1742-6596/1228/1/012014>
- [7] Sombir Singh, Sunil K. Maakar, Dr.Sudesh Kumar “Enhancing the Security of DES Algorithm Using Transposition Cryptography Techniques” International Journal of Advanced Research in Computer Science and Software Engineering, ISSN 2249-6343, Volume 2, Issue 1, Jan 19 2012. Online, https://www.researchgate.net/publication/310828708_Enhancing_the_security_of_des_algorithm_using_transposition_cryptography_techniques
- [8] "Vigenère Cipher." Crypto Museum, 14 August 2010, <https://www.cryptomuseum.com/crypto/vigener/>
- [9] Padhye, Sahadeo, Rajeev A Sahu, and Vishal Saraswat, “Introduction to Cryptography”, CRC Press, March 31, 2021, Taylor & Francis Group, <https://www-taylorfrancis-com.libproxy2.usc.edu/books/mono/10.1201/9781315114590/introduction-cryptography-sahadeo-padhye-rajeev-sahu-vishal-saraswat>
- [10] Devi, T. Rajani. "Importance of cryptography in network security." In 2013 International conference on communication systems and network technologies, pp. 462-467. IEEE,



Adaptive PoLP: Tailoring Least Privilege Access Controls for Dynamic IoT Environments

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KEYWORDS

Adaptive Policy Language
Dynamic Access Control
Least Privilege Principles
IoT Security Framework
Adaptive Authorization Model
Access Control Adaptability
Internet of Things (IoT)
Security
Policy-Driven IoT Security
Dynamic Privilege
Managemen
Secure IoT Environments

ABSTRACT

As the Internet of Things (IoT) becomes more interconnected, it is critical to make sure security measures are strong. Because of the dynamic nature of IoT contexts, traditional methodologies frequently fall short, necessitating the development of novel solutions. This paper explores the application of the Adaptive Principle of Least Privilege (PoLP) in dynamic Internet of Things ecosystems to strengthen security. Critical holes in current security paradigms are highlighted by a thorough assessment of the literature, including major publications by diverse writers. These vulnerabilities highlight the need for customized security solutions that can change with the Internet of Things. In order to fill this gap, we present the idea of Adaptive PoLP and develop the following main research question: In what ways may Adaptive PoLP improve security in real-time Internet of things environments? By means of a methodically planned approach that combines case studies and simulations, we assess the security and adaptability consequences of implementing dynamic access controls in Internet of Things environments. Our findings provide insights that can guide future research and practical application, and they also highlight the potential of Adaptive PoLP to strengthen the security posture of IoT ecosystems. The main objective of our research, which is to improve IoT security, is summarized in this abstract, which also highlights the role that Adaptive PoLP will play in creating a more secure and resilient IoT environment.

1. Introduction

The introduction of the Versatile Standard of Least Honor (Versatile PoLP), which is firmly meant to improve security in situations that are always evolving, emerges as an important worldview in the powerful Web of Things (IoT) scene. This analysis embarks on a journey to unravel the potential of flexible access controls, specifically the Versatile PoLP, to fortify IoT environments against the steadily increasing threats. As the intricacy of IoT organizations strengthens, the basic for a nuanced understanding and capable execution of dynamic access

controls turns out to be progressively clear. This acquaintance fills in as an entryway with investigate the significant meaning of Versatile PoLP inside the IoT domain. Drawing motivation from a union of experiences gathered from different exploration papers and certifiable contextual analyses, we recognize the intricacy and weaknesses intrinsic in current IoT frameworks. The focal inquiry that surfaces in this setting is: How could versatile access controls, exemplified by Versatile PoLP, act as a hearty protection component in the midst of the unique complexities of IoT? Expanding upon the establishments laid by existing writing and certifiable situations, our



investigation expects to give an extensive comprehension of Versatile PoLP as well as reasonable bits of knowledge into its application. The union of bits of knowledge is certainly not a simple hypothetical activity; it is established in the different points of view of scientists, for example, Koen Buyens, Bart De Win, and Wouter Joosen [1], who featured the difficulties and potential open doors in planning application-explicit security strategies. In their work, they provide the Guideline of Least Honor as an excellent security standard and argue for the use of a reference screen to apply sensible solutions. This talk opens the door to a thorough analysis of the complex field of IoT security. Versatile PoLP, positioned as a fundamental participant, emerges as a potent defense mechanism, fortifying networked settings against potential threats. As we delve into the details of our request, we do so armed with information from authoritative voices in the field, ensuring that our research is not only theoretical but also deeply informed by the combination of academic discourse and real-world scenarios.

2. LITERATURE REVIEW

Within the dynamic and networked realm of the Internet of Things (IoT), combining the Principle of Least Privilege (PoLP) with adaptable safety measures becomes an essential goal. The findings derived from the analysis of six assessment papers point the way toward enhancing Versatile PoLP, which are specifically tailored Least Honor Access Controls meant to investigate the always shifting landscape of IoT situations. The experiences of Koen Buyens, Bart De Win, and Wouter Joosen with application-explicit security procedures [1] provide the framework for understanding the delicate balance between usefulness and limitation.. Their Guideline of Most Honor offers a nuanced point of view as we navigate the confusing maze of dynamic IoT scenarios, advocating the modification of honors to align with the fluid concept of the climate. The practical challenges associated with acquiring connected devices underscore the need for adaptable security protocols designed to meet the evolving demands of the Internet of Things domain. In order to achieve flexibility, Paul Kenyon's work on risk-based flexible security in eHealth [2] charts a path that emphasizes observation, analysis, predictive modeling,

and navigation working together. Versatile PoLP becomes evident in the context of IoT connected to medical careThe novel concept of eHealth biological systems necessitates safety measures that may adapt over time in response to hazard assessments and projections, providing ongoing protection against emerging threats. The study of usage-specific security procedures by Samuel Jero et al. [3] highlights the practical challenges associated with integrating connected devices into the Internet of Things. Unauthorized access and information breaches serve as potent reminders of the fundamentals of tailoring security policies to the unique aspects of the Internet of Things. Versatile PoLP emerges as a source of strength in the medical care arena, where sensitive patient data is intertwined with IoT devices. The focus on developing flexible security metrics for healthcare organizations [4] is a response to the need for subtle safety measures in robust eHealth biological systems. The complex interplay between benefits and considerations in IoT-related medical issues reinforces the need to modify honor codes to correspond with the evolving threat landscape. As we delve more into the specifics of patient observation systems, the need for flexible and fine-grained security becomes even more apparent. Regarding Versatile PoLP, Ed Felten's crucial expertise in comprehending danger models in security examination [5] is relevant. The constantly evolving IoT threat landscape necessitates both a static understanding of potential threats and an ongoing flexible response. Versatile PoLP becomes an essential tool for preventing unauthorized access and effectively addressing emerging threats over time. The State-Based Honor Control Model proposed by Container Liang, Heng Liu, Wenchang Shi, and Yanjun Wu [6] aligns with the Versatile PoLP paradigm. This approach provides the fine-grained and programmed honor control required in the distinct IoT environment by breaking down a cycle's duration into honor expressions. This approach's adaptable concept resonates with the need for security measures that can effectively address the various states and exercises within an Internet of Things environment. In summary, the overall knowledge derived from these exploratory works highlights the goals and challenges of adapting Versatile PoLP to the particular IoT environment. Installing Least Honor Access Controls is a continuous and flexible process that adapts honors to the recurrent pattern of Internet of Things components rather than being a static



endeavor. These findings serve as benchmarks as we embark on this research project, pointing the path toward a security worldview that is not only theoretical but also mostly real despite the rapidly evolving IoT scenarios. Versatile PoLP emerges as a logical framework and a clear, responsive defense, energizing IoT situations against the constant stream of emerging threats.

3. METHODOLOGY

Exploring Adaptive PoLP in the Dynamic IoT Landscape: A Practical Assessment

3.1 Simulation-Based Analysis:

Virtual Experiments:

Picture a digital field that accurately represents real-world IoT scenarios. Our objective goes beyond simple trial and error; we meticulously design reenactments to randomly reproduce various device communications, responses to ongoing changes, and the mitigation of potential hazards. This is the equivalent of a virtual test drive, where variables such as the diversity of devices, network components, and Versatile PoLP settings are meticulously adjusted. This goes beyond idle chatter; it's a thorough inquiry to determine whether our safety initiatives are feasible. Motivated by the insights of Koen Buyens, Bart De Win, and Wouter Joosen [1], we investigate the complexities of virtual investigations, executing a reference screen to maintain rational techniques, akin to the excellent Guideline of Least Honor.

Trying Things Out:

We welcome trial and error without reservation in our virtual sandbox. A boundary's potent calibration takes into account the complexity of actual subtleties. Similar to adjusting the parameters on a single device, our focus is on observing how Versatile PoLP investigates various scenarios. Motivated by Tesla's continual improvement of self-driving highlights, we make an effort to understand how our safety initiatives evolve. Our approach mirrors the flexible methodology advocated by Wu et al. [4], incorporating real components into the process of trial and error, mirroring Tesla's iterative improvement of self-driving features.

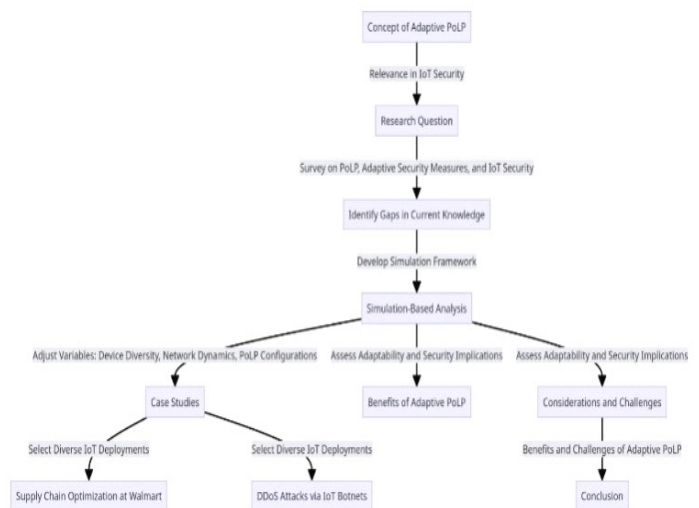
3.2 Case Studies:

Real-Life Stories:

Our discussions go beyond theoretical contemplation and delve into carefully selected real examples that tackle the challenges and setups within the IoT landscape. Consider Tesla, for instance—a classic example. Our discussion goes beyond cars; it unravels the ways in which Tesla protects its fleet by routinely updating its software. This is by no means a straightforward tale; rather, it provides a clear overview of dynamic security measures in practical application. Consistent with the experiences reported by Samuel Jero et al. [3], our contextual analyses provide a valuable lens through which to view the challenges and successes associated with implementing security controls, and they align with Tesla's actual application of dynamic safety measures.

