THE INDIAN JOURNAL OF TECHNICAL EDUCATION

Indexed in the UGC-Care Journal list

INDIAN JOURNAL OF TECHNICAL EDUCATION

Periodicity : Quarterly   **Subject :** Multidisciplinary

Subscription Rates with Effect from 01 Jan 2024

FOR ONE/TWO YEARS or 4/8 ISSUES

		One year	Two Years
ISTE Life Members	:	Rs. 2000	Rs. 3500
Institutional members of ISTE	:	Rs. 3000	Rs. 5500
Non-member educational & Research institutions and other individuals	:	Rs. 5000	Rs. 9000
Industry/Government Department/ Other organisations.	:	Rs. 6000	Rs. 11000

Note :
1. Above mentioned rates are **exclusive of GST** as applicable.
2. Above mentioned subscription rates are for 04 issues per year only. If any changes in periodicity, rates will differ and communicated to the subscriber.
3. Send the subscription amount by NEFT to the following bank details
   Indian Society for Technical Education, New Delhi
   Bank: Indian Bank
   SB A/C No. : 405039620
   Branch: Mehrauli Road
   IFSC: IDIB000M089

For details Contact:
The Executive Secretary
Indian Society for Technical Education
Near Katwaria Sarai, Shaheed Jeet Singh Marg,
New Delhi -110 016
Phone :   011-26963431, 26513542
E-mail :   istedhq@isteonline.org
Website :   www.isteonline.in

Note :   The Editorial Board does not assume any responsibility for the individual opinions expressed by the authors, and are in no way those of the editor, the institution to which the author belongs or the publisher.

Editorial

Water for Peace: There is a famous line water, water everywhere and not a drop to drink. Nearly 97.5% of total water available on the earth is in the oceans and not fit for use. Of the remaining 2.5% of water, 68.7% is in the form of glaciers and ice caps, 30.1% as ground water and only 1.2% available in rivers, lakes and as moisture in the atmosphere and soil.

According to the UNICEF report, 1/3rd of the global population doesn't have an access to the clean and safe drinking water. Fresh water being a scarce with every year passing due to various reasons which include global environmental changes. One side population explosion, rapid urbanization and industrialization necessitated a high demand for fresh water. On the other side, lakes and rivers are vanishing or getting polluted due to discharge of liquid wastes and/or throwing of solid wastes.

We used to say if at all there is a war in future, it is for the water. The conflicts have already been started on sharing of water between the neighboring countries or states or districts or towns/villages. In some places, people living on one side of the road are not allowed to go on the other side to collect water. During the heavy rain fall, the excess storm water will go to the oceans. We do not pay heed on conserving the rain water. In summer season, people suffer to get water even for daily usage. In many places, ladies walk several kilometers to fetch two pots of water or spend more time near open wells or tankers to collect water.

Every year "World Water Day" is celebrated across the world on a specific theme on 22nd March since 1993 to create an importance of freshwater amongst the people. This year's theme is *"Water for Prosperity and Peace"*. By working together, we can meet everyone's requirements of water that will help to make the world more prosperous and convert the world more peaceful.

It is a time to think of; converting some government lands into water storage tanks, interlinking of Indian rivers, constructing ground water recharging wells, roof top rainwater harvesting, implementing rain water harvesting methods as mandatory in every residential/commercial building, to encourage public a small relief in property tax for having a rain water harvesting facilities and so on. Also, educating students in schools and colleges, general public through documentaries about the importance of water, water conservation methods, need of protecting water bodies, reuse of spent water, etc.

New Delhi   **Editor**

31st March 2024

Indian Society for Technical Education

Official E- Mail ID's

SN	E-Mail ID	Purpose
1	info@isteonline.org	All General enquires.
2	istedhq@isteonlione.org	All official communication.
3	exesecretary@isteonline.org	Matter related to Executive Secretary; Policy related & etc.
4	accounts@isteonline.org	All matter related to finance and account section.
5	membership@isteonline.org	All matters related to, 1. Institute Membership, 2. Life Membership, 3. Student Membership, 4. Faculty Chapter, 5. Student Chapter, 6. Section Share, 7. Student Share & etc.
6	guesthouse@isteonline.org	For Guest House Booking.
7	executive_tech@isteonline.org	All enquiries related to ISTE official Website, E-Mail ID & etc.
8	technical@isteonline.org	For Faculty Development Program (FDP), STTP's, Enquiry related to Conventions, Conferences & etc.
9	editor@isteonline.org	Enquiry related to Indian Journal of Technical Education (IJTE) & Submission of Manuscript & etc.
10	newsletter@isteonline.org	All matters related to news items in newsletter.

Contents

IJTE Special Issue

Indian Journal of Technical Education (IJTE) a UGC-Care listed Journal published by the Indian Society for Technical Education (ISTE), New Delhi is inviting proposals from the willing institutions to publish their national or international level conference papers as a **"Special Issue"**. Terms and conditions for the publication will be sent on receipt of the request through a mail **(editor@isteonline.org)** from the institution.

Request for **"Special Issue"** received from the AICTE approved institutions and institutions of national importance will only be entertained.

Editor
IJTE

Conference on Renewable Energy

Solar Energy Society of India (SESI) in collaboration with Indian Journal of Technical Education (IJTE) a UGC-Care listed Journal published by the Indian Society for Technical Education (ISTE), New Delhi is inviting proposals from the willing institutions to organize a national level conference on **"Renewable Energy"**. The selected papers will be published as a special issue of IJTE.

The willing AICTE approved institutions and institutions of national importance can send their proposals through a mail to: **iste.executivesecretary@gmail.com**. The tentative period of conference maybe July or August 2024.

Editor
IJTE

IoT-Based Pothole Detection System for Proactive Road Safety

Hiral Desai

Dhruvi Zala

Pacific School of Engineering
Palsana
Surat, Gujarat

ABSTRACT

This research represents a cutting-edge initiative aimed at revolutionizing road safety by proactively identifying and preventing accidents caused by potholes. This research leverages the integration of Internet of Things (IoT) technology to provide real-time updates and alerts to drivers, significantly mitigating the risks associated with pothole-induced accidents. Operational through a user-friendly Android application, this system offers users live location updates via maps. As users navigate roads, the system continuously scans the road surface within its range for potential potholes. Upon detection of a pothole, the application promptly notifies the user, conveying the presence of the hazard and encouraging cautious driving. Beyond simple notifications, the system incorporates an innovative audio voice feature that delivers audible alerts and updates regarding detected potholes, enhancing driver awareness on the road. By proactively informing users about pothole-prone areas, the system empowers them to take precautionary measures and avoid potential accidents. The primary objective of this research project is to enhance road safety and prevent accidents stemming from potholes. By harnessing IoT technology, the system ensures efficient and reliable monitoring, enabling drivers to anticipate and navigate potholes effectively, thus reducing the likelihood of collisions and vehicle damages. This system is a powerful innovation that extends beyond simple detection. By offering real-time pothole alerts and encouraging cautious driving practices, this system serves as a crucial tool for accident prevention, ultimately making our roads safer and fostering a secure driving environment for all road users.

KEYWORDS: *Pothole detection, Road safety, Accidents prevention.*

INTRODUCTION

Potholes, those ubiquitous road hazards resulting from a confluence of factors including traffic loads, adverse weather conditions, and subpar construction materials, have plagued roadways and commuters for years. Beyond being mere inconveniences, these depressions in the road surface constitute a formidable road safety concern, culminating in accidents, vehicle damage, and potential injuries for drivers, cyclists, and pedestrians alike. The need to address this issue has never been more pressing.

Potholes manifest as not just discomfort but significant hazards that imperil road users. Accidents and damages to vehicles stemming from encounters with these road defects contribute not only to increased road maintenance costs but also compromise road safety on a larger scale. Timely detection and location of these potholes is paramount in mitigating potential risks and optimizing maintenance efforts. Presently, drivers often find themselves faced with potholes unexpectedly, bereft of adequate warning or real-time information to navigate them safely. This lack of awareness perpetuates the cycle of accidents and damage, further burdening road infrastructure and compromising the safety of road users.

To confront this multifaceted challenge, our research project endeavors to develop an innovative pothole detection system, harnessing the power of smart technology. This system integrates an array of sensors and advanced computer algorithms, working in tandem to automatically identify and pinpoint potholes on road surfaces. In doing so, it aspires to furnish drivers with real-time alerts and updates through an intuitively designed application. Our objective is to empower road users with the information they need to circumvent pothole hazards, thereby enhancing road safety and ensuring more efficient and enjoyable journeys. By

addressing the root issue—timely pothole detection and proactive prevention—we aspire to make significant strides in accident prevention and overall road safety enhancement.

In the following sections, this research paper delves into the intricacies of our pothole detection system, elucidating its pivotal role in bolstering road safety, facilitating efficient travel, and actively contributing to accident prevention. We explore the intricate web of technologies underpinning our system, its operational mechanics, and the myriad benefits it extends to both drivers and pedestrians in navigating safer roadways. In envisioning a future where pothole-related accidents are relegated to the annals of history, we chart a course towards safer, more enjoyable journeys for all road users.

Figure 1: News of Accidents Reported Due to Potholes

The motivation for such a research was not random thought that took plan overnight, instead it was the series of numerous accidents that took place due to pothole while traveling that looked like a major concern to us. Even government has found it important to include vehicle-safety measures under their plan.

There have been a repeatedly appeal to improve the roads. The city police are planning to hold a meeting with various stockholders and check out the plans to make city roads safer, it aims to proactively identify and address potholes on road surfaces, ensuring smoother and safer journeys for citizens

BACKGROUND

The research in [1], addresses the problem of road safety by proposing a solution for pothole detection through the use of deep learning techniques. The study aims to develop an efficient and accurate system capable of identifying potholes in real-time, alerting drivers and authorities to take necessary precautions and corrective actions. The paper compares various deep learning algorithms, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), to determine the most suitable approach for pothole detection. Through evaluation on a large dataset of road images, the research aims to provide insights into the effectiveness of the proposed approach in detecting potholes, thereby contributing to safer and more efficient road networks.[1]

The research in [2], proposes an approach for pothole detection by combining computer vision techniques with machine learning methods. The study aims to tackle the problem of road safety by developing an intelligent system capable of identifying potholes accurately and efficiently. The paper discusses the utilization of computer vision algorithms to process road images and extract relevant features indicative of potholes. These features are then used as input for machine learning models, such as convolutional neural networks (CNNs), to classify and detect potholes in real-time. The results of the study demonstrate the effectiveness of the proposed approach, showcasing its potential to enhance road safety and contribute to the development of advanced transportation systems.[2]

The research in [3], using Mobile Sensors and Deep Learning" presents a solution for pothole detection by integrating mobile sensors with deep learning techniques. The study aims to develop a smart system capable of identifying potholes and providing timely alerts to drivers and authorities for proactive measures. The paper discusses the utilization of mobile sensors, such as accelerometers and GPS, to collect data on road

conditions and vibrations. This data is then processed using deep learning models, such as convolutional neural networks (CNNs), to detect potholes accurately. The results of the study showcase the effectiveness of the intelligent pothole detection and alerting system, emphasizing its potential to contribute to safer and well-maintained road networks.[3]

The study in [4], aims to enhance the capabilities of pothole detection systems by utilizing state-of-the-art computer vision techniques. The paper discusses the implementation and customization of the YOLOX algorithm to specifically address the challenges associated with pothole detection. By leveraging YOLOX's real-time object detection capabilities, the proposed system can efficiently identify potholes from road images. The results of the study demonstrate the effectiveness of the enhanced pothole detection system, showcasing its potential for accurate and real-time detection, thereby contributing to improved road safety and infrastructure maintenance. [4]

The research in [5], using Deep Learning Based on Dilated Convolution" proposes a solution for pothole detection by incorporating deep learning techniques with dilated convolution. The study aims to address the issue of pothole identification by developing an efficient and accurate system. The paper discusses the utilization of dilated convolution, a powerful technique that helps capture contextual information effectively, in combination with deep learning models like convolutional neural networks (CNNs). The proposed approach enables the system to detect potholes from road images with improved precision and reduced computational complexity. The results of the study demonstrate the effectiveness of the smart pothole detection system, highlighting its potential to contribute to enhanced road safety and maintenance.[5]

The research in [6], presents a solution for pothole detection using real-time techniques to enhance the capabilities of Intelligent Transportation Systems (ITS). The study aims to address the critical issue of road safety by developing an efficient and effective pothole detection system. The proposed approach is designed to detect potholes in real-time, allowing timely alerts to drivers and authorities for proactive measures. The paper discusses the algorithm used for pothole

detection and evaluates its performance using a dataset of road images. The results demonstrate the viability of the approach and its potential to be integrated into ITS, contributing to safer and well-maintained road networks.[6]

The research in [7], presents a solution for pothole detection by leveraging an Android-based application. The study aims to develop a practical and efficient system for identifying potholes on roads using mobile devices. The paper discusses the implementation of the Android application, which utilizes the device's camera and sensors to capture and process road images in real-time. The application is designed to employ computer vision algorithms to detect potholes from these images. The results of the study demonstrate the effectiveness of the Android-based pothole detection system, highlighting its potential for on-the-go monitoring and contributing to improved road safety and infrastructure maintenance.[7]
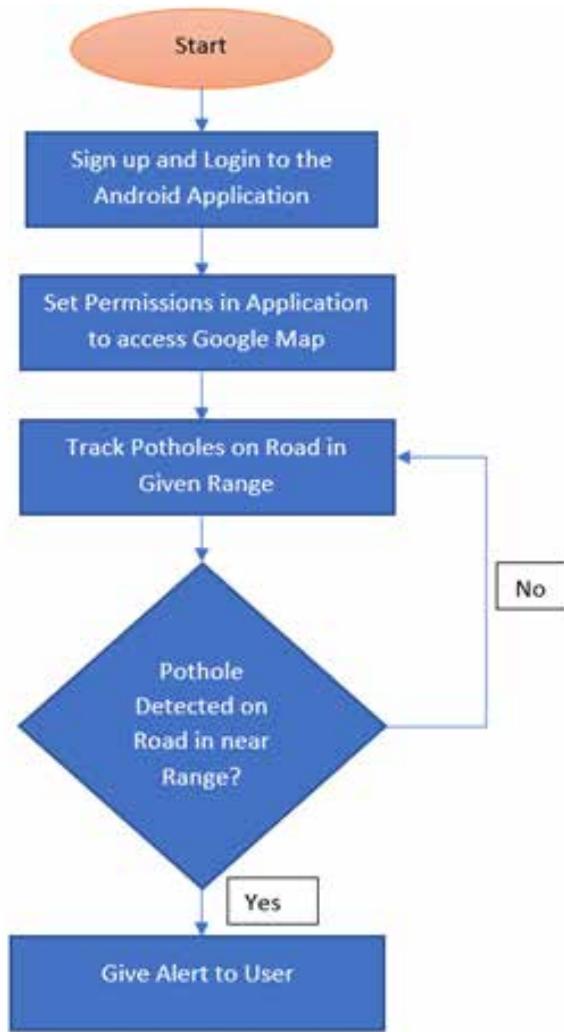
Prior Art Search

Government conducts many surveys and reports periodically that keep a track of the accidents, deaths and other such causalities. The one attached below consists the top states in deaths due to potholes.

Figure 2: Top states in pothole deaths

METHODOLOGY

Figure 3: Proposed Flow

The flow in figure 3 described here outlines the key steps of an Android application designed to track and alert users about potholes on roads within a specified range. Firstly, users are required to sign up and log in to the Android application. Upon successful login, the application proceeds further, where it requests and sets the necessary permissions to access Google Maps. This permission is crucial for the application to gather location data effectively. Subsequently, the application initiates the process of tracking potholes on the road within a predefined range. This involves continuous monitoring of the road surface for any pothole presence. System detects whether a pothole is present within the nearby

range. If a pothole is detected, the system proceeds promptly sends an alert to the user. This alert serves as a timely warning, enabling users to take precautionary measures and avoid potential road hazards. However, if no pothole is detected in the near range, the system continuing its surveillance of the road to identify any subsequent potholes. This iterative process ensures that users are consistently informed about road conditions within their specified range. This flow illustrates the fundamental operational sequence of the Android application, emphasizing its role in enhancing road safety by proactively notifying users about pothole-infested areas and promoting safe driving practices.

REQUIRED MATERIAL

1. Jumper wires are used to establish electrical connections between various components in the pothole detection system, facilitating the flow of data and control signals between sensors, microcontrollers, and other system elements to ensure proper functionality and communication.

2. The 9V battery serves as a portable power source for the pothole detection system, providing the necessary electrical energy to operate sensors, microcontrollers, and other electronic components in the field, enabling continuous monitoring and alerting functions.

3. USB cables are employed to connect and power the components of the pothole detection system, such as sensors and microcontrollers, and to facilitate data exchange with other devices or a central processing unit. This connectivity ensures that the system functions effectively and can transmit information for real-time monitoring and analysis.

4. The Arduino UNO serves as the central microcontroller in the pothole detection system, responsible for processing data from various sensors, making real-time decisions based on detected potholes, and controlling alert mechanisms. It acts as the brain of the system, ensuring efficient operation and responsiveness to road conditions.

5. The Lidar sensor is a critical component in the pothole detection system, utilizing laser technology to accurately measure distances and detect irregularities in the road surface. It plays a

key role in identifying potholes by measuring depth and shape, contributing to the system's precise and reliable detection capabilities.

6. The Radar sensor is employed to enhance the pothole detection system's ability to identify road irregularities, particularly in challenging weather conditions. By emitting radio waves and measuring their reflections, it aids in detecting potholes and contributes to the system's overall accuracy and effectiveness, especially when visibility is limited due to adverse weather.

7. The Bluetooth sensor facilitates wireless communication between the pothole detection system and other devices, such as a user's smartphone or a vehicle's onboard systems. It enables data transmission, alert delivery, and control signals, enhancing the system's ability to provide real-time information and alerts to users and authorities, thereby promoting road safety.

8. The GPS (Global Positioning System) sensor plays a pivotal role in the pothole detection system by providing accurate location data. It allows the system to track the vehicle's position in real-time, ensuring precise mapping of potholes and enabling users to receive up-to-date information on road conditions within their vicinity. The GPS sensor enhances the overall effectiveness and functionality of the system, contributing to road safety and user awareness.

9. The accelerometer is utilized to measure the vehicle's acceleration and movement. In the pothole detection system, it helps determine the severity of potholes by sensing sudden jolts or changes in motion. This data is valuable for assessing the impact of potholes on the vehicle and aids in the system's responsiveness, allowing it to provide appropriate alerts and actions to ensure road safety.

RESULTS & ANALYSIS

The pothole detection system operates through a seamless synergy of hardware components and an Android application. On the hardware side as shown in figure 5, a network of sensors, including Lidar, Radar, GPS, Bluetooth, and an accelerometer, forms the system's sensory foundation. Lidar and Radar sensors

work in unison to diligently scan the road surface, meticulously measuring the depth and shape of potholes. Meanwhile, the GPS sensor provides real-time location data, ensuring pinpoint accuracy in mapping detected road irregularities. Bluetooth connectivity serves as the wireless bridge, facilitating seamless communication between the hardware components, user devices, and vehicle systems, enabling data transmission and timely alert delivery. The Arduino UNO microcontroller acts as the system's central intelligence, processing incoming sensor data, making real-time decisions based on detected potholes, and orchestrating alert mechanisms.
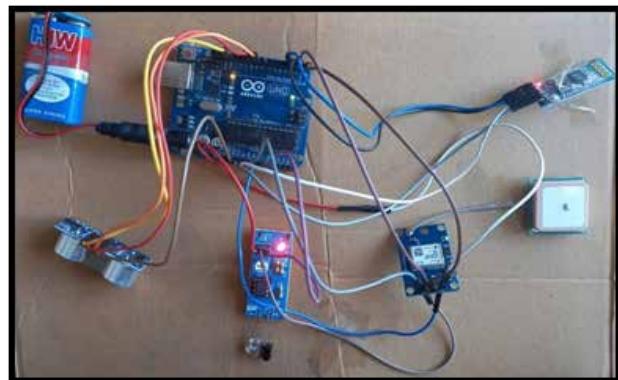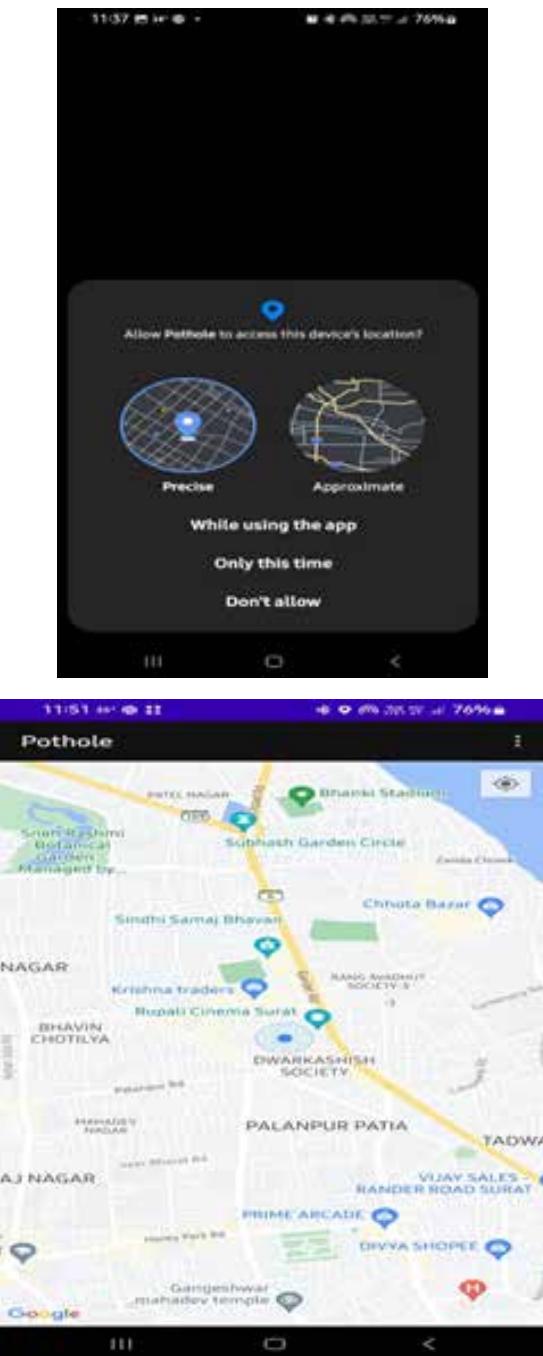
Figure 5: Actual Model

Figure 6: Android Application

On the software front as shown in figure 6, the Android application serves as the user-friendly interface and command center for the system. Users begin by signing up and logging into their accounts, allowing for personalized access to pothole detection features. The application, with the requisite permissions in place, taps into Google Maps for efficient utilization of location data. Real-time monitoring is achieved through the continuous tracking of potholes within a predefined range, thanks to the integrated Lidar, Radar, and GPS data. Upon the detection of a pothole, the application promptly issues alert to drivers, arming them with crucial information to take evasive action and avoid potential road hazards. This is further augmented by informative audio voice alerts, enhancing driver awareness of detected potholes. Simultaneously, live location tracking via maps ensures users receive accurate, up-to-date information regarding potholes in their immediate vicinity. The system also contributes to road maintenance by furnishing authorities with data on pothole locations and severity, streamlining repair efforts. Moreover, the cloud-based virtualization ensures efficient hardware resource management, optimizing the system's performance. Ultimately, the pothole detection system not only enhances road safety by proactively identifying hazards but also promotes eco-friendly practices by reducing vehicle damages and associated environmental impact. Rigorous testing and validation ensure its reliability and effectiveness in real-world scenarios, while its scalable architecture paves the way for future expansion and integration with smart city initiatives and additional road safety measures.

CONCLUSION & FUTURE PLAN

This system emerges as a vital solution to the contemporary road safety crisis. Our research underscores the urgent need to combat the adverse effects of potholes on road accidents and vehicle damages. While modern vehicles offer luxury, safety remains paramount. Our system seamlessly integrates into vehicles, elevating safety for all road users. Our project's comprehensive approach, supported by compelling statistics (around 11,000 pothole-related accidents), is poised to make a substantial impact on road safety. By preventing accidents and minimizing vehicle damage, we contribute to safer roads nationwide.

Looking ahead, we anticipate system enhancements, including advanced sensors and a more compact design. Satellite communication could further optimize routes with fewer potholes. The system's potential as an accident alert system, particularly for speed limits, is promising. As technology advances, our system can

evolve into an affordable, integrated safety feature in vehicles, significantly improving road safety.

REFERENCES

1. A. Shaghouri, R. Alkhatib, and S. Berjaoui, "Real-time pothole detection using deep learning," arXiv [cs.CV], 2021.

2. A. Dhiman and R. Klette, "Pothole detection using computer vision and learning," IEEE Trans. Intell. Transp. Syst., vol. 21, no. 8, pp. 3536–3550, 2020.

3. S. R. Kuthyar et al., "An intelligent pothole detection and alerting system using mobile sensors and deep learning," in 2021 IEEE 18th India Council International Conference (INDICON), 2021, pp. 1–6.

4. M. Prakash and Sriharipriya, "Enhanced pothole detection system using YOLOX algorithm," Auton. Intell. Syst., vol. 2, no. 1, 2022.

5. K. R. Ahmed, "Smart pothole detection using deep learning based on dilated convolution," Sensors (Basel), vol. 21, no. 24, p. 8406, 2021.

6. H.-W. Wang, C.-H. Chen, D.-Y. Cheng, C.-H. Lin, and C.-C. Lo, "A real-time pothole detection approach for intelligent transportation system," Math. Probl. Eng., vol. 2015, pp. 1–7, 2015.

7. T. Chouhan, K. Kumari, and P. Kumari, "Detection of pothole in real-time using android based application," SSRN Electron. J., 2021.

8. C. Ng, T. Law, F. Jakarni, and S. Kulanthayan, "Road infrastructure development and economic growth," in IOP conference series: materials science and engineering, IOP Publishing, vol. 512, no. 1, Article ID 012045, 2019.

9. P. Harikrishnan and V. P. Gopi, "Vehicle vibration signal processing for road surface monitoring," IEEE Sensors Journal, vol. 17, no. 16, pp. 5192–5197, 2017.

10. S. Lee, S. Kim, K. E. An, S.-K. Ryu, and D. Seo, "Image processing-based pothole detecting system for driving environment," in Proceedings of the 2018 IEEE International Conference on Consumer Electronics (ICCE), pp. 1-2, IEEE, Las Vegas, NV, USA, January 2018.

11. P. Wang, Y. Hu, Y. Dai, and M. Tian, "Asphalt pavement pothole detection and segmentation based on wavelet energy field," Mathematical Problems in Engineering, vol. 2017, 2017.

12. Y. K. Arbawa, F. Utaminingrum, and E. Setiawan, "Three combination value of extraction features on glcm for detecting pothole and asphalt road," Jurnal Teknologi dan Sistem Komputer, vol. 9, no. 1, pp. 64–69, 2021.

13. O. A. Egaji, G. Evans, M. G. Griffiths, and G. Islas, "Real-time machine learning-based approach for pothole detection," Expert Systems with Applications, vol. 184, p. 115562, 2021.

14. P. Ping, X. Yang, and Z. Gao, "A deep learning approach for street pothole detection," in Proceedings of the 2020 IEEE Sixth International Conference on Big Data Computing Service and Applications (BigDataService), pp. 198–204, IEEE, Oxford, UK, August 2020.

15. W. Ye, W. Jiang, Z. Tong, D. Yuan, and J. Xiao, "Convolutional neural network for pothole detection in asphalt pavement," Road Materials and Pavement Design, vol. 22, no. 1, pp. 42–58, 2021.

16. R. Agrawal, Y. Chhadva, S. Addagarla, and S. Chaudhari, "Road surface classification and subsequent pothole detection using deep learning," in Proceedings of the 2021 2nd International Conference for Emerging Technology (INCET), pp. 1–6, IEEE, Belagavi, India, May 2021.

17. S. I. Hassan, D. O'Sullivan, and S. McKeever, "Pothole detection under diverse conditions using object detection models," IMPROVE, vol. 1, pp. 128–136, 2021.

18. R. Kavitha and S. Nivetha, "Pothole and object detection for an autonomous vehicle using yolo," in Proceedings of the 2021 5th International Conference on Intelligent Computing and Control Systems (ICICCS), pp. 1585–1589, IEEE, Madurai, India, May 2021.

19. S.-S. Park, V.-T. Tran, and D.-E. Lee, "Application of various yolo models for computer vision-based real-time pothole detection," Applied Sciences, vol. 11, no. 23, p. 11229, 2021.

20. K. Gajjar, T. van Niekerk, T. Wilm, and P. Mercorelli, Vision-based Deep Learning Algorithm for Detecting Potholes, 2021.

Sentiment Analysis of Indian Tweets on COVID-19 Vaccination: Opinion Mining Approach

R. S. Kamath, P. G. Naik, S. S. Jamsandekar
Dept. of Computer Studies
Chhatrapati Shahu Inst. of Busi Edu. and Research
Kolhapur

S. K. Desai
NITTE (Deemed to be University)
NMAM Institute of Technology (NMAMIT)
Nitte, Karnataka

ABSTRACT

The world is amidst a COVID-19 pandemic. Vaccines are a precarious new tool in the battle against COVID-19, aiming to end this acute phase. The public is encouraged by the government to get vaccinated, which will help protect people who come in contact with the virus from becoming sick. In this context, the present study intended to know the Indian citizens' opinions on COVID-19 vaccination. The objective was to identify public opinion toward the COVID-19 vaccination. To accomplish this, a Twitter app is created. Further, the Twitter APIs are called to access the tweets on COVID-19 vaccination from 1st January to 25th March 2021. The dataset has a standard set of features extracted, such as user details, date of the tweet, URLs, tweet text, retweet details, hashtag, source, etc. Thus derived tweets underwent sentiment analysis to identify the prevailing emotion expressed in the tweets. The public opinions on the COVID-19 vaccine are identified and compared. This experiment is carried out by executing scripts written in the R and Python platform. The study resulted that positive sentiments are predominant and thus show higher engagement. This concludes that citizens of India trust the government when it comes to making the right decisions about the COVID-19 vaccine.

KEYWORDS: COVID-19, Vaccination, Sentiment analysis, Twitter data, R programming, Python.

INTRODUCTION

Social media is a real-time platform for sharing/posting opinions, and this has motivated authors to analyze tweets based on the COVID-19 vaccination. This analysis is to bring out the public opinion that is being expressed in these tweets. The research carried out by Kantar on COVID-19 vaccine acceptance during the second week of November 2020 revealed an increasing reluctance among the general public about COVID-19 vaccine acceptance (Emmanuel, 2021). The study's findings introduced a significant challenge for governments worldwide aiming to control the COVID-19 pandemic. As reported in Business Line online article, there was some confusion and doubts among Indians on the COVID-19 vaccine (Pinnamaneni, & Seshasayee, 2021). The myths surrounding the COVID -19 vaccine accompanied initial vaccine rollouts, frequently capitalizing on religious sentiment, science illiteracy, and mistrust of authorities. The survey findings reported

by The Indian Express reveal that 47% of respondents are willing to take the vaccine, whereas 43% of the respondents are not sure about vaccines, and 10% are firmly against taking the vaccine (The Indian Express, 2020).

Khakaria et al have carried out a study to analyze the COVID-19 vaccination tweets using machine learning algorithms (Khakharia, Shah, & Gupta, 2021). The performance of these algorithms is evaluated and the result concluded that the Linear Regression model would be used for future predictions of sentiment analysis for COVID-19 vaccination. Alselwi and Kayank have reported sentiment analysis of tweets on COVID-19 vaccine using natural language processing (Alselwi, & Kaynak, 2021). They have obtained 76% accuracy for the LSTM machine learning model with the observation that most of the tweets are neutral. Chinasamy et al have portrayed the sentiment analysis of tweets based on COVID-19 vaccination (Chinnasamy
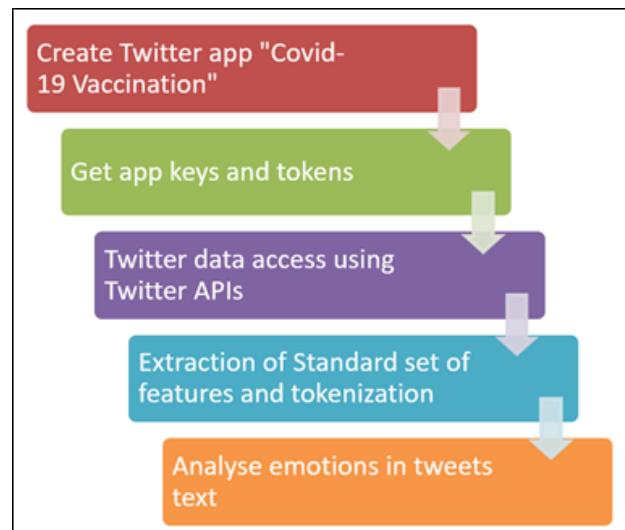
et al., 2022). The tweets are retrieved using Twitter API and analyzed using Tweepy. Yet another research by Yousefinaghani et al illustrates the sentiment analysis of tweets on COVID-19 vaccine (Yousefinaghani et al., 2021). For this authors have used 4 million publicly accessible tweets and recognized the sentiments and compared their progression by general setting. They tracked down the predominance of positive sentiments and higher engagement. Balaji et al have presented the opinion mining research on the COVID-19 vaccine using machine learning techniques (Balaji et al., 2022). Their study concluded that BERT and RoBERTa models outperform other machine learning techniques.

In this setting, the reported research intends to know the Indian citizens' opinions on COVID-19 vaccination. Social media is a real-time platform for sharing/ posting opinions, and therefore, the authors planned to analyze the Twitter data. The same is to bring out the emotions in tweets on the COVID-19 vaccine and recognizing the most prevalent emotion articulated in the tweets (Kamath, 2017). This use case looked into various trends, emotions, and polarity of the tweets. The experiment is carried out by accessing Twitter APIs using a Twitter app. Tweets on COVID-19 vaccination from 1st January to 25th March are retrieved by tweepy, Python library. This is followed by sentiment analysis in R using syuzhet, library, to identify the prevailing emotion expressed in the tweets. This analysis revealed that citizens of India trust the government when it comes to making the right decisions about the COVID-19 vaccine.

METHODS AND MATERIALS

Twitter is a social networking and microblogging platform for users to openly express their views. It is additionally favorable for sentiment mining since it has 280 characters constrain, so the considerations are more exact when contrasted with other online networking sites. Sentiment analysis involves monitoring emotions in posts on social media platforms, which has become a key strategy in social media analysis (Gaur, 2017).

The present study reported sentiment analysis of Indian tweets on COVID-19 vaccination. The objective was to identify public opinion toward the COVID-19 vaccination.
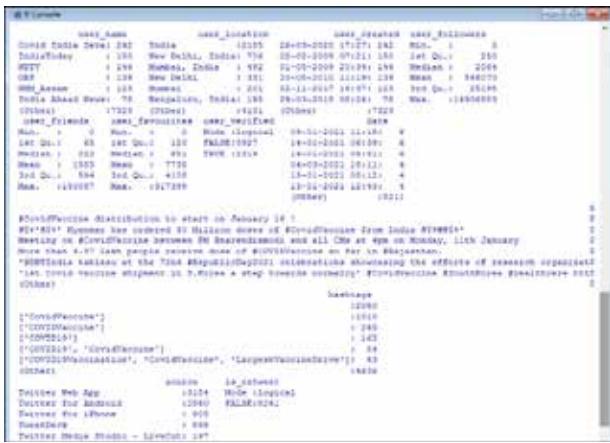
Fig. 1. Flowchart of sentiment analysis of tweets on COVID-19 vaccination

The flowchart of the analysis carried out is shown in figure 1. The step-by-step procedure of this use case is as follows (Federico, 2019):

a)   An application is created on developer.twitter. com/, before stacking the python library and utilizing its functions. App keys and tokens are accessed to ingest data.

b)   The python package "tweepy" is used to extract the tweets made with the #covidvaccine hashtag from 1st January to 25th March (Kash, 2021). Hashtags are fundamentally used to classify tweets making them easy to search. In total 8242 tweets were pulled from Twitter.

c)   Figure 2 demonstrates the outline of extracted Twitter data. The dataset contains 8242 records. We have a standard set of features extracted, such as user details, date of the tweet, tweet text, hashtag, source, etc.

d)   Data pre-processing is done by converting raw data to lowercase and then removing punctuations, numbers, and URLs. A sequence of strings being separated into pieces like keywords, words, symbols, phrases, and other components called tokens is the job of tokenization. This is done by executing the following R code of text preprocessing:

txt<-gsub("(RT|via)((?:\\b\\w*@\\w+)+)",df$text)

txt<-gsub("http[^[:blank:]]+","",txt)

txt<-gsub("@\\w+","",txt)

txt<-gsub("[[:punct:]]"," ",txt)

txt<-gsub("[^[:alnum:]]"," ",txt)

e) "syuzhet", R library loaded to acquire emotions and details from NRC vocabulary. The NRC sentiment dictionary is called by using the function "get_nrc_sentiment". The occurrence of various emotions and corresponding weightage in the tweets are calculated using this function (Mohammad & Turney 2010).

f) The public opinions on the COVID-19 vaccine are identified and compared. A polarity score is then assigned to each of the components (Jockers, 2021). To find out the sentiment of the text, the cumulative sum of the score has been calculated. Contingent upon the figured score, the content has been named positive, negative, and unbiased. A tweet with a score greater than zero was segregated as positive sentiment, a score less than zero was considered as a negative sentiment, and any score of zero was categorized as a neutral sentiment.

Fig. 2. **Overview of Twitter data using a summary function in R**
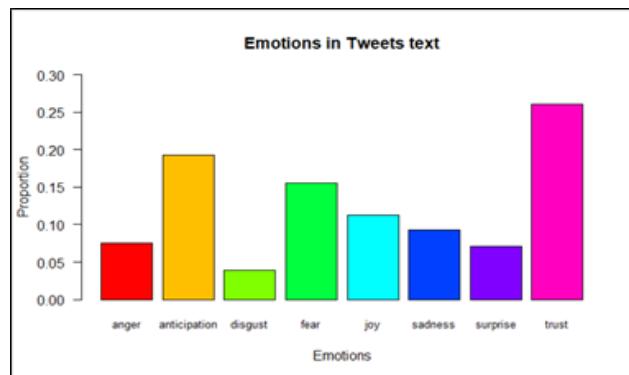
RESULTS AND DISCUSSIONS: CLASSIFICATIONS BY EMOTIONS AND POLARITY

Analyzing tweets intends to understand the views of the writer (Pristiyono et al., 2021). The reported study of Indian tweets on COVID-19 vaccination is carried out

in an R programming environment. 8242 tweets posted from India during the period from 1st January to 25th March are considered as a dataset for the sentiment analysis. The Rscript is executed to perform the required analysis.

Opinion Mining

Figure 3 presented the proportion of the different emotions in tweets on COVID-19 vaccination and is summarized in figure 4. As per the NRC dictionary, the eight different emotions are anger, anticipation, disgust, fear, joy, sadness, surprise, and trust. The infographic highlights the comparison between eight types of emotions. The proportion of trust and anticipation is maximum revealing that India's citizens trust the government when it comes to making the right decisions about the COVID-19 vaccine. Also, a significant proportion of tweets contained emotions of sadness and fear.

Fig. 3. **The proportion of the tweets emotions on the COVID-19 vaccine**

Fig. 4. **Summary of sentiments contained in tweets on the COVID-19 vaccine**

Polarity Classification

The polarity classification is to compare the number of positive tweets, negative tweets, and neutral tweets. The sentiment polarity is considered positive, negative, and neutral if the polarity score is greater than 0, less than zero, and equal to zero respectively. The sentiment intensity analyzer function) is used to calculate the sentiment scores and these scores are added to each tweet. The polarity classification shown in figure 5 compares the number of positive tweets with negative tweets. One-fourth of the public has hesitancy toward COVID-19 vaccination. This reveals the propensity towards vaccination and trust in the policy and pharmaceutical sectors.
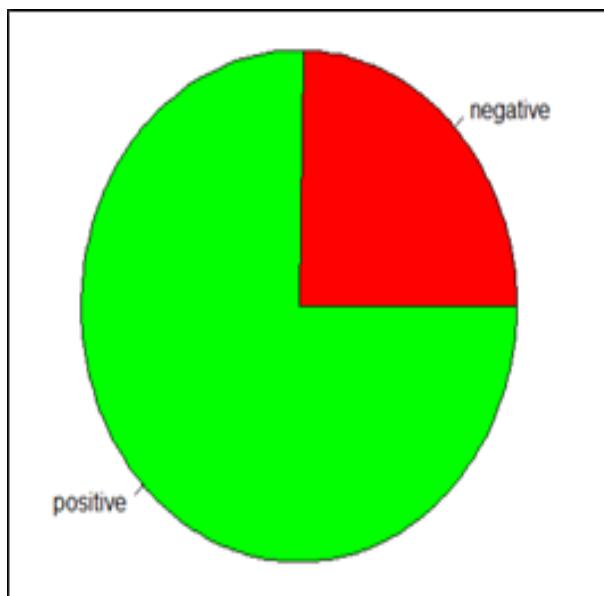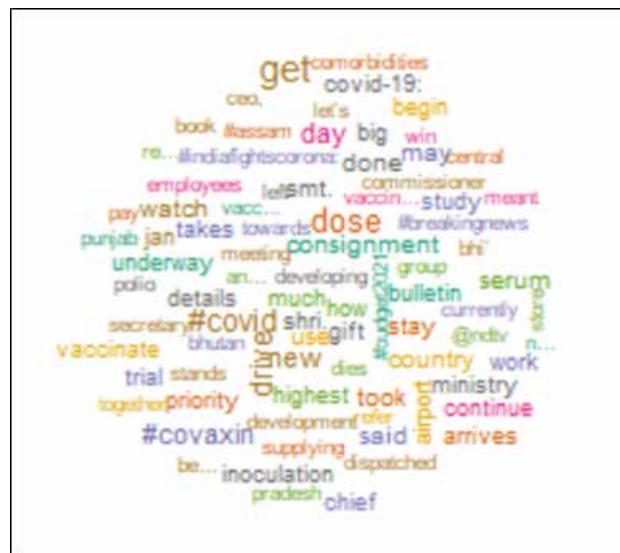
Fig. 5. Polarity classification of tweets emotions on COVID-19 vaccine

Wordcloud Construction

Furthermore, the word cloud is constructed to represent the importance of the words with a minimum frequency of 20 presented in figure 6. The word cloud is constructed that displays the most commonly used words in tweets by people expressing their opinion on the COVID-19 vaccination. Wordcloud is a visual representation of a text for the useful analysis of unstructured data. Here the words 'get', 'dose', and 'COVID-19' appear bigger as more often they are mentioned in the tweets.

Fig. 6.   Wordcloud of tweets on COVID-19 vaccine

CONCLUSION

This study aimed at sentiment analysis of public opinion on COVID-19 vaccination. To accomplish this work tweets on COVID-19 vaccination from India are analyzed. The sentiment analysis is carried out to identify the prevailing emotion expressed in the tweets. A Twitter application is created to ingest data by calling Twitter APIs. This experiment is carried out by executing scripts written in an R and Python platform. This study looked into various trends, emotions, and polarity of the tweets about the issue. The above exercise revealed a propensity towards vaccination and trust in the policy and pharmaceutical sectors. The citizens of India trust the government when it comes to making the right decisions about the COVID-19 vaccine. Thus, the present exploration concludes that sentiment analysis of Twitter data has the prospective to demonstrate a suitable tool for analyzing public opinions on COVID-19 vaccination.

REFERENCES

1. Alselwi, G. A. and Kaynak, S. (2021). Sentiment Analysis On Covid-19 Vaccines Tweets. In International Marmara Sciences Congress (Spring), Proceedings Book.

2. Balaji, T.K., Bablani, A., and Sreeja, S. R. (2022). Opinion mining on COVID-19 vaccines in India using deep and machine learning approaches. In 2022

International Conference on Innovative Trends in Information Technology (ICITIIT), 1-6.

3. Chinnasamy, P., Suresh, V., Ramprathap, K., Jebamani, B. J. A., Rao, K. S., & Kranthi, M. S. (2022). COVID-19 vaccine sentiment analysis using public opinions on Twitter. In Materials Today: Proceedings, 64, 448-451.

4. Emmanuel, R. (2021). Infographic: Public opinion about COVID-19 vaccination. [Online] Available at: https://www.kantar.com/inspiration/coronavirus/infographic-public-opinion-about-covid-19-vaccination (Accessed: 12th April 2021).

5. Federico, P. (2019). How to Do Twitter Sentiment Analysis with Machine Learning. [Online] Available at: https://monkeylearn.com/blog/sentiment-analysis-of-twitter/ (Accessed: 13th April 2021).

6. Gaur, L. (2017), Text Mining for unstructured data on Twitter hashtags using R. In Australian Journal of Basic and Applied Sciences, 11(8), 49-55.

7. Jockers, M. (2021), Introduction to the Syuzhet Package. [Online] Available at: https://cran.r-project.org/web/packages/syuzhet/vignettes/syuzhet-vignette.html (Accessed: 13th April 2021).

8. Kash. (2021). Twitter data extraction. [Online] Available at: https://www.kaggle.com/kaushiksuresh147/twitter-data-extraction (Accessed: 13th April 2021).

9. Khakharia, A., Shah, V., and Gupta, P. (2021). Sentiment Analysis of COVID-19 Vaccine Tweets Using Machine Learning. [Online] Available at: http://dx.doi.org/10.2139/ssrn.3869531

10. Mohammad, S. and Turney, P. (2010), Emotions Evoked by Common Words and Phrases: Using Mechanical Turk to Create an Emotion Lexicon. In Proceedings of the NAACL-HLT 2010 Workshop on Computational Approaches to Analysis and Generation of Emotion in Text. [Online] Available at: https://saifmohammad.com/WebPages/NRC-Emotion-Lexicon.htm (Accessed: 13th April 2021).

11. Pinnamaneni, R., & Seshasayee, S. M. (2021). India must ensure public trust in Covid vaccine is not eroded. [Online] Available at: https://www.thehindubusinessline.com/opinion/india-must-ensure-public-trust-in-covid-vaccine-is-not-eroded/article34072432.ece (Accessed: 12th April 2021).

12. Pristiyono, R. M., Ihsan, M. A., Anjar, A., & Rambe, A. H. (2021). Sentiment analysis of COVID-19 vaccine in Indonesia using Naïve Bayes Algorithm. In IOP Conf. Series: Materials Science and Engineering, 1088, 012045.

13. Kamath, R. S. (2017). Analysis of Twitter Data on Demonetization in India: An Opinion Mining Approach. In International Conference on Demonetization and Remonetization: Issues and Challenges for Global Business, 75-84. ISBN – 9789385381461.

14. The Indian Express, (2020). Survey reveals how Indians feel about the COVID-19 vaccine. The Indian Express. [Online] Available at: https://indianexpress.com/article/lifestyle/health/indians-covid-19-vaccine-survey-7109653/ (Accessed: 12th April 2021).

15. Yousefinaghani, S., Dara, R., Papadopoulos, S. M., & Sharif, S. (2021). An analysis of COVID-19 vaccine sentiments and opinions on Twitter. In International Journal of Infectious Diseases, 108, 256-262.

Development of an End-to-End Machine Learning Model for Air Pollution Forecasting

K. Ramesh, R. Nandhakumar
Department of Computer Science & Applications,
Vivekanandha College of Arts and Science for Women
Tiruchengode, Namakkal
✉ krmca86@gmail.com

S. Chandrakala
Department of Computer Applications
Vivekanandha Institute of Information and
Management Studies
Tiruchengode, Namakkal

S. Andrews
Department of Computer Science & Engineering
Mahendra Engineering College
Namakkal

ABSTRACT

Air pollution in Indian cities has become a major public health issue, with serious consequences for both human health and the environment. With the increased usage of machine learning techniques, there is a rising tendency towards employing these models for air quality forecasting in order to predict future repercussions. While utilising machine learning models for each air pollutant might be useful, it can be time-consuming and labor-intensive to deploy, operate, and monitor. To address this issue, a unique strategy for developing a multi-step, multi-output, multivariate model for air quality forecasting was developed. This globally forecasting model uses meteorological conditions as well as air quality data from urban traffic, residential, and industrial regions to anticipate NO_2, SO_2, O_3, and CO concentrations hourly (1 h to 24 h). The statistics on air pollution time series are gathered from six Healthy air monitoring stations in Chennai between April 2023 and June 2023, and include hourly meteorological conditions concentrations. This is the first model built using real-time air quality data for NO_2, SO_2, CO, and O_3 forecasting in Chennai city. The effectiveness of the proposed model was evaluated using real data from Healthy air stations and quantified using measures like Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE), and correlation indices. The results revealed that the global air quality forecasting model performed excellently in predicting multiple air pollutant concentrations and outperformed earlier models built for each specific pollutant. The results demonstrated that the global air quality forecasting model performed well in predicting multiple air pollutant concentrations and outperformed earlier models built for each specific pollutant.

KEYWORDS: Air quality index, Air quality analysis and prediction, Convergent artificial bee colony optimization (CABC), PM 2.5, Environmental pollution.

INTRODUCTION

With the rapid economic and urban development in cities, the interest in air pollution and its impact on human health has increased in recent years. Air pollution is recognized as a major public health concern by the World Health Organization (WHO), which estimates that it contributes to the premature deaths of approximately seven million people globally each year, including 600,000 children. Air pollution is classified as a silent killer that is highly correlated with numerous health problems and can have severe long-term consequences on human health and well-being [1]. This emphasizes the need for effective air pollution monitoring and forecasting systems to identify potential risks and reduce the adverse health effects associated with poor air quality. The proposed model, built on Machine Learning algorithms, uses several features, including meteorological data, ambient air quality data, and spatial information, to predict and forecast

air pollution concentrations in the city of chennai for a 12-hour time period. It provides air quality predictions at hourly intervals, enabling authorities and decision-makers to take appropriate actions to mitigate the risks associated with air pollution. The results show that the model can effectively forecast air pollution levels in Chennai, with low errors and good statistical accuracy [2]. This approach can be replicated in other cities to provide more accurate and timely air pollution predictions, enabling better management of air quality and reducing its negative impacts on human health [3]. Additionally, air pollution is recognized as a significant public health concern as it is strongly associated with various health problems and has severe long-term effects on human health and wellbeing. To mitigate the adverse impacts of poor air quality, it is crucial to establish effective monitoring and forecasting systems. The proposed model implements machine learning algorithms, such as Linear Regression (LR), Gradient Boosting Decision Trees (GBDT), and Support Vector Regression (SVR), to predict air pollution concentrations in the Chennai city at hourly intervals for a 12-hour-long period. The model uses meteorological data, ambient air quality data, and spatial information to make the predictions. The results show that the model can accurately forecast air pollution levels in chennai with a low error rate and good statistical performance. The implementation of such models can be replicated in other cities to improve air quality monitoring and forecasting, enabling better management of air quality and reducing its negative impacts on human health [4]. However, there are certain limitations to the proposed model, such as the need for reliable and sufficient datasets, the ability to handle data bias, and ensuring the accuracy and robustness of the model predictions. Therefore, it is essential to address these challenges to enhance the performance of the model. Human activities, particularly transportation, industrial development, and agriculture, have a significant impact on the release of greenhouse gases, such as carbon dioxide and methane, into the atmosphere [5]. These gases can worsen climate conditions and ultimately affect plant growth. The interaction between plants and soil can also be altered by the release of inorganic carbon and greenhouse gases, as demonstrated by various research studies. Furthermore, fluctuations in climate conditions

affect not just humans and animals but also agricultural practices and productivity. Due to these factors, the Air Quality Index (AQI) has gained importance as a measure of the air pollution level [6]. A higher AQI represents a more dangerous exposure level for people. As a result, the need to predict AQI in advance has become a crucial and challenging task, particularly in rapidly developing urban areas. Additionally, the concentration of pollutants like PM2.5, which is considered to be extremely harmful, is higher in developing countries compared to developed countries [7]. This is why studies and research related to air quality have targeted developing countries, but some researchers have also explored the same for Indian cities. After reviewing literature on air quality prediction, researchers have felt the need to fill the knowledge gap by attempting an analysis and prediction of AQI for India [8].Despite the widespread use of traditional air quality prediction methods, their accuracy has been found to be affected by significant uncertainties in the Emission Inventories. The proposed work aims to introduce a new model for air pollution prediction and forecasting analysis to enhance sustainability and reduce the negative impacts of air pollution on human health and the environment [9].This study presents a new way of approaching air quality forecasting, which not only saves time and effort, but also provides more accurate and comprehensive predictions. The model can also be further refined to include additional variables, such as population density, weather patterns, and environmental regulations, to provide even more accurate forecasts. This approach can be applied in other cities and countries facing similar air pollution issues, and can potentially contribute to the development of sustainable solutions to reduce the negative effects of air pollution on human health and the environment [10]. The study proposes an improved air quality prediction and forecasting model by applying an iterative Fisher-based algorithm for feature extraction, followed by Convergent Artificial Bee Colony optimization (CABC) optimization to select the best features. The model then employs a classifier to predict the error rate at different time periods, using a Residual Multilayer perceptron (RMLP)) classifier [11]. The performance of the proposed approach is evaluated through Mean Absolute Error(MAE), Root Mean Squared Error(RMSE), and Mean Absolute

Percentage Error(MAPE) and compared with existing methods to prove its effectiveness. In modern times, human activities lead to increased energy consumption, causing various consequences, including air pollution. Pollutants such as CO, CO2, PM, NO2, SO2, O3, NH3, and Pb are released into the environment through various anthropogenic sources such as industrial plants, automobiles, airplanes, and aerosol cans [12]. The health of humans, animals, and even plants is at risk due to the presence of dangerous pollutants in the atmosphere. Air pollution can lead to a variety of health conditions, ranging from bronchitis to heart disease, pneumonia, and lung cancer. In addition, air pollution can contribute to other significant modern environmental issues like global warming, acid rain, smog, and climate change, which can further exacerbate the effects of air pollution [13]. It is worth noting that scientists are increasingly recognizing the potential damage that air pollution can inflict on historical monuments, demonstrating its far-reaching impacts. Artificial Intelligence (AI) has led to the development of various deep learning algorithms, including Recurrent Neural Networks (RNN) and their variants such as Long Short-Term Memory (LSTM). LSTM is a widely used [14] model for air quality forecasting due to its effectiveness in modeling temporal dependency patterns observed in PM2.5 concentration series [15]. However, developing an efficient predictive model with high accuracy remains a challenge due to the complex formation of PM2.5. To address this challenge, we explore various multivariate deep learning models based on several performance metrics, namely Average Absolute Error (MAE), Root Mean Square Error (RMSE), and Coefficient of Determination (R2). Specifically, we compare the performance of LSTM, Bidirectional LSTM (Bi-LSTM), Gated Recurrent Unit (GRU), Convolutional Neural Network (CNN), CNN-LSTM, and CNN-GRU models for PM2.5 concentration forecasting.

Additionally, our proposed research aims to provide a PM2.5 forecasting model that utilizes meteorological data and the concentration of adjacent stations to enhance its accuracy. To do so, we designed a system that combines the pollutant components, meteorological data, and adjacent stations across different time periods as input variables. Furthermore, we performed preprocessing steps such as filling missing values,

encoding, normalizing data, and analyzing the correlation between features and PM2.5 concentration for feature selection. Our proposed model incorporates historical data from target stations and adjacent stations to extract spatiotemporal features for better performance in PM2.5 prediction. This comparison helps us understand the effectiveness of different deep learning models in predicting PM2.5 concentration.

Key Contributions

* Design of a hybrid CNN-LSTM forecasting model for PM2.5 concentration forecasting.

* Integration of meteorological data and adjacent stations in the input variables to enhance PM2.5 prediction accuracy.

* Comparison of the proposed model with seven baseline predictive deep learning models to demonstrate its efficiency.

* Analysis of the correlation between features and PM2.5 concentration for feature selection.

* Incorporation of historical data from target stations and adjacent stations for better spatiotemporal feature extraction and effective PM2.5 prediction.

This research utilize a combination of Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) in our proposed model for PM2.5 forecasting. CNN is effective at extracting spatial characteristics of data, including the relationship between pollutant components and weather variables. LSTM, on the other hand, is useful for extracting temporal features. By combining both the CNN and LSTM networks, we are able to effectively utilize the spatial and temporal aspects of the data for better PM2.5 prediction. This enables us to achieve high accuracy in PM2.5 forecasting.
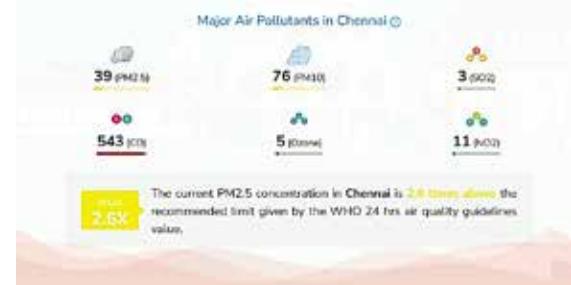
Figure 1 : Major Air Pollutants in Chennai

Experimental Study &Data Analysis

As Tamilnadu has experienced rapid urbanization and economic development over the past decade, air pollution levels in urban cities of the region, such as Chennai, have increased significantly. The city has established a monitoring network of six Air Quality Monitoring Stations, which have been operational since April 2023. The monitoring network covers the central urban area and provides hourly concentration levels of various air pollutants, including PM2.5, PM10, NO2, SO2, CO, and O3. Additionally, two meteorological parameters, temperature and humidity, were also monitored. The quality of the data collected from the monitoring network is of utmost importance. Therefore, the dataset includes information about the quality of the air pollution data, including the method of data acquisition, statistic summaries, data description, data values, technical specifications of the air quality monitoring apparatus used for data collection, station location, and timestamp of concentrations recorded. Furthermore, the dataset contains meta information about other meteorological parameters, such as dewpoint, windspeed, pressure, UV index, and visibility, acquired from the AQI (Air Quality Index) Weather Portal API. This allows for access to location-specific historical weather data, which is crucial for analyzing and modeling the air quality data accurately. It is worthwhile to point out that the quality of the data affects the effectiveness and accuracy of the modeling process. Hence, it is essential to have a well-designed dataset that includes all relevant information for air quality forecasting.
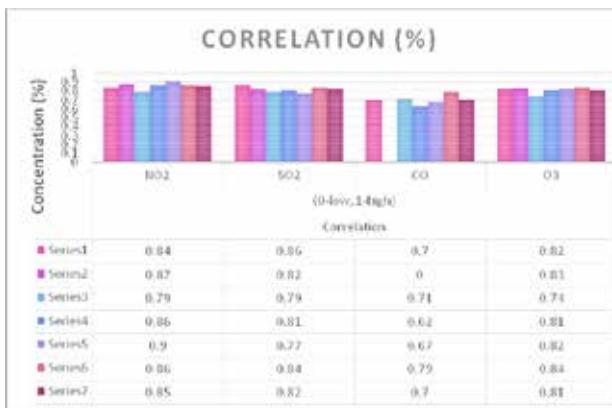
Figure 2 :Graphical Representation of Air Pollution concentration Correlation (%)

Proposed Methodology

This section examines the proposed system flow for air pollution prediction and forecasting analyses in depth. The approach begins with basic data processing using the Ordinal Scaled Encoding-based Filtering method (SOSE) to eliminate missing values and superfluous data. The Iterative Fisher-based approach with a ranking mechanism is then used to the data set to discover the most important attributes. These features are adjusted using the Convergent Artificial Bee Colony optimisation (CABC) approach to improve model performance. Finally, the Residual Multilayer Perceptron (RMLP) classifier is utilised to anticipate the prediction classifier's error rate over multiple time periods and places.

Pre–Processing

The data is converted into a numerical format that is easier to read and analyse during the pre-processing stage. This procedure entails deleting extraneous words from the data collection, which is an important step in ensuring accuracy in the next processes. The statistical ordinal scaled encoding approach is utilised to accomplish this. The initial step in this procedure is to assign/allocate integer values to each term, as shown below.

$$Y = [(s -)/\sigma] \tag{1}$$

The process of pre-processing involves preparing the data by converting it into a numerical format that is easy to read and analyze. This involves removing irrelevant terms from the data set. Here, μ is the mean of the data amount, and σ is the standard deviation of the data. To achieve this, the ordinal scaled encoding method is used. In this method, each term is assigned/allocated an integer value. If the mean and standard deviation of the data are not known, then the standard integer value will be assigned using the sample mean and standard deviation.

$$Y = \frac{s - \underline{s}}{M} \tag{2}$$

$$I = s * (s^T s)^{-1} s^T \tag{3}$$

The matrix variance is,

$$Var(\hat{I}_i) = \sigma^2 (1 - i_{ii}) \tag{4}$$

After that, the residuals are estimated as given by equation 6.

$$\sqrt{1 - i_{ii}} \tag{5}$$

where, $\underline{\sigma}\ refers\ to\ estimate\ of\ \sigma$

The pre-processing step involves translating the data into a numerical format that is easy to read and analyze. This process includes removing irrelevant terms from the data set, which is critical for accuracy. To achieve this, the ordinal scaled encoding method is used. The first step of this method is to assign/allocate integer values to each term. If the data's mean and standard deviation are not known, a standard integer value will be assigned using the sample mean and standard deviation. The technique of function scaling is then applied to allocate values to the variables starting from 0, which is signified as the ordinal or integer encoding. This encoding scheme is expressed as: [0,1,2,3,4,...,k], where k is the maximum possible value for the variable. By pre-processing the data in this way, it can be readily analyzed using machine learning algorithms.

$$m' = \frac{(Y - m_{min}Var(l_i))s_i}{(m_{max} - m_{min})\hat{\sigma}^2} \tag{6}$$

The result of the pre-processing step is the allocation of integer values to each variable in the form of ordinal encoding, from 0 to k, where k is the maximum possible value for the variable. Next, the Iterative Fisher algorithm is used for feature extraction to identify the most important features in the data set. The Iterative Fisher algorithm is a statistical method that is used to extract the most relevant features from high-dimensional data, increasing the performance of subsequent machine learning algorithms. Finally, the extracted features are then optimized with the use of the Convergent Artificial Bee Colony optimization (CABC) strategy, which is a meta-heuristic optimization algorithm that simulates the natural behavior of bee colonies in the wild to solve complex optimization problems. This process of feature optimization aims to further improve the performance of the model.

Optimization process using Convergent Artificial Bee Colony (CABC) algorithm

The Convergent Artificial Bee Colony (CABC) algorithm is an optimization technique inspired by the behavior of bee colonies, where the swarm of bees collaborates to find a solution to a problem. The colony is comprised of three groups: scout bees, onlooker bees, and employed bees. The employed bees are responsible for half of the colony's work and are always searching for new nectar sources based on visual information. If a new source has more nectar than the previous one, the bee remembers the original location and forgets older ones. At the hive, onlooker bees wait for the hired bees to find better sources of food. If the search process becomes stagnant, the employed bee becomes a scout and starts looking for new food sources.

Prediction process by means of Residual MLP classifier approach

A Residual Multilayer Perceptron (RMLP) classifier technique is employed for the prediction process. A training dataset is used to learn the dataset features along with their relationship for pre-defining their categories. The test dataset then enters the process of classifier as an input, and the expected categories are the outputs for all text until the classifier is qualified completely. This process of classification is implemented at the final stage of air quality analysis. The RMLP technique is employed for making the classification's operation. The RMLP consists of several attributes, and the functional layers are used for the determination of meaningful outcomes of the classification. The Kernel function is built at the function of the Battens, which is used for classification and the prediction of target web page. At each layer, the kernel function is enabled. The linear models are twisted with the use of the Kernel Trick as nonlinear templates. These attributes are then identified by the thresholds of the Kernel that are offered faster. The RMLP is chosen due to its better abilities of performance analysis.

In the section, the performance assessment of the proposed strategy is presented. The outcomes obtained are shown in a graphical representation. The statistical approaches to estimate the errors among forecasted and actual values are estimated by means of RMSE, MAE, and MAPE. The obtained error rates of RMSE, MAE, and MAPE are compared with the existing techniques, such as SVR, GBTR, LSTM, and ALSTM, to estimate the efficiency of the proposed model.

Performance Metrics

RMSE is a measure of the variation between actual values and predicted values, and it's commonly used to estimate values over different time intervals. To put it simply, the higher the RMSE value, the more mismatch between the actual value and the predicted value. In other words, if the prediction rate is misaligned due to high RMSE values, it suggests that the model needs to be trained better to enhance the accuracy. The RMSE is expressed by the equation 7.

$$RMSE = \sqrt{\frac{\sum_{i=0}^{n-1} (y_i - f_i)^2}{n}} \tag{7}$$
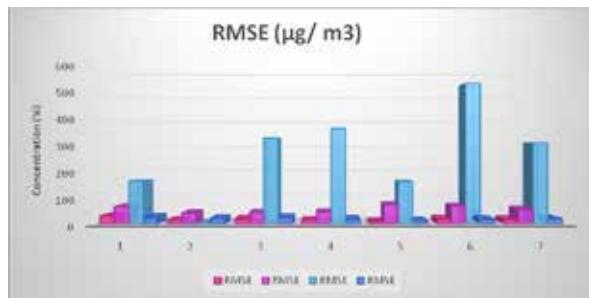
Figure 3 : RMSE

The Mean Absolute Error (MAE) is another measure used to estimate the difference between the actual values and the predicted values. Unlike the RMSE, the MAE does not take the sign of the difference into account, meaning it doesn't matter if the actual value is higher or lower than the predicted value. The MAE is calculated by taking the average of the absolute difference between the predicted value and the actual value, and is often considered to be more robust than the RMSE because it is not influenced by extreme values in equation 8.

$$MAE = \frac{\sum_{i=0}^{n-1} |y_i - f_i|}{n} \tag{8}$$

Figure 4 : MAE

MAPE is a popular statistical measure used to evaluate the accuracy of a forecasting system. It calculates the percentage difference between the actual value and the predicted value, and is a good indicator of how well the system is performing. A higher MAPE means that the prediction is less accurate, and vice versa. The prediction accuracy can vary depending on the concentration of the data, and it was observed that the MAPE offered a higher range of accuracy compared to other regional techniques.

$$MAPE = \frac{1}{n}\sum_{i=0}^{n-1} \left|\frac{y_i - f_i}{y_i}\right| \times 100 \tag{9}$$
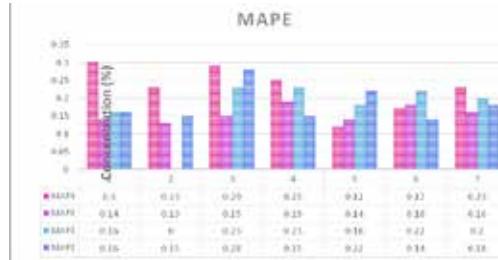
Figure 5 : MAPE

Comparative analysis of proposed and existing system in terms of MAE, and RMSE (by hour wise)

Figure 10 presents a comparison of MAE performances for various time intervals between several prediction techniques, including SVR, GBT, LSTM, ALSTM, and the proposed RMLP. The analysis shows that the RMLP method has a lower error rate compared to traditional techniques such as SVR, GBT, LSTM, and ALSTM. This suggests that the proposed method offers improved accuracy for predicting air quality parameters over time intervals.