Learning from Experience:

Our contextual studies go beyond theoretical ideas and provide a comfortable glimpse into the practical aspects of real-world industrial pioneers such as Tesla. This is by no means a dry analysis of a handbook; rather, it is a visceral examination of how Tesla skillfully navigated challenges in acquiring its armada. The center isn't restricted to theoretical developments; rather, it offers a firsthand account of how Versatile PoLP combats the inherent irrationality of the IoT environment in a sensible manner.





4. DISCUSSION

This section delves into the intricate implications of the Versatile Guideline of Least Honor (Versatile PoLP) by conducting a comprehensive contextual analysis and examining challenges and achievements within the distinct IoT landscape.

4.1 Case Study: Enhancing Walmart's Supply Chain

Benefit 1:

Enhanced Stock Management: Walmart's pivotal integration of RFID tags for continuous inventory tracking, supported by Versatile PoLP, exemplifies the remarkable impact on production network development. This not only ensures the protection of these labels but also randomly arranges the inventory network, highlighting the dual benefits of increased safety and functional proficiency.

Benefit 2:

Safe Information Transfer Versatile PoLP emerges as an unflappable gatekeeper in the bewildering maze of store network pieces, ensuring the confidentiality and reliability of information in transit. Its fundamental role extends beyond security to become a fundamental enabler of a steady flow of information. The Walmart example exemplifies the flexible nature of PoLP by illustrating how it may be tailored to meet the particular requirements of obtaining data within the retail network.

4.2 The Mirai Botnet Incident: A Stark Reminder

Challenge 1:

IoT Device Weakness: The Mirai botnet incident serves as a clear indication of the inherent vulnerability of IoT devices, highlighting the sincerity with which Versatile PoLP must be implemented to prevent misuse. Because of its adaptability, versatile PoLP anticipates playing the role of a vigilant gatekeeper, drastically altering defensive strategies to thwart potential IoT device exploitation.

Preventive Measure:

PoLP as a Watchman: Versatile PoLP anticipates playing a crucial role as a cautious watchman in light of threats such as Mirai. Its adaptability surpasses traditional safety

measures, drastically altering defensive strategies to anticipate and thwart probable misuse of IoT devices.

4.3 Advantages of Adaptive PoLP

Development in Security:

Versatile PoLP, positioned as a revolutionary force, fosters advancement within the security landscape. It works as a learning instrument, guaranteeing that safety efforts moderate dangers as well as adjust to developing difficulties. The Walmart inventory network case epitomizes how Versatile PoLP catalyzes imaginative and secure practices.

Enabling Clients and Gadgets:

Through careful access control instruments, Versatile PoLP engages clients and IoT gadgets by laying out a safe structure that permits gadgets to safely execute tasks. The fact that this strengthening is achieved without sacrificing the integrity of safety protocols emphasizes the critical role that Versatile PoLP plays in fostering safe practices within the potent IoT domain. This in-depth discussion surpasses hypothetical discussions, providing a thorough understanding of how Versatile PoLP efficiently influences the IoT security landscape. Despite previous speculative developments, it continues to be a crucial element that influences and is practiced inside the potent IoT domain.

5. CONCLUSION

We've made a big commitment to the ongoing conversation about achieving dynamic IoT circumstances with Versatile PoLP as we close up our assessment. As we sifted through existing examination in the writing survey, we recognized a few holes, giving a guide to more designated investigation. Our examination philosophy went past hypothesis, giving us down to earth experiences into how dynamic access controls, particularly Versatile PoLP, can adjust and what influence they can have on security. Through reenactments and genuine contextual investigations, we've plunged into the complicated universe of IoT security, investigating how Versatile PoLP interfaces with developing dangers.

This present reality illustration of Walmart's inventory network streamlining is a brilliant illustration of the advantages of Versatile PoLP. It oversees stock better as well as goes about as a protection from possible issues,



displaying how this security approach can really have an effect. Looking forward, the execution of Versatile PoLP appears to be a unique advantage in the consistently impacting universe of IoT. Its flexibility turns into major areas of strength for a for getting associated gadgets, assisting them with exploring the eccentric universe of online protection. As IoT continues developing, picking Versatile PoLP isn't simply a brilliant move; it's a change, getting another period of strength and security for associated gadgets. Our exploration lays the basis for making IoT more secure, adding to a safer and strong computerized world.

6. Reference

[1] Koen Buyens, Bart De Win, and Wouter Joosen. "Identifying and Resolving Least Privilege Violations in Software Architectures." In Proceedings of the 2009 International Conference on Availability, Reliability and Security (pp. XX-YY). IBBT-Distrinet Katholieke Universiteit Leuven, Belgium. Email: first.last@cs.kuleuven.be.

[2] Paul Kenyon. "What Australia can teach the world about least privilege." Avecto.

[3] Samuel Jero, Juliana Furgala, Runyu Pant, Phani Kishore Gadepalli, Alexandra Clifford, Bite Yet, Roger Khazan, Bryan C. Ward, Gabriel Parmer, and Richard Skowyra. "Practical Principle of Least Privilege for Secure Embedded Systems." In 2021 IEEE 27th Real-Time and Embedded Technology and Applications Symposium (RTAS). Affiliations: MIT Lincoln Laboratory, The George Washington University, Draper Laboratory.

[4] Haoqi Wu, Zhengxuan Yu, Dapeng Huang, Haodong Zhang, Weili Han. "Automated Enforcement of the Principle of Least Privilege over Data Source Access." Laboratory for Data Analytics and Security, Fudan University, Shanghai, China.

[5] "Whitehat application security statistics report." [Online]. Available: <https://www.whitehatsec.com/blog/2018-whitehat-app-sec-statistics-report/>

[6] C. Kambalyal, "3-tier architecture," Retrieved On, vol. 2, 2010.

[7] J. H. Saltzer and M. D. Schroeder, "The protection of information in computer systems," Proceedings of the IEEE, vol. 63, no. 9, pp. 1278–1308, 1975.

[Online]. Available: <https://doi.org/10.1109/PROC.1975.9939>

[8] M. Sendiang, O. Mellolo, and M. Langie, "Implementation pdo parameterized query to prevent sql injection," International Journal of Computer Applications, vol. 149, no. 11, 2016.

[9] M. M. Madden, "Challenges using linux as a real-time operating system," in AIAA Scitech 2019 Forum, 2019.

[10] "Mitre common vulnerabilities and exposures: <http://cve.mitre.org/>."

[11] J. Saltzer and M. Schroeder, "The protection of information in computer systems," in Proceedings of the IEEE, vol. 9, no. 63, 1975.

[12] G. Klein, K. Elphinstone, G. Heiser, J. Andronick, D. Cock, P. Derrin, D. Elkaduwe, K. Engelhardt, R. Kolanski, M. Norrish et al., "seL4: Formal verification of an OS kernel," in Proceedings of the ACM SIGOPS 22nd symposium on Operating systems principles, 2009, pp. 207-220.

[13] F. Mehnert, M. Hohmuth, and H. Hartig, "Cost and benefit of separate address spaces in real-time operating systems," in Proc. of the 23rd IEEE Real-Time Systems Symposium (RTSS), December 2002.

[14] P. K. Gadepalli, R. Pan, and G. Parmer, "Slite: OS support for near zero-cost, configurable scheduling," in 2020 IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS). IEEE, 2020, pp. 160-173.

[15] P. Kocher, J. Horn, A. Fogh, , D. Genkin, D. Gruss, W. Haas, M. Hamburg, M. Lipp, S. Mangard, T. Prescher, M. Schwarz, and Y. Yarom, "Spectre attacks: Exploiting speculative execution," in 40th IEEE Symposium on Security and Privacy (S&P'19), 2019.

[16] Y. Kim, R. Daly, J. Kim, C. Fallin, J. H. Lee, D. Lee, C. Wilkerson, K. Lai, and O. Mutlu, "Flipping bits in memory without accessing them: An experimental study of DRAM disturbance errors," ACM SIGARCH Computer Architecture News, vol. 42, no. 3, pp. 361-372, 2014.

[17] M. Simos, "Overview of petya, a rapid



cyberattack," Feb 2018. [Online]. Available:
[https://www.microsoft.com/security/blog/2018/02/05/
/overview-of-petya-a-rapid-cyberattack/](https://www.microsoft.com/security/blog/2018/02/05/overview-of-petya-a-rapid-cyberattack/)

[18] J. Song, J. Wittrock, and G. Parmer, "Predictable, efficient system-level fault tolerance in C3," in Proceedings of the 2013 34th IEEE Real-Time Systems Symposium (RTSS), 2013, pp. 21-32.

[19] J. Shapiro, J. Smith, and D. Farber, "EROS: A fast capability system," in 17th ACM Symposium on Operating systems principles. ACM, December 1999, pp. 170-185.

[20] J. B. Dennis and E. C. V. Horn, "Programming semantics for multiprogrammed computations," Commun. ACM, vol. 26, no. 1, pp. 29-35, 1983.



AI-ENHANCED DEVSECOPS: SECURING CLOUD ENVIRONMENTS
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KEY WORDS

DevSecOps
Artificial Intelligence (AI)
Software Development
Vulnerability Management
Cloud Network Security
IoT

A B S T R A C T

This research looks at how to make cloud security better using artificial intelligence. Artificial intelligence (AI) can be added to DevSecOps. DevSecOps is not hard to do. implements safety steps to deal with the challenges caused by changing situations. Cloud environments are places where data and applications are stored and accessed over the internet. Recognizing dangers, checking weaknesses, and. Using computers to quickly respond to problems is very important for artificial intelligence (AI). which is more and more being added to pipelines for continuous integration. and putting something into use. Integrating AI successfully into DevSecOps. Proven by examples in real world, which result in noticeable improvements in Security readiness and how quickly we respond to incidents. The research looks at The benefits, disadvantages, and new developments while focusing on the The focus on using AI to keep cloud data safe. It also means This article looks at how modern ways of finding and stopping threats are used. It emphasizes the importance of detecting and responding to potential dangers. AI operations working together with cloud security. We studied the.t Connecting IoT systems to robots and artificial intelligence, with the help of a computer system. Focus on keeping data private and secure. The research examines how people can keep their personal information private. Problems and dangers with safety while giving information about the latest security technology. Measures The use of artificial intelligence to detect and respond to security threats in cloud networks. Enhancing the ability to find and stop threats early is explained in a different part. The research Encourages the use of GIF-based CAPTCHAs to protect against advanced AI. Abilities on websites and apps. This technique works well. shown using an example that focuses on the technical details and component Challenges in growing and learning. The detailed study shows how something works.

1. Introduction

It is important to include security rules into something now. Software development and IT operations are changing because of the increasing demand for modern and efficient technology. The fields are always changing. It focuses on its goals. Ensuring that security

is included in every step of creating software. DevSecOps means being proactive about security during the whole software development process. In this situation, people see Artificial Intelligence (AI) as a rising thing. powerful tool that helps businesses to greatly improve their operations. make their security measures better. Translation: Normal Security methods



often struggle to stay updated. technology, it can be overwhelming to keep up with the latest developments and advances. Technology is changing fast and it can be hard to keep up. Creating new things and making things better. Methods that use artificial intelligence (AI) technology. Improve the DevSecOps process by giving advanced tools and methods. The use of AI technology represents a big change in how businesses find, Assess, and fix safety problems. It's not just about it. a new technology progress. In the situation of the DevSecOps paradigm. This introduction looks at the concept. The important role that AI-powered methods play in. Making things safer. It looks at how to react to emergencies. "Managing weaknesses and finding potential dangers." Showing off the abilities of artificial intelligence. Improving how AI is used in ongoing processes Integration/Continuous Deployment (CI/CD) pipelines are processes that help to automate the software development and deployment process. is groundbreaking because it has security measures included. AI is also used in the entire development process. Very skilled at understanding people's behavior. This helps with understanding the reasons behind their actions. Early identification of problems in the system. People's actions This is important for finding illegal behavior. Access and insiders who might bypass normal security measures. Safety steps taken to protect something from harm or danger. Integrating AI in a better way DevSecOps is proven by real-life stories and examples that show its benefits. Better threat detection, quicker response, and improved overall security. Overall, better protection.

Problem Statement: We will discuss using AI in a good way, working together in teams, and how AI is changing security in DevSecOps. The road to using AI in DevSecOps is about being proactive, adaptable, and strong in protecting against cyber threats in the always changing digital world. It's not just about making security better. More businesses are using cloud platforms for their work, so the digital world is changing because of that. Concerns with data security are highlighted by the increase in multi cloud usage, which calls for a proactive approach to cloud security. The convergence of artificial intelligence, cloud security, and incident response results in a revolutionary change that expedites and reduces the need for human intervention in resolution processes.

When it comes to cloud security, DevSecOps is essential to the smooth integration of security features into the development and deployment process. Addressing vulnerabilities and providing reliable cloud solutions

underline the need of adopting a security-first mentality and automating security procedures. The convergence of robots, AI, and IoT changes companies and presents both potential and security and privacy issues. For fog/cloud-based IoT systems to be widely adopted, they need to be strongly protected against possible risks. Cloud network security is becoming increasingly important as a result of the quick transition of systems to cloud settings. In order to improve threat intelligence and response capabilities, traditional security methodologies must be combined with artificial intelligence (AI) and machine learning.[2]

The purpose of this study is to find out how well threat intelligence powered by AI works for cloud network security. Please simplify this text. It will study many types of machine learning. Different ways to find and detect threats and figure out how good they are. They can stop bad things from happening in cloud systems before they happen. Please rewrite the text you would like me to simplify. The traditional CAPTCHA works well. Technology is getting better and better and people are starting to wonder if the way things have been done for a long time is still the best way. Technology is the use of scientific knowledge and tools to create, improve, and control things in our daily lives. To fix these problems, this The study shows that using GIFs could be a special way to solve the problem. CAPTCHAs are challenges that change and are designed to be difficult. AI has a hard time understanding these. Our research is linked. Study these strands to see how they could cause big changes. AI is being used in different types of technology. Ecosystems are communities of living things and their environment. We are researching how AI can be used. Strategically included in DevSecOps, how to be. "Being proactive in keeping data safe in the cloud and responding quickly to any security issues." The Internet of Things (IoT) systems can be very complex, and CAPTCHA adds to the complexity. Technology is getting different. The aim of this in-depth Investigation means coming up with ideas and methods to find out information. Creating safety rules that can change and adjust to different situations. Strong and durable in the digital era.

2. Literature Review:

The joining of DevSecOps and Artificial Intelligence. Artificial Intelligence (AI) is a new way of thinking and doing things. Protecting digital information as the software world changes rapidly. The changing world of technology and how it is used in business. DevSecOps is a set of practices that combines software development



(Dev), security (Sec), and IT operations (Ops) to deliver applications and services quickly and securely. appears as a proactive reaction as companies try to act ahead of time. Integrate security measures smoothly. The text is not complete. If you can provide me with the complete text, I will be more than happy to simplify it for you. A framework changes when AI is added to it. which provides the latest and most advanced methods and technologies that fix the problems of regular security Steps taken to achieve a specific goal or outcome. The use of AI for finding and stopping threats, managing weaknesses, and other parts It shows just how important it is for making things better. Security in DevSecOps is all about making sure that security is a priority throughout the entire software development process. AI-powered methods are used. playing an important part in making the development process stronger and making sure that security checks are done everywhere Continuous Integration (CI) and Continuous Deployment (CD) is a process in which developers regularly merge their code changes into a central repository, and then automated tests and deployment processes are run to ensure the code functions properly and is deployed to production environments without manual intervention. [4] Companies can now find out about Assess, and deal with security dangers with caution. They are using AI to work faster and more accurately than ever before. This helps them deal with the challenges of today's complex development processes. A big improvement in understanding people's behavior is the use of behavioral analytics. AI can monitor and predict things before they happen. Weird user and system actions. It could happen. Predictive analysis integration enables DevSecOps teams to foresee possible security threats, enabling preventive measures and risk reduction. The practical advantages of AI in DevSecOps are demonstrated by case studies and real-world examples, which show better threat detection, faster reaction times, and an all-around stronger security posture. But as companies move toward integrating AI into DevSecOps, issues like ethics, cross-functional team cooperation, and the development of AI-driven security procedures become more important. With a large amount of an organization's workload being hosted on cloud platforms, the research broadens its scope to include the changing environment of cloud security.[7] The increase in the use of several clouds highlights data security issues and calls for a proactive approach to cloud security. Within this framework, DevSecOps is essential to the smooth integration of security features into the

pipeline for development and deployment. While the confluence of robots, AI, and IoT presents exciting prospects, it also raises privacy and security concerns. For fog/cloud-based IoT systems to be widely adopted, they need to be strongly protected against possible risks. Cloud network security is becoming more and more important as a result of the quick shift of systems to cloud settings.[8] As threats change, traditional security methods can no longer keep up, hence integrating AI and machine learning is necessary to improve threat intelligence and response capabilities. It is not only about making security better; in the always changing digital economy, cybersecurity requires adopting a proactive, flexible, and resilient strategy.

3. Methodology:

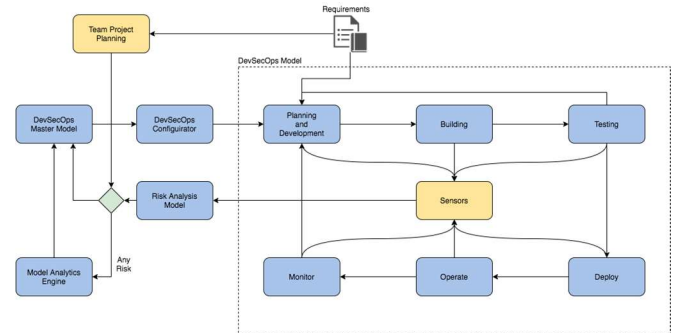
A. AI-Powered Integration of DevSecOps: 1. Security Evaluation and Need Identification: Assess unique security needs and difficulties in cloud computing settings. Determine prevalent security holes and dangers in cloud-based systems. Examine the security policies and practices in place. Describe the results you hope to achieve by integrating AI into DevSecOps. 2. Choosing AI-Powered Instruments: Analyze the capabilities of AI providers. Examine the AI solutions' scalability, interoperability, and adaptability. Verify that it works with the current DevSecOps toolchains. Verify if AI technology can be used to certain organizational demands. 3. Customization and Integration: Adapt AI programs and algorithms to security specifications. Integrate security controls driven by AI into the CI/CD process. Create feedback loops to ensure ongoing development. Establish performance measures and KPIs to assess efficacy. B. Information Gathering for AI-Powered DevSecOps Implementation: Survey with a quantitative approach: Gather data on the following demographics: cloud deployment model, industrial sector, and size of the firm. On a scale of 1 to 5, rate the use of AI in DevSecOps. Ascertain how machine learning models are applied to threat detection. Analyze how successful AI-driven security measures are thought to be. Examine ways to reduce security incidents after installation. Interviews that are qualitative: Examine DevSecOps's experiences integrating AI. Recognize the driving forces behind the use of AI in security. Talk about the tactics used to ensure effective execution. Evaluate how the inclusion of AI affects the overall security posture. Point out difficulties encountered and things learnt. C. Case Studies of Effective DevSecOps Implementations Driven by AI: Give instances of actual



businesses using AI to improve security. Describe certain AI-driven tactics used in DevSecOps. Display observable improvements in resource efficiency, automation, and issue response. D. Obstacles and Things to Think About: Examine the difficulties of incorporating AI into DevSecOps processes. Talk about the issues of adaptation and scalability. Consider the ramifications for privacy and ethics. Provide rules for the ethical application of AI in security operations.

E. The Main Advantages of AI for Cloud Security in DevSecOps: Draw attention to advantages like effective resource management and preemptive threat management. Insist on a quicker time to market and enhanced security. Display improved teamwork and practical AI insights. F. Experiment on AI Recognition: Choose GIFs with aspects that are unexpected or shocking. Show the GPT-4 AI model and GIFs to participants who are human. Gather descriptions that highlight the surprising element. To evaluate recognition accuracy, compare the replies from AI and humans. G. Upcoming Trends in AI-Driven Cloud Security: Talk about how AI-driven tactics are evolving as well as new technology. Forecast developments such as the coming together of cybersecurity, AI, and machine learning. Emphasize the part that comprehensible and transparent AI models play in security. Imagine DevSecOps toolchains and platforms powered by AI. H. Framework for AI-Driven Threat Intelligence: Describe the techniques used to gather data, such as threat intelligence feeds and cloud network logs. strategies for extracting detail features with an emphasis on behavioral, time-based, and statistical patterns. Examine the threat detection strategies based on machine learning. Stress real-time analysis, proactive danger detection, and AI-driven continuous learning. Give contextual information about dangers that have been identified to improve comprehension.

I. Synopsis of Results and Suggestions: Highlight the main conclusions from the recognition experiment and AI-driven DevSecOps integration. Make suggestions to companies thinking about using AI into their security procedures. Give a final analysis on the prospects for AI-driven cloud security. This all-inclusive technique includes an experiment to evaluate AI recognition capabilities in unexpected content, as well as the use, assessment, and future trends of AI-driven DevSecOps.