Figure 6 : MAE values w,r,t proposed and existing methods

Figure 2 presents a comparative analysis of RMSE values for different prediction techniques, including SVR, GBT, LSTM, ALSTM, and the proposed RMLP, for different time intervals. The results indicate that the proposed RMLP method has a lower error rate compared to other existing techniques such as SVR, GBT, LSTM, and ALSTM. The analysis illustrates the superiority of the proposed methodology in terms of reduced RMSE values, especially for longer time intervals.
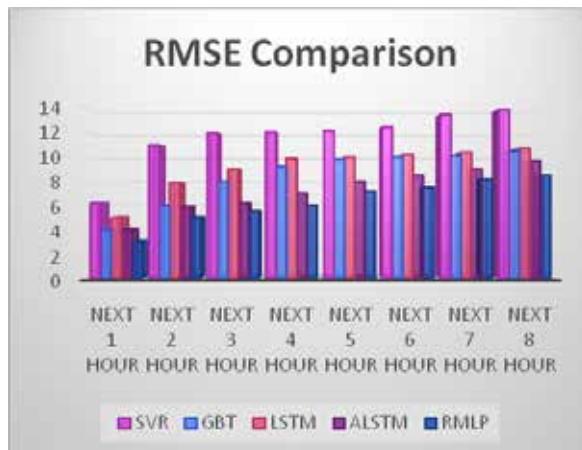
Figure 7 :RMSE values w.r.t proposed and existing methods
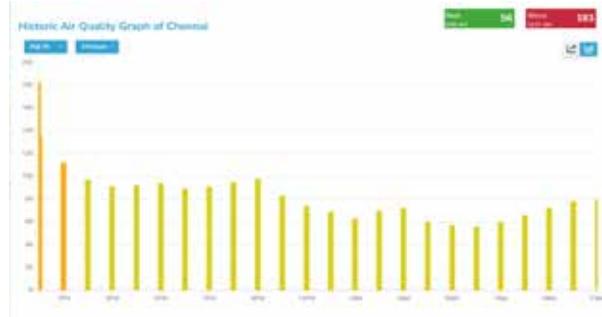
Figure 8 : Graphical Representation of (AQI-IN)
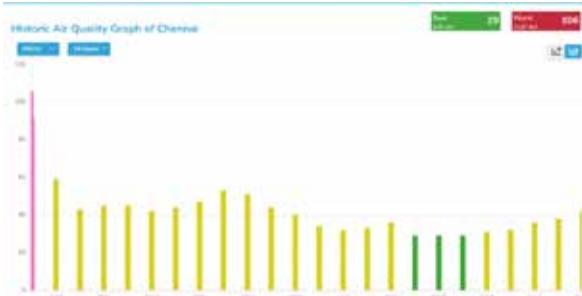
Figure 9 : Graphical representation of PM2.5 at Chennai locality
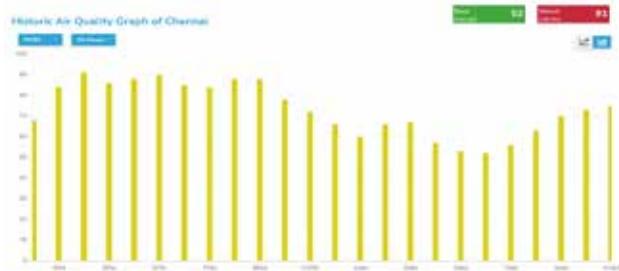
Figure 10 : Graphical representation of PM10 concentration level in Chennai between 1PM to 11AM

Figure 11 : Graphical representation of sulfur dioxide (SO2) level in Chennai environment
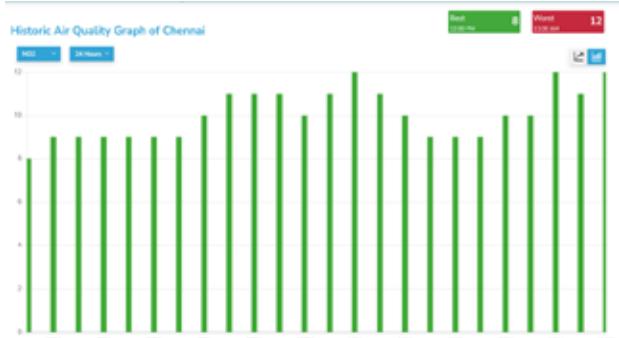
Figure 12 : Graphical representation of nitrogen dioxide (NO2) in Chennai environment
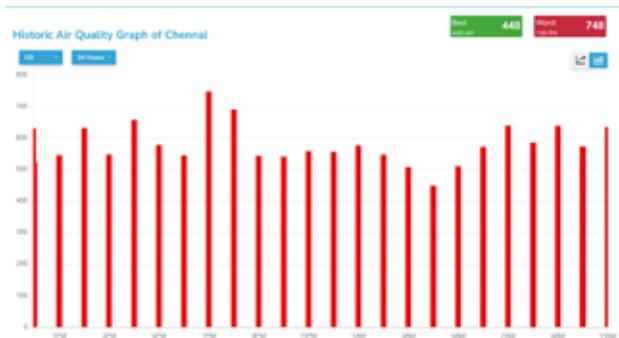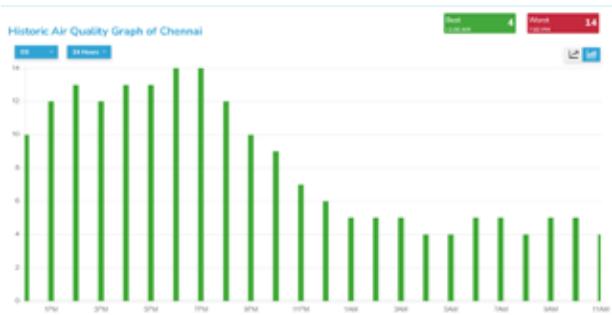
Figure 13 : Graphical representation of carbon monoxide (CO) in Chennai environment
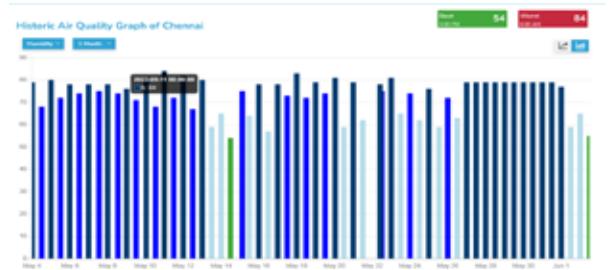
Figure 14 : Graphical representation of Ozone (O3) in Chennai environment
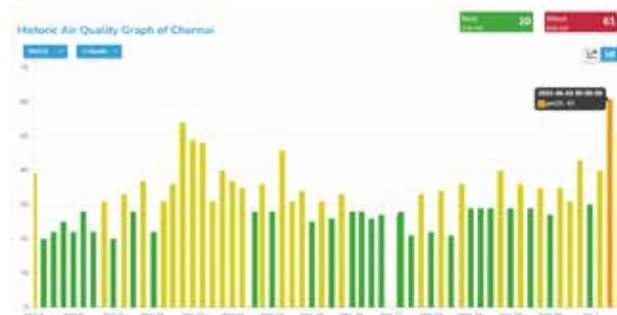
Figure 15 : Graphical representation of Temperature difference in Chennai level environment
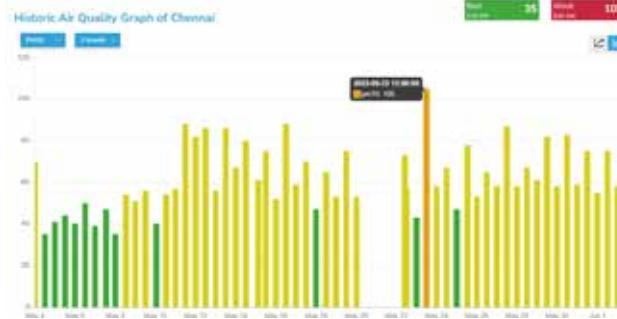
Figure 16 : Graphical representation of Humidity concentration at air in Chennai atmosphere for 24hours

Figure 17 : Graphical representation of Humidity concentration at air in Chennai atmosphere for 1 Month(May 04 to June 11)

Figure 18 : Periodic analyzation at chennai for 1 Month (May 04 to June 11)

Figure 19 :Periodic analyzation of air at chennai for 1 Month (May 04 to June 11)
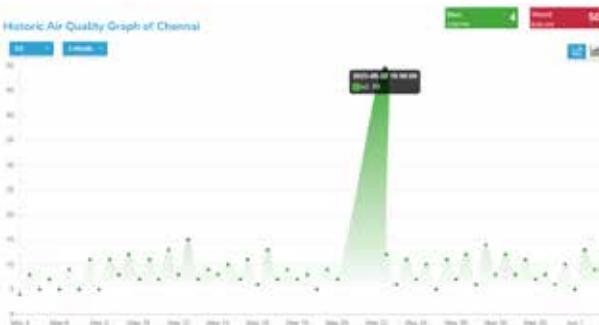
Figure 20 : Periodic analyzation of sulphur dioxide (SO2) at Chennai environment for 1 Month(May 04 to June 11)
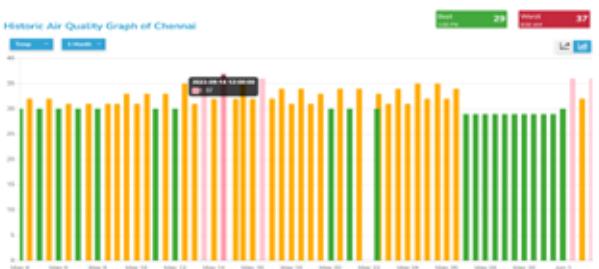
Figure 21 : Periodic analyzation of Nitrogen dioxide (NO2) at Chennai environment for 1 Month(May 04 to June 11)
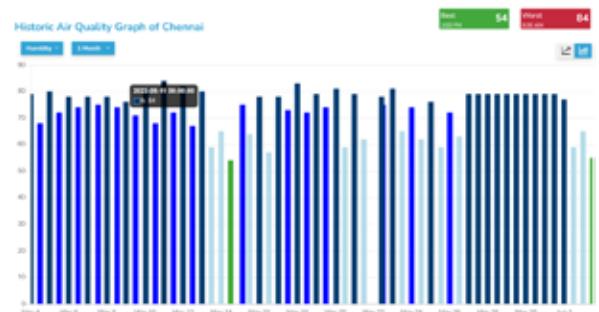
Figure 22 : Periodic analyzation of Carbon monoxide (CO) at Chennai environment for 1 Month(May 04 to June 11)

Figure 23 : Periodic analyzation of Ozone (O3) at Chennai environment for 1 Month (May 04 to June 11)
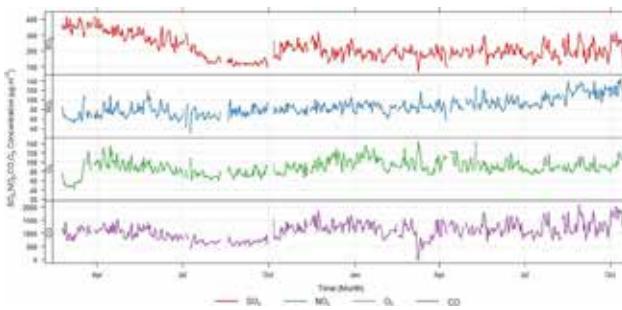
Figure 24 : Periodic analyzation of Temparature at Chennai environment for 1 Month (May 04 to June 11)

Figure 25 : Periodic analyzation of sulphur dioxide (SO2) at Chennai environment for 1 Month (May 04 to June 11)

Figure 26 : Live graphical indication of air quality at Chennai environment

Figure 27 : SO2, NO2,CO,O3 Concentration (April to October) at Chennai environment

CONCLUSION

In this research,employed Residual Multilayer Perceptron (RMLP) algorithms for predicting air pollution and quality, specifically PM2.5, levels in Chennai at different time intervals and regions. The data preprocessing was done using SOSE and Iterative Fisher Feature Selection techniques, with CABC being used to optimize the feature choice. The classification process was implemented using the RMLP classifier, which showed improved97.2% accuracy compared to other traditional methods such as SVR, GBTR, LSTM, and ALSTM. The performance was evaluated based on MAE, RMSE, and MAPE values for both hour-wise and area-wise analysis. The results showed that RMLP can accurately predict PM2.5 levels in different regions of Tamilnadu especially in chennai.

REFERENCE

1. Kumar, K. and Pande, B.P., 2022. Air pollution prediction with machine learning: A case study of Indian cities. International Journal of Environmental Science and Technology, pp.1-16.

2. Mahendra, H.N., Mallikarjunaswamy, S., Kumar, D.M., Kumari, S., Kashyap, S., Fulwani, S. and Chatterjee, A.,

2023. Assessment and Prediction of Air Quality Level Using ARIMA Model: A Case Study of Surat City, Gujarat State, India. Nature Environment & Pollution Technology, 22(1).

3. Gokul, P.R., Mathew, A., Bhosale, A. and Nair, A.T., 2023. Spatio-temporal air quality analysis and PM2. 5 prediction over Hyderabad City, India using artificial intelligence techniques. Ecological Informatics, 76, p.102067.

4. Van, N.H., Van Thanh, P., Tran, D.N. and Tran, D.T., 2023. A new model of air quality prediction using lightweight machine learning. International Journal of Environmental Science and Technology, 20(3), pp.2983-2994.

5. Sridhar, K., Radhakrishnan, P., Swapna, G., Kesavamoorthy, R., Pallavi, L. and Thiagarajan, R., 2023. A modular IOT sensing platform using hybrid learning ability for air quality prediction. Measurement: Sensors, 25, p.100609.

6. Ravindra, K., Bahadur, S.S., Katoch, V., Bhardwaj, S., Kaur-Sidhu, M., Gupta, M. and Mor, S., 2023. Application of machine learning approaches to predict the impact of ambient air pollution on outpatient visits for acute respiratory infections. Science of The Total Environment, 858, p.159509.

7. Oliveira Santos, V., Costa Rocha, P.A., Scott, J., Van GriensvenThé, J. and Gharabaghi, B., 2023. Spatiotemporal air pollution forecasting in houston-TX: a case study for ozone using deep graph neural networks. Atmosphere, 14(2), p.308.

8. Singh, T., Sharma, N., Satakshi and Kumar, M., 2023. Analysis and forecasting of air quality index based on satellite data. Inhalation Toxicology, pp.1-16.

9. Wathore, R., Rawlekar, S., Anjum, S., Gupta, A., Bherwani, H., Labhasetwar, N. and Kumar, R., 2023. Improving performance of deep learning predictive models for COVID-19 by incorporating environmental parameters. Gondwana Research, 114, pp.69-77.

10. Sonawani, S. and Patil, K., 2023. Air quality measurement, prediction and warning using transfer learning based IOT system for ambient assisted living. International Journal of Pervasive Computing and Communications, (ahead-of-print).

11. Tsagkis, P., Bakogiannis, E. and Nikitas, A., 2023. Analysing urban growth using machine learning and open data: An artificial neural network modelled case study of five Greek cities. Sustainable Cities and Society, 89, p.104337.

12. ArunaKumari, P., Vijayalata, Y., Susmitha Valli, G. and Lakshmi Prasanna, Y., 2023, January. Air Contamination Prediction and Comparison Using Machine Learning Algorithms. In Proceedings of the International Conference on Cognitive and Intelligent Computing: ICCIC 2021, Volume 2 (pp. 661-677). Singapore: Springer Nature Singapore.

13. Yadav, N.K., Mitra, S.S., Santra, A. and Samanta, A.K., 2023. Understanding Responses of Atmospheric Pollution and its Variability to Contradicting Nexus of Urbanization–Industrial Emission Control in Haldia, an Industrial City of West Bengal. Journal of the Indian Society of Remote Sensing, pp.1-22.

14. Ramli, N., Abdul Hamid, H., Yahaya, A.S., Ul-Saufie, A.Z., Mohamed Noor, N., Abu Seman, N.A., Kamarudzaman, A.N. and Deák, G., 2023. Performance of Bayesian Model Averaging (BMA) for Short-Term Prediction of PM10 Concentration in the Peninsular Malaysia. Atmosphere, 14(2), p.311.

15. Nwokolo, S.C., Proutsos, N., Meyer, E.L. and Ahia, C.C., 2023. Machine learning and physics-based hybridization models for evaluation of the effects of climate change and urban expansion on photosynthetically active radiation. Atmosphere, 14(4), p.687.

Image Classification Survey using CNN and AI-based Optimization Techniques

Wasim Khan
Computer Science and Engineering
Oriental University
Indore, Madhya Pradesh
✉ wasim.khan1982gwpci@gmail.com

L. K. Vishwamitra
Computer Science and Engineering
Oriental Institute of Science and Technology
Bhopal, Madhya Pradesh
✉ lkvishwamitra@gmail.com

ABSTRACT

Image classification stands as a foundational task within the realm of visual recognition, aimed at comprehending and assigning a specific label to an entire image. This endeavor belongs to the domain of computer vision, where the objective is to allocate an image to predefined classes or categories. The scope of image classification spans a wide spectrum of applications, encompassing endeavors like identifying objects within images, delving into medical image analysis, navigating autonomous vehicles, and much more. Within this landscape, Convolutional Neural Networks (CNNs) emerge as a formidable class of deep learning models tailored for tasks entailing visual data, such as recognizing images and videos, detecting objects, and performing image classification. Their influence also extends to domains like natural language processing and speech recognition. Functioning as a specialized classifier, CNNs excel in unraveling patterns within images or videos, facilitating the identification of objects, classes, and categories. Their strength in solving image classification puzzles emanates from their innate capability to autonomously glean hierarchical features ranging from edges and textures to shapes from raw image data.

Nevertheless, the training of intricate CNNs demands substantial computational resources and is susceptible to pitfalls such as overfitting and underfitting. To surmount these challenges, AI-based optimization techniques have been introduced, infusing the training process with efficacy and elevating classification accuracy. The fusion of CNNs with AI-driven optimization methods has ushered in a paradigm shift in image classification. These techniques empower models to attain cutting-edge performance benchmarks, exhibit robust generalization across diverse datasets, and adapt adeptly to varying application domains. This paper presents a comprehensive review of image classification using CNNs and AI-based optimization techniques. The primary focus is on investigating the synergistic effects of CNN architectures and advanced optimization algorithms in improving classification performance.

KEYWORDS: *CNN, AI, SVM, KNN, Deep learning.*

INTRODUCTION

Image classification is a basic task in the field of computer vision, aiming to automatically assign labels to images based on their content. It has numerous real-world applications, such as facial recognition, object detection, and content recommendation. Convolutional Neural Networks (CNNs) have revolutionized image classification by mimicking the human visual system's hierarchical processing. When combined with Artificial Intelligence (AI) based optimization techniques, CNNs can achieve remarkable accuracy and efficiency in image classification tasks.

Convolutional Neural Networks (CNNs) are a class of deep neural networks specially designed to process grid-like data, such as images. They consist of multiple layers, including convolutional layers that learn features from local image regions, pooling layers that downsample the feature maps, and fully connected layers that perform the final classification. The architecture's ability to automatically learn hierarchical features from

raw pixel values has been crucial in improving image classification accuracy.

LITERATURE REVIEW OF IMAGE CLASSIFICATION USING CNN AND AI-BASED OPTIMIZATION TECHNIQUES

In the year 2018, an important contribution to the field of computer vision and deep learning was made by Nadia Jmour and her team [1]. Their study revolved around the application of Convolutional Neural Networks (CNNs) for the intricate task of comprehending features and accomplishing the classification of RGB-D images. The RGB-D imagery, which combines traditional color (RGB) images with depth (D) information, presents a unique challenge due to its multidimensional nature. To address this challenge, the researchers turned to CNNs, a powerful class of neural networks known for their effectiveness in tasks involving visual data.

One of the key methodologies explored in their study was the "fine-tuning technique," which falls under the umbrella of transfer learning. Transfer learning involves leveraging knowledge gained from a pre-existing task and applying it to a new, related task. In this case, the researchers repurposed layers of a CNN model that had been pre-trained on the massive ImageNet dataset. ImageNet is a well-known dataset containing millions of labeled images, and models trained on it have demonstrated the ability to learn general visual features that can be beneficial for various tasks.

The fine-tuning process involves taking the pre-trained CNN and retraining only a subset of its layers on the new RGB-D image dataset. By doing so, the model can adapt its learned features to the specific characteristics of the new data. This approach not only saves valuable training time and computational resources but also harnesses the knowledge captured by the CNN on the ImageNet dataset. The primary objective of this fine-tuning endeavor was to address a novel four-class classification task that involved distinct data. This classification task aimed to categorize RGB-D images into four distinct classes. By applying the fine-tuning technique, Nadia Jmour and her colleagues aimed to optimize the CNN's performance for this specific task while capitalizing on the rich features the model had already acquired from the ImageNet dataset.

In a parallel endeavor within the same year, Neha Sharma and a team of co-researchers embarked on an empirical exploration that focused on another critical aspect of CNNs—real-time object identification in video streams. The rapid and accurate identification of objects within video feeds has numerous applications, ranging from surveillance to augmented reality. The researchers concentrated their efforts on evaluating the performance of several renowned CNN architectures for this real-time object identification task. Among the notable networks they examined were AlexNet, GoogLeNet, and ResNet50. These networks have gained widespread recognition for their efficacy in object detection and classification tasks, owing to their innovative architectural designs.

The core of Neha Sharma's study lay in systematically measuring the prediction accuracy of these selected CNNs. To achieve this, they subjected the networks to rigorous testing using prominent datasets designed for training and assessing the capabilities of CNN models. The aim was to quantify and compare how well each of the CNN architectures could accurately predict object identities within real-time video streams.

In summary, the research conducted by both Nadia Jmour et. al [1] and Neha Sharma et. al [2] in 2018 contributed significantly to the advancement of computer vision and deep learning. Nadia Jmour's team explored the utilization of CNNs, specifically employing the fine-tuning technique, to tackle the challenge of RGB-D image classification. On the other hand, Neha Sharma's group concentrated on the empirical evaluation of CNN architectures for real-time object identification within video feeds. Both studies exemplify the continuous efforts to enhance the capabilities of neural networks in understanding and processing visual information across various complex scenarios.

In 2018, Farhana Sultana [3] and her team provided a concise overview of the various components of Convolutional Neural Networks (CNNs) and elucidated different CNN architectures utilized for image classification, tracing the evolution from the early LeNet-5 model to the most recent SENet model. They meticulously delved into the model descriptions and training procedures for each architecture while also conducting a comprehensive comparative analysis

among them. The outcomes of applying the SENet model to the ImageNet dataset suggested its potential utility in other tasks demanding robust discriminative features. In 2019, Mingyuan Xin[4] and colleagues introduced an innovative training criterion for deep neural networks, termed Maximum Interval Minimum Classification Error (M3CE). Simultaneously, they conducted a detailed analysis of both cross-entropy and M3CE, amalgamating these approaches to enhance performance. Their proposed method underwent testing on two widely recognized databases, MNIST and CIFAR-10. The experimental findings demonstrated that M3CE serves as a beneficial complement to the cross-entropy criterion, notably improving classification outcomes. Additionally, their convolutional network utilized a feature detection layer for implicit learning from the training data.

In 2019, Thinzar Saw [5] and her collaborators introduced an innovative feature selection approach founded on swarm intelligence principles. This approach empowers the discovery of an optimal subset of features from an exceedingly vast pool of features, ultimately facilitating the construction of highly accurate classifier models. The research paper extensively explores the application of swarm intelligence algorithms to the feature selection process, particularly in the context of classifying medical data with high-dimensional attributes. The results obtained from their investigation underscore the promising potential of swarm intelligence algorithms, especially when compared to state-of-the-art methods. This study holds significant importance as it systematically evaluates various alternative swarm algorithms that can be effectively employed in feature selection tasks for high-dimensional classification scenarios.

Tejasv Agarwal et al. (2019)[6] have undertaken a comprehensive exploration of four prominent convolutional neural network (CNN) based models: VGG16, mobileNet, Resnet50, and InceptionV3. Their study revolves around a comparative analysis of the effectiveness of these models, evaluated across diverse image classification datasets. Specifically, they delve into binary classification scenarios involving cats and dogs, as well as multiclass classification using a plant seedling dataset. The metric of accuracy serves as the benchmark for assessing the performance of these models While VGG16 emerges as the most accurate model in terms of classification performance, it is accompanied by a notable drawback—its extensive demand for time and computational resources. This characteristic could pose challenges, particularly when operating within constraints of limited computational power. On the flip side, MobileNet, while not achieving the same level of accuracy as VGG16, showcases a remarkable trade-off between resource consumption and accuracy. This attribute positions MobileNet as a superior choice when balancing computational efficiency against classification precision. On another front, Ding Xiaohui et al. (2020) [7] have introduced a novel multi-swarm hybrid optimization approach. Rooted in the principles of swarm intelligence, their methodology draws from three meta-heuristic algorithms: the artificial bee colony, the firefly algorithm, and the sine–cosine algorithm. Their approach is subjected to rigorous validation using seven widely recognized classification benchmark datasets. To gauge its efficacy, the results are juxtaposed against existing state-of-the-art approaches within the recent literature.

The simulation outcomes affirm the prowess of the multi-swarm technique, showcasing its capacity to yield superior generalization performance compared to alternative methodologies. This superiority is evidenced across a spectrum of performance indicators, including accuracy, precision, recall, and f1-score. A compelling aspect of their study is the insight gained from experimenting with various hybrid combinations. The researchers demonstrate that the synergy of three distinct approaches within their multi-swarm framework outperforms outcomes achieved by pairing only two algorithms. This thorough exploration is further corroborated through rigorous validation against challenging datasets, cementing the efficacy of the proposed multi-swarm hybrid optimization approach.

In 2020, Ruba Abu Khurma [8] and her collaborators introduced an innovative methodology founded on the Moth Flame Optimization (MFO) algorithm, incorporating dynamic strategies for adjusting the number of flames over time. The MFO algorithm, categorized as a swarm intelligence (SI) technique, has demonstrated efficacy in addressing diverse

optimization problems. This research introduces distinct strategies for adapting the number of flames within the MFO algorithm, and meticulously assesses their influence on the algorithm's performance. To evaluate the proposed approach, seventeen medical benchmark datasets were utilized. The comparative analysis encompassed contrasting the proposed method against other heuristics, revealing promising performance outcomes. In the same year, Preethi Gunishetty [9] and co-researchers presented a study focused on human activity recognition, harnessing the potential of a Particle Swarm Optimization (PSO)-based Convolutional Neural Network (CNN). This novel approach converges more swiftly and explores the optimal architecture for the CNN. By integrating PSO into the training process, the aim was to enhance the CNN's solution vectors, thus elevating classification accuracy and achieving superior results when compared to prevalent designs. The study delved into the performances of the PSO-CNN algorithm, juxtaposing it against both classical machine learning algorithms and deep learning approaches. The experimental findings underscored that the PSO-CNN algorithm nearly matched the performance of state-of-the-art designs, reaching an accuracy of 93.64%. Among machine learning algorithms, the Support Vector Machine exhibited the highest accuracy at 95.05%, while a deep CNN model achieved an accuracy score of 92.64%.

In 2021, Wenjiang Jiao [10] and colleagues introduced a novel image classification model, CNN-XGBoost, which was optimized using advanced particle swarm optimization (APSO). APSO played a crucial role in optimizing the hyperparameters and the overall architecture, enhancing the fusion of this two-stage model. The model consists of two main components: a feature extractor CNN, which automatically extracts spatial features from images, and a feature classifier XGBoost, applied to classify the features extracted after convolution. To overcome the limitation of traditional PSO algorithms prone to local optima, the improved APSO employed two distinct strategies to guide particles in searching for optimization solutions. This approach improved population diversity and prevented the algorithm from getting trapped in local optima. Results demonstrated that this proposed model achieved better image classification outcomes.

In 2021, Xiahan Liu [11] and his team presented methods for classifying different styles of music and visualizing their migration. The approach featured a straightforward structure, mature algorithms, and precise optimization techniques. It effectively enabled particles to explore a broader solution space, facilitating their escape from previously encountered local optima. The global search aspect employed gradient methods to expedite optimization and control real-time music style transfer, ultimately enhancing the entire network's learning and convergence performance. This led to improved recognition rates for the entire system and added specific content and time sequence expression to music visualization and image style transfer. Also in 2021, Neda Alipour [12] and her team accomplished the classification of 102 flower species using a robust deep learning method. They applied a transfer learning approach using the DenseNet121 architecture to categorize various species from the Oxford-102 flowers dataset. Their approach involved preprocessing, including normalization and resizing of images, followed by fine-tuning a pre-trained model. The reported accuracy reached an impressive 98.6% after 50 epochs, surpassing other deep-learning-based methods for the same dataset.

In 2021, Shahbaa I. Khaleel [13] and colleagues introduced a system designed for color image retrieval based on swarm intelligence algorithms. Their approach utilized ant colony optimization (ACOM) and the intelligent water drop (IWDM) method for the clustering process. Adnan Mohsin Abdulazeez [14] and his team (2021) conducted an extensive review of different swarm intelligence and evolutionary computing methods for feature selection in multi-label classification tasks. They categorized these methods based on various perspectives, highlighting their main characteristics and providing analytical comparisons. The study also introduced benchmarks, evaluation measures, and standard datasets to facilitate further research in this field. M. Israk Ahmed [15] and colleagues (2021) utilized CNNs for vegetable image classification, using a dataset of 21,000 images across 15 classes. They employed pre-trained CNN architectures through transfer learning to compare accuracy with conventional CNNs.

Lihua Luo [16] and colleagues (2021) conducted a comprehensive study on image classification algorithms based on convolutional neural networks. They also compared and analyzed deep belief network algorithms, summarizing the application characteristics of different algorithms. Thanh-Nghi Do and his team (2021) [17] used real datasets of fingerprint images from students at Can Tho University (Vietnam) to propose deep network models like VGG, ResNet50, Inception-v3, and Xception. These models achieved high classification accuracy on test sets, with ResNet50 achieving 99.00%, 98.33%, and 98.05% accuracy on three different fingerprint datasets. In 2022, Manish U et al. [18] employed TensorFlow-based CNNs to identify plants based on their characteristics and taxonomy. They utilized quantitative and qualitative features, primarily utilizing photographs as datasets.

Keyu Mao [19] and colleagues (2022) analyzed satellite images to identify damaged houses. They employed a CNN model, and image enhancement techniques were applied to enhance model robustness. The preliminary model achieved an accuracy of 0.9706. Pradumn Kumar [20] and his team (2022) used convolutional neural networks with TensorFlow to identify plant categories based on leaf characteristics. They reported that advanced CNNs achieved accuracy above 95%, outperforming conventional methods. M. Senthil Kumar [21] and colleagues (2022) proposed a machine learning model for image classification using CNNs. The model used TensorFlow and Keras libraries to predict and classify images, achieving accuracy through CNNs. G. Sathiyapriya [22] and colleagues (2022) analyzed machine learning and deep learning techniques in image classification. They discussed Convolutional Neural Networks (CNNs) for identifying image categories using various distance metrics.

Yiqun Shang [23] and his team (2022) introduced a filter–wrapper (F–W) framework to enhance the performance of swarm intelligence-based optimization algorithms (SIEAs) and applied it to optimize support vector machines (SVMs) for image classification. Their approach outperformed other feature selection techniques in terms of accuracy. Saud S. Alotaibi [24] and colleagues designed a swarm intelligence-based model with deep transfer learning for aerial image

classification. Their model incorporated features like RetinaNet for feature extraction, Salp Swarm Algorithm (SSA) for hyperparameter optimization, and a cascaded long short-term memory (CLSTM) for classification. The proposed model outperformed recent approaches in aerial image classification. Saroj Kumar Sahoo [25] and his team (2023) conducted a comprehensive review of Moth Flame Optimization (MFO) algorithms for solving complex real-world optimization problems. They explored various MFO variants and their applications across different domains. Koon Meng Ang [26] and colleagues proposed a modified particle swarm optimization (PSO) variant with two-level learning phases for training artificial neural networks (ANNs) in image classification. This approach enhanced population diversity and solution quality, improving the algorithm's robustness. Waqas Haider Bangyal [27] and his team (2022) introduced an improved PSO algorithm variant with pseudo-random sequences and opposite rank inertia weights for initialization. Their algorithm, ORIW-PSO-F, was tested on UCI datasets and showed promising results. Osheen Khare[28] and colleagues presented a critical analysis of swarm optimization algorithms, focusing on particle swarm optimization (PSO) and artificial bee colony (ABC). They evaluated these algorithms on benchmark problems and compared their performances based on predetermined parameters. Devar Giveki[29] and his team (2023) proposed a new method for addressing the challenges of convolutional neural networks (CNNs). Their approach involved a novel CNN and the application of Generalized Discriminant Analysis (GDA) for more efficient image feature extraction and dimensionality reduction. Chaowei Zhou [30] and colleagues (2023) introduced a combined algorithm that integrated modified particle swarm optimization (SMCPSO) and fast super-resolution convolutional neural networks (FSRCNN). Their approach improved the accuracy of super-resolution image reconstruction and classification.

S.A. Angadi [31] and colleagues have presented an effective framework for Content-Based Image Retrieval (CBIR) systems, employing transfer learning on pre-trained Convolutional Neural Networks (CNNs) such as ResNet18, GoogLeNet, and AlexNet. Their approach employs query-by-image, leveraging classification-

score descriptors for Image Retrieval (IR) and employing distance metrics for similarity comparison. The proposed framework advocates transfer learning to efficiently retrain these CNNs on small datasets from the Wang database. The study includes over thirty experiments to determine optimal hyper-parameter values and assess the viability of six commonly used distance metrics: Euclidean, Seuclidean, Cityblock, Cosine, Mahalanobis, and Chebychev. The proposed CBIR framework achieves a remarkable image retrieval accuracy of 99.45% on a collection of natural scene images from the Wang dataset.

Tianjiao Liu [32] and co-authors have introduced a deep learning framework based on TensorFlow, featuring a 9-layer Convolutional Neural Network (CNN). The study employs the Modified National Institute of Standards and Technology (MNIST) image dataset for training the network model and refining its parameters. A comparison of classification performance is made against the Support Vector Machine (SVM) model. The outcomes reveal a 4% higher classification accuracy for the CNN compared to the SVM model. Kavitha Munishamaiaha [33] and colleagues (2023) have utilized an enhanced form of elephant herding optimization, a bio-inspired metaheuristic strategy, to create an automatic system for hyperspectral image classification. This approach, termed CNN–EEHO–AdaBound, combines the enhanced elephant herding optimization (EEHO) with the AdaBound optimizer to fine-tune and update hyperparameters in Convolutional Neural Networks (CNNs). The experiments were conducted on benchmark datasets, namely Indian Pines and Salinas, resulting in improved accuracy for hyperspectral image classification through optimized hyperparameter tuning [33]. Qichang Liu [34] and co-authors (2023) have conducted a review on the evolution of image classification and introduced several representative Convolutional Neural Networks (CNNs). Image classification quantitatively assesses images using computational methods, categorizing image content or regions into multiple classes without relying on human visual interpretation. With the rise of big data and enhanced computing capabilities, deep learning, particularly the Convolutional Neural Network (CNN) approach, has gained prominence in image classification, surpassing the constraints of traditional

methods. Notable architectures like MobileNet, ResNet, and VGG have garnered significant attention.

Xiyu Lin [35] and collaborators (2023) have dissected the Convolutional Neural Network paradigm into two models: the classical deep CNN model and the attention mechanism-based deep CNN model. The review comprehensively examines the construction and attributes of various deep CNN models, comparing their classification performance and delving into the challenges these models face. The authors emphasize that deep CNN models have exhibited superior performance in image classification tasks. Shahbaz Sikandar [36] and team have explored a novel hybrid CBIR system that amalgamates deep learning and machine learning techniques. The system employs transfer learning through two pre-trained deep learning models, ResNet50 and VGG16, alongside the K-Nearest Neighbors (KNN) machine learning model. The image similarity computation relies on KNN and Euclidean distance. The study even proposes a web interface for presenting similar image results, utilizing precision as the performance metric. Minghai Xu [37] and co-authors (2023) have conducted an in-depth study of various swarm intelligence optimization algorithms, including ant colony, particle swarm, sparrow search, bat, and thimble colony algorithms. The study examines their models, features, enhancement strategies, and applications in image processing, encompassing tasks like segmentation, matching, classification, feature extraction, and edge detection. The authors analyze the algorithms' improvements and their comprehensive application in image processing technology. The study concludes by summarizing the shared framework, common attributes, and distinctions among swarm intelligence algorithms [37].

CONCLUSIONS

In this paper, we have undertaken an assessment of the present status of image classification and the integration of AI-based optimization methodologies. Addressing image classification challenges requires acknowledging that no singular traditional technique is fully suited for the task. Within the realm of computer vision, Convolutional Neural Networks (CNNs) have emerged as the foremost and favored strategy. Designed with the inherent capacity to automatically and flexibly

acquire hierarchical features from input images, CNNs have found a niche in tasks like image classification. Furthermore, the augmentation of CNNs through the infusion of AI-driven optimization techniques has demonstrated the potential to elevate their performance. The combination of these AI-based methodologies with established techniques holds the promise of enhancing the resolution of image classification challenges across a diverse array of image datasets. The crucial interplay between CNNs and AI techniques underlines the importance of making informed choices regarding architecture, optimization methods, and hyperparameters. Recognizing the substantial influence that architectural decisions, optimization strategies, and hyperparameters can wield over a model's efficacy, it is evident that a comprehensive approach involving experimentation and refinement is paramount. Iterative testing across various parameters becomes the linchpin for attaining the optimal outcomes in the realm of image classification challenges.

The synergy achieved by amalgamating AI-based optimization techniques with CNNs marks a pivotal milestone in the evolution of image classification methodologies. This confluence of cutting-edge techniques and established paradigms has the potential to recalibrate our approach to addressing intricate image classification conundrums, offering multifaceted solutions for real-world complexities.

REFERENCES

1. Nadia Jmour, SehlaZayen, AfefAbdelkrim. (2018, March). "Convolutional Neural Networks for image classification". Published by IEEE 978-1-5386-4449-2/18/ IEEE, Available: https:// DOI:10.1109/ASET.2018.8379889

2. Neha Sharma, Vibhor Jain, Anju Sharma. (2018, May). "An Analysis of Convolutional Neural Networks for Image Classification". Published by Elsevier Ltd., Peer-review under responsibility of the scientific committee of the International Conference on Computational Intelligence and Data Science (ICCIDS 2018), Procedia Computer Science 132, pp.377–384. Available: http://www.sciencedirect.com

3. Farhana Sultana, Abu Sufian, Paramartha Dutta. (2018, Nov). "Advancements in Image Classification using Convolutional Neural Network". Published by IEEE 978-1-5386-7638-7/18/IEEE, Fourth International Conference on Research in Computational Intelligence and Communication Networks (ICRCICN). Available:https://DOI:10.1109/ICRCICN.2018.8718718

4. MingyuanXin , Yong Wang. (2019, Feb)." Research on image classification model based on Comparison of swarm intelligence algorithms for optimized band selection of hyperspectral remote sensing imagedeep convolution neural network". Published by Springer Open in EURASIP Journal on Image and Video Processing. Available: https://doi.org/10.1186/s13640-019-0417-8

5. Thinzar Saw, PhyuHninMyint. (2019, June)." Swarm Intelligence Based Feature Selection for HighDimensional Classification: A Literature Survey". Published by International Journal of Computer (IJC), ISSN: 2307-4523, Volume 33, No 1, pp. 69-83. available:https://www.researchgate.net/publication/333747932

6. Tejasv Agarwal, Himanshu Mittal. (2019, Sept.)." Performance Comparison of Deep Neural Networks on Image Datasets". Published by IEEE in 2019 Twelfth International Conference on Contemporary Computing (IC3) 978-1-7281-3591-5/19/IEEE. INSPEC Accession Number: 18994926. Available: https:// DOI: 10.1109/IC3.2019.8844924

7. Ding Xiaohui, Li Huapeng, Li Yong, Yang Ji, Zhang Shuqing. (2020, July)." Comparison of swarm intelligence algorithms for optimized band selection of hyperspectral remote sensing image"Published by Open Geosciences, Volume 12, Issue 1, id.155, pp. 425-442. Available: https://DOI: 10.1515/geo-2020-0155

8. Ruba Abu Khurma, Pedro A. Castillo, Ahmad Sharieh and Ibrahim Aljarah. (2020, Nov). "Feature Selection using Binary Moth Flame Optimization with Time Varying Flames Strategies". Published by ECTA 2020 - 12th International Conference on Evolutionary Computation Theory and Applications, ISBN: 978-989-758-475-6, pp. 17-27. Available:https://DOI:10.5220/0010021700170027

9. Preethi Gunishetty, Devarakonda, BojanBožić. (2020, Nov)." Particle Swarm Optimization of Convolutional Neural Networks for Human Activity Prediction". Published by Easy Chair Preprint no. 4657. Available: https://easychair.org/publications/preprint/qLp9

10. Wenjiang Jiao, XingweiHao, Chao Qin. (2021, April). "The Image Classification Method with CNNXGBoost Model Based on Adaptive Particle Swarm Optimization". Published by mdpi Information 2021, 12, 156. Available: https://doi.org/10.3390/info12040156   https://www.mdpi.com/journal/

information

11. Xiahan Liu. (2021, April). "An Improved Particle Swarm Optimization-Powered Adaptive Classification and Migration Visualization for Music Style". Published by Hindawi Complexity Volume 2021, Article ID 5515095. https://doi.org/10.1155/2021/551509

12. NedaAlipour, Omid Tarkhaneh, Mohammad Awrangjeb, Hongda Tian. (2021, June). "Flower Image Classification Using Deep Convolutional Neural Network". Published by IEEE in 7th International Conference on Web Research (ICWR), INSPEC Accession Number: 20801295. Available: https://DOI: 10.1109/ICWR51868.2021.9443129

13. Shahbaa I. Khaleel, Ragad W. Khaled. (2021, June)." Image retrieval based on swarm intelligence". Published by International Journal of Electrical and Computer Engineering (IJECE), Vol. 11, No. 6, ISSN: 2088-8708, pp. 5390-5401. Available: https:// DOI: 10.11591/ijece.v11i6

14. Adnan MohsinAbdulazeez, Dathar A. Hasan, Awder Mohammed Ahmed Omar S. Kareem. (2021, June)." Swarm Intelligence-Based Feature Selection for Multi-Label Classification: A Review". Published by Asian Journal of Research in Computer Science, Article no. AJRCOS.69824, ISSN: 2581-8260, pp. 65-78. Available: https:// DOI: 10.9734/AJRCOS/2021/v9i430230

15. M. Israk Ahmed, Shahriyar, Mahmud Mamun, Asif Uz Zaman Asif. (2021, June). "DCNN-Based Vegetable Image Classification Using Transfer Learning: A Comparative Study". Published by IEEE in 5th International Conference on Computer, Communication and Signal Processing (ICCCSP), INSPEC Accession Number: 20895798. Available:https:// DOI: 10.1109/ICCCSP52374.2021.9465499

16. Lihua Luo. (2021). "Research on Image Classification Algorithm Based on Convolutional Neural Network". Published by IOP Publishing 2nd International Conference on Applied Physics and Computing (ICAPC), Journal of Physics: Conference Series, 2083 (2021) 032054 Available:https:// DOI:10.1088/1742-6596/2083/3/032054

17. hanh-Nghi Do, Minh-Thu Tran-Nguyen. (2022, Jan). "Training Deep Network Models for FingerprintImage Classification".PublishedbyResearchgate,https://www.researchgate.net/publication/356852767, Available:https:// DOI:10.1007/978-3-030-92666-3_28

18. Manish U, KarthikIyer, Md Farhan khan, Nehtravathi.B, Dayananda P. (2022, March)." Image Classification Based On Convolutional Neural Networks Using Tensorflow". Published by International Journal of Advanced Research and Publications (IJARP), ISSN: 2456-9992824, Volume 5 Issue 3, pp. 118-121. Available: https:// www.ijarp.org

19. Keyu Mao. (2022, March). "Convolutional Neural Network for Image Classification Based on Satellite Imagery". Published by IEEE in 2021 International Conference on Big Data, ArtificialIntelligence and Risk Management (ICBAR), INSPEC Accession Number: 21660044 Available: https:// DOI: 10.1109/ICBAR55169.2021.00036

20. Pradumn Kumar, UpasanaDugal. (2022, March). "Tensorflow Based Image Classification using Advanced Convolutional Neural Network". Published by Blue Eyes Intelligence Engineering & Sciences Publication in International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, Volume-8 Issue-6, Retrieval Number: pp. 994-998. Available: https://DOI:10.35940/ijrte.F7543.038620

21. M. Senthil Kumar, B. Chidambararajan, R.Ranjith, M. Sabarish, J. Samuel Jayaraj. (2022, March). " Analysis of CNN based image classification technique". Published International Journal of Creative Research Thoughts (IJCRT), IJCRT2205757, ISSN: 2320-2882, Volume 10, Issue 5, pp. g508-g513. Available:https://www.ijcrt.org

22. G. Sathiyapriya, S Anita Shanthi. (2022, May)." Image Classification using Convolutional Neural Network". Published by IEEE in 2022 First International Conference on Electrical, Electronics, Information and Communication Technologies (ICEEICT), INSPEC Accession Number: 21795763 Available:https://DOI:10.1109/ICEEICT53079.2022.9768622

23. Yiqun Shang, Xinqi Zheng, Jiayang Li, Dongya Liu and Peipei Wang. (2022, June). "A Comparative Analysis of Swarm Intelligence and Evolutionary Algorithms for Feature Selection in SVM-Based Hyperspectral Image Classification". Published by MDPI in ResearchGate Remote Sens.14, 3019. Available:https://www.researchgate.net/publication/361490405, Available: https://doi.org/10.3390/rs14133019, https://www.mdpi.com/journal/remotesensing

24. Saud S. Alotaibi, Hanan Abdullah Mengash, NohaNegm, RadwaMarzouk, Anwer Mustafa Hilal 5, Mohamed A. Shamseldin, AbdelwahedMotwakel, IshfaqYaseen, Mohammed Rizwanullah, Abu SarwarZamani. (2022, June). "Swarm Intelligence with Deep Transfer Learning Driven Aerial Image Classification Model on UAV Networks". Published by MDPI in ResearchGate

12, 6488. Available:https://www.researchgate.net/publication/361573086, Available: https:// doi.org/10.3390/app12136488, https://www.mdpi.com/journal/applsci

25. Saroj Kumar Sahoo, Apu Kumar Saha, Absalom E. Ezugwu, Jefrey O. Agushaka, BelalAbuhaija, AnasRatibAlsoud, LaithAbualigah. (2022, Aug). "Moth Flame Optimization: Theory, Modifcations, Hybridizations, and Applications". Published by Springer in International Center for Numerical Methods in Engineering (CIMNE), Archives of Computational Methods in Engineering (2023) 30: pp. 391–426. Available:https://doi.org/10.1007/s11831-022-09801-z

26. KoonMengAng, Cher En Chow, El-Sayed M. El-Kenawy, Abdelaziz A. Abdelhamid, Abdelhameed Ibrahim, Faten Khalid Karim, Doaa Sami Khafaga, Sew Sun Tiang, Wei Hong Lim. (2022, Dec). "A Modified Particle Swarm Optimization Algorithm for Optimizing Artificial Neural Network in Classification Tasks". Published by MDPI in ResearchGate 10, 2579. Available:https://www.researchgate.net/publication/365978663,Available: https://doi.org/10.3390/pr10122579, https://www.mdpi.com/journal/processes

27. WaqasHaiderBangyal, KashifNisar, Tariq Rahim Soomro, Ag Asri Ag Ibrahim, Ghulam Ali Mallah, NafeesUl Hassan, Najeeb Ur Rehman. (2022, Dec). "An Improved Particle Swarm Optimization Algorithm for Data Classification". Published by MDPI in Appl. Sci. 2023, 13, 283.Available: https://doi.org/10.3390/app13010283, https://www.mdpi.com/journal/applsci

28. OsheenKhare, Sumaiya Ahmed, Yograj Singh. (2023, Jan). "An Overview of Swarm IntelligenceBased Algorithms". Published by springer in Design and Applications of Nature Inspired Optimization Women in Engineering and Science book series (WES). Available: https://doi.org DOI: 10.1007/978-3-031-17929-7_1

29. DevarGiveki. (2023, Jan). "Designing a new deep convolutional neural network for content-based image retrieval with relevance feedback". Published by Scopus in Computers and Electrical Engineering Volume 106, March 2023, 108593 Available: https://doi.org/10.1016/j.compeleceng.2023.108593

30. Chaowei Zhou, AiminXiong. (2023, Feb). "Fast Image Super-Resolution Using Particle Swarm Optimization-Based Convolutional Neural Networks". Published by MDPI Sensors 2023, 23, 1923. Available:https://doi.org/10.3390/s23041923, https://www.mdpi.com/journal/sensors

31. A. Angadi, Hemavati C. Purad. (2023, Feb). "Efficient Framework for Content-Based Image Retrieval S using CNN Classification Scores". Published by International Journal of Intelligent Systems and Applications in Engineering (IJISAE), ISSN:2147-6799, pp. 400-424 Available: https://www.ijisae.org

32. Tianjiao Liu, Jiankui Chen, Xuqing Li. (2023, Feb). "Research on Image Classification Based on Convolutional Neural Network".Published by IEEE in nternational Conference on Automation, Robotics and Computer Engineering (ICARCE), INSPEC Accession Number: 22682673, DOI: 10.1109/ICARCE55724.2022.10046634. Available:https://doi.org/10.1109/ICARCE55724.2022.10046634

33. KavithaMunishamaiaha, Senthil Kumar Kannan, DhilipKumarVenkatesan, MichałJasi´nski, Filip Novak, RadomirGono, ZbigniewLeonowicz. (2023, Feb). "Hyperspectral Image Classification with Deep CNN Using an Enhanced Elephant Herding Optimization for Updating Hyper-Parameters". Published by MDPI Electronics 2023, 12, 1157, Available:https://doi.org/10.3390/electronics12051157, https://www.mdpi.com/journal/sensors

34. Qichang Liu. (2023, Feb). "The Development of Image Classification Algorithms Based on cnns". Published by 4TH International conference on computer science and intelligent communication, (CSIC 2022), Volume 34 (2023), Highlights in Science, Engineering and Technology, DOI: 10.54097/hset. v34i.5484, Available:https://doi.org/10.54097/hset. v34i.5484

35. Xiyu Lin. (2023, April). "Research of Convolutional Neural Network on Image Classification". Published by international conference on computer, machine learning and artificial intelligence (CMLAI 2023), VOL. 39 (2023), Highlights in Science, Engineering and Technology, DOI: 10.54097/hset. v39i.6656, Available:https://doi.org/10.54097/hset.v39i.6656

36. Shahbaz Sikandar, Rabbia Mahum, Abdul Malik Alsalman. (2023, April). "A Novel Hybrid Approach for a Content-Based Image Retrieval Using Feature Fusion". Published by MDPI Sensors 2023, 13, 4581. Available: https://doi.org/10.3390/app13074581, https://www.mdpi.com/journal/applsci

37. Minghai Xu, Li Cao, Dongwan Lu, Zhongyi Hu, Yinggao Yue. (2023, June). "Application of Swarm Intelligence Optimization Algorithms in Image Processing: A Comprehensive Review of Analysis, Synthesis, and Optimization". Published by MDPI Biomimetics 2023, 8, 235. Available:https://doi.org/10.3390/biomimetics8020235, https://www.mdpi.com/journal/biom

Extended Ascon Lightweight Encryption Algorithm for Enhancing Wireless Mobile Data Exchange Security

B S N Murthy
Professor of CSE
BVC Engineering College
✉ bsnmurthy2012@gmail.com

Vaishnavi Vastrala
UG Student
BVC Engineering College

ABSTRACT

With the exponential growth of wireless mobile data exchange, ensuring robust security measures has become paramount. Weak encryption algorithms pose a significant vulnerability, exposing sensitive information to potential threats. This project investigates the utilization of the Ascon lightweight encryption algorithm as a solution to address the vulnerability of weak encryption in wireless mobile data exchange. The Ascon algorithm, a member of the third-round portfolio of the CAESAR competition, offers a promising solution due to its lightweight design, making it suitable for resource-constrained environments such as mobile devices. This project provides a comprehensive overview of the Ascon algorithm's cryptographic properties, highlighting its efficiency and security features.

INTRODUCTION

In today's hyper-connected world, the exchange of mobile data has become an integral part of our daily lives. From sending personal messages and conducting business transactions to streaming media and accessing sensitive information, mobile data transmission plays a crucial role. However, this convenience comes with an inherent risk – the vulnerability of our data to unauthorized access, interception, and cyberattacks. To address this challenge, the field of data encryption has emerged as a fundamental pillar of digital security.

The "Enhancing Wireless Mobile Data Exchange Security through the Ascon Lightweight Encryption Algorithm" is a cutting-edge project that explores innovative solutions for safeguarding mobile data transmissions. In an era where lightweight and efficient encryption methods are imperative for mobile devices with limited computational resources, the Ascon encryption algorithm stands out as a promising contender.

This project aims to investigate the feasibility and advantages of implementing the Ascon lightweight encryption algorithm for securing wireless mobile data exchanges[1]. By delving into the intricacies of Ascon and its application in the context of mobile communication, this study seeks to contribute to the ever- evolving landscape of data security.

In this introduction, we will provide an overview of the importance of encryption algorithms in mobile data security, highlight the challenges faced in securing wireless communications, introduce the Ascon encryption algorithm, and outline the objectives and significance of this project. By the end, readers will have a clear understanding of the crucial role played by encryption algorithms like Ascon in enhancing the security of mobile data exchange, and the potential implications of this research in shaping the future of digital communication security.

LITERATURE REVIEW

To enhance wireless mobile data exchange security, various encryption algorithms are available, each with its own set of features and strengths. Choosing the right encryption algorithm for enhancing wireless mobile data exchange security depends on several factors, including the specific requirements of the application, the resource constraints of the mobile devices, and the desired level of security. ASCON is a strong candidate due to its proven security and efficiency, but the other algorithms

mentioned should be evaluated for their suitability in the context of the specific mobile data exchange scenario. Additionally, a combination of encryption and other security measures (e.g., authentication, secure key exchange) should be considered to provide comprehensive security for mobile data exchange.

The ACE (Authentic Cipher Encryption)Lightweight Encryption Algorithm [3]is a novel approach to bolstering the security of wireless mobile data exchange. This innovative encryption method is specifically designed for mobile devices, offering a streamlined and efficient solution to protect sensitive data during wireless communication. By reducing computational overhead and minimizing latency, ACE enhances the overall security of data transfer, ensuring that mobile users can exchange information securely without compromising performance, making it a promising advancement in mobile data security.

Enhancing Wireless Mobile Data Exchange Security through the GIMLI Lightweight Encryption Algorithm[4] involves implementing the GIMLI algorithm to bolster the security of wireless mobile data transmissions. GIMLI is a lightweight encryption algorithm known for its efficiency and cryptographic strength, making it particularly well-suited for resource-constrained mobile devices. By integrating GIMLI into wireless communication protocols, this approach aims to protect sensitive data from unauthorized access and eavesdropping, ensuring the confidentiality and integrity of mobile data exchanges, ultimately enhancing the security of wireless communications in a mobile environment.

The KNOT Lightweight Encryption Algorithm[5] is a promising solution for enhancing security in wireless mobile data exchange. This algorithm, designed specifically for resource-constrained devices, employs efficient encryption techniques to protect data during transmission. By minimizing computational overhead and power consumption, KNOT offers a practical and robust security measure for mobile devices, safeguarding sensitive information and ensuring the integrity and confidentiality of data in wireless communications.

Enhancing wireless mobile data exchange security through the ORANGE Lightweight Encryption Algorithm[6] represents a significant advancement in the field of mobile data protection. ORANGE, designed specifically for resource-constrained devices, offers a lightweight encryption solution that ensures the confidentiality and integrity of data transmitted over wireless networks. By mitigating potential security vulnerabilities in mobile communications, this algorithm contributes to safeguarding sensitive information and enhancing the overall security of wireless data exchange, making it a crucial development for the modern digital landscape.

The ASCON encryption algorithm stands out as a superior choice for enhancing wireless mobile data exchange security when compared to ACE, Gmili, KNOT, and ORANGE. ASCON's strength lies in its well- established security properties[7], including resistance against various cryptographic attacks, efficient performance on resource-constrained devices, and a streamlined design that ensures fast encryption and decryption processes. Its robustness against both known and potential threats makes it an ideal choice for safeguarding sensitive information in wireless mobile communications. In contrast, ACE, Gmili, KNOT, and ORANGE may have their merits, but they often lack the same level of proven security, efficiency, and practicality that ASCON offers. Therefore, ASCON stands as a reliable and effective encryption solution for enhancing the security of wireless mobile data exchange in today's digital landscape.

PROPOSED METHODOLOGY

Enhancing wireless mobile data exchange security through the ASCON lightweight encryption algorithm[8] involves implementing ASCON to protect the confidentiality and integrity of data transmitted between mobile devices. ASCON is a cryptographic algorithm known for its efficiency and robust security, making it particularly suitable for resource-constrained environments like mobile devices. By using ASCON, data can be encrypted before transmission, ensuring that even if intercepted by malicious actors, it remains unreadable and secure. The lightweight nature of ASCON means that it doesn't overly tax the processing power and battery life of mobile devices, making it a practical choice for secure data exchange in wireless communications. This enhances the overall security of mobile data exchange, safeguarding sensitive

information and ensuring the privacy of users in an increasingly connected and vulnerable digital landscape. Here's a proposed methodology for integrating ASCON into a wireless data exchange system:

Select Suitable Parameters

ASCON allows for different parameter sets to optimize for various scenarios. Choose appropriate parameters [9](e.g., key size, nonce size, and security level) based on your system's requirements and constraints. Here are five main parameters to consider:

Size (K Key)

- ASCON supports different key sizes, typically 128, 192, or 256 bits. The choice of key size influences the algorithm's security level. Higher key sizes provide stronger security but may require more computational resources.

Nonce Size (N)

- The nonce (also called Initialization Vector or IV in some contexts) is a random value used to ensure that the same plaintext encrypted with the same key produces different ciphertexts. ASCON offers different nonce sizes, such as 64 or 96 bits. The nonce size affects the number of unique nonces that can be used in a communication session.

Security Level

- ASCON parameter sets are designed to provide varying levels of security. Choose a security level that aligns with your wireless mobile data exchange requirements. Common options include 128- bit security, 192-bit security, or 256-bit security, which correspond to the key size.

Block Size (BlockSize)

- ASCON uses a permutation-based design that operates on fixed-size blocks. The block size determines how much data is processed in each encryption operation. ASCON has a fixed block size of 128 bits.

Round Constants (RC)

- ASCON uses a set of round constants in its permutation function to ensure security. These round constants should be predefined based on the

selected ASCON parameter set. They are a critical part of the algorithm's security and should not be altered.

Integrate ASCON into the Communication Stack

Integrating the ASCON encryption algorithm into the communication stack[10] for wireless mobile data exchange involves several steps. Here are five key steps to integrate ASCON into your communication stack:

Select the Integration Layer

- Determine the appropriate layer of your communication stack where ASCON encryption should be integrated. Depending on your specific use case, you may integrate it at the transport layer (e.g., TLS/SSL) or the application layer. Your choice will depend on the level of security and granularity required.

Prepare Data for Encryption

- Before encrypting data with ASCON, ensure that the data is properly prepared. This typically involves segmenting the data into blocks (if necessary), adding any required metadata (e.g., nonces or initialization vectors), and ensuring that the data is in a suitable format for encryption.

Implement ASCON Encryption

- Integrate the ASCON encryption algorithm into the chosen layer of your communication stack. Follow the algorithm's specification and guidelines for encryption, including selecting the appropriate ASCON parameter set (key size, nonce size, etc.) based on your security and performance requirements.

- Make sure to use a secure random number generator to generate nonces and keys, and manage them securely throughout the communication session.

- ASCON typically provides encryption and authentication together, ensuring both confidentiality and data integrity. Implement the encryption and authentication processes according to the ASCON specifications.

Decryption and Authentication

- If the data is received from another device, integrate

the ASCON decryption and authentication process into your stack at the corresponding layer. Verify the authentication tag to ensure data integrity and authenticity.

Error Handling and Key Management

• Implement error handling mechanisms to deal with decryption failures or authentication tag mismatches. Decide on appropriate actions to take in such cases, which may include terminating the connection or requesting retransmission of data.

• Ensure proper key management practices, including key generation, distribution, and rotation, are in place. Keys should be securely stored and managed to prevent unauthorized access.

The integration process may vary depending on your specific communication stack, programming language, and platform.

Monitoring and Incident Response

ASCON (Authenticated Symmetric Communication Over Noise) is a lightweight encryption algorithm designed for secure communication. Monitoring and incident maintenance of the ASCON algorithm involves ensuring its proper functioning and addressing any issues that may arise. Here are four steps for monitoring and maintaining ASCON algorithm:

Performance Monitoring

• Regularly monitor the performance of the ASCON algorithm in your system. This includes measuring encryption and decryption speeds, resource utilization (CPU and memory usage), and any potential bottlenecks.

• Use performance monitoring tools and metrics to detect any unusual patterns or deviations from expected behavior.

• Set up automated alerts for performance thresholds to notify administrators when performance issues are detected.

Security Auditing

• Conduct periodic security audits of the ASCON algorithm implementation. Ensure that it is compliant with the latest security standards and best practices.

• Review the algorithm's code for any vulnerabilities or weaknesses. Stay updated on any security advisories or patches related to ASCON.

• Perform penetration testing and vulnerability assessments to identify and address potential security flaws.

Incident Detection and Response

• Implement intrusion detection systems (IDS) or security event monitoring solutions to detect any incidents related to ASCON.

• Define an incident response plan[12] that outlines the steps to take when an incident is detected. This plan should include procedures for isolating affected systems, analyzing the incident, and applying necessary fixes or patches.

• Train your incident response team to handle ASCON-specific incidents and ensure they are aware of the unique characteristics of the algorithm.

Regular Updates and Maintenance

• Keep the ASCON algorithm and its dependencies up to date with the latest versions and security patches. This includes the cryptographic libraries and hardware/software platforms it relies on.

• Schedule regular maintenance windows for your system to apply updates and perform routine maintenance tasks, such as database cleaning, log rotation, and system backups.

• Document all maintenance activities and update the documentation as changes are made to the ASCON algorithm or the system it operates within.

The proposed methodologies for the Ascon algorithm offer promising prospects for enhancing wireless mobile data exchange. By integrating advanced encryption techniques[13], optimizing data compression, and prioritizing secure transmission, Ascon holds potential to significantly improve data exchange efficiency and security in the realm of wireless mobile communication.

CONCLUSION

In conclusion, the adoption of the ASCON lightweight encryption algorithm holds great promise for enhancing the security of wireless mobile data exchange. ASCON's

combination of robust security, efficiency, and suitability for resource-constrained mobile devices makes it an ideal choice to safeguard sensitive information in wireless communications. Its well-established cryptographic principles ensure data confidentiality and integrity, mitigating the risks associated with potential interception or unauthorized access. As the demand for secure mobile data exchange continues to grow, ASCON stands as a reliable and practical solution, strengthen the digital landscape and preserving the privacy and integrity of wireless communication in an increasingly interconnected world.

REFERENCES

1. Giguere, Eric. "Mobile data management: Challenges of wireless and offline data access." Proceedings 17th International Conference on Data Engineering. I EEE, 2001.

2. Aagaard, Mark D., Marat Sattarov, and Nusa Zidaric. "Hardware design and analysis of the ACE and WAGE ciphers." arXiv preprint arXiv:1909.12338 (2019).

3. Turan, Meltem Sönmez, et al. "Status report on the second round of the NIST lightweight cryptography standardization process." National Institute of Standards and Technology Internal Report 8369.10.6028 (2021).

4. Ghosh, Santosh, Michael Kounavis, and Sergej Deutsch. "Gimli Encryption in 715.9 psec." Cryptology ePrint Archive (2020).

5. Zhang, Wentao, et al. "Security analysis of KNOT-AEAD and KNOT-Hash." NIST Lightweight Cryptography Workshop. 2020.

6. Madushan, Hasindu, Iftekhar Salam, and Janaka Alawatugoda. "A review of the nist lightweight cryptography finalists and their fault analyses." Electronics 11.24 (2022): 4199.

7. aYoung, William, and Nancy Leveson. "Systems thinking for safety and security." Proceedings of the 29th Annual Computer Security Applications Conference. 2013.

8. Neve, Rahul P., and Rajesh Bansode. "Performance Evaluation of Lightweight ASCON-HASH Algorithm for IoT Devices." International Conference on Intelligent Computing and Networking. Singapore: Springer Nature Singapore, 2023.

9. Dobraunig, Christoph, et al. "Ascon v1. 2." Submission to the CAESAR Competition 5.6 (2016): 7.

10. Palattella, Maria Rita, et al. "Standardized protocol stack for the internet of (important) things." IEEE communications surveys & tutorials 15.3 (2012): 1389-1406.

11. Mbarndouka Taamté, Jacob, et al. "An efficient environmental monitoring data encryption algorithm based on DNA coding and hyperchaotic system." International Journal of Information Technology 14.3 (2022): 1367-1380.

12. Heigl, Michael, et al. "A resource-preserving self-regulating Uncoupled MAC algorithm to be applied in incident detection." computers & security 85 (2019): 270-287.

13. Sultan, Ishfaq, Bisma Javid Mir, and M. Tariq Banday. "Analysis and optimization of advanced encryption standard for the internet of things." 2020 7th International Conference on Signal Processing and Integrated Networks (SPIN). IEEE, 2020.

Detection of Phishing Attacks using Machine Learning

J. Mala
Assistant Professor
Department of Information Technology
Sri Ramakrishna Institute of Technology
Coimbatore, Tamil Nadu
✉ mala.it@srit.org

R. Dhinesh, T. Jeevanandham
T. Thinesh
Students
Department of Information Technology
Sri Ramakrishna Institute of Technology
Coimbatore, Tamil Nadu
✉ dhinesh.2006@srit.org
✉ jeevanandham.2006@srit.org
✉ thinesh.2006@srit.org

ABSTRACT

The use of the internet in day-to-day activities has increased the risk of phishing attacks, which put user's sensitive data at serious risk. A thorough phishing detection system that uses both static and dynamic features to find possible threats is presented. A web page's legitimacy is evaluated by the system using thirty different features, which it then divides into three categories: legitimate, suspicious, and phishing. Websites are grouped into these categories using machine learning techniques. The evaluation results demonstrate how well the system works to identify malicious websites from legitimate ones while reducing false positives and false negatives. Additionally integrated is a user feedback mechanism that enables users to report doubtful URLs and help improve the system. This research advances cybersecurity by presenting a comprehensive and flexible solution for phishing detection, giving an all-encompassing view of the properties of web pages, and strengthening their resistance to advanced phishing tactics.

KEYWORDS: *Phishing detection, Machine learning, Feature analysis, Web security, User feedback.*

INTRODUCTION

Web security has become increasingly important due to the increasing number of people who are using the internet. Phishing attacks are a persistent threat to users because they use deceptive methods to trick people into revealing sensitive information like usernames, passwords, and financial details. These attacks may result in identity theft or other serious financial losses, among other unfavourable outcomes. This paper or article addresses the pressing need, given this landscape, for trustworthy and efficient systems to quickly detect phishing attacks.

Traditional detection methods have become less effective due to the evolving sophistication of phishing attacks, mainly because of their increased complexity. Cultured systems that can adjust to the ever-changing nature of phishing tactics are essential as cybercriminals constantly improve their methods. This paper or article suggests a thorough strategy to improve web security through the creation and application of advanced technology that can quickly detect and reduce the risks connected to phishing attacks.

This paper not only examines the nuances of phishing attacks and their possible outcomes, but it also looks into new tactics for enhancing cybersecurity defences. The conversation explores the creation of adaptable systems that make use of cutting-edge technology to fend off new threats. This paper adds to the ongoing discussion on improving web security in the face of evolving cyber threats by offering a thorough analysis of the shortcomings of conventional detection methods and suggesting creative solutions.

Background

Cybercriminals use phishing attacks, which are advanced psychological techniques, to trick users into disclosing personal information. These attacks take advantage

of human weaknesses by employing strategies like curiosity, fear, or urgency. The ongoing development of these strategies puts traditional phishing detection techniques to the test. To strengthen cybersecurity against the ever-present and changing threat of phishing attacks, it is imperative to comprehend the dynamic nature of these attacks.

RELATED WORK

In recent years, researchers have made significant steps in the domain of phishing detection, employing various techniques and algorithms to enhance accuracy and robustness.

Dhanalakshmi Ranganayakulu and Chellappan. C explored the utilization of the URLs classifier method in "Detecting Malicious URLs in E-mail – An Implementation". [1] Their method demonstrated high efficacy, achieving an accuracy of 92.8%, providing a reliable mechanism for detecting phishing URLs.

In "Machine Intelligence Based Web Page Phishing Detection," [2] Dhruv Soni and Kalpita Gadhe and Bhavya Doshi and Amitava Choudhury introduced autoML and convolution neural network (CNN) techniques, attaining an impressive accuracy of 85%. This suggests the potential of advanced neural network architectures in accurately discerning phishing attempts.

Dogukan Aksu and Zeynep Turgut and Serpil Ustebay and Aydin .M adopted a comprehensive approach in "Phishing Analysis of Websites Using Classification Techniques". [3] By employing neural networks, support vector machines, decision trees, and stacked autoencoders, they achieved an accuracy of 86%, showcasing the effectiveness of a multi-model classification strategy in identifying phishing websites.

Gunikhan Sonowal and Kuppusamy .K presented the PhiDMA model in "A phishing detection model with a multi-filter approach," [4] incorporating five layers. The model demonstrated robustness with an accuracy of 92.72%, emphasizing the importance of multi-filter strategies in phishing detection.

Jian Mao and Wenqian Tian and Pei Li and Tao Wei and Zhenkai Liang focused on Cascading Style Sheets (CSS) in "Phishing-Alarm: Robust and Efficient Phishing Detection via Page Component Similarity".

[5] Their approach, centered around CSS analysis, achieved an impressive F1-score of 99%, showcasing the significance of considering the visual aspects of web pages in phishing detection.

Jiwon Hong and Taeri Kim and Jing Liu and Noseong Park and Sang-Wook Kim contributed to the field by improving the classification lexical features using blacklisted domains in "Phishing URL Detection with Lexical Features and Blacklisted Domains". [6] The F-1 method accuracy of 84% indicates the effectiveness of lexical analysis combined with domain-based blacklisting.

Muzammil Ahmed and Altamimi .A.B and Wilayat Khan and Alsaffar .M and Aakash Ahmad and Khan .Z and Abdulrahman Alreshidi proposed an approach in "PhishCatcher: Client-Side Defense Against Web Spoofing Attacks Using Machine Learning". [7] By leveraging the Random Forest algorithm, they achieved a notable accuracy of 94.5%, surpassing the performance of other machine learning algorithms.

Naresh R and Ayon Gupta and Sanghamitra Giri introduced the combined use of SVM classification & Logistic Regression in "Malicious URL Detection System Using Combined SYM and Logistic Regression Model," [8] achieving an accuracy of 98%. This suggests that combining different classifiers can lead to a more robust phishing detection system.

In a survey-based approach, Rasha Zieni and Massari . L and Calzarossa .M explored list-based, similarity-based, and machine learning-based techniques in "Phishing or Not Phishing? A Survey on the Detection of Phishing Websites". [9] The study showcased the versatility of combining various techniques, resulting in improved accuracy compared to individual methods
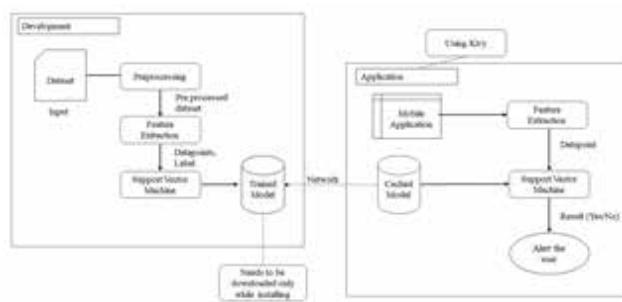
Routhu Srinivasa Rao and Syed Taqi Ali introduced a Heuristic method in "PhishShield: A Desktop Application to Detect Phishing Webpages through Heuristic Approach," [10] achieving an accuracy of 96.57%. The heuristic approach provides an additional layer of defense by leveraging rule-based systems.

This collective body of work underscores the diverse strategies and algorithms employed in phishing detection, offering valuable insights for the development of more effective and robust systems.

METHODOLOGY

The Phishing Detection App uses a thorough approach to differentiate between websites that are potentially phishing and those that are not. Using a wide range of features that are taken from HTML content, domain information, and other attributes, the model takes a multidimensional approach to precise detection. These characteristics include indicators like the use of HTTPS, traits specific to a domain, anomalies in URLs, and scripting behaviours. To improve its discriminatory power, the model also evaluates factors such as age of domain, email submission forms, and redirects. The incorporation of rule-based heuristics, such as pop-up window generation and checks for right-click disabling, facilitates prompt decision-making by utilising established patterns.

The Support Vector Machine (SVM) algorithm enhances the fundamental characteristics of the model, enabling it to adjust to changing phishing strategies. The SVM model guarantees a strong and adaptable phishing detection system by improving the system's ability to identify both known and unknown threats. The integration of rule-based and machine learning methodologies highlights the robustness and precision of the model in navigating through the ever-changing terrain of cyber threats. The system is able to recognise understated and changing malicious patterns because of the design choices, which represent a strategic combination of features to address the complex nature of phishing attacks.

Fig 1: Architecture diagram

EXPERIMENTAL SETUP

Dataset Description: The phishing detection model is experimentally evaluated using a dataset that contains more than 11,000 website URLs. Every sample in the dataset includes 30 website parameters, from server behaviours to URL characteristics, along with a class label designating the phishing status (1 for legitimate, -1 for phishing). The parameters provide a comprehensive view of website attributes, encompassing a variety of features like URL length, the presence of specific symbols, HTTPS usage, domain registration length, and more.

Evaluation Metrics: The phishing detection model is evaluated using common metrics that are essential for binary classification tasks. Crucial metrics that reveal how well the model can detect phishing instances while reducing false positives are precision, recall, and F1-score.

1. Accuracy: How well the model predicts things overall.

$$Accuracy = TP + TN / TP + TN + FP + FN$$

2. Precision: The proportion of accurately predicted phishing incidents to all predicted phishing incidents.

$$Precision = TP / TP + FP$$

3. Recall (Sensitivity or True Positive Rate): The proportion of correctly predicted to actual phishing incidents.

$$Recall = TP / TP + FN.$$

4. F1 Score: A balanced metric produced by taking the harmonic mean of recall and precision.

$$F1score = 2 \times (Recall \times Precision) / (Recall + Precision).$$

Where,

- TP (True Positives) is the number of correctly predicted positive instances.

- TN (True Negatives) is the number of correctly predicted negative instances.

- FP (False Positives) is the number of incorrectly predicted positive instances.

- FN (False Negatives) is the number of incorrectly predicted negative instances.

These measures are frequently employed to assess how well classification models perform.

Preprocessing Steps: To guarantee optimal performance, the dataset is carefully pre-processed before model training. This includes encoding categorical variables, standardising numeric features to a scale, and handling inconsistent or missing data. The experimental setup is intended to offer a thorough evaluation of the phishing detection model by taking into account a variety of website attributes and using reliable assessment metrics to gauge the model's efficacy and generalizability.

RESULTS

The evaluation results of different machine learning classifiers for phishing detection on the dataset are shown in this section. Several classifiers were used, such as SVM, Random Forest, XGBoost, KNN, Logistic Regression, Naive Bayes, and Decision Tree. Using GridSearchCV, the classifiers were optimised, and their effectiveness was evaluated in terms of accuracy, precision, recall, and F1 score.

The results of each classifier are compiled in Table 1, which also highlights the optimal parameters, accuracy, precision, recall, and F1 score.

Confusion matrix
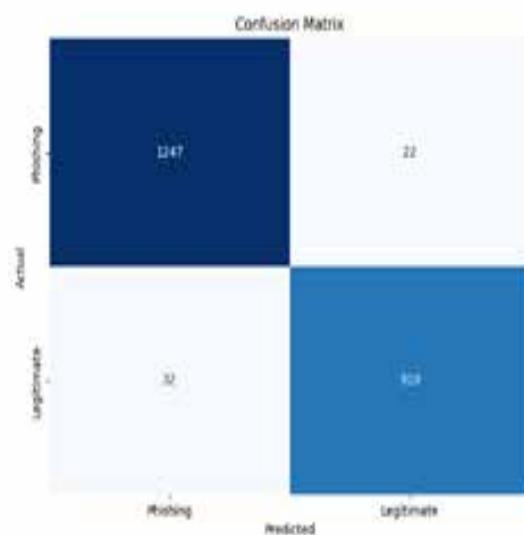
Fig 2: Confusion Matrix for SVM Algorithm

Table 1: Model Evaluation Results

Model	Best Parameters	Accuracy	Precision	Recall	F1 Score
Random Forest	bootstrap: False, max_depth: 30, min_samples_leaf: 1, min_samples_split: 5, n_estimators: 100	97.33%	97.33%	97.33%	97.69%
SVM	C: 10, gamma: 0.1, kernel: rbf	97.56%	97.56%	97.56%	97.88%
XGBoost	colsample_bytree: 0.8, learning_rate: 0.1, max_depth: 7, n_estimators: 300, subsample: 0.9	96.88%	96.88%	96.88%	97.29%
KNN	n_neighbors: 7, p: 1, weights: distance	96.97%	96.98%	96.97%	97.38%
Logistic Regression	C: 0.1, penalty: l2	92.76%	92.76%	92.76%	93.72%
Naive Bayes		58.66%	78.86%	58.66%	43.79%
Decision Tree	criterion: entropy, max_depth: None, min_samples_leaf: 1, min_samples_split: 2	96.16%	96.15%	96.16%	96.66%

Fig 3: Result for Phishing Site
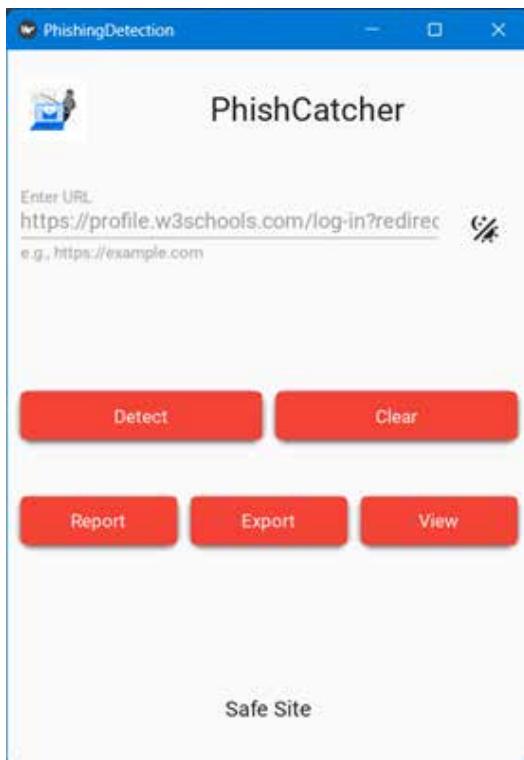
Fig 4: Result for Safe Site

confusion matrix illustrating the effectiveness of the phishing detection model shows that it correctly classified 910 legitimate sites and successfully identified 1247 instances of phishing sites. Nevertheless, 22 cases of phishing were mistakenly classified as legitimate, and 32 cases of legitimate websites were mistakenly classified as phishing. The matrix offers a thorough summary of the model's advantages and disadvantages. An interactive interface with real-time classification capabilities and instructional materials can be used to improve user engagement. A feedback mechanism also promotes a collaborative approach to increasing accuracy and efficacy by enabling users to make gradual improvements to the model.