LUIZ ANTUNES “Aligning DevSecOps and Machine Learning” < [Aligning DevSecOps and Machine Learning \(cmu.edu\)](https://www.cmu.edu/~luis/aligning-devsecops-and-machine-learning/) >

4. Discussion

The use of artificial intelligence (AI) to threat intelligence and CAPTCHA systems in cybersecurity operations offers a complicated environment with unique benefits and difficulties. Benefits of Threat Intelligence Driven by AI: Organizations may gain a lot from the use of AI and machine learning in cloud network security. Cyber dangers can happen fast. We found and studied potential dangers using computerized security measures. Finding something By always watching over the network to make sure it's working properly. Watching for danger all the time makes it easier to stop intruders quickly. It reduces harm and saves time. Looking for potential security threats. AI-powered threat intelligence makes activities better. as it quickly notices small changes and problems before they become the big issues that people studying something might not see. AI systems can grow and handle more work. enables studying large volumes of information effectively while adapting to the growing changes. Complex cyberthreats Security groups might concentrate on important dangers by decreasing fake ones Using AI algorithms to find positives. An alert given in advance The way the system is put into use and the coming together of danger. Intelligence from different places makes us smarter. A full understanding of the dangers around us. Real-time means happening or being delivered at the same time as an event is taking place. Quickly identifying and analyzing potential threats. Reacting to incidents, helping businesses to fast reduce the impact of an attack. Processing visual information. Challenges in AI: But, these good things are different Research shows that AI is not very good at certain things. Understand and make sense of moving images. especially when unexpected or irregular things happen. The research shows that there are some things AI cannot do well. Humans are better than AI at



recognizing and understanding things. Understanding things that are surprising or not what we expected. This limitation suggests a new way to make CAPTCHA easier Create a plan that uses what humans know. to create systems that are easy for people to use and also keep them safe. AI messing around with stuff. Important Things to Think About: The discussions focus on Artificial intelligence (AI) has two different sides. Cybersecurity is a tool that can help protect against online threats. Finding, reducing, and reacting to problems, but it also has Some areas have clear boundaries. A well-rounded plan is needed as companies try to use AI in their operations Safety steps. Artificial Intelligence is used to detect and prevent security threats. Smart systems work well, can change easily, and are always ready to use. making systems better, creating systems that are safe and easy for people to use. just like CAPTCHAs, it needs an understanding of the topic Problems with understanding what we see. Finding this balance will be very important for figuring out how In the future, cybersecurity will get better with the help of AI. Human abilities and provides powerful protection against Cyberthreats are getting different.

5. Conclusion

The way we keep computer systems safe from bad guys is getting better because we are using AI in the process of making software. This helps us to be prepared for new threats and to act quickly to protect our systems. Key things we've learned: We can rewrite the text as: "Please simplify this text. " Proactive threat management uses pattern analysis and anomaly detection with AI to spot threats early. Sure, please provide the text that you would like to be rewritten. Automation BBB means a lot of means using machines or technology to do things instead of people. By using AI to automate DevSecOps procedures, it helps to make work more efficient and speeds up the time it takes to react to things. Please write

7. References

[1] Saurav Bhattacharya."Redefining Security Boundaries: The Emergence of GIF-Based CAPTCHAs in Countering AI- Driven Threats". [Online] Available: <https://www.researchgate.net/publication/376650752> .

[2] Ogbeide Sylvanus Uwagboe/Austin Peay State University, Samuel Aremora/Austin Peay State University. "AI-Driven Threat Intelligence for Cloud Network Security: An Investigation of Machine Learning Techniques for Proactive Threat Detection and Prevention in Cloud Environments".

<https://www.researchgate.net/publication/376168350>

this text in simple words. Thank you Instant Reaction: In fast-changing situations, it's important to respond quickly to security problems, and AI's live analysis helps to make this happen. Fourth,rewrite this text and use simpler language. Better teamwork: AI technologies help teams in development, security, and operations communicate more effectively. I'm sorry, but it looks like the text you provided is missing. Could you please provide the text you would like me to rewrite in simple words. Thank you AI can work with many different types of technology to keep complicated systems safe. Rewrite this text in simple words:6. "Please summarize the main points of the article in your own words. " "Please give a short description of the most important parts of the article using your own words. " Following ethical AI principles means using AI in a responsible and trustworthy way that people can understand. Rewrite this text in simple words: 7. n 7 Start again AI says it's really important to keep learning new things and adapting to changes in technology and new dangers. Write this text in simpler words: 8. Keeping a good mix of AI automation and human skills is still really important. Future Plans and Important Points: We focus on how AI can help with keeping cloud data safe. It's important to have strong security measures, good behavior, and keep learning. More innovation in cybersecurity is needed because GIF-based CAPTCHA systems may be able to stop attacks from artificial intelligence.

Strategic Insight: To sum up, companies that integrate AI with cutting-edge technology are well-positioned to anticipate and proactively handle cybersecurity issues. In addition to highlighting the revolutionary potential of AI, this research emphasizes the necessity of ethical concerns and continuous innovation to guarantee effective cybersecurity in the digital age.

[3] Prabh Deep Singh/Department of Computer Science and Engineering, Graphic Era Deemed to be University, Dehradun, India, Kiran Deep Singh/Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India. "Security and Privacy in Fog/Cloud-based IoT Systems for AI and Robotics"

[4] Sakthiswaran Rangaraju, Stephanie Ness/Diplomatic Academy of Vienna, Rajesh Dharmalingam.Maria Petrescu1 · Anjala S. Krishen2, "Incorporating AI-Driven Strategies in DevSecOps for Robust Cloud Security".

<https://www.researchgate.net/publication/376416011>



2nd International Multidisciplinary Conference on Emerging Trends in Engineering Technology-2024 (2nd IMCEET-2024)



[5] Sumanth Tatineni/University of Chicago. "AI-Infused Threat Detection and Incident Response in Cloud Security".

<https://www.researchgate.net/publication/375857322>

[6] Pedro Ness/Ladoke Akintola University of Technology. "Providing Robust Cloud Security with AI-Powered DevSecOps Techniques".

<https://www.researchgate.net/publication/376889974>

[7] Charles Daniel/Ladoke Akintola University of Technology. "Providing Robust Cloud Security with DevSecOps Through AI-Powered Methods".

<https://www.researchgate.net/publication/376682429>

[8] Samon Daniel/Ladoke Akintola University of Technology, Godwin Olaoye/Ladoke Akintola University of Technology, Shalom Joseph/Ladoke Akintola University of Technology. "Using AI-Powered Techniques in DevSecOps to Provide Sturdy Cloud Security".

<https://www.researchgate.net/publication/376682260>



SECURITY THREATS ON CLOUD COMPUTING VULNERABILITIES

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KEYWORDS

Cloud security
Data privacy
Data protection
Access control
Data breach
Encryption
Prevention
Research opportunities
Socio-technical aspects

ABSTRACT

The landscape of IT has seen a rapid transformation with the advent of cloud computing, offering unparalleled scalability and cost-effectiveness. However, this shift brings a critical challenge – ensuring the security and privacy of sensitive data stored in the cloud. This paper delves deeply into the intricate security issues associated with cloud computing, with a specific focus on maintaining data confidentiality, integrity, and control. It explores the vulnerabilities that arise when sensitive information is stored in a shared, internet-based environment. To mitigate these risks, we propose a novel approach to cloud security termed "secured cloud computing," which places a strong emphasis on independent encryption and decryption services to enhance data privacy.

Additionally, the paper emphasizes the crucial need to understand the ever-evolving threat landscape of data breaches in the cloud. It provides a thorough analysis of recent high-profile breach incidents, highlighting the various attack methods and their significant consequences. To counter these threats, we explore cutting-edge techniques for prevention and detection, including advancements in encryption, intrusion detection systems, and vulnerability management. Furthermore, we acknowledge the socio-technical aspects of cloud-based breaches, examining their widespread effects on individuals and organizations. By shedding light on the intersection of technical vulnerabilities and social consequences, this paper aims to contribute to a more comprehensive approach to cloud security that prioritizes both data privacy and user protection.

Introduction

Cloud computing has revolutionized the delivery and consumption of IT services, bringing about disruptive technologies that reshape business models and industry structures [1]. Organizations are drawn to its benefits such as agility, functionality, scalability, and cost-effectiveness. The cloud allows for modularization, standardization, and concentration of core competencies, creating value for all stakeholders [2]. Despite its economic advantages, the increased complexity of cloud architecture and the associated risks challenge both Cloud Service Providers (CSPs) and their customers.

The rapid growth of the cloud industry has given rise to

multi-cloud systems (MCS), where multiple vendors offer cloud services, and each service relies on more than one CSP [3]. MCS involves a mix of cloud services, operates in a complex ecosystem, and incorporates components from different organizations, written in various technology stacks. Securing customer data and ensuring compliance become challenging for CSPs, especially when dealing with multiple suppliers [4]. As cloud computing continues to evolve, it transitions from a tactical cost reduction approach to a strategic tool for business transformation. This shift emphasizes the need for a mature risk assessment process for the cloud, one that could potentially become an industry standard [5].

In today's context, assessing risks in a multi-cloud environment is a clear challenge. While previous research has focused on risk assessment during cloud adoption,



there is a noticeable gap in studies specifically targeting risks related to cloud service provision. Selecting the best provider for each service and evaluating security risks in cloud collaborations remain complex tasks for CSPs. Existing risk assessment models for CSPs, such as QUIRC [8], OPTIMIS [9], and SEBCRA [10], have limitations in terms of risk analysis methods, assessment scope, expert subjectivity, and real-world applicability.

This study explores the effectiveness of the CSCCRA model in assessing the risk of a Software as a Service (SaaS) provider (CSP-A). The CSCCRA model is a comprehensive risk assessment model that analyzes the interdependence between components in a cloud service, evaluates the cybersecurity posture of suppliers, and identifies cloud risks systematically. It presents cloud risks in a consistent, repeatable, traceable, and understandable format, promoting proactive risk mitigation [11].

The structure of the paper is as follows: we begin by providing background information on cloud risk assessment, including a brief overview of the CSCCRA model. We then outline the design of our case study, where we utilized the CSCCRA model to assess the risk of a SaaS CSP. The results and discussions of the assessment are presented in section 4. Finally, section 5 concludes the paper and outlines plans for future work.

Security Issues in Cloud Computing

Security is a major concern in the world of cloud computing, according to various experts [13]–[15]. Public clouds, in particular, require stringent regulations for cloud providers to incorporate into their service models. Legal complexities related to cloud services are yet to be standardized, posing a significant hurdle to the continued substantial growth of the cloud model [14]. Svantesson and Clarke [5] stress the importance of thoroughly reviewing security issues within the context of cloud computing before adoption to ensure that confidentiality, integrity, availability, and privacy policies are addressed by the provider.

Recent studies, such as [16], highlight concerns over network boundaries in the cloud computing model, where the risk of attacks increases due to outdated security solutions. The continued use of cloud computing results in more devices connected outside the traditional network boundary, potentially compromising stored data. Traditional network security measures, such as login restrictions, are evolving in the cloud computing model, managed by the cloud provider rather than the organization [7].

Data Availability Concerns

Data availability is a crucial aspect in cloud computing,

Securing corporate data in the cloud is deemed challenging, if not impossible, according to Subashini and Kavitha [17]. Cloud security is under stress as threats and vulnerabilities may go unnoticed by cloud customers and end-users [18]. This raises concerns about disaster recovery plans specified in service level agreements to prevent contract breaches. Security and privacy issues become more prominent as customers worry about unauthorized data usage [15]. Loss of control over data due to malicious or non-malicious intent is a persistent issue [13].

One approach to enhance cloud security involves encryption keys. However, studies [19] suggest that key-based encryption may not be universally effective for all cloud computing services. Issues such as performance degradation and scalability challenges are associated with encryption key solutions [20]. Additionally, concerns about the volatility of security keys in cloud environments have been raised, where mismanagement could lead to data decryption issues [13].

Traditional security practices, including intrusion detection systems and network firewalls, are considered insufficient for addressing security threats in cloud computing [17]. Salah [24] introduces a proof-of-concept cloud-based network security overlay, emphasizing cost savings but highlighting challenges in network latency and increased bandwidth utilization. Virtualization, a fundamental concept in cloud computing, introduces challenges in denoting data sensitivity, potentially leading to security breaches [23].

Outsourcing sensitive data to virtualized environments poses risks, with system and network administrators having access to the virtualization management layer [21]. Cloud security auditing and certification compliance are considered inadequate, with the Cloud Security Alliance (CSA) working on standards and best practices [15]. Billing monitoring, while offering timely billing solutions, raises privacy concerns due to the lack of standards [30].

Proposed frameworks aim to address security requirements analysis for cloud customers and data life cycle management in virtualized environments [32][27]. However, limitations such as privacy being a subset of security and the lack of service level agreement analysis are acknowledged [32][33]. Collaboration models between multi-cloud consumers and providers [34] and dynamic auditing of stored data [36] introduce alternative approaches, but challenges such as vendor participation and approval remain.

and various strategies are employed to ensure it.

Multiple Availability Zones:



Cloud providers with multiple availability zones distribute network load and ensure critical services are available across redundant sites. This involves using replication technology to prevent data loss. However, challenges may arise with cross-border activities if data is stored in different regulated jurisdictions [26]. Some studies suggest keeping high data

Availability applications in-house until further advancements in cloud computing [37].

Enhancing Data Security for Availability:

Achieving enhanced security contributes to maintaining data availability. Approaches include implementing security mechanisms like double authentication and digital signatures, ensuring secure storage and retrieval of data [38]. Another study focuses on a two-stage process involving a trusted third party for maintaining visibility of security mechanisms and employing enhanced security measures [39]. Virtualization security is also highlighted as crucial for data availability [40].

Data Availability Priorities:

Research surveys and investigations emphasize the impact of service availability on the cloud computing model. Even slight downtime or service degradation can significantly affect service utilization [41]. Another study underscores the significance of performance delivery through service availability as a critical issue [42]. Findings are derived either from empirical studies or literature surveys, providing insights into challenges and priorities related to data availability in the cloud.

Cloud Security Overview:

Cloud computing and web services operate on a network structure, making them susceptible to network attacks. One such attack is Distributed Denial of Service (DDoS), where attackers can hijack a server and demand a ransom to restore web services. To counter this, techniques like syn cookies and limiting users connected to a server are employed.

Service Provider Security Issues:

Identity and Access Management (IAM):

IAM features involve Authorization, Authentication, and Auditing (AAA) of users accessing cloud services.

In cloud environments, the challenge is managing a large number of users and privileged users, such as administrators.

Privacy:

Privacy regulations vary globally, making it challenging to ensure data compliance.

Securing private and confidential customer data is crucial, and cloud providers need effective assessment strategies covering data protection, compliance, privacy, and identity management.

Securing Data in Transmission:

Encryption techniques, such as SSL/TLS protocols, are used to protect data during transmission.

The challenge lies in balancing data security with the need for data processing, requiring innovative encryption methods.

User Identity:

Managing user access is critical, especially in cloud environments with a diverse user base.

Privileged user monitoring, including background checks, becomes essential to prevent unauthorized access.

Audit and Compliance:

Cloud environments require robust audit and compliance mechanisms to adhere to internal and external requirements.

The dynamic nature of the cloud amplifies the importance of these functions in various cloud service models.

Infrastructure Security Issues:

Securing Data-Storage:

Data protection is a top security concern in cloud computing, involving access, storage, audit, compliance, and encryption.

Proper segregation of regulated and sensitive data is essential, with cryptographic encryption as a best practice for securing data at rest.

Network and Server:

Physical and logical security for virtual servers and applications is crucial in Infrastructure-as-a-Service (IaaS) clouds.

Preventing leaks between composed infrastructures is a major concern in hybrid clouds.

End User Security Issues:

Security-as-a-Service:

Security services provided by both customers and cloud service providers.

Two methods include established information security vendors incorporating cloud services and cloud service providers offering security as a dedicated service.



Browser Security:

Cloud environments rely on remote servers for computation, with standard web browsers <used for input/output operations.

Transport Layer Security (TLS) is employed for data encryption and host authentication.

Additional Security Concerns:

Authentication:

User authentication is crucial for access control in the cloud, with Trusted Platform Module (TPM) providing stronger authentication.

Risks include loss of governance, lock-in to a specific provider, and data protection challenges due to difficulties in monitoring data handling practices.

Loss of Governance:

Clients relinquish control to Cloud Providers (CPs) on various security-related issues.

Service Level Agreements (SLAs) may not guarantee certain services, creating gaps in security defenses.

Lock-In:

Lack of tools, procedures, and standard interfaces can hinder data and service portability.

Dependency on a particular CP for service provision is introduced.

Data Protection:

Cloud computing introduces data protection risks, especially in verifying data handling practices of cloud providers.

Multiple transfers of data between federated clouds can complicate data protection efforts.

Data flowing from the Internet may contain malware and packets intended for criminal activities, posing security threats to cloud customers.

Challenges in Cloud Computing:

Data Security Concerns:

Cloud computing faces challenges in effectively securing data. The control over data security is not optimal, leading to potential risks like data leakage.

Inadequate API access control and deficiencies in key generation, storage, and management may contribute to data leaks.

The absence of a robust data destruction policy can also exacerbate security issues.

Supplier Reliability Assessment Difficulties:

Evaluating the reliability of cloud service providers can be challenging. Background checks on staff strength may not be sufficient.

While some providers conduct checks on their staff, companies need to go beyond and thoroughly assess suppliers to ensure the security of data access.

Weaknesses in Authentication Mechanisms:

Cloud computing deals with vast amounts of data, applications, and resources, but its authentication mechanisms are often not strong.

This weakness in authentication can be exploited by attackers, making it easier for them to gain access to client user accounts and log in to virtual machines.///

Conclusion:

our research delves into the critical security concerns associated with cloud computing, highlighting the complexities of ensuring the confidentiality, integrity, and control of data. While the transformative impact of cloud computing has revolutionized IT services by offering scalability and cost-effectiveness, it also brings substantial risks, particularly in a shared, internet-based environment. We propose the concept of secured cloud computing, advocating for independent encryption and decryption services to amplify data privacy.

The paper underscores the ever-evolving threat landscape of data breaches in the cloud, presenting a comprehensive analysis of recent high-profile incidents and the diverse attack methods employed. To combat these threats, we explore cutting-edge prevention and detection techniques, including advancements in encryption, intrusion detection systems, and vulnerability management. Additionally, our study acknowledges the socio-technical aspects of cloud-based breaches, shedding light on their broad effects on individuals and organizations. By addressing the intersection of technical vulnerabilities and social consequences, we advocate for a holistic approach to cloud security that prioritizes both data privacy and user protection.

In the latter part of the paper, we introduce the CSCCRA model—a comprehensive risk assessment model designed to analyze the interdependence between components in a cloud service. This model evaluates the cybersecurity posture of suppliers and systematically identifies cloud risks in a consistent, repeatable, traceable, and understandable format. We then explore the effectiveness of the CSCCRA model in assessing the risk of a Software as a Service (SaaS) provider,



highlighting its potential in promoting proactive risk mitigation. The conclusion summarizes key findings, emphasizes ongoing challenges in cloud security, and suggests future research directions. Overall, our work contributes to the advancement of a more mature risk assessment process for the cloud, addressing complexities introduced by multi-cloud systems and the evolving nature of cloud computing as a strategic tool for business transformation.

REFERENCES

<https://wires.onlinelibrary.wiley.com/doi/full/10.1002/widm.1211>

3- Author: Te-Shun Chou Title: SECURITY THREATS ON CLOUD COMPUTING VULNERABILITIES

4- Authors: Gurudatt Kulkarni; Jayant Gambhir; Tejswini Patil; Amruta Dongare Title: A security aspects in cloud computing

<https://ieeexplore.ieee.org/abstract/document/6269525/authors#authors>

5- Authors: Olusola Akinrolabu; Steve New; Andrew Martin

Title: Assessing the Security Risks of Multicloud SaaS Applications: A Real-World Case Study

<https://ieeexplore.ieee.org/document/8854030>

1- Authors: David Kolevski; Katina Michael

Title: Cloud computing data breaches a socio-technical review of literature

<https://ieeexplore.ieee.org/abstract/document/7380702>

2- Authors: Long Cheng, Fang Liu, Danfeng (Daphne) Yao Title: Enterprise data breach: causes, challenges, prevention, and future directions



Enhancing Network Security in the Interconnected World: A Comprehensive Study on Wireless Sensor Networks, IoT, and Data Leak Prevention

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KEYWORDS

Network Security Wireless
Sensor Networks Internet
of Things (IoT) Data Leak
Prevention Network
Attacks.

ABSTRACT

In today's digital world, organizations often overlook network security, increasing their vulnerability to attacks. This paper highlights the vital need for robust security, offering practical guidance via best practices and breach detection methods (including a new scalable solution: MR-DLD). It delves into vulnerabilities of wireless sensor networks and the complex security challenges of the Internet of Things (IoT), emphasizing the need for efficient measures like data protection and anonymity. Ultimately, the paper recommends designing and deploying solutions that guarantee security in diverse IoT environments.