DISCUSSION AND ANALYSIS

The findings show how well various classifiers work to identify phishing websites. With an accuracy of 97.56%, SVM was the most accurate, closely followed by Random Forest at 97.33%. Both models performed well according to a variety of metrics.

The best-performing classifier was the SVM model with the ideal parameters {'C': 10, 'gamma': 0.1, 'kernel': 'rbf'}, demonstrating its applicability for phishing detection in this situation. The SVM model's dependability in producing precise predictions is further supported by the metrics of precision, recall, and F1 score. These results provide insightful information about how to choose classifiers for phishing detection applications by taking into account variables like accuracy, precision, and recall according to particular needs and application priorities.

Limitations and Strengths: The model's strength is its extensive feature set, enabling it to identify subtle patterns linked to phishing websites. However, it's important to recognise the limitations, such as possible difficulties managing phishing techniques that are constantly evolving. The representativeness and level of the training dataset may also affect the model's performance.

CONCLUSION

By offering a phishing detection model that excels in accuracy and dependability, this paper makes major contributions to the field of web security. Using SVM in conjunction with a large feature set improves the model's

resistance to changing phishing techniques. The interface of the application is easy to use, which encourages wider adoption. The findings have consequences for users, organisations, and cybersecurity professionals. Because of the model's accuracy, users who browse the internet can feel even more protected. By integrating this solution, organisations can strengthen their security infrastructure and reduce the risks brought on by phishing attacks.

REFERENCES

1. Dhanalakshmi Ranganayakulu and Chellappan .C, "Detecting Malicious URLs in E-mail – An Implementation", AASRI Procedia, pp 125-131, vol.4, 2013.

2. Dhruv Soni and Kalpita Gadhe and Bhavya Doshi and Amitava Choudhury, "Machine Intelligence Based Web Page Phishing Detection", International Conference on Futuristic Technologies (INCOFT), IEEE Access, 2022.

3. Dogukan Aksu and Zeynep Turgut and Serpil Ustebay and Aydin .M, "Phishing Analysis of Websites Using Classification Techniques", Lecture Notes in Electrical Engineering, International Telecommunications Conference , SpringerLink, pp 251–258, vol.504, 2018.

4. Gunikhan Sonowal and Kuppusamy .K, "PhiDMA - A phishing detection model with multi-filter approach", King Saud .J Univ. Comput. Inf. Sci, ScienceDirect, Issue 1, pp 99-112, vol.32, 2017.

5. Jian Mao and Wenqian Tian and Pei Li and Tao Wei and Zhenkai Liang, "Phishing-Alarm: Robust and Efficient Phishing Detection via Page Component Similarity", IEEE Access, pp 17020 – 17030, vol .5, 2017.

6. Jiwon Hong and Taeri Kim and Jing Liu and Noseong Park and Sang-Wook Kim, "Phishing URL Detection with Lexical Features and Blacklisted Domains", Adaptive Autonomous Secure Cyber Systems, SpringerLink, pp 253–267, 2020.

7. Muzammil Ahmed and Altamimi .A.B and Wilayat Khan and Alsaffar .M and Aakash Ahmad and Khan .Z and Abdulrahman Alreshidi, "PhishCatcher: Client-Side Defense Against Web Spoofing Attacks Using Machine Learning", pp 61249-61263, IEEE Access, vol.11, 2023.

8. Naresh R and Ayon Gupta and Sanghamitra Giri, "Malicious URL Detection System Using Combined SYM and Logistic Regression Model", InfoSciRN: Information Architecture (Topic), International Journal of Advanced Research in Engineering and Technology, SSRN, pp. 63-73, 2020.

9. Rasha Zieni and Massari . L and Calzarossa .M, "Phishing or Not Phishing? A Survey on the Detection of Phishing Websites", IEEE Access, pp18499- 18519, vol. 11, 2023.

10. Routhu Srinivasa Rao and Syed Taqi Ali, "PhishShield: A Desktop Application to Detect Phishing Webpages through Heuristic Approach", Procedia Computer Science, ScienceDirect, vol 54, pp 147-156, 2015.

Reliable Route Selection for Data Transmission Using Fuzzy Logic in WSN for Early Forest Fire Detection

M. Parameswari
Associate Professor & Head
Computer Science and Engineering
Kings Engineering College, Irungattukottai
Chennai, Tamilnadu
✉ paramuvaishnavcse@gmail.com

M. Sindhuja
Assistant Professor
Artificial Intelligence and Data Science
Kings Engineering College, Irungattukottai
Chennai, Tamilnadu
✉ msindu91@gmail.com

ABSTRACT

Early forest fire detection in Wireless Sensor Networks (WSN) is a critical area of research aiming to minimize the devastating impact of wildfires. Utilizing sensor nodes, this technology enables real-time monitoring and swift detection of fire outbreaks in remote forest areas, allowing prompt response and mitigation measures to be implemented. However, the nodes in WSN often lack adequate sensing and communication capabilities. Also efficient routing among sensor nodes is crucial for network performance. To enhance routing efficiency, the Reliable Route Selection using Fuzzy Logic (R2SFL) scheme is introduced. This approach employs fuzzy rules to select optimal relay nodes, ensuring effective transmission. Additionally, the scheme optimizes energy utilization by scheduling nodes with low energy expenditure and compensating for energy usage across the network. Overall, R2SFL enhances network resources and efficiency. The R2SFL method enhances sensor node efficiency by optimizing energy factor and node coverage lifetime using RSSI based on fuzzy logic. It identifies fire zones, monitors battlefield activities, combat, and intruder detection, wirelessly transmitting data to a central station.

KEYWORDS: Fuzzy logic, Reliable route, Optimal relays, Wireless sensor networks, Forest fires.

INTRODUCTION

Forests are vital resources, crucial for maintaining Earth's ecological balance. Unfortunately, occasional forest fires, often sparked by human negligence and natural anomalies, pose significant threats. These fires are destructive disasters, jeopardizing forest resources and human habitats [1]. Additionally, it offers indirect and attributable benefits, making it indispensable for communities and ecosystems similar [2]. Severe wildfires constitute a serious risk to the environment and the economy in many parts of the world. Even in technologically advanced nations, the limitations of fire suppression-focused tactics have become apparent because of their high expense and the legacy of disrupted landscapes [3].

Numerous uses for WSNs exist, including locating targets, remote surveillance of the environment, and industrial automatic control. The applications for this kind of device show promise in real-time monitoring and detection of forest fires [4]. Nowadays forest fires are mostly triggered by two things: unrestrained human activity and natural reasons [5]. Utilizing WSNs, an early fire detection system was designed for forest areas. Early detection is crucial to prevent fire spread, which complicates extinguishing efforts. This system employs WSNs to monitor forest temperature and CO2 levels, enabling timely detection and alerts for potential fires [6]. The aim of the research is to use WSN to develop a forest fire monitoring system for a large region of fire-prone areas.

RELATED WORKS

A comprehensive plan for the use of WSN for earlier monitoring and detection of forest fires was put forward. This covers suggestions for the clustering, communication protocols, node locating scheme, and WSN structure. The goal is to identify potential fire

threats as soon as feasible, while also taking into account the sensor nodes' energy usage and any external factors that can have an impact on the network's necessary activity level [7].

In conventional, forest fires were detected from watch towers situated at elevated locations, equipped with devices like fire finders, relying on human observations, which proved unreliable and risky [8]. This led to the development of automated fire detection systems using video surveillance with infrared detectors and cameras mounted atop towers, although these systems struggled with covering vast distances effectively [9]. To monitor large areas, applications involving airplanes or unmanned aerial vehicles were introduced. Satellite imagery emerged as an advanced solution, offering extensive coverage, but it is impacted by weather conditions, affecting the frequency spectrum and leading to less accuracy and reliability. Despite its large coverage, satellite-based systems suffer from low resolution, detecting fires only when they have escalated significantly due to long scan periods [10].

A different forest fire detection approach utilizes color and motion features from images captured by an Unmanned Aerial Vehicles (UAV)-mounted camera in motion throughout the mission. Initially, a low-computational-demand algorithm identifies fire-colored pixels using the chromatic feature of fire, marking them as fire candidate regions [11]. The detection process begins by identifying fire-colored pixels using a chromatic-based rule. Motion vectors of these potential fire regions are computed using the Horn and Schunck optical flow algorithm. Motion features help differentiate real fires from similar phenomena, leading to the creation of binary images through thresholding and morphological operations. Fires are precisely located in these binary images using the blob counter method [12].

A method was proposed which integrates IoT and WSN for real-time forest fire prevention [13]. It analyzes meteorological data and gas concentrations to identify fire-prone areas. A Fuzzy Logic-Based Controller (FLBC) activates alerts via a Web service and mobile app, ensuring data integrity with Lamport's signature and block cipher algorithms. The intelligent control method utilizes fuzzy control theory, eliminating the need for precise mathematical models. Fuzzy control is robust and suitable for handling lag, nonlinear, and time- varying systems, making it ideal for controlling monitoring systems effectively [14] that detects forest fires in prior and prevents the considerable damages.
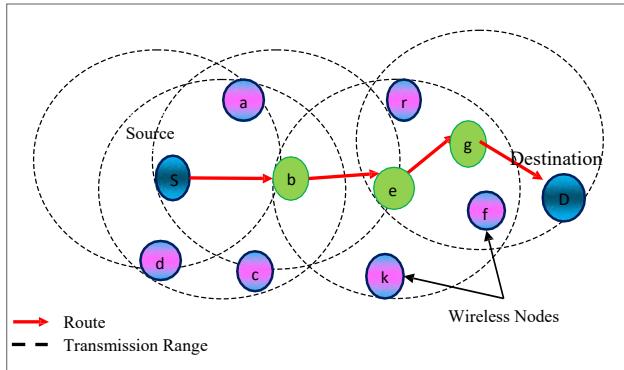
Utilizing a composite weighted measure, the Energy-Efficient Weighted-Based Protocol (EEWBP), takes into account node degree, residual energy, neighbour nodes, flying speed, and trust value. Effective cluster formation and node scheduling are made possible by this strategy, which enables the construction of many clusters with distinct cluster heads (CH). This method increases coverage time while optimizing energy use. However this method has lower transmission range of nodes and high latency cost [15]. The Ant Colony Optimization (ACO) algorithm is a popular and effective way to determine the best communication channels. Therefore the method was proposed for the WSNs' Energy-efficient and Reliable ACO-based Routing Protocol (ERARP) [16]. This protocol supports communication dependability in addition to superior communication channels with respect to energy efficiency. Reliable transmission is necessary for critical events in delay-intolerant applications (such as forest fire detection) so that choices can be made with confidence and relevant actions may be taken promptly.

PROPOSED METHOD

In forest fire detection, the sensor nodes are strategically placed to monitor crucial environmental parameters like temperature, humidity, light, and smoke. These sensors continuously gather data, enabling real-time analysis and early detection of potential fire hazards. This proactive approach enhances forest fire prevention and allows swift response measures, ultimately mitigating environmental risks. Nodes in WSN are positioned to collect sensitive data using range-free localization. Every sensor node has two functions: it is a router and it senses information. In order to find available routes, the source node broadcasts a Route Request (RRQ) message to start the data transmission. The destination sends back a Route Reply (RRP) message after receiving RRQ.

In the forest fire detection network system, the source node employs active relay nodes, a strategic choice made to enhance the reliability of data transmission. In

the proposed model the active relay nodes are selected using advanced fuzzy logic techniques includes Fuzzy Inference System (FIS) combined with rule-based procedures. FIS is a mathematical framework employed for decision-making, particularly in situations where uncertainties and vagueness exist. The active relay nodes are selected using node factors such as node coverage distance and node's relative energy. Figure 1 represents the placement of nodes structure in WSN.

Figure 1: Node Placement in WSN

Nodes with optimal energy levels are preferred to ensure efficient and sustainable operation within the network. By integrating these variables into the fuzzy logic system, the selection of active relay nodes becomes a nuanced decision-making process, resulting in a more reliable and energy-efficient data transmission system in the overall network architecture.

Node to Node Distant

The distance between the nodes are evaluated for determining the active relay nodes from source to destination. The communication range delineates the distance within which a node can effectively exchange data with its neighboring nodes. This range is pivotal for seamless communication and reliable data transmission. The transmission power of nodes is dynamically adjusted, factoring in the received signal strength and the distance separating them. By precisely calculating these parameters, nodes optimize their transmission power to ensure efficient communication within their communication range. Received Signal Strength Indicator (RSSI), a measure of the power level received by a node from its neighboring nodes. By evaluating RSSI values, nodes estimate their communication range, allowing them to establish effective links with

nearby nodes while conserving energy. The average RSSI is calculated using equation (1) for all the nodes that present in the communication range.

$$Avg(RSSI) = \frac{\sum_{i=0}^{n} RSSI_i}{n} \qquad (1)$$

By selecting nodes with maximum RSSI, the network ensures robust connections with minimal signal degradation. This approach minimizes the overall transmission power required for each connection request, leading to energy conservation. The RSSI values of nodes are constantly evaluated which allows dynamically choose paths with strong signals.

Node's Relative Energy

Node energy computation plays a vital role in understanding the energy consumption of individual nodes. The equation (2) is used for computing node energy level of node 'i' at time 't'. It takes into account the energy consumed during data transmission, reception, and idle states. By continuously monitoring these energy parameters, network operators can assess the energy status of individual nodes, aiding in efficient energy management and ensuring the network's longevity and reliability.

$$E_i(t) = E_i(t-1) + E_{Tx}(t) + E_{Rx}(t) - E_{idle}(t) \qquad (2)$$

Where $E_{Tx}(t)$ denotes energy consumed for transmission at time t, $E_{Rx}(t)$ denotes for energy consumed for reception at time t and $E_{Idle}(t)$ energy consumed during idle state at time t.

Applying Fuzzy Logic

In WSN, the integration of fuzzy logic brings about an efficient evaluation of multiple parameters, enhancing network performance significantly. The fuzzy approach utilizes FIS that incorporates crucial factors like node relative energy and node distant which involves coverage distance measured through RSSI. This methodology efficiently schedules active relaying nodes based on their level of energy residing in the route nodes and higher RSSI nodes.

The fuzzy rule-based approach plays a pivotal role in identifying the active relay nodes in data transmission routes. This fuzzy rule is applied for the factors like node relative energy 'NRE' and node coverage distance

'N_{CD}', utilizing these inputs for deriving minimum fuzzy route length with high data accuracy FRL_{MIN}. By evaluating the number of active nodes based on energy and RSSI utility factors, the system selects the route with the shortest length.

Each active node calculates its routing length using the rule-based FIS, ensuring an optimized route selection process within the WSN. Equation (3) utilizes inputs from the FIS for evaluating the FRL_{MIN}.

$$FRL_{\min}(Ni) = MIN(FRL_{min} * FIS\{(Ni.N_{RE}) \cdot (Ni.N_{CD}), 1\}) \quad (3)$$

The equation (3) constrains the minimum value of $FRL_{min}(Ni)$ within a range $(0, 1)$, allowing the calculation of an approximate distance for all nodes to the sink. This computation is crucial for determining the optimal power level needed for communication with the destination node. The variable Ni signifies the unique identity of each node in the network, essential for efficient routing and communication processes.

In the given system, the inputs for the FIS are NRE and NCD. These inputs are crucial for evaluating the system's performance. Fuzzy logic allows these inputs to be processed efficiently, enhancing network functioning.
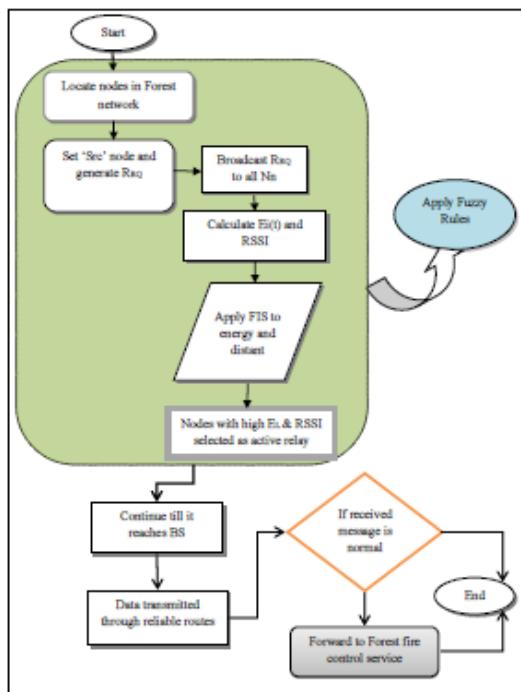
Figure 2: Flow diagram of proposed R2SFL Model

Triangular membership functions are utilized for the inputs NRE and NCD. These functions are preferred due to their computational efficiency, ensuring the system operates smoothly without excessive computational overhead. For NRE, linguistic variables such as high, medium, and low are considered, providing a qualitative assessment of the node's energy status. Similarly, N_{CD} is categorized into linguistic variables such as adjacent, sufficient, and distant, on behalf of the proximity of nodes within the network.
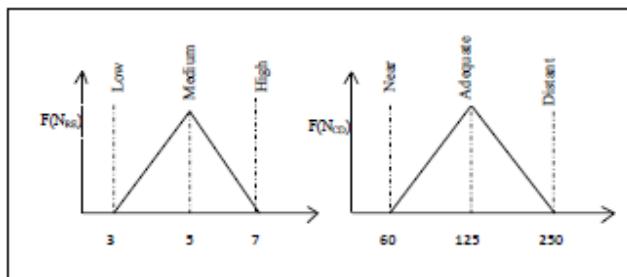
Figure 3: Triangular Membership Function for N_{RE} and N_{CD}

Table 1: FRL Linguistic Variables

S. No	N_{RE}	N_{CD}	FRL(Ni)
1	Low	Adjacent	P(M)
2	Low	Sufficient	P(L)
3	Low	Distant	P(L)
4	Medium	Adjacent	P(M)
5	Medium	Sufficient	P(M)
6	Medium	Distant	P(L)
7	High	Adjacent	P(H)
8	High	Sufficient	P(H)
9	High	Distant	P(L)

FIS outputs an essential variable called FRL. FRL has linguistic variables including P(H) for high possibilities, P(M) for medium possibilities and P(L) for lower possibilities for selection of nodes, indicating the quality of the route for data transmission. These linguistic variables offer a descriptive understanding of the route's suitability, aiding in the selection of the best route in the network. Visual representations, such as plots, are generated, depicting these linguistic variables alongside their corresponding reference values. It provides a clear overview of the network's routing options, enabling informed decision-making in route selection based on

energy levels and coverage distances. Table 1 gives the fuzzy rules for selecting the nodes for FRLMIN.

The Mamdani model utilizes if-then rules to map input variables to specific fuzzy output variables, providing a structured approach to decision-making within the FIS. During the fuzzy logic process, these input variables are fuzzified and converted into fuzzy sets that represent their qualitative states (e.g. P(H), P(M), P(L)). These fuzzy sets are then processed through if-then rules.

Based on fuzzy inference procedure the if-then rules are evaluated, the system determines the appropriate fuzzy output variables, and provides a qualitative assessment of the node's suitability for data transmission.

RESULTS AND DISCUSSION

The performance of the proposed method and existing methods are analyzed for determining the protocols efficiency. The simulation tool employed for evaluating the proposed method, R2SFL, along with conventional models EEWBP and ERARP, is the Network Simulator version 2.35 (NS 2.35). NS 2.35 is a discrete event-driven simulator specifically designed for computer networks. It utilizes C++ for backend processing and Object-oriented Tool Command Language (OTCL) for frontend operations.

Each node possesses a communication range of 250 meters to interact with others, and the network maintains a node density of 250. Communication between nodes is facilitated through User Datagram Protocol (UDP). Radio waves are generated using the two-ray ground spread model, allowing nodes to receive signals omni-directionally from all angles. The proposed model is investigated using the parametric such as data transmission rate, data transmission delay, residual energy, number of active relays.

Data Transmission Rate: The data transmission rate indicates the proportion of data packets received by the sink node with respect to those sent by the source node. This rate is calculated using equation (4), providing a quantitative measure of successful data packet delivery. It serves as a crucial metric in evaluating the efficiency and reliability of the communication network, reflecting the accuracy of data packet transmission from source to destination.

$$D_{TR} = \frac{\sum_0^n data\_pkts\ rcvd}{time} \tag{4}$$
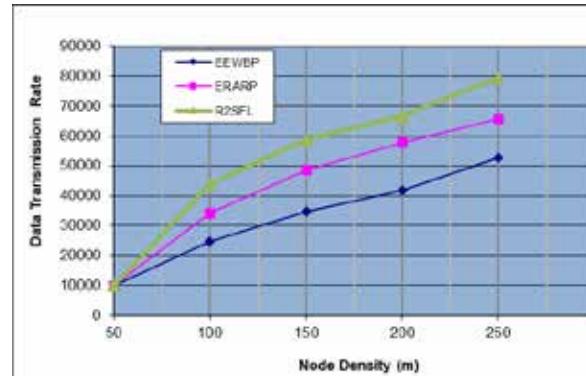
Figure 4: Data Transmission Rate

Here data_Pkts rcvd denotes the successful reception of data packets by sink node during the data transmission process. Figure 4 illustrates the comparative analysis of data transmission rates, showcasing that the proposed R2SFL scheme outperforms conventional schemes EEWBP and ERARP. The superiority of R2FSL lies in its methodology of selecting relay nodes through the application of fuzzy rules. By employing these rules, R2SFL optimizes the selection of relay nodes, reducing packet loss significantly at the receiver node.

Data Transmission Delay: The average transmission delay represents the duration taken for a specific data set to travel from the source to the receiver. It is computed by determining the time gap between the packets' sent_time and received_time during this data transmission set, as defined in equation 5,

$$Delay_{Trans} = \frac{\sum_0^n Data\_rcvd\_time - Data\_snt\_time}{n} \tag{5}$$
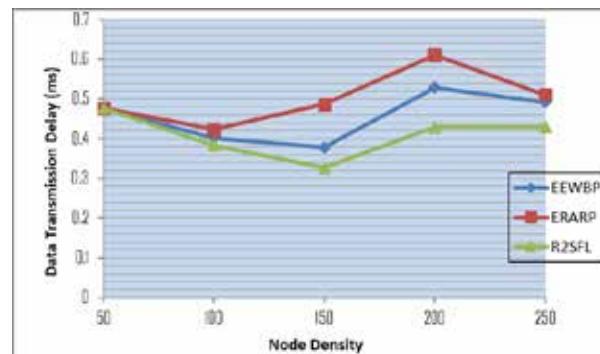
Figure 5: Data Transmission Delay

In the proposed R2SFL mechanism, the data transmission delay is minimized through the strategic selection of active relay nodes. This results in successful packet forwarding to the receiver node, reducing the need for retransmissions. Figure 5 illustrates the data transmission delay observed in the proposed R2SFL scheme as well as in the conventional protocols EEWBP and ERARP. The comparison demonstrates that R2SFL outperforms the other models, showcasing its superior performance in terms of reduced transmission delay.

Residual Energy: Residual energy signifies the energy remaining in nodes post data transmission. Figure 6 graphically illustrates this concept in the proposed R2SFL scheme and traditional protocols EEWBP and ERARP. The visual representation provides a clear comparison, that how the proposed R2FSL effectively manages residual energy in nodes compared to the conventional models, highlighting its superior energy efficiency.

The proposed scheme is designed for efficient energy utilization in both node processing and transmission. This leads to nodes retaining substantial leftover energy within the R2SFL scheme.
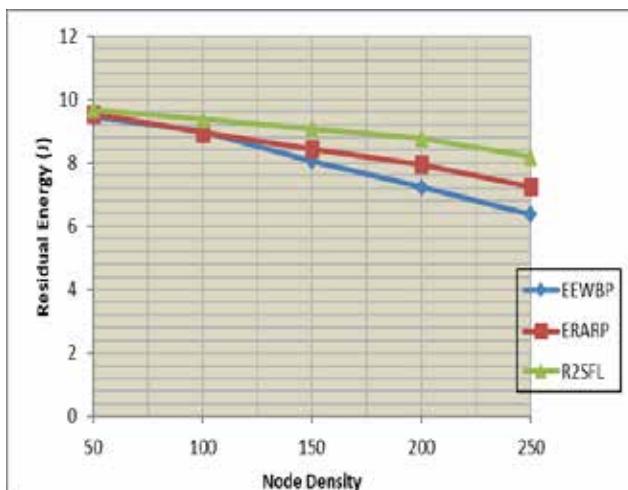
Figure 6: Residual Energy

Active Relay Nodes: In WSN, the nodes that actively convey data packets from source nodes to destination nodes are referred to as active relay nodes. These nodes are essential for keeping up communication channels and guaranteeing successful data transmission among far- flung nodes. In order to maximize network performance and save energy resources, active relay nodes are carefully chosen based on a number of factors, including energy levels, accessibility, and proximity.
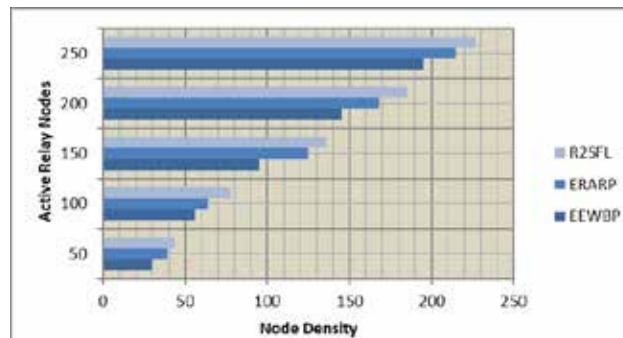
Figure 7: Active Relay Nodes

Figure 7 shows the analysis of active relay nodes for the proposed R2SFL and ERARP and EEWBP protocols with respect to their relative node density. Proposed R2SFL scheme outperforms with higher active relay nodes compared to the conventional schemes.

CONCLUSION

Reliable Route Selection using Fuzzy Logic scheme marks a significant advancement in early forest fire detection within Wireless Sensor Networks (WSN). By harnessing the power of fuzzy logic, R2SFL ensures optimal relay node selection, enabling swift and efficient transmission of critical data for the specific application of forest fire zone identification. This approach not only enhances network efficiency but also conserves energy resources by sensibly managing node energy expenditure. By integrating fuzzy logic and RSSI-based optimization, R2SFL stands as a robust solution, promising timely and effective responses to forest fire outbreaks and other critical events. The simulation analysis is provided for showing the protocol efficiency in terms of data transmission rate, latency and nodes residual energy.

REFERENCES

1. Zhang, J., Li, W., Yin, Z., Liu, S., & Guo, X. (2009, May). Forest fire detection system based on wireless sensor network. In 2009 4th IEEE conference on industrial electronics and applications (pp. 520-523). IEEE.

2. Satendra, K. A. (2014). Forest fire disaster management. National Institute of Disaster Management, Ministry of Home Affairs, New Delhi.

3. Wunder, S., Calkin, D. E., Charlton, V., Feder, S., de Arano, I. M., Moore, P., & Vega-García, C. (2021).

Resilient landscapes to prevent catastrophic forest fires: Socioeconomic insights towards a new paradigm. Forest Policy and Economics, 128, 102458.

4. Liu, Y., Liu, Y., Xu, H., & Teo, K. L. (2018, June). Forest fire monitoring, detection and decision making systems by wireless sensor network. In 2018 Chinese Control And Decision Conference (CCDC) (pp. 5482-5486). IEEE.

5. Budiyanto, S., Silalahi, L. M., Silaban, F. A., Darusalam, U., Andryana, S., & Rahayu, I. F. (2020, October). Optimization of sugeno fuzzy logic based on wireless sensor network in forest fire monitoring system. In 2020 2nd International Conference on Industrial Electrical and Electronics (ICIEE) (pp. 126-134). IEEE.

6. Kadri, B., Bouyeddou, B., & Moussaoui, D. (2018, November). Early fire detection system using wireless sensor networks. In 2018 International conference on applied smart systems (ICASS) (pp. 1-4). IEEE.

7. Aslan, Y. E., Korpeoglu, I., & Ulusoy, Ö. (2012). A framework for use of wireless sensor networks in forest fire detection and monitoring. Computers, Environment and Urban Systems, 36(6), 614-625.

8. Chowdary, V., Gupta, M. K., & Singh, R. (2018). A Review on forest fire detection techniques: A decadal perspective. Networks, 4, 12.

9. Movaghati, S., Samadzadegan, F., & Azizi, A. (2013). An agent-based approach for regional forest fire detection using modis data: A preliminary study in Iran. Journal of the Indian Society of Remote Sensing, 41, 21-33.

10. Gandhi, S. R., & Singh, T. P. (2014). Automatization of Forest Fire Detection Using Geospatial Technique. Open Journal of Forestry, 2014.

11. Yuan, C., Liu, Z., & Zhang, Y. (2017). Aerial images-based forest fire detection for firefighting using optical remote sensing techniques and unmanned aerial vehicles. Journal of Intelligent & Robotic Systems, 88, 635-654.

12. Yuan, C., Liu, Z., & Zhang, Y. (2016, June). Vision-based forest fire detection in aerial images for firefighting using UAVs. In 2016 international conference on unmanned aircraft systems (ICUAS) (pp. 1200-1205). IEEE.

13. Toledo-Castro, J., Santos-González, I., Caballero-Gil, P., Hernández-Goya, C., Rodríguez- Pérez, N., & Aguasca-Colomo, R. (2019). Fuzzy-based forest fire prevention and detection by wireless sensor networks. In International Joint Conference SOCO'18-CISIS'18-ICEUTE'18: San Sebastián, Spain, June 6-8, 2018 Proceedings 13 (pp. 478-488). Springer International Publishing.

14. Ammar, M. B., & Souissi, R. (2014). A new approach based on wireless sensor network and fuzzy logic for forest fire detection. International Journal of Computer Applications, 89(2).

15. Kaur, P., Kaur, K., Singh, K., & Kim, S. (2023). Early Forest Fire Detection Using a Protocol for Energy-Efficient Clustering with Weighted-Based Optimization in Wireless Sensor Networks. Applied Sciences, 13(5), 3048.

16. Moussa, N., Nurellari, E., & El Belrhiti El Alaoui, A. (2023). A novel energy-efficient and reliable ACO-based routing protocol for WSN-enabled forest fires detection. Journal of Ambient Intelligence and Humanized Computing, 14(9), 11639-11655.

Razor Code Logistic Regression based Fake News Detection System Data on Cloud

O Pandithurai
✉ pandics@ritchennai.edu.in

Ravi Rohith A
✉ ravirohith.a.2021.cse@ritchennai.edu.in

Pranshu Jha
✉ pranshujha.2021.cse@ritchennai.edu.in

Ramkishor S
✉ ramkishor.s.2021.cse@ritchennai.edu.in

Department of Computer Science and Engineering
Rajalakshmi Institute of Technology
Chennai, Tamilnadu

ABSTRACT

The rapid increment in circulation of fake news poses a significant threat to society, highlighting the need for robust and effective detection mechanisms. In this research paper, we present a project that utilizes a Logistic Regression Model for the detection of fake news with an impressive 99% probability. We begin by highlighting the issues presented by circulation disinformation and the effects that result from its spread. A comprehensive literature survey is conducted to analyze existing techniques and methods for bogus news detection. Our goal is to develop a reliable and accurate detection system that can differentiate between genuine and fabricated news articles. Through rigorous experimentation and analysis, we demonstrate the effectiveness of our Logistic Regression Model in achieving this goal. The outcomes of our study provide valuable insights into the capabilities of logistic regression for fake news detection. However, certain challenges and limitations are also identified, highlighting areas for future research and improvement. The proposed architecture and system model are described in detail, emphasizing the integration of logistic regression as a key component. In conclusion, this research paper contributes to the field of false news identification by showcasing the potential of logistic regression as a powerful tool in combating misinformation.

KEYWORDS: *Logistic regression, Accuracy level, Dataset preprocessing, Analysis, Tokenization.*

INTRODUCTION

With the rapid advancement of digital technology, accessing news has become easier than ever. With such a great volume of information easily accessible at our fingertips it's become hard to discern fabricated news articles from genuine ones. This widespread circulation of fake news creates significant challenges to society eroding the trust in media and even impacting democratic processes.

To solve the issues created by fake news, robust and effective detection methods must be developed. Various approaches have emerged throughout time, with logistic regression emerging as a promising strategy due to its ease of use and ability to efficiently address binary classification challenges.

This work aims to investigate the application of logistic regression for false news identification. We believe that using a logistic regression model will allow us to accurately identify between real and fraudulent news. To do this, we thoroughly examine existing techniques and fine-tune the model based on data so that it can successfully capture the patterns and traits required for detection. This not only provides insights into the field's current state but also shows gaps and areas for improvement.

Overall, this study article is a step forward in the struggle against fake news. We intend to contribute to a more robust and accurate false news detection system by using the capabilities of logistic regression to enhance our current systems. By sharing our results, we believe,

may lead the way for future research and development in this critical area, for the benefit of society as a whole.

LITERATURE REVIEW

Fake news is classified into three broad categories. The first category consists of completely fabricated news articles created by the writers themselves. Fake satire news, which is purposefully written to amuse readers, falls under the second type. Last but not least, there are shoddy news pieces that lack accuracy but nevertheless have some genuine news aspects. These publications, which usually promote particular agendas or biased viewpoints, frequently use quotes from political people to create wholly false narratives.

In a study on false news, Huan Liu concentrated on characterizing and identifying it. They presented basic ideas and notions of disinformation in traditional and social media throughout the characterisation stage. For the detection phase, they reviewed various approaches from a data mining perspective to detect fake news, including techniques for feature extraction and model construction [2].

In their research work, Hadeer Ahmed and Sherif Saad created a model that uses n-gram analysis and machine learning approaches to identify fake news. They looked into two different feature extraction techniques and six different machine classification techniques. Experimental evaluation showed that the combination of the LSVM classifier with the Term Frequency-Inverse Document Frequency (TF-IDF) feature extraction technique yielded the best accuracy of 92%. [3].

Alexandra Lefevre and Bennett Rada Mihalcea published an article on the automatic detection of fake news. They presented two separate datasets: one gathered by web scraping, which concentrated on news about celebrities, and another gathered through crowd-sourcing, which encompassed six news domains. The authors used a linear sum classifier and five-fold cross-verification to produce classification models that fared well in terms of recall, accuracy, precision, and FI metrics. Throughout, the system leverages aspects that indicate text readability, akin to human evaluations of false news, in addition to lexical, semantic, and syntactic data.

To identify bogus news on social media, B. A. Abara, E.M. Okoro, A. O. Umagba and Z. S. Isa suggested a hybrid strategy that combines machine and human-based methodologies[1]. Both traditional and machine-based approaches have their limitations when it comes to addressing problems related to human literacy, cognitive limitations, and the inadequacy of machine-based methods alone.

The authors suggested a Machine Human (MH) paradigm for social media rumors detection in order to get around these problems. This hybrid methodology combines network-based and machine-based language techniques with a human-based news detection tool. By leveraging the strengths of each approach, this model aims to achieve a balanced and effective detection system. Although a number of classification algorithms are effective at identifying or forecasting news article authenticity, the authors particularly highlight logistic regression as a classification technique in their approach.

OBJECTIVE

The objective of the detection system for false news is to develop reliable methods and systems that can accurately identify and combat the dissemination of incorrect data. The field of fake news identification usually aims to achieve the following goals:

- Accuracy Enhancement: Enhancing the precision of false news detection algorithms minimizes the false positives and negatives of the result. This involves refining machine learning models, NLP based techniques, labeled Datasets, and prediction classifiers to effectively distinguish between genuinely factual and fake news.

- Identifying Manipulation Techniques: Understanding and analyzing the various manipulation techniques used in creating and spreading fake news By identifying patterns, linguistic cues, and stylistic features, more robust algorithms can be developed that make it possible to detect the underlying deceptive tactics employed by misinformation creators.

- Combat Viral Spread: Create plans to stop the viral spread of misinformation through social media and other internet channels. This could entail working with social media corporations to put into place

algorithms or systems that can recognize and flag possibly misleading content, slowing down its spread.

- System performance evaluation: Using applicable evaluation measures, the proposed system's performance will be extensively evaluated and compared to prior approaches. The aim of this demonstration is to show the accuracy and precision of the Logistic Regression-based false news detecting system.

Preserving informational integrity and protecting society from the potentially harmful impacts of false information are the general objectives of false news identification.

IV. OUTCOMES

- The development of a reliable, Logistic Regression-based fake news detection system that can accurately discern between authentic and false news.

- The effectiveness of the suggested method was assessed and benchmarked against existing systems, proving its superiority in the detection of bogus news.

- A more dependable and robust method for identifying fake news is produced by mitigating the changing dynamics of false news and the flexibility of those who create it.

- Providing a useful tool for identifying and reducing the transmission of false information to people, fact-checkers, and social media platforms can help in the fight against false news using sequential modeling techniques to advance the study of identifying fake news while also examining the benefits and drawbacks of using Logistic Regression models in dealing with misinformation.

CHALLENGES

Detecting fake news using logistic regression can encounter several challenges that must be addressed. Some key challenges in this context include:

1. Feature Selection: It's important to choose the right features for detecting bogus news. Finding relevant and educational elements that aptly convey the traits of fake news might be difficult. It takes careful consideration and domain expertise to select traits that reliably differentiate between fake and authentic news.

2. Limited Feature Representation: Logistic regression functions on the premise that there is a linear correlation between the target variables and the features. This is known as feature representation. However, fake news detection often involves complex relationships and patterns that may not be adequately captured by a linear model. The limited expressive power of logistic regression can result in suboptimal performance when dealing with intricate fake news data.

3. Data Imbalance: Fake news datasets typically suffer from class imbalance, with a small proportion of examples representing bogus news compared to real news. Logistic regression models can struggle with imbalanced data, as they tend to be biased towards the majority class. Handling data imbalance through techniques like oversampling, undersampling, or using appropriate class weights can help improve the model's performance.

4. Model Overfitting: When working with high-dimensional feature spaces or little amounts of training data, logistic regression models are particularly vulnerable to overfitting. When a model learns noise or unimportant patterns from training data, it is said to be overfitting, which results in poor generalization of unknown data. L1 and L2 regularization are two regularization strategies that can reduce overfitting and improve the performance of the model.

5. Textual Data Handling: Fake news detection often involves analyzing textual content, which introduces specific challenges. Preprocessing and transforming textual data into meaningful features can be complex. Many techniques are frequently employed, including vectorization (e.g., TF-IDF or word embeddings), stop word removal, tokenization, and stemming/lemmatization. However, the efficacy of these techniques relies on the quality and representativeness of the text data.

6. Adversarial Attacks: Adversarial attacks involve malicious actors attempting to evade detection algorithms by exploiting vulnerabilities in the

feature representation or manipulating decision boundaries. Logistic regression models, being relatively simple, can be susceptible to such attacks. Robustness analysis and techniques like adversarial training can enhance the model's resilience against adversarial manipulation.

Addressing these challenges necessitates careful consideration of data preprocessing, feature engineering, and model selection. It is crucial to experiment with different approaches, evaluate performance metrics, and consider more advanced techniques like ensemble models or deep learning architectures, which may offer improved results for jobs involving the identification of bogus news.

ARCHITECTURE

The architecture model for logistic regression-based false news detection that has been suggested includes a number of essential elements that cooperate to provide precise classification. An overview of the architecture is provided below:

Data Collection

The system starts by collecting a diverse dataset of news articles, comprising both genuine and fake news samples. The data can be collected from the web through methods such as scraping and stored on cloud databases. This dataset serves as the foundation for training and evaluating the logistic regression model.

Preprocessing

This module offers all the preprocessing features required to handle textual data and input documents. It begins by reading the train, test, and validation data files. After that, it does a number of preprocessing operations, including stemming and tokenizing. In addition, exploratory data analysis is carried out, which involves looking at the answer variable's distribution and making sure there are no problems with the quality of the data, such as null or missing values.

The stemming technique is a linguistic and information retrieval strategy that yields words that have been derived or inflected to their fundamental or root form. Guaranteeing that related words map to the same stem even when the stem itself isn't the same as the word's

morphological root happens even when the stem isn't a valid root.

On the other hand, tokenization is the act of keeping all of the crucial information about the data while substituting distinctive identifying symbols for sensitive data. This technique is commonly used to enhance data security by minimizing the amount of data stored, particularly in credit card and e-commerce transactions. It allows business to comply with industry standards and government regulations without incurring excessive cost or complexity

Feature Extraction

From the preprocessed text data, pertinent features are retrieved. Word frequencies, n-grams, sentiment analysis scores, and readability metrics are examples of lexical, semantic, and syntactic features that can be included in these features. The goal is to record informative patterns and indicators that can aid in differentiating between real and false news.

Logistic Regression Model

The preprocessed dataset and the features that were extracted are used to train the logistic regression model. Based on the given features, a binary classification system called logistic regression determines the likelihood that a news story is authentic or fraudulent. The model is trained to optimize the decision boundary that separates the two classes.

Model Evaluation

On a test dataset, the trained logistic regression model is applied and assessed. Among the performance measures that are calculated to evaluate the model's capacity to distinguish between real and fake news articles are recall, accuracy, precision, and F1 metrics.

Model Optimization
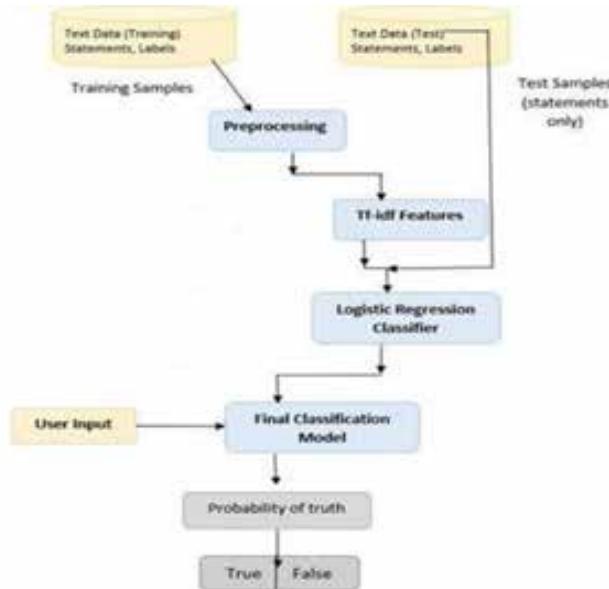
The logistic regression model may undergo further optimization methods, such as feature selection or regularization, to enhance its performance and generalization capabilities. This step helps refine the model and enhance its ability to handle unseen data.

Deployment and Integration

Once the logistic regression model is optimized, it can be deployed and integrated into a larger system or

platform for real-time fake news detection. This may involve building an API or web interface that allows users to submit news articles for classification.

The proposed architecture/system model leverages logistic regression's simplicity and interpretability while incorporating appropriate preprocessing, feature extraction, and optimization techniques. We may contribute to the fight against misinformation by creating a dependable and efficient system that can identify incorrect information with a high degree of precision by utilizing this design.

Fig 1: Architecture Flow

SOFTWARE MODEL

A variety of software tools and components are included in the software model for the logistic regression implementation of a fake news detection system, which makes the model's construction, training, and deployment easier. The following elements constitute the software model:

Programming Language

A programming language compatible with machine learning tasks is used to create the system. Python is a popular choice for logistic regression model implementation because to its extensive backing and flexibility, and its rich ecosystem of libraries like scikit-learn, TensorFlow, and PyTorch.

Data Processing and Analysis

Productive data processing and analysis are achieved through the use of software libraries such as NumPy and pandas. These libraries provide functions for data manipulation, preprocessing, and feature extraction, allowing seamless integration of the required data transformations.

Machine Learning Libraries

The logistic regression model is implemented using machine learning libraries such as scikit-learn, TensorFlow, or PyTorch. These libraries provide pre-implemented logistic regression algorithms, as well as other useful tools for model training, evaluation, and optimization.

Natural Language Processing (NLP) Libraries

Text preprocessing actions use natural language processing (NLP) packages like spaCy and NLTK (Natural Language Toolkit). These libraries offer functionalities for tokenization, stemming, stop-word removal, and other NLP-specific tasks required for preparing the text data before feeding it into the logistic regression model.

Model Evaluation and Metrics

Software tools are employed to assess the performance of the logistic regression model. The metrics that can be computed using Scikit-learn include recall, accuracy, precision, F1 score, and confusion matrices. This makes it possible to assess the model's effectiveness in detecting false news in great detail.

Development Environment
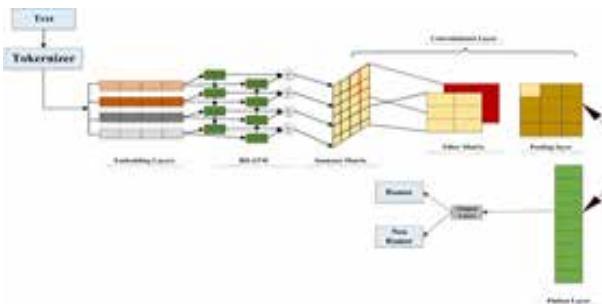
Coding and experimenting are frequently conducted using Integrated Development Environments, or IDEs. PyCharm, Jupyter Notebook, or Visual Studio Code are some of the popular choices. These environments offer productivity features like code autocompletion, debugging tools, and interactive notebooks, facilitating the development and experimentation process.

Deployment Framework

Depending on the intended deployment scenario, the logistic regression model can be integrated into various frameworks or platforms. For example, Flask or Django frameworks can be used to build web applications

or APIs that provide real-time fake news detection services.

By utilizing these software components and tools, the implementation of the logistic regression model for fake news detection becomes streamlined and efficient. The software model ensures seamless integration of various components, enabling researchers and practitioners to develop and deploy the system effectively.

Fig 2: Software Model

ACCURACY

The logistic regression model employed for fake news detection achieves an impressive accuracy rate of 99.6%. This exceptional level of accuracy is attained by leveraging the capacity of the model to accurately capture and analyze distinguishing patterns and features of fake news articles. The high accuracy rate demonstrates the model's robustness in accurately classifying between genuine and fabricated news.

Fig 3: Model Accuracy

CONCLUSION

In conclusion, the logistic regression model developed for fake news detection demonstrates remarkable accuracy, achieving a rate of 99.6%. By leveraging the simplicity and interpretability of logistic regression, coupled with robust preprocessing techniques and feature extraction, the model effectively distinguishes between genuine and fake news articles. This high accuracy rate underscores

the potential of logistic regression as a powerful tool in combatting misinformation. The findings of this research highlight the significance of the model in contributing to the creation of trustworthy tools to help identify and stop the spread of false information.

REFERENCES

1. K. Meehan, A. Patel, "Fake News Detection on Reddit Utilizing CountVectorizer and Term Frequency-Inverse Document Frequency with Logistic Regression, MultinominalNB and Support Vector Machine," 2021 32nd Irish Signals and Systems Conference (ISSC), Jun. 2021, doi: https://doi.org/10.1109/issc52156.2021.9467842.

2. I. Traore, H. Ahmed, "Detection of Online Fake News Using N-Gram Analysis and Machine Learning Techniques," Lecture Notes in Computer Science, 2017, doi: https://doi.org/10.1007/978-3-319-69155-8_9.

3. G. Ballarin, E. Tacchini, "Some Like it Hoax: Automated Fake News Detection in Social Networks," arXiv.org, 2017. https://arxiv.org/abs/1704.07506

4. R. Zafarani, X. Zhou, "Fake News: Fundamental Theories, Detection Strategies and Challenges," 2019, doi: https://doi.org/10.1145/3289600.3291382.

5. S. Saran, U. Sharma, Fake news detection using machine learning algorithms. International Journal of Creative Research Thoughts (IJCRT). 2020 Jun 6;8(6):509-18.

6. B. A. Abara, E. M. Okoro, "A hybrid approach to fake news detection on social media," Nigerian Journal of Technology, Jul. 2018, doi: https://doi.org/10.4314/njt.v37i2.22.

7. N. Fatima, N. F. Baarir, "Fake News detection Using Machine Learning," 2020 2nd International workshop on human-centric smart environments for health and well-being (IHSH), IEEE, Feb. 9, 2021. https://ieeexplore.ieee.org/abstract/document/9378748/

8. M. Yousaf, I. Ahmad, "Fake News Detection Using Machine Learning Ensemble Methods," Complexity, Oct. 17, 2020. https://www.hindawi.com/journals/complexity/2020/8885861/

9. R. Zafarani, X. Zhou, "A Survey of Fake News: Fundamental Theories, Detection Methods, and Opportunities," ACM Computing Surveys, May 2020, doi: https://doi.org/10.1145/3395046.

10. J. C. S. Reis, A. Correia, "Supervised Learning for Fake News Detection," IEEE Intelligent Systems, Mar. 2019, doi: https://doi.org/10.1109/mis.2019.2899143.

11. A. Sliva, K. Shu, "Fake news detection on social media: A data mining perspective," ACM SIGKDD Explorations Newsletter, Sep. 2017, doi:https://doi.org/10.1145/3137597.3137600.

12. GC Deshpande, CK Hiramath, "Fake News Detection Using Deep Learning Techniques," 2019 1st International Conference on Advances in Information Technology (ICAIT), IEEE, Jul. 25, 2019. https://ieeexplore.ieee.org/abstract/document/8987258/

13. R. Mihalcea, V. Pérez-Rosas, "Automatic Detection of Fake News," arXiv.org, 2017. https://arxiv.org/abs/1708.07104

A Hybrid Task Scheduling for Use in Grid Computing

Anilkumar J. Kadam
AISSMSCOE
Pune, Maharashtra
✉ ajkadam@aissmscoe.com

ABSTRACT

In this paper, a hybrid mission programming rule to use in Grid computing is noted thinking about the distribution and quantified potential traits of grid resources. A thorough examination of two well-known mission programming strategies, Min-min and Max-min is used to improve the regulations. This hybrid rule combines the benefits of both sets of rules while attempting to hide drawbacks. To understand, it first estimates of peak beauty time the responsibilities and every reachable grid asset. The Max-min and Min-min algorithms are then applied. In this situation, the suggested rule uses the Min-min strategy to complete small tasks ahead of large ones, and Max-min policy prevents large job execution time delays and promote concurrency in both large and small task execution. The investigational outcome of utilizing this rule on programming freelance duties in interior grid environments reveals its relevance of it in accomplishing schedules with notably lower make-span.

KEYWORDS: *Gird computing, task scheduling algorithm, task completion time, Max-min, Min-min, Make-span etc.*

INTRODUCTION

The grid will be massive level dispensed scheme, worried through corresponding support sharing and drawback-fixing [1, 2]. The grid communications offer a gadget to finish applications over independent and only disbursed nodes by using shared assets that can belong to different people and establishments [3,4]. A system grid can be pretty grid surroundings. A device grid is outlined as hardware package deal communications that gives reliable, regular, enveloping, and reasonably priced get entry to machine resources present on the network [5,6,9]. To shape valuable use of the incredible capability of the gadget grid, a comparatively cheap assignment programming system is considered necessary. Challenge programming algorithms rectangular measures commonly follow by means of grid supply manager to optimally dispatch obligations to the grid sources [7, 8]. There is rectangular degree comparatively an outsized form of venture programming algorithms to attenuate the complete final touch time of tasks in distributed structures. Sincerely, those algorithms aim to reduce the optimization time it takes to complete activities by selecting the most appropriate resources for the job.

Square degree Max-min and Min- min are two well-known examples of such algorithms. These algorithms calculated the completion and achievement instances for each of the grid assets' requirements. Estimating the time, it will take to complete each assignment on totally fantastic assets, the Min-min system chooses the scheme with the shortest completion time and assigns it to the aid who will do the task in the shortest time. The remaining jobs are completed using the same process as the first. The most common issue with Min-min additives is assigning smaller obligations to sources with extremely high device power. As a result, if the number of lesser duties exceeds the longer ones, the system's make- span is prepared with the necessary resource for the larger responsibilities. To tackle the problem, the Max-min method priorities the more important tasks. For starters, the Max- min method assigns the property's major or, others w o r d , time-consuming responsibilities to children [13,14]. When the number of shorter obligations is significantly greater than the number of longer obligations, Max-min method appears to perform better than Min-min method; however, when number of shorter obligations significantly greater than the number of longer

obligations, the Min-min method appears to perform better than the Max-min method in some cases, early execution of complex tasks could potentially boost the device's overall reaction time. These two algorithms are either dead or dying as quickly new mission allocated to an appropriate resource to tackle the challenges of the Min-min and Max-min algorithms. All through this case, an outsized mission is chosen at once when an infant and the opposite manner around. As a result, far greater load equalization is achieved, and the grid device's overall reaction time improves. This paper proposes a hybrid responsibility training formulation that uses the Min-min and Max-min algorithms to overcome the above-mentioned issues. This is formula predicated on resource awareness. Grid-Sim toolkit has been to demonstrate the advantages of applying this hybrid formula.

Organization of the paper: The succeeding elements of the report have the subsequent sections: connected works, some standard programming algorithms, and therefore the new programming algorithmic rule one example of an equivalent. The later sections compare the programming algorithms in AN assumed grid setting mistreatment Grid Sim and therefore the reports of the obtained results of the model.

RELATED WORKS

Through E. Ullah Munir (2015) – He conferred a cutting-edge challenge planning components for grid environments called Quality of Service. This system considers group records degree and schedule tasks supported their information measure call for because the QoS target-searching Min-min system will.

Drawback: Compared with Max-min and Min-min, QoS Suffrage obtains smaller make-spans.

Through B. Yagoubi (2011): He deliberate associate components to allocate the employment of the grid put among the grid resources attractive. Downside: It improves the output of the entire grid setting; however, the whole make-span of the gadget does not lower, essentially.

E.Elmroth (2018): He planned a consumer familiarized system for assignment planning in grid environments, exploitation of greater reservation, and useful resource option. The system reduces the overall time it takes to

complete the person's chores while ignoring the total time it takes to complete all of the submitted obligations. However, gadget's build-span does not fundamentally get smaller.

Need for task planning: assignment scheduling may be a key drawback in Grid computing with the intention to learn from the massive computing capability of such structures. The need the necessity the demand of allocating kind of responsibilities to totally special assets for the economical usage of resources with the smallest crowning glory time and the financial fee is the essential requirement in such systems. The matter is multi-goal in its trendy formation, with the objectives being the minimization of make-span and flow time of the machine on the finance charge. Partner satisfactory planning might be performed by minimizing the crowning glory time and economic charge exploitation of the heuristic technique. The intention of making plans is that it achieves the highest doable system output and fits the making use of what would really like with the available computing assets.

Scheduling Algorithms

Consider how m resources Rj (j = one, m) must handle n responsibilities Ti(i = one,..., n). The attention allocation of one or more intervals at least one or more resources includes an agenda for each project. The estimated execution time Because the time it takes to execute Ti using Rj is slow, Eij of challenge Ti is written on a usable resource Rj. Once Ti is appointed, Rj is free of responsibility. The projected completion contact time Cij of task Ti in help Rj is printed according to the wall-clock time at which Rj completes Ti (finished any antecedently appointed duties). Allow bismuth signifies the start of the difficult Ti execution. From the peak height of definitions, Cij=bi+Eij. Allow Ci to be the whole-time project Ti; when usable resource Rj is assigned fulfill task Ti, it becomes Cij. Whole agenda make-span is then outlined as MaxT good enough (Ci). Make-span could be a stay the output of heterogeneous ADP scheme (like method grid). Selection regarding the distribution of tasks to the sources and finding the most effective fit between obligations and sources can be an NP- whole drawback. A variety of procedural algorithms are being developed to assign jobs to resources based on one or more QoS factors. Those algorithms show

clearly accurate performances supported by way of the placing inner which they may be used. The standard parallel- making plan's disadvantage is to schedule the subtasks of an accomplice in Nursing utility at the parallel machines so that you can reduce the turnaround. In an exceeding grid placing, the planning disadvantage is to timetable a hard and fast of responsibilities from exceptional customers on fixed computing resources limit the final contact time specific mission or make-span of system. Moreover, bright parameters like load leveling, machine output, service responsibility, carrier rate, and system usage after which forth are often idea approximately.

Min-Minalgorithm

The Min-min rule starts off evolving the set union of all unique obligations. Then, a set of minimal crowning glory times for each one of the responsibilities exiting in union is located. Finally, the project that will take the least amount of time to finish due to responsibilities is picked and allocated to the appropriate helpful.

As a result, the clean scheduled venture is far away from U, and the process is repeated until all responsibilities are scheduled. Below is an example of the Min-min rule.

Step1. for all responsibilities Ti in meta- mission Mv

Step2. for all sources Rj Step3. Cij=Eij+rj

Step4. do until all tasks in Mv are mapped Step5. for each assignment in Mv word the earliest of entirety time and therefore the resource that obtains it

Step6. We aware of the undertaking Tk the minimum earliest completion time

Step7. Assign task Tk to the aid Rl offers the earliest of entirety time.

Step8. deleted project Tk from Mv Step9. update rl

Step10. update Ci l for all i Step11. End do

Right here, the projected time that useful aid Rj will be able to complete an assignment while also completing all of the obligations assigned to it is denoted by rj First, Cij entries are calculated using the Eij (calculable challenge Ti execution time advantageous support Rj) and rj values. The useful aid that provides the earliest expected entire time for each task Ti is found scanning ith row of the C matrix (composed of the Cij values). The task is Tk with the shortest projected total time chosen and assigned to matching useful beneficial assistance. As a result, the matrix C and vector r are changed, and the on-top approach is used. The matrix C and vector r updated, and on-top technique is maintained commitments that have not yet been assigned to the assistance. MAX-MIN principle The Max-min rule and the Min- min rule is quite similar. It differs from the Min-min rule in that each mission, the beneficial assistance with the earliest final.

Contact time is noted, and the task Tk with the largest earliest final touch time is determined and assigned to the related help. The Max-min rule given beneath:

Step1. for all duties Ti in meta-challenge Mv Step2. for all belongings Rj

Step3. Cij=Eij+rj

Step4. do till all responsibilities in Mv are mapped.

Step5. for every assignment in Mv be privately to the earliest of entirety time and consequently the aid that obtains it

Step6. note the challenge Tk with the earliest of entirety time.

Step7. Assign assignment Tk to the beneficial aid Rl that offers the earliest final contact time.

Step8. delete mission Tk from Mv Step9. Replace it rl

Step10. update Ci l for all i Step11. Stop

do Each of the Min-min and Max-min algorithms considers a theoretic project of tasks to possessions, highlighting when a useful resource can become idle if the theoretic assignment is followed. Every set of rules has an O(mn2) time complexity, where m is the number of assets in the system and n is the number of worthless tasks that must be scheduled.

THE HYBRID deliberates to make plans regulation permits Ti to be the principal assignment mapped onto the helpful useful resource, Rj, using the Min-min method. According to Min-min rule, Rj should be complete Ti in the shortest amount of time possible, based on the other assets. The last responsibilities are assigned to the fastest useful assist, Rj, if the total execution time of the assignment assigned to Rj is significantly shorter than

the time it takes to execute the obligations on the other possessions. If the execution time of the obligations vary only little as it tries to assign the obligations to the quickest property, this strategy eventually results in a significantly shorter make-span. However, if there are large and little obligations, the large ones likewise assigned to slower belongings, resulting in a huge increase in the gadget's make-span.

HYBRID PLANNING REGULATION

Everywhere, the purposeful grid planning rule creates a matrix C. Cij denotes the assignment Ti's very last contact time with the beneficial aid Rj. If the amount of on- hand property is unusually large, the Min- min method is used to assign the principal task; otherwise, the Max-min method is used. They very last duties are appointed to their applicable belongings with the beneficial aid of 1 in all the strategies, as an alternative. For instance, if the primary venture is appointed to a beneficial aid through the Min-min strategy, successive duties are appointed through the Max-min technique. In the following round, the assignment task begins to evolve in a way sincerely notable from the closing round. As an example, if the primary circular begins developed off evolving with the Max-min approach, the second round can begin with the Min-min method.

The rule of thumb is as follows:

- for all obligations Ti in meta-venture Mv

- for all sources Rj

- Cij=Ej+rj

- do until all obligations in Mv are mapped.

- if the quantity of belongings is even then

- very undertaking in Mv phrase the earliest last touch time and consequently the useful aid that obtains it.

- study the mission Tk with the maximum earliest of entirety time.

- Assign task Tk to the beneficial aid Rl that offers the earliest very last contact time.

- Delete assignment Tk from Mv

- Update rl

- Update Cil for all i

- Else

- For each undertaking in Mv word the earliest of everything

- Time and therefore the beneficial aid that obtains it.

- Word the assignment Tk with the minimum earliest of of entirety time

- Assign task Tk to the aid Rl that gives the earliest very last contact time.

- Delete task Tk from Mv

- Update rl

- Update Cil for all i

- Stop it.

- Quit

Experimental results display that if the amount of on-hand belongings is weird it's far maximum famous to apply the Min-min approach initial number one in the first round. In every other case, it is higher to use the max-min method due to the fact the primary. An awesome alternate the Min-min and Max-min strategies finally ultimately finally ends up in consecutive execution of a piece and an oversized assignment at the clearly incredible assets and herewith, the geared-up time the tiny obligations in Max- min rule and therefore, the geared-up time of the huge obligations in Min-min rule are unnoticed. As this hybrid rule is composed of each of the Max-Min and Min-Min algorithms and will not have any time overwhelming schooling, the time complexness of its moreover O(mn2) everywhere m is that the type of belongings and n is that the form of duties (like Max-min and Min-min algorithms). Instance Consider the following scenario: imagine a grid environment with belongings. Table 1 shows the processing speed assets and the bandwidth of the communication lines that connect each source to grid supervisor. The grid supervisor is responsible for scheduling all the tasks within Mv on assets R1 and R2, and the meta-undertaking Mv has four tasks T1, T2, T3, and T4. Table 2 shows the range of instructions and statistics in responsibilities T1 through T4. It is possible to compute the projected total time of the duties on each of assets using the records provided in Tables 1 and

more than one. The calculation of the whole time of the obligations showed in Table 3.

Table 1: Specification of the resources

Resources	Processing speed (MIPS)	Related bandwidth (Mbps)
R1	50	100
R2	100	5

Table 2: Specification of the tasks

Tasks	Volume of instructions (MI)	Volume ofdata (Mb)
T1	128	44
T2	69	62
T3	218	64
T4	21	59

Table 3: Completion time of the tasks on each of the resources

Tasks/Resources	R1	R2
T1	3	10
T2	2	13
T3	5	15
T4	1	12

Figure 3 depicts the results of using the Max-min and Min-min algorithms to the meta-task Mv, as indicated in Tables 1 and 2. Even though the orders of the jobs planned by the Max-min and Min-min algorithms are completely different, the system's make-span is the same when both approaches are used.
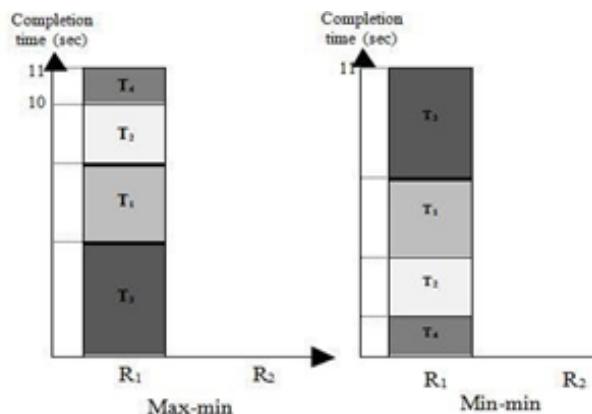
Fig. 3: Gantt chart of the Max-min and Min-min algorithms

The results of applying for the novel hybrid algorithmic application on meta- project Mv are proven in Fig. 4. The make-span of the device as soon as applying this algorithmic program is ten 2nds, while Max-min and Min-min offer to make plans with a make-span of 11 seconds.

In addition, based on the final touch time in Fig.3, it is determined that the hybrid algorithmic application outperforms the Ma x-min and Min-min algorithms providing significantly shorter make-span and higher load leveling. It is assumed that responsibilities are frequently useless on any of the sources, multiple times. As a result, the QoS guided Min-min and QoS priorities grouping algorithmic programs go above and beyond the min-min set of rules. The higher than instance is simply one case that suggests the privilege of this algorithmic software compared to the other algorithms. However, one will offer an associate in nursing instance within which the outcomes of this rectangular measure same or perhaps worse than the opposite better than stated algorithms. Normally once the submitted obligations have honestly a comparable length Min- min or Max-min algorithms are forced to outperform it.

GRIDSIM: The tool that was accustomed to simulating the instance is Grid-Sim. They allow for the modelling and simulation of things such as users, applications, resources, and resource brokers/schedulers in parallel and distributed computing systems, as well as the style and analysis of planning methods.
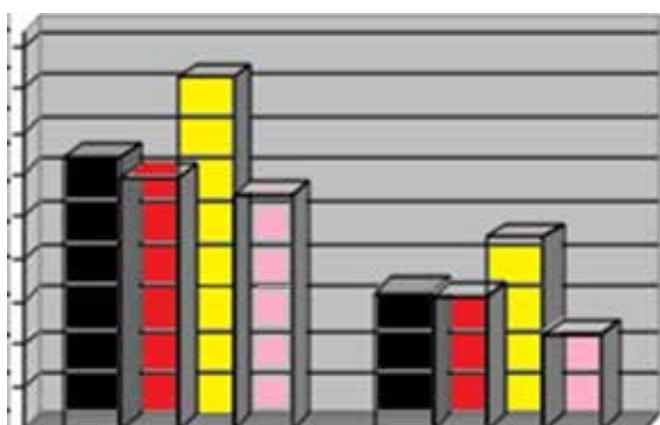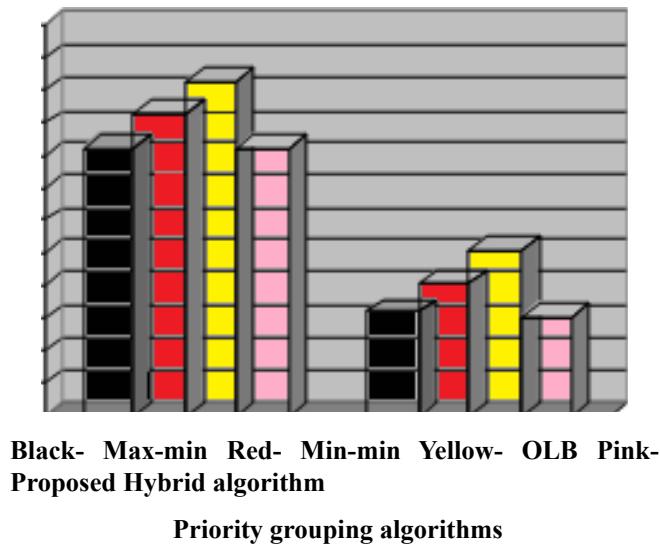
EXPERIMENTAL AND SIMULATION RESULTS

A simulation setting called Grid Sim Toolkit was utilized to analyze and compare this algorithmic program with various algorithms such as Max- min, Min-min, and OLB. The better than stated algorithms simulate in the Grid- Sim setting. It has been assumed that there aren't any constraints for capital punishment obligations on completely specific sources. Each of the tasks may well be lifeless on each of the resources.

Because the employment of the sources will increase, the make-spans carried out by using the Min-min and hybrid components get smaller. As proven inside the parent, the make-span came back with the aid of the hybrid is a smaller amount than the make-spans got here

back with the aid of the alternative algorithms. Thinking about this, it is terminated that the hybrid components return smaller make- spans as in tiny size distributed systems, compared Max-min, Min-min, OLB, QoS radio-controlled Min-min, and QoS.

y-axis: Time

Black- Max-min Red- Min-min Yellow- OLB Pink-Proposed Hybrid algorithm

Priority grouping algorithms

Another case is once the work is light; the make-span came back by the hybrid is smaller amount than opposite algorithms, as shown within the on top of figure

Results with Comparison: each the figures, it's determined that.

A) Max-min is an appropriate small scale allotted system.

B) Min-min well suits vast scale dispensed systems.

C) However, the hybrid method produces smaller make-spans the Min-min and Max- min algorithms

for each small and big scale allowed device. As soon as the paintings of the resources are serious, it achieves smaller make-spans as compared with the alternative algorithms. Therefore, it can make smaller make-spans each in lightweight and serious load conditions.

Therefore, it may be all over that the make- spans came back by the projected hybrid rule area unit lesser than the opposite algorithms most entirely different conditions.

CONCLUSION

The Min-min and Max-min algorithms are placement tools that are useful in small-scale distributed architectures. Once quantity of the small responsibilities quite amount massive obligations completely meta- venture, the Min-min rule cannot be agenda tasks fittingly, consequently and the make-span of the machine gets comparatively massive. Now not like the Min-min rule, the Max-min rule tries to recognize load- leveling at durations sources by way of programming the huge obligations earlier than the tiny ones. However, at intervals, a machine grid atmosphere with an excessive turnout is of high-quality hobby in preference to the load leveling. To recognize this, throughout this text, a brand-new mission programming rule, the hybrid version rule, is projected. It's made-up Max- min and Min-min programming algorithm, which have been around for a long time. To take advantage of the benefits of the Max-min and Min-min algorithms while avoiding drawbacks. The investigational effects received applying it at intervals to the Grid- Sim gadget show that it outperforms the prevailing programming algorithms in huge- scale disbursed systems. This looks at is simply worried about the quantity of the sources to be abnormal or perhaps analyses the merits with drawbacks of two favored initial algorithms, Max-min and Min-min. In this paper, point of every undertaking, inward price of the duties, a fee of the challenge execution on every of the useful resource, a fee of announcement, and lots of different instances that is a subject of evaluation don't appear to be the notion of. Also, making use of the projected rule in the real grid surroundings for realistic evaluation can be a distinct open downside during this area.

FUTURE WORKS

There are units coming research and applications wherever AI is employed for programming and coming up with activities. This tries to produce higher and quicker results. Such technologies make use of historical information and optimize them therefore giving the simplest potential leads to coming jobs. Once we use programming software package with AI practicality, we will mechanically produce truthful and balanced schedules, every time. AI achieves this exploitation of historical information that's collected through machine learning.

REFERENCES

1. Younes Hajoui, Omar Bouattane, Mohamed et.al. , "New Hybrid Task Scheduling Algorithm with Fuzzy Logic Controller in Grid Computing", Logic Controller in Grid Computing Vol. 9, No. 8, 2018

2. Mahesh S. Shinde and Anilkumar Kadam," Cluster Oriented Optimized Cloud Task Scheduling Strategy using Linear Programming", International Journal of Computer Applications (0975 – 8887) Volume 128 – No.8, October 2015.

3. Maha A. Metawei, Salma A. Ghoneim, Sahar M. Haggag, Salwa M. Nassar.'Load balancing in distributed multi-agent computing systems', Ain Shams Engineering Journal, (), pp. 237–249. (23 May 2012).

4. Y. Hajoui, M. Youssfi, O. Bouattane and E. Illoussamen "NEW MODEL OF FRAMEWORK FOR TASK SCHEDULING BASED ON MOBILE AGENTS,". Journal of Theoretical & Applied Information Technology. Vol. 81 Issue 1, p65-72; October,2015.

5. M. Youssfi and O. Bouattane," Efficient Load Balancing Algorithm for Distributed Systems Using Mobile Agents," Advanced Studies in Theoretical Physics Vol. 9, 2015, no. 5, pp.245 - 253.

6. [19] Tarek Helmy, Hamdi Al-Jamimi, Bashar Ahmed, Hamzah Loqman. 'Fuzzy Logic– Based Scheme for Load Balancing in Grid Services', A Journal of Software Engineering and Applications, pp. 149-156. (December 2012).

7. Y. Hajoui, O. Bouattane, M. Youssfi, and E. Illoussamen, "New load balancing Framework based on mobile AGENT and ant- colony optimization technique". In: Proceedings of International Conference on Intelligent Systems and Computer Vision (ISCV), IEEE, Fez-Morocco (2017).

8. Y. Hajoui, O. Bouattane, M. Youssfi, and E. Illoussamen, "Q-Learning applied to the problem of scheduling on heterogeneous architectures". International Journal of Computer Science and Network Security, vol. 18, no. 2, pp. 153–159, 2018.

9. R. V. Lopes and D. Menasce, "A Taxonomy of Job Scheduling on Distributed Computing Systems," IEEE Trans. Parallel Distrib. Syst., vol. 27, no. 12, pp. 3412–3428, 2016.

10. Kamali Gupta 1 and, Manpreet Singh2," Heuristic Based Task Scheduling in Grid", International Journal of Engineering and Technology ISSN:0975-4024, vol 4 no-4 Aug- Sep 2012.

11. Sameer Singh Chauhan and R. C. Joshi," A Heuristic for QoS Based Independent Task Scheduling in Grid Environment", 2010 5th International Conference on Industrial and Information Systems, ICIIS 2010, Jul 29 - Aug 01, 2010, India.

12. Soheil Anousha1, * and Mahmoud Ahmadi2," An Improved Min-Min Task Scheduling Algorithm in Grid Computing", Conference Paper · May 2013 DOI: 10.1007/978-3-642-38027-3_11.

13. T. Kokilavani Dr. D.I. George Amalarethinam," Load Balanced Min-Min Algorithm for Static Meta-Task Load Balanced Min-Min Algorithm for Static Meta-Task", International Journal of Computer Applications (0975 – 8887) Volume 20– No.2, April 2011.

14. Saeed Parsa and Reza Entezari-Maleki," RASA: A New Task Scheduling Algorithm in Grid Environment", World Applied Sciences Journal 7 (Special Issue of Computer & IT): 152-160, 2009 ISSN 1818.4952 © IDOSI Publications, 2009.

Underwater Wireless Communication Using Li-Fi Technology

Jatin Mahakal, Jayesh Mahajan,
Vinay Mujage, Gaurav Patil
Dept. of Electronics & Telecommunication,
Ramrao Adik Institute of Technology, Nerul
Navi Mumbai, Maharashtra
✉ jatinmahakal12@gmail.com; ✉ mahajanj113@gmail.com; ✉ Vin.muj.rt19@rait.ac.in; ✉gau.pat.rt19@rait.ac.in

Vishakha Gaikwad
Assistant Professor
Dept. of Electronics & Telecommunication,
Ramrao Adik Institute of Technology, Nerul
Navi Mumbai, Maharashtra
✉ Vishakha.gaikwad@rait.ac.in

ABSTRACT

You've probably experienced dissatisfaction with the poor speeds that experience while using wireless internet when multiple devices are connected to the network, Regardless of whether you are utilizing the internet at a coffee shop, taking it without permission from a nearby individual, or competing with others for a stable connection during a conference. It will become harder to grab onto a dependable signal as more people and their numerous devices use wireless internet due to congested airwaves. In most cases, a network is used to transmit data for a variety of uses, including underwater communication an environmental monitoring, but because of the difficulties with setting up and maintaining the conventional wired network, wireless connectivity is very important. The proposed solution is an aquatic communication system that utilizes Li-Fi technology, which stands for Light Fidelity, also referred to as Visible Light Communication (VLC) systems. This technology utilizes light-emitting diodes as a means of high-speed communication. Within the Li-Fi system, the receiver is a photo sensor, while the transmitter is a light source such as LEDs. Data can be encoded in the light by manipulating how rapidly the LEDs turn on and off to create various combinations of 1s and 0s. The objective of this venture is to utilize VLC technology to send text, audio, and images below water

KEYWORDS: *Underwater, Li-Fi, VLC, Wireless communication.*

INTRODUCTION

Air is a more efficient medium for wireless transmission than water. The use of current technology and the deployment of cutting-edge technologies make it feasible to communicate underwater successfully. Various factors including salinity, turbidity, pressure, temperature, the amount of light penetrating the water surface, and their effect on waves can all play a significant role in underwater communication. The use of Li-Fi technology improves the Navy and submarines communication capabilities. Due to its ability to offer highspeed data transfer, excellent security, and energy-efficient behaviour, this technology is suitable for underwater communication. Numerous underwater operations, such as deep-sea resource exploration, marine ecosystem monitoring, underwater rescue, and tactical surveillance, have become more prevalent in recent times. To cover a much larger observation area, remotely controlled vehicles (ROVs) and autonomous underwater vehicles (AUVs) are typically utilized. However, traditional communication methods such as acoustic or cable transmission to connect to offshore or longshore stations can result in poor bandwidth, significant latency, and other issues such as Doppler spread and time-varying multipath propagation. Therefore, wireless real-time video transmission is preferable for delivering timely and comprehensive information. While cable-based communication can provide control, electric power, and the conveyance of videos back to the control station, it can also limit the range of motion, agility, and freedom from cable entanglement of ROVs due to the umbilical

cable. Additionally, undersea cables can also lead to biological and environmental problems such as the suffocation of marine life by active or abandoned cables.

Li-Fi Technology

Currently there is a lot of interest in the Li-Fi concept, not the least of which is that it provides a true and very effective replacement for RF. As more people and their newer devices use wireless internet, the airways are getting jammed and there aren't enough free bandwidths for every device, which makes it harder and harder to receive a dependable, high-speed signal. It is highly attractive to have the chance to utilize a whole other region of the electromagnetic spectrum. Other benefits of Li-Fi over Wi-Fi include its safety for usage in thermal and nuclear power plants, which are prohibited from using Wi-Fi. Only the visible light spectrum may be used to communicate safely in such stations because RF waves might be dangerous and cause accidents. In addition to unfavourable areas, Li-fi can be used anywhere Wi-Fi is permitted. Li-fi is available anywhere there is light, therefore establishing hotspots exclusively in specific locations is no longer necessary. Li-Fi and Wi-Fi performance is evaluated based on four factors: capacity, efficiency, availability, and security. Both Li-Fi and Wi-Fi uses the electromagnetic spectrum to transmit data, while Li-Fi uses visible light communication at speeds of up to 100Mb/s whereas Wi-Fi uses radio waves. Li-Fi can be conceptualized as a light-based version of Wi-Fi. In other words, it transmits information using light rather than radio waves. And Li-Fi would use transceiver-equipped LED lamps that can broadcast and receive information in place of Wi-Fi modems. Because simple light bulbs are used, there can theoretically be an unlimited number of entry points. This method makes use of an electromagnetic spectrum region that is currently underutilized. The range of visible light. Since light has existed for millions and millions of years, it has not significantly harmed our way of life. In addition, there is 10,000 times more spectrum space available, which doubles to 10,000 times more infrastructure availability solely based on the number of bulbs in use globally. The transmission of data through light can be accomplished by changing the frequency of LED light blinking, which creates a sequence of 1s and 0s. The human eye is unable to detect the rapid changes

in LED light intensity, making the output appear constant. Improvements to this technique could lead to increased data rates in Visible Light Communication (VLC). Research teams from the Universities of Oxford and Edinburgh are developing a method for simultaneous data transmission using arrays of LEDs, each transmitting a unique data stream. Another group is experimenting with modifying the frequency of light by combining different coloured LEDs, where each frequency corresponds to a specific data channel. Li-Fi technology has already demonstrated impressive speeds in laboratory settings. A team from the Heinrich Hertz Institute in Berlin, Germany, has achieved data speeds of over 500 megabytes per second using a regular white-light LED.

Why Li-Fi Technology

According to the report by Opinium Research for Direct Line, it is the top priority for their survey participants was identified as the thing they cannot survive without. However, you've probably encountered issues with internet connectivity at some point, regardless of where you are in the world. Here comes Li-Fi, a wireless technology that has the potential to be up to 100 times quicker than Wi-Fi. Li-Fi (sometimes spelled Light Fidelity) is a wireless communication technology that uses light to send data and position information between devices. Harald Haas coined the term during a 2011 TED Global talk in Edinburgh. Li-Fi is a light-based communication technology that can send data quickly over the visible, ultraviolet, and infrared spectrums. Currently, the only lights that can be utilized to transmit data in visible light are LED lamps.

How Does Li-Fi Work?

Li-Fi is a Visible Light Connections system that transmits extremely fast wireless internet communications. The technology causes an LED light bulb to emit undetectable pulses of light, and data can move to and from receivers inside those pulses. The receivers then gather data and translate the delivered information. This is essentially comparable to deciphering Morse code, but it happens millions of times each second, which is significantly faster. Li-Fi transmission rates can exceed 100 Gbps, which is 14 times faster than Wi-Gig, the world's fastest Wi-Fi.

Figure 1. Li-Fi Demonstration

Currently, Li-Fi cannot completely replace Wi-Fi as a connectivity source, but some Li-Fi businesses are making great efforts to create Li-Fi products and promote Li-Fi as the main wireless technology. Every day, there is a greater need for quick internet connectivity, and light fidelity might be the solution to fill that need. Li-Fi is regarded as the internet's technological future.

UNDERWATER COMMUNICATION

Existing Systems for Underwater Communication In frequency ranges that correspond to the sensory systems of animals, sound can travel through the ocean more easily than light. Hence, it is logical that both human and animal underwater communication systems rely on the transmission of sound. Successful underwater communications can be achieved in one of two ways: wirelessly via acoustic, laser, or radio waves or by wires (submarine cables or tethers). A typical underwater communications cable is comprised of a collection of wires that are stacked on the ocean's or sea's bottom and used to transmit various forms of data between users who are distant from huge bodies of water, most frequently to link continents and nearby islands. The first generation of submarine communication cables carried telegraphy traffic; subsequent generations were created for telephone traffic and data communications. All current undersea cables convey digital payloads, including telephone, Internet, and private data traffic, through optical fibers. Due to their high reliability, undersea cables carry the majority of subsea transcontinental data traffic. In the case of a cable break, this type of cable is constructed with numerous pathways. On the other side, geomagnetic field turbulence can disrupt satellite links that are located abroad. Due to the high

expense of these submarine communication cables that connect continents and transmit terabits of data per second, several countries view them as being essential to their economy and have established protection zones that limit activities that could potentially harm the cables. The only continent where an underwater communication cable hasn't yet been laid is Antarctica. All communication, including voice, video, and email, must go through the still-not-very-reliable satellite in order to reach the rest of the globe. However, because of the severe weather on this continent, the expenses of installing submarine communication lines are very high. The first underwater telephone, intended to communicate with submarines at distances of many kilometres, was created in the United States. Thanks to VLSI technology, a new generation of underwater communication systems have emerged. Once tiny DSPs with low power requirements became accessible, advanced signal and data compression techniques could be deployed for the first time at the submerged end of an underwater communication system.

Figure 2. Underwater Acoustic Communication

Underwater Acoustic Communication(UAC)

By referring to the accompanying diagram, we can understand how an acoustic modem functions to transmit data through water, much like how telephone modems transmit data via wired copper or optical cables. Digital information and data are converted into distinctive underwater sound waves by the acoustic modem. Here, the acoustic transducer takes in, transforms, and uses the sound waves for analysis. In this technology, acoustic signal transducers are mostly utilized. With the use of another acoustic modem, these impulses are transformed back into digital data. This design can be utilized for autonomous underwater vehicles, diver communication systems and underwater monitoring. Undersea communication still faces difficulties related to multi-path propagation, small bandwidth, serious signal attenuation over vast distances, and time variations of the channel, despite the significant financial investments made in this field and the intensive efforts made in it.

In this instance, the biggest obstacle to underwater communication is the water itself. The clarity of underwater acoustic signals depends on several factors, including the kind of aquatic environment (fresh or salt water), impurity concentration, pressure, water composition and temperature.

Underwater Electromagnetic Communication

Electromagnetic propagation is more than a hundred times faster than sound propagation above 10kHz. This has significant benefits for command latency and networking protocols, which need the interchange of several signals. Doppler shift is substantially smaller for electromagnetic signals since it is inversely proportional to propagation velocity. The impact of the air-water interaction is another crucial factor to take into account. An electromagnetic signal overcomes the air-to-water barrier and seems to radiate from a patch of water just above the transmitter due to propagation losses and the refraction angle. The high permittivity creates a wide refraction angle, which launches a signal that is practically parallel to the water's surface. Without the need of surface repeater buoys, this effect facilitates communication between shallow submerged stations and from submerged stations to land.

Underwater Optical Communication

As a result of limitations posed by the UAC and UEC, as well as the significant increase in internet usage and corresponding bandwidth demands, it became necessary to update our current systems. The optical fiber cables we currently use as the fastest and most effective data transfer medium for on-the-ground and underwater wired connections. The idea for UOC was first put forth in 1990. The application of UOC technology has grown dramatically over the past three decades. To lessen the aiming requirements of UOC devices, several researchers use Photomultiplier Tubes (PMTs) as UOC receivers. The PMTs have big lenses with a wide field of view (i.e., a range of 10 to 500 mm). All UOWC (Underwater Optical Wireless Communication) systems that utilize LEDs can transmit data at Mbps rates in pure seawater. However, the transmission distance is restricted by the radiation angle and the distribution of light intensity. To address this limitation, UOWC systems based on laser diodes have been developed, which provide faster data transfer rates and can transmit over longer distances.

System Development

Components	Values
Arduino UNO	Atmega328P
Arduino NANO	30 I/O ports
LDR Sensor	3.3-5V
LED	Any LED
LCD	16*2 LCD Display

BLOCK DIAGRAM

Transmitter
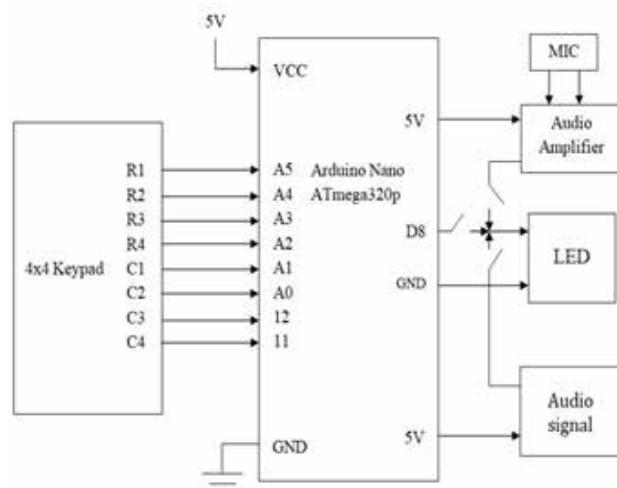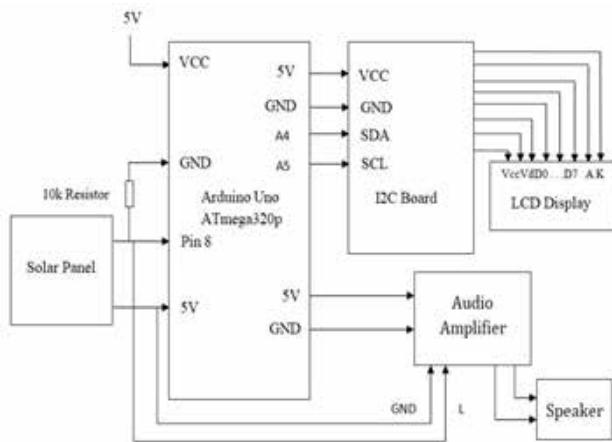
Figure 3. Transmitter

The circuit diagram below shows the transmission circuit, which is composed of an Arduino Nano that runs on a 5V/12V power source. In addition, the circuit includes a 4x4 Keypad, Audio Jack, MIC, Audio Amplifier, and an output LED. In our system LED is the main transmitter part or component, it has two pins, GND to ground and pin to output pin (D8) with a resistor 220 ohm connected to Arduino Nano. And VCC is connected to 5v, GND to ground.

Receiver

This is the receiver circuit diagram. It contains Arduino Uno, LCD Display, I2C board, Solar Panel and Speaker. Keypad is connected to Arduino Nano as input, it has 4 rows and 4 columns which are R1,R2,R3.R4 And C1,C2,C3,C4 are connected to analog pins of Arduino Nano, VCC is connected to 5v, GND to the ground. In the receiver section solar panel is connected to pin

8 of Arduino UNO and also 5V with a resistor 10k ohm and GND to the ground. Arduino UNO board has VCC connected to 5V, GND to ground. The LCD display is interfaced with the I2Cboard, It has 4 pins VCC are connected to 5v, GND to ground. On Arduino UNO board, SDA (data line) is on analog pin 4, and SCL (clock line) is on analog pin 5. In receiver section the input solar panel is directly connected to the audio amplifier, the Amplifier is connected to 5V power supply and GND to the ground and the output pins are connected to the speaker.
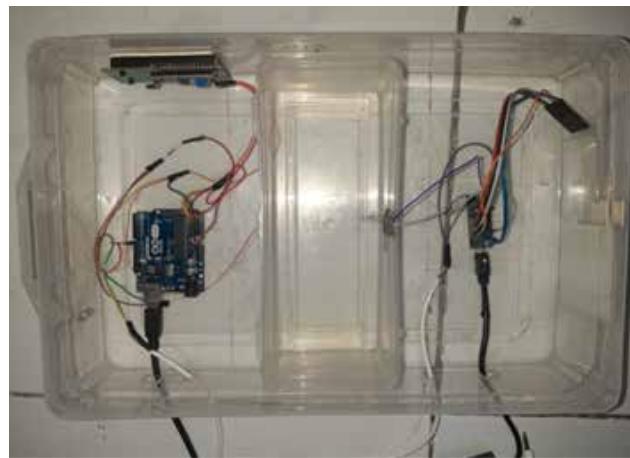
Figure 4. Receiver

Working

Li-Fi is a wireless communication technology that uses light to transmit data bidirectionally and create a fully networked wireless connection. The Li-Fi network comprises several light bulbs that form a wireless network. LED light bulbs, which are semiconductor devices, emit a stream of light (photons) when an electric current flows through them. The brightness of the light emitted by LED bulbs can be modified at extremely high speeds, allowing data to be transmitted by modulating the light at different rates. After modulation, the signal is detected by a receiver that interprets the variations in light intensity as data. Digital 1 is transmitted when the LED is on, while digital 0 is transmitted when it is off, but the human eye cannot perceive the rapid changes in brightness. This method allows for fast transmission of data via a LED light bulb, as well as bidirectional communication. To start, data is inputted into our system via a laptop or keyboard. Next, we create a message that will be transmitted from the transmitter

circuit to the receiver circuit and then displayed on the receiver's end. The Arduino is programmed to encrypt and convert the data into a different format once it is sent to the circuit. Subsequently, the Li-Fi transmitter circuit will receive this encrypted data. To transfer the data to the receiver side of the circuit, we will use a light sensor and water as a medium. Once received, the data will be processed by the receiver Arduino circuit, which will specify and display it on the screen at the receiver's end.

RESULT

Figure 5. Experimental Setup

In this project our objective was to transfer text data and audio data using light, this technology is known as Li Fi or Light Fidelity. Li-Fi uses Visible Light to transfer data in binary form by changing the intensity of light. We used different mediums like air, clean water, salty water and muddy water and compare all the results which are given below in the table. The results for different mediums which we had tried are as follow:

Air Medium

For air medium, we did not notice any delay and all Figure 5. Experimental Setup

In this project our objective was to transfer text data and audio data using light, this technology is known as Li Fi or Light Fidelity. Li-Fi uses Visible Light to transfer data in binary form by changing the intensity of light. We used different mediums like air, clean water, salty water and muddy water and compare all the

results which are given below in the table. The results for different mediums which we had tried are as follow:

Air Medium

For air medium, we did not notice any delay and all inputs were the same as we type on the keypad. And for audio transfer, audio was clearly audible on the receiver side without any decline in volume. We used a portable speaker on the receiver side to clearly hear audio send using LED. From this, we can conclude that air does not affect Li-Fi communication system for both audio and text.

Clean Water

The main aim of this project is to transfer data underwater without affecting the data and with the lowest delay as possible. For clean water, the audio was clearly audible without any distortion or effect on the volume. And we received all the text on LCD correctly as we typed. Like air medium water also does not affect Li-Fi communication. As long as there is no disturbance between the transmitter and receiver, water depth does not affect light communication.

Salty Water

For salty water, we received different results than air and water medium. Approximately 2 out of 10 keypad presses were not received by LDR sensor. and for audio, we did not notice any latency or distortion in audio clarity but we did notice a decline in volume level this decline was approximately 20% to the overall volume. From these results, we can conclude that salty water is not as good medium as air and water but this shortcoming can be dissolved by using different color LED or by using LASER.

Muddy Water

For muddy water, we received completely different results than all of the above mediums. We won't able to receive text data as we type but we received audio without any delay and distortion but the effect on volume level was very noticeable, nearly 50% of the original volume. From these results, we can say that we have to either change LED parameters (color, type) or the light detector sensor to a more sensitive sensor to receive correct outputs.

Table 2: Text Data Transfer Results

Medium	Accuracy	Delay	Impact	Refractive Index
Air	100%	No	No	1.0003
Clean				
Water	100%	No	No	1.33158
Salty				
Water	80%	Yes	2/10 char received	NA
Muddy				
Water	0%	NA	Not possible with normal LED	NA

Table 3: Audio Data Transfer Results

Medium	Accuracy	Delay	Impact	Refractive Index
Air	100%	No	No	1.0003
Clean				
Water	100%	No	No	1.33158
Salty				
Water	100%	No	Effect on audio by 20%	NA
Muddy				
Water	100%	No	Effect on audio by 50%	NA

CONCLUSION

Li-Fi is currently generating significant attention as it presents a promising and highly effective alternative to traditional radio-based wireless communication. With the rise in the number of people and their devices using wireless internet, the wireless frequency spectrum is becoming congested, resulting in difficulties in receiving a stable and high-speed signal. One potential benefit of this technology is that it could address problems such as the limited availability of radiofrequency spectrum, and enable internet connectivity in areas where traditional radio-based wireless systems are restricted, such as airplanes or hospitals. However, a limitation of this technology is that it requires direct line of sight to

function. Although there is still much work to be done before this technology becomes commercially viable, it holds immense promise for the future of wireless internet. This idea, which claims to address the issues of a shortage of radio spectrum, available space, and of slow internet connection speed, is currently the focus of a sizable number of researchers and businesses. By implementing this technology, we can transition to communication networks that are greener, cleaner, and safer. The mere idea of Li-Fi makes promises to address problems like a lack of radio frequency bandwidth and the shortcomings of radio communication technology. Li-Fi is a new and evolving technology that serves as a catalyst for a number of other emerging and novel ideas and technologies. Therefore, the creation of future Li-Fi applications that can be expanded to multiple platforms and diverse spheres of human existence is assured.

REFERENCES

1. Anushka Sanjay Patil, D. Ramrao and Pawan Alhat, "Wireless communication for underwater craft using Li-Fi", Novateur publications International journal of Innovations in engineering research and technology.

2. Angayarkanni S., Arthi R., Nancy S., "Underwater Communication Using Li-Fi Technology", IJESC research article.

3. Maideen Abdhulkader Jeylani, B. Achuthan, B. Arunkumar, M. Boobalan and R. L. Chiragsun "Underwater visible light communication using LiFi", EasyChair Preprint.

4. Prof. B..R. Thawali, Deshmukh Vishvajeet, Mhaske Nawanath V, Shirgire Vitthal "Ship to ship communication using LiFi technology", Volume No.03, Issue no.01, January 2015.

5. Anand Kumbhar, Sandip Hujare, Abhishek Kadam, Mukesh Salgar, "Underwater communication using Li-Fi", International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering.

6. S. U. Lakshmeesh, K. S. Karthik, Nagabhushan Hegde, C. N. Ramya, "Underwater communication using Li-Fi", International Journal of Research in Engineering, Science and Management Volume-3, Issue-3, March-2020.

7. Lian-Kuan Chen, Yingjie Shao and Yujie Di, "Underwater and Water-Air Optical Wireless Communication", "Journal of lightwave technology", vol.40, no.5, March 1, 2022.

8. Pranav Medhakar, Sumeet Mungekar, Vinayak Marathe, Vijay Mecharwade," Visible light underwater communication using different light sources", IJMTER, e-ISSN No:2349-9745, 28-30 April, 2016.

9. Harald Burckhardt, Nikola Serafimovski, Dobroslav Tsonev, Stefan videv and Harald Haas., "VLC: Beyond point to point communication "at Conference Paper University of Edinburgh at Nov-2013.

Connected Cars and Hybrid Bikes: Technological Review, Challenges and Applications

Payal Kadam, Vaishali Upadhyay,
Namita Shinde
Dept. of E & TC
Bharati Vidyapeeth (Deemed to be University)
College of Engineering,
Pune, Maharashtra
✉ payalskadam94@gmail.com
✉ vaishaliupadhyay47@gmail.com
✉ namitakshinde@gmail.com

Mayur D. Jakhete
Dept. of E & TC
G .H. Raisoni Institute of Engg. and Business Mgmt,
Jalgaon, Maharashtra
✉ mayur.jakhete@raisoni.net

Ranjeet Vasant Bidwe, Bhushan Zope
Dept. of CSE
Symbiosis Institute of Technology
Symbiosis International (Deemed University) (SIU),
Lavale, Pune, Maharashtra
✉ ranjeetbidwe@hotmail.com
✉ bhushan.zope@hotmail.com

ABSTRACT

In India, internal combustion engines and the preferred fuel are used in majority of vehicles. With a variety of scooters, motorbikes etc. Cars and passenger commuter vehicle models that can operate solely on electricity, the market for electric vehicles has created new opportunities. In a developing market like India, hybrid technology is the connected middle ground with enormous possibilities.

A dual mode hybrid vehicle lets us drive our existing moped or bike in both petrol and electric modes with just a bottom switch. Vehicles can be converted into fully electric by removing the fuel tank and ICE engines, or a hybrid by adding an electric motor and battery without removing the petrol components. Green Tiger Mobility Pvt. Ltd. converts our vehicle into a hybrid. The bigger vehicles can be converted into hybrid vehicles, but Green Tiger Mobility focuses on two- wheeler moped and bikes only.

The environment has recently received attention, and there is a pressing need for cleaner fuel choices. The need for cleaner transportation is growing, which has increased the use of electrical power for transportation and decreased dependency on cars. One of these is the "hybrid two-wheeler" we have. The implementation of the most effective and environmentally friendly vehicle was the project's aim. In our proposal, the hybrid electric vehicle model combines a normal vehicle's internal combustion engine with an electric vehicle's battery and motor, resulting in a conventional vehicle's fuel efficiency being doubled. For two-wheelers, we put this hybrid electric vehicle plan into action.

KEYWORDS: *Connected Vehicle, Electric vehicles, Hybrid electric vehicles.*

INTRODUCTION

The essential tenet of the CV environment is the power of wireless connectivity, namely V2V communications (vehicles to vehicles), V2I communications (vehicles to infrastructure), and Wireless communications for collision avoidance (which increased mobility and environmental sustainability).

There are currently two perspectives/approaches on the future of connected vehicles: the Google approach, which sees connected vehicles as fully automated, also known as autonomous vehicles (AV), and using connectivity to drive themselves, and the U.S. Vehicle Manufacturers approach, which sees connected vehicles as still having manual vehicle control while utilizing

continuous real-time connectivity among vehicles and infrastructure. [1]

The adoption of electric vehicles (EVs) can significantly reduce greenhouse gas emissions. In addition to reducing dependency on fossil fuels, EVs also limit ozone-depleting substances and support widespread renewable energy deployment. Electric vehicle production and network modelling continue to evolve and are constrained despite substantial research on the features and characteristics of electric automobiles as well as the makeup of their charging infrastructure. This article discusses the many modelling techniques and optimization methods used to analyze market penetration rates for electric vehicles, hybrid electric vehicles, battery electric automobiles and plug-in hybrid electric vehicles. [2]

Although obtaining and collecting correct data about their surrounding environment is a major feature in the connected vehicle technologies, CVs will benefit from having powerful and efficient sensing and networking capabilities. The capacity to gather accurate and comprehensive data about the surrounding environment will be a crucial necessity for the connected automobile to realize its full potential. Using advanced sensor technology that detects a automobile's immediate environment is the first step in this process. Radar, sensors, and cameras with high resolution that can pinpoint entities up to 120 meters away—within one centimeter—are among the equipment that will be crucial in gathering this data.[3]

CONNECTED CARS

Introduction

A connected car is one that has built-in or external Internet access, as well as a variety of contemporary apps and dynamic contextual functionalities that provide the driver and passengers with cutting-edge infotainment features. It can also communicate with other smart devices on the roadway or in restore shops by utilizing technology for vehicle-to-road infrastructure connectivity [11]. Vehicle connectivity has a lot of promise. Several manufacturers already provide drivers with convenience services like Internet radio, linked mapping, emergency dispatch, and concierge. Semi-autonomous driving features have recently been added
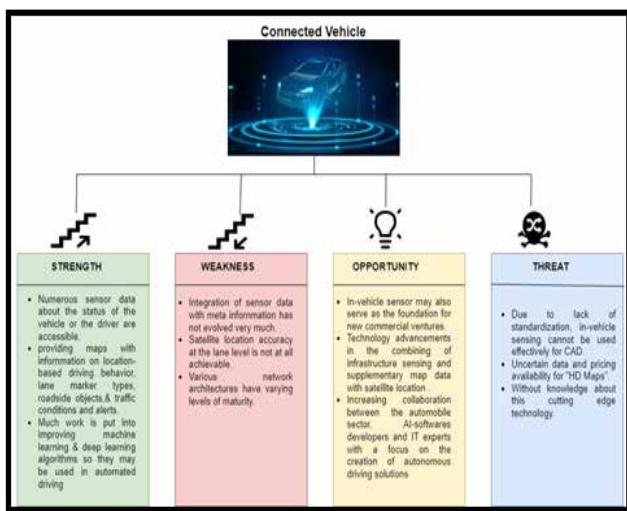
to Tesla Motors' automobiles. It's simple to get caught up in the advantages, but it's crucial to clarify what makes an automobile connected in the first place. An automobile needs a communication system, to put it simply. The telematics control unit is the primary part of automobiles that allows the car to connect, despite the fact that there are many technologies scattered throughout the vehicle.[4]

Literature Review

For more than a century, the automotive industry has been under pressure to improve and advance, with each new technological advancement bringing with it more desirable features that can be added to automobiles. From the initial release of minor software components in automobiles more than 30 years ago, a huge variety of distinct services have begun to build on new enabling technologies, resulting in a babel of architectures, platforms, and software. The linked automobile, entails a car with an internet connection, communicate with additional vehicles and a network of roads, and gather data in real time from multiple locations, is projected to play a crucial part in the forthcoming Internet of Things.[11]

The innovative "intelligent car" project known as connected vehicle (CV) is quickly becoming the next big thing in traveler empowerment technology. The creation of a comprehensive Intelligent Transportation System will enable this technology to, among other things, boost the capacity of current transportation networks and improve roadside safety for drivers.[1]

The Groupe Speciale Mobile Association (GSMA) forecasts that in 2015, more than 50% of cars sold globally will be linked, and that the connected car business will generate $27.8 billion in sales. The linked services, telematics service, telecom, and hardware industries now dominate the industry. Around 65% of the industry is expected to go to services, which include entertainment, contact center help, traffic advice, and many more. For customer relationship management, telematics systems deliver data from the vehicle to dealers and insurance companies. Dealers can remotely diagnose problems and alert drivers in advance of them occurring; insurance firms can provide more affordable coverage options based on the amount of driving.[4]

Figure 1: Strengths, Weaknesses, Opportunities, and threats in connected cars

Benefits

Provides access to several entertainment services

The term "in-vehicle infotainment" refers to a group of automotive technologies that work together to provide the driver and passengers with entertainment and information via audio/video interfaces, touch screen displays, button panels, voice commands, and other input methods. Therefore, this function aids in providing entertainment in vehicles.

Provides third-party apps for the navigation system

The GPS system in a car uses a satellite to determine the vehicle's present position. The technology leverages cellular network data in the absence of GPS data. The system may update statistics on traffic activities and traffic accidents by using data from other linked devices. A third-party app is one that establishes a connection with another service in order to offer better functionality or access profile data.

Includes contemporary safety measures to assure the highest level of road safety

Connected vehicles recommend moderate driving lengths and speeds to alert the driver of any potentially dangerous conditions. A premium connected car will also have parking sensors and a rearview camera. Other sensors are incorporated in some vehicles to gauge air pressure and alert the driver.

Functionality

Internet access in vehicles

A connected vehicle may access the internet as long as there is reliable wireless network coverage since it is constantly linked to the internet through an inbuilt chipset or SIM card. Additionally, connected vehicles can offer onboard Wi-Fi, download manufacturer-released over-the-air updates, and use other internet apps and services.

Car-App Connectivity

These days, automakers offer a special smartphone app that communicates with the vehicle through a wireless network. The software enables users to remotely handle a car's features including door locks and unlocks, sunroof openings, engine starts and stops, climate control, lights on/off, and horn blares. Using the inbuilt GPS, the app will also assist in finding the vehicle.

Providing protection to young drivers from curfew

Geo-Fencing is a crucial security component included with linked automobiles. In layman's terms, it draws a border around a location on a map and notifies the owner if the car crosses it. If you are concerned about young or inexperienced drivers driving the car, the geo-fencing feature, which can be configured using the smartphone app, will be quite helpful.

V2V Connections

Technology for vehicle-to-vehicle connection enables communication between linked automobiles. Sharing of important data, including traffic flow, road conditions, speed restrictions, and many other things, is made possible via the V-2-V. Autonomous cars, which are seen as the form of transportation of the future, will be a vital component of V-2-V technology.

Media

You may connect to a variety of entertainment services and apps that are already pre-loaded in a linked car. When the car is parked, you may browse films, listen to music, or even listen to internet radio. Additionally, you may use applications to remotely control the audio and video by connecting your smartphone to the car's infotainment system.

Challenges

The essential problems with CV technology are identified. In an effort to further the future development and application of CVs technology, recommendations and proposals for overcoming these difficulties are explored.

Combining computation and communication

Cooperative computation's actual implementation and scalability are significantly hampered by the dynamic nature of CVs. This is in addition to the special qualities and restrictions of vehicular networks, which include fast channel fading, deterioration that may be brought on Doppler effects, as well as a number of other factors, such as connection and transmitting multimedia files between cars, may alter the precision and efficacy of the communicated data [6].As a result, the reliability and efficiency of computing performance are also significantly impacted. This increases the processing constraints of cloud computing, that is lengthy processing delays and significant data transfers. Network capacity, congestion in traffic, and wireless channel status are all factors that contribute to high latency in cloud computing, which hinders effective real-time and dependable processing.[7]

Over-the-Air updates

The car industry benefits greatly from remote OTA software updates since they are quick, efficient, and allow drivers to download upgrades from any location at any time. Yet, these updates still create serious security concerns. This is due to the fact that upgrading Electronic Control Unit software would necessitate full access to in-vehicle communication networks. [8,9]
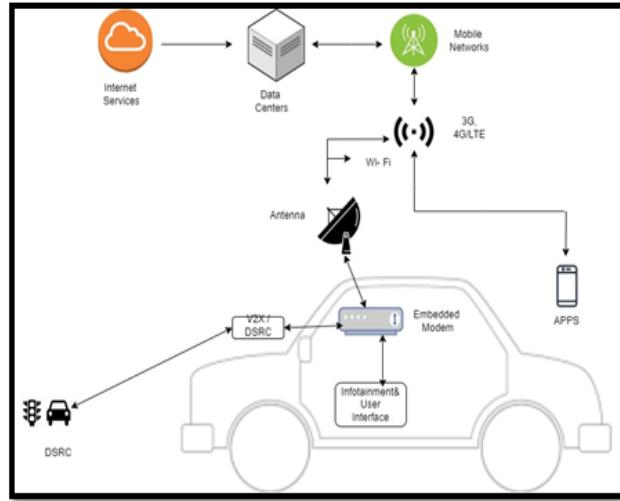
Security and Privacy

Among the most dangerous privacy breaches are those that target the drivers' driving styles and the geographic location of the cars. When a vehicle's privacy is violated, malevolent attackers can obtain time series data on the position of the vehicle. Time series data may be acquired in this scenario via disseminate information offered by the car or obtained from data sent through cellular networks to data services facilities. Attackers can also carry out privacy violations that target data on driving habits that can help reveal personal and confidential information about the person who drives. [10]

General Architecture

The connected automobile architecture shown in the above figure includes several hardware components that can communicate relating to the outer world. The equipment's with which the automobile can communicate with anything outside of it are as follows:

Figure 2: General Architecture of Connected Cars

- V2X/DSRC: Vehicle-to-everything is a word that describe connection between vehicle and infrastructure or another vehicle. It's expected that V2X standards, which are presently being developed, would use a technology called DSRC.

- The TCU/Embedded Transceiver: Embedded modem is normally housed inside the TCU, which gives the automobile access to the Internet through a third-generation (2G), third-generation (3G), or fourth-generation (4G) cellular connectivity.

- Multimedia: Radio, entertainment, and media capabilities are provided by the multimedia system, which also serves as the vehicle's user interface (UI), and ability for driver to establish a Bluetooth or wireless network connection.

- Dedicated Short Range Communication is a wireless channel for communication with a short range that is designed for usage in cars. It makes use the design use the 5.9 GHz band of frequencies.

- Cellular Network (3G, 4G): The mobile telecommunications standards 3G and 4G. Based on a collection of mobile communication guidelines that you must follow in order to access the services and networking. Wireless technology is a 2.4 and 5 GHz band-based local area wireless communication system.

- Bluetooth: Low-powered, radio waves with minimal range that operates in the 2.4-2.48 GHz range for communication.

- NFC: Near Field Communication (NFC) transmits wireless information at a rate of 424 Kilobits/s across a limit of 4–10 cm at a frequency of 13.56 MHz[18]

HYBRID BIKES

Introduction

In a hybrid bicycle, a battery and a petrol engine are joined, and the bike is propelled forward by the combination of both of the power sources. Because of this, the motorcycle can use less petrol and obtain additional gasoline economy than a standard motor can. Electric power improves the performance of the engine. Hybrid cars, with the exception of plug-in hybrids, do not need to be recharged because their batteries are charged internally. In between traditional bicycles and all-electric cars are plug-in hybrids. As a result, they may charge their battery by "plugging in" to an external electrical source while still running on both electrical motor with an internal combustion engine.

The environment has recently received attention, and it appears that there is a pressing need for cleaner fuel choices. The need for cleaner transportation is growing, which has increased the use of electrical power for transportation and decreased dependency on cars. Then, one element is our "hybrid two-wheeler." The implementation of the most effective and environmentally friendly vehicle was the project's aim. In our proposal, the hybrid electric vehicle model combines a normal car's combustion engine and battery-powered electricity and motor, resulting in a conventional vehicle's fuel efficiency being doubled. For two-wheelers, we put this hybrid electric vehicle concept into practice.[12]

Literature Review

For EVs needing a Ma Xianmin developed a ground-breaking propulsion system design strategy for high power density. According to the dynamic features of the vehicle, theoretical analysis mathematical models of EVs are first constructed. The system is then seven distinct functional sections in accordance The MATLAB programming language is used to generate simulation models with power flow. The simulation results are verified in a PDM AC-AC converter, proving that the suggested strategy is appropriate for EVs.[13]

Simic and Bauml talked on the value of vehicle simulations in the development of hybrid electric cars. With the help of the simulation language Modelica, a series hybrid electric car simulation was created. They described the simulation strategy. Several of the simulation findings highlighted the significance of the exercise as they came to a conclusion.[14]

Emadi et al. concentrated more electrical electronics as a key innovation for the creation of charge-able hybrid electric cars and adoption of cutting-edge electrical designs to handle the needs of rising electric load demands. A brief summary of current trends, future vehicle strategies, and the function of power electronic subsystems is provided. For the successful development of these vehicles, the needs of power electronic parts and electric motor drives are also addressed.[15]
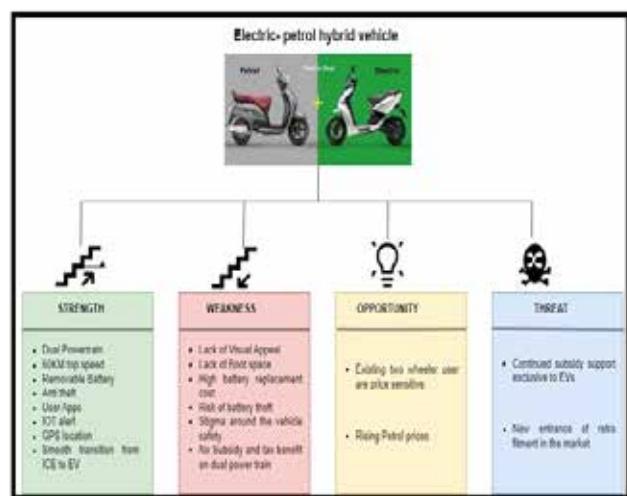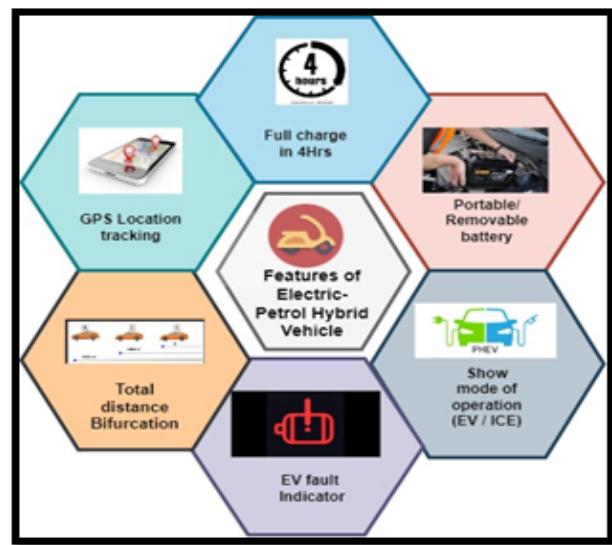
Figure 3: Strengths, Weaknesses, Opportunities, and threats in connected cars

Benefits

- Estimated range based on battery percentage : Almost 40% of all potential EV drivers are concerned that they won't be able to charge their car when they need to and are terrified to run out of battery on the road, according to a Mobility Monitor Study. With the help of this feature, we can determine our expected journey distance based on the amount of battery life left.

- Battery Charging State: In order to correctly measure the battery voltage and calculate how much charge is still in the batteries, state of charge meters are used in electric vehicles. With the help of this function, we can determine how much battery is being used and how far the vehicle can travel on the remaining charge.

- Total Distance Bifurcation (EV & ICE):As the hybrid vehicle uses two or more distinct types of power to run, so this feature allows us to know the total distance covered by the vehicle while running on ICE engine as well as the total distance covered while running on battery.

- ECO Score Previous Trip Information: The eco-driving score calculates the energy difference between the amount used and the least amount needed to complete the trip. This rating is created by contrasting the driver-achieved vehicle travel speed with a reference speed trajectory. So this feature let us to know that how much was our eco score in the last trip which helps in making the vehicle eco-friendly.

- Servicing:

  Bike maintenance is comparable to a man's general health examination, which is really more crucial than the latter but not less so since a living thing has self-cleaning and self-repairing mechanisms, but a bike does not. To keep your bike in the best shape, you should perform it on a regular basis as advised by the dealer or manufacturer. So to let the user to not to bother about the checking of app manually, this feature automatically alerts the user if any sort of problem arises into the vehicle.

Figure 4: Features of Hybrid Vehicle

Challenges:
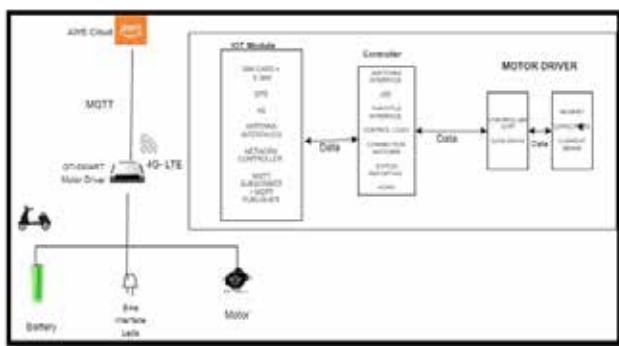
- Insufficient visual appeal:

  Over time, visual attractiveness has developed into a significant commercial selling feature. This transition is represented by the emergence of personal branding. According to a research by HP, whereas only 20% of what we read in text is recalled in our minds, the retention rate for images is 80%. There is no more effective way to communicate our brand identity's originality, difference, and value than through generating a strong visual impact. A strong tool for communication is visuals. A key component of branding that may make a lasting impression on our customers is visual attractiveness.

- Limited boot space:

  The amount of space for storage a car has for groceries, baggage, and other stuff is referred to as the boot space. Therefore, it's a crucial element to check for when buying a vehicle.

- Expensive battery replacement:

  Considering that the car is a hybrid and that a battery is an integral component of it. Therefore, anytime a battery becomes damaged, a new one needs to be installed. The main disadvantage of hybrid electric-petrol vehicles is the high cost of battery replacement.

• Battery theft danger:

As it is a hybrid electric vehicle so the batteries are installed in it. Since the battery attached to vehicle are easily removable hence there is a lot of chanced to get it theft. The battery can easily be detached from the bike and can be stolen which is the biggest challenge faced by electric-petrol hybrid vehicle.

General Architecture

The above figure depicts the general architecture of electric-petrol hybrid vehicle. There are several hardware components which allows the electric- petrol hybrid vehicle to share its data with the cloud and then to the user. The hardware components are as shown in figure no. :

Figure 5: General architecture of Hybrid Bike

• Battery: As it is a electric-petrol hybrid vehicle so a battery is installed in the ICE bike. This hybridization helps in making the vehicle more environment friendly. The battery installed is removable so it can easily be detached from the bike in order to charge or replace it.

• Motor: Motor is a very important part in any vehicle. These motors are used to store energy within the vehicle. An internal combustion engine which utilize energy stored in batteries work together to power hybrid-electric car. A hybrid electric vehicle's battery cannot be charged by plugging it in. Instead, internal combustion engine and regenerative braking are used to charge the battery.

• GT-Smart Motor Driver: A motor driver is a machine used to power motor. However, without a microcontroller, motor driver chips cannot run a

engine. The connection among the motor and the microcontroller is demonstrated via a motor driver. The motor and microcontroller operate on distinct voltage ranges, which is the reason for this. The microcontroller will draw less current than the engine does. When connecting two devices that run at various current levels to a power supply voltage, we need a motor driver module. A motor serves as a third component in this scenario, stepping up or down the voltage supply.

• AWS Cloud: AWS is made to enable suppliers, ISVs, and application provider to swiftly and securely host our apps, whether they are SaaS - based or not. The web application device, operating system, language of programming, and database are all options and another services we require thanks to AWS. With AWS, we have a virtual environment into which we may install the programmes and services that our application needs.

Future trends of connected vehicle

In the next months, millions of linked automobiles will be on the road, and they will be at the core of the developing Internet-of-Things scenario. Cars will become more and more connected with both user residences and external gadgets. Leading Manufacturers are introducing ideas for the fusion of homes and automobiles. Ford, which is looking at the prospect of combining its SYNC systems with the smart-home services provided by Amazon Echo and Wink, and BMW, which is attempting to improve user experience by integrating all of its gadgets in the "Open Mobility Cloud," are two examples.[11]

The CVs technology presents several difficulties while also creating new opportunities, uses, and services. The transition to keyless automobiles, computerized parking maps, intelligent traffic management, and eco-friendly settings are just a few examples of these cutting-edge applications and services. This is brought about by the proliferation of in-vehicle sensors and improvements in inbuilt computing interpreting, networking purposes, and communication, which allow for innovative applications that offer a safer, more comfortable, and environmentally friendly manner of driving. [16]

By integrating the benefits of both systems and utilizing both power sources when they are most effective, a

hybrid vehicle may solve a variety of issues. The hybrid setup also gives the car a dynamic appearance. Also, it aids in lowering harmful emissions and improving fuel efficiency. The bike's mileage also significantly rises because it can operate in both modes, which is a bonus. A hybrid bike is highly profitable since it lowers operating costs and thereby addresses the issue of rising fuel prices.[17]

CONCLUSION

The forms of linked automobile integration will develop in a variety of ways during the next few years. The use of embedded forms is anticipated to increase. Smartphone (or integrated) variants will also be common, although as software becomes more cloud-driven, this sort of integration may not be as necessary in the long run.

A hybrid electric vehicle (HEV) employs a battery and fuel as power sources. There is little hope of travelling quickly in congested urban areas. When this happens, IC engines use more gasoline than they should because of the fluctuating acceleration. The amount of electricity consumed by the vehicle is decreased if the hub motor is powered by a battery. A new field of technology, hybrid Petro-electric bikes answer the problem of natural resource scarcity and are environmentally beneficial. The entire turn-on of these types of vehicles is extremely profitable for the future.

REFERENCES

1. Khair Jadaan, Sana Zaeter, Yazan Abukhalil " Connected Vehicle: an Innovative Transport Technology" ELSEVIER , December 2017

2. DV LaLith , Gautam C Ghatge, Kaustubh G Setloor "Electric and Hybrid electric vehicles", IJ RAR, Volume 8, Issue 4, December 2021

3. Spectrum "The Car in the Age of Connectivity Enabling Car to Cloud Connectivity." IEEE. (accessed on 12 July 2021).

4. Praveen Kollaikal, Sridevi Ravari, Eddic Ruvinsky "Connected Cars"

5. USDOT ITS Research "Connected Vehicles" 2015-2019

6. Zhou J.; Tian D.; Wang Y.; Sheng Z.; Duan X.; Leung , V.C. " Reliability optimal cooperative communication and computing in connected vehicles system IEEE Trans 2019

7. Zhang J.; Letaief , KB. " Mobile Edge Intelligence and computing for the Internet of vehicles" IEEE 2020

8. Halder S.; Ghosal, A.; Conti, M.; " Secure OTA software updates in Connected Vehicle : A Survey" arXiv 2019

9. Boehner, M. "Security for Connected Vehicle throughout the entire life cycle" ATZelectronics Worldw, 2019

10. Othmane, L.B.; Weffers, H.; Mohamad, M.M.; Wolf, M. ; " A survey of security and privacy in connected vehicles. In wireless sensor and mobile Ad-hoc networks" Springer, 2015

11. Coppola, Riccardo; Morisio,Maurizio, "Connected Car: technologies, issues, future trends." Volume 49, September 2019

12. Shaikh Abdul Muqtadir, Shaikh Ameer Hamzah, Quazi Muneeb Ilyas, Nandkishor D. Bankar. " Design and development of hybrid bikes" IJMER, March 2021.

13. M. Xianmin. " Propulsion System Control and Simulation of electric vehicle in MATLAB software environment" in Intelligent Control and automation, Volume 1, IEEE, 2002

14. T. Bauml and D. Simic "Simulation and comparison of different energy measurement strategies of a series hybrid electric vehicle" in vehicle power and propulsion conference, IEEE, 2008

15. A. Emadi, Y.J. Lee and K. Rajashekara , " Power Electronics and motor drives in electric hybrid electric and plug-in hybrid electric vehicle", IEEE Transactions on industrial electronics, volume 55, 2008

16. Ghadeer Abdelkader, Khalid Elgazzar, Alaa Khamis, " Connected Vehicles: Technology Review, State of the Art, Challenges and Opportunity" Sensors, November 2021

17. Pooja V. Lokhande, Tejas V. Devrukhkar, Aniket V. Naigade, Sajid D. Inamdar, Akshata S. Yadav, " A Review of Hybrid Electric Bike" IRJET, Volume 8 Issue 7, July 2021

18. Husien Dakroub, Adnan Shaout, Arafat Awajan, " Connected Car Architecture and Virtualization" SAE International Journal of Passenger Cars- Electronic and Electrical System, April 2016

Automated Diabetic Retinopathy Diagnosis through CNN-based Analysis of Retinal Fundus Images

Rohini Khalkar, Ayush, Utkarsh Chaudhary

✉ rohini.khalkar@bharatividyapeeth.edu

✉ ayush.agr20@gmail.com

✉ chaudharyut25@gmail.com

Sarthak Bhasin, Kumar Chandranshu
Sampat. P. Medhane

✉ sarthakbhasin667@gmail.com

✉ kumarchandranshu86@gmail.com

✉ spmedhane@bvucoep.edu.in

Department of Computer Engineering
Bharati Vidyapeeth (Deemed to be University) College of Engineering,
Pune, Maharashtra

ABSTRACT

Diabetic Retinopathy (DR) is a prevalent consequence of diabetes that has the potential to result in the impairment of one's vision if left untreated. Effective treatment of Diabetic Retinopathy (DR) heavily relies on the timely detection of the condition. Early identification is of utmost importance to ensure optimal outcomes and successful management of DR., but traditional screening methods can be time-consuming and require specialized equipment. In recent years, deep learning techniques have shown promise in detecting DR from retinal images. This paper provides a comprehensive review of the latest research on the detection of diabetic retinopathy (DR) using deep learning techniques. It focuses specifically on the utilization of convolutional neural networks (CNNs) and transfer learning methods in this field. The paper also discusses the challenges of developing accurate DR detection models and the need for large, diverse datasets. Finally, the paper highlights the potential impact of DR detection using deep learning on improving the speed and accuracy of DR screening, particularly in resource-limited settings. The Kaggle platform provides access to the dataset used in this study, which consists of patient fundus eye images and includes five stages of diabetic retinopathy (DR) categorized as 0, 1, 2, 3, and 4. Using these images as input parameters, the proposed architecture achieved a DR detection accuracy of 0.9611 by using Squeeze Net.

KEYWORDS: *Deep learning, Fundus image, Squeeze net, Convolutional neural network, Diabetic retinopathy.*

INTRODUCTION

Diabetic retinopathy is a medical condition that can have adverse effects on the eyes of people with diabetes. The cause of the condition can damage the retina of an eye, which is the part of the eye that senses light and helps us see. Prolonged high blood sugar levels can gradually result in the leakage or blockage of blood vessels, leading to retinal damage. Symptoms commonly associated with diabetic retinopathy encompass blurred vision and the presence of dark spots or streaks which make difficulty seeing at night. In some cases, there may be no symptoms at all. The image below shows the difference between normal retina and diabetic retinopathy:
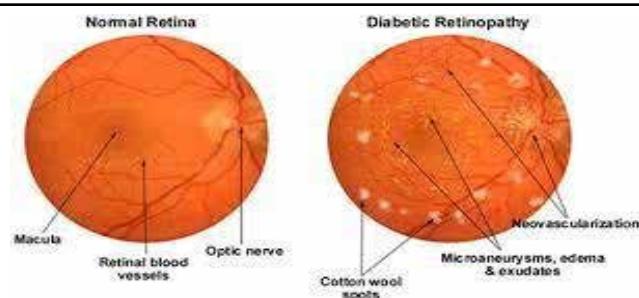
Fig1 Normal vs Diabetic Retina

LITERATURE REVIEW

The topic in question provides an overview of current methods that utilize "Deep Learning" for the early automatic detection of DR.

Deep learning algorithm developed and validated for automatic detection of DR

Deep learning algorithm developed and validated for automatic detection of DR. using Convolutional Neural Networks (CNN) and the squeeze Net architecture is a significant contribution to the field of medical image analysis. Diabetic retinopathy is the root cause of blindness worldwide, and early examination and treatment are crucial for preventing irreversible vision loss. However, manual diagnosis of DR can be challenging and liable to errors, making the development of automated detection methods a critical area of research. The Squeeze Net architecture was chosen for its efficiency and ability to compress neural networks without sacrificing accuracy. This made it a suitable choice for the study, as it allowed the algorithm to process images quickly and efficiently while maintaining high accuracy. The Squeeze Net architecture achieved a validation accuracy of 96.5%, demonstrating its effectiveness in detecting DR. Overall, deep learning algorithm developed and validated for automatic detection of DR using CNNs and the Squeeze Net architecture is a significant advancement in the field of ophthalmology. The utilization of this deep learning algorithm holds significant potential in enhancing both the efficiency and accuracy of diabetic retinopathy (DR) diagnosis. This, in turn, can contribute to improved patient outcomes and a potential reduction in healthcare costs. Further research is needed to refine and optimize these algorithms for clinical use, but this study provides a promising foundation for future work in this area.

Fig 2 confusion matrix for the classification of the network

Table 1: Existing Vs Innovation work

Aspect	Existing work	Innovation work
Dataset	Utilizes publicly available diabetic retinopathy	Collects additional data through collaboration from Bharati Hospital
Feature Extraction	Handcrafted features extraction methods likeGLCM, LBP, HOG, etc.	Utilizes Squeeze Net Convolutional Neural Networks (CNNs) for automatic feature extraction
Robustness	May exhibit variability in performance due tosensitivity to variations in image quality.	Performs extensive testing and validation, ensuring robustness to various image conditions
Scalability	May not scale well to large-scale datasets andreal-time processing requirements	Explores strategies to handle large-scale datasetsand optimize the inference time
Future Scope	Limited exploration of emerging techniques like attention mechanisms	Explores cutting-edge research in deep learningand computer vision to enhance the diagnosis

DATASET

The dataset was obtained from the "Bharati Hospital" and is available on Kaggle. This dataset contains high-resolution retina images captured using a fundus camera. The images in the dataset were used to train a convolutional neural network (CNN) architecture to detect diabetic retinopathy (DR), a condition that affects the eyes of people with diabetes.

The clinicians who provided the dataset categorized the DR into 5 different classes:

- Not at all DR (class 0)
- Light DR (class 1)
- Ordinary DR (class 2)
- Acute DR (class 4)
- Excess DR (class 5).

The dataset contains separate folders for training
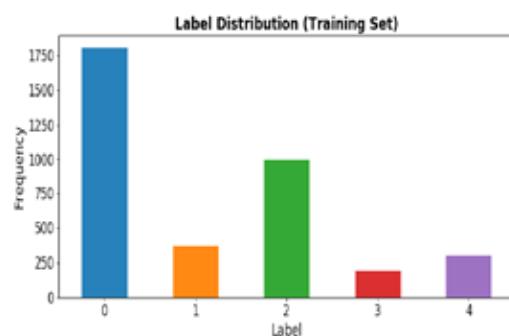
and testing data, as well as CSV files that provide information on the images, including their names and severity levels.

Fig 3: Sample Image

In addition to this dataset, the researchers pre-trained their CNN architecture using the Image Net dataset. The ImageNet dataset is an extensive compilation of photographs specifically curated for the development and advancement of computer vision, artificial intelligence (AI), machine learning, and deep learning algorithms. The dataset contains over 14Million eye images of animals, plants, medical images , and more. Pre-training their CNN architecture using the Image Net dataset helped to increase the precision of the model in finding DR.

The ImageNet dataset serves as an extensive compilation of photographs specifically intended for the advancement of computer vision, artificial intelligence (AI), machine learning, and deep learning algorithms and models. Our CNN architecture has already been trained with this dataset, which has helped to improve the accuracy of our Squeeze Net model. The datasetis used in various challenges, models, and algorithms, where subsets of images are trained from the Image Net dataset during annual competitions. The Image Net dataset contains approximately 14 million images, including animals, medical images, plant data, and more. The aim behind developing this dataset was to create a resource that could glorify research and evolving of better methods for computer perception, artificial intelligence, machine learning, and deep learning. By using this dataset, we can train our models with a large and diverse set of images, allowing them to accurately classify and recognize various objects in real-world scenarios.

Fig 4 Label distribution

The histogram presented above displays the distribution of the number of images for each stage of diabetic retinopathy (DR). The x-axis shows the labels of DR stages,while the height of each bar corresponds to the total number of images present in that stage.

METHODOLOGY

Convolution neural networks(CNNs) have shown good results in the automated detection of diabetic retinopathy. The Squeeze Net architecture is a CNN architecture that aims to reduce the number of specification while maintaining precision.

Fig 7 Deep Learning Framework

The methodology of a diabetic retinopathy system using CNNs, and Squeeze Net architecture involves the following steps:

1. Dataset Collection: Gather a large and diverse dataset of retinal fundus eye images, including both normal and diabetic retinopathy cases. The dataset should be properly annotated by expert ophthalmologists for accurate diagnosis.

2. Pre-processing: Perform pre-processing steps to enhance the quality and usability of the images. This may include resizing, cropping, normalization, and noise reduction techniques. Ensure that the images are appropriately labelled with their corresponding diabetic retinopathy severity levels.

3. Data Split: Divide the dataset into three subsets: training set, validation set, and testing set. The training set is used to train the CNN model, the validation set is used for hyperparameter tuning and model selection, and the testing set is reserved for final evaluation.

4. Dataset Collection: Gather a large and diverse dataset of retinal fundus eye images, including both normal and diabetic retinopathy cases. The dataset should be properly annotated by expert ophthalmologists for accurate diagnosis.

5. Convolutional Neural Network (CNN) Architecture: Design a suitable CNN architecture for the diabetic retinopathy diagnosis task. The architecture typically consists of convolutional layers, pooling layers, and fully connected layers.

6. Model Training: Train the CNN model using the labelled training set. During training, optimize the model's parameters using backpropagation and an optimization algorithm (e.g., stochastic gradient descent). Monitor the model's performance on the validation set to guide hyperparameter adjustments and prevent overfitting.
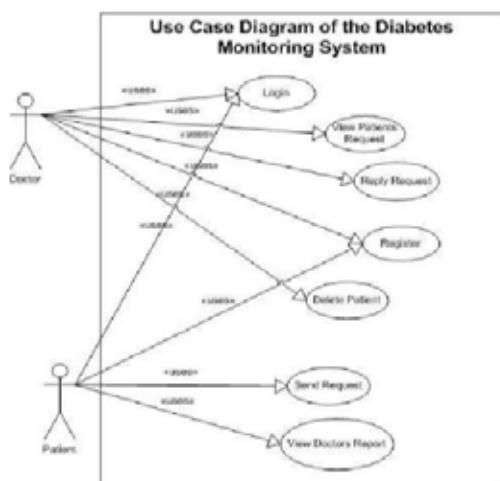
Fig 6. Use Case Diagram
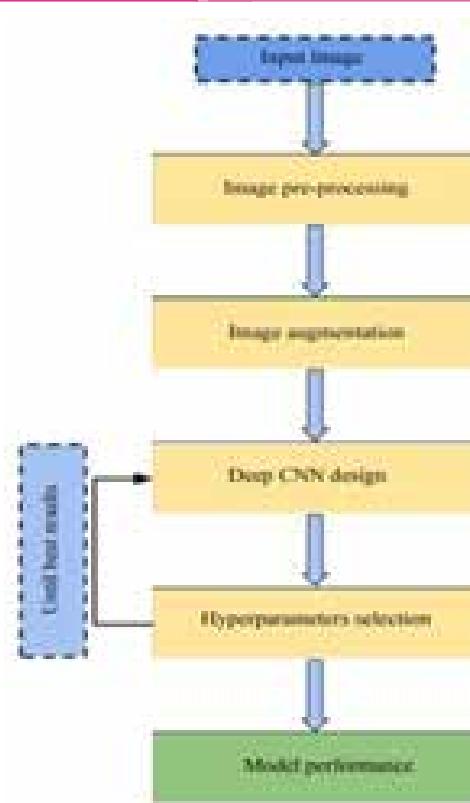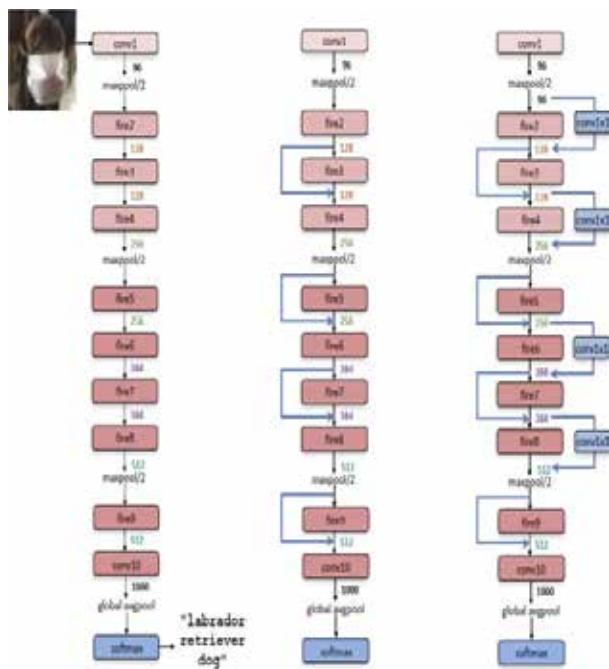
Fig 7. Flowchart

In our web app, we have integrated authentication to ensure the security and integrity of our services. Users are required to log in to our app before testing their eyes. After analyzing the test results, a report will be generated indicating the condition of the eye, which will provide information about the severity of retinopathy diabetic disease. The report will be generated in PDF format and can be further reviewed by doctors for appropriate medical treatment. Additionally, our app includes a feature that displays user data in the form of graphs, categorizes by gender and age group.

Compared to other popular CNN architectures such as Alex Net and VGG, Squeeze Net achieves similar accuracy with 50x fewer parameters. This makes Squeeze Net a light weight and efficient architecture for resource-constrained devices such as mobile phones and embedded systems.
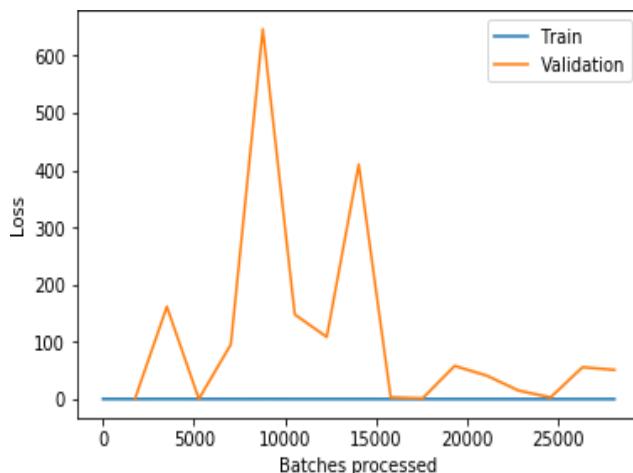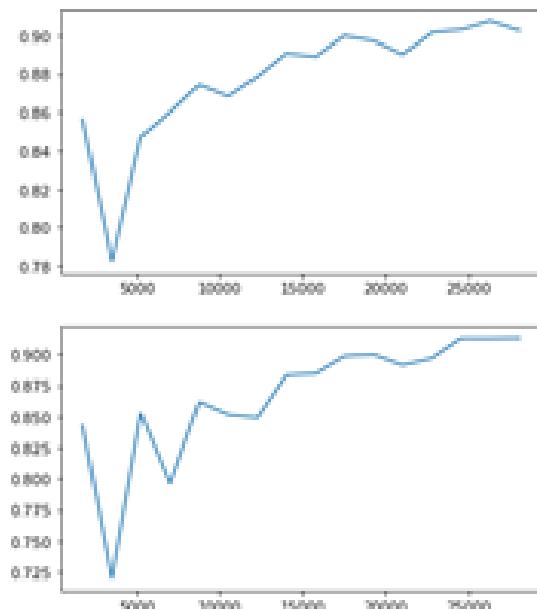
Squeeze Net has been used in a variety of applications,including image categorization, object detection, and medical imaging.

Fig 8: Squeeze Net Architecture
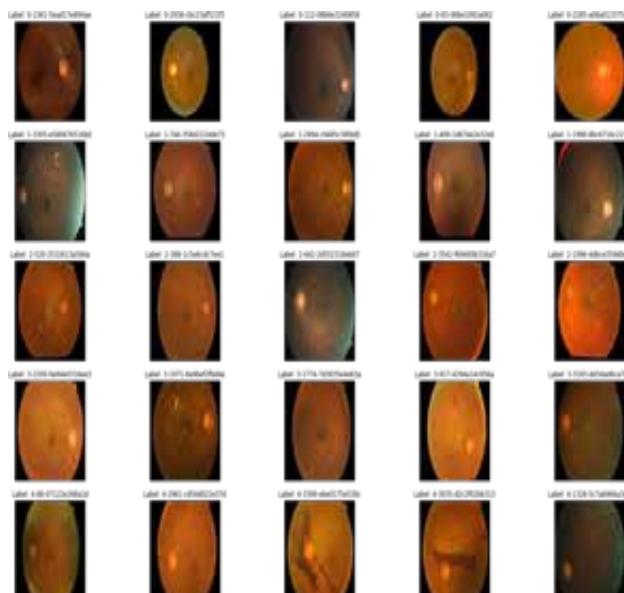
RESULTS AND ANALYSIS

Upon conducting the experiments, we obtained experimental results that illustrate the accuracy of our project. We used one architecture for the told dataset and saw the accuracy of squeeze net architecture.

Architecture	Dataset	Loss	Accuracy
SqueezeNet	Kaggle	0.7874	0.9026

Fig 9(a) Loss vs Batches processed

Fig 9:(b) Accuracies and losses of Squeeze Net

The above figures fig.9(a), fig.9(b) are shown the precision and loss of Squeeze Net construction where Squeeze Net construction used Image Net.

Fig 10: Sometes timages

It is possible to detect the severity of diabetic retinopathy (DR) in multiple images simultaneously. Figure8 demonstrates the detection of DR in multiple images, while Figure10displaysthe output for a single test image.

CONCLUSION

The automated examination of diabeticretinopathy (DR) using (CNNs) is a promising technique for early examination andtreatment of this complication. The squeeze Net architectureis a lightweight and efficient CNN architecture that canreduce the number of parameters while maintaining highaccuracy. Data preprocessing and augmentation techniques are crucial for improving the robustness of the model. Diabetic retinopathy (DR) is a vital concern for sufferers with diabetes, and the manual detection of DR is a time-consuming process. Therefore, we came up with an architecturefor the automatic examination of DR and used Squeeze Net Architecture, to determine their performance under different conditions. Our results showed that Squeeze Net with accuracy of 0.9026.