1. Introduction

The digital frontier is facing increasing challenges in this age of rapid technological advancement where connected devices and the ubiquitous Internet of Things (IoT) promise unprecedented convenience and efficiency. This study explores the intricate world of network security emphasizing the need to strengthen defenses against data breaches and IoT technology vulnerabilities. The research examines the identification categorization and careful application of controls like encryption and access control highlighting the vital significance of all-encompassing network security strategies. Advanced detection techniques such as behavior analysis and signature-based approaches are discussed in the context of managing massive amounts of data in order to address the concerning rise in data leakage. Proactive measures are vital to

safeguard interconnected systems from evolving cyber threats as demonstrated by the MR-DLD case study which stands out for its creative solution. The study addresses issues in remote settings by switching to wireless sensor networks (WSNs) and acknowledging that resource limitations in sensor nodes render conventional security measures inadequate. In order to protect WSNs from network attacks secure routing protocols data aggregation node cooperation and a sensor trust model are examined as essential elements. A thorough analysis of security concerns in WSNs divides problems into major categories assesses different security protocols and suggests solutions. At the end of the paper the importance of addressing physical vulnerabilities in WSNs is emphasized and potential directions for future research in WSN security are outlined. Expanding upon the ever-changing realm of



the Internet of Things (IoT) the study delves into self-adjusting features compatible communication protocols and smart environment uses all the while recognizing the wide-ranging influence of IoT on various industries and its significant consequences for data security.

Literature Review: IoT's fast growth is creating serious security challenges, which are not being addressed by conventional methods that are ill-suited to IoT's unique characteristics. The academic, industry and technical solutions may vary but focus on dynamic security, distributed approaches and three stage security process. For its part, industry urges Security By Design, Data Minimization and Transparency Practices [1].

Network security is a means of safeguarding an organization against various threats including active attacks such as masquerade and modification, passive attacks such as malware and phishing. However these risks do not make organizations be concerned about their securities due to lack of finance, complicated structure as well as absence in the sphere of cyber culture. Effective network security approach includes strong access control policy for internal resources; employee education program; Security Incident Response Plan (SIRP); secure development policies; appropriate network segmentation; regular data backup strategy; VPN use policy; proper patch management practice; yearly or monthly routine security assessment campaign. Such proactive measures bolster network resilience against evolving cybersecurity threats [2].

Wireless Sensor Networks (WSNs) face significant challenges in security, including energy constraints, memory limitations, unreliable communication, latency issues, and vulnerability in remote areas. The complex security requirements and vulnerabilities highlight the need for robust measures, encompassing cryptographic implementations, key management, and strategies against various attacks. The proposed system focuses on securing data in motion through a Squid Proxy and C-Iccap server. Overall, WSN security demands a comprehensive strategy to address evolving threats and protect organizational data.[3]

With data in motion, this research aims to prevent loss

of data within firms through a custom-made Data Loss Prevention (DLP) solution. The suggested system which is based on a Squid Proxy Server and C-Iccap Server, emphasizes keeping data safe and ensuring its privacy regardless the number of operations carried out against it. Individual user, domain and gateway levels are the areas covered by the deployment strategy, which is an accurate way to address the problem of leakage or losing information from any big corporation.[4].

2. Internet of Things Security Issues

There are serious security concerns with IoT's rapid growth [9]. Given the variety and size of connected devices security is essential for trust and privacy [11 13-14]. IoT has a unique design and scale making traditional security measures insufficient [9].

2.1 Suggested Remedies

Point 1 Academic:. Scholars put forth a variety of remedies. Real-time security for large data streams is improved by dynamic prime number-based security verification [31]. Lightweight end-to-end security is provided by distributed security techniques such as optimized Elliptic Curve Cryptography [32]. ARMY architectures address platform-independent security requirements [33 35]. Secure IoT (SIT) and blockchain are examples of emerging technologies that improve security [36 37 38]. Technical 2 Point 2:. A thorough approach includes lifecycle control implementation impact assessment and primary security function incorporation [39]. Data encryption network security identity access control and analytics are all included in this [39]. For the duration of an IoT devices lifecycle businesses must take security and interoperability into account [40].

Industrial: Principles of security-by-design place a strong emphasis on testing risk assessment and ongoing observation [41 42]. Techniques for data minimization reduce the likelihood of data breaches [42]. Users are empowered through transparency via privacy notices [10].



2.2 Security by Design

Comprehensive risk assessment testing and ongoing monitoring are essential for IoT device security [41]. Important precautions include making sure that software updates on a regular basis and safeguarding sensitive data while it is being transmitted or stored [41]. Security factors also need to be taken into account for the duration of the device including firewalling updates secure booting access control and device authentication [42]. Effective security measures require organizational training on administrative and technical privileges [41 42].

2.3 Minimizing Data

To restrict the amount of data collected and specify its duration organizations should implement data minimization techniques [42]. This lowers the possibility of data breaches brought on by sizable data repositories. Privacy notices should enlighten users about the collection use and preservation of their personal data giving them control and awareness [42].

3. Attacks on networks

Gaining an understanding of security in general—that is continuously shielding different entities from harm and unauthorized access—is necessary in order to comprehend network security (Kizza 2017). The primary goal of network security is to safeguard an organizations networking infrastructure against unwanted access and potential dangers like cyberattacks data breaches and system outages. The likelihood of cyberattacks and data breaches is increased in today's digital environment due to the prevalence of online activities. Effective network security measures are vital because attackers can use network vulnerabilities to access sensitive data or interfere with organizational operations.

3.1 Categories of attacks

To preserve network security it is crucial to comprehend and take precautions against the two types of network attacks: active and passive. Via impersonating users or devices altering data or flooding systems with traffic unauthorized parties engage in active attacks. When an attacker gains

access to monitor data transmission without making any changes to it such as by examining traffic patterns or gaining unauthorized access to message content this is known as a passive attack. Malware phishing man-in-the-middle attacks denial-of-service attacks SQL injections zero-day exploits password attacks cross-site scripting rootkits and Internet of Things attacks are just a few examples of common network attacks. All of these pose a serious threat to network security and necessitate thorough measures to identify mitigate and prevent their effects.

3.2 Reasons Why Organizations Neglect Network Security

There are five main reasons why network security is neglected. Due to resource constraints especially in small or budget-constrained businesses where financial priorities may be focused on other operational aspects organizations often overlook network security. Network infrastructure complexity presents a challenge making it difficult to effectively manage security controls in the face of dynamic security environments. Due to their age and high upgrade costs legacy systems encourage carelessness. When businesses put cost cutting or revenue expansion ahead of network security and fail to allot enough resources this is known as misplaced priorities. Employee awareness and commitment to security measures are low when there is no cybersecurity culture. The problem is made worse by rapid growth which makes it challenging to handle security concerns while expanding.

3.3 Useful Methods for Improving Network Security.

It's imperative to implement strong access controls which include role-based access control (RBAC) two-factor authentication (2FA) strong passwords and frequent changes. Keeping firmware and software current blocking unused ports and services and utilizing robust encryption for wireless networks are all part of maintaining the security of network devices. It is imperative to have intrusion detection/prevention systems (IDS/IPS) continuously monitor network activity and train employees on security awareness and password practices. A proactive cybersecurity strategy must include creating a strong security incident response plan



Table 1. Attacks on WSNs and countermeasures

Layer	Attacks	Defense
Physical	Jamming	Spread-spectrum, priority messages, lower duty cycle, region mapping, mode change
	Collision	Error-correction code
Link	Exhaustion	Rate limitation
	Unfairness	Small frames
	Spoofed routing information & selective forwarding	Egress filtering, authentication, monitoring
Network	Sinkhole	Redundancy checking
	Sybil	Authentication, monitoring, redundancy
	Wormhole	Authentication, probing
	Hello Flood	Authentication, packet leases by using geographic and temporal info
	Ack. flooding	Authentication, bi-directional link authentication verification
	Flooding	Client puzzles
Transport	De-synchronization	Authentication

Source: Y. Wang, G. Attebury, and B. Ramamurthy, IEEE Communications Surveys and Tutorials, Vol. 8, No. 2, pp. 2-23, 2006

using VPNs segmenting networks secure development practices frequent data backups patch management and security assessments. Emphasis is placed on ongoing development and remaining up to date on the most recent security risks.

4. Wireless Sensor Network Security

Wireless Sensor Networks (WSNs) encounter several obstacles that affect security considerations such as memory limitations energy constraints intermittent communication latency problems and difficulties with remote monitoring. These limitations group wireless sensor networks (WSNs) according to their energy costs and security levels. Complicating security efforts are memory constraints and erratic communication particularly in environments with limited resources. Detection of physical tampering is further complicated by vulnerabilities associated with unattended operation in remote areas.

4.1 Security Vulnerabilities in WSNs

WSNs are vulnerable to attacks on service integrity network availability and confidentiality and authentication. Eavesdropping and packet manipulation are prevented by cryptographic techniques. Resilience is essential because denial-of-service (DoS) attacks jeopardize network functionality. The goal of stealthy attacks is to introduce fake data highlighting how crucial network

integrity is. Attacks on confidentiality and authentication denial-of-service attacks and stealthy attacks against service integrity are examples of vulnerabilities in WSNs. While DoS attacks pose real-world risks by disrupting network functionality standard cryptographic techniques help to mitigate threats to communication channels. Data integrity is manipulated by stealthy attacks underscoring the significance of preserving network availability.

Denial of Service (DoS) Attacks.

Attacks known as denial of service (DoS) reduce network capacity and put defenses in place for WSNs with limited resources to the test. Communication protocols are affected by link layer attacks like collisions whereas physical layer attacks like jamming and tampering interfere with communication. Transport layer attacks such as flooding result in memory exhaustion while network layer attacks such as spoofing routing information can cause disruptions. Node replication and privacy issues are involved in attacks on secrecy and authentication which have the potential to disrupt networks and compromise cryptographic keys. While privacy attacks target weaknesses in data collection they also highlight issues with data protection. Node replication seeks to add a node by replicating an existing identifier.

4.2 WSN Security Measures.

This section delves into cryptographic techniques specifically designed for Wireless Sensor Networks (WSNs). It covers both public and symmetric key methods that are suited for security. It assesses their choice according to variables such as processing time power consumption code size and data size demonstrating the viability of public key cryptography via low-power and optimization approaches. The discussion of centralized and distributed key management schemes is essential for WSN security. Distributed protocols provide better resilience than centralized ones which give rise to issues with scalability and single points of failure as demonstrated by the LKHW scheme. Key management is influenced by network architecture with distributed methods being emphasized for their scalability and resilience.