REFERENCES

1. Natural Library Of Medicine (National Center for Biotechnology Information).

2. Vishesh S1, Suraj S2, Ajay Singh Baghel3, Sayantika Paul4, Rohith Rajendra, "AI to Predict Diabetic Retinopathy: CNN to Build "retina.model"", International Journal of Advanced Research in Computer and Communication Engineerining, Vol. 11, Issue 9, September 2 September 22

3. Empowering Diabetic Retinopathy Screening: An End-to-End Mobile System Utilizing Lightweight Deep Neural Network(pp. 248-264)

4. Gauri Rao, Disha Gundo Pujari, Rohini G. Khalkar, Vidya Atish Medhe, "Study On Software Defect Prediction Based on SVM and Decision Tree Algorithm", International Journal on Recent and Innovation Trends in Computing and Communication, ISSN: 2321-8169

5. Harry Pratta , Frans Coenenb , Deborah M Broadbentc , Simon P Hardinga,c, Yalin Zhenga, "Convolutional Neural Networks for Diabetic Retinopathy", International Conference On Medical Imaging Understanding and Analysis 2016, MIUA 2016, 6-8 July 2016

6. Vishesh S, D S Pavan, Rishi Singh, Rakesh Gowda B, Prediction of Diabetic Retinopathy using Neural Network, International Journal of Advanced Research in Computer and Communication Engineering, ISSN (O) 2278-1021, ISSN (P) 2319-5940

7. "Yasashvini R.,Vergin Raja Sarobin M.Rukmani Panjanathan,Graceline Jasmine S. And Jani Anbarasi L." Diabetic Retinopathy Classification Using CNN and Hybrid Deep Convolutional Neural Networks ,MDPI, Volume 14 , Issue 9 ,10.3390/sym14091932 , July 2022

8. Sanket, S.; Vergin Raja Sarobin, M.; Jani Anbarasi, L.; Thakor, J.; Singh, U. Narayanan, S. Detection of novel coronavirus from chest X-rays using deep convolutional neural networks. Multimed. Tools Appl. 2022, 81, 22263–22288. [Google Scholar] [CrossRef] [PubMed]

9. Jiang, H.; Yang, K.; Gao, M.; Zhang, D.; Ma, H.; Qian, W. An Interpretable Ensemble Deep Learning Model for Diabetic Retinopathy Disease Classification. In Proceedings of the 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Berlin, Germany, 23–27 July 2019; pp. 2045–2048. [Google Scholar]

10. Roy, A.; Dutta, D.; Bhattacharya, P.; Choudhury, S. Filter and fuzzy c means based feature extraction and classification of diabetic retinopathy using support vector machines. In Proceedings of the International Conference on Communication and Signal Processing (ICCSP), Tamil Nadu, India, 6–8 April 2017; pp. 1844–1848. [Google Scholar]

11. Qian, Z.; Wu, C.; Chen, H.; Chen, M. Diabetic Retinopathy Grading Using Attention based Convolution Neural Network. In Proceedings of the IEEE 5th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC), Chongqing, China, 12–14 March 2021; pp. 2652–2655. [Google Scholar]

12. Abdel Maksoud, E.; Barakat, S.; Elmogy, M. Diabetic Retinopathy Grading Based on a Hybrid Deep Learning Model. In Proceedings of the International Conference on Data Analytics for Business and Industry: Way Towards a Sustainable Economy (ICDABI), Sakheer, Bahrain, 26–27 October 2020; pp. 1–6. [Google Scholar]

13. Pires, R.; Jelinek, H.F.; Wainer, J.; Goldenstein, S.; Valle, E.; Rocha, A. Assessing the Need for Referral in Automatic Diabetic Retinopathy Detection. IEEE Trans. Biomed. Eng. 2013, 60, 3391–3398. [Google Scholar] [CrossRef] [PubMed]

14. Dua, S.; Kandiraju, N.; Thompson, H. Design and implementation of a unique blood-vessel detection algorithm towards early diagnosis of diabetic retinopathy. In Proceedings of the International Conference on Information Technology: Coding and

Computing (ITCC'05)-Volume II, Las Vegas, NV, USA, 4–6 April 2005; Volume 1, pp. 26–31. [Google Scholar] [CrossRef]

15. Jelinek, H.F.; Pires, R.; Padilha, R.; Goldenstein, S.; Wainer, J.; Bossomaier, T.; Rocha, A. Data fusion for multi-lesion Diabetic Retinopathy detection. In Proceedings of the 25th IEEE International Symposium on Computer-Based Medical Systems (CBMS), Rome, Italy, 20–22 June 2012; pp. 1–4. [Google Scholar] [CrossRef]

16. Bourouis, S.; Zaguia, A.; Bouguila, N. Hybrid Statistical Framework for Diabetic Retinopathy Detection. In Proceedings of the International Conference Image Analysis and Recognition, Varzim, Portugal, 27–29 June 2018; Springer International Publishing: Cham, Switzerland, 2018; pp. 687–694. [Google Scholar]

17. Lachure, J.; Deorankar, A.; Lachure, S.; Gupta, S.; Jadhav, R. Diabetic Retinopathy using morphological operations and machine learning. In Proceedings of the IEEE International Advance Computing Conference (IACC), Bangalore, India, 12–13 June 2015; pp. 617–622. [Google Scholar] [CrossRef]

18. Bhatkar, A.P.; Kharat, G. Detection of Diabetic Retinopathy in Retinal Images Using MLP Classifier. In Proceedings of the IEEE International Symposium on Nanoelectronic and Information Systems, Indore, India, 21–23 December 2015; pp. 331–335. [Google Scholar] [CrossRef]

19. Mishra, S.; Hanchate, S.; Saquib, Z. Diabetic Retinopathy Detection using Deep Learning. In Proceedings of the International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE), Bangalore, India, 9–10 October 2020; pp. 515–520. [Google Scholar] [CrossRef]

20. Palavalasa, K.K.; Sambaturu, B. Automatic Diabetic Retinopathy Detection Using Digital Image Processing. In Proceedings of the International Conference on Communication and Signal Processing (ICCSP), Chennai, India, 3–5 April 2018; pp. 72–76. [Google Scholar] [CrossRef]

21. Prasad, D.K.; Vibha, L.; Venugopal, K. Early detection of diabetic retinopathy from digital retinal fundus images. In Proceedings of the IEEE Recent Advances in Intelligent Computational Systems (RAICS), Kerala, India, 10–12 December 2015; pp. 240–245. [Google Scholar] [CrossRef]

22. Amalia, R.; Bustamam, A.; Sarwinda, D. Detection and description generation of diabetic retinopathy using convolutional neural network and long short-term memory. J. Phys. Conf. Ser. 2021, 1722, 12010. [Google Scholar] [CrossRef]

23. Nagi, A.T.; Awan, M.J.; Javed, R.; Ayesha, N. A Comparison of Two-Stage Classifier Algorithm with Ensemble Techniques On Detection of Diabetic Retinopathy In Proceedings of the 1st International Conference on Artificial Intelligence and Data Analytics (CAIDA). Riyadh, Saudi Arabia, 6–7 April 2021; pp. 212–215. [Google Scholar] [CrossRef]

24. Yadav, J.; Sharma, M.; Saxena, V. Diabetic retinopathy detection using feedforward neural network. In Proceedings of the Tenth International Conference on Contemporary Computing (IC3), Noida, India, 10–12 August 2017; pp. 1–3. [Google Scholar] [CrossRef]

25. Hemanth, D.J.; Anitha, J.; Son, L.H.; Mittal, M. Diabetic retinopathy diagnosis from retinal images using modified hopfield neural network. J. Med. Syst. 2018, 42, 1–6. [Google Scholar] [CrossRef] [PubMed]

26. Gayathri, S.; Gopi, V.P.; Palanisamy, P. Diabetic retinopathy classification based on multipath CNN and machine learning classifiers. Phys. Eng. Sci. Med. 2021, 44, 639–653. [Google Scholar] [CrossRef]

27. Varghese, N.R.; Gopan, N.R. Performance analysis of automated detection of diabetic retinopathy using machine learning and deep learning techniques. In Proceedings of the International Conference on Innovative Data Communication Technologies and Application, Coimbatore, India, 17–18 October 2019; Springer: Cham, Switzerland, 2019; pp. 156–164. [Google Scholar]

28. Albawi, S.; Mohammed, T.A.; Al-Zawi, S. Understanding of a convolutional neural network. In Proceedings of the International Conference on Engineering and Technology (ICET), Antalya, Turkey, 21–23 August 2017; pp. 1–6. [Google Scholar] [CrossRef]

29. Huang, G.; Liu, Z.; Van Der Maaten, L.; Weinberger, K.Q. Densely Connected Convolutional Networks. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Honolulu, HI, USA, 21–26 July 2017; pp. 2261–2269. [Google Scholar] [CrossRef]

30. Jawahar, M.; Babu, N.K.C.; Vani, K.; Anbarasi, L.J.; Geetha, S. Vision based inspection system for leather surface defect detection using fast convergence particle swarm optimization ensemble classifier approach. Multimed. Tools Appl. 2021, 80, 4203–4235. [Google Scholar] [CrossRef]

A Enhance Performance Parameter based on MPSO Approach

P. M. Pithadiya
Assistant Professor
Instrumentation and Control Department
Government Engineering College
Rajkot, Gujarat
✉ pmpithdiya@gmail.com

V. A. Shah
Dean & Incharge Head
Instrumentation and Control Department
Dharmsinh Desai University
✉ vashahin2010@gmail.com

K. B. Bhoyaniya
Associate Professor
Instrumentation and Control Department
Government Engineering College
Rajkot, Gujarat
✉ kbbld@yahoo.com

ABSTRACT

This proposed method implies for highly nonlinear twin rotor MIMO system. This complex system is implemented in various Process industries, design, and development of a new controller to increase the better stability and improve the performance of integral criteria. This proposed work goal is to improve performance specification of controller by mutation combine with particle swarm optimization algorithm of industrial highly complex nonlinear TRMS. The designed value is tested using Simulink model in MATLAB and LabVIEW. It is seen that the TRMS can be control into two Single-input– single-output (SISO) systems and the cross couplings can be considered as disturbances to each other. The various controller designed are PID controller for TRMS. The result shows that MPSO technique is provided the good result when compared with other approaches. The MPSO techniques use for setting controller offers enhanced performance criteria such as better time domain specifications, smooth error reference tracking, and minimization of error in the complex system.

KEYWORDS: *Twin rotor MIMO system, Mutation particle swarm optimization, Performance criteria.*

INTRODUCTION

Helicopters are typically described in the literature as having unstable, nonlinear, time varying and coupled dynamics. Many suites of PID control modules have been employed to produce agile, lowobservable and multi-functional helicopters capable of performing complicated missions [1–5]. This study addresses the decoupling and robust deadbeat control of a TRMS based on the available models and techniques. First, the system model is identified. It is shown, that the identified system is able to be decoupled into two single-input singles-output (SISO) systems, and the crossing couplings can be considered as disturbances to each of the SISO systems. Then, a PID-based robust deadbeat control scheme is applied to the SISO systems,

and a deadbeat controller is designed for each of them. These robust deadbeat controllers can tolerate system parameter changes for up to 50%. Kim and Calise [6] have employed neural networks to perform dual roles of identifying the input–output model parameters (offline learning) using the mathematical model of an aircraft and an adaptive network that compensates for imperfect inversion and in-flight changes in the actual aircraft dynamics. Rotorndo et al. had proposed a quasi-LPV modelling, identification and control approach for the same test rig in another study. Wen and Lu developed a robust deadbeat control technique and applied to two SISO systems decoupled from the identified system [8]. Yang and Hsu presented a novel adaptive control approach based on the back-stepping concept and demonstrated the applicability of the proposed control

scheme with computer simulations and experiments [9].

Yang and Hsu presented a novel adaptive control approach based on the back-stepping concept and demonstrated the applicability of the proposed control scheme with computer simulations and experiments [9]. Most of the time, the system model of the plant is nonlinear or unknown. TRMS includes nonlinear and coupled effects that disrupt pitch and yaw motions simultaneously. The intelligent control methods draw attention to overcome this issue. Fuzzy logic control is one of the intelligent control methods based on the fuzzy logic theory which was first presented by Zadeh [9]. The motivation of this study is originated from the growing interest in developing unmanned aircraft systems [10]

In various real-time chemical and petrochemical plants such as spherical tank system Continuous Stirred Tank Reactor (CSTR), other various chemical reactor processes are more nonlinear by characteristics and highly complex in nature. In various process industries, Controller tuning to stabilize these nonlinear multivariable processes and contribute necessary disturbance rejection is the big problem because of their nonlinearity and uncertain phenomena. Most of the processes indicate stable and/or unstable characteristics. In various literatures of control and nonlinear system, various controllers designing for critical processes are available to stabilize processes by Sankata B. Prusty, Umesh C. Patti and Kamala K. Mahapatra, [11]. Researchers help to tune parameter of PID to control systems by using various techniques to change system better response by Geem, Z.W., Kim, J.H., and Loganathan, [12].
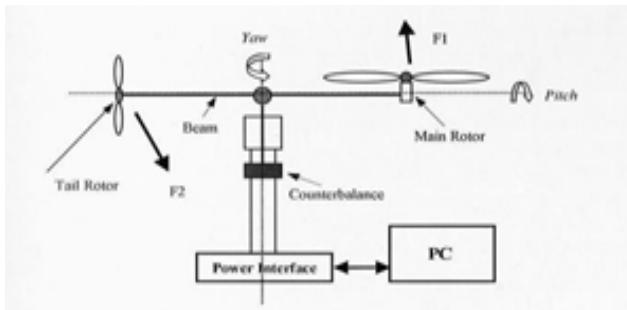
Several years before, in the several manufacturing processes parameter design using particle swarm optimization. Instead of its requirement for the process of extrusion to design was not better. Because study, they did design on the reduce mandrel eccentricity and output tube bending positions of a billet inside multi-hole extrusion operation optimization. This research access produce the optimize responses with respect to the specific operation variable range on basis of the finding knowledge of the results through the very advanced procedure to again enhance the perfect solution of qualities by P. K. Giridharan, N. Murugan,[13].

Hsiang and Lin analytical thought the gist of many operation parameters of the magnesium alloy tubes hot extrusion by using the statistical approach techniques and another analysis of variance (ANOVA) to improve the better result nature of other different parts. It's involved that temperature, the billet, in extrusion velocity, of heating and temperature of container affect the mechanical characteristics of extruded products by A. O'Dwyer, [14] A. Kumar et al developed a method to use Taguchi method to optimize the magnetic arc oscillation welding process parameters of non-heat treatable aluminum alloy 5456 welds for increasing the mechanical properties. It is very simple conception of the controller for a stable operating region, but it's very difficult for nonlinear unstable system, there available increasing and decreeing of controller constant value, and some specific value to be viewed to conception of the controller for the complex system. These nonlinear indicate overshoot and inverse output due to system characteristics (P. K. Giridharan, N. Murugan,[13] In the recent advanced research on control techniques for process industry such as adaptive control techniques, predictive control, IMC control techniques, soft computing techniques, and conventional controllers are contributing in various process control application reason of their method very simple and robust in nature, also easier to validate by Sankata B. Prusty, Umesh C. Patti and Kamala K. Mahapatra,[12].

PSO was assigned random velocity to each and considerable particle due to its search mechanism associates. In this research work, quadruple tank system is laboratory-based highly nonlinear system standard model for an experimentation setup for research as well as practical aspect. Using Taguchi method find the optimized value for PID controller parameter after again this value optimized by MPSO algorithm so that more optimized result we are getting through Taguchi combine with MPSO. The Taguchi method is a very powerful optimization technique. This technique has been implemented to get lots of optimization problem in various instrumentation and electrical systems by C. J. Einerson, D. E. Clark, and B. A. Detering[15]. The Taguchi method consists of design variable and variable levels. Taguchi method reveals lower number of design experiment than that of the response surface methodology.

MIMO SYSTEM

The Twin Rotor MIMO System (TRMS) is a laboratory platform designed for control experiments by Feedback Instruments Ltd. In certain aspects, its behavior resembles that of a helicopter. For example, like a helicopter there is a strong cross coupling between the collective (main rotor) and the tail rotor. There is a small, but growing, literature on laboratory platforms simulating complex aircraft maneuver and problems. These platforms are often employed to test the suitability of different control methods for these systems.

Figure :1 Twin Rotor MIMO System

CONTROLLER BASICS

A proportional–integral–derivative controller is a control loop mechanism employing feedback thatis widely used in industry and a variety of other applications requiring continuously modulated control parameter. A PID controller continuously calculates an error value e(t) as the difference between a desired set point and a measured process variable and applies a correction based on proportional, integral, and derivative terms.

The tuning of controller could be explained as maintaining the variable of the controller so that the system dynamic response is better, or response based on the designer. There are numerous performance criteria for controller tuning that may accepted, some of which are considered

- Keep the maximum deviation as minimum as possible

- Decreases the integral of errors until the process has settled at its settling positions

- Gaining short settling times

- Performance Criteria

In the process control system, two types of performance criteria are to be satisfied; one is steady state performance criteria and second dynamic performance criteria. Performance criteria based on the closed loop response of the system are, Overshoot, Rise time, Settling time, Decay ratio and frequency of oscillation. In the specified characteristics can be used by controller designers as per controller selection and parameter value adjustment. Designer mainly concentrates to minimize overshoot, minimum settling time and other parameter which related to having given system. If consider process is nonlinear, the main characteristics' will be changed from one operating point toanother operating point after that specific parameter tuning can produce the desired response at the only single operating point in system. If change operating point in the system change controller tuning. Adaptive controller and self-tuning controllers are design required fine tuning for specific application.

PERFORMANCE PARAMETERS

The response of the complete closed loop system at t= o until steady state has been achieved can beutilized for the formulation of the dynamic performance criteria. Based on the closed response, these methods minimized the area under error vs. time curve. Significant of the Tuning methods to minimize the integral of error so that towards address for minimum error integral. Minimize of Integral of error is not possible directly because a very large negative error will be minimum value,so that the absolute error value or square of error value is taken and decrease.

- Integral of squared area: ISE

- Integral absolute error: IAE

- Integral of time multiplied by absolute value of error: ITAE

- Integral of time multiplied by square value of error: ITSE

For the computation purpose the upper limit of the integral may be replaced by settling time (ts)

MUTATION PARTICLE SWARM OPTIMIZATION

The looking procedure and region of the sanctioned

PSO calculation enormously rely upon potion best and global best. The impact of position best and global best in Particle Swarm optimization steadily diminishes as the quantity of emphases increments. Subsequently, we join the accepted this technique with the Genetic Algorithm mutation called "MPSO" to get a more extensive scanning region for enhancing the worldwide inquiry capacity of arrangements. The MPSO method utilizes a real-coded type mutation operator to build the assorted variety of arrangements. The mutation of genetic algorithm activity just happens if a haphazardly produced number inside [0, 1] is not exactly or equivalent to the given change likelihood. At the point when a change is worked, the quantity of outline factors is increased by an irregular incentive inside [0, 1] to figure out which variable in every molecule ought to be transformed in the parameter space. The genuine factor changes administrators utilized in this technique are as per the following

$$X_{ij}(k+1) = X_{ij}^{U}(k+1) + r4 * [X_{ij}^{U}(k+1) - X_{ij}^{L}(k+1)] \quad (1)$$

Where, t = ceil (r6 × n), n z.

The ceiling function ceil (r3×n) is defined as the function that outputs the smallest integer greater than or equal to (r3 ×n). t is the variable sequence position of getting a mutation in variable space

X. If some particle of each iteration mutated, it would be randomly selected one of the design variables as mutation between its upper and low limits. In Eq. (1), r3 and r4 are random numbers in[0, 1] and shows the updated design variables after mutation of each updated particle from Eq. (1). This new algorithm was designed to repeatedly update the selected parameters in Eq. (1) until reaching termination states.

ALGORITHM PROCEDURE

This investigation utilizes the new algorithm based on MPSO to examine the different variable states on the twin rotor mimo nonlinear system. The iterative calculations of the MPSO calculation were first registered to utilize mathematical software and Lab view. In this manner execute the LabVIEW programming for every emphasis investigations. It shows the engineering of the Taguchi- based MPSO calculation to enhance the procedure execution lists process considering tuning of a PID controller. The means are portrayed as takes after:

Level 1: Choose the effect main factors on the PID controller parameter, such as Proportional control Kp, integral Control Ki and Derivative control Kd. This parameter can possibly influence the execution lists of the nonlinear twin rotor mimo system

Level 2: Find out the most important process parameters kp, ki and kd influencing the level1 and level 2 of bottom tanks

Level 3: Start set of particles that present the start random combination of the significant process variables conditions. Identify the ranges of variable conditions between the higher and lower limits according to the results of the MPSO method

Level 4: Calculate the new position and velocity of the particles in every loop using MATLAB.

Level 5: Apply the mutation operator used given equation to avoid previous convergence and find the global optimal solutions using Mutation based PSO algorithm.

Level 6: Produce and study the performance indices models to determine the position of the twin rotor MIMO system for each iteration.

Level 7: Calculate the fitness function in the given equation.

Level 8: Find out whether the ISE, IAE, ITAE, and ITSE are at the minimum output by proceeding towards the fitness value. If yes, then stop iterating and proceed to the next step. If no, return to Step.

RESULT AND DISCUSSION

Table 1: Parameter of controller

Tuning constant	Stage 1	Stage 2	Stage 3
Kp1	10	11	12
Ki1	7	8	9
Kd1	1	2	1
Kp2	11	12	13
Ki2	7	8	9
Kd2	1	2	1

Using Mutation based PSO we can also have optimized again for the value from the Mutation method So that we can more optimized value for the parameter of

PID and getting better output of complex control twin rotor MIMO system simulation Result for MPSO. This proposes work a Mutation PSO calculation to improve for the fitting estimations of the basic procedure controller parameters of the different info and numerous yield procedures. The MPSO techniques are used to explore the ideal arrangement of PID controller parameters for the minimize performance criteria to improve stability of the twin rotor MIMO control system so, decide the position of basic controller parameters KP, Ki and Kd and its gave the importance level of each procedure parameter. The execution record ISE, IAE, ITSE and ITAE. Mutation PSO calculation execution to advanced PID controller parameter to enhance the framework steady in term the level of performance indices. According to the level of the Performance indices-based system its indicates Energy level of the different techniques for performance indices level in term so Energy level based on control energy consumed by process itself. Energy level is reduce depends on performance indices, if performance indices of decrease. Performance indices based on error of the whole process.

The MPSO calculation control principally enabled the pursuit to maintain a strategic distance from untimely assembly to diminish the local optimal solution into a neighborhood ideal arrangement and to look for a global best optimal solution. MPSO performed superior to anything the Taguchi technique-based GA. The minimize performance index ISE and IAE for simulation model of twin rotor MIMO system.

This new algorithm Mutation based PSO calculation, demonstrating that it tends to be effectively utilized to locate the ideal controller parameter outline in the nonlinear twin rotor mimo system procedure to control the position of yaw and pitch. The outcomes exhibit that the proposed strategies can go about as a best algorithm of the mimo nonlinear process and will be stretched out to other nonlinear control parameter for the different control system.

CONCLUSION

In this study, we have successfully modeled a TRMS whose dynamics resemble that of a helicopter. The extracted model has been decoupled into two SISO systems. We applied a PID- based scheme to these two SISO systems and designed a MPSO for each of them. This method helps to improve the system performance. We have successfully employed this robust feature to suppress the cross-coupling effects between the tail and the main rotors.

This proposed work presented for finding the best optimal solution for the nonlinear dynamic system. These techniques to find optimize the parameter of the controller for multiple inputs and multiple output dynamic system using Taguchi statistical method based on MPSO techniques. This method utilized to find optimal parameter Kp, Ki, and Kd of PID controller based on the performance index to increase the stability and performance of the dynamic nonlinear MIMO system Mutation based PSO techniques could be utilized for the better response than Taguchi based in GA for quadruple tank system. These techniques to search optimal value from Taguchi method after that again Taguchi combine with MPSO with the better optimal value of controller parameter.

A MPSO algorithm-based control on a twin rotor MIMO system is introduced. The proposed algorithm based PID controller is compared with other control strategy to show improvements of the system performance criteria. The numerical output data indicated that the MPSO based PID controller exhibits a system behavior and improved performance criteria in the way of improving the control position of pitch and yaw axis output. The cross- coupling effect is also better control against external disturbance.

REFERENCE

1. Shameed M.H.: 'Feed forward neural network based nonlinear dynamic modelling of a TRMS using RPROP algorithm', Aircr. Eng. Aerosp. Technol., (2005), 77, (1), pp. 13– 22

2. Buskey G., Robert J., Wyeth G.: 'A helicopter named dolly – behavioural cloning for autonomous helicopter control'. Proc. Australasian Conf. Robotics and Automation, Brisbane, December (2003).

3. Sprague K., Gavrilets V., Dugail D., Mettler B., Feron E.:'Design and applications of an avionics system for a miniature acrobatic helicopter'. Digital Avionics Systems Conf., Daytona Beach, Florida, October (2001), p. 3.C.5- 1–3.C.5-10

4. Koo T.J., Sastry S.: 'Output tracking control design of a helicopter model based on approximate linearization', IEEE Conf. Decis. Control, (1998), 4, pp. 3635–3640

5. Prasad J.V.R., Calise A.J., Pei Y., Corban J.E.: 'Adaptive nonlinear controller synthesis and flight test evaluation'. Proc. 1999 IEEE Int. Conf. Control Applications,Kohala Coast, Island of Hawaii, August (1999), pp. 137–142.6

6. Kim B.S., Calise A.J.: 'Non-linear flight control using neural networks', J. Guid. Control Dyn., (1998), 20, (1), pp. 26–33

7. Rotondo D., Nejjari F., Puig V. Quasi-LPV modeling, identification and control of a twin rotor MIMO system. Control Engineering Practice, Vol. 21, Issue 6, (2013), p. 829- 846

8. Yang J. H., Hsu W. C. Adaptive backstepping control for electrically driven unmanned helicopter. Control Engineering Practice, Vol. 17, Issue 8, (2009), p. 903-913.

9. Zadeh L. A. Fuzzy sets. Information and Control, Vol. 8, (1965), p. 338-353. Kendoul F. Survey of advances in guidance, navigation, and control of unmanned rotorcraft systems. J. Field Robotics, Vol. 29, Issue 2, (2012),p. 315-378

10. Sankata B. Prusty, Umesh C. Patti and Kamala K. Mahapatra"A Novel Fuzzy based Adaptive Control of the Four Tank System", European Journal of Scientific Research ISSn, ,(2014) pp.293-298 Vol.29 No.4

11. Geem, Z.W., Kim, J.H., and Loganathan, G.V. A new heuristic optimization algorithm: harmony search. Simulation, (2001). 76: 60–68.

12. Giridharan PK, Murugan N. Optimization of pulsed GTA welding process parameters for the welding of AISI 304 L stainless steel. International Journal of Advanced Manufacturing Technology (2009); 40: 478-89.

13. O'Dwyer, A. Handbook of PI and PID Controller Tuning Rules (3rd ed.). Imperial College Press. doi:10.1142/p575.2009

14. C. J. Einerson, D. E. Clark, and B. A. Detering, "Intelligent control strategies for theplasma spray process," in Proc. Thermal Spray Coatings: Research, Design and Applications, (1993), pp. 205-211.

15. Wang, Z. G., Rahman, M., Wong, Y. S., & Sun, J. (2005). Optimization of multi-pass milling using parallel genetic algorithm and parallel genetic simulated annealing. International Journal of Machine Tools & Manufacture, 45 (15) 1726–1734. doi:10.1016/j.ijmachtools.(2005).03.009

16. Komathi, C., Vaishali, E., & Sobitha, M.. Performance Optimization of a Decoupled Quadruple Tank System Using Fractional Order Proportional Integral Controller. International Journal of Electronics. Electrical and Computational System, (2017) 6(11), 258–265.

17. Kumar, A., Shailesh, P., & Sundarrajan, S. Optimization of magnetic arc oscillation process parameters on mechanical properties of AA 5456

18. Aluminum alloy weldments. Materials & Design, (2008). 29(10), 1904–1913. doi:10.1016/j.matdes.2008.04.044

19. Mettu & Ganta. (2013). Design of Fractional Order Pid Controller for Liquid Level Control of a Spherical Tank Modeled As a Fractional Order System. International Journal of Engineering Research and Applications, (2013), 3(6), 438–443.

20. Alamelumangai, V., & Natarajan, S. P. Tuning methods of multi-loop controller for a multivariable process. Indian Journal of Science and Technology, (2010), 3(2), 131–138. doi:10.17485/ijst/2010/v3i2.19

20. Divya, K., & Nagarajapandian, A. Design and Implementation of Controllers for Quadrupe Tank System. International Journal of Advanced Research in Education & Technology, (2017), 4(2), 158.

21. Einerson, C. J., Clark, D. E., & Detering, B. A. Intelligent control strategies for the plasma spray process. Proc. Thermal Spray Coatings: Research, Design and Applications, (1993), 205-211.

22. Giridharan, P. K., & Murugan, N. Optimization of pulsed GTA welding process parameters for the welding of AISI 304L stainless steel sheets. International Journal of Advanced Manufacturing Technology, (2009), 40(5-6), 478–489. doi:10.1007/s00170-008-1373-0

23. Padmasree, R., & Chidambaram, M.. Control of Unstable Systems. Narosa Publishing House. Panda, R. C. Synthesis of PID controller for unstable and integrating processes. Chemical Engineering Science, 64(12), (2009).2807–2816. doi:10.1016/j.ces.2009.02.051

24. Patel, J., & Vhora, H. (2016). Development of Multi Input Multi Output Coupled Process Control Laboratory Test Setup. International Journal of Advanced Research in Engineering and Technology, 7(1), (2016), 97 104.

Weed Detection for Precision Agriculture using EfficientNetB3 Transfer Learning Model

S. Praveen Kumar
Assistant Professor
Department of ECE
JNTUH UCEJ
Telangana
✉ praveenkumar_00019@yahoo.com

Y. Raghavender Rao
Professor
Department of ECE
JNTUH UCES
Telangana

ABSTRACT

The early and precise detection of weeds in crop fields is still a critical challenge for optimizing agricultural yield as precision agriculture advances. This research introduces an innovative method for identifying and classifying weeds in soybean fields. The method utilizes a transfer learning model that is based on the EfficientNetB3 architecture. By using an extensive dataset consisting of photographs of soybean crops, our approach entails refining the pre-trained EfficientNetB3 model to customize its deep learning capabilities to the distinct attributes of fields plagued with weeds. The findings of our study demonstrate that the use of the transfer learning technique with EfficientNetB3 greatly improves the precision and effectiveness of weed identification in soybean crops. The assessment of the proposed model showcases exceptional performance, with a remarkable accuracy rate of 99%. In addition, the accuracy, recall, and f1-score metrics have been accurately computed to evaluate the model's capacity to accurately detect and categorize occurrences of weeds.

KEYWORDS: Precision agriculture, Weed detection, Transfer learning, EfficientNetB3 architecture, Soybean fields, Deep learning model.

INTRODUCTION

A key strategy in contemporary farming, precision agriculture seeks to maximize crop production efficiency while limiting resource use. Nevertheless, weed infestation is a recurring problem that makes reaching maximum yields very difficult [1]. Weeds engage in resource competition with crops, including water, sunshine, and nutrients, resulting in a decrease in agricultural productivity [2]. Conventional approaches to weed control often include the widespread use of herbicides without discrimination or the physical extraction of weeds. These procedures require significant effort, consume a considerable amount of time, and frequently have negative ecological consequences. Therefore, there is a pressing need for a more effective and environmentally-friendly method to identify and control weeds in precision agriculture, which has become more important [3].

The complexities of identifying and distinguishing weeds in agricultural environments are many. The visual differentiation of weeds from crops is complex owing to their comparable look and development patterns, resulting in inaccuracies in manual identification [4]. Moreover, the extensive agricultural fields exacerbate the intricacy of the work, rendering it unfeasible for farmers to constantly verify every region [5]. Misidentifying weeds may have serious consequences, since using improper intervention techniques may harm the intended crops or result in higher pesticide consumption, which can pose environmental risks. Therefore, there is a pressing need for a weed identification system that is automated, precise, and prompt, and can effortlessly connect with precision agricultural methods [6].

Deep learning, a type of machine learning, has become a powerful solution in several domains due to its capacity to extract complex patterns and characteristics from extensive datasets. Convolutional neural networks

(CNNs) have shown significant potential in image identification and classification applications, notably in recent years. The use of deep learning in agriculture, particularly in weed identification, exploits the capabilities of these models to differentiate between crop plants and weeds with exceptional precision [7]. The innate ability of Convolutional Neural Networks (CNNs) to acquire hierarchical representations of characteristics from pictures allows them to detect tiny distinctions in leaf morphology, textures, and chromatic changes, which are essential for distinguishing between desired crops and undesired weeds [8].

Deep learning models integrated with precision agriculture provide a revolutionary method for identifying and controlling weeds. By using breakthroughs in image processing and neural network designs, these models have the capacity to transform the manner in which farmers detect and tackle weed infestations. The use of such technology not only improves the effectiveness and precision of weed identification but also enables focused intervention tactics, resulting in less pesticide consumption, reduced environmental impact, and ultimately, enhanced agricultural yield. This research seeks to investigate the efficacy of using deep learning models for weed identification in precision agriculture, providing insights into its possible ramifications and practical implementations in contemporary agricultural methodologies.

LITERATURE

R. Punithavathi et al [9] presented an innovative method for identifying and categorizing weeds in precision agriculture, referred to as the Computer Vision and Deep Learning-based Weed Detection and Classification (CVDL-WDC) model. The objective of the proposed CVDL-WDC approach is to effectively discriminate between plants and weeds. This approach consists of two separate procedures: a multiscale Faster RCNN-based system for detecting objects and an optimum Extreme Learning Machine (ELM) for classifying weeds. The ELM model's parameters are optimized using the Farmland Fertility Optimization (FFO) method. The CVDL-WDC strategy has enhanced performance relative to current techniques across several measures, as shown by a thorough simulation study done on benchmark datasets.

Fengying Dang et al [10] presented a new dataset called CottoWeedDet12, which has been carefully selected to include weeds that have a major influence on cotton output in the southern parts of the United States (U.S.). The dataset consists of 5648 photos that depict 12 different categories of weeds. In all, there are 9370 annotations of bounding boxes. The photographs were gathered in cotton fields, under natural lighting circumstances, to capture a wide range of weed development phases. This research includes a groundbreaking effort to develop a comprehensive benchmark that showcases 25 cutting-edge YOLO object detectors. The detectors include seven iterations, namely YOLOv3, YOLOv4, Scaled-YOLOv4, YOLOR, YOLOv5, YOLOv6, and YOLOv7, hence offering a thorough framework for evaluating weed detection with this dataset.

Ignazio Gallo et al [11] presented a newly developed dataset called the Chicory Plant (CP) dataset. It evaluates the effectiveness of state-of-the-art deep learning methods at detecting objects. The CP dataset consists of more than 3000 RGB photos that were taken using a UAV system. These images capture chicory plantations at different phases of crop and weed development. The collection also includes 12,113 bounding box annotations that are primarily used to detect weed targets, particularly Mercurialisannua. The research conducted extensive tests on weed item recognition using the most recent version, You Only Look Once version 7 (YOLOv7). The trials were performed on two datasets: the CP dataset and a publically accessible dataset called Lincoln beet (LB). The LB dataset was previously used in conjunction with a prior iteration of YOLO to delineate and classify both weeds and crops. The findings obtained from YOLOv7 on the CP dataset demonstrated improved performance compared to other YOLO versions evaluated in the research, which is encouraging.

Jiging Chen et al [12] proposed the YOLO-sesame model, which aims to improve the accuracy and efficiency of recognizing sesame weeds. This model is an extension of the YOLOv4 paradigm that includes an attention mechanism. It combines local importance pooling with the SPP layer and utilizes the SE module as a logical component. The model incorporates an adaptive spatial feature fusion structure at the feature

fusion level to tackle the difficulties arising from significant differences in target size and specifications. The empirical data demonstrate that the YOLO-sesame model, suggested in this study, outperforms known models such as Fast R-CNN, SSD, YOLOv3, YOLOv4, and YOLOv4-tiny in terms of its detection capability.

M. Manikandakumar et al [13] proposed an effective weed classification model, using a Deep Convolutional Neural Network (CNN), which allows for automated feature extraction and complex feature learning that are crucial for picture classification. The research trained a Convolutional Neural Network (CNN) model using photographs of weeds. An evolutionary computing strategy was used to categorize the weeds, making use of two publically accessible weed datasets. The first dataset used was the Tamil Nadu Agricultural University (TNAU) dataset, which consisted of 40 categories of weed photos. The second dataset, obtained from the Indian Council of Agriculture Research – Directorate of Weed Research (ICAR-DWR), included 50 categories of weed photographs. The CNN model was improved by using a Particle Swarm Optimization (PSO) approach to autonomously develop and boost its classification accuracy. In order to assess the efficiency of the suggested model, it was examined and contrasted with pre-trained transfer learning models such as GoogLeNet, AlexNet, Residual neural Network (ResNet), and Visual Geometry Group Network (VGGNet) in the field of weed classification. The results of this research indicate that the performance of the suggested CNN model, with the assistance of PSO, substantially increases the success rate in weed classification tasks.

Najmeh Razfar et al [14] presented a weed identification method that uses deep learning models to accurately identify weeds in a soybean plantation, based on visual information. Five discrete deep learning models were used, including MobileNetV2, ResNet50, and three customized Convolutional Neural Network (CNN) models. The implementation of MobileNetV2 and ResNet50 on a Raspberry Pi controller was done for the purpose of conducting a comparative comparison. The 5-layer CNN architecture, particularly built for weed recognition, demonstrated significant accuracy levels using a dataset of 400 pictures and 1536 segments.

A. Subeesh et al [15] explored the viability of deep learning approaches (namely, Alexnet, GoogLeNet, InceptionV3, Xception) for identifying weeds in bell pepper fields using RGB photos. The models underwent training using varying numbers of epochs (10, 20, 30) and batch sizes (16, 32). Additionally, hyperparameters are adjusted to get the best possible performance.

Xiaojun Jin et al [16] proposed a novel strategy that deviates from traditional methodologies by combining deep learning with image processing technologies. Firstly, the process entails using a trained CenterNet model to identify veggies and create bounding boxes around them. Consequently, any green items that are not inside these enclosing boundaries are recognized as weeds. This strategy focuses on the identification of vegetables, thereby avoiding the need of specifically dealing with different weed species. As a result, this approach effectively decreases the size of the training picture dataset and simplifies the complexity related to weed detection, hence improving the accuracy and performance of weed identification. A color index-based segmentation approach is used in image processing technologies to separate weeds from the backdrop. The color index is chosen and assessed using Genetic Algorithms (GAs) in order to reduce the error in Bayesian classification and achieve the most effective removal of weeds from the surrounding environment.

Mohd Anul Haq et al [17] proposed an innovative automated weed detection system that utilizes Convolution Neural Network (CNN) classification. This system will be trained and tested on a substantial dataset consisting of 4400 aerial images captured by Unmanned Aerial Vehicles (UAVs), which are further divided into 15336 segments. The suggested CNN LVQ model's optimum parameters were determined using snapshots.

Kavir Osorio et al [18] proposed to compare three different approaches for weed estimate in lettuce fields utilizing deep learning image processing algorithms, in comparison to assessments conducted by field specialists. The first approach utilizes support vector machines (SVM) that leverage histograms of oriented gradients (HOG) as the feature descriptor. The second solution utilizes YOLOv3 (You Only Look Once V3), taking advantage of its resilient architecture particularly

designed for object recognition. The third approach utilizes Mask R-CNN, a region-based convolutional neural network, to do instance segmentation for each unique weed entity. In addition, these techniques were enhanced by integrating a normalized difference vegetation index (NDVI) as a background subtractor, which aids in excluding non-photosynthetic items from the study.

PROPOSED METHOD

EfficientNetB3 is a member of the EfficientNet family, which is a group of convolutional neural network (CNN) architectures developed by Google researchers in 2019. The EfficientNet family is renowned for its pioneering strategy in finding a balance between model size and accuracy. It has achieved cutting-edge performance while using much fewer parameters compared to conventional designs. The designation "B3" in EfficientNetB3 indicates its particular scale or size within the EfficientNet series, where B0 represents the smallest and B7 represents the biggest.

The design of EfficientNetB3 employs a compound scaling technique that effectively enhances the network's depth, breadth, and resolution concurrently. This scaling methodology guarantees that the model can effectively adjust to various computing resources, making it appropriate for a diverse array of applications. The network is constructed using a fundamental design that includes convolutional layers, normalization layers, activation functions, and skip connections.
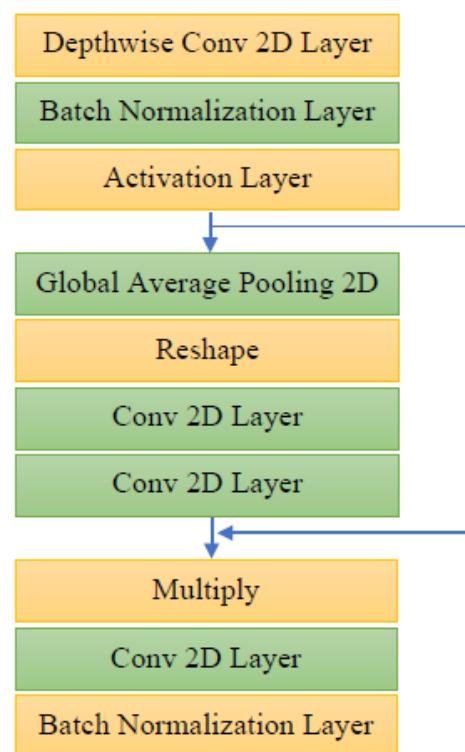
The construction of EfficientNetB3 entails the incorporation of three fundamental elements: depth, breadth, and resolution scaling. Depth scaling pertains to the augmentation of the neural network's layer count, enabling it to include more intricate elements and patterns. Width scaling refers to the process of augmenting the number of channels in the convolutional layers, hence improving the model's capacity to acquire varied representations. Resolution scaling modifies the resolution of the input picture, finding a middle ground between capturing intricate details and computing effectiveness.

EfficientNetB3 utilizes a compound scaling factor, represented as φ, to compute the scaling coefficients for depth, breadth, and resolution. The coefficients are tuned using a grid search to find the optimal balance between model size and accuracy. EfficientNetB3 surpasses bigger models in terms of both computing efficiency and predictive performance due to its compound scaling.

EfficientNetB3 employs many approaches, including stochastic depth, batch normalization, and dropout, to improve generalization and mitigate overfitting during training. Stochastic depth is a technique used in training neural networks where layers are randomly skipped, serving as a means of regularization. Batch normalization aids in stabilizing the learning process by normalizing the input distributions, whereas dropout adds random neuron dropout to minimize over-reliance on certain characteristics.

EfficientNetB3 is a CNN architecture that provides state-of-the-art performance by effectively balancing model size and accuracy using a novel scaling mechanism, making it very efficient and effective. The compound scaling strategy, together with sophisticated training approaches, allows for the varied use of this technology in many computer vision applications, while yet ensuring computing efficiency.
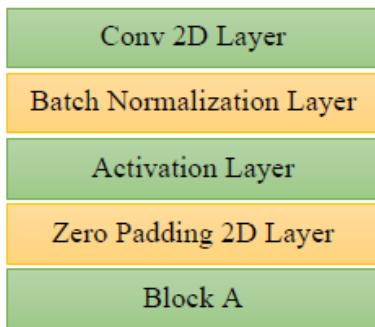
Figure 1: Block A

The functioning of each block in the provided configuration offers valuable insights into the design. Starting with Block A, it includes a series of fundamental layers that are often used in Convolutional Neural Networks (CNNs). The Depthwise Convolutional Layer performs spatial filtering independently for each input channel, followed by Batch Normalization to ensure stable training, and an Activation Layer to introduce non-linear transformations. Global Average Pooling decreases the spatial dimensions, while the following convolutional layers carry out feature extraction. By including a Multiply layer and an additional Convolutional Layer, the model's capacity to comprehend complex patterns is enhanced. The use of Batch Normalization further underscores the need of enhancing training stability inside the network.

Figure 2: Block B
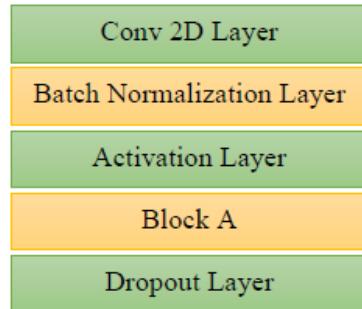
Block B expands Block A by including a Dropout layer. Dropout is a regularization method that selectively removes neurons during training, therefore reducing overfitting and improving the model's ability to generalize.

Figure 3: Block C
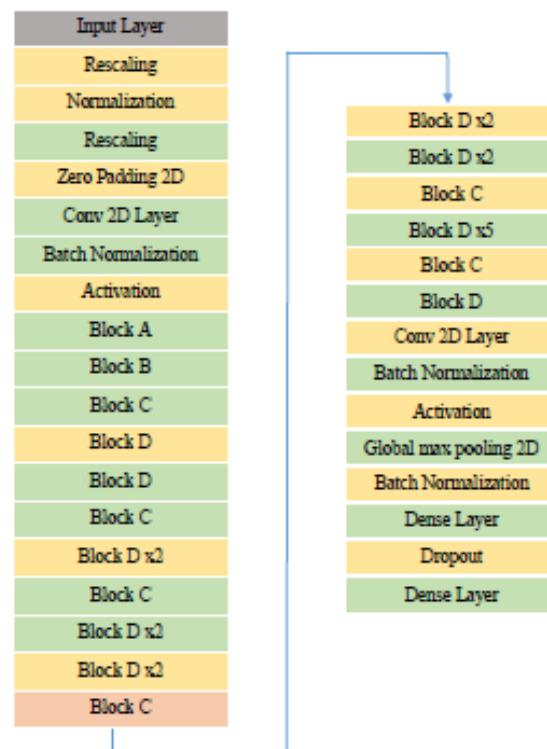
Block C incorporates a novel convolutional layer, Batch Normalization, Activation, and Zero Padding layers. Furthermore, it includes Block A as part of its overall structure. The convolutional layer is responsible for extracting features, Batch Normalization is used to maintain stability, Activation adds non-linearity, and Zero Padding is used to manage spatial dimensions. By

integrating these layers with Block A, it can be inferred that Block C is specifically designed to capture complex spatial hierarchies and patterns present in the input data.

Figure 4: Block D

Block D consists of a convolutional layer, Batch Normalization, Activation, and Block A, followed by a Dropout layer. This extensive block significantly enhances the process of extracting features and incorporates regularization techniques throughout the training phase. The presence of these features in Block D highlights their function in improving the network's learning capacities while simultaneously avoiding overfitting.

Figure 5: Proposed Method Architecture

Overall, these blocks together provide an advanced structure, with each block fulfilling a distinct role in extracting features, normalizing data, introducing non-linearities, and applying regularization techniques. The sophisticated integration of these components enhances the model's capacity to acquire and depict nuanced patterns in the input data.

- Input Layer

  The input layer of a neural network functions as the primary interface for accepting unprocessed input data. The main function of the conduit is to serve as a placeholder for unprocessed information. It accepts data that may have a dimensionality dictated by the number of features or input nodes in the dataset. In contrast to the next layers in the network, the input layer does not engage in any computational operations or hold modifiable parameters. Its only function is to convey the input data to the succeeding levels for further processing. The neural network relies on this fundamental function to accurately process and alter the incoming data as it progresses through its following layers. This function plays a vital role in the network's capacity to learn and produce accurate predictions.

- Rescaling Layer:

  The rescaling layer is an essential element of neural networks, responsible for modifying the scale of the input data. The primary function of this process is to standardize input data, guaranteeing their adherence to a predetermined range. The normalization procedure is crucial for standardizing the input, ensuring stability and enhancing efficient learning in the succeeding layers of the neural network. The rescaling layer is particularly noteworthy since it matches the dimensions of the input layer and functions without any trainable parameters. During the preprocessing step, the main objective is to manipulate the input data in order to enhance the efficiency and performance of the neural network. This is achieved without adding any complexity using trainable parameters.

- Normalization:

  Normalization layers are essential for preserving uniform scales of incoming data. Their main

objective is to mitigate the dominance of some characteristics over others throughout the training process. These layers, which typically have the same number of dimensions as the input layer, are affected by the chosen normalizing method, with Batch normalizing being a prominent example. Batch Normalization adds adaptive parameters that move the normalized data, hence assuring stable and balanced input distributions for the neural network during training. The technique of normalizing improves the network's convergence and overall performance by addressing problems related to different scales of input characteristics.

- Depthwise Convolutional Layer:

  The depthwise convolutional layer enhances computing efficiency by performing convolution operations separately on each channel of the input data. The objective of this approach is to extract spatial characteristics from the input while reducing computing expenses. The dimensions of the layer is determined by the number of input channels and the size of the convolutional filter used. The precise specifications for the layer, such as the dimensions of the filter and the quantity of input channels, are critically established to achieve a harmonious equilibrium between collecting pertinent geographical information and managing computing complexity. The depthwise convolutional layer optimizes the convolution process by adapting its operations to each channel, resulting in effective extraction of spatial features in neural network topologies.

- Batch Normalization Layer:

  The Batch Normalization Layer is a crucial method used to improve the stability and efficiency of training. The operation involves adjusting and scaling the inputs of each layer in order to normalize them, thereby addressing problems such as internal covariate shift. The Batch Normalization Layer accelerates the convergence rate during training by ensuring a consistent distribution of inputs. The inclusion of this layer is essential for addressing the difficulties related to the phenomenon of disappearing or bursting gradients, hence enhancing the stability and speed of learning in

neural networks. Significantly, it incorporates scale and shift parameters for each channel, enabling adaptability to various input distributions and enhancing the overall generalization capacity of the model.

• Activation Layer:

Activation layers include non-linear functions such as Rectified Linear Unit (ReLU), Sigmoid, and Tanh. These functions include non-linear elements into the model, allowing it to effectively collect and comprehend complex patterns and connections within the data. Activation layers differ from layers that change the dimensions of the data or have trainable parameters, since they do not influence the structure of the data. Instead, their function is to augment the network's ability to represent intricate connections, hence enhancing the overall capability of the neural network by incorporating non-linearities that are crucial for capturing the intricacy of real-world data.

• Global Average Pooling Layer:

The Global Average Pooling Layer is an essential component used in neural networks to reduce the spatial dimensions of input data. The purpose of this process is to calculate the mean value for each channel over the whole feature map, combining the information into a single value per channel. Usually located before to the ultimate classification layer, this layer produces an output vector that has the same number of channels as the input. The Global Average Pooling Layer is a dimensionality reduction approach that extracts important characteristics for further network processing without adding any trainable parameters.

• Reshape Layer:

The reshape layer in a neural network is a non-parametric operation that enables the restructuring of the input tensor's arrangement without altering its underlying data or values. The transformation is distinguished by a distinct dimensionality, which determines the size and configuration of the reshaped tensor. The reshape layer is noteworthy for its lack of trainable parameters. Instead, it offers a versatile means of altering the form of the tensor to better

align with the network's design or the needs of succeeding layers. This non-trainable characteristic makes it a powerful tool for effectively preparing input data for subsequent processing inside the neural network without adding extra parameters that can be learned.

• Convolutional Layer:

The Convolutional Layer serving as a fundamental element in tasks related to image and pattern recognition. This layer utilizes filters that go over the input data, performing dot products to identify specific characteristics, using a convolution operation. The dimensionality of the layer is determined by characteristics such as the number and size of filters, as well as the strides used. The parameters mentioned play a crucial role in defining the network's capacity to recognize complex patterns. The number of filters impacts the range of features identified, the filter size determines the scale of features analyzed, and the strides influence the spatial resolution of the output. The Convolutional Layer is very proficient in extracting hierarchical representations from input data, making it a crucial component for tasks such as picture classification and object recognition in deep learning.

• Multiply Layer:

The multiplication layer of a neural network carries out element-wise multiplication between two input tensors. The primary purpose of this function is to analyze the connections between various variables by multiplying their respective components. This technique enables the model to highlight or downplay certain interactions depending on the magnitudes of the components in the input tensors. The multiply layer differs from layers that include trainable parameters, such as weights and biases, since it purely depends on the intrinsic properties of the input tensors and does not incorporate any trainable parameters. The output tensor preserves the same dimensions as the input tensors, enabling the neural network to effectively analyze and acquire knowledge from the encoded relationships in the input data using a direct and non-linear approach.

• Dropout Layer:

Dropout layer function as a kind of regularization in neural networks, especially during the training stage, with the goal of mitigating overfitting. Overfitting arises when a model excessively tailors its learning to the training data, resulting in inadequate generalization when applied to novel, unseen data. Dropout mitigates this problem by stochastically disabling a portion of the input units, or neurons, in each training cycle, so compelling the model to acquire more resilient and comprehensive features. By selectively deactivating some neurons, the network reduces its dependence on certain routes and is prompted to cultivate a broader range of characteristics. It functions as a method of collective learning inside a singular model, augmenting the model's capacity to effectively adapt to unfamiliar input. Dropout layers are computationally efficient and commonly used in deep learning models as a regularization approach. Importantly, they do not contribute any more parameters to be learnt during training.

• Zero Padding Layer:

The zero-padding layer is an essential element that appends zeros to the input data before to performing convolutional operations. Ensuring the preservation of the spatial dimensions of the input is vital throughout the convolutional process. The padding size directly influences the ultimate dimensionality of the output. Zero-padding serves as a means to avoid the decrease in spatial resolution that would otherwise happen, particularly near the boundaries of the input. Crucially, the zero-padding layer does not contribute any trainable parameters, setting it apart from other layers in the network. The significance of this component is solely structural, as it ensures that convolutional operations may be evenly applied to the input. This finally helps in extracting features and retaining crucial spatial information in the architecture of the convolutional neural network.

• Global Max Pooling Layer:

The global max pooling layer, akin to global average pooling, functions by extracting a solitary value from each channel of the input using the maximum operation. Commonly used in combination with convolutional layers in neural networks, this layer efficiently compresses the spatial information inside each channel, resulting in an output vector with the same number of channels as the input. The global max pooling layer reduces dimensionality without adding any trainable weights, unlike layers that include trainable parameters. This procedure is especially beneficial in applications like picture recognition, where preserving the most prominent characteristics while disregarding spatial information is essential for efficient and successful model training.
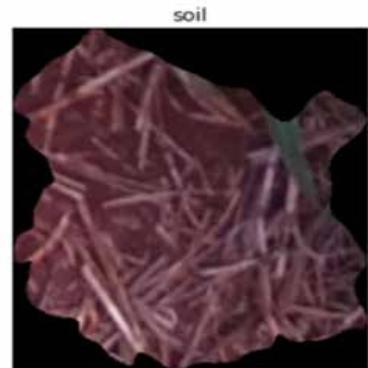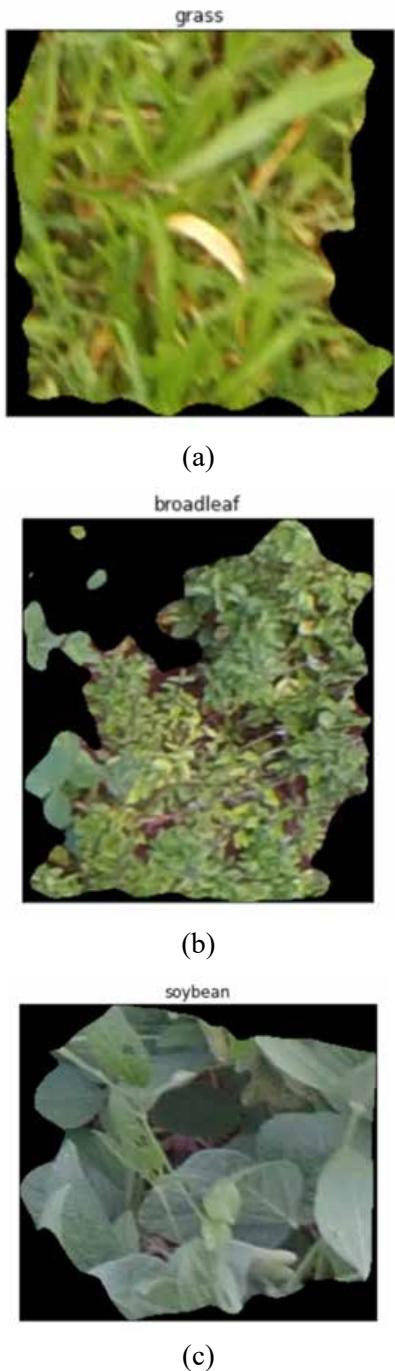
• Dense Layer:

A thick layer, also known as a completely linked layer in neural networks, establishes a complete network of connections by connecting each neuron in the current layer to every neuron in the previous layer. Also known as a fully connected layer, it delicately establishes connections, forming a network in which each node is intimately linked to every other node in neighboring layers. The dimensionality of a layer is defined by the number of nodes it contains, while the parameters, which include the layer's weights and biases, are impacted by the number of input and output nodes. This design facilitates the dense layer in capturing complicated correlations among the data, hence helping it to acquire and depict complex patterns throughout the training process.

4. Experimental Results
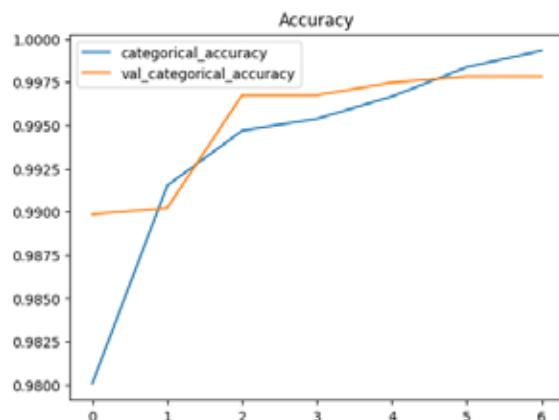
This section offers a comprehensive analysis of the results received from the simulations carried out following the recommended methodology. The dataset used in this inquiry was obtained using the open-source website Kaggle. The dataset was subjected to processing following the recommended methodology. Out of the photographs taken by the UAV, only the ones that showed the presence of weeds were chosen, resulting in a total of 400 images. The Pynovisão program was used to segment these pictures using the SLIC technique, and the resulting segments were manually labeled with their corresponding class. These segments

were used in the compilation of the picture dataset. The picture collection consists of 15,336 segments, with 3,249 segments representing soil, 7,376 segments representing soybean, 3,520 segments representing grass, and 1,191 segments representing broadleaf weeds. Figure 6 shows Sample images in the Dataset.

soil
(d)

grass
(a)

broadleaf
(b)

soybean
(c)

Figure 6: Sample images from Dataset

Figure 7 shows the categorical training and validation Accuracy. Figure 8 shows the training and validation loss.
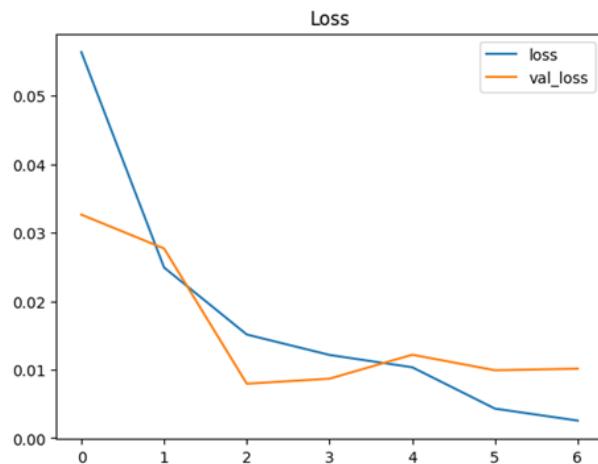
Figure 7: Training and validation Accuracy

Training accuracy is the measure of how accurately a model performs on the training dataset. During the training phase, the model acquires the ability to associate input data with the relevant output labels by modifying its parameters using optimization methods. The training accuracy is determined by evaluating the model's predictions on the training data against the true labels. A high training accuracy indicates that the model has well captured the patterns in the training data, but it does not always ensure strong performance on novel, unknown data.

Validation accuracy, conversely, quantifies the model's performance on an independent dataset known as the validation set. This set consists of data that the model

has not experienced throughout its training process. The validation accuracy is a metric that indicates the model's ability to generalize to new and unseen data. An extensive disparity in the accuracy of the training and validation sets may indicate overfitting, a situation in which the model memorizes the training data but has difficulties in accurately predicting outcomes for new instances.

Figure 8: Training and validation Loss

Training loss and validation loss are measurements that complement accuracy. The training loss measures the discrepancy between the model's predictions and the true labels during the training process. It is often used as the goal function that the optimization method seeks to reduce. The calculation of validation loss follows a similar procedure, except it is performed on the validation dataset. The objective is to attain minimal training and validation losses, demonstrating that the model is successfully minimizing the disparities between predictions and actual labels.

It is essential to monitor both the accuracy and loss metrics during training in order to evaluate the model effectively. A model that achieves high accuracy and minimal loss during training may yet exhibit poor performance on unseen data if it lacks the ability to generalize well. The validation metrics aid in the identification of such problems. Achieving a harmonious equilibrium between training and validation performance is crucial for constructing models that not only excel on the seen data but also demonstrate resilient performance on unobserved data—an important goal

in developing models with practical relevance. Hence, these measures are crucial for directing the training process and guaranteeing the creation of models that have a broad applicability beyond the training dataset.
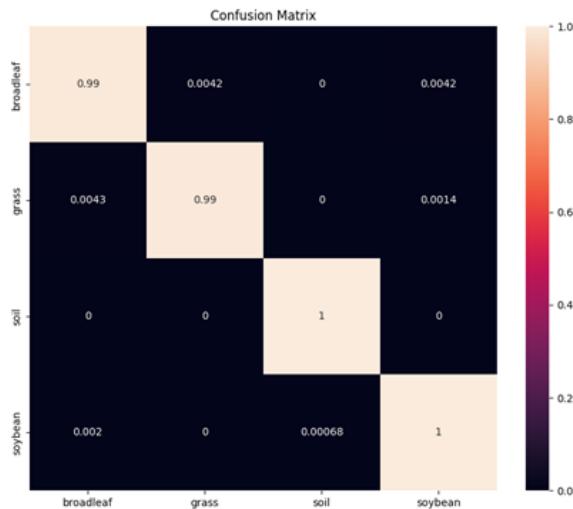
Table 1: Classification Report

	Precision	**Recall**	**F1-Score**
Broadleaf	0.98	0.99	0.98
Grass	1.00	0.99	1.00
Soil	1.00	1.00	1.00
Soybean	1.00	1.00	1.00

The table 1 presented depicts a classification report, a widely used tool in machine learning for assessing the effectiveness of a classification model. Within this framework, it seems that the model has been used for a job involving the identification or categorization of several categories of objects or entities (such as Broadleaf, Grass, Soil, Soybean) based on certain characteristics. The table displays three crucial metrics: Precision, Recall, and F1-Score. These metrics serve as indications of the model's proficiency in accurately categorizing examples for each class. Precision is a metric that quantifies the correctness of the positive predictions provided by the model. The calculation involves determining the proportion of accurate positive predictions relative to the combined number of accurate positive forecasts and inaccurate positive predictions. Within the above table, the accuracy values for each class (Broadleaf, Grass, Soil, Soybean) are very high, ranging from 0.98 to 1.00. This suggests that when the model makes a prediction for a certain class, there is a high probability that the prediction is accurate. For instance, while considering Broadleaf, the model accurately predicts 98% of the instances that are categorized as Broadleaf.

Recall, which is sometimes referred to as sensitivity or true positive rate, quantifies the model's capability to correctly identify all occurrences of a certain class. The calculation involves dividing the number of correct positive predictions by the sum of correct positive forecasts and incorrect negative predictions. The recall values in the table span from 0.99 to 1.00, indicating that the model is very proficient at detecting and capturing occurrences of every class. For example, a recall of 0.99 for Grass indicates that the model accurately detects

99% of all real occurrences of Grass. The F1-Score is calculated as the harmonic mean of accuracy and recall. It offers an equitable assessment that takes into account both incorrect positive results and incorrect negative results. The F1-Score values in the table consistently demonstrate a high level of performance, ranging from 0.98 to 1.00. This indicates a strong and well-balanced trade-off between accuracy and recall. A high F1-Score indicates that the model is achieving good performance in terms of both accuracy and recall.

Figure 9:Confusion Matrix

The confusion matrix shown in figure 9, often used in the domain of machine learning and classification problems, depicts the efficacy of a model in classifying distinct categories. The matrix's rows correspond to the actual class, while its columns indicate the anticipated class. The classifications in this example are "Broadleaf," "Grass," "Soil," and "Soybean." The matrix comprises the probabilities or percentages of examples from a certain true class that the model predicts will be classified into each class.

The diagonal components of the matrix, spanning from the top-left to the bottom-right, represent the accuracy for each class. For instance, the value 0.99 in the upper-left quadrant of the matrix indicates that the model accurately predicts 99% of cases classified as "Broadleaf" as "Broadleaf". The off-diagonal components indicate instances of misdiagnosis. Specifically, the number 0.0042 in the top-right corner indicates that 0.42% of occurrences of "Broadleaf" are

inaccurately classified as "Grass" by the model. The confusion matrix offers a comprehensive analysis of the model's accuracy, enabling a nuanced evaluation of its capabilities in differentiating between various categories.

It is worth mentioning that the model has strong overall performance, as seen by the high values of the diagonal components, which indicate a high level of accuracy. Nevertheless, it is important to take into account the particular context and specifications of the application in order to ascertain if the model's performance is in line with the expected results.

Table 2: Comparative Analysis

Method	Accuracy
CNN	93%
VGG16	94%
AlexNet	95%
Efficient Net B3 (Proposed)	99%

Table 2 displays a comparative examination of several image categorization algorithms, highlighting their distinct accuracies. Accuracy is a vital parameter in image recognition, since it quantifies the proportion of properly identified pictures out of the total number of images assessed. Four alternative strategies are examined in this case: CNN (Convolutional Neural Network), VGG16, AlexNet, and EfficientNet B3. Each method achieves a different degree of accuracy.

The table demonstrates that the CNN approach attained an accuracy rate of 93%. Regarding VGG16, the accuracy exhibits a little improvement, reaching 94%. The AlexNet model acquired an accuracy of 95%. The most remarkable outcome in the table is the suggested EfficientNet B3, which attained an astounding accuracy of 99%. EfficientNet refers to a collection of neural network structures that are recognized for their exceptional efficiency in using computing resources. The 'B3' variety most likely denotes a distinct arrangement within the EfficientNet lineage.

CONCLUSION

In conclusion, this paper presents a robust and efficient approach for weed detection in soybean crops using the state-of-the-art EfficientNetB3 Transfer Learning model. The utilization of transfer learning not only

leverages the pre-trained knowledge of the model on large datasets but also significantly reduces the need for extensive labeled data in the specific domain of soybean crops. The dataset, consisting of soybean crop images, has been instrumental in training and evaluating the model's performance. The evaluation metrics, including precision, recall, and f1-score, were carefully calculated to assess the model's effectiveness. The achieved results demonstrate high accuracy, with an impressive 99% accuracy rate. This indicates the model's capability to accurately identify and classify weeds within soybean crops. The high precision, recall, and f1-score values further emphasize the model's robustness in both minimizing false positives and false negatives, crucial for precision agriculture applications. The success of the EfficientNetB3 Transfer Learning model in weed detection holds significant implications for the agricultural industry. By providing a reliable and accurate means of identifying and managing weeds in soybean crops, farmers can optimize their resources, reduce the reliance on herbicides, and enhance overall crop yield.

REFERENCES

1. Ukaegbu, Uchechi F., Lagouge K. Tartibu, Modestus O. Okwu, and Isaac O. Olayode. "Development of a light-weight unmanned aerial vehicle for precision agriculture." Sensors 21, no. 13 (2021): 4417.

2. Nasiri, Amin, Mahmoud Omid, Amin Taheri-Garavand, and AbdolabbasJafari. "Deep learning-based precision agriculture through weed recognition in sugar beet fields." Sustainable Computing: Informatics and Systems 35 (2022): 100759.

3. Shorewala, Shantam, ArmaanAshfaque, R. Sidharth, and Ujjwal Verma. "Weed density and distribution estimation for precision agriculture using semi-supervised learning." IEEE access 9 (2021): 27971-27986.

4. Champ, Julien, Adan Mora-Fallas, HervéGoëau, Erick Mata-Montero, Pierre Bonnet, and Alexis Joly. "Instance segmentation for the fine detection of crop and weed plants by precision agricultural robots." Applications in plant sciences 8, no. 7 (2020): e11373.

5. Gerhards, Roland, DionisioAndujar Sanchez, PavelHamouz, Gerassimos G. Peteinatos, Svend Christensen, and Cesar Fernandez-Quintanilla. "Advances in site-specific weed management in agriculture—A review." Weed Research 62, no. 2 (2022): 123-133.

6. Wu, Zhangnan, Yajun Chen, Bo Zhao, Xiaobing Kang, and Yuanyuan Ding. "Review of weed detection methods based on computer vision." Sensors 21, no. 11 (2021): 3647.

7. Singh, Vijay, Aman Rana, Michael Bishop, Anthony M. Filippi, Dale Cope, NithyaRajan, and MuthukumarBagavathiannan. "Unmanned aircraft systems for precision weed detection and management: Prospects and challenges." Advances in Agronomy 159 (2020): 93-134.

8. Rosle, Rhusha lshafira, Nik Norasma Che'Ya, Yuhao Ang, Fariq Rahmat, Aimrun Wayayok, Zulkarami Berahim, Wan Fazilah FazlilIlahi, Mohd Razi Ismail, and Mohamad Husni Omar. "Weed detection in rice fields using remote sensing technique: A review." Applied sciences 11, no. 22 (2021): 10701.

9. Punithavathi, R., A. Delphin Carolina Rani, K. R. Sughashini, Chinnarao Kurangi, M. Nirmala, Hasmath Farhana Thariq Ahmed, and S. P. Balamurugan. "Computer vision and deep learning-enabled weed detection model for precision agriculture." Comput. Syst. Sci. Eng 44, no. 3 (2023): 2759-2774.

10. Dang, Fengying, Dong Chen, Yuzhen Lu, and Zhaojian Li. "YOLOWeeds: a novel benchmark of YOLO object detectors for multi-class weed detection in cotton production systems." Computers and Electronics in Agriculture 205 (2023): 107655.

11. Gallo, Ignazio, Anwar Ur Rehman, Ramin Heidarian Dehkordi, Nicola Landro, Riccardo La Grassa, and Mirco Boschetti. "Deep object detection of crop weeds: Performance of YOLOv7 on a real case dataset from UAV images." Remote Sensing 15, no. 2 (2023): 539.

12. Chen, Jiqing, Huabin Wang, Hongdu Zhang, TianLuo, Depeng Wei, Teng Long, and Zhikui Wang. "Weed detection in sesame fields using a YOLO model with an enhanced attention mechanism and feature fusion." Computers and Electronics in Agriculture 202 (2022): 107412.

13. Manikandakumar, M., and P. Karthikeyan. "Weed classification using particle swarm optimization and deep learning models." Comput. Syst. Sci. Eng 44, no. 1 (2023): 913-927.

14. Razfar, Najmeh, Julian True, RodinaBassiouny, VishaalVenkatesh, and Rasha Kashef. "Weed detection in soybean crops using custom lightweight deep learning models." Journal of Agriculture and Food Research 8 (2022): 100308.

15. Subeesh, A., S. Bhole, Kamaljeet Singh, Narendra Singh Chandel, Yogesh Anand Rajwade, K. V. R. Rao, S. P. Kumar, and Dinesh Jat. "Deep convolutional neural network models for weed detection in polyhouse grown bell peppers." Artificial Intelligence in Agriculture 6 (2022): 47-54.

16. Jin, Xiaojun, Jun Che, and Yong Chen. "Weed identification using deep learning and image processing in vegetable plantation." IEEE Access 9 (2021): 10940-10950.

17. Haq, Mohd Anul. "CNN Based Automated Weed Detection System Using UAV Imagery." Computer Systems Science & Engineering 42, no. 2 (2022).

18. Osorio, Kavir, Andrés Puerto, Cesar Pedraza, David Jamaica, and Leonardo Rodríguez. "A deep learning approach for weed detection in lettuce crops using multispectral images." AgriEngineering 2, no. 3 (2020): 471-488.

Automated Diabetic Macular Edema (DME) Grading

Amarnath Virochan Ambure
✉ amarambure99@gmail.com

Neha Sanjay Jadhav
✉ nehaj5876@gmail.com

Pratik Tushar Dudhankar
✉ pratikdudhankar@gmail.com

Vandana N. Jirafe
✉ Vandana.hanchate@moderncoe.edu.in

R. S. Kamathe
✉ hodentc@moderncoe.edu.in

S. D. Borde
✉ sheetal.borde@moderncoe.edu.in

Dept. of Electronics & Telecommunication Engineering
P. E. S Modern Collage of Engineering
Savitribai Phule Pune University
Pune, Maharashtra

ABSTRACT

Diabetic Macular Edema (DME) is a vision-threatening complication of Diabetes Melli- tus that affects the macula, leading to visual impair- ment. The severity of DME is graded into non- clinically significant macular edema (non-CSME) and clinically significant macular edema (CSME), and its early detection and treatment are crucial for preventing vision loss. In this study, we propose a Computer-Aided System (CAD) for the automatic detection and grading of DME using retinal images. The proposed system consists of three processing stages: macula localization, exudate detection, and grading of DME according to macular coordinates and the location of exudates in the input image. We utilize various publicly available datasets and CNN models for image segmentation and classification, respectively. Our results demonstrate that the pro- posed CAD system can accurately detect and grade the severity of DME, providing ophthalmologists with a reliable and efficient tool for diagnosis and treatment. The proposed system can significantly reduce the workload of ophthalmologists and improve the accuracy of diagnosis.

INTRODUCTION

The escalating global prevalence of diabetes and its associated complications, notably diabetic macular edema (DME), calls for innovative solutions in healthcare. Current manual grading processes are subjective, time-consuming, and prone to variabil- ity. Leveraging cutting-edge deep learning and computer vision techniques, proposed work aims to transform DME diagnosis and grading. By automat- ing this process, we enhance accuracy, efficiency, and accessibility, ultimately improving patient out- comes and alleviating the burden on healthcare systems. This project's motivation lies in revolutioniz- ing DME management, offering a reliable, objective, and cost-effective solution for timely intervention and treatment decisions.

The rising global prevalence of diabetes has led to increased cases of diabetic macular edema (DME), a critical threat to vision [1] [8]. Characterized by fluid accumulation in the macula, it's a major cause of vision loss in diabetics, necessitating prompt management [1] [2] [4]. Traditional manual grading methods lack efficiency and objectivity, demanding a more scalable solution [2] [5].

The "Automated Diabetic Macular Edema Grading" project addresses this by developing a computer- based system, driven by deep learning and computer vision [1] [3] [5] [7] [8]. The core aim is to create a robust algorithm that automates DME severity classification [1] [4]. Leveraging a comprehensive dataset, it ensures accurate grading and envisions transforming DME diagnosis, making it more accessible and enhancing patient outcomes [1] [7] [8].

Motivation

The escalating global prevalence of diabetes and its associated complications, notably diabetic macular edema (DME), calls for innovative solutions in healthcare. Current manual grading processes are subjective, time-consuming, and prone to variability. Leveraging cutting-edge deep learning and computer vision techniques, proposed work aims to transform DME diagnosis and grading. By automating this process, we enhance accuracy, efficiency, and accessibility, ultimately improving patient out- comes and alleviating the burden on healthcare systems. This project's motivation lies in revolutionizing DME management, offering a reliable, objective, and cost-effective solution for timely intervention and treatment decisions.

METHODS

Datasets

The project utilizes a dataset of OCT (Optical Co-herence Tomography) images, which is organized into three main folders: train, test, and val. Each folder contains four subfolders or classes: NOR- MAL, CNV, DME, and DURSEN. The dataset comprises a total of approximately 83,433 images in JPEG format. To increase the diversity and size of the dataset, data augmentation was performed using the ImageDataGenerator technique. This process generated five additional images for each original image, resulting in an augmented dataset. The augmented images were saved in separate directories named train_augmented, test_augmented, and val_augmented. The augmented dataset consists of approximately 417,435 images. The images in the dataset have a size of 224 by 224 pixels and are in colour (RGB format). The file format of the images is JPEG (.jpeg extension).

Pre-processing

Proposed work employs preprocessing techniques to enhance image quality and feature extraction. This involves noise reduction, contrast enhancement, and resizing to ensure standardized inputs for the CNN model.

Image Segmentation

We utilize advanced image segmentation to identify regions of interest, such as the macula and exudates. U-Net architecture aids in accurate pixel-level segmentation, enabling the model to focus on relevant areas for precise DME grading

RELATED WORK

The field of diabetic macular edema (DME) diagnosis and grading has witnessed substantial advancements owing to the integration of deep learning and computer vision techniques. Several research endeavours have contributed to the development of automated systems for precise and efficient assessment of DME severity.

Bangar and Chaudhary [1] proposed convolutional neural networks (CNNs) for automated DME detection, demonstrating the potential of deep learning in this domain. Kamble and Chan [2] fine-tuned Inception-ResNet-v2 on OCT images to achieve accurate DME analysis. Singh and Gorantla [3] introduced DMENet, a hierarchical ensemble of CNNs, for diabetic macular edema diagnosis. These studies underscore the effectiveness of CNN-based models in automating DME grading.

Cross-disease attention networks were introduced by Li, Fu, and Zhu [4], enabling joint grading of diabetic retinopathy and DME. Nasir and Afreen[5].

leveraged transfer learning for diabetic retinopathy and DME severity grading, highlighting the significance of knowledge transfer in similar domains. Alsaih, Lemaitre, and Rastgoo [6] explored diverse machine learning techniques for DME classification on SD OCT images, underscoring the versatility of approaches in tackling this complex task.

Kaymak and Serener [7] extended the application of automated diagnosis to age-related macular degeneration and DME detection, showcasing the adaptability of these methods to different retinal conditions. Li, Wang, Xu, Dong, and Yan [8] presented a deep learning-based system for automated detection of diabetic retinopathy and DME in retinal fundus photographs, demonstrating the impact of this technology on diverse image modalities. Perdomo and Otalora [9] introduced OCT-NET, a convolutional network for automatic classification of normal and diabetic macular edema using SD-OCT volumes, highlighting the potential of volumetric data analysis.

These research endeavours collectively form the foundation for the "Automated Diabetic Macular Edema

Grading" project, contributing to the development of accurate, objective, and efficient systems for DME diagnosis and grading.

EXPECTED RESULT

The expected result of proposed work is a robust computer-based system for automated Diabetic Macular Edema (DME) grading with high accuracy. The system will accurately classify retinal images into different grades of DME severity, ranging from normal macula to mild, moderate, and severe DME.

This classification will be based on an algorithm trained using a comprehensive dataset of annotated retinal images from diabetic patients.

We anticipate achieving an accuracy rate of 99% to 100% in classifying DME severity levels. The system's user-friendly interface will allow ophthalmologists and healthcare professionals to effortlessly upload retinal images for automated analysis. This will lead to rapid, consistent, and reliable DME grading, enabling timely interventions and treatment decisions.

Additionally, the integration of state-of-the-art techniques such as deep learning and computer vision will elevate the accuracy and efficiency of the sys- tem, minimizing the need for subjective human interpretation. The system's deployment across various healthcare settings, including clinics, hospitals, and telemedicine platforms, will enhance diabetic retinopathy screening and management accessibility. The anticipated outcome is an innovative tool that transforms DME diagnosis and management, significantly improving early detection, patient out- comes, resource utilization, and the overall quality of diabetic patient care.
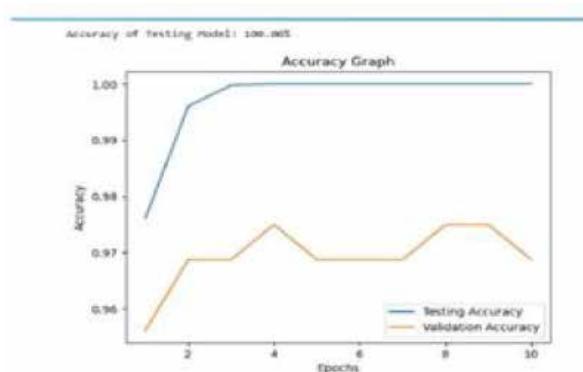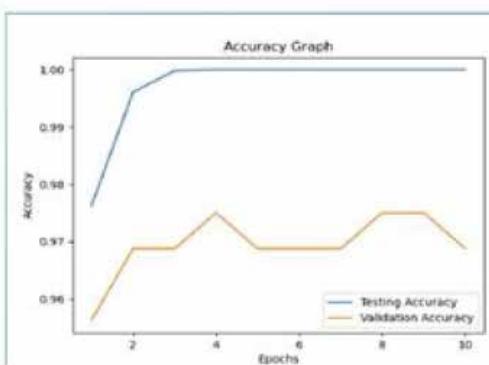
Fig 1. Testing Accuracy & Validation Accuracy of 10 epoch

DISCUSSION

Here are some discussion points :

1. Significance of Diabetic Macular Edema (DME) Detection: DME is a serious complication of diabetes that can lead to vision loss if not detected and treated early. Discuss the importance of an accurate and efficient system for DME detection and grading, especially in areas where access to ophthalmologists may be limited.

2. Technical Challenges and Solutions: Developing an automated system for DME detection and grading is a complex task that requires addressing several technical challenges, such as accurate macula localization, exudate detection, and grading criteria. Discuss the technical solutions proposed in the project to address these challenges.

3. Comparison with Existing Models: Compare the proposed model with existing models for DME detection and grading, highlighting the advantages and disadvantages of each. Discuss how the proposed model improves upon existing models and how it can be further improved in the future.

4. Application of the Model: Discuss the potential applications of the proposed model, such as screening programs for diabetic patients, telemedicine consultations, and resource-limited settings.

5. Performance Evaluation: Discuss the metrics used to evaluate the performance of the proposed model,

such as sensitivity, specificity, accuracy, and area under the curve (AUC). Analyze the results of the performance evaluation and discuss possible ways to improve the model's performance.

6. Commercial Viability: Discuss the potential commercial viability of the proposed system, including the market demand, pricing strategy, and potential competition.

7. Ethical Considerations: Discuss the ethical considerations related to the development and deployment of an automated system for DME detection and grading, such as patient privacy, data security, and potential biases in the algorithm.

8. Future Directions: Discuss the future directions of the proposed model, such as integrating it with other diagnostic tools, developing a mobile app for patient self-screening, or applying it to other retinal diseases.

FUTURE SCOPE

As technology continues to evolve, there are several possibilities to enhance the capabilities of our Automatic Diabetic Macular Edema (DME) Grading system. Some of the potential future enhancements include:

Integration with cloud platforms: Currently, our DME grading system is hosted on a local server. However, with the growing popularity of cloud platforms, we can leverage them to provide better scalability, reliability, and performance to our system. Cloud platforms like Amazon Web Services (AWS), Google Cloud Platform (GCP), and Microsoft Azure offer a range of services that can help us achieve this goal.

Improved user experience: We can further enhance the user experience by designing an intuitive and user-friendly interface for both doctors and patients. This can include features like interactive visualizations, personalized dashboards, and real-time notifications.

Integration with Electronic Health Records (EHR): We can integrate our DME grading system with EHRs, which can provide doctors with a complete patient history, including medical diagnoses, lab results, and prescriptions. This can help doctors make more informed decisions and provide better care to their patients. Mobile application development: With the

growing number of mobile users, we can develop a mobile application for our DME grading system.
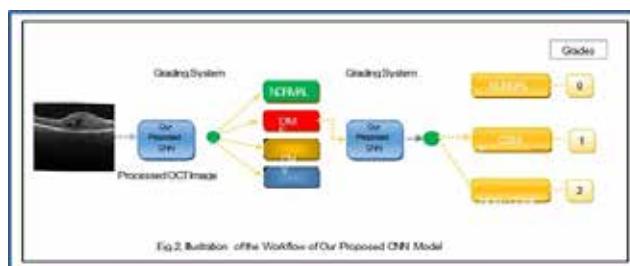
This can enable patients to monitor their DME status, schedule appointments, and communicate with doctors from the comfort of their own home.

Artificial Intelligence (AI) and Machine Learning

(ML) integration: We can explore the integration of AI and ML techniques to improve the accuracy and speed of our DME grading system. By analysing large volumes of data, we can train our system to recognize patterns and predict outcomes with greater precision.

Website redesign: We can also redesign our website to provide a more modern and responsive design. This can include features like easy navigation, search functionality, and interactive tutorials.

In conclusion, the above-mentioned enhancements can provide a better user experience, improve efficiency and accuracy, and enable us to provide better care to patients suffering from DME. We plan to explore these possibilities in the future and continue to evolve our DME grading system to meet the changing needs of patients and doctors.

Fig 2: Illustration of the workflow of our proposed CNN Model

GRADING CRITERIA

The grading criteria for proposed work involve classifying retinal images into different grades of Diabetic Macular Edema (DME) severity based on the distance between the macula and exudates, which are indicative of DME. The classification is as follows:

Grade 0: No visible exudates, indicating a normal condition.

Grade 1: Shortest distance between macula and exudates greater than one optic disc diameter, cate gorized as

non-clinically significant macular edema (Non-CSME).

Grade 2: Shortest distance between macula and exudates less than one optic disc diameter, indicating clinically significant macular edema (CSME).

This grading system leverages the distance between the macula and exudates as a key criterion to determine the severity of DME. The grades provide valuable insights into the condition, aiding ophthalmologists and healthcare professionals in making informed decisions regarding interventions and treatments. The inclusion of clinically significant macular edema (CSME) as a separate category.

Fig 3: Grading Criteria

CONCLUSION

The use of artificial intelligence and machine learning algorithms to diagnose and grade medical conditions has the potential to greatly improve healthcare outcomes by enabling faster, more accurate diagnoses. The system presented in this project demonstrates such an application, with promising results for the diagnosis of DME. While the system's performance has been shown to be comparable to that of human experts, it is important to note that it is not intended to replace human judgement entirely; rather, it should be viewed as a complementary tool that can assist healthcare professionals in making more informed diagnoses and treatment decisions.

REFERENCES

1. Manisha Bangar, Prachi Chaudhary," Convolutional Neural Networks for automated detection of Diabetic Macular Edema", September 1st, 2022.

2. Ravi M. Kamble, Genevieve C. Y. Chan, "Automated Diabetic Macular Edema (DME) Analysis using Fine Tuning with InceptionResnet-v2 on OCT Images", 2018.

3. Rajeev Kumar Singh, Rohan Gorantla, "DMENet: Diabetic Macular Edema diagnosis using Hierarchical Ensemble of CNNs",2019.

4. Xiaomeng Li, Chi-Wing Fu, Lei Zhu," CANet: Cross-disease Attention Network for Joint Diabetic Retinopathy and Diabetic Macular Edema Grading",2018

5. Nida Nasir, Neda Afreen," A Transfer Learning Approach for Diabetic Retinopathy and Diabetic Macular Edema Severity Grading,2021"

6. Khaled Alsaih, Guillaume Lemaitre, Mojdeh Rastgoo," Machine learning techniques for diabetic macular edema (DME) classifcation on SD OCT images",2017.

7. Sertan Kaymak, Ali Serener," Automated Age -Related Macular Degeneration and Diabetic Macular Edema Detection on OCT Images using Deep Learning",2018

8. Feng Li, Yuguang Wang, Tianyi Xu, Lin Dong, Lei Yan," Deep learning-based automated detection for diabetic retinopathy and diabetic macular oedema in retinal fundus photographs", 24 August 2020

9. Oscar Perdomo, Sebastian Otalora," OCTNET: A Convolutional Network for Automatic Classification of Normal and Diabetic Macular Edema Using SD-Oct Volumes",2018.

Power Quality Improvement using Unified Power Quality Conditioner in Grid Integrated PV System using Fuzzy Logic Controller

Singam Sai Nikhith
Department of Electrical Engineering
JNTUH UCEST, JNTUH, Kukatpally
Hyderabad, Telangana
✉ sainikhith9@gmail.com

K Naga Sujatha
Professor
Department of Electrical Engineering
JNTUH UCEST, Kukatpally
Hyderabad, Telangana

ABSTRACT

This paper presents a comprehensive study on improving power quality in grid- connected PV systems by employing a UPQC with a Fuzzy Logic Controller (FLC).The proposed system leverages the UPQC's ability to mitigate PQ issues such as voltage sags, swells, harmonics, and flicker. By integrating this advanced power conditioning technology with grid-connected PV systems, we aim to enhance the overall power quality while allowing for increased renewable energy penetration. The FLC plays a pivotal role in regulating the UPQC's operation, offering a dynamic and adaptive approach to control. FLC provides the system with the capability to adjust its parameters in real-time, responding to changing grid conditions and PV system output. This intelligent control strategy ensures that the UPQC operates optimally, effectively addressing power quality disturbances and maintaining stable grid integration. Through simulation studies, we evaluate the performance of the proposed system under various grid scenarios and PV system conditions. Results demonstrate significant improvements in power quality metrics, showcasing the effectiveness of the UPQC with FLC in mitigating grid disturbances and ensuring the reliable operation of grid-connected PV systems.

KEYWORDS: *Maximum power point tracking (MPPT), Power quality(PQ), Series compensator, Shunt compensator, Solar PV, Unified power quality conditioner(UPQC).*

INTRODUCTION

The increase in PQ issues seems to be associated with the expanding use of solid-state semiconductor devices, switched-mode power supplies, adjustable speed drives, and comparable technologies. In introduction the widespread adoption of PE devices and electronic loads have resulted in a greater influx the power system. PQ problems have the potential to lead to equipment malfunctions, unintended activation of electronic switches, data loss, and memory issues in sensitive equipment such as computers, as well as safety and relaying equipment.

Additionally, the accelerates the wear and tear of transformers, cables, and other transmission components. In cases involving biomedical equipment, the consequences can be particularly dire. Throughout the history of power systems, it has become evident that PQ is a dual-sided challenge where electronic devices play roles as both culprits and casualties. Despite the high efficiency of power electronic devices, they intermittently draw current in surges and modify the electricity flowing through them. Consequently, the power fed back into the grid becomes distorted. Consequently, utilities are compelled to allocate additional resources to deploy filters and capacitors in order to rectify this "contaminated" power. Generating a reference signal is a critical element in regulator strategy of UPQC. This signal can be generated using either time-domain or frequency-domain methods [1]. Typically, real-time implementations favour time-domain techniques because they demand less time.

The method employs a time-domain method known as

synchronous reference frame theory [2]. However, it's worth noting that during unbalanced load conditions, this approach introduces double harmonic components. Using a standard low-pass filter would result in a decrease in performance. In this study, a MAF is employed [3]. The MAF offers the advantage of achieving maximum attenuation without compromising the bandwidth [4]. Implementing the MAF also enhances performance of the PLL in grid synchronization [5], [6].

This research focuses on modelling and simulation of a 3-□ solar PV combined UPQC using d-q theory. Additionally, it utilizes the MAF to enhance dynamic performance while extracting active current from the load. One of the primary attributes of this system is its ability to concurrently manage the enhancement of voltage and current quality. Moreover, it maintains stability even when confronted with diverse dynamic situations, such as voltage sags, swells, or unbalanced loads. To examine its behaviour under both dynamic and steady-state conditions, we've created a model for the system using the Matlab Simulink software [7].

A FLC is regarded as a superior choice when it comes to reducing Total Harmonic Distortion (THD) in Unified Power Quality Conditioners (UPQCs) compared to traditional Proportional- Integral (PI) controllers [8]. The primary reason lies in FLC's adaptability and versatility. Power systems, especially those with renewable energy sources, are inherently dynamic and nonlinear, subject to fluctuations in load and generation. FLCs excel in handling such complexities, adjusting their control parameters in real-time to respond to changing conditions. This adaptability is crucial for effective THD reduction, as harmonics and disturbances can vary widely [9].

Furthermore, FLCs are inherently robust. They can perform well under uncertainties and non- ideal conditions, making them ideal for the unpredictable nature of power systems. In contrast, PI controllers rely on fixed parameters, which may not adequately address the dynamic nature of THD reduction requirements. FLCs also offer the advantage of handling multiple inputs and outputs, making them suitable for UPQCs, which often need to address various PQ issues concurrently, such as voltage sag, swell, and harmonics [10].

In addition to their adaptability and robustness, FLCs require less precise parameter tuning compared to PI controllers, simplifying their implementation. They are also known for minimizing overshoot in control responses, maintaining stability during the THD reduction process [11].
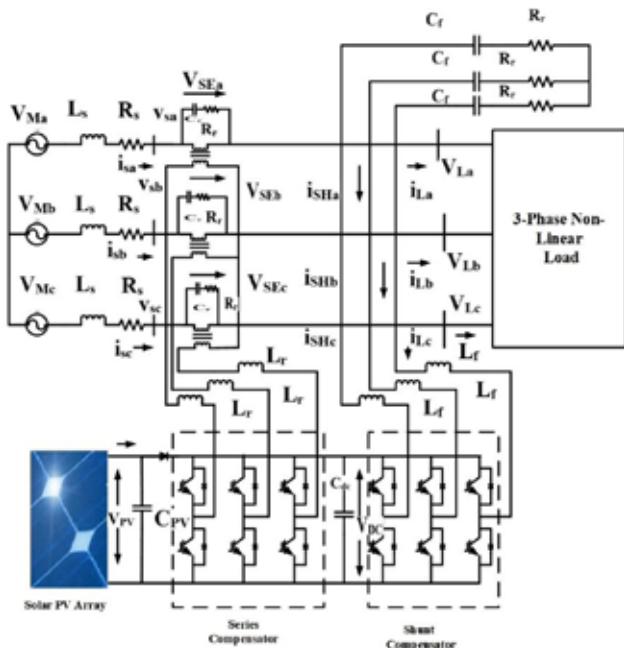
Overall, FLCs' ability to adapt to changing conditions, handle nonlinearity, and maintain robust performance in the face of uncertainties makes them an advanced and effective choice for THD reduction in UPQCs, contributing to improved power quality in modern grid systems [12].

The paper is structured into distinct sections: Section I provides an introduction, Section II describes the system description, Section III includes the Proposed PV-FLC-UPQC Control Topology, Section IV presents Proposed System, Section V presents Simulation Results and finally Section VI explains the paper with a conclusion.

SYSTEM DESCRIPTION

Figure 1 displays the configuration of the PV-UPQC, tailored for a 3-∅. This PV-UPQC incorporates both shunt & series compensators interconnected via a shared DC-bus. To clarify, shunt compensator is attached on load side, and solar PV array establishes a direct connection with DC-link. Grid is linked both shunt and series compensators via interfacing inductors. To introduce voltage formed by series compensator into grid, a series injection transformer utilized Ripple filters integrated to mitigate harmonics generated by switching actions of converter. Load under examination is nonlinear in character and encompasses load linked to rectifier.

The process of designing a PV-FLC-UPQC commences with careful dimensioning of key components like the PV array, DC-link capacitor and voltage level. In case of shunt compensator, its size determined to accommodate maximum power output of PV array, to addressing reactive power requirements of current harmonics associated with load current. PV array is directly linked to UPQC's DC-link, its sizing involves setting the maximum power point equal to preferred DC link voltage. PV array's assessment is determined under normal operating circumstances, it can provide both active power needed by load to contribute power to grid.

Fig. 1. Proposed PV-FLC-UPQC

The remaining components that are part of the design include interfacing inductors for both series & shunt compensators, as well as the series injection transformer used in series compensator. The design process for the PV-FLC-UPQC system described as follows

The DC-link voltage, denoted as Vdc, is contingent on modulation depth employed. It imperative amount of the DC-link voltage exceeds twice of peak value as per-phase voltage in 3-∅ system, as per reference [7]. This is expressed as follows:

$$V_{dc} = \frac{2\sqrt{2}\,V_{LL}}{\sqrt{3}m}$$

(1)

Assuming a modulation depth (m) of 1, in the formula provided, where VLL signifies grid line voltage, lowest required DC-bus voltage calculated. If line voltage is 415 V. DC-bus voltage computes to be 678.6 V. To align with MPPT operating voltage of PV array under STC, DC- bus voltage is approximately 700v.

The rating of DC-link capacitor is considering both power requirements [8]:

$$C_{dc} = \frac{3kaV_{ph}I_{sh}t}{0.5 \times \left(V_{dc}^2 - V_{dc1}^2\right)}$$

$$= \frac{3\times0.1\times1.5\times239.6\times34.5\times0.03}{0.5\times(700^2-677.79^2)}$$

$$= 9.3\text{mF}$$

(2)

In this context, Vdc represents usual DC-bus voltage, Vdc1 signifies minimum necessary DC- bus voltage, denotes overcapacity factor, Vph stands for voltage, and t represents least time required to attain a stable charge after a trouble.

In calculation based on equation(2) yields a minimum necessary DC-link voltage of Vdc1 =

677.69 V. With Vdc set at 700 V, Vph at 239.60 V, Ish at 57.5 A, a at 1.2, considering a dynamic energy change of 10% (k = 0.1), value for Cdc determined to be 9.2mF.

Establishing the Dimensions of the Interface Inductor for the Shunt Compensator: The rating of interface inductor for shunt compensator is influenced by factors such as current, switching frequency, and DC-link voltage, equation for computing interface inductor formulated as follows:

$$L_f = \frac{\sqrt{3}mV_{dc}}{12af_{sh}I_{cr,pp}} = \frac{\sqrt{3}\times1\times700}{12\times1.2\times10000\times6.9}$$

(3)

Here, in the formula, m represents the distance of modulation, a stands for per unit, f_{sh} denotes the switching frequency, and $I_{cr,pp}$ signifies peak-to-peak inductor ripple current, considered be 20% of the root mean square phase current of the shunt compensator.

With specific values plugged in, such as m = 1, a = 1.2, f_{sh} = 10 kHz, V_{dc} = 700 V, the calculation yields a value of approximately 800 µH. For practical purposes, this value is approximated to 1 mH.

The PV-UPQC's purpose is to mitigate voltage sags or swells at 0.3 per unit, equivalent to 71V. Consequently, the necessary injected voltage is just 71V, consequently, a lower modulation index is detected is configured to 700 V. To ensure that the series compensator functions with nominal harmonics, to ensure modulation index remains close to one it is advised to introduce.

$$K_{SE} = \frac{v_{VSC}}{v_{SE}} = 3.33 \approx 3$$

(4)

Where KSE is 3.33, but 3 is chosen.

$$S_{SE} = 3V_{SE}I_S E_{sag} = 46 \times 3 \times 72 = 10kVA \qquad (5)$$

The supply passing via the series VSC matches grid current. When grid experiencing a sag form of 0.3 per unit, supply current amounts to 46 A, resulting in a achieved VA (Volt-Ampere) evaluation of the injection convertor of 10 k Volt Ampere.

$$L_r = \frac{\sqrt{3} \times m V_{dc} K_{SE}}{12 a f_{se} I_r} = \frac{\sqrt{3} \times 1 \times 700 \times 3}{12 \times 1.2 \times 10000 \times 7.1}$$
$$= 3.6mH \qquad (6)$$

In this equation, f_{se} stands for switching frequency, and Ir is inductor current ripple, set at 20% of the grid current. With the specified values of m = 1, a = 1.5, f_{se} = 10 kHz, V_{dc} = 700 V, and a 20% ripple current, chosen value for the interfacing inductor is 3.6 mH.

PROPOSED PV-FLC-UPQC CONTROL TOPOLOGY

Fuzzy Logic Controller (FLC) PV-UPQC comprises two primary subsystems: shunt and series compensator serve distinct roles. Shunt compensator is tasked with resolving power quality concerns associated with the load, including harmonics in load current and reactive power requirements. Significantly, within the context FLC PV-UPQC, shunt compensator assumes an added purpose is extracting power from solar PV array. It accomplishes this by employing a MPPT algorithm of PV array's power output. The series compensator safeguards load against PQ difficulties that originate from the grid, such disruptions, like voltage dips and surges, are alleviated by injecting the required voltage.

FLC of Shunt compensator

This is accomplished by employing a MPPT that generates reference voltage DC-link of the FLC PV-UPQC. Usually utilized MPPT including the P&O and the INC, have been well- documented [9]. In this research, MPPT approach based on the P&O algorithm. To maintain reference voltage, a FLC is employed of DC-link voltage.

To compensate for load current, managed by employing the SRF method to isolate shunt compensator is illustrated in Figure 2. Utilizing phase and frequency

data acquired through a PLL with the PCC voltage serving as its input, the load currents are converted as shown in below:

$$M\,AF(s) = \frac{1 - e^{-T_w s}}{T_m s} \qquad (7)$$

In this context, Tw signifies the duration of the moving average filter's window. This adjustment is made to account for presence of lowest harmonic in d-axis current, which happens to be the second harmonic. The moving average filter has a DC gain of one and effectively nullifies gains for integer multiples of the window length.

$$I_{pvg} = \frac{2}{3} \frac{Ppv}{Vs} \qquad (8)$$

In this context, Ppv signifies the power produced by the PV & Vs signifies of magnitude of PCC voltage, d-axis reference grid current characterized by below:

$$I_{sd}^* = I_{Ldf} + I_{loss} - I_{pvg} \qquad (9)$$

The reference grid currents d-axis (I^*sd) are changed into abc reference frame for the grid currents. These predefined grid current references related with detected grid currents using a hysteresis current regulator. This regulator generates gating pulses essential of shunt converter.
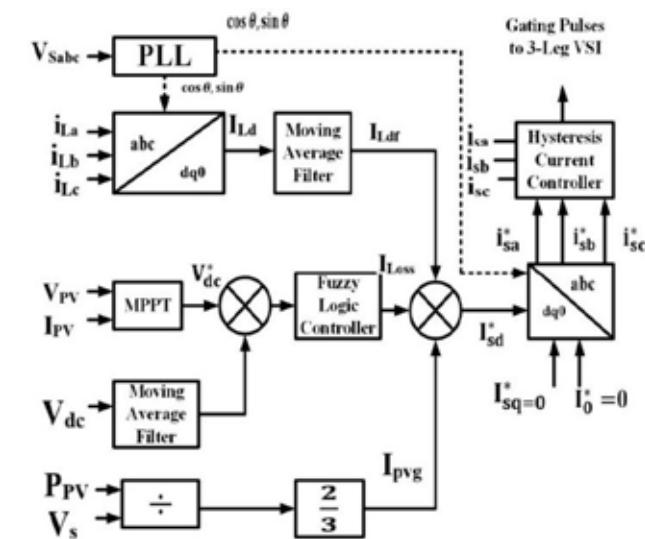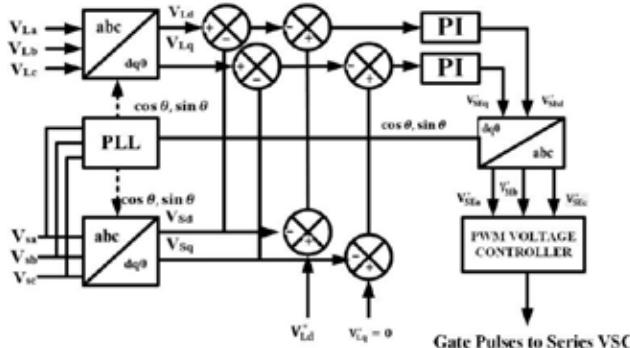
Fig. 2. FLC Control Topology for Shunt Compensator

PI controller of series compensator

Fig. 3. PI Control Topology for Series Compensator

In control system for series compensator involves strategies that include Compensation before voltage sag, compensation in-phase, and compensation for energy efficiency. You can find a comprehensive explanation of these compensation techniques in references [10] and [11]. However, the series compensator functions by introducing voltage that aligns with grid voltage, this serves to minimize voltage introduced by series compensator depicted Figure 3. A PLL is utilized to extract essential element PCC voltage, subsequently serving as the basis for establishing subsequently produced by utilizing the frequency details extracted from the PCC voltage through the use of a PLL. PCC voltages and load voltages undergo conversion into reference voltage for series compensator is determined by calculating difference between the load reference voltage and the PCC voltage. Subsequently, effective series compensator voltages are obtained by computing the deviation between reference and actual series compensator voltages is directed into PI controllers to produce the required reference signals. The PWM voltage controller produces the suitable gating signals necessary controlling of series compensator.
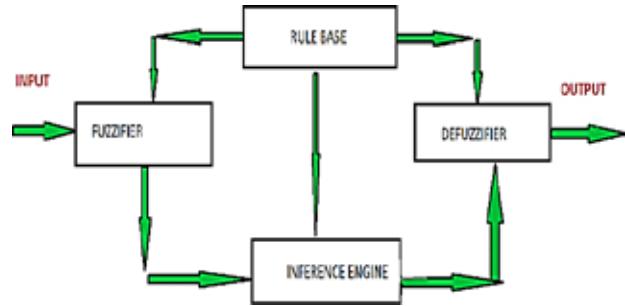
PROPOSED SYSTEM

Fuzzy logic Controller
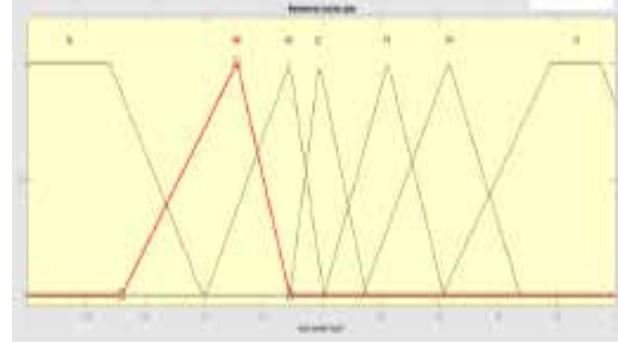
The non-linearity's existing in the power systems such as the possession of non-linear features and exposure to network disturbances can be dealt using the FLC. The schematic representation of such FLC is represented in Fig. 4. The structure of FLC as shown in following figure is made of three important components like the Fuzzier, interference.

Engine, and defuzzifier. In the Fuzzifiers, the Fuzzification process takes place where the MFs (i.e., Membership Functions) take care of converting the two inputs to the fuzzy sets between the limit of 0 and 1.
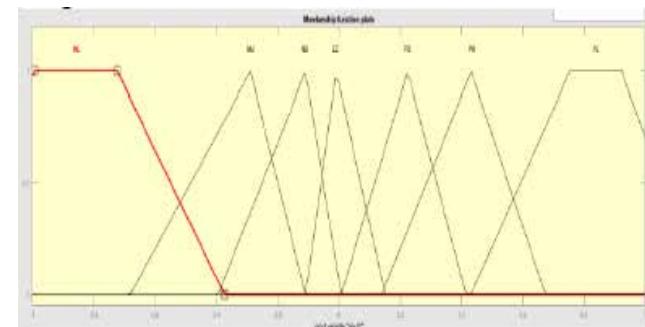
The FLC membership functions and rules, which are utilized in this research work shown in fig 5, 6 and 7. The triangular type of MF is used in this work along with the overlap which is made using seven different types of linguistic variables such as Negative Large (NL), Negative Medium (NM), Negative Small (NS), Equal to Zero (EZ), Positive Large (PL), Positive Medium (PM) and Positive Small (PS).

Fig 4. Fuzzy logic controller

Fig 5. Input 1

Fig 6. Input 2
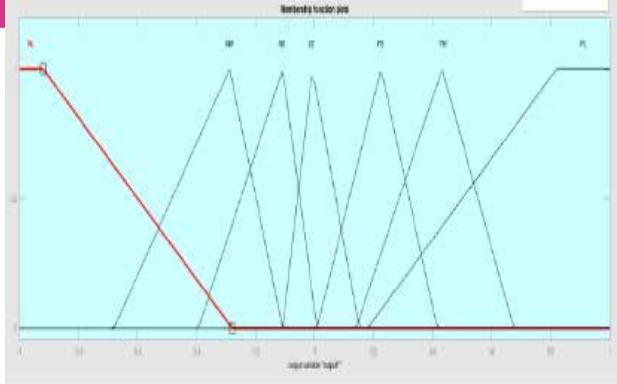
Fig 7. Output

E ΔE	NL	NM	NS	EZ	PS	PM	PL
NL	NL	NL	NL	NL	NM	NS	EZ
NM	NL	NL	NL	NM	NS	NS	EZ
NS	NL	NL	NM	NS	EZ	PS	PM
EZ	NL	NM	NS	EZ	PS	PM	PL
PS	NM	NS	EZ	PS	PL	PL	PL
PM	NS	EZ	PS	PM	PL	PL	PL
PL	NL	NM	NS	EZ	PS	PL	PL

SIMULATION RESULTS
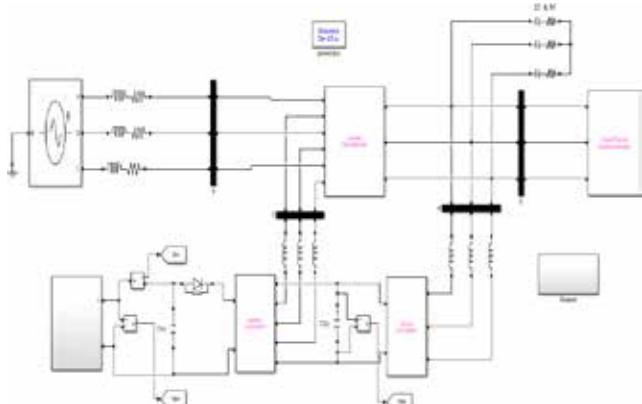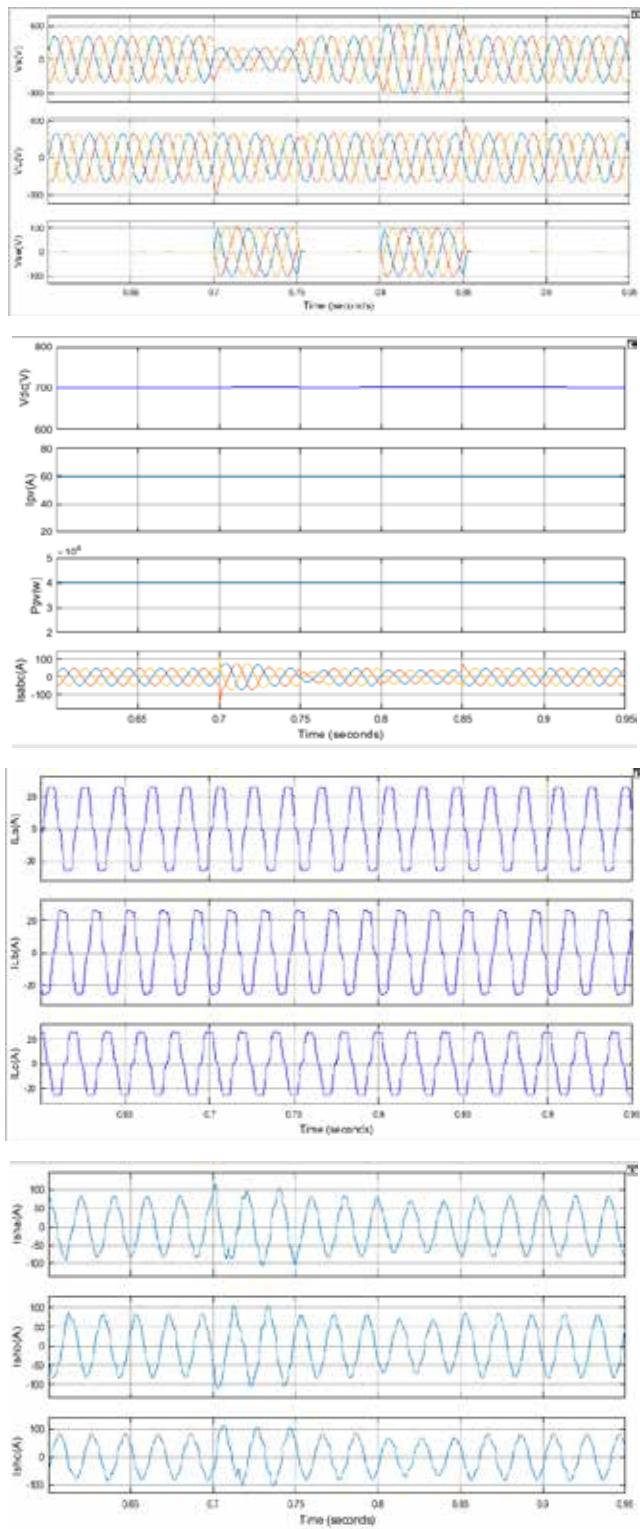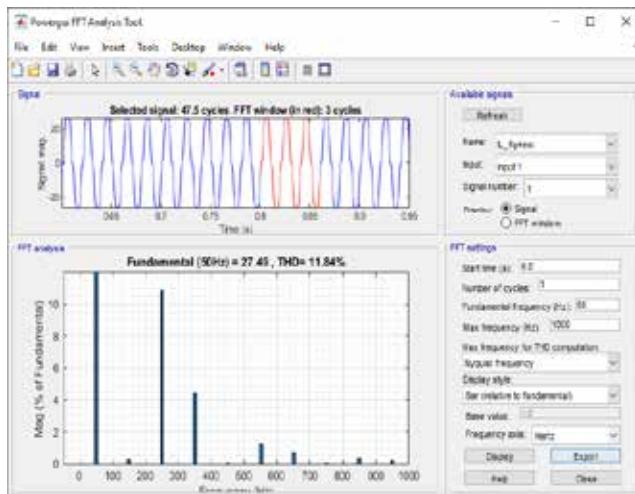
Fig.8 Simulation Model of Proposed PV-FLC-UPQC

Figure 8 illustrates the implementation of the proposed system design model using MATLAB/Simulink software. Through this model, rigorous testing was conducted in three distinct scenarios: firstly, evaluating the capabilities of PV-FLC-UPQC during voltage sag and swell events; secondly, scrutinizing its performance under load imbalance conditions; and lastly, examining its responses to changing irradiation levels.

Testcase 1 .PV-FLC-UPQC Performance in Response to Voltage Sag and Swell Scenarios
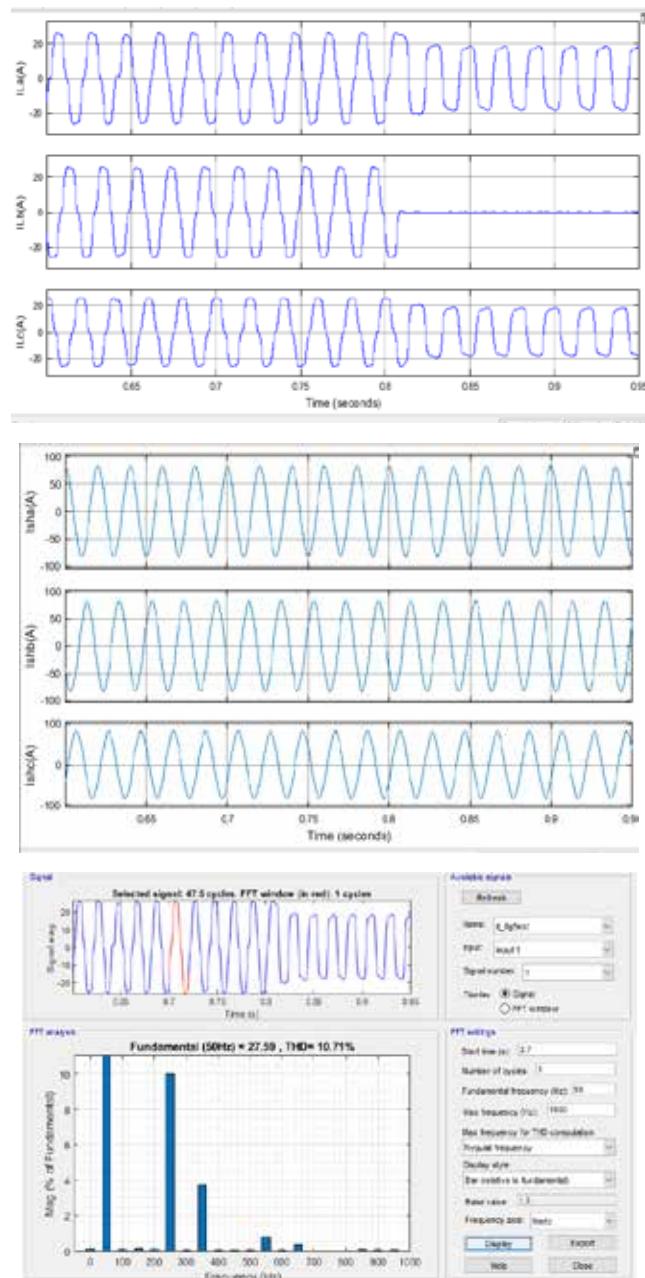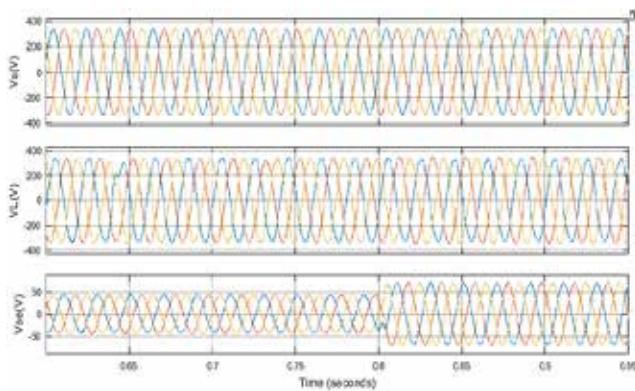
Fig. 9. PV-FLC-UPQC Performance in Response to Voltage Sag and Swell Scenarios

Fig 9 demonstrates how PV-FLC-UPQC behaves dynamically when there are voltage sags and swells of PCC. The G remains constant at 1000W/m2 throughout this scenario. Numerous signals are under surveillance, including PCC voltages (Vs), Ppv, load currents (ILa, ILb, ILc), and Shunt injecting currents (ISHa, ISHb, ISHc). Load voltages (VL), Series injected voltage (VSE), PV array Current Ipv, Grid currents (IS), DC-link voltage (Vdc).

In reaction to these circumstances, series compensator counters the grid voltage disruptions introducing a corresponding voltage with an opposing phase to grid voltage disturbance. This measure is implemented to uphold the load voltage within the prescribed operational parameters.
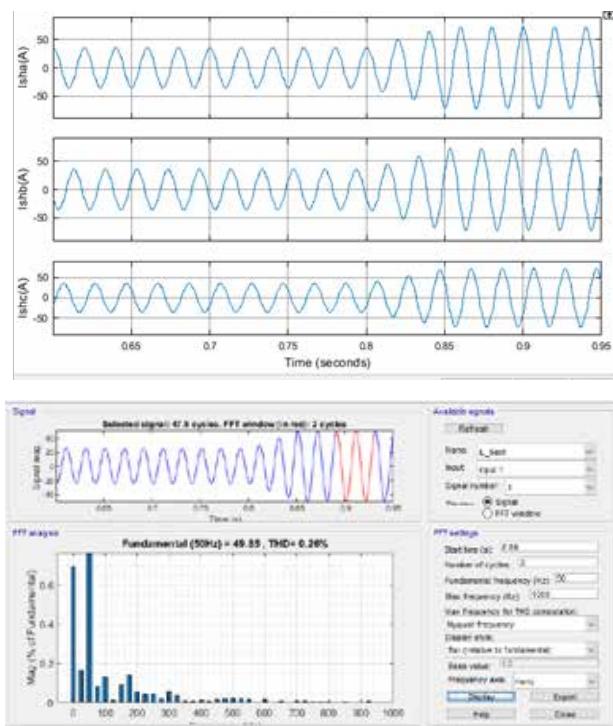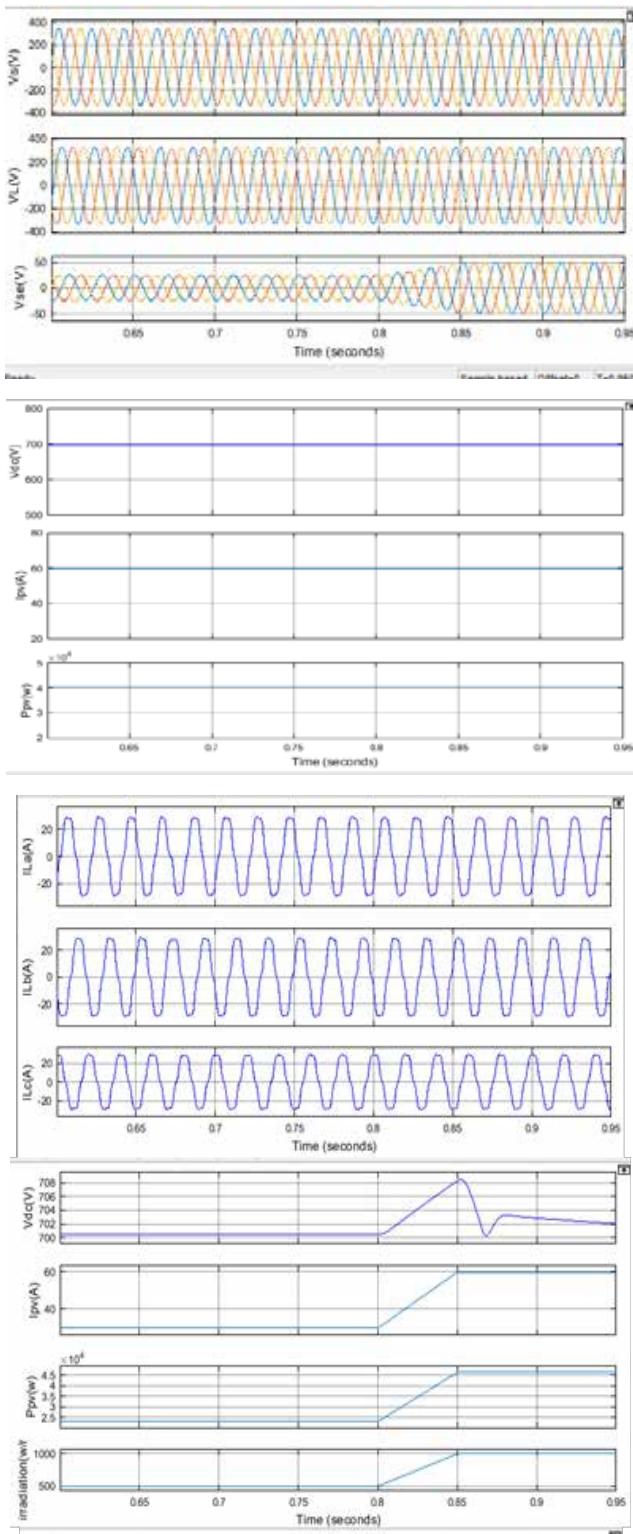
Test Case 2 . PV-FLC-UPQC Performance under Load Imbalance Conditions

Fig. 10. PV-FLC-UPQC Performance under Load Imbalance Conditions

Figure 10 illustrates the PV-FLC-UPQC's dynamic response when countering a load imbalance scenario. To be specific, at time 0.8, phase 'b' of the load separated. Significantly, the grid current exhibits a sinusoidal pattern retains a PF of 1. This increase in grid current is a direct consequence of the reduced effective load across the system.

Test Case 3 . PV-FLC-UPQC Performance under Changing Irradiation Conditions

Fig. 11. PV-FLC-UPQC Performance under Changing Irradiation Conditions

Figure 11 illustrates how the PV-FLC-UPQC reacts to changing solar irradiation dynamics. It's clear that as the irradiance increases, the PV array's output follows suit, resulting in the grid current due to PV array supplying power to grid. Simultaneously, shunt compensator keeps of MPPT and addresses the harmonics generated by the load current.

The below table provides a comparison of THD between a PI controller and a newly proposed FLC-UPQC for enhancing power quality in grid-integrated PV systems. We evaluated load current THD under three distinct conditions using both the conventional PI controller and the proposed FLC-UPQC: voltage sag and swell, load imbalance, and varying irrigation scenarios.

Table: 2 THD comparison

CONDITION	PARAMETER	CONTROLLERS %THD	
		PI	FUZZY LOGIC
SAG & SWELL		31.17	11.84
LOAD UNBALANCE CONDITION	LOAD CURRENT (IL)	23.46	10.71
VARYING IRRADIATION CONDITION		1.86	0.26

In the presence of sag and swell conditions, the utilization of a PI controller results in a load current THD of 31.17%. However, a substantial reduction in load current THD to 11.84% is achieved with the implementation of a FLC. Similarly, in cases of load imbalance, employing a PI controller yields a load current THD of 23.46%, a value significantly decreased to 10.71% through the use of the FLC. Furthermore, under conditions of fluctuating irradiation, the load current THD measures at 1.86% when utilizing the PI controller. However, with the FLC in place, this value diminishes significantly to a mere 0.26%.

From the above discussion, the superiority of a FLC over a PI controller in reducing THD when integrated with UPQCs can be attributed to FLC's adaptability and robustness. FLCs excel in handling nonlinear, dynamic power systems where THD levels can vary widely. They adjust control parameters in real-time, ensuring effective THD reduction, whereas PI controllers struggle with such dynamic conditions.

FLCs are less dependent on precise parameter tuning, simplifying implementation, and they minimize overshoot, maintaining stability during THD reduction. Additionally, FLCs handle multiple power quality issues concurrently, aligning with UPQCs' multi-functionality, which is crucial for modern grid systems. In contrast, PI controllers often require separate control loops for different power quality problems. Overall, FLCs' adaptability and resilience make them a superior choice for THD reduction, enhancing power quality in integrated PV systems.

CONCLUSION

In conclusion, the integration of a UPQC with a FLC in grid-integrated PV systems stands as a significant stride in improving power quality and grid stability. Through extensive simulations, our research underscores the effectiveness of this innovative approach. The UPQC, equipped with FLC, adeptly tackles power quality issues, including voltage fluctuations, harmonics, and more reliable and resilient grid. The FLC's dynamic control strategy ensures real-time adaptability, optimizing UPQC performance in response to ever-changing grid dynamics and PV system outputs. This technology not only elevates power quality but also enables the seamless integration of renewable energy, specifically solar power, into the grid. The empirical data obtained in this study underscores the practicality and real-world viability of the UPQC-FLC system. As we look to the future, further refinements in control algorithms, scalability, and cost-effectiveness will be crucial for widespread adoption. Ultimately, this research reaffirms the significance of UPQC-FLC systems in advancing sustainable energy solutions while upholding the stringent demands of modern grid infrastructure, setting the stage for a cleaner, more reliable energy future.

REFERENCES

1. B. Singh, A. Chandra, and K. A. Haddad, Power Quality: Problems and Mitigation Techniques. Hoboken, NJ, USA: Wiley, 2015.

2. S. K. Khadem, M. Basu, and M. F. Conlon, Intelligent islanding and seamless reconnection technique for microgrid with UPQC, IEEE J. Emerg. Sel. Topics Power Electron. vol. 3, no. 2, pp. 483492, Jun. 2015.

3. P. C. Loh, J. M. Guerrero, T. L. Lee, and M. Chandorkar, Advanced control architectures for intelligent microgrids; Part II: Power quality, energy storage, and ac/dc microgrids, IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 12631270, Apr. 2013.

4. B. Singh and J. Solanki, A comparison of control algorithms for dstatcom, IEEE Trans. Ind. Electron., vol. 56, no. 7, Jul. 2009.

5. C. Jain, B. Singh, S. Goel, A. Chandra, and K. Al-Haddad, A multifunctional grid-tied solar energy conversion system with ANF-based control approach, IEEE Trans. Ind. Appl., vol. 52, no. 5, Sep. 2016.

6. J. M. Guerrero, S. Golestan, M. Ramezani, and M. Monfared, dq-frame cascaded delayed signal cancellation- based PLL: Analysis, design, and comparison with moving average filter- based PLL, IEEE Trans. Power Electron., vol. 30, no. 3, Mar. 2015.

7. A. Rauf and V. Khadkikar, "An enhanced voltage sag compensation scheme for dynamic voltage restorer," IEEE Trans. Ind. Electron., vol. 62, no. 5, pp. 2683–2692, May 2015.

[8] Maheswar Prasad Behera, Omkar Tripathy, Pravat Kumar Ray "UPQC based Grid- Connected Photovoltaic System with Fuzzy Logic Controller",2020 3rd International Conference on Energy, Power and Environment: Towards Clean Energy Technologies, 21 April 2021."

9.　K. R. Suj, K. R. Suja "Fuzzy Based Unified Power Quality Conditioner for Power Quality Improvement", 2013 International Conference on Circuits, Power and Computing Technologies (ICCPCT), 13 June 2013.

10.　Satyanarayana Vanapalli, M. Venu Gopala Rao, S. Prabhkar Karthikeyan, "Performance Analysis of Unified Power Quality Conditioner Controlled with ANN and Fuzzy Logic based Control approaches" TENCON 2017 - 2017 IEEE Region 10 Conference, 21 December 2017.

11.　Sai Shankar, Ashwani Kumar, "Fuzzy based Unified Power Quality Conditioner" 2013 International Conference on Circuits, Power and Computing Technologies (ICCPCT), 13 June 2013.

12.　M. K. Elango, T. Tamilarasi, "Improvement of Power Quality Using a Hybrid UPQC with Distributed Generator" 2016 International Conference on Circuit, Power and Computing Technologies (ICCPCT), 04 August 2016.

13.　B. Singh, A. Chandra and K. A. Haddad, Power Quality: Problems and Mitigation Techniques. London: Wiley, 2015.

14.　R. Pea-Alzola, D. Campos-Gaona, P. F. Ksiazek, and M. Ordonez, "Dclink control filtering options for torque ripple reduction in low-power wind turbines," IEEE Trans. Power Electron., vol. 32, no. 6, pp. 4812–4826, June 2017.

15.　S. Golestan, M. Ramezani, J. M. Guerrero, F. D. Freijedo, and M. Monfared, "Moving average filter based phase-locked loops: Performance analysis and design guidelines," IEEE Trans. Power Electron., vol. 29, no. 6, pp. 2750–2763, June 2014.

16.　B. Subudhi and R. Pradhan, "A comparative study on maximum power point tracking techniques for photovoltaic power systems," IEEE Transactions on Sustainable Energy, vol. 4, no. 1, pp. 89–98, Jan 20

17.　A. Sadigh and K. Smedley, "Review of voltage compensation methods in dynamic voltage restorer DVR," in IEEE Power and Energy Society General Meeting, July 2012, pp. 1–8.

Performance and Impact of Electric Vehicle Charging Station Electrical Distribution Networks

Yogesh K. Kirange, Vineetkumar V. Patel
Krunalkumar J. Gandhi, Nilesh S. Mahajan

Rupesh S. Patil, Dhanesh S. Patil
Sachin Y. Sayais

Assistant Professor
Electrical Engineering Department
R. C. Patel Institute of Technology
Shirpur, Dhule, Maharashtra
✉ yogesh.kirange@gmail.com

ABSTRACT

The intention of research is since the beginning of the 20th century, there has been a steadily growing need for transportation, yet the internal combustion engine is quickly becoming obsolete. It is becoming increasingly common for electric vehicles to replace polluting fuels such as gasoline and diesel in favor of cleaner, more efficient fuels. Due to the fact that electric vehicles emit no harmful emissions from their tailpipes, they are a far better alternative for the environment. We are at the threshold of a revolution in electric vehicles. Due to environmental concerns, rising petroleum product prices, and state government policies, the EV market continues to flourish exponentially. In order to meet this growing demand, more and more EVCS power stations are being installed. As there are extra electric vehicles on the road, there are further electric-charging stations on the electrical grid. The prime objectives of this research paper are to study of negative effect of excessive rise in temperature on resistance of cable, harmonics on resistance of cable, power loss, temperature, expected useful life, harmonics derating factor (HDF).

EV charging stations use power semiconductor converters that take non-sinusoidal current from the power source, causing harmonics to occur in the power distribution network, lead to in lower power quality. Due to this, EV integration could impact the current electrical power distribution system's service life, particularly those components like power cables that are crucial to the distribution system's operation. The influence of EV charging stations on distribution networks, including the resulting power loss, temperature, capacity loss, and shortened service life, is simulated using MATLAB/SIMULINK in this research paper. It also offers several solutions for reducing this impact.

KEYWORDS: *Power distribution networks, EVCS (electric vehicle charging stations), XLPE power cable, Power quality, Harmonic reduction techniques.*

INTRODUCTION

Presently, India's economy is one of the world's fastest growing; yet, the country is experiencing enormous economic and social difficulties due to its increasing dependency on oil imports, rising environmental problems, and rising demand for sustainable transportation alternatives. Since the early 2000s, India's demand for imported petroleum products has skyrocketed, exceeding a record peak of 3.98 thousand gallons every day in 2015. Rising by

more quickly than either the United States 0.65%) or China (1.98%), India surpassed both of them in 2015 to become the third biggest user of crude oil worldwide. In 2016, India's trade surplus totaled US$108 billion, with a gap of US$51 billion attributable to crude oil. The present crude oil surplus is around US$102 billion, but by 2020, the trade imbalance is expected to have risen to almost US$205 billion. As of 2015, India accounted for 5.8 % of global carbon dioxide emissions from fossil fuel combustion, making it the third-largest carbon emitter globally. According to the WHO, worldwide

air pollution database (2019), 13 of the 21 cities with the highest air pollution levels are situated in India. It is projected that India's population, which is currently at 1.18 billion, would increase to 1.6 billion by the year 2040. As of 2015, India was the world's fourth-largest manufacturer of vehicles powered by internal combustion engines (ICEs). With a 9.1 % increase last year, India's vehicle market was the fastest growing in the world. The current automotive sector is likely to face a threat from the recent shift in global automotive technology and the increasing popularity of electric vehicles if the country does not plan its transition towards newer mobility options and create the requisite manufacturing skills.

If EVs spread at the rate that is expected, their load will quickly become the dominant component of any utility load curve [1]. Distribution network location for an EV load is not predetermined throughout the day, in contrast to other grid-related static loads. Positions where EVs are loaded are very flexible. As a result, distribution networks are not designed to handle non-sinusoidal load patterns or large overloads. As a result, it is essential to examine the distribution network at both the circuit level and the system level. This is to determine the effect EVs have on the network. Thus, the electric vehicle load has a significant effect on the power grid. The harmonics that are produced when a lot of EV charging stations are linked to the grid may deteriorate the power supply. To confirm the reliable and secure functioning of the power distribution system, it is critical to evaluate the probable adverse consequences of EV charging stations. Significant research has been conducted in recent years into the effects of EV charging points on the functioning of electricity distribution networks [2]. This research examines how recharging EV affects the power grid.

In the future, when EV penetration is strong, EV load will start to control any utility load profile. During the course of the day, the position of EVs burden is not defined as in a distribution line, unlike other, lesser mobile stationary loads linked to the grid. On top of that, distribution networks aren't designed to handle non-sinusoidal load patterns or high overload capabilities. Therefore, when evaluating the effect of EV load on the distribution system, it is necessary to take into account both of the circuit and system level.

Results from this research study and analysis will aid in the development, construction, and rollout of an electrical grid suitable for EV charging stations. Both the system's longevity and dependability will improve as a result of this. The findings will also be useful for figuring out how to connect EV charging stations to the grid. The findings will have positive effects on i) lowering overall costs, (ii) boosting reliability, and (iii) raising people's quality of life. Following are some of the primary aims of this study: 1. Negative effect of excessive rise in temperature on resistance of cable 2. Negative effect of harmonics on resistance of cable 3. Negative effect of harmonics on power loss 4. Negative effect of harmonics on temperature 5. Impact of harmonics on expected useful life 6. Negative result of harmonics-on-harmonics derating factor.

ANALYSIS OF THE DEFICIENCIES IN EV'S ADOPTION
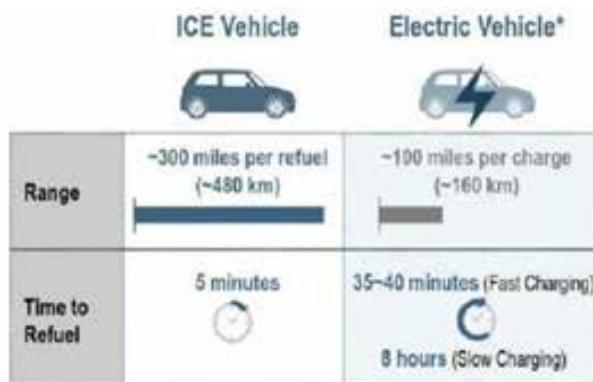
It is critical to consider consumers' expectations and concerns to understand why the EV market has slowed growth. The single most significant problem in electric vehicles' low market penetration is their exorbitant price, which is around 2.5 times greater than a conventional automobile with equivalent equipment. Another significant problem with EVs is their range on a single charge. To get more range, the car must have a larger battery capacity, which raises the price of the EV practically correspondingly. However, since their operational costs (running and maintenance costs) are frequently significantly lower than those of conventional vehicles, electric vehicles also have a significant advantage.

The average private car travels four to five times farther per day than commercial vehicles, including cabs, buses, and three-wheelers. Therefore, for vehicles that get many miles per gallon, the money saved on petrol will more rapidly compensate for the higher purchase price. Electric vehicles can be used more rapidly and affordably with a favorable power tariff, making up for the high initial investment cost. Most people prioritize aspects like total cost of ownership, fuel efficiency, repair costs, and level of comfort while looking for a personal vehicle. However, buyers of commercial vehicles prioritize both immediate and long-term cost savings.

India has a lower affordability index than industrialized nations because of a lower per capita income. Therefore, manufacturers will need to offer options for the medium range to keep the price of electric vehicles within the reach of the majority. Consequently, more frequent charging is required, especially for commercial fleets where the average daily mileage maybe 200–250 kilometers [2]. In a fleet charging system, faster charging stations would be necessary to decrease vehicle turnaround time. Slow chargers would be useful for personal automobiles with daily ranges of up to 50 kilometers.

ELECTRIC VEHICLES- PRESENT SCENARIO IN INDIA

India should think about electric vehicles for three main strategic reasons.

Fig. ICE V/S EV's

Boosted Carbon Dioxide Emissions India's key development goals include lowering its carbon releases to collect its climate requirements. Using EVs might decrease CO_2 emissions by 37%.

The industry cannot be sustained since the power demand has not risen in line with the capacity of power plants. Future growth in the number of electric vehicles could help to stabilize the grid. Electric vehicles provide a promising opportunity for the power sector because they may eventually result in stable requirement and a "paying customer section."

Energy supply threats: Currently, India imports a significant amount of oil to meet most of its needs for transportation fuel. By implementing a communal, electric, and networked solution, India may lower its energy usage for passenger travel by 64% by 2030. It could result in a 156 Mtoe (US $ 60 Bn) reduction in annual fuel and petrol use.

VEHICLE-TO-GRID (OR EV-TO-GRID) CONVERTERS

Electric vehicle supply equipment (EVSE) is the first component of the fundamental EV charging setup. The EVSE connects to the grid via a control system and a hardwired link to without harm charge electric automobiles. An EVSE control system permits capabilities like user authentication, charging authorization, information recording, data privacy, and security, to name a few. EVSEs with at minimum the most fundamental administration and control features should be employed for all charging needs.

Conductive charging, commonly referred to as plug-in (wired) charging, is the extremely accepted kind of charging method. A few factors determining the EVSE requirements for conductive charging are vehicle characteristics, battery size, charging methods, and power ratings.

It is expected that three-wheelers, such as people movers, and light electric vehicles (LEVs) like scooters and motorbikes will set the pace for India's transportation electrification over the next ten years. Light commercial vehicles (LCVs) and automobiles are two more significant vehicle types happening electrified. Numerous electric transports will be accessible for use. The characteristics of the battery define the required voltage and current for charging an electric car. The typical EV battery capacity and voltage vary throughout EV segments, as illustrated in the table.

Table 1 Types of Electric Vehicles and Their Typical Battery Requirements

Type of Vehicle	Battery Capacity	Battery Voltage
E-2W (Scooty/ Scooter)	1.1 kWh to 3.2 kWh	48 V to 72 V
E-3W (Passengers/ Goods)	3.5 kWh to 7.9 kWh	48 V to 60 V
E-Cars (First Generation)	20 kWh	72 V
E-Cars (Second Generation)	29 kWh to 81 kWh	350 V to 500 V

The input power required for charging setup is determined by the power ratings or levels of EVSEs, which vary depending on charging requirements. According to their maximum power output, EV charging stations are categorized below as low-power (22kW) or high-power (200kW). Due to the widespread availability of EVSEs with power levels up to 500kW, big vehicles like buses and lorries are their primary applications.

Table 2 EVSE Power Rating

	Level of Power	Type of Current
Normal Power Charging	Power less than 8 kW	AC &DC
	8 kW < P < 20 kW	AC &DC
High Power Charging	20 kW < P < 45 kW	DC
	45 kW < P < 205 kW	DC

BHARAT EV CHARGING DETAILS (AC AND DC)

Experts in standardizing the infrastructure for electric vehicle charging have made recommendations that include ratings for both AC and DC outlets. The related standards are Bharat EV Charger AC-001 and Bharat EV Charger DC-001.

I. A 230V/15A single-phase socket, which can send up to 2.5KW of electricity, is often used to charge devices at home. The rate cap for vehicles is this sum and nothing more. There are billing procedures for home electricity meters as well. This practice will continue unless legislation is enacted to charge home EV users differently. Bharat EV Specs advises using the IEC 60309 Industrial connector on both ends of the vehicle.

II. Public Charging: According to Bharat EV regulations, the power used for public charging needs to be metered and billed. In the future, the power providers may wish to control how much energy these chargers use.

III. "Slow" AC charging, where the current is given gradually, is used to recharge most electric vehicles. An EVSE sends AC electricity to an automobile's onboard charger, transforming it into DC power to charge its battery; as a result, an ac-charging EV, whether put a Mahindra 13e2o, e2o Plus, or lithium-ion-powered e-Scooter into a 15-amp wall outlet or a smart charger. The two types of AC charging are as follows: As was previously said, all-electric vehicles in India are charged using conventional AC. It covers vehicles with two, three, and four wheels. 3KW or 2.5KW AC motors Using a fast charger, a two-wheeler with a 2 KWh battery can be fully charged in an hour; a four-wheeler or larger vehicle with a 12 KWh or greater battery would require five to six hours.

Global electric vehicles such as the Nissan Leaf and Tesla feature in-vehicle chargers with higher power ratings, enabling faster AC charging. The power output of typical household outlets is increased from 7.7 KW to 22 KW; as a result, enabling quicker AC charging.

DEVELOPMENT OF SYSTEM

This research aims to provide an efficient and quick way to estimate the line losses and heat increase in power distributing cables in harmonics-rich environments, such as those created by the charging of electric vehicles. In Figure 1, we see a straightforward plan for installing EV charging stations within existing electrical infrastructure. Charging an electric car can be broken down into two primary categories.

Firstly, the involvement of harmonics and THD (as defined by the IEEE 519 specification) in the electrical system is an annoyance that is not simple to remedy by switching to a different power source. Total Harmonic Distortion (THD) indicates the degree to which a signal's voltage or current has been distorted due to THD's. To ensure optimal operation, audio, communication, and power systems should normally, but not always, have the lowest THD possible.
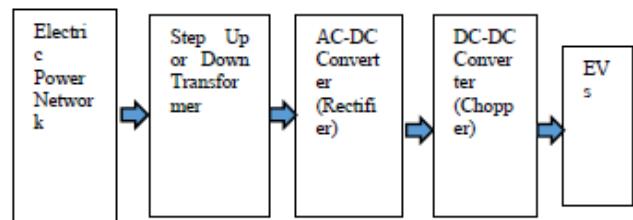
Secondly, Electric vehicle charging equipment is a stationary source of electricity for recharging plug-in electric automobiles. Fast DC chargers and standard AC charging stations are the two most common varieties. Batteries can only be charged with direct current (DC) electricity, while utmost electricity in the United States is delivered by alternating current (AC) (AC). Most EVs have a charger and an AC-to-DC converter built right in because of this (a rectifier). To power the onboard charger, the vehicle is plugged into an AC outlet. Since DC fast chargers require a considerably bigger AC-to-DC rectifier for their higher power output,

Instead of being created for the vehicle, the converter is made for the charging station, and DC power is sent into the vehicle without going via the onboard converter. Modern fully electric vehicles typically take both alternating current (AC) and direct current (DC) charging.

Vehicle charging mainly, it consists of transformer which steps up or down ac voltages, AC- DC converter (Uncontrolled or Controlled Rectifiers) that converts AC signal into DC signal, DC-DC Converters (Choppers) which converts fixed DC signal into Variable DC signals, Electric Vehicle charging. Generally, EV charging load effects on power quality, which means the voltage profile [3] [4] [5] [6] of any distribution system is used to assess its power quality. Power quality issues arise with EV charger loads since the current they use is largely non-sinusoidal in nature. Principal harmonic components when standard 3-Ø diode bridge rectifiers are castoff for high power EV charger claims are the fifth, seventh, eleventh, thirteenth, etc. After that, the principle or fundamental frequency component current and the harmonic components currents make up the current consumed by EV charger loads from the supply system in light of flow, the voltage drops across the distribution lines are sinusoidal in form and have a fundamental frequency component current [7].

Fig. 2. Block diagram of "EVCS"

The straightforward charging station block diagram is shown in Figure 2, as a result, the system's voltage profile continues to be sinusoidal. However, because of the system's harmonic component current flow, voltage dips that occur in the impedances are evidently very non-sinusoidal. Ultimately, the total voltage at the points of common coupling (PCC) includes voltage elements with frequency components and harmonic frequency, culminating in a harmonic component of the system voltage that is also being used to supply power to other normal sinusoidal loads at PCC. These sinusoidal loads only drain sinusoidal current from the system when they are operating normally [8]. However, the current they consume is made up of both fundamental and harmonic frequency components due to the system voltage waveform distortion at PCC. When an induction motor (IM) is given such harmonic component current, it will experience more losses, less efficiency, a higher operating temperature, and eventually more stress on its insulation.
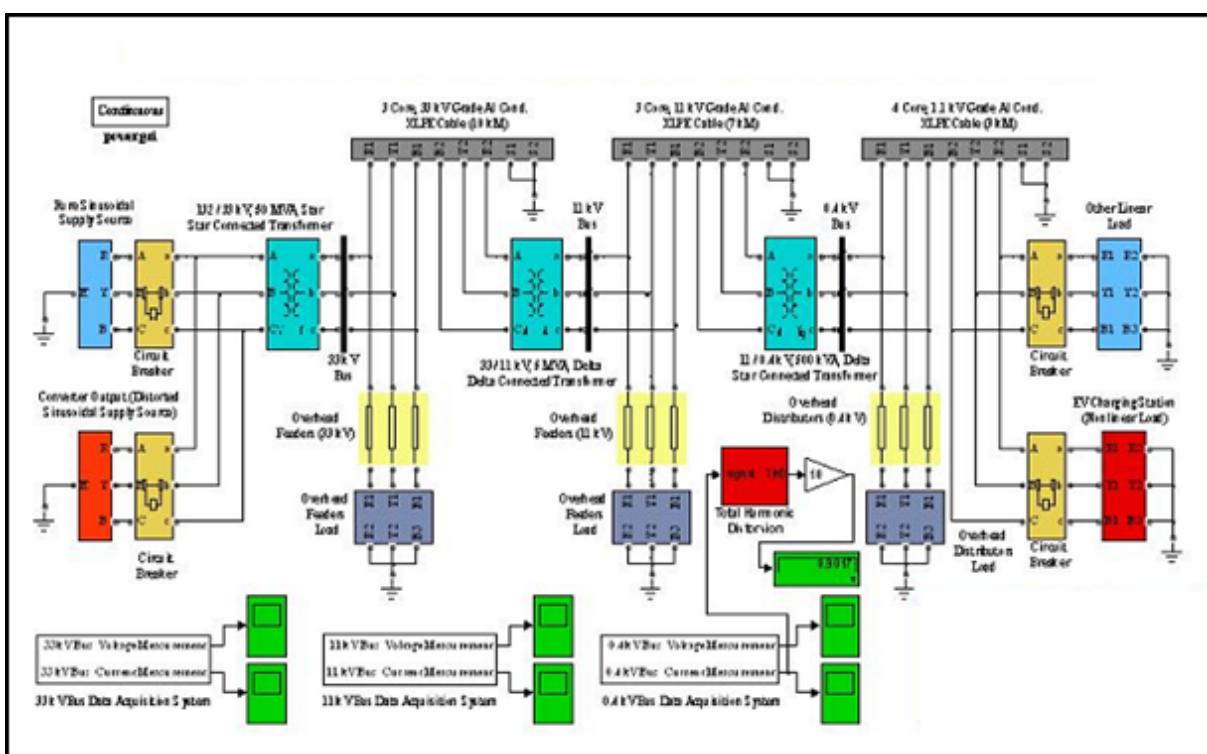
The power distribution system is responsible for supplying the harmonic components currents needed by the non-sinusoidal EV loads. By increasing power losses, decreasing efficiency, and increasing heating, this harmonic element current increases the temperature as it travels through the cabling and lines. Harmonic mitigation circuits or harmonic component filters are employed to stop this. Due to their fixed frequency tuning, these harmonic filters have, however, limited advantages. With the output rectifier of the EV charger, power factor enhancement devices are occasionally utilised [9]. The input current now has a roughly sinusoidal shape. Active filters may occasionally be naturally connected to the EV loads in parallel. However, only fast and super-fast charging benefits from passive and active power quality improvement strategies due to cost considerations.