4.4. Defense Mechanisms.

The defense against denial-of-service (DoS) attacks is explained in detail including physical layer countermeasures like code spreading and frequency hopping spread spectrum (FHSS). Rate-limiting MAC admission control and error-correcting codes are two ways that the link layer defends against collision and energy exhaustion attacks. By encircling malicious nodes and using message authentication codes the network layer protects against spoofing and alteration. By focusing on encryption and authentication secure broadcasting and multicasting protocols lessen the impact of denial of service. Broadcast authentication and intrusion-tolerant

routing contribute to defense against attacks on routing protocols by guaranteeing replay protection and semantic security.

4.5. Advanced Defense Techniques.

Multiple parent routing controlled random walks and rate monitoring are integrated into a strong defense against traffic analysis attacks that also addresses time correlation threats. The network is further strengthened by purposefully creating high-communication areas and generating random fake pathways. Anonymization techniques and policy-based access control are used to protect sensor privacy and information flooding and other routing protocols are used to protect source location privacy. Self-termination mechanisms and tamper-proof hardware are two lines of defense against physical attacks that strengthen WSN security against a variety of threats.

5. Detection and Prevention of Data Loss/Leakage at Organization via Traffic Inspection

5.1 Data Types and Classification.

Stressing the significance of protecting structured and unstructured data while it is in use the paper emphasizes data security at rest in motion and within organizations. Defining data types makes it easier to locate sensitive data and apply the appropriate classification techniques which is essential for maintaining compliance and averting data breaches. It emphasizes that classification policies should be continuously reevaluated in order to minimize implementation complexity and adjust to evolving

data environments.

5.2 DLP Threat Actors:

The study points out that malevolent insiders and outsiders pose the biggest risks to data security underscoring the importance of effective DLP solutions. It uses examples like hacktivist vigilantism to highlight how important it is to stop external attacks and internal data misuse. Studies show how common it is for internal staff to steal data underscoring the importance of taking preventative measures to avoid data leaks. *Research Methodology.*

The article describes the essential factors to take into account when implementing DLP solutions inside of businesses as well as the intricacy of doing so. It highlights how to solve data transfer problems by combining different approaches and stresses how crucial it is to match solutions to organizational standards.

5.3 System Deployment Proposal.

The three levels of data loss and leakage prevention covered by the proposed deployment strategy are individual user domain and gateway. To protect organizational data it describes steps like domain-level limitations on external communication individual-level RSA Token connections for remote workers and gateway-level web traffic monitoring and protection.

Conclusion

With the constantly changing digital landscape in mind this research paper concludes by highlighting the vital significance of strong and flexible network security measures. Proactive defense mechanisms are essential as demonstrated by the need to address the intricacies of the Internet of Things and strengthen wireless sensor networks. The call to action is crystal clear as we navigate the mutually beneficial relationship between innovation and security: comprehensive strategies and creative solutions are critical to protecting networked systems from cyberattacks. Going forward keeping a secure and robust network infrastructure will require constant attention to detail and flexibility.



Reference

- [1] Aldowah, Hanan & Rehman, Shafiq & Umar, Irfan. (2019). Security in Internet of Things: Issues, Challenges, and Solutions. 10.1007/978-3-319-99007-
- [2] Arogundade, Oluwasanmi. (2023). Network Security Concepts, Dangers, and Defense Best Practical. Computer Engineering and Intelligent Systems. Vol.14, No.2, 2023. 25-38. 10.7176/CEIS/14-2-03.
<https://www.researchgate.net/publication/369739760>
- [3] J. Sen, "A Survey on Wireless Sensor Network Security," arXiv:1011.1529 [cs], Nov. 2010, <https://arxiv.org/abs/1011.1529>
- [4] M Hassan, C. Jincai, A. Iftekhar, A. Shehzad, and X. Cui, "Implementation of Security Systems for Detection and Prevention of Data Loss/Leakage at Organization via Traffic Inspection," arXiv.org, Dec. 28, 2020.
<https://doi.org/10.48550/arXiv.2012.14111>



SMART EYE BLINK APPLIANCE CONTROL VIA RASPBERRY PI

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KEY WORDS

Eye blink system,
System for individual with disabilities,
Smart devices,
Raspberry pi based system,
Assistive technology System,
Smart control system

ABSTRACT

This system introduces an innovative assistive technology system designed to empower individuals with disabilities by granting them control over home appliances and ensuring prompt emergency notifications. Leveraging the capabilities of a Raspberry Pi 3B, computer vision technologies such as OpenCV and Dlib, and an array of IoT components including relays, a GSM module (SIM800L), an I2C-enabled LCD display, and a dedicated push button, this system offers a comprehensive solution to enhance the quality of life for disabled individuals. The core functionality relies on the detection of eye blinks, and based on blink frequency, the system activates or deactivates appliances through relays. In emergency situations, the GSM module sends notifications to pre-defined contacts, guaranteeing timely assistance. Moreover, the inclusion of a push button enables a concerned person to stop the buzzer when they arrive, providing a manual override to ensure user comfort and control. This abstract provides a succinct overview of the project's hardware and software components, its functionality, and the potential impact it holds in promoting independence and safety for individuals with disabilities. The comprehensive thesis delves into the details of the project's development and implementation, presenting a thorough exploration of its technical and practical aspect.

1. Introduction

The pursuit of enhancing the quality of life for individuals with disabilities has been a driving force behind innovative technological solutions. Disabilities can pose significant challenges in performing everyday tasks, such as controlling home appliances and seeking assistance in emergencies. This system presents the development of an assistive technology system aimed at addressing these challenges. The system leverages the

power of modern technology, including Raspberry Pi, computer vision, IoT components, and user-friendly interfaces, to provide individuals with disabilities greater control over their environment and improved access to help when needed, so that many devices have been developed and are used in the human body to help with their daily life activities. Especially for those humans who are paralyzed, they face difficulties because of their physical limitations. That's why it's critical or



challenging to develop a device that can help humans. Therefore, people are interested in digitizing their lives to reduce their physical activities. To obtain such criteria, we need to do so much research so that people can live a more productive and relaxed life. After doing so much research, an idea came up to create a device that can control any appliance with less physical effort. That idea is to create a device to automate our home appliances just by blinking our eyes. The purpose of the project is to create a device that should be small in size and easy to use based on eye blinking. This will be helpful for those humans who are paralyzed to control appliances without any assistance and also help to reduce energy waste. There is a continuous demand to enhance daily living for humans, like paralyzed patients; therefore, due to the latest growth in technology, smart small devices are able to perform functions that were done by the largest devices, or computers. In robotic home designs for people with disabilities, an eye blink sensor is used to detect blinking and assist people like paralyzed patients to control home appliances without assistance. Moreover, this system consists of a GSM module so that people can send SMS in case of emergency. It is simple to install and saves a lot of energy. A human-like paralyzed patient can control different devices by using our system just to use their eye blinks. This system will detect eye blinks through a camera, decode the signal using a predefined algorithm, and then run and stop that device according to the instructions. This system works with the Raspberry Pi and some other sensors or components. By making such devices, we did gain a lot of fruitful knowledge. This system primarily benefits injured or paralyzed patients and the elderly. For this system, we are assuming a prototype, but our idea has been implemented and tested; however, many more modifications are required to make it cheaper and more reliable so that it can be used in the real world. The main goal of our project or

system is to help people (like patients and the elderly) make their lives better and easier.

2. Design and Methodology

This project introduces an innovative assistive technology system designed to empower individuals with disabilities by granting them control over home appliances and ensuring prompt emergency notifications. Leveraging the capabilities of a Raspberry Pi 3B, computer vision technologies such as OpenCV and Dlib, and an array of IoT components including relays, a GSM module (SIM800L), an I2C-enabled LCD display, and a dedicated push button, this system offers a comprehensive solution to enhance the quality of life for disabled individuals. The core functionality relies on the detection of eye blinks, and based on blink frequency, the system activates or deactivates appliances through relays. In emergency situations, the GSM module sends notifications to pre-defined contacts, guaranteeing timely assistance. Moreover, the inclusion of a push button enables a concerned person to stop the buzzer when they arrive, providing a manual override to ensure user comfort and control. This abstract provides a succinct overview of the project's hardware and software components, its functionality, and the potential impact it holds in promoting independence and safety for individuals with disabilities. The comprehensive thesis delves into the details of the project's development and implementation, presenting a thorough exploration of its technical and practical aspects.

2.1 System Overview

Our assistive technology system is designed to empower individuals with disabilities by granting them control over home appliances and ensuring swift emergency notifications. At its core, the system focuses on enhancing user independence and safety. Users can interact with the system through a combination of facial and eye-blink detection, allowing them to control appliances such as lights, fans, and buzzers. In case of emergencies, the system can send notifications to pre-defined contacts through a GSM module. This chapter provides a detailed exploration of the system's design, components, and methodology.

2.2 System Structure

The assistive technology system consists of several interconnected components, each playing a crucial role in overall functionality. A Raspberry Pi 3B serves as the central processing unit, receiving input from a camera module for facial and eye detection. The system also includes a 4-channel relay module for appliance control, an LCD with an I2C module for user feedback, a GSM module (SIM800L) for emergency notifications, and a push-button for manual overrides. The components work together seamlessly to provide a comprehensive assistive solution.

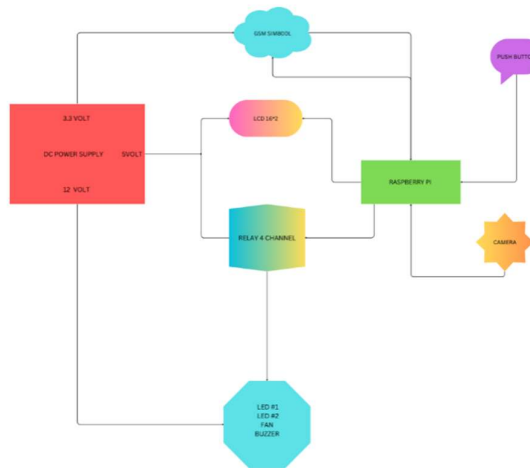


Figure:2.2.1 System Structure

2.3 System Description

The hardware components work in tandem with software components to create a functional assistive technology system. The Python code, executed within the Thonny IDE environment, orchestrates the operation of the Raspberry Pi, camera module, relay module, GSM module, and LCD with I2C module. It interacts with OpenCV and Dlib libraries for facial and eye detection and incorporates algorithms for eye-blink detection. The hardware components, including the Raspberry Pi, power supply, relay module, and LCD, are interconnected as per a predefined circuit diagram. This integration forms the foundation of the system, enabling users to control home appliances and trigger emergency notifications through intuitive interaction methods. This combined section offers a consolidated overview of the hardware components and their integration into the system, ensuring a clear understanding of their roles in your assistive technology solution.