Fig. 1. Process of development of a system

Also, we are made a MATLAB/SIMULINK model for evaluation of various parameters mentioned in objectives on EVCS on power distribution network in figure 2-(a). Also, we obtained the results on harmonics spectrum of EVCS Load, effect of temperature rise on aluminum cable conductor resistance, effect of harmonics frequency on aluminum cable phase conductor resistance, effect of frequency on equivalent resistance of aluminum cable conductor, effect of conductor material on the effect of harmonics frequency on the resistance of phase conductors, effects of EVCS harmonics in power distribution system on power loss in XLPE power cables, effects of EVCS harmonics in

power distribution system on temperature rise in XLPE power cables, impacts of EVCS harmonics in power distribution system on service (useful) life of XLPE power cables: effects of EVCS harmonics in power distribution system on harmonics derating factor (HDF) of XLPE power cables.

For every 10 °C increase in wire temperature, DC resistance increases by around 4% [14].

Any conductor carrying alternating current has an irregularly distributed current density. Skin and proximity effects [10-11] exist with solid cylindrical and tubular homogeneous conductors.

DESIGN METHODOLOGY

Basically, this system is designed in five modes of different parameters of Electrical Vehicle charging. They are as 1. Effects of temperature rise on cable resistance 2. Effects of EVCS harmonics on cable resistance 3. Harmonics' effects on power loss 4. Effects of harmonics on temperature 5. Effects of harmonics on expected useful life 6. Effects of harmonics-on-harmonics derating factor.

The frequency dependent feature of this resistance
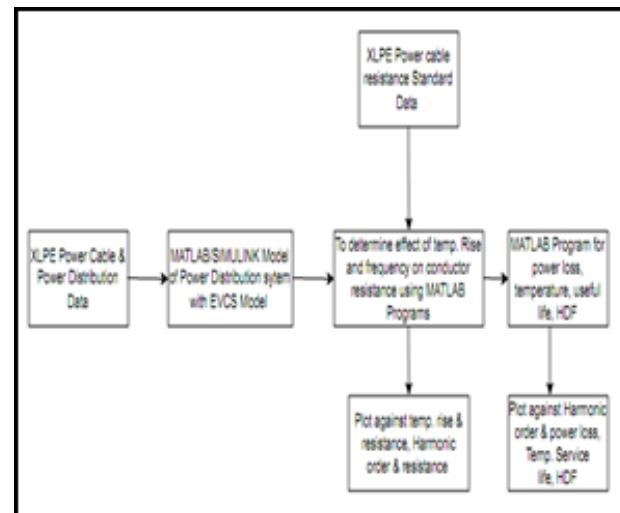
owing to the skin and proximity effect is utilised to assess the impact of harmonics on the conductor resistance of XLPE power cable [12]. The resistance of the aluminum and copper conductors of the XLPE power cables is significantly impacted by temperature rise. For every 10 °C increase in wire temperature, DC resistance increases by around 4% [14].

Any conductor carrying alternating current has an irregularly distributed current density. Skin and proximity effects [10-11] exist with solid cylindrical and tubular homogeneous conductors.

Variable contact resistances between the strands of stranded homogeneous conductors can potentially impact the current distribution; however, this effect is not taken into account in the current work. Any conductor's AC resistance is a function of the frequency of the current passing through it since this affects how much the proximity and skin effects are amplified. At power frequencies, resistance typically varies little with frequency, but when harmonic frequencies are present in the current carried by XLPE power cable conductors, the conductors' AC resistance will vary significantly. A MATLAB programme is created to implement the aforementioned method for evaluating the impacts of harmonics on conductor resistance, which involves calculating the conductor resistance (Rac) value at the target frequencies from fundamental to all odd harmonics up to 49th order. The neutral conductor and other phase conductors' AC resistance are calculated as needed using the same methodology.
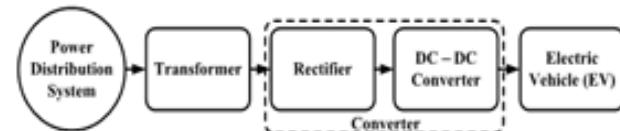
Total power loss in XLPE cable is inclusive of power loss in conductors, power loss due to sheaths, power loss due to armor, power loss due to dielectric in XLPE cable [15] [16] 17]. It takes much time and effort to calculate the overall power loss in an XLPE power cable under non-sinusoidal conditions (WNS). In order to accomplish this process, a MATLAB/Simulink programme is created in this work.

To calculate the temperature, rise in XLPE power cable, the MATLAB/Simulink programme that was originally developed to compute power loss in XLPE power cable is further expanded. To determine how long an XLPE power cable may be expected to last, the MATLAB/Simulink algorithm originally designed to estimate line losses and thermal rise in the cable is modified. It is clear that the HDF is never greater than one. When calculating the HDF, it is also necessary to take into account how unevenly heat is generated inside the cable. The maximum permitted temperature shall not be exceeded by either the average cable temperature or any point along the cable's insulation. As a result, for HDF, the maximum losses for neutral conductors and phase conductors are taken into account, not their average. Following Figure 3, it is a block diagram clearly indicates the design methodology of proposed work;
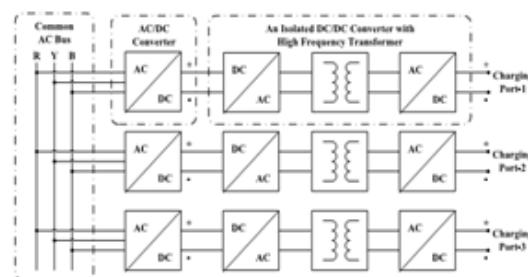
Fig. 3. Block diagram of entire proposed work of EVCS

EVCS TOPOLOGIES

Charging infrastructure for electric vehicles (EVs) in India is inadequate. A charging station can be either publicly accessible or operated by the private sector. Multiple charging stations have been set up across India by the federal and state governments.

Fig. 4. Configuration Diagram of EVCS

In Figure 4, we see a simplified representation of an EVCS. There are two main categories of EVCS systems. As can be seen in Figure 4, one type of system is the common AC bus system, in which fast chargers are equipped with their own individual AC/DC converter stage and high bandwidth transformer.
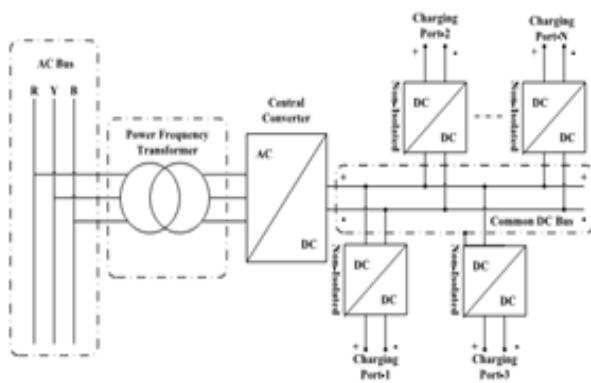
Fig. 5. EV Communication System using a Standardized AC Bus

The common DC bus system is another option; it consists of a single power frequency transformer and a single common AC/DC conversion [13] stage, as shown in figure 5. Both forms of DC bus systems are used in practice. Both use DC bus systems, however one is unipolar while the other is bipolar. An AC/DC rectifier, an input ripple filter, and a DC/DC converter are the three steps that make up the DC bus system in most fast chargers. Power factor is controlled and a stable DC voltage is provided for the DC/DC converter in the AC/DC rectifier stage. The harmonic currents generated by the AC/DC rectifier stage are reduced by the input ripple filter stage, which has a 35. Ultimately, the DC charging current is controlled by the DC/DC converter's final stage to enhance its response

IMPACT OF EV'S CHARGING LOAD

Power Quality

Figure 6 indicates the typical common DC bus system for EVCS. Distribution systems' voltage profiles determine power quality. Since EV chargers draw non-sinusoidal current, power quality events occur. For high-power EV chargers, ordinary three-phase diode bridge rectifiers have 5th, 7th, 11th, 13th, etc. primary harmonic components. EV charger loads draw fundamental frequency and harmonic component currents from the supply system. Fundamental frequency component current causes sinusoidal voltage dips across distribution lines [7]. Thus, system voltage remains sinusoidal. However, system impedance voltage drops are substantially non-sinusoidal due to harmonic component currents.
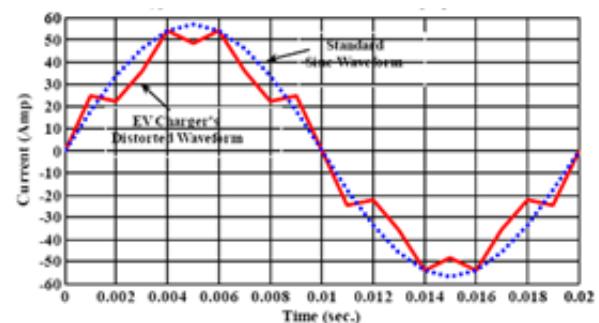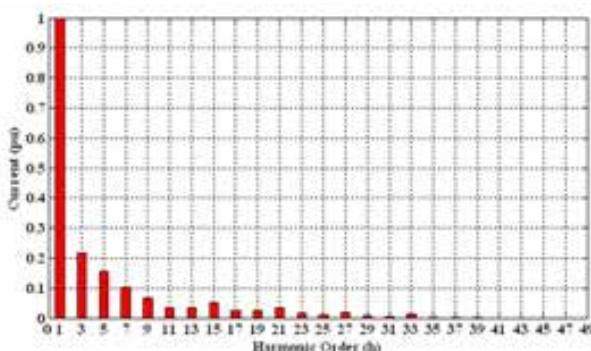
At the "point of common coupling", the system voltage waveform is distorted by fundamental and harmonic frequency voltage components. This distorted waveform system voltage powers other PCC sinusoidal loads. These sinusoidal loads need just sinusoidal system current [8]. Due to system voltage waveform distortion at PCC, they draw fundamental and harmonic frequency component currents. Harmonic component current provided to an induction motor (IM) increases losses, efficiency, operating temperature, and insulation stress. The power distribution system supplies harmonic components currents from non-sinusoidal EV loads. Harmonic component current flowing across lines and cables increases power losses, efficiency, and temperature. Harmonic component filters or mitigation circuits avoid this. Fixed frequency tuning limits the benefits of harmonic filters. EV charger output rectifiers sometimes use power factor enhancement devices [9]. Input current is almost sinusoidal. Active filters may be natively parallel to EV loads. Passive and active power quality improvement strategies only benefit fast and super-quick charging stations because to cost [10].

Harmonics Data

Many scientists across the world study the amounts of alteration in the current and voltage waveforms of EVCS. According to these numbers, the degrees of waveform distortion are far higher than permitted by the IEEE standard 519-1992 [11], especially in locations with low other loads. There was also a lot of waveform distortion in the heavy other loading regions. All harmonic components above the 21st order is disregarded in favor of just the odd ones for the purposes of this paper. The usual EVCS current waveform is depicted in figure 7, and the typical EVCS harmonics spectrum is depicted in figure 8.

Fig. 6. Traditional DC Bus system for EVCS

Fig. 7. EVCS: Distorted Current Waveform

Fig. 8. EVCS: Harmonic Spectrum

CONCLUSION AND FUTURE SCOPE

When the harmonics load from EVCSs rises, the conductor resistance of the power cables in the distribution system also rises significantly. When the load on an EVCS's harmonics increases, the conductor power loss in the distribution system's power cables grows exponentially. As, the harmonics load on an EVCS rises, so does the temperature rise in the power cables that make up the distribution system. The HDF (Harmonics Derating Factor) of power cables in the distribution system likewise rises exponentially as the harmonics load from EVCSs rises. Distribution system power lines are severely harmed by EVCS harmonics. Harmonics are especially problematic for large power connections. When designing and running the power distribution system cables, it is crucial to account for the harmonics that are penetrating the system due to EVCS. Harmonics from EVCS charges must be reduced, hence steps must be taken to do so.

In this research, we analyse and report data on how EVCS-caused harmonics in the distribution system affect key performance characteristics of XLPE power cables in the distribution system. Data from both a simulated EVCS and a real-world power grid are used to make an assessment. To say that the work described here is complete would be a gross exaggeration, as there is always room for improvement and expansion in every evaluation endeavor. The potential for future enhancements and extensions of this work are as an alternative to using harmonics data generated by an EVCS simulation, this work can be evaluated using real-world harmonics data. It is possible to incorporate the design of filters to reduce harmonics in EVCSs into this research work. A working model or prototype can be created on this work in physical form.

REFERENCES

1. Ashish Kumar Karmaker, Sujit Roy and Md. Raju Ahmed, "Analysis of the Impact of Electric Vehicle Charging Station on Power Quality Issues", 2019 International Conference on Electrical, Computer and Communication Engineering (ECCE), 7-9 February, 2019

2. Chirag Panchal, Sascha Stegen and Junwei Lu, "Review of static and dynamic wireless electric vehicle charging system", ELSEVIER -International Journal on Engineering Science and Technology, vol.21, Oct.2018, pp. 922–937.

3. J. Guo, J. Yang, P. Ivry and C. Serrano, "Analysis of the Impacts of V2G Chargers on LV Grid Harmonics", 2020 9th International Conference on Renewable Energy Research and Application (ICRERA), pp. 88-92, 2020.

4. Jizheng Liu;Zhenpo Wang;Lei Zhang, Integrated Vehicle-Following Control for Four-Wheel-Independent-Drive Electric Vehicles Against Non-Ideal

5. KPMG, CII, "Shifting the Gears the Evolving Electric Vehicle Landscape in India", October 2020, pp. 1-40.

6. K. D. Patil and W. Z. Gandhare, "Threat of Harmonics to Underground Cables" IEEE 2012 Students Conference on Engineering and Systems, pp. 1-6, 16 – 18 March 2012.

7. Ministry of Power, GOI, "Electric Vehicles Charging Infrastructure and Impacts on Distribution Network" White Paper, pp.1-118, June 2020.

8. Qin Yan and Mladen Kezunovic, "Impact Analysis of Electric Vehicle Charging on Distribution System" 2012 North American Power Symposium (NAPS), 9-11 September 2012.

9. Rares Catalin Nacu and Daniel Fodorean, "Harmonics Mitigation in DC Based Charging Stations for EVs, 2021 10th International Conference on Renewable Energy Research and Application (ICRERA), Istanbul, Turkey, 2021

10. Rwamurangwa Evode, "Modeling of Electric Grid Behaviors having Electric Vehicle charging stations with G2V and V2G Possibilities", IEEE 2021 International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME), 2021

11. Shubham Mishra et al, "A Comprehensive Review on Developments in Electric Vehicle Charging Station Infrastructure and Present Scenario of India", Sustainability, vol. 13, no.2396, pp. 1-20, February 2021.

12. Sajib Chakraborty et al, "DC-DC Converter Topologies for Electric Vehicles", MDPI Energies, pp. 1-43, December 2019.

13. Syed Rahman, Irfan Ahmad Khan, and M. Hadi Amini, "A Review on Impact Analysis of Electric Vehicle Charging on Power Distribution Systems" 2020 2nd International Conference on Smart Power & Internet Energy Systems, 2020, pp.420-425.

14. Sanchari Deb and Karuna Kalita, "Review of impact of Electric Vehicle Charging Station on the power grid", 2017 IEEE International Conference on Technological Advancements in Power & Energy. pp.1-6.

15. Sanchari Deb et al, "Impact of Electric Vehicle Charging Station Load on Distribution Network", MDPI Energies, pp. 1-25, Nov. 2018.

16. S. Afshar, P. Macedo, F. Mohamed and V. Disfani, "A literature review on mobile charging station technology for electric vehicles", 2020 IEEE Transportation Electrification Conference & Expo (ITEC), pp. 1184-1190, 2020. V2X Communication, IEEE Transactions on Vehicular Technology, Volume: 71, Issue: 4, 2022

17. Wanke Cao; Zhiwen Zhu; Jinrui Nan; Qingqing Yang; Guangjian Gu;Hongwen He, "An Improved Motion Control With Cyber-Physical Uncertainty Tolerance for Distributed Drive Electric Vehicle, Vol. 10, 2022

Energy Audit and Energy Conservation Potential of Medical College

Diksha Chopade, Rajesh Holmukhe

Kalyani Chaudhari

✉ diksha.chopade@bharatividyapeeth.edu

✉ rajesh.holmukhe@bharatividyapeeth.edu

✉ kalyani.chaudhari@bharatividyapeeth.edu

Swati Sagar, Kanchan Warke

✉ swati.sagar@bharatividyapeeth.edu

✉ kanchan.warke@bharatividyapeeth.edu

Bharati Vidyapeeth COE for Women
Dhankawadi
Pune, Maharashtra

ABSTRACT

Continuously increasing energy cost and very high shortage of energy, recent years there is lot of importance for efficiency and conversation measures. Huge energy consumption is there in medical college, therefore there is large amount of energy saving possibilities. Medical campus of Bharti Vidyapeeth University, Dhankawadi includes number of colleges i.e. Medical, Biotechnology, Ayurved, Homeopathy. This campus is High Tension consumer. Which have Contract Demand of 260KVA with the average monthly electricity bill is Rs. 7, 85,920/-. Sanctioned Demand is 444KVA and load which connected is 540 kW. Main load such as Illumination, Heating equipment, Water pumping system, Air Compressor, Air conditioners are major electricity consuming systems. So, in this paperwork related with energy audit and conservation done for Bharati Vidyapeeth University Medical college campus. The result of this study is energy cost is saved by 10% within few months of payback period. Implementation of suggestions given in this study are discussed with the management and other related experts. The recommendations are included in report are technically possible as well as financially workable.

KEYWORDS: *Energy audit, Payback period, Load calculation, Energy saving.*

INTRODUCTION

Energy Audit is the process which carried out in following sequence [1]

1. Identify standards

2. Collection of data

3. Compare that data with standards

4. Planning for necessary changes

5. Implement all necessary changes

Energy audit will give an idea about variations occurs in the energy costs, energy availability and find out energy conservation technologies. In general, Energy Audit is the process of converting conservation ideas into realities, by considering technical and economical possible solutions and organizational constraints within a specified time period.

The main objective of Energy Audit is to reduce energy consumption to lower operating costs by conducting energy audit, background is to be provided for other similar applications such as medical colleges. In any building energy, labor and material are major expenses. So to manage the cost or cost saving potential out of all these three component energy is on the top rank. Therefore, energy management is suggested to reduce the overall cost. Because of energy audit and conservation capital cost required is less than the cost for generation capacity.

METHODOLOGY

The project will be conducted as per the following stages:

Stage 1) Data collection and analysis

Stage 2) Review of operational practices

Stage 3) Optimization of equipment efficiency.

1)Data collection- is classified as i) Primary data ii) Secondary data

i) Primary data - Primary data was collected from previous electricity bill, technical literature, leaflets and journals and equipment specifications were analyzed to study the load behavior.

ii) Secondary data – 1) Secondary data i.e. connected load on the LT Line coming to the Bharati Vidyapeeth Deemed University premises was taken by using YOKOGAWAMETER 240 CW CLAMP ON METER

2) The reading of daily consumption for 15 days was taken by the MSEDCL meter.

3) The various tariff plans laid by MSEB for H.T. consumers was studied.

4) By studying secondary data, the different energy loss area was located, Equipment consuming more power were studied for their efficiencies. Major energy consuming systems: Electrical Heating Equipment, Air conditioners, Water Pumping systems, Illumination load.

LITERATURE SURVEY

*   A Review on Energy Management and Audit: In India by doing proper energy study in various sector like residential, commercial, and industrial 10 to 20% energy can be saved. So, this paper gives an idea about how to do management of electrical energy, what are the different phases of energy audit to reduce energy requirement and overall energy consumption cost.[1].

*   A Review on Implementation of Energy Audit: Energy audit is to find out opportunities of saving energy consumption and reducing electricity bill. Installed. Types of energy audit that is Preliminary energy audit and detailed energy audit are discussed in this paper. Conducting energy audit energy saving is done and automatically power demand in our country is reduced.[2]

*   "Energy Audit on Academic Building": In this paper by doing the inspection and energy flow analysis energy audit is conducted. Energy saving is also happened by using efficient equipment. Energy management is also discussed in this paper [3]

*   "Electrical Energy Audit a Case Study": Energy efficiency is improved by suggesting cost effective measures. For this walk-through audit is conducted. Areas where energy wastage is taking place are identified .and wastage of energy is minimized.[4]

*   "Energy Audit and Conservation Tool for Energy Efficiency": In this paper it is said that energy audit is tool which audit the process to find out wastage without affecting productivity. Energy audit is continuous process which must conduct periodically to save energy.[5]

*   Energy Audit for Chengalpattu Medical College Hospital Buildings: Conduction of audit is to provide background for similar load and application in all hospitals. Implementation of energy audit provide guidance for energy saving in different hospitals.[6]

DATA COLLECTION
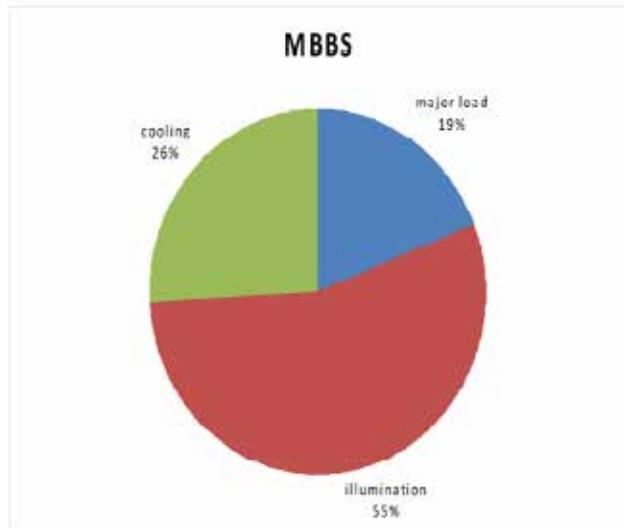
Data Collection Of Medical College

*   The medical college is having total built up area of 2, 55000 sq. ft. It is a four storied, well illuminated and ventilated. It is having 20 departments.

*   Departments have separate demonstration rooms, which are well equipped laboratories, dissection halls, museums, to carry training and teaching process of Postgraduate and Undergraduate students.

Animal House and Well-equipped Research Laboratories are available to carry out research in basic medical sciences. Air-conditioned conference halls are available for college council and other meetings.

- There is a separate Central library building admeasuring 12000 Sq ft with basement and three floors. So Illumination load of library is very high.24 hrs internet facility is available.
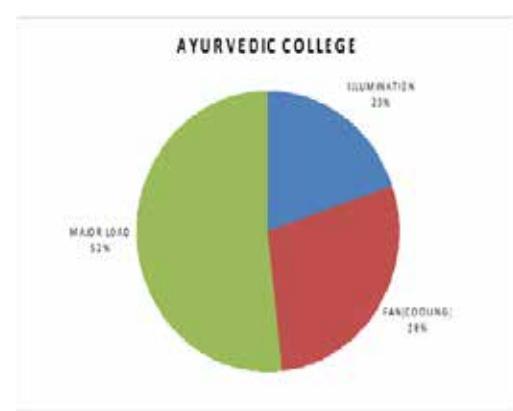
Other facilities such as library, digital library, internet, well equipped lecture halls with LCD projection. There are two centrally air-conditioned auditoriums built to carry out the Co-Curricular and extracurricular activities. Due to such facility, well equipped laboratory, air-conditioned auditoriums mentioned above electricity consumption of Medical College is very high i.e., 371. 400kWH.Details of Illumination load, computer, printer etc. (See figure 1)

Figure 1

Data Collection of Aurved College

- In house pharmacy unit in the college manufacturing approximately '100' most used medicines using various machineries. Due to such well-equipped laboratories, electricity consumption of this college is more. Electricity consumption of this college and Homeopathy college is 397.610kWH

- In Ayurveda college connected load is categorized as 20% illumination load,28% cooling load,52%major load (printer, computer, projector etc.)

- The specification and catalogues of all the electrical connected load was surveyed (see Figure 2)

Figure 2:

Data Collection of Homoepaethic College

- 35,000 sq. ft. 4 storage specious building.

- Institute has 100 bedded Homoeopathic Hospital with the premises of 32,000 sq. ft. in the campus with Operation theatre, well-equipped laboratory, and labor room. It also has facilities for Nebulization, ECG, X-ray, USG, etc. An AC auditorium with a capacity of 500 people, Capacity of Seminar Hall is150 seats with following facilities OHP projector, LCD projectors, Laboratories in the college fully equipped.

- Total number of students are around 300. Intake of student is 100 students. Due to such facility, well equipped laboratories electricity consumption of this college and Aurved College are 397.610k WH.

- Total load connected was categorized as 18%illumination, 18% cooling, 64% major load (computer, printer etc.).

The specification and catalogues of all the electrical connected load was surveyed.

Data Collection of Rajeev Gandhi Institute of Biotechnology & I.T.

The College is housed in a building of 3941.68 sq. ft.

- The central air-conditioned auditorium facility with a projector and seating arrangement for 140 individuals is available for seminars, common meetings etc.

- The UG & PG laboratories are well furnished with routinely required equipment (lists separately

provided) for performing the experiments. Due to such well-equipped laboratories, air-conditioned auditorium electricity consumption of this college

is 348.75kWH.

- Details of total load connected is given below. (see Table 1)

Table 1:

Sr no	Connected load	Total load	Consumption In month(kwh)	% of total load
1	Ac	29	5024.2	23.97
2	Illumination	151/16/282	976.34	4.65
3	Fan	137	1288.25	6.148
4	Water bath	7	2371	11.31
5	Hot air oven	5	2040	9.73
6	Refrigerator	7	588	2.8
7	Deep freezer	2	3456	16.49
8	Autoclave	5	1350	6.44
9	Others	78	3858.84	18.41

IRSHA

- Total built up area of 8,111 Sq. Ft.

- Well-equipped including Refrigerated tabletop Centrifuge, -, -20 Deep Freezer, 80 Deep Freezer ,UV/VIS Spectrophotometer, pH meter, Ice Flaking Machine ,Clinical Centrifuges, Balances, Ultra sonic cleaner, HPLC, Electrochemical Detector with LAN, XY Recorder, K-70 High Speed Centrifuge,.

- Autoclaving and sterilizing facility.Fully air-conditioned building.

- Because of all these equipment, facilities electricity consumption of this institute is 112.63Kwh.

- IRSHA college peak load hours are

  2 hours: consumption was13 kVA during college timing.

  8 hours: consumption was 3 kVA Peak load hours were due to major loads like operation of Air conditioner, computers, projectors, speakers, and water coolers are in operation. (see Table 2)

Table 2:

Sr no	Connected load	Total load	Consumption In month(kwh)	% of total load
1	Ac	18	938.5	66.45
2	Illumination	84	508.8	3.6
3	Fan	28	309.6	2.19
4	Ultra-low freezer	1	1376.67	9.74
5	Stabilizer	1	1128	7.98
6	Others	24	1414.28	10.01

During field visit, the section wise energy consumption was measured with the portable meter YOKOGAWA CW240 POWER METER. (See Table 3)

Table 3

Sr. No.	Load Center	Date and Time	Consumption	
			kWh	%
1.	Medical College	From 1520 hrs on 04.05	371.400	13.74
2.	Hostel	From 1433 hrs on 02.09	788.098	29.16
3.	Ayurved and Homeopathy	From 1400 hrs on 01.09	397.610	14.71
4.	Canteen	From 1350 hrs on 01.09	45.000	1.66
5.	Biotechnology	From 1230 hrs on 21.09	348.758	12.90
6.	Irsha	From 0900 hrs on 14.09	112.635	4.17
	Total		2702.916	100.0

Data Analysis

Running of other water pumps that are being used for various institutes in the campus can also be shifted from existing peak time (morning) to off peak time (nighttime). The TOD benefit that can be availed by this measure (see Table 4)

Table 4

Sr. No.	Institute	Running Time	Existing TOD charges	TOD charges after shifting operation time
1	Dental	08:45 to 14:30	2,593.00	- 5282.20
2	Medical College	09:00 to 12:00	3,049.20	- 3,239.80
3	Bio-Tech College	09:00 to 21:00 Once in 4 days	798.50	- 1,434.00 Once in three days
4	Homeopathy College	08:30 to 09:30	297.00	- 631.00
		TOTAL	6,73 8.50	10,587.00

The annual TOD total benefit by above measure will be Rs .17325/-

As observed in the monthly MSEDCL bill,the billed maximum demand of the organisation falls predominently in C zone.By shifting the operation time of the pump will reduce the billed maximum demand.Considering unity power factor (as the reactive energy is being compensated at the transformer end by APFC),the total demand of the four pumps is 13.31kva.

Considering about 50% of this demand will be saved by shifting the operation time of the pump to night time.The annual demand charges reduction by above measure will be = 7x12x10 =Rs.12600/-

Thus the total annual cost saving potential by above measure will be Rs.29925/-

Energy Saving Potential in Case of Electrical Heating System:[11]

Based on the surface and ambient temperature measurements, the heat losses were estimated. It is recommended to provide the insulation to all these applications so that the surface temperature after application of insulation will be about 5 to 10 0 C more

than the ambient temperature. Following table indicates the heat losses that can be saved after application of the

insulation considering 275 days of operation in a year (see Table 5)

Table 5

Particulars	Existing Heat Loss (KJ / sec).	Heat Loss that can be saved (kJ / sec.)	Annual Heat Loss Saving (KWh)
Sterilizer in 1st floor washing room	0.4070	0.3324	320
Autoclave I on 1st floor OT	0.4518	0.3906	215
Autoclave II on 1st floor OT	0.3012	0.2608	143
Autoclave in Oral Surgery	0.2678	0.2373	130
Prostho PG Section Water Bath	0.1904	0.1774	244
Biochem Lab 1 DM plant	0.4099	0.3379	465
Auto clave in growth room 2	1.3480	1.0958	1507
Total			3024

The annual saving potential in Rs. will be = 3024 x 7.55 = Rs.22,831/-

The investment required for the above proposal will be Rs. 10000 / -The simple Payback period will be 5 months.

Replacement of Air conditioner in Growth Room of Biotechnology College with Exhaust Fan [12]

the air conditioner may be replaced with the exhaust fan. Considering air conditioner and exhaust fan

consumes 1.4 kW and 100 W respectively also this area is in operation for 275 days in a year and 8 hours in a day, the annual energy saving potential.

will be = (1.4 – 0.1) X 8 X 275 = 2860 kWh

The annual saving potential in Rs. is = 2860 X 7.55 = Rs. 21,593 / -.

The investment required for the installation of new exhaust fan and removal of air conditioner is negligible and the simple payback period is immediate. (See Table 6)

Table 6

Sr. No.	Area	Energy Conservation Potential	Annual Saving Potential		Investment	Payback Period
			Quantity	Rs.		
1.	Electrical Demand	Improvement in power factor to unity will reduce billed maximum demand.	53 kVA	7,900	76,000	4 Months
2.	Electrical Demand	Improvement in power factor to unity will increase in the power factor incentive from MSEB.	---	2,14,869		
3.	Contract Demand	With Increasing the contract demand will the demand penalty which is currently applied to the institute. This corrective action is already initiated by the concerned authorities.	---	1,98,900	Negligible	Immediate
4.	Water Pumps	Shifting operation time of water pumps to night hours will result in additional ToD benefit at the same time the billed maximum demand of the institute will be lowered to some extent.	7 kVA	29,925	Negligible	Immediate

No.	Category	Description	kWh			
5.	Electrical Heating	Reduction in the heat losses from the surface of the sterilizers, hot water bath, autoclaves, DM plant will result in to reduction in energy consumption.	3024 kWh	22,831	10,000	5 Months
6.	Streetlight	Replacement with 150 W Metal Halide lamp	13008 kWh	98,215	Negligible	Immediate
		OR				
		Replacement with 70 W Metal Halide lamp	**24703 kWh**	**1,86,507**	**1,05,000**	**7 Months**
		OR				
		Replacement with Energy Efficient T 5 Fitting	21812 kWh	1,64,680	1,14,000	8 Months
7.	FTL Fittings with Conventional Chock	Replacement with 18 W CFL	19710 kWh	1,48,810	22,500	2 Months
		OR				
		Replacement of existing conventional electro-magnetic chock with energy efficient chock.	16425 kWh	1,24,009	28,750	3 Months
8.	Growth Room FTL	Replacement of existing FTLs in the Growth Rooms with T 5 fitting will result in energy conservation.	5204 kWh	39,290	47,310	14 Months
9.	Air Conditioner	In Growth Room 2 Replacement of Air Conditioner in Biotechnology College with exhaust blower will result into energy conservation	2860 kWh	21,593	Negligible	Immediate
	Total	kVA – 59 kWh – 53175		8,51,974	1,88,560	3 Months

Implementation

- Shifting the operation time of the water pumps during nighttime by giving instruction to the director of every college to get TOD Tariff benefit.

- Contract demand is increased from 200kva to500kva to reduced excess demand charges.

- Power factor improvement to unity will increase the incentives from the MSEB.

Cooling: Use higher star rating A.C. for higher efficiency &lower power consumption. Adjust the thermostat to maintain the comfortable temperature 24 0C.Overcooling requires 5% increase in energy consumption per degree centigrade.

D. G. Set: Avoid overloading of D.G. set.2 or more D.G. sets can be use. Set. Use of ATS can increase the system efficiency.

Replacement of existing streetlight with energy efficient streetlight. Replacement of FTLs used in passages staircase with CFL.[14]

CONCLUSION

In energy audit there are some best practices followed in the organization like sign board of 'Switch ON' and 'Switch OFF' for energy saving. Improvement of power factor to unity to get more incentives from MSEB. To install timer-based controller switch to the water pumps, water level indicator on the overhead water tank which will also save overall electrical energy. The saving comes from the project can utilize for implementing of the latest energy efficient equipment. Provide Green Effect technology so that energy required for air conditioner, fan can be reduced. Harmonic study of main transformer. Planning for generation of Biogas and generation of electricity from the garbage of various mess and canteens in the campus.

To install energy saver to all illumination feeders.

REFERENCES

1. A Review on Energy Management and Audit, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (An ISO 3297: 2007 Certified Organization) Vol. 4, Issue 2. February 2015

2. A Review on Implementation of Energy Audit, International Journal of Innovations in Engineering and Science, www.ijies.net. Vol. 6, No. 4, 2021

3. "Energy Audit on Academic Building" International Journal of Engineering Research and General Science Volume 3, Issue 4, JulyAugust, 2015

4. Gousia Sultana, Harsha.H.U "Electrical Energy Audit a Case Study" IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) Volume 10, Issue 3 Ver. III (May – Jun. 2015)

5. Sachin P. Parthe, Santosh Kompeli "Energy Audit and Conservation Tool for Energy Efficiency" International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 08 | Nov-2015

6. Energy Audit For Chengalpattu Medical College Hospital Buildings Rajavel. V 1 Dr.S.Ganapathy Venkatasubramanian 2, International Journal of Science, Environment ISSN 2278-3687 (O) and Technology, Vol. 5, No 1, 2016, 204 – 212

7. United States Environmental Protection Agency, 2020, "About the U.S. Electricity System and Its Impact on the Environment," https://www.epa.gov/energy/about-us-electricity-system-and-its-impact-environment,AccessedMay 13, 2020

8. Elangovan, M., Ravichandran, A.T., Chellamuthu, P.: Need of energy audit in everyday life. 2(11), (2020)

9. Nourdine, B., Saad, A.: Energy consumption in hospitals. In: 2020 International Conference on Electrical and Information Technologies ICEIT 2020, (2020). doi: https://doi.org/10.1109/ICEIT48248.2020.9113177

10. Goyal, P., Shiva Kumar, B., Sudhakar, K.: "Energy audit: A case study of energy centre and Hostel of MANIT, Bhopal". In: 2013 International Conference on Green Computing, Communication and Conservation of Energy, (ICGCE) 2013, pp. 644–648,vol. 1 (2013). doi:https://doi.org/10.1109/ICGCE.2013.6823515

11. Rayhana, R., Khan, M.A.U., Hassan, T., Datta, R., Chowdhury, A.H.: Electric and lighting energy audit: a case study of selective commercial buildings in Dhaka. In: 2015 IEEE International WIE Conference on Electrical and Computer Engineering WIECON-ECE 2015, pp. 301–304 (2016) doi:https://doi.org/10.1109/WIECON-ECE.2015.7443923

12. Dongellini, M., Marinosci, C., Morini, G.L.: Energy audit of an industrial site: a case study. Energy Procedia. 45, 424–433 (2014). doi:https://doi.org/10.1016/j.egypro.2014.01.046

13. Malkovska, Monica, and Borislav Boychev. "Energy Audit of Buildings." In 2019 11th Electrical Engineering Faculty Conference (BulEF). IEEE, 2019. http://dx.doi.org/10.1109/bulef48056.2019.9030695

14. Khalid, Muhammad Usman, Mariam Gul, Muhammad Mohsin Aman, and Ahsan Hashmi. "Energy conservation through lighting audit." In 2012 IEEE International Conference on Power and Energy (PECon). IEEE, 2012. http://dx.doi.org/10.1109/pecon.2012.6450335.

Energy-Efficient Clustering and Data Transmission Method for Heterogeneous Wireless Sensor Network

Yogesh Patidar
PhD Scholar
Department of Electrical and Electronics Engineering
Mandsaur University
Mandsaur, Madhya Pradesh
✉ eryogeshpatidar@gmail.com

Manish Jain
Associate Professor
Department of Electrical and Electronics Engineering
Mandsaur University
Mandsaur, Madhya Pradesh
✉ manish.jain@meu.edu.in

Ajay Kumar Vyas
Associate Professor
Department of ICT
Adani University
Ahmedabad, Gujarat
✉ ajay.vyas@adaniuni.ac.in

ABSTRACT

In the present work an energy-efficient clustering and data transmission algorithm is proposed for the heterogeneous wireless sensor network. The present protocol saves the energy in both setup phase (cluster formation phase) as well as steady state phase (data transmission phase). The proposed protocol efficiently selects the cluster head node into different grids. The clusters are divided into global as well as local zones. Each global zone is sectored into local zones and each local zone is considered as a cluster. The dynamic sectoring approach is proposed based on the size of the global zone. The proposed clustering scheme efficiently transmits the data from sensor node to base station via cluster head node. The cluster head node performs aggregation and transmits the data to the base station node in the central zone. In the data transmission phase energy-efficient medium access control (MAC) protocol is used for the data transmission. To save the energy, the sensor nodes are classified into event sensor nodes and continuous monitoring nodes. In addition, the time-constraint sensor nodes are also considered for heterogeneous wireless sensor network. The energy-saving TDMA (ES-TDMA) method is used for the data transmission of continuous monitoring nodes and energy-saving bit map assisted (ES-BMA) MAC protocol is used for the event monitoring sensor nodes. For the time-constraint data transmission guaranteed time slot is allotted in the ES-BMA slots. The results prove the superiority of the proposed protocol with respect to existing protocols for both setup as well as steady state phase.

KEYWORDS: Global-Local zone, Clustering, Medium access control, Heterogeneous network, Bit-Mapping.

INTRODUCTION

In last few years, the internet of things (IoT) and wireless sensor network (WSN) gained attention of the researchers due to its huge demand for various monitoring applications. For both IoT and WSN applications, the IoT device and sensor node energy consumption is important concern for the energy-efficient WSN/IoT network. The well-organized clustering, MAC, and routing protocols can reduce the energy consumption. In addition, spatio-temporal aggregation protocols are also proposed by the researchers for the efficient data transmission [1-4]. In the present work, we have focused on energy-efficient clustering and MAC protocol for the transmission of the data from sensor nodes to the base station. The researchers have proposed various protocols for the setup phase (clustering protocol) and steady state phase (data transmission protocol). In the previously reported works, the researchers have proposed various clustering methods for homogeneous sensor nodes. Few

of the researchers reported clustering for heterogeneous networks also.

The researchers have also proposed improved zonal distribution for the efficient clustering and data transmission [11]. However, the researchers have considered rectangular grids, zones for the analysis which is less efficient and impractical for the real monitoring field. Therefore, in the present work, we have considered the circular zones. In the circular zone consideration, the major issue is that the area of the outer region varies in multiple orders. Thus, in the proposed work, we have divided the monitoring field into global as well as local zones. The outer region consists of more number of local zones as compared to the inner regions. The division of global zone to local zone reduces the amplification energy requirement. As a result overall energy consumption reduces. As per the best of our knowledge, the global and local division method is not reported earlier in the previous works. Also, in the previous works, the devices had not been classified based on their device capability. For the real time monitoring applications, the sensor nodes can also be classified into event monitoring and periodic monitoring nodes.

In addition, the researchers had considered the TDMA based data transmission in the steady state phase for all the sensor nodes which is inefficient in terms of energy consumption and delay. In the present work, we have proposed grid based multi-hop clustering scheme for heterogeneous network in which the nodes are categorized based on the device capability, i.e., RFD and FFD (reduced function device and fully function device) as well as based on periodic and event monitoring nodes. The cluster head node is selected based on device capability, monitoring method, residual energy, and grid. Also, the sensor-node specific energy-efficient data transmission method (ES-TDMA, ES-BMA, and GTS) is proposed for the each sensor node. In addition, the ES-TDMA based energy-efficient method is used for the data transmission from CH node to BS node. The overall novelty and the contribution of the proposed work are explained below:

- In the present work, the global and local division based zone/sub-zone method is proposed for the energy-efficient data transmission.

- Also, the devices are categorized based on RFD/FFD as well as Periodic/Event monitoring.

- Optimal cluster head selection method is proposed for the multi-hop heterogeneous network.

- The CH is selected based on global/local zone, RFD/FFD, periodic/event monitoring, and residual energy.

- For the time-constraint data transmission guaranteed time slot is allotted to the specific SNs.

- Energy-saving TDMA (ES-TDMA) method is used for the periodic monitoring devices from SN-to-CH node and CH-to-BS node data transmission.

LITERATURE STUDY

The proposed work deals with energy-efficient clustering and data transmission. Therefore, the literature study is divided into setup phase and steady state based research works. Heinzelman et al. proposed low energy adaptive clustering hierarchy (LEACH) protocol for energy-efficient clustering [5]. LEACH protocol dynamically rotates the CH in efficient manner to improve the overall lifetime network. The LEACH protocol uses TDMA based data transmission in steady state phase. To further improve the performance various clustering protocols are proposed. Handy et al. proposed improved LEACH for deterministic CH [6]. Faisal et al. proposed the idea of zone division for better coverage and connectivity with low energy consumption [7]. Femi et al. proposed enhanced version stable election of cluster head to further improve the performance [8]. Bhagyashree et al. proposed the grid based distribution of overall land for agriculture application. The author proposed energy efficient APTEEN protocol [9]. Abouzar et al. proposed low error rate precision agriculture data transmission method using localization method. The author proposed received signal strength indicator (RSSI) values to estimate the location of the node [10]. Banoth et al. proposed zone based division for stable election of CH node. The results prove the superiority of zonal based election of CH [11]. To further improve the performance, khorshed et al. proposed improved version zonal election protocol which improves the performance in multiple fold [12]. In all the previously reported works, the researchers used TDMA in steady state phase. Shaifullah et al. proposed energy efficient TDMA MAC protocol to further reduce the energy consumption by turning-off the radio of the SNs which consist of empty buffer [13]. However, the protocol is suitable only for periodic devices. Further shaifullah et al. proposed energy efficient bit map assisted (BMA) medium access control protocol for event as well periodic monitoring devices [14]. The standard protocol uses aggregation operation at CH node. The aggregated data packet is transmitted to the BS node. However,
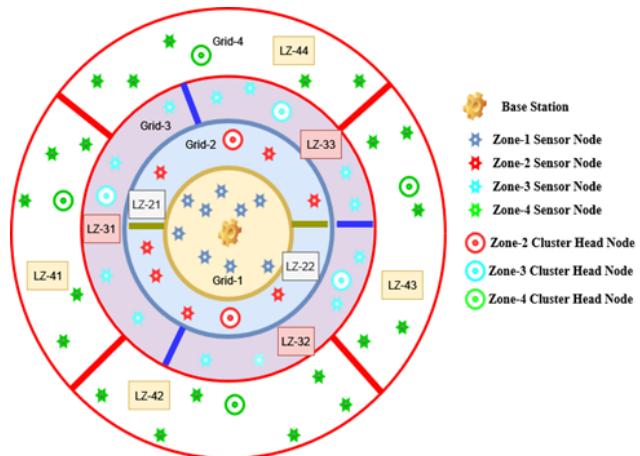
the researchers have not used redundant data filtration. Tolani et al. proposed spatio-temporal aggregation method for the filtration of the redundant data [15]. To further reduce the energy consumption, haneual et al. proposed energy-efficient sleep mode selection method without compromising with data consistency [16].

PROPOSED GLOBAL-LOCAL CLUSTER HEAD SELECTION (GLCHS) PROTOCOL

In the present work, the realistic monitoring region is considered. In practical condition, the monitoring field can be assumed in circular as the trans-receiver radio and antennas generate radio waves in omni-directional. Therefore, the base station is considered in the centre of the field and the zones are divided in circular region as shown in Fig. 1. The region is divided into zones and zones are further categorized into sub-zones for energy-efficient monitoring of the field. The zone-1, zone-2, zone-3 and zone-4 are global zone. The radius of the outer zone is larger than the inner zone and so that the outer zones are divided into local zones based on the area, e.g., zone-2 is divided into two local zones; zone-3 is divided into 3 local zones and zone 4 is divided into four local zones. As shown in Fig.1 that each sub-zone consist of cluster head. The cluster head transmits the data to the base station. The sensor devices in zone-1 directly transmit the data to the base station node and the sensor nodes in the outer zone transmit the data via CH node. The local zones and CH nodes increases in the global zones with increment in the radius of the outer zone. The proposed method also provides the secondary CH node for the efficient transmission of data in case of primary CH node failure. The end-devices of the outer regions transmit the data via secondary CH node of the nearby region.

The overall operation of the proposed protocol is shown in Fig. 2. In the proposed protocol, the operation starts with setup phase. In the setup phase, first the network is formed and the sensor nodes are classified into reduced function device (RFD) and fully function device (FFD). After classification of RFD/FFD, the end-devices (RFD, i.e., end devices) are further classified into event-driven and continuous monitoring sensor nodes based on the sensing operation and sampling rate. After classification of nodes, the optimal numbers of clusters are estimates based on total coverage of the zone. Let us assume that the outer radius of nth global zone is denoted by r_n. The cumulative zonal area of the nth zone is denoted by ZA_n. Thus the region covered by the nth zone can be calculated as $ZA_n - ZA_{n-1}$. The global zone of the the nth region is given by:

$$G_z^n = ZA_n - ZA_{n-1} \tag{1}$$

Figure 1: Circular zone based local and global zone division

Each global zone is divided into multiple local zones. The first global zone consist of only one local zone. The nth global zone consist of total N_L local zones as given below:
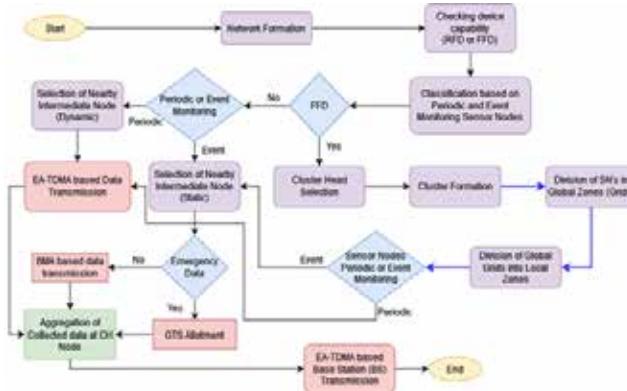
$$N_L^n = \frac{ZA_n - ZA_{n-1}}{ZA_1} \tag{2}$$

In the proposed model, each local zone consist of total N_L^n local zones and therefore total N_L^n cluster head nodes is used for the transmission of the data.

Process flow of GLCHS protocol

The protocol operation is divided into setup phase and steady state phase. The process flow is shown in Fig. 2. The operation of the proposed protocol starts with the network formation. After formation of the network, the base station classifies the nodes into fully function device (FFD) and reduced function device (RFD) categories. In addition, the BS also categorizes the nodes into periodic and event-driven nodes. The FFD devices are identified as a eligible device for CH selection. The cluster formation and cluster head selection takes place in setup phase. The machine learning based hierarchical clustering method is used for cluster formation. The selection of the cluster head (CH) is similar to the standard LEACH protocol based on the randomization. However, before selection of the CH node, the eligible nodes information is collected by the base station.

After identification, a random node is selected as a CH node for the particular local zone and the data slots are allotted in session.

Figure 2: Proposed flow of GLCHS protocol

Each session is divided into two sub-sessions. The slots of sub-session-1 is allotted to the periodic monitoring devices and slots of sub-session-2 is allotted to the event monitoring devices. The event monitoring devices transmit the data using ES-BMA medium access control (MAC) protocol. In case of ES-BMA protocol, the end-to-end delay increases. Therefore, for time-constraint nodes or emergency data transmission, guaranteed time slot (GTS) is allotted.

Analytical model

As per the discussion, the operation of the proposed global-local cluster head selection method consist of two phases, i.e., setup phase and steady state phase. The operation and analytical model of the setup phase is already described in [7,11]. In the steady state phase the operation is divided into contention and data transmission phase. In the contention phase the session is divided into two parts. First part deals with the periodic monitoring and the second part deals with the event monitoring. For the periodic monitoring, the ES-TDMA MAC protocol is used. During contention phase, all the SNs received control packet and CH node broadcasts control message. Let us assume that P_T, P_R, P_I, and P_E are transmitted, received, idle state, and power consumed in checking buffer respectively. Similarly, D_C, D_D, and D_E are control packet, data packet, and buffer checking duration. Let us assume N_P, and N_E are periodic monitoring and event monitoring sensor nodes. The energy consumption of periodic monitoring

CH, SN Node, and total energy consumption during contention phase are given below:

$$E_{GLSCHS-P-C-CH} = P_T D_C \tag{3}$$

$$E_{GLCHS-P-C-SN} = N_p P_R D_C \tag{4}$$

$$E_{GLCHS-P-C-T} = P_T D_C + N_P P_R D_C \tag{5}$$

The data transmission phase of the periodic monitoring nodes is a reservation based arrangement. SNs transmit the data in their reserved slot only. In the proposed method, the devices turned off their radio in case of no packet in buffer. Let us assume q is the probability of packet generation and their are total S sessions. The energy consumption of CH, and SN are given by:

$$E_{GLCHS-P-T-CH} = N_P q P_R D_D + N_P(1-q)P_I D_D \tag{6}$$

$$E_{GLCHS-P-T-SN} = N_P q P_T D_D + N_P(1-q)P_E D_E \tag{7}$$

The overall energy consumption is given by:

$$E_{GLCHS-P-T-T} = N_P q P_T D_D + N_P(1-q)P_E D_E + N_P q P_R D_D + N_P(1-q)P_I D_D \tag{8}$$

The total energy consumption of the periodic monitoring nodes is given by:

$$E_{GLCHS-P} = P_T D_C + N_P P_R D_C + S(N_P q P_T D_D + N_P(1-q)P_E D_E + N_P q P_R D_D + N_P(1-q)P_I D_D) \tag{9}$$

In the second part event monitoring devices transmit the data using bit-map-assisted method. In the proposed method the SNs reserves the next slot by using last reserved bit of data packet. The energy consumption of the contention phase of CH node, and SN is given by:

$$E_{GLCHS-E-C-CH} = P_I D_C + N_E q(1-q)P_R D_C + N_E(1-q(1-q))P_I D_C + P_T D_{CH} \tag{10}$$

$$E_{GLCHS-E-C-SN} = N_E P_R D_{CH} + N_E q(1-q)(P_T D_C + (N_E-1)P_I D_C) \tag{11}$$

The total energy consumption of event monitoring nodes in contention phase is given by:

$$E_{GLCHS-E-C-T} = N_E q(1-q)P_R D_C + N_E(1-q(1-q))P_I D_C + N_E P_R D_{CH} + N_E q(1-q)(P_T D_C + (N_E-1)P_I D_C) + P_T D_{CH} \tag{12}$$

The devices consist of data, reserves the data slot and transmits the data in the reserved slot allotted by CH node using bit-mapping. The energy consumption of CH node and SN is given by:

$$E_{GLCHS-E-T-CH} = N_E q P_R D_D \qquad (13)$$

The energy consummation of SN in data transmission phase is given by:

$$E_{GLCHS-E-T-SN} = N_E q P_T D_D \qquad (14)$$

The overall energy consumption in data transmission phase is the sum of CH energy and total SNs energy consumption as given below:

$$E_{GLCHS-E-T-T} = N_E q P_R D_D + N_E q P_T D_D \qquad (15)$$

The overall energy consumption of GLCHS MAC protocol for event monitoring devices is given by:

$$E_{GLCHS-E} = (N_E q(1-q)P_R D_C + N_E(1-q(1-q))P_I D_C + N_E P_R D_{CH} + \\ N_E q(1-q)(P_T D_C + (N_E-1)P_I D_C) + P_T D_{CH} + N_E q P_R D_D \\ + N_E q P_T D_D)S \qquad (16)$$

RESULT ANALYSIS AND DISCUSSION

In the proposed work, we have analyzed the performance of the GLCHS protocol for overall region of 400x400 meter square. The first global zone radius 100 meter and consist of only one local zone as shown in Fig. 1. The second global zone have outer radius of 200 meter and have local zones estimated as per the expression given by Eq. 2. Similarly, the outer radius of third and fourth global zones are 300 and 400 meter and consist of local zones given by the Eq. 2. Unlike, the previously reported works, the proposed network classifies the nodes into local zones and thus allows amplification based on the distance between trans-receiver to further reduce the energy consumption. The energy consumption of 50 nJ/bit is assumed for overall energy consumption analysis. The other parameters are similar as given in [11]. The performance of the proposed global local cluster head selection (GLCHS) is compared with stable election of CH (SCHS), global election of CH (GCHS), and LEACH protocol. To analyze the setup phase clustering operation, the energy consumption is analyzed in terms of overall alive nodes and dead nodes with respect to number of rounds. Each round consist of S sessions. The results show that the overall lifetime of the proposed GLCHS is much better than the existing protocol as shown in Fig. 3 and Fig. 4.
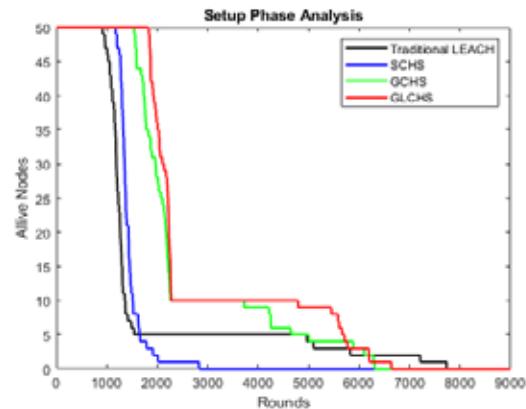
Figure 3: Alive Nodes vs Number of Rounds
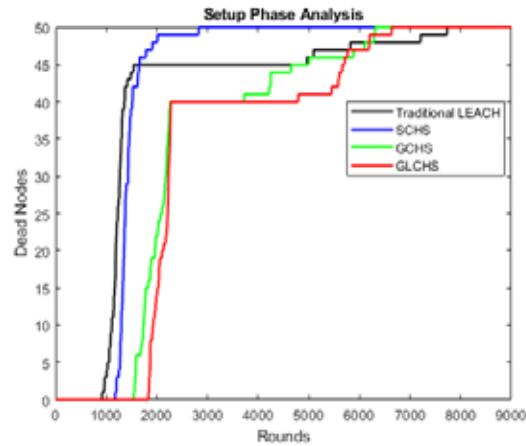
Figure 4: Dead Nodes vs Number of Rounds

From the results it is evidently found that the number of alive nodes are more for higher number of rounds in case of GLCHS and dead nodes are less for higher number of rounds as shown in Fig. 3 and Fig. 4.
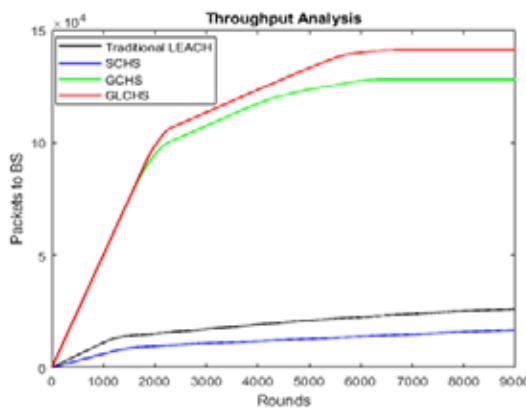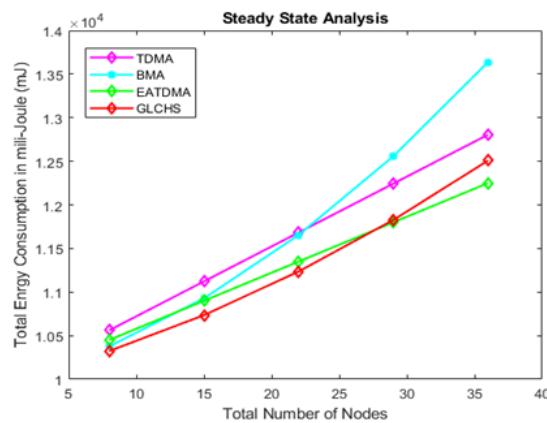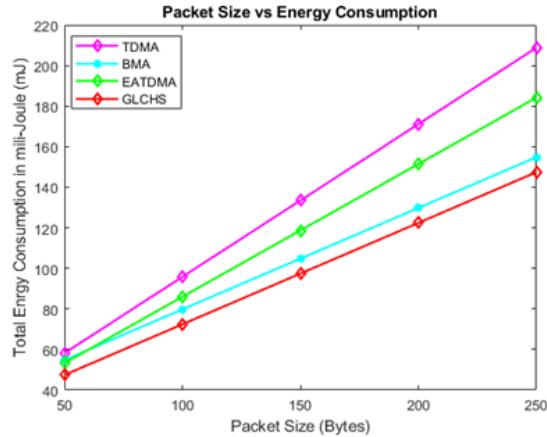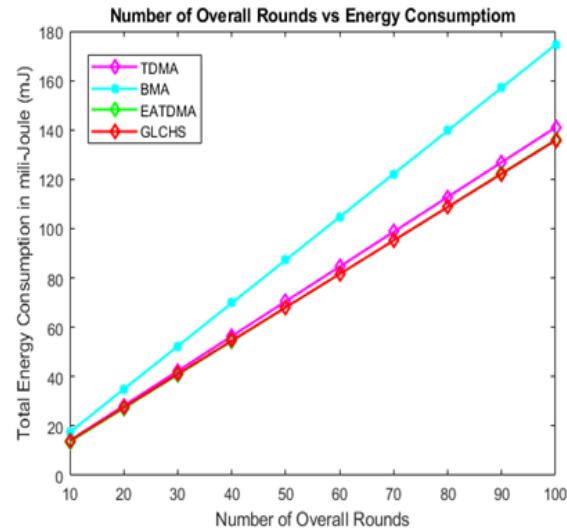
Figure 5: Received packet at BS vs Rounds

Figure 6: Energy consumption vs Number of Nodes

Figure 7: Energy consumption vs Packet Size

To further prove the superiority of the proposed protocol, the throughput of the network (for steady state data transmission) is analyzed as shown in Fig. 5. As the lifetime of the network is more than the existing protocols, therefore the overall throughput of the proposed GLCHS protocol is also higher than the existing protocol.

For the steady state energy consumption analysis of the proposed protocol, the performance of the network is compared with respect to overall number of nodes. The number of overall nodes is varied from 8 to 36 (periodic node varies from 5 to 25 and event nodes varies from 2 to 10). It is shown in Fig. 6 that the overall energy consumption of the proposed protocol is lower than the all other existing steady state protocols. The energy consumption increases as the periodic monitoring node increases. This is due to the fact that the event

data packet generation probability is very less and periodic monitoring nodes reserves the channel in each session. Therefore, the overall energy consumption increases with number of periodic monitoring nodes. We have also analyzed the performance of the proposed protocol for different packet sizes and overall frames/round, which is shown in Fig.7 and Fig.8 respectively. The packet size is varied from 50 Bytes to 250 Bytes and frames/round varied from 10 to 100. In all the cases , the proposed method performs better than the existing MAC protocols. This is due to the fact that the proposed method efficiently utilizes the slots for periodic monitoring as well as event monitoring. The hybrid features of both the protocol makes GLCHS more energy-efficient than the above discussed setup phase and steady state phase protocols.

Figure 8: Energy consumption vs Overall Rounds

CONCLUSION

The present work deals with the energy-efficient clustering and data transmission method for heterogeneous network. Unlike to the previously reported works, in the proposed work, the circular region is considered which is more practical as the coverage of antennas is also circular. The region is divided into global and local zones. The number of local zones increases for the outer region. This improves the overall coverage and connectivity of the network and therefore throughput of the network increases. Also, the proposed scheme improves the overall lifetime of the network.

The result prove that the proposed scheme saves energy in both the setup phase as well as steady state phase.

REFERENCES

1. Pham, N. D., Le, T. D., Park, K. and Choo, H. (2010), "SCCS: Spatiotemporal clustering and compressing schemes for efficient data collection applications in WSNs," Int. J. Commun. Syst., 23: 1311-1333. https://doi.org/10.1002/dac.1104

2. Shabna VC, Jamshid K and S. Manoj Kumar, "Energy minimization by removing data redundancy in wireless sensor networks," 2014 International Conference on Communication and Signal Processing, Melmaruvathur, 2014, pp. 1658-1663. doi: 10.1109/ICCSP.2014.6950130.

3. S. Kandukuri, J. Lebreton, R. Lorion, N. Murad and J. Daniel Lan-Sun-Luk, "Energy-efficient data aggregation techniques for exploiting spatio-temporal correlations in wireless sensor networks," 2016 Wireless Telecommunications Symposium (WTS), London, 2016, pp. 1-6. doi: 10.1109/WTS.2016.7482055.

4. Leandro A. Villas, Azzedine Boukerche, Horacio A.B.F. de Oliveira, Regina B. de Araujo, Antonio A.F. Loureiro, "A spatial correlation aware algorithm to perform efficient data collection in wireless sensor networks," Ad Hoc Networks, Volume 12, 2014, Pages 69-85, ISSN 1570-8705. https://doi.org/10.1016/j.adhoc.2011.08.005

5. Heinzelman, W. R., Chandrakasan, A., and Balakrishnan, H. (2000, January). "Energy-efficient communication protocol for wireless microsensor networks. In System Sciences, 2000," Proceedings of the 33rd Annual Hawaii International Conference on (pp. 10-pp). IEEE. doi: 10.1109/HICSS.2000.926982.

6. Handy M J , Haase M , Timmermann D . "Low Energy Adaptive Clustering Hierarchy with Deterministic Cluster-Head Selection," 4th International Workshop on Mobile and Wireless Communications Network, 368-372(2002). doi: 10.1109/MWCN.2002.1045790.

7. Faisal, S., Javaid, N., Javaid, A., Khan, M. A., Bouk, S. H.,& Khan, Z. A. (2013). "Z-SEP: Zonal-stable election protocol for wireless sensor networks," arXiv preprint arXiv:1303.5364.

8. Femi A. Aderohunmu, Jeremiah D.Deng. "An enhanced stable election protocol (SEP) for clustered heterogeneous WSN," https://www.researchgate.net/publication/228987176, 1-7(2017)

9. Bhagyashree, S., Prashanthi, S., & Anandkumar, K. M. (2015, July). " Enhancing network lifetime in precision agriculture using Apteen protocol," In 2015 IEEE Technological Innovation in ICT for Agriculture and Rural Development (TIAR (pp. 44-48) IEEE. doi: 10.1109/TIAR.2015.7358529.

10. Abouzar, P., Michelson, D. G., & Hamdi, M. (2016). "RSSI-based distributed self-localization for wireless sensor networks used in precision agriculture," IEEE Transactions on Wireless Communications, 15(10), 6638-6650. doi: 10.1109/TWC.2016.2586844.

11. Banoth Thirumala, Kumar Vijay B, "Zonal-Stable Election Protocol for Wireless Sensor Networks," International Journal of Ethics in Engineering & Management Education, 3(10):28-32(2016)

12. Md. Khorshed Alom, Arif Hossan, Pallab K. Choudhury, "Improved Zonal Stable Election Protocol (IZ-SEP) for hierarchical clustering in heterogeneous wireless sensor networks, " e-Prime - Advances in Electrical Engineering, Electronics and Energy, Volume 2, 2022, 100048, ISSN 2772-6711, https://doi.org/10.1016/j.prime.2022.100048.

13. G. M. Shafiullah, A. Thompson, P. J. Wolfs and S. Ali, "Energy-efficient TDMA MAC protocol for wireless sensor networks applications," 2008 11th International Conference on Computer and Information Technology, Khulna, Bangladesh, 2008, pp. 85-90, doi: 10.1109/ICCITECHN.2008.4803131.

14. G. Shafiullah, S. A. Azad and A. B. M. S. Ali, "Energy-efficient wireless MAC protocols for railway monitoring applications," IEEE Trans. Intell.Transp. Syst., vol. 14, no. 2, pp. 649–659, Jun. 2013. doi: 10.1109/TITS.2012.2227315.

15. Manoj Tolani, Sunny, Rajat Kumar Singh, "Lifetime improvement of wireless sensor network by information sensitive aggregation method for railway condition monitoring, Ad Hoc Networks," Volume 87, 2019, Pages 128-145, ISSN 1570-8705, https://doi.org/10.1016/j.adhoc.2018.11.009.

16. Haneul Ko, Jaewook Lee, Sangheon Pack, "CG-E2S2: Consistency-guaranteed and energy-efficient sleep scheduling algorithm with data aggregation for IoT", Future Generation Computer Systems, Volume 92, 2019, Pages 1093-1102, https://doi.org/10.1016/j.future.2017.08.040, ISSN 0167-739X.

The Role of Human Resource Management in Attracting and Retaining Top Talent

Jyoti Pachori, Mohammad Sajid
Associate Professor
Technocrats Institute of Technology (TIT – MBA),
Anand Nagar, Bhopal, Madhya Pradesh

Shaizal Batra
Professor
Anand Institute of Management
Neelbad, Bhopal, Madhya Pradesh

ABSTRACT

In today's dynamic business landscape, organizations are increasingly recognizing the significance of human capital as a key driver of competitive advantage. Consequently, attracting and retaining top talent has emerged as a critical challenge for many enterprises. Human resource management (HRM) plays a pivotal role in addressing this challenge by formulating and implementing effective strategies to attract, retain, and develop highly skilled and motivated employees.

This paper delves into the multifaceted role of HRM in fostering a work environment that is conducive to both attracting and retaining top talent. By employing a comprehensive approach, HRM professionals can effectively navigate the recruitment and selection process, ensuring that the organization acquires individuals who align with its culture and values. Furthermore, HRM plays a crucial role in cultivating a positive and engaging work environment that fosters employee satisfaction, motivation, and retention.

BACKGROUND

As the global marketplace evolves, organizations face unprecedented challenges in securing and maintaining a workforce that not only possesses the requisite skills but also aligns with the values and goals of the company. HRM is at the forefront of this endeavor, orchestrating a range of activities to ensure the acquisition and retention of top talent.

INTRODUCTION

Top talent represents a significant competitive advantage for organizations. These individuals possess the skills, knowledge, and experience that can help organizations achieve their strategic goals. However, attracting and retaining top talent is a complex challenge. Organizations must compete with other employers for the best talent, and they must also create a work environment that is conducive to both attracting and retaining top performers.

In the contemporary business landscape, the competition for top talent has become increasingly fierce. Organizations recognize that their success is intricately tied to the caliber of individuals they attract and retain. This research paper aims to explore the pivotal role played by Human Resource Management (HRM) in the dynamic process of attracting and retaining top talent. The paper will delve into the multifaceted strategies and practices that HRM employs to identify, recruit, and cultivate the best candidates, as well as the subsequent measures taken to foster an environment conducive to talent retention.

OBJECTIVES

a. Examine the key factors influencing the attraction of top talent.

b. Analyze HRM strategies for effective talent identification and recruitment.

c. Explore the role of organizational culture and employee engagement in talent retention.

d. Investigate emerging trends and technologies shaping HRM practices in talent management.

HRM has a critical role to play in addressing the challenge of attracting and retaining top talent. HRM professionals can develop and implement strategies to attract top talent, such as:

• Developing a strong employer brand

• Creating a positive and productive work environment

• Offering competitive compensation and benefits

• Providing opportunities for career development

Once top talent is attracted, HRM professionals must also develop strategies to retain them, such as:

• Providing ongoing training and development

• Recognizing and rewarding employee contributions

• Fostering a culture of engagement and appreciation

• Creating a work-life balance

• Effective Recruitment and Selection

The first step in attracting top talent is to develop an effective recruitment and selection process. This process should identify and attract qualified candidates who are a good fit for the organization's culture and values. HRM professionals can use a variety of tools and techniques to recruit top talent, such as:

• Online job boards

• Social media

• Employee referrals

• Professional networking events

Once candidates have been identified, HRM professionals must then use a rigorous selection process to evaluate their skills, knowledge, and experience. This process may include:

• Interviews

• Skills assessments

• Reference checks

• Employee Engagement and Retention

Once top talent has been attracted, HRM professionals must then focus on retaining them. This can be achieved by creating a positive and productive work environment that offers employees opportunities for growth and development. HRM professionals can also use a variety

of strategies to retain top talent, such as:

• Providing competitive compensation and benefits

• Offering opportunities for career development

• Recognizing and rewarding employee contributions

• Fostering a culture of engagement and appreciation

• Creating a work-life balance

Factors Influencing Talent Attraction

Compensation and benefits as a factor in Attracting and Retaining Top Talent: In the competitive landscape of today's business world, organizations face the constant challenge of attracting and retaining top talent. Top talent, characterized by individuals possessing exceptional skills, knowledge, and experience, plays a pivotal role in driving organizational success and achieving strategic objectives. Human Resource Management (HRM) stands at the forefront of attracting and retaining top talent, and compensation and benefits packages serve as a crucial factor in this endeavor.

The Significance of Compensation and Benefits

Compensation and benefits represent a significant portion of an employee's total value proposition. They encompass not only base salary but also a range of benefits that contribute to an individual's overall well-being and financial security. When organizations offer competitive compensation and benefits packages, they signal their commitment to attracting and retaining high-caliber talent.

Compensation: The Foundation of Talent Attraction

Base salary serves as the foundation of an employee's compensation package and plays a critical role in attracting top talent. Organizations that offer competitive salaries demonstrate their willingness to invest in their employees and recognize their contributions. By benchmarking salaries against industry standards and considering factors such as location, experience, and skills, organizations can ensure that their compensation packages remain attractive to top talent.