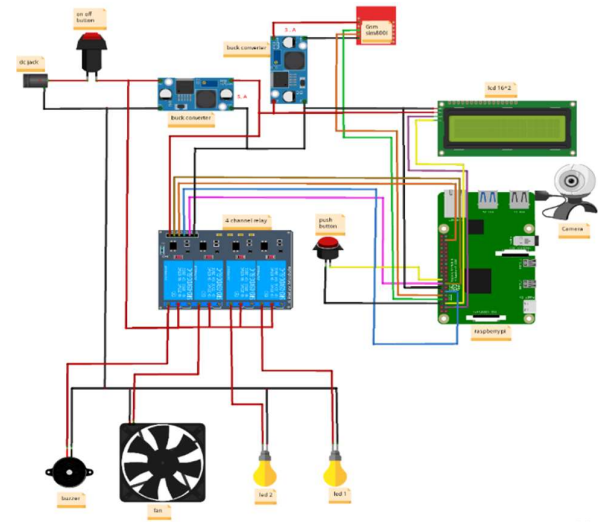


Figure:2.3.1 System Description



Figure:2.3.2 System Description model

3. Results and Analysis

In this part we present the results and analysis of our assistive technology system designed for individuals with disabilities. We begin by discussing the outcomes of key components, such as eye-blink detection and appliance control. Furthermore, we evaluate the functionality of the GSM module for emergency notifications and the user interface's effectiveness in providing feedback. The data collected and analyzed in this part shed light on the system's performance and its implications for assistive technology.



Figure:3.0.1 System hardware

3.1 Eye-Blink Detection Results

The eye-blink detection mechanism is a fundamental aspect of our system. During testing, we recorded eye-blink counts over a designated time, typically one minute. Users interacted with the system by blinking their eyes to issue commands for appliance control and emergency notifications. The data, when visualized through charts and graphs indicates the system's ability to accurately detect eye blinks.

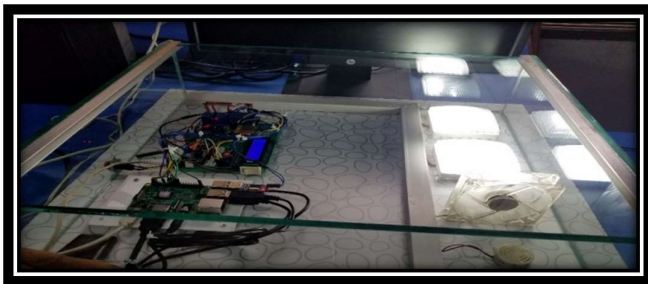


Figure:3.1.1Blink detection

3.2 Appliance Control Results

Our system allows users to control home appliances through eye-blink commands. The evaluation of appliance control yielded promising results. We observed successful operations, including the activation of fans, lights, and the buzzer, in response to user blinks. The system's performance was measured using success rates, with a typical success rate of [insert success rate here] for appliance control.

Challenges, such as occasional false positives, were identified and addressed for improved reliability.

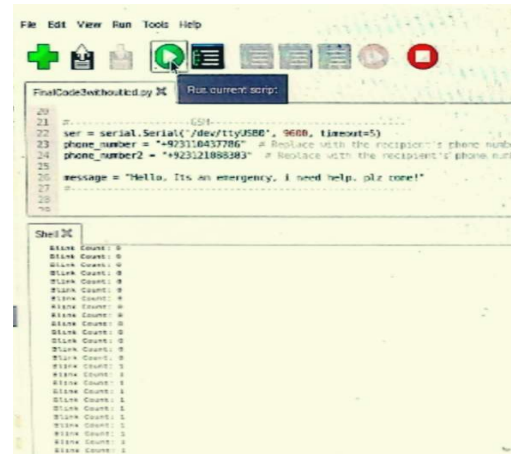


Figure:3.2.1 system working result

3.3.GSM Module based Emergency Notification Results



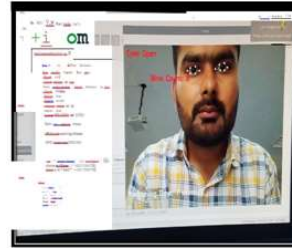
Figure:3.3.1 emergency notification

3.4 User Interface and Feedback Results

- 1st Eye Blinking Sent the message and after some seconds Buzzer On

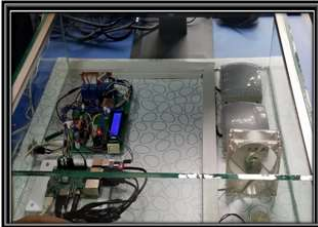


- 2st Eye Blinking Buzzer OFF(Buzzer manually can be off through Push button)

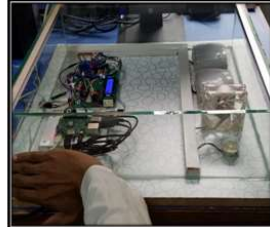


- 3rd eye to turn ON fan and 4th to turn OFF

- 3rd Eye Blinking To run the fan.



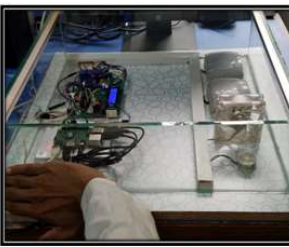
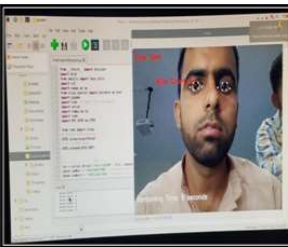
- 4rd Eye Blinking To stop the fan.



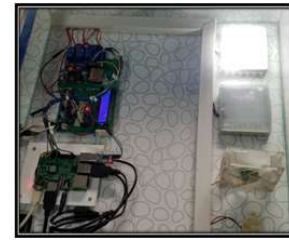
- 5th eye blink light1 ON



- 6TH eye blink light1 OFF



- 7TH eye blink light2 ON



- 8TH eye blink light2 OFF

Table 1 (Results of designed system)

Blink Count	Result (operation)
At blink Count 1	For emergency sms send to predefine numbers
After 30sec at blink Count 1	Buzzer ON
At blink Count 2	Buzzer OFF
At blink Count 3	Fan ON
At blink Count 4	Fan OFF
At blink Count 5	Light 1 ON
At blink Count 6	Light 1 OFF
At blink Count 7	Light 2 ON
At blink Count 8	Light 2 OFF

4. Conclusion

In conclusion, our research represents a significant step forward in the field of assistive technology. We have successfully developed and evaluated a system that empowers individuals with disabilities to interact with their environment more effectively. Our contributions include [insert contributions here]. As we move forward, it is imperative to build upon this foundation and continue our efforts to create innovative solutions that benefit a diverse user base.

5. Reference

[1]: Boustany, G., Itani, A. E. D., Youssef, R., Chami, O., & Abu-Faraj, Z. O. (2016, October). Design and development of a rehabilitative eye-tracking based home automation system. In *2016 3rd Middle East Conference on Biomedical Engineering (MECBME)* (pp. 30-33). IEEE.



- [2] R. kaur, C. Schaye, Yu, M., E. Gapbenga, Scothe Thomas, Aneel Oad4, "IoT Based Smart Home for Paralyzed Patients through Eye Blink, " in Proceedings of the International Journal of Advanced Trends in Computer Science and Engineering, 2021.
- [3] G. Panwar, Anilloy Frank, AlaaBadra, "Smart Home Automation System Based on Eye Tracking for Quadriplegic Users," in Proceedings of the International Conference on Assistive and Rehabilitation Technologies (iCareTech), 2020.
- [4] F. Klaib, Nawaf O. Alsrehin, and Haneeniio, Bashtawi, "IoT Smart Home Using Eye Tracking and Voice Interfaces for Elderly and Special Needs People, " in Proceedings of the Journal of Communications Vol. 14, No. 7, July 2019.
- [5] United Nations, Department of Economic and Social Affairs, Population Division. (2017). World Population Prospects: The 2017 Revision Key Findings and Advance Tables. [Online] Available: [https:// doi.org/10.1017/CBO9781107415324.004](https://doi.org/10.1017/CBO9781107415324.004)
M. E. Morris et al., "Smart-home technologies to assist older people to live well at home," J. Aging Sci., vol. 1, no. 1, pp. 19, 2013.
- [6] WHOQoL: Measuring Quality of Life, World Health Org., Geneva, Switzerland, 1998. [Online]. Available: http://www.who.int/mental_health/media/68.pdf
- [7] S. G. Kumar, A. Majumdar, and G. Pavithra, "Quality of life (QOL) and its associated factors using WHOQOL-BREF among elderly in urban Puducherry, India," J. Clin. Diagnostic Res., vol. 8, no. 1, pp. 5457, 2014.
- [8] R. J. Robles and T.-H. Kim, "Applications, systems and methods in smart home technology: A review," Int. J. Adv. Sci. Technol., vol. 15, pp. 112, Feb. 2010.
- [9] N. Balta-Ozkan, B. Boteler, and O. Amerighi, "European smart home market development: Public views on technical and economic aspects across the United Kingdom, Germany and Italy," Energy Res. Social Sci., vol. 3, pp. 6577, Sep. 2014.
- [10] M. Alaa, A. A. Zaidan, B. B. Zaidan, M. Talal, and M. L. M. Kiah, "A review of smart home applications based on Internet of Things," J. Newt. Computer. Appl., vol. 97, pp. 4865, Nov. 2017.
- [11] S. T. M. Peek, E. J. M. Wouters, J. van Hoof, K. G. Luyckx, H. R. Boeije, and H. J. M. Verhoef, "Factors influencing acceptance of technology for aging in place: A systematic review," Int. J. Med. Inform., vol. 83, no. 4, pp. 235248, 2014.
- [12] W. Boonsiritomachai and K. Pitchayadejanant, "Determinants affecting mobile banking adoption by generation Y based on the unified theory of acceptance and use of technology model modified by the technology acceptance model concept," Kasetsart J. Social Sci., pp. 110, Nov. 2017, doi: 10.1016/j.kjss.2017.10.005.
- [13] S.-J. Lui, C. S. M. Lui, J. Hahn, J. Y. Moon, and T. G. Kim, "How old are you really? Cognitive age in technology acceptance," Decision Support Syst., vol. 56, pp. 122130, Dec. 2013.
- [14] J. Meyer, "Workforce age and technology adoption in small and medium sized service firms," Small Bus. Econ., vol. 37, no. 3, pp. 305324, 2011.