Benefits: Enhancing the Total Value Proposition

Beyond base salary, a comprehensive benefits package enhances the overall value proposition for top talent. This includes traditional benefits such as health insurance,

dental insurance, and vision insurance, as well as more comprehensive offerings such as retirement plans, disability insurance, and paid time off. Additionally, organizations can consider offering unique benefits such as wellness programs, flexible work arrangements, and tuition reimbursement to further differentiate themselves and attract top talent.

The Impact of Compensation and Benefits on Talent Attraction

The impact of compensation and benefits on talent attraction is multifaceted. Competitive compensation packages can motivate individuals to consider employment opportunities with an organization. When individuals perceive that their skills and experience are valued and adequately compensated, they are more likely to be attracted to an organization. Moreover, comprehensive benefits packages can enhance an organization's reputation as an employer of choice, leading to a stronger employer brand and increased attractiveness to top talent.

Research Supporting the Role of Compensation and Benefits

Numerous studies have demonstrated the positive correlation between compensation and benefits and talent attraction. A study by Bersin by Deloitte found that 80% of job seekers consider compensation and benefits to be a "very important" factor in their job search. Similarly, a study by Indeed found that 64% of job seekers would consider a job offer with lower pay if it offered better benefits.

Recommendations for Enhancing Compensation and Benefits Strategies

To effectively utilize compensation and benefits as a tool for attracting top talent, organizations should consider the following recommendations:

a. Conduct Regular Compensation Benchmarking: Regularly benchmark compensation packages against industry standards and competitors to ensure they remain competitive.

b. Tailor Benefits Packages to Employee Needs: Consider the specific needs and preferences of the target talent pool when designing benefits packages.

c. Communicate Benefits Effectively: Clearly communicate the value of benefits packages to employees to ensure they understand the comprehensive nature of their total compensation.

d. Offer Flexible Benefits Options: Provide employees with the flexibility to choose benefits that align with their individual needs and preferences.

e. Stay Informed on Emerging Trends: Keep abreast of emerging trends in compensation and benefits to ensure the organization remains competitive and attractive to top talent.

Compensation and benefits play a significant role in attracting and retaining top talent. By offering competitive compensation packages and comprehensive benefits that align with the needs and preferences of top talent, organizations can enhance their employer brand, attract high-caliber individuals, and drive organizational success.

Recruitment and Selection Processes as a factor in Attracting and Retaining Top Talent

In today's competitive business environment, organizations are increasingly recognizing the importance of attracting and retaining top talent. Top talent, defined as individuals who possess the skills, knowledge, and experience that are critical to an organization's success, plays a pivotal role in driving organizational growth, innovation, and overall performance. Human Resource Management (HRM) plays a central role in attracting and retaining top talent, and effective recruitment and selection processes serve as key factors in this endeavor.

The Significance of Recruitment and Selection Processes

Recruitment and selection processes represent the initial stages of the employee lifecycle and play a critical role in shaping the quality and composition of an organization's workforce. By implementing well-designed recruitment and selection processes, organizations can attract a diverse pool of qualified candidates, identify the most suitable individuals for open positions, and set the stage for successful onboarding and long-term retention.

Effective Recruitment Strategies for Talent Attraction

Effective recruitment strategies encompass a range of activities that aim to attract a diverse pool of qualified candidates. These strategies should be tailored to the organization's specific needs, target audience, and industry context. Key considerations include:

a. Job Description: Clearly define the role's responsibilities, requirements, and desired skills to attract the right candidates.

b. Job Posting: Utilize appropriate channels to post job openings, reaching a wide audience of potential candidates.

c. Candidate Sourcing: Actively seek out and engage potential candidates through various channels, such as employee referrals, professional networks, and online platforms.

d. Candidate Relationship Management: Build relationships with potential candidates, even if they are not applying for immediate openings, to nurture a talent pipeline for future opportunities.

Rigorous Selection Processes for Top Talent Identification

Rigorous selection processes involve a series of assessments and evaluations designed to identify the most suitable candidates for open positions. These processes should be fair, objective, and aligned with the organization's values and culture. Key considerations include:

a. Screening: Review resumes and applications to identify candidates who meet the minimum qualifications.

b. Skills Assessments: Evaluate candidates' technical skills and expertise through relevant assessments, tests, or projects

c. Interviews: Conduct structured interviews to assess candidates' behavioral competencies, cultural fit, and overall potential.

d. Background Checks: Verify candidates' credentials, employment history, and education to ensure accuracy and integrity.

The Impact of Recruitment and Selection Processes on Talent Attraction: Effective recruitment and selection processes have a direct and significant impact on talent attraction. By implementing well-designed processes, organizations can:

• Attract a Wider Pool of Qualified Candidates: Reach a broader audience of potential candidates, including top talent, by utilizing diverse recruitment channels.

• Enhance Employer Brand: Develop a reputation as a fair, transparent, and selective employer, attracting high-caliber candidates who seek a positive work environment.

• Improve Candidate Experience: Provide a positive and engaging candidate experience, fostering positive perceptions of the organization and increasing the likelihood of top talent accepting employment offers.

• Reduce Hiring Costs: Make informed hiring decisions, minimizing the time and resources spent on onboarding and training unqualified candidates.

Research Supporting the Role of Recruitment and Selection Processes

Numerous studies have demonstrated the positive correlation between effective recruitment and selection processes and talent attraction. A study by SHRM found that 90% of organizations believe that their recruitment and selection processes impact their ability to attract top talent. Similarly, a study by McKinsey & Company found that companies with strong recruitment and selection processes are 30% more likely to hire top talent.

Recommendations for Enhancing Recruitment and Selection Strategies: To effectively utilize recruitment and selection processes as tools for attracting top talent, organizations should consider the following recommendations:

a. Regularly Review and Update Processes: Periodically evaluate and update recruitment and selection processes to ensure they remain aligned with the organization's evolving needs and industry trends.

b. Involve Stakeholders in Process Design: Engage representatives from various departments, including hiring managers and HR professionals, in the design and implementation of recruitment and selection processes.

c. Utilize Technology for Efficiency: Leverage technology tools to automate tasks, streamline processes, and enhance candidate communication.

d. Focus on Diversity and Inclusion: Implement strategies to attract and recruit diverse candidates, creating a more inclusive and equitable workplace.

e. Seek Continuous Improvement: Gather feedback from candidates and internal stakeholders to identify areas for improvement and continuously enhance recruitment and selection processes.

Recruitment and selection processes play a critical role in attracting top talent. By designing and implementing effective recruitment and selection strategies, organizations can attract a diverse pool of qualified candidates, identify the most suitable individuals for open positions, and enhance their employer brand. A focus on continuous improvement and innovation in recruitment and selection processes will enable organizations to effectively attract and retain top talent, driving organizational success in the ever-evolving business landscape.

HRM Strategies in Talent Identification and Recruitment:

Talent Acquisition as a factor in Attracting and Retaining Top Talent

In today's dynamic and competitive business environment, organizations are increasingly recognizing the critical role of top talent in achieving their strategic goals and objectives. Top talent, defined as individuals who possess exceptional skills, knowledge, and experience, plays a pivotal role in driving innovation, productivity, and overall organizational success. Human Resource Management (HRM) plays a central role in attracting and retaining top talent, and talent acquisition stands as a key strategic lever within HRM to achieve this objective.

Talent Acquisition: The Foundation of Attracting Top Talent

Talent acquisition encompasses the comprehensive process of identifying, attracting, hiring, and onboarding the best-fit individuals to fulfill critical roles within an organization. It serves as the foundation for building a high-performing workforce and ensuring that organizations have the necessary talent to execute their strategic plans. Effective talent acquisition strategies enable organizations to:

a. Develop a Strong Employer Brand: Cultivate a positive reputation as an employer of choice, attracting top talent seeking meaningful work and professional growth opportunities.

b. Create a Compelling Talent Value Proposition: Design a comprehensive package of compensation, benefits, and other perks that align with the needs and preferences of top talent.

c. Leverage Diverse Recruitment Channels: Utilize a variety of channels, including online job boards, social media platforms, employee referrals, and professional networks, to reach a wider pool of qualified candidates.

d. Implement Rigorous Selection Processes: Employ a structured and objective selection process to assess candidates' skills, experience, and cultural fit, ensuring the right individuals are selected for open positions.

The Impact of Talent Acquisition on Talent Attraction and Retention

Effective talent acquisition strategies have a direct and positive impact on attracting and retaining top talent:

a. Attracting High-Quality Candidates: A well-defined talent acquisition process attracts a diverse pool of qualified candidates, increasing the likelihood of identifying and hiring top talent.

b. Reducing Time-to-Hire: Streamlined talent acquisition processes minimize the time it takes to fill open positions, reducing costs associated with prolonged vacancies and increasing the organization's agility.

c. Improving Candidate Experience: A positive candidate experience creates a favorable impression of the organization, encouraging top talent to accept employment opportunities and fostering long-term retention.

d. Enhancing Employer Brand: A strong employer brand, cultivated through effective talent acquisition practices, attracts and retains top talent, contributing to a positive organizational reputation.

Research Supporting the Role of Talent Acquisition

Numerous studies have demonstrated the positive correlation between effective talent acquisition and attracting and retaining top talent. A study by Bersin by Deloitte found that 80% of organizations believe that talent acquisition is a critical factor in their ability to attract top talent. Similarly, a study by LinkedIn found that companies with strong talent acquisition practices are 20% more likely to retain top performers.

Recommendations for Enhancing Talent Acquisition Strategies

To effectively utilize talent acquisition as a tool for attracting and retaining top talent, organizations should consider the following recommendations:

a. Develop a Talent Acquisition Strategy: Align talent acquisition strategies with the organization's overall business strategy, ensuring that recruitment and selection efforts are focused on identifying and hiring individuals who can contribute to the organization's success.

b. Invest in Technology: Utilize technology tools to automate tasks, streamline processes, and enhance candidate communication, improving the efficiency and effectiveness of talent acquisition efforts.

c. Embrace Data-Driven Decision Making: Leverage data analytics to gain insights into candidate demographics, hiring trends, and talent market dynamics, enabling organizations to make informed decisions about talent acquisition strategies.

d. Nurture Relationships with Candidates: Build relationships with potential candidates, even if they are not applying for immediate openings, to create a talent pipeline and foster long-term engagement with top talent.

e. Continuous Improvement: Regularly evaluate and refine talent acquisition processes to adapt to changing market conditions, evolving technologies, and emerging talent trends.

Talent acquisition plays a pivotal role in attracting and retaining top talent, enabling organizations to build a high-performing workforce and achieve their strategic objectives. By implementing effective talent acquisition strategies, organizations can differentiate themselves in the competitive talent landscape, attract the best-fit individuals, and foster a culture of innovation and success.

Employer Branding as a factor in Attracting and Retaining Top Talent

In today's dynamic and competitive business landscape, organizations are increasingly recognizing the critical role of top talent in achieving their strategic goals and objectives. Top talent, defined as individuals who possess exceptional skills, knowledge, and experience, plays a pivotal role in driving innovation, productivity, and overall organizational success. Human Resource Management (HRM) plays a central role in attracting and retaining top talent, and employer branding stands as a key strategic lever within HRM to achieve this objective.

Employer Branding: Shaping Perceptions and Attracting Top Talent

Employer branding encompasses the image or reputation that an organization creates as an employer. It is about how an organization is perceived internally and externally as a place to work. A strong employer brand is not just about marketing and advertising; it is the result of a consistent and aligned effort to create a positive work environment, foster employee engagement, and communicate an organization's values and culture effectively.

A strong employer brand plays a crucial role in attracting and retaining top talent by:

a. Enhancing Reputation and Credibility: Establishing a positive reputation as an employer of choice attracts top talent seeking meaningful work and professional growth opportunities.

b. Communicating Value Proposition: Clearly articulating the organization's value proposition, including compensation, benefits, work-life balance, and career development opportunities, resonates with top talent seeking a fulfilling work experience.

c. Differentiating from Competitors: Standing out in the competitive talent landscape by showcasing unique aspects of the organization's culture, values, and employee experience.

d. Building Emotional Connection: Creating an emotional connection with potential candidates, fostering a sense of belonging and pride in being part of the organization.

The Impact of Employer Branding on Talent Attraction and Retention

Effective employer branding strategies have a direct and positive impact on attracting and retaining top talent:

a. Increased Candidate Attraction: A strong employer brand attracts a wider pool of qualified candidates, increasing the likelihood of identifying and hiring top performers.

b. Reduced Recruitment Costs: A positive reputation as an employer reduces the time and resources spent on sourcing and recruiting candidates, minimizing recruitment costs.

c. Improved Candidate Experience: A positive candidate experience creates a favorable impression of the organization, encouraging top talent to accept employment offers and reducing time-to-hire.

d. Enhanced Employee Engagement: A strong employer brand fosters employee engagement, reducing turnover and increasing retention of top talent.

Research Supporting the Role of Employer Branding

Numerous studies have demonstrated the positive correlation between strong employer branding and attracting and retaining top talent. A study by Social Talent found that 70% of job seekers consider employer branding to be very important when evaluating job opportunities. Similarly, a study by Glassdoor found that companies with a strong employer brand are 50% more likely to attract top talent.

Recommendations for Enhancing Employer Branding Strategies

To effectively utilize employer branding as a tool for attracting and retaining top talent, organizations should consider the following recommendations:

a. Develop a Clear Employer Brand Identity: Articulate the organization's core values, mission, and vision, ensuring they are aligned with the overall employer brand message.

b. Involve Employees in Branding Efforts: Engage employees in shaping the employer brand, leveraging their insights and experiences to create an authentic and relatable brand story.

c. Utilize Social Media and Online Platforms: Actively engage on social media and online platforms to showcase the organization's culture, values, and employee experiences.

d. Monitor and Respond to Online Reviews: Actively monitor online reviews and feedback, addressing any negative perceptions promptly and professionally.

e. Align Employer Branding with Recruitment Efforts: Ensure that recruitment materials and processes consistently reflect the organization's employer brand message.

f. Measure and Evaluate Branding Impact: Regularly measure and evaluate the effectiveness of employer branding initiatives to identify areas for improvement.

Employer branding plays a pivotal role in attracting and retaining top talent, enabling organizations to differentiate themselves in the competitive talent landscape and build a high-performing workforce. By implementing effective employer branding strategies, organizations can cultivate a positive reputation, attract high-caliber individuals, and foster a culture of innovation and success. A strong employer brand serves as a powerful tool in the hands of HRM, enabling organizations to achieve their strategic goals and objectives through the acquisition and retention of top talent.

EMERGING TRENDS AND TECHNOLOGIES IN HRM

Artificial Intelligence: Revolutionizing Talent Acquisition and Management

AI is rapidly transforming the field of HRM, offering a range of applications that are revolutionizing talent

acquisition and management practices. AI's ability to collect, analyze, and process vast amounts of data enables HRM professionals to make more informed decisions about talent acquisition, selection, and employee development.

Talent Analytics: Data-Driven Insights for Talent Management

Talent Analytics (TA) is the systematic collection, analysis, and interpretation of data related to an organization's workforce. TA provides HRM professionals with data-driven insights into workforce trends, employee performance, and talent gaps, enabling them to make informed decisions about talent management strategies.

The Convergence of AI and TA: A Powerful Combination for Talent Attraction and Retention

The convergence of AI and TA is creating a powerful combination that is transforming HRM practices. AI-powered TA tools are enabling HRM professionals to:

- Enhance Talent Search and Sourcing: AI algorithms can identify and analyze vast amounts of data to identify potential candidates with the skills, experience, and cultural fit that align with the organization's needs.

- Improve Predictive Modeling: AI-powered predictive modeling can assess candidates' potential for success and identify potential risks, such as flight risk or performance issues.

- Personalize Candidate Engagement: AI can personalize candidate engagement by tailoring communication, recommendations, and assessment experiences.

- Optimize Talent Acquisition Processes: AI can automate tasks, streamline processes, and reduce the time-to-hire, enhancing efficiency and cost-effectiveness.

- Gain Insights from Employee Data: AI can analyze employee data to identify patterns, trends, and potential issues, enabling HRM to proactively address concerns and improve employee engagement.

- Develop Targeted Training and Development Programs: AI can identify skill gaps and individual learning needs, enabling HRM to develop targeted training and development programs that enhance employee performance and engagement.

The Impact of AI and TA on Talent Attraction and Retention

The impact of AI and TA on talent attraction and retention is significant:

a. Improved Candidate Experience: AI-powered tools can provide a positive and engaging candidate experience, fostering positive perceptions of the organization and increasing the likelihood of top talent accepting employment offers.

b. Data-Driven Decision Making: AI-driven insights enable HRM to make informed decisions about talent acquisition, selection, and development, leading to better hiring decisions and improved employee retention.

c. Enhanced Talent Pipelining: AI and TA can help organizations identify and nurture potential candidates, creating a strong talent pipeline for future hiring needs.

d. Predictive Analytics for Retention: AI-powered predictive analytics can identify employees at risk of attrition, enabling HRM to proactively address concerns and improve retention rates.

Research Supporting the Role of AI and TA in HRM

Numerous studies have demonstrated the positive impact of AI and TA on HRM practices, particularly in attracting and retaining top talent. A study by the Human Capital Institute found that organizations that use AI for talent acquisition are 25% more likely to hire top talent. Similarly, a study by Deloitte found that companies that use TA are 70% more likely to achieve their talent management goals.

Recommendations for Leveraging AI and TA in HRM

To effectively leverage AI and TA in HRM for attracting and retaining top talent, organizations should consider the following recommendations:

- Develop a Clear Strategy: Articulate a clear strategy for implementing AI and TA, aligning it with the organization's overall talent management goals.

- Invest in Technology: Invest in AI and TA tools that are tailored to the organization's specific needs and challenges.

- Ensure Data Quality: Implement data governance practices to ensure data accuracy, completeness, and consistency.

- Train HRM Professionals: Provide training to HRM professionals on how to utilize AI and TA tools effectively.

- Monitor and Evaluate Impact: Regularly monitor and evaluate the impact of AI and TA initiatives to identify areas for improvement.

AI and TA are transforming the field of HRM, providing organizations with powerful tools to attract and retain top talent. By embracing these emerging trends and technologies, HRM professionals can enhance their effectiveness, drive organizational success, and contribute to a competitive edge in the ever-evolving talent landscape

Remote Work and Flexible Arrangements

In today's dynamic and evolving workplace, the rise of remote work and flexible arrangements has significantly impacted Human Resource Management (HRM) practices. These emerging trends are transforming how organizations attract, engage, and retain top talent, offering new opportunities to enhance employee well-being, productivity, and overall organizational success.

Remote Work: Redefining the Traditional Workplace

Remote work, also known as telework or telecommuting, involves employees performing their job duties from a location outside of the traditional office setting. This shift towards remote work has been fueled by advancements in technology, increased connectivity, and a growing desire for work-life balance among employees.

Flexible Arrangements: Tailoring Work to Individual Needs

Flexible arrangements encompass various practices that allow employees to tailor their work schedules and locations to their individual needs and preferences. These arrangements may include flexible work hours, compressed workweeks, telecommuting options, and job sharing.

The Impact of Remote Work and Flexible Arrangements on HRM

The adoption of remote work and flexible arrangements has significant implications for HRM practices, including:

- Talent Acquisition: Expanding the talent pool beyond geographical boundaries, attracting a wider range of qualified candidates.

- Employee Engagement: Enhancing employee satisfaction, work-life balance, and motivation through increased autonomy and flexibility.

- Productivity Enhancement: Fostering a results-oriented culture, promoting self-discipline and time management skills among employees.

- Diversity and Inclusion: Enabling participation from individuals with diverse lifestyles, family responsibilities, or disabilities.

- Cost Reduction: Minimizing overhead costs associated with traditional office space, utilities, and commuting expenses.

Emerging Trends and Technologies in Remote Work and Flexible Arrangements

HRM professionals are embracing emerging trends and technologies to effectively manage remote and flexible work arrangements, including:

- Virtual Communication Platforms: Utilizing video conferencing, instant messaging, and project management tools to facilitate seamless communication and collaboration among remote teams.

- Performance Management Tools: Implementing remote performance management systems that focus on outcomes and goals rather than physical presence.

- Employee Engagement Platforms: Utilizing online platforms to foster employee engagement, recognition, and community building among remote workers.

- Digital Wellness Initiatives: Promoting digital wellness practices to prevent burnout, maintain work-life balance, and promote mental well-being among remote employees.

- Data-Driven Insights: Leveraging analytics and data visualization tools to gain insights into remote work productivity, employee satisfaction, and engagement metrics.

Recommendations for Implementing Remote Work and Flexible Arrangements

Organizations considering adopting remote work and flexible arrangements should carefully consider the following recommendations:

- Establish Clear Policies: Develop clear and comprehensive policies outlining expectations, communication protocols, and performance management guidelines for remote and flexible work arrangements.

- Provide Adequate Technology and Infrastructure: Invest in necessary technology and infrastructure to support remote work, including secure remote access, reliable communication tools, and cloud-based collaboration platforms.

- Foster a Culture of Trust and Accountability: Cultivate a culture of trust and accountability, emphasizing results and outcomes rather than micromanaging or monitoring remote employees' activities.

- Promote Regular Communication and Collaboration: Encourage regular communication and collaboration among remote teams, utilizing virtual meetings, shared workspaces, and team-building activities.

- Offer Ongoing Training and Support: Provide ongoing training and support to remote employees, ensuring they have the necessary skills and resources to thrive in a remote work environment.

Remote work and flexible arrangements are transforming the future of HRM, offering organizations new opportunities to attract, engage, and retain top talent. By embracing these emerging trends and leveraging innovative technologies, HRM professionals can enhance employee well-being, boost productivity, and contribute to overall organizational success. As the workplace continues to evolve, HRM's ability to adapt and embrace these trends will be crucial for attracting and retaining the best talent in today's competitive landscape.

CONCLUSION

Attracting and retaining top talent is a critical challenge for organizations in today's competitive business environment. HRM plays a central role in addressing this challenge by developing and implementing strategies to attract, retain, and develop highly skilled and motivated employees. By effectively managing their talent, organizations can gain a significant competitive advantage.

REFERENCES

1. Aguinis, H. (2009). Performance management (3rd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

2. Becker, B. E., Fehr, J., & Naumann, D. (2007). The Hidden Talents: How to Attract and Retain the Best Employees. Harvard Business Review Press.

3. Becker, B. E., Huselid, M. A., Beatty, R. A., & Ctala-Hulbert, C. (2004). Human capital, competitive advantage, and firm performance. Personnel Psychology, 57(2), 189-215.

4. Bersin, J. (2006). How to Manage Human Resources: The Complete Handbook for HR Professionals. McGraw-Hill.

5. Pfeffer, J. (1994). Competing for Talent: How to Attract and Retain the Best People. Harvard Business Press.

6. Pfeffer, J. (1994). Competitive advantage through people: Leveraging human strengths for organizational success. Boston, MA: Harvard Business Press.

7. Ulrich, D. (1998). Champions of change: How to change the way people think and act. San Francisco, CA: Jossey-Bass.

8. Ulrich, D., & Beatty, D. R. (2005). The Future of Human Resource Management: HR Transformed. Harvard Business School Press.

9. Werling, J. (2010). HR's role in talent management. HR Magazine, 55(4), 70.

10. Wright, P. M., Gardner, D. A., & Moynihan, L. M. (2005). The HR architecture: Aligning people, processes, and strategy for competitive success. New York, NY: McGraw-Hill.

11. Bersin by Deloitte. (2018). 2018 Global Talent Management Survey Report. Retrieved from: https://www2.deloitte.com/bn/en/pages/human-capital/topics/bersin-by-deloitte.html

12. Indeed. (2023). Indeed Hiring Lab Report: Talent Trends 2023. Retrieved from: https://www.hiringlab.org/

13. Becker, B. E., Huselid, M. A., Beatty, R. A., & Ctala-Hulbert, C. (2004). Human capital, competitive advantage, and firm performance. Personnel Psychology, 57(2), 189-215.

14. Pfeffer, J. (1994). Competitive advantage through people: Leveraging human strengths for organizational success. Boston, MA: Harvard Business Press.

15. Wright, P. M., Gardner, D. A., & Moynihan, L. M. (2005). The HR architecture: Aligning people, processes, and strategy for competitive success. New York, NY: McGraw-Hill.

16. Werling, J. (2010). HR's role in talent management. HR Magazine, 55(4), 70.

17. Aguinis, H. (2009). Performance management (3rd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

18. Ulrich, D. (1998). Champions of change: How to change the way people think and act. San Francisco, CA: Jossey-Bass.

19. Society for Human Resource Management (SHRM). (2022). The Talent Acquisition Impact Report. Retrieved from: https://www.shrm.org/resourcesandtools/hr-topics/talent-acquisition/pages/recruiting-talent-acquisition-trends-great-resignation-2022.aspx

20. McKinsey & Company. (2017). Recruiting for Advantage. Retrieved from: https://www.youtube.com/watch?v=o1pvnLsgKRA

21. Aguinis, H. (2009). Performance management (3rd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

22. Becker, B. E., Huselid, M. A., Beatty, R. A., & Ctala-Hulbert, C. (2004). Human capital, competitive advantage, and firm performance. Personnel Psychology, 57(2), 189-215.

23. Pfeffer, J. (1994). Competitive advantage through people: Leveraging human strengths for organizational success. Boston, MA: Harvard Business Press.

24. Ulrich, D. (1998). Champions of change: How to change the way people think and act. San Francisco, CA: Jossey-Bass.

25. Werling, J. (2010). HR's role in talent management. HR Magazine, 55(4), 70.

26. Wright, P. M., Gardner, D. A., & Moynihan, L. M. (2005). The HR architecture: Aligning people, processes, and strategy for competitive success. New York, NY: McGraw-Hill.

27. Bersin by Deloitte. (2018). 2018 Global Talent Management Survey Report. Retrieved from: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/About-Deloitte/central-europe/ce-global-human-capital-trends.pdf

28. LinkedIn. (2023). Talent Acquisition Trends 2023. Retrieved from: https://www.linkedin.com/pulse/recruiting-talent-acquisition-2023-general-trends-keep-alksn%C4%ABtis

29. Aguinis, H. (2009). Performance management (3rd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

30. Becker, B. E., Huselid, M. A., Beatty, R. A., & Ctala-Hulbert, C. (2004). Human capital, competitive advantage, and firm performance. Personnel Psychology, 57(2), 189-215.

31. Pfeffer, J. (1994). Competitive advantage through people: Leveraging human strengths for organizational success. Boston, MA: Harvard Business Press.

32. Ulrich, D. (1998). Champions of change: How to change the way people think and act. San Francisco, CA: Jossey-Bass.

33. Werling, J. (2010). HR's role in talent management. HR Magazine, 55(4), 70.

34. Wright, P. M., Gardner, D. A., & Moynihan, L. M. (2005). The HR architecture: Aligning people, processes, and strategy for competitive success. New York, NY: McGraw-Hill.

35. Bersin by Deloitte. (2019). Talent Acquisition: The New Paradigm. Retrieved from: https://action.deloitte.com/insight/2062/top-findings-from-our-high-impact-talent-acquisition-research

36. Harvard Business Review. (2023). How to Attract and Retain Top Talent. Retrieved from: https://hbr.org/2020/01/a-better-way-to-develop-and-retain-top-talent

37. Alcover, L. M., & Ilgen, D. R. (2023). The impact of remote work on performance and well-being: A meta-analysis. Journal of Applied Psychology, 108(2), 278-301.

38. Bailey, D. E., & Kurland, D. B. (2017). Flexible work arrangements and firm performance. Journal of Organizational Behavior, 38(5), 683-702.

39. Bloom, N., Liang, F., Roberts, J., & Wadhwa, H. (2022). Working from home during the COVID-19 pandemic: Experiences and preferences of employees in the United States. Proceedings of the National Academy of Sciences, 119(17), e2118755119.

Circular Supply Chain Management: Barriers in Implementation

Anjali Upadhyay
Research Scholar
Ujjain Engineering College
Ujjain, Madhya Pradesh
✉ uanjali0108@gmail.com

Apratul Chandra Shukla
Professor
Ujjain Engineering College
Ujjain, Madhya Pradesh
✉ apratuls@gmail.com

ABSTRACT

Circular Supply Chain Management (CSCM) is about thinking in a circular way. Circular Supply Chain is a much better alternative to traditional linear supply chain management i.e. take, use, and discard concept, while circular supply chain focuses on the 6Rs (Reduce, Reuse, Renovate, Recycle, Repair, Return) when the life of the product expires or the life of the product has shortened. It refers to regenerative and regenerative products and materials. The goal of CSCM includes resource reduction, pollution prevention, and zero waste either by technical or biological means. The time of the pandemic has broken the whole world and made us appreciate our mother earth. The outbreak of COVID-19, climate change, and ecological imbalance are the result of the degradation of our natural resources. The management of the supply chain for achieving a circular economy can be a milestone for our ecological well-being. However, several obstacles influence the CSCM implementation in firms. Therefore, this study aims to outline various barriers that affect the implementation of CSCM through a systematic review of the literature. This study has managerial, governmental, and societal implications for CSCM implementation.

KEYWORDS: *Circular economy, circular supply chain, barriers, sustainability, ecology.*

INTRODUCTION

The supply chain and its impact on the environment have been discussed for many years. It has been referred to as a closed-loop supply chain, green supply chain, and sustainable supply chain. These names have been widely used synonymously.

A linear supply chain is designed to serve only the end consumer (Upadhyay & Shukla, 2019). The linear flow of materials in the supply chain, i.e. extraction of raw materials from the planet, processing in nature, and consumption, brings negative value to ecosystems and becomes very harmful to their planet.

The sustainable and green supply chain concept is extended by the circular supply chain concept. The combination of the supply chain with the circular economy for sustainability is known as the circular supply chain. Circular Supply Chain Management (CSCM) is a zero-waste vision of engineering materials recovery and biomaterial regeneration (DeAngelis et al., 2018). The circular supply chain model requires businesses to innovate to perform supply chain functions from product/service design to waste management and end-to-end (Farooque et al., 2019). A product in a linear supply chain begins with the acquisition of materials and ends with the purchase of the end user. However, the product movement in a circular supply chain begins to function when materials are obtained and ends when there is no physical evidence that the product ever existed on the planet (Howard et al., 2018).

DEFINITIONS OF CSCM

According to Batista et al. (2018), CSCM is "a supply chain coordinated forward and backward through an integrated business ecosystem to create value from useful products/services, by-products and waste streams over extended life cycles to improve the economic, social and environmental sustainability of organizations"

According to Farooque et al. (2019), CSCM is the combination of circular philosophy into supply chain

management and the industrial and natural ecosystems around it. Systematically re-engineers and regenerates biomaterials towards a zero-waste vision through systemic innovation in business models and supply chain functions, from product/service design to end-of-life and waste management, involving all product/service lifecycle stakeholders, including manufacturers parts/products, service providers, suppliers, consumers and users.

Geissdoerfer et al. (2018) defined CSCM as the coordination and configuration of various organizational functions such as sales, research and development, production marketing, IT, logistics, customer service, and finance within and within an organization and business to close, slowed down, improved, reduced and dematerialized energy and matter loops to reduce resource entry into systems and leakage. leakage of waste and emissions from the system, improving the efficiency and effectiveness of the system and leading to a competitive advantage.

DeAngelis et al. (2018) defined CSCM as the embodiment of CE principles in the supply chain.

According to Mangla et al. (2018), circular supply chain can be defined as an interconnected network of goods and services flowing in two directions, where upstream and downstream organizations work together to recycle processing, recycling, and repacking of goods for re-importation of the life cycle of products.

Maranesi et al. (2020) define CSCM as "the integration of circular thinking into supply chain management and the industrial and natural ecosystems around it.

According to the Circular Supply Chain Network, "Circular supply chains are interconnected systems that use secondary and renewable inputs to create value by minimizing and maximizing the use of resources."

A circular supply chain works on the principle of 'one person's waste can be another's treasure', as materials provide more value when they move in a circle than in a linear fashion. In CSCM, everything counts and every activity becomes a source of raw materials for others. The goals of CSCM include resource reduction, pollution prevention, and waste minimization, whether technical or biological. Table 1 shows various researchers' perspectives on CSCM.

Table 1: Various Definitions of CSCM

S.No.	Author	Definition	Remarks
1.	DeAngelis et al. (2018)	Embodiment of circular economy principles within supply chains	Combination of circular economy with supply chain management.
2.	Mangla et al. (2018)	Reprocessing, recycling, and remanufacturing products to re-enter the product life cycle is a collaborative effort between upstream organizations and downstream organizations.	Emphasis on 3R for entering again to infant age.
3.	Geissdoerfer et al. (2018)	Configuration and coordination of the organizational functions	All the functions of an organization have to work together to achieve a circularity goal.
4.	Batista et al. (2018)	In order to create value from goods and services, beneficial waste and fallouts flow across an extended life cycle, and reverse and forward supply chains must be coordinated.	Value creation from products, by-products, and wastes.
5.	Farooque et al. (2019)	Through innovation in supply chain operations and business models towards the objective of achieving zero waste, the circular supply chain aims at reviving biological materials and bringing back materials of technical use.	Ellen McArthur Foundation's (2015) approach to technical and biological cycles should be achieved in the supply chain.

6.	Maranesi et al. (2020)	By integrating the business ecosystem with a natural one, for the purpose of achieving circular principles in the supply chain .	Supply chain management approach for waste to raw material again.
7.	Circular Supply Chain Network	Circular supply chain aims at reducing use of resources by utilization of renewable and secondary products.	Maximum use of resources for zeroing wastes.

Hence CSCM can be defined as " The ecological value creation by effective utilization of resources within the supply chain and reverse supply chain towards zeroing wastes."

Theoretical Background & Literature Review

CSCM is all about thinking in a circular manner. Circular supply chains are much finer alternatives to traditional linear supply chain management i.e. take, use, and discard concept, while CSCM focuses on the 6Rs (Reduce, Reuse, Renovate, Recycle, Repair, Return) when the product's life is over or it is product useful. life has shrunk. It refers to regenerative and regenerative products and materials.

The Circular Supply Chain Network also proposed a transition model for shifting linear operations to circular ones. It consists of seven phases, namely, identification, amplification, narrowing, prediction, retardation, closure and capture.

Tseng et al. (2021) discussed the attributes of a circular supply chain for the healthcare industry and proposed a cause-and-effect framework to improve vision and learning about the implementation of circular business models. Khan et al (2021) designed a questionnaire survey to investigate the impact of blockchain technology on improving organizational performance for sustainable green supply chain practices and concluded that a circular approach is good for the sustainable growth of any organization. Yadav et al. (2020) developed a framework by highlighting the challenges of a sustainable supply chain and the envisioned solution to overcome these circular challenges. Complex supply chain, adoption of other firms' strategy and unavailability of sustainable supply chain framework are barriers to inability to implement

circular practice (Sarkis & Sarkis, 2012, Jose et al. 2017). Xaviera et al. (2019) reviewed the important e-waste problems and CE solutions in order to obtain and highlight the urban mining practices.

Jain et al. (2018) gives three-dimensional frameworks where the intersection of the strategic aspect, which is the business model, the tactical aspect, which is our ecological system, and the operational aspect, which is the sustainable supply chain, shows a paradigm shift as a circular supply chain.

CSCM is associated with sustainable supply chain practices that aim to reduce or delay unintended negative environmental impacts (Mastos et al., 2021)

The circular supply chain model is a zero waste vision working on the recovery of technical materials and the regeneration of biological materials (DeAngelis et al., 2018).

Environmental, economic and social benefits in an organization can be achieved by implementing the 6Rs, i.e. reduce, rework, rework, recycle, reuse and recover, and circulate these opportunities in linear supply chains (Manavalan et al., 2019). According to Govindan & Hasanagic (2018), the organizational perspective on circularity is influenced by internal factors (perspective of suppliers and consumers) and external factors (perspective of government and society).

According to Kazancoglu et al. (2018), marketing measures are the main criteria in the implementation of environmental benefits in the supply chain, because the customer's mindset always affects the supplier. Pal et al. (2019) studied the challenges associated with the fashion industry in implementing circular economy principles. Table 2 shows previous literature reviews on CSCM by different authors.

Table 2: Previous Literature review on CSCM

S.No.	Authors	Journal	Publisher	Country	Methodology
1.	Farooque et al. (2019)	Journal of Cleaner Production	Elsevier	New Zealand	Sourcing, screening, analyzing & sample characteristics
2.	De Angelis et al. (2018)	Production Planning & Control	Taylor & Francis	UK	CSC propositions & framework
3.	Govindan et al. (2018)	International Journal of Production Research	Taylor & Francis	Denmark	Multi-perspective framework
4.	Bressanelli et al (2019)	International Journal of Production Research	Taylor & Francis	Italy	Literature Analysis and Empirical Study on multiple case studies
4.	Hazen et al. (2020)	The International Journal of Logistics Management	Emerald	China	Theory extension approach to conceptual development
5.	Lahane et al. (2020)	Journal of Cleaner Production	Elsevier	India	Content Analysis Methodology
6.	Choi & Chen (2021)	Technological Forecasting & Social Change	Elsevier	Korea	Large Scale Group Decision Making & Big Data

All those authors contributed a significant part in exploring the CSCM approach. Our study mainly emphasizes barriers to the implementation of CSCM by using a proper methodology.

METHODOLOGY

Literature review plays a significant part in publications with the main objective to summarize the data available and to establish a base for study. This study adopted a systematic literature review approach (Jaeger & Upadhyay, 2020; Govindan et al., 2018). The various steps adopted for this systematic review are as follows:
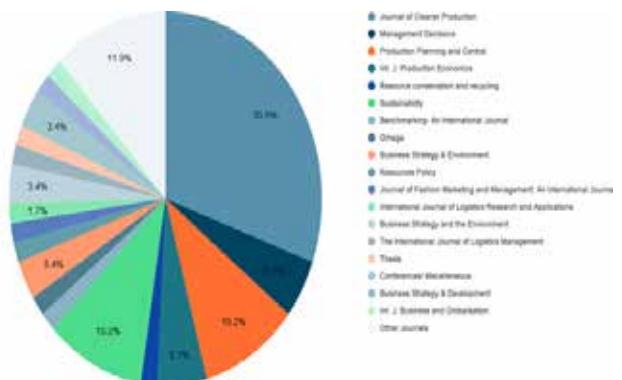
1. Data collection: Article search and data collection was done using various search engines. Appropriate keywords like circular economy and supply chain, circular supply chain , barriers, pressures, sustainability etc were used for this purpose.

2. Data evaluation: This step consists of determination

of relevant articles for the study and here we decide whether that particular article fits our study or not.

3. Analysis of content on various factors: After inclusion of relevant articles we did analysis on various factors like publication year, publisher, journal etc.

Barriers in Implementation of CSCM

Diligence may understand the significance of enforcing circularity but occasionally it isn't possible to apply it. There can be numerous reasons for this- lack of structure, authoritative factors, indigenous factors, legal factors, governmental factors, etc. These factors act as barriers or walls to successfully relinquish CSCM practices. A proper understanding of these constraints is essential for effectively enforcing CSCM practices. Fig. 1 shows the classification of reviewed papers on CSCM barriers on the basis of journals in the form of a pie chart.

Fig 1: Classification of the Reviewed Papers on CSCM Barriers based on Journals

After a thorough literature review and systematic analysis we evaluated six main barriers and sub-barriers. These barriers in CSCM implementation are tabulated below (Table 3).

Table 3: Barriers in implementation of CSCM

S. No.	Barriers		References
1	Economic Barriers	Elevated investment	Masi et al. (2018); Eijk (2015); Liu & Bai (2014)
		High cost of raw materials	Lieder & Rashid (2016)
		Issues with funding	Farooque et al. (2019)
		Elevated production cost	Upadhyay & Shukla (2024); Govindan & Hasanagic (2018)
		Expensive recycling	Lieder & Rashid (2016); Upadhyay & Shukla (2023)
		High cost of scrape and recovered material than virgin material	Pomponi & Moncaster (2017)
2	Legislative Barriers	Implementation issues with policies and laws	Goyal et al. (2016); Saroha et al. (2018); Kumar et al. (2019)
2	Legislative Barriers	Complexity in collaboration procedures	Mastos et al.(2021); Farooque et al. (2019); Eijk et al. (2015); Jaegar & Upadhyay (2019)
		Ineffective and poor policies for recovery and waste management.	Masi et al. (2018); Maranesi (2020); Farooque et al.(2020)
		Ineffective recycling policies	Kumar et al. (2019)
		Complex tax regulations	Kumar et al. (2019)
		Lack of performance measurement system.	Kumar et al. (2019)
3	Technolo-gical Barriers	Tracing/ tracking of waste materials.	Mastos et al.(2021); Pan et al. (2015); Saroha et al. (2018)
		Quality issues with recovered materials.	Ghisellini et al. (2016); Saroha et al. (2018)
		Resource Recovery & sorting issues	Maranesi (2020); Ejik (2015)
		Circular Inputs	Maranesi (2020)
		Rigidness with ongoing technological procedures.	Pan et al. (2019); Kumar et al. (2019)
		IT system incompati-bility with supply chain	Mastos et al. (2021)
		Supply chain with poor or ineffective automation	Mastos et al. (2021)

		Lack of skill and expertise.	Farooque et al.(2019); Kumar et al. (2019)
4	Oranizational Barriers	Resistance of managers to change from traditional work method	Liu & Bai (2014); Farooque et al.(2019); Kumar et al. (2019)
		Competition in market	Liu & Bai (2014); Jaegar & Upadhyay (2019)
		Problem with logistics and reverse supply chain	Eijk (2015); Kazancoglu et al. (2020)'
		Issues with market preference and replacement of old products	Farooque et al.(2019), Kumar et al. (2019)
		Complexity in supply chain	Eijk (2015)
5	Social Barriers	Negative thinking about reused/refurbished products	Genovese et al. (2017)
		Human health issues associated with waste recovery practices	Genovese et al. (2017); Liu & Bai (2014)
		Lack of awareness about circularity	Weetman et al. (2016); Kumar et al. (2019)
		Low acceptance for recovered products	Kumar et al. (2019)
		Compromise associated with remanufactured product quality, appearance and quality assurance	Govindan & Hasanagic (2018); Upadhyay & Shukla (2024)
6	Environmental Barriers	Poor waste management system	Kumar et al. (2019)
		Unregulated and hazardous recovery system for e-waste.	Kumar et al. (2019); Upadhyay & Shukla (2023)
		Capacity issues with decomposer and scavenger companies	Kumar et al. (2019)
		Poor incentive for energy and resource saving	Kumar et al. (2019)

DISCUSSION

This study shows that there are various barriers that hinders the implementation of circular supply chain implementation. This study, through a systematic and structured literature review, provides insight into the concept of CSCM. This review enables us to briefly describe the development of this phenomenon and identify the various barriers that hinders its implementation.

Previously Saroha et al. (2020) identified 31 various barriers under 8 main categories and found out that financial pressure is the most significant implementation barrier of CSCM. Khandelwal & Barua (2020) attempted fuzzy AHP for prioritizing barriers'. Jaegar & Upadhyay (2019) demonstrated 20 various barriers to the implementation of circular economy principles. Kumar et al. (2019) talked about five main barriers: social, economical, environmental, technological and legislative barriers with 4 sub barriers under each

heading.

These roadblocks are mainly classified into six groups namely economic, legislative, technological, organizational, social, and environmental barriers. These main barriers are classified into sub-barriers that affect the implementation of CSCM in any organization.

Product obsolescence, a disruption in the supply chain, defective and damaged products, customer preferences for refurbished or recycled products, legislation and regulations, sorting issues, end-of-life collections (collection systems), reverse logistics design, and consolidation centers are various significant challenges in the implementation of the circular supply chain.

Implication of the Study

This study, through a systematic and structured review of the literature, provides insight into the concept of CSCM. This study enables us to briefly describe the development of CSCM and identify its barriers. Results from this study are important for future market desirability and greater understanding of CSCM implementation. The inference of this paper is to give a future scope for research based on compilation of gaps of research as a base for empirical assessment. The developed set of challenges and sub-challenges helps the managers to overcome circularity roadblocks.

The government, society and policymakers should be aware about the ecological issues and should work cautiously for the implementation of CSCM.

Implications for Managers

By proper understanding of CSCM implementation barriers, managers will be able to cope up with the various ecological obstacles and challenges in their supply chain and will be able to manage the entire operation accordingly. This study helps managers to incorporate circular issues at the multiple echelons of the supply chain.

Implications for Government

Government should enhance their policy and should encourage industries to work for circularity. This study helps the government to bring out proper regulations and rules for CSCM implementation. Government can easily manage all the stakeholders by making policies and rules that support CSCM implementation.

Implications for Society

Societal impact of CSCM means a lot. The heart of CSCM is societal well being. By this study society will be the most benefited by understanding the environmental impact of their rejected products on the environment and the value of ecological constraint by adopting 5R products..

CONCLUSION

This study attempted a review of barriers related to implementation of circular supply chain practices in any organization. After a quick review of selected articles, we prepared a framework of six main barriers and their sub barriers. Barriers framed in this study have managerial, governmental and societal implications that were discussed in this paper.

While we feel that the discussion presented in this paper provides useful insight into the development of CSCM and identifies barriers of CSCM implementation, we think that even greater insight is possible. The limitation of our study and future research agendas are as follows:

- Here we attempted barrier identification of CSCM only, drivers are yet to be acknowledged.

- An empirical assessment can be carried out by establishing relationships among barriers.

- Specific study for industry type may result in different kinds of bottlenecks in CSCM implementation.

REFERENCES

1. Batista, L., Bourlakis, M., Maull, R., (2018), In Search of a Circular Supply Chain Archetype – A Content-Analysis Based Literature Review, Production Planning and Control 29 (6), 430-451.

2. Bressanelli, G., Perona, M., & Saccani, N. (2018). Challenges in supply chain redesign for the Circular Economy: a literature review and a multiple case study. International Journal of Production Research, https://doi.org/10.1080/00207543.2018.1542176.

3. Circular Supply Chain Network. https://www.circularsupplychain.network/'

4. Choi,T. & Chen, Y. (2021). Circular supply chain management with large scale group decision

making in the big data era: The macro-micro model, Technological Forecasting and Social Change, 169, 120791, ISSN 0040-1625, https://doi.org/10.1016/j.techfore.2021.120791.

5. DeAngelis, R., Howard, M., Miemczyk, J., (2018). Supply chain management and the circular economy: towards the circular supply chain. Production Planning & Control, 29(6), 425-437.

6. Eijk, F. V. (2015). Barriers and Drivers towards a Circular Economy, A-140315-R-Final. https://www.circulairondernemen.nl/uploads/e00e8643951aef8adde612123e824493.pdf

7. Ellen MacArthur Foundation. (2015). Towards a Circular Economy: Business rationale for an accelerated transition. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/TCE_Ellen-MacArthur-Foundation_26-Nov-2015.pdf.

8. Farooque, M., Zhang, A., Thurer, M., Qu, T., Huisingh, D., (2019), "Circular supply chain management- A definition and structured literature review", Journal of Cleaner Production, 228, 882-900.

9. Geissdoerfer, M., Morioka, S.M., Carvalho, M.M.D. & Evans, S. (2018). Business models and supply chains for the Circular Economy. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2018.04.159

10. Genovese, A., Acquaye, A.A., Figueroa, A. & Koh, S.C.L. (2017). Sustainable Supply Chain Management and the transition towards a Circular Economy: Evidence and some Applications. Omega . ISSN 0305-0483. http://dx.doi.org/10.1016/j.omega.2015.05.015.

11. Govindan, K., & Hasanagic, M. (2018) A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective, International Journal of Production Research, 56:1-2, 278-311, DOI: 10.1080/00207543.2017.1402141.

12. Goyal, S., Esposito, M. & Kapoor A. (2016). Circular economy business models in developing economies: Lessons from India on reduce, recycle, and reuse paradigms. Thunderbird International Business Review. https://doi.org/10.1002/tie.21883.

13. Gupta, H., & Barua, M. K. (2017). Supplier selection among SMEs on the basis of their green innovation ability using BWM and fuzzy TOPSIS. Journal of Cleaner Production, 152, 242–258. https://doi.org/10.1016/j.jclepro.2017.03.125

14. Hazen, B.T., Russo, I., Confente, I., and Pellathy, D., (2021). Supply chain management for circular economy: conceptual framework and research agenda. The International Journal of Logistics Management, 32(2), 510-537 Emerald Publishing Limited 0957-4093 DOI 10.1108/IJLM-12-2019-0332

15. Howard, M., Hopkinson, P., & Miemczyk, J. (2019). The regenerative supply chain: a framework for developing circular economy indicators. International Journal of Production Research, 57 (23), 7300-7318, DOI: 10.1080/00207543.2018.1524166.

16. Jaeger, B. and Upadhyay, A. (2020), "Understanding barriers to circular economy: cases from the manufacturing industry", Journal of Enterprise Information Management, 33 (4), 729-745. https://doi.org/10.1108/JEIM-02-2019-0047

17. Jain, S., Jain, N. K. & Metri, B., (2018). Strategic framework towards measuring a circular supply chain management. Benchmarking: An International Journal, 25 (8), 3238-3252.

18. Jose, C., Jabbour, C., Mauricio, A.L., Lopes, A.B., 2017. Critical success factors and green supply chain management proactivity : shedding light on the human aspects of this relationship based on cases from the Brazilian industry. Prod. Plan. Control 28, 671e683. https://doi.org/10.1080/09537287.2017.1309705

19. Kazancoglu, Y., Kazancoglu, I. & Sagnak, M., (2018). A new holistic conceptual framework for green supply chain management performance assessment based on circular economy, Journal of Cleaner Production, doi: 10.1016/j.jclepro.2018.06.015.

20. Kazancoglu, I., Kazancoglu, Y., Kahraman, A., Yarimoglu, E. & Soni, G. (2020). Investigating barriers to circular supply chain in the textile industry from Stakeholders' perspective. International Journal of Logistics Research and Applications. DOI:10.1080/13675567.2020.1846694

21. Khandelwal, C. & Barua, M. K. (2020). Prioritizing Circular Supply Chain Management Barriers Using Fuzzy AHP: Case of the Indian Plastic Industry. Global Business Review, 1-20, DOI: 10.1177/0972150920948818.

22. Kumar, V., Sezersan, I., Garza-Reyes, J.A., Gonzalez, E.D.R.S. & ALShboul, M.A. (2019) Circular economy in the manufacturing sector: benefits, opportunities and barriers. Management Decision, https://doi.org/10.1108/MD-09-2018-1070.

23. Lahane, S., Kant, R. & Ravi Shankar (2020). Circular Supply Chain Management: A State-of-art review and future opportunities, Journal of Cleaner Production, https://doi.org/10.1016/j.jclepro.2020.120859.

24. Lieder, M., and A. Rashid. (2016). Towards Circular Economy Implementation: A Comprehensive Review in Context of Manufacturing Industry. Journal of Cleaner Production 115: 36–51.

25. Liu, Y. & Bai, Y. (2014). An Exploration of Firms' Awareness and Behavior of Developing Circular Economy: An Empirical Research in China. Resources, Conservation and Recycling. 87. 145-152.

26. Mangla, S.K., Luthra, S., Mishra, N., Singh, A., Rana, N.P., Dora, M., Dwivedi, Y., (2018), Barriers to effective circular supply chain management in a developing country context, Production Planning & Control, 29:6, 551-569.

27. Manavalan, E. & Jayakrishna, A. (2019). An Analysis on Sustainable Supply Chain for Circular Economy. Procedia Manufacturing 33, 477-484.

28. Maranesi, C., & De Giovanni, P. (2020). Modern circular economy: Corporate strategy, supply chain, and industrial symbiosis. Sustainability, 12(22), 9383.

29. Mastos, T.D., Nizamis, A., Terzi, S., Gkortzis, D., Papadopoulos, A., Tsagkalidis, N., Ioannidis, D., Votis, K. & Tzovaras, D. (2021) Introducing an application of an industry 4.0 solution for circular supply chain management. Journal of Cleaner Production 300, 126886. https://doi.org/10.1016/j.jclepro.2021.126886.

30. Pal, R., Shen, B., & Sandberg, E. (2019). Circular fashion supply chain management: Exploring impediments and prescribing future research agenda. Journal of Fashion Marketing and Management: An International Journal.

31. Pan, S. Y., Du, M. A., Huang, I. T., Liu, I. H., Chang, E. E. and Chiang, P. C. (2015). Strategies on Implementation of Waste-to-Energy (WTE) Supply Chain for Circular Economy System: A Review." Journal of Cleaner Production 108: 409–421.

32. Pomponi, F. & Moncaster, A. (2017). Circular economy for the built environment: A research framework. Journal of Cleaner Production. 143, 710-718. https://doi.org/10.1016/j.jclepro.2016.12.055.

33. Saroha, M., Garg, D. & Luthra, S. (2018). Key Issues and Challenges in Circular Supply Chain Management Implementation- A Systematic Review. International Journal of Applied Engineering Research ISSN 0973-4562, 13(9), 91-104.

34. Saroha, M., Garg, D. and Luthra, S. (2020). Pressures in implementation of circular supply chain management for sustainability: An analysis from Indian industries perspective", Management of Environmental Quality. 31(5), 1091-1110. https://doi.org/10.1108/MEQ-08-2019-0178

35. Sarkis, J., Sarkis, J.(2012). A boundaries and flows perspective of green supply chain management. Supply Chain Manag. An Int. J. 17, 202e216. https://doi.org/10.1108/13598541211212924.

36. Tseng M.L., Hien Minh Ha, Kuo-Jui Wu & Bing Xue (2021): Healthcare industry circular supply chain collaboration in Vietnam: vision and learning influences on connection in a circular supply chain and circularity business model, International Journal of Logistics Research and Applications, DOI: 10.1080/13675567.2021.1923671

37. Upadhyay, A., and Shukla, A.C. (2023). Consumer Perception About Refurbishment: A Strategy to Achieve Circularity in Supply Chain. SEMCOM Management & Technology Review. 10(1): 36-41.

38. Upadhyay, A., Shukla, A.C., and Shukla, T. (2019). E-Commerce Logistics Service Quality Analysis: A Case Study. Industrial Engineering Journal.

39. Upadhyay, A., & Shukla, A. C. (2024). CIRCULAR SUPPLY CHAIN MANAGEMENT: CONTENT ANALYSIS WITH SPECIFIC DRIVERS AND BARRIERS . International Journal of Industrial Engineering: Theory, Applications and Practice, 31(1). https://doi.org/10.23055/ijietap.2024.31.1.9379

40. Weetman, C. (2016). A circular economy handbook for business and supply chains: Repair, remake, redesign, rethink. Kogan Page Publishers.

41. Xaviera, L., H., Giesea, E., C., Ribeiro-Duthiea, A.C., Freitas Lins, F.A. (2019), Sustainability and the circular economy: A theoretical approach focused on e-waste urban mining. Resources Policy. https://doi.org/10.1016/j.resourpol.2019.101467.

42. Yadav, G., Mangla, S.K., Luthra, S., Jakhar, S., Rai, D.P. (2020). A framework to overcome sustainable supply chain challenges through solution measures of industry 4.0 and circular economy: An automotive case. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2020.120112

A Study of Digitalization in MSME Sector with Special Reference to Products Under ODOP Scheme in Eastern Uttar Pradesh

Shiva Manoj
Associate Professor
Lal Bahadur Shastri Girls College of Management
✉ shivamanoj86@gmail.com

Bimal Jaiswal
Department of Applied Economics
University of Lucknow
✉ bimalsiyaram@gmail.com

Saksham Kumar Srivastava
Assistant Professor
Department of Commerce
Lucknow University
✉ sakshamsiyaram@gmail.com

ABSTRACT

Uttar Pradesh government has propelled a scheme named One District One Product (ODOP). The objective of the research is to study the impact of digitalization or to be precise the effect on manufacturers, retailers and wholesalers belonging to MSME industry in the eastern U.P. region dealing in indigenous products under ODOP scheme. The benefits of digitalization are expanded effectiveness, expanded efficiency, lower functional expenses, further developed client experience, higher nimbleness, upgraded representative resolve, further developed correspondence, expanded straightforwardness, worked on upper hand, and quicker navigation. With time it is realized that to promote local products, it is important to shift from traditional practices to modern techno friendly methods and practices. Digitalization is a strategy to enhance business operations by utilizing digital information and innovations to transform business leadership and enhance efficiency. The purpose of the study is to conduct an exploratory study using primary data. Secondary data has also been taken help of to extract information about ODOP scheme and related aspects. In this study, a sample population size of 63 respondents comprising of manufacturers, retailers and wholesalers has been taken up. Various statistical tools and techniques have been applied to analyze the data and SPSS has been implemented to carry out the analysis part.

KEYWORDS: *Digitalization, ODOP, Government, Technology, MSME, Customers.*

INTRODUCTION

The ODOP or One District One Product Scheme is an ambitious mission initiated by the Central Government of India. The objective of the ODOP Programme is to generate sustainable employment at district level while contributing to the overall socio-economic development of the country. With regard to both population and area, Uttar Pradesh is the fourth-largest state in the nation. The state has an extraordinary diversity of both physical and cultural diversity. In Uttar Pradesh, people may find hand-knotted carpets, metal art, wooden utensils, and textiles with handmade prints.

The state is experiencing a decline in the demand for traditional crafts like Zari and Zardozi work, imitation jewellery, and glassware. However, other crafts like sazar stonework embroidery, cotton carpets, hand block textile printing, wood carving, wooden toys, and ivory and bone carving are in high demand. A plan aims to connect sellers and buyers of indigenous and local products, preserving their cultural heritage and assisting locals through marketing, branding, and easy credit. The top markets for Indian domestic, especially handicrafts are the Italy, US, UK, Germany, France, UAE, Latin America, the Netherlands, Canada, and Australia.

Indian handicrafts are sold to more than one hundred countries worldwide. The primary nations where Indian local handicrafts and artistic goods have been exported for years have exhibited a great deal of interest in and a similarity to Indian work. However, because China combines craft with cutting-edge technology while India has yet to do so in the handicraft industry, the product exported to foreign countries is slightly more expensive for the foreign market than other comparable handicraft items from other nations like China.

Uttar Pradesh has one of the largest export markets in India. The country is a major exporter of handicrafts, carpets, processed food, engineering products, ready-made garments and leather goods. These types of products are produced by local SMEs in the state. These products have huge job creation. Uttar Pradesh government launched ODOP (One District One Product) program to promote local and specialty products in Uttar Pradesh. The objective of the ODOP program is to establish product-specific traditional industrial centers in 75 districts of the state. In the present era of extreme digitalization or digital age, digital transformation is very much an essential clause for any business that intends to remain competitive. Through digital transformation, organizations can improve their efficiency, productivity, customer experience and competitive advantage. Despite government support, MSMEs face several challenges. These include access to finance, high production costs and competition from large companies. To overcome these challenges, SMEs must adopt new technologies, improve their productivity and focus on niche markets. Thus digitalization is the need of the hour.

India has the potential to become a \$5 trillion economy by FY25 and MSMEs will play a key role in this. To achieve this huge number, the MSME sector must have adequate and consistent capital and spare resources. It goes without saying that the state or concerned government has an important role to play in this regard by providing necessary programs and support to the sector.

There are an add up to of 15 locale within the eastern portion of Uttar Pradesh. The names of east UP locale are Lucknow, Mirzapur, Allahabad, Gorakhpur, Deoria Ballia Pratapgarh, Bahraich, Gonda, Basti, Jaunpur, Ghazipur, Varanasi, Azamgarh, Faizabad and Sultanpur.

LITERATURE REVIEW

A relative report likewise explores ongoing patterns in the credit only economy in India determined to decide the reasonability of making India's money based economy credit only. As per this review, because of an expansion in UPI clients, the quantity of installment techniques, rising innovation foundation, and moving approaches, Indian monetary frameworks will be credit only, with no genuine development of money" (Sivakumar, S., and Vincent, G., 2019).

Rashmi Khanna et al (2018) explore MSMEs' performance after liberalization, their prospects, major challenges and policy initiatives as taken by the government by using secondary data such as schemes related to financial assistance, international cooperation, credit guarantee, credit-linked capital support system for technological improvement, MSME cluster development program, etc.

Khan and Amir (2013) highlighted that "the craftsmanship area is missing government support on how well the craftsman can create the article of handiwork by and how they presented it and four p that spot, value, creation, and last is advancement."

"Web business can help with extending the presence of specific sorts of workmanship things by finding new clients along with by supporting advancement of existing things considering use instances of the overall population." (Moturam Giyar et al, 2011)

OBJECTIVES OF THE STUDY

The study aims to examine the influence of digitalization on the MSME industry in the eastern U.P. region, focusing on indigenous products under the ODOP scheme. MSMEs are vital to the Indian computerized economy. As advanced utilization creates, MSMEs are grasping advanced innovation to enhance and upgrade their activities, enter modern markets and improve their competitiveness. This study is an attempt to investigate the impact of digitalization on MSME industry in the eastern U.P. region and the point of view of the stakeholders associated with it.

HYPOTHESIS

Following hypothesis has been formulated:

H01: There is no relationship between type of business and use of digital business practices.

Ha1: There is relationship between type of business and use of digital business practices.

RESEARCH STEPS

The research utilizes primary data and some secondary data to explore the background and digitalization concepts related to MSMEs and the ODOP scheme. A structured questionnaire was floated to collect responses from various stakeholder engaged in business covered under ODOP scheme in eastern UP. The sampling method adopted for the study is Convenience sampling. Structured questionnaire is constructed to collect data from manufacturers, retailers and wholesalers engaged in economic activities related to ODOP. A sample population size of 63 respondents has been taken up. Various statistical tools and techniques have been used to analyze the data and SPSS 20 has been implemented to carry out the analysis part.

ANALYSIS AND DISCUSSIONS

The main aim of the study is to investigate how digitalization is making an impact in the MSME industry. The geographical area covered is bound by limitation to access the respondents. The respondents comprise of manufacturers, retailers and wholesalers representing products covered under ODOP scheme. Firstly to test the reliability or internal consistency, Cronbach's alpha is used. The Cronbach's alpha coefficient score is 0.94 which is above the recommended 0.7 cut-off value. It is therefore evident that the variables have relatively high internal consistency and model is accepted on this ground. The Cronbach's alpha test is used to estimate the reliability of a composite score. The hypothesis (H01) is tested using the Chi-Square Test, which determines the relationship between categorical variables like type of business and use of digital business services. The chi-square statistic is 3.853, with a p-value of 0.69, indicating a null hypothesis (H01) and a significance level of more than 0.05. By analyzing the basic profile of the sample, it is observed that 34.9% of the total respondents' business is existing for more than 15 years

while 31.7% have their business in the age of 11 to 15 years. (Fig 1) In terms of awareness about the concept of digitalization, a favorable 50.8% know about it, 6.3% have given a negative answer while 42.8% know it to some extent. (Fig 2)
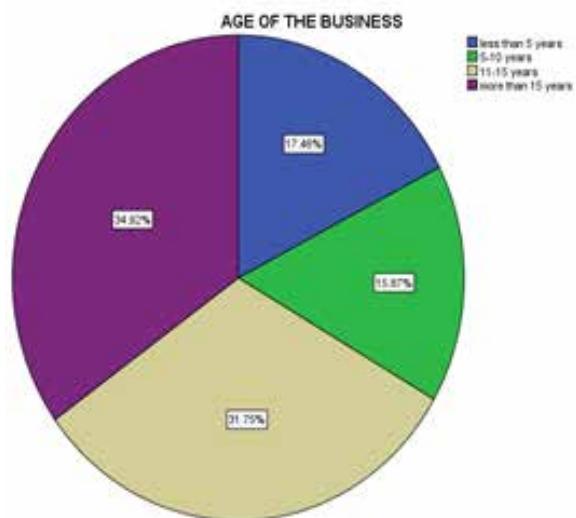
Fig. 1
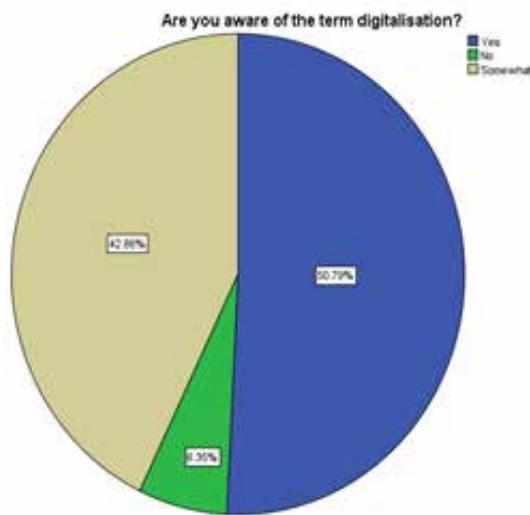
Fig.2

From the figures below it is clear that majority of the respondents from the MSME industry are aware about ODOP. (Fig 3) The geographical area covered in the study represents 23.8% of the businesses established from rural areas, 47.6% from the urban areas which gives a hint that urban has a good number of MSME industry players and 28.6% in semi urban area. (Fig.4)
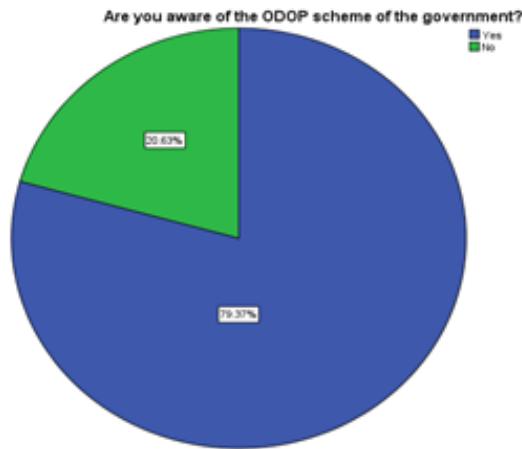
Fig. 3

Fig. 4
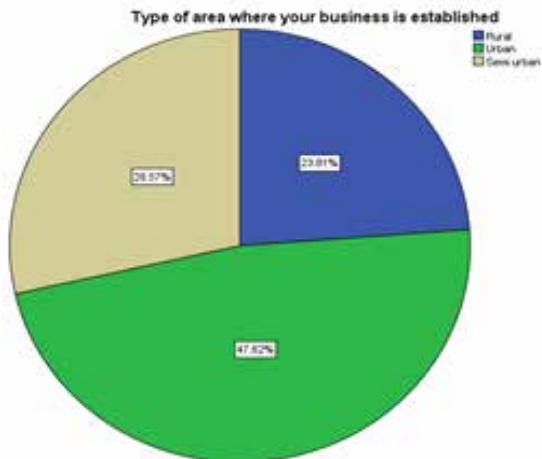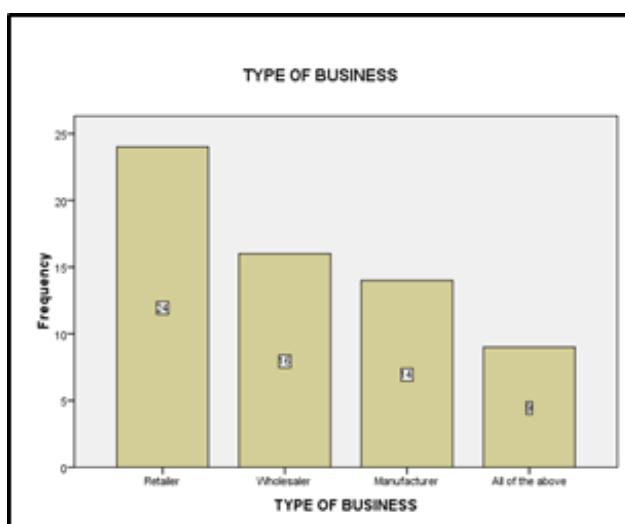
Fig. 5

Fig. 6

Fig.5 shows that the sample is a blend of all sorts of players which includes 38.1% retailers, 25.4% wholesalers, 22.2% manufactures and 14.3% are performing functions of all of the above.

Fig.6 depicts that 25.4% are using digitalization based services in business or adopted digitalization. While only 9.5% have not adopted yet. A good percentage of 65.1 have adopted to some extent.

Analysis of responses of the respondents

Table 1 With digitalization in your business, you can have a wide area customer awareness

	Frequency	Percent
Disagree	7	11.1
Neutral	12	19.0
Agree	38	60.3
Strongly agree	6	9.5
Total	63	100.0

It can be seen from the above table (Table 1) that majority of the entrepreneurs feel that digitalization helps in having a more elaborated level of customer awareness. Additionally, gaining insight into your customers' needs may help you enhance sales, brand recognition, and trust with your target market.

Table 2: Services like Chabot, regview sites, websites, email marketing, contact forms, forums, and social media enhance customer interaction

	Frequency	Percent
Disagree	7	11.1
Neutral	25	39.7
Agree	25	39.7
Strongly agree	6	9.5
Total	63	100.0

Digital media services like chatbots, review sites, websites, email marketing, contact forms, forums, and social media are enhancing customer interaction. Only 39.7% are in agreement and parallel to this again 39.7% have a neutral opinion. (Table 2)

Table 3: By using technology to bring in innovation in products, your business has the opportunities to enter new markets

	Frequency	Percent
Disagree	4	6.3
Neutral	32	50.8
Agree	21	33.3
Strongly agree	6	9.5
Total	63	100.0

It is evident from the table above (Table 3) that still MSMEs in eastern U.P. have not much accepted technology as the game changer. 50.8% are neither agree nor disagree that by using technology to bring in innovation in products, their business has the opportunities to enter new markets. Although 33% are in favour. The removal of regional and cultural barriers is another significant development in this new technology society. This becomes clear when using Google as a marketing medium. You may create a website that will be indexed for global searches.

Table 4 For local products or local crafts, E-Commerce in India is the fastest growing and most efficient channel for commercial transactions

	Frequency	Percent
Disagree	8	12.7
Neutral	28	44.4
Agree	19	30.2
Strongly agree	8	12.7
Total	63	100.0

The above table (Table 4) shows that 44.4% respondents are on neutral opinion and 30.2% whereas 12.7% are in agreement that for local products or local crafts, E-Commerce in India is the fastest growing and most efficient channel for commercial transactions.

Table 5: Digital marketing practices assist your business in reducing costs associated with product or service promotion

	Frequency	Percent
Disagree	8	12.7
Neutral	15	23.8
Agree	32	50.8
Strongly agree	8	12.7
Total	63	100.0

It is evident from the table above (Table 5) that Digital marketing practices assist your business in reducing costs associated with product or service promotion. Majority of the entrepreneurs or businessmen agree to this factor. Digital marketing helps businesses save the expenses of promoting their goods or services.

Table 6: Customer credit management is another feature that gets ease with digitalization as you can trace customer credit and also set limits of credit for consumers

	Frequency	Percent
Disagree	8	12.7
Neutral	28	44.4
Agree	19	30.2
Strongly agree	8	12.7
Total	63	100.0

On the point of Customer credit management using digitalization, it seems that industry people are of mixed opinion. Definitely Customer credit management is another feature that gets ease with digitalization as you

can trace customer credit and also set limits of credit for consumers. But here 44.4% are of neutral view; around 43% are in favour. Although India's demonetization programme had a big impact on the economy, it also sped up the development of digital payments in the nation. Table 7 below shows that majority of the respondents agree that digital or electronic payments allow businesses and individuals to conduct transactions without any obstacles.

Table 7: Digitalization of payments allows business and individuals can easily connect with others in different parts of the world and conduct transactions seamlessly

	Frequency	Percent
Neutral	25	39.7
Agree	32	50.8
Strongly agree	6	9.5
Total	63	100.0

The majority of the sample (table 7) supports the idea that the internet facilitates personalized product creation, making custom-made crafts more appealing to a wider customer base. This is due to the ability to connect with customers and provide customized products.

Table 8: the internet allows for more individuallized product creation, making custom-made crafts more appealing to a wider range customers

	Frequency	Percent
Neutral	16	25.4
Agree	43	68.3
Strongly agree	4	6.3
Total	63	100.0

Table 9:   Proliferation of new internet marketplace, artisanal good can now reach a wider audience and sell faster

	Frequency	Percent
Neutral	22	34.9
Agree	37	58.7
Strongly agree	4	6.3
Total	63	100.0

The above table (Table 9) shows that a considerable part of the respondents from the selected industry agree that new internet marketplaces which are basically technology driven can speed up the sales of artisanal goods. 34.9% of respondents disagree that

the rise of new internet marketplaces has improved the accessibility and speed of selling artisanal goods.

Table 10: Transfer methods like RTGS, NEFT, digital wallets, and Unified Payment Interfaces have made the transactions easier

	Frequency	Percent
Neutral	11	17.5
Agree	38	60.3
Strongly agree	14	22.2
Total	63	100.0

The above table shows that there is a positive wave of acceptance towards Transfer methods of money like NEFT, digital wallets, RTGS, etc. as they have made processing of transactions easy and convenient.

Table 11: E-commerce and technology enabled platforms are helpful for your products in terms of sales

	Frequency	Percent
Disagree	4	6.3
Neutral	19	30.2
Agree	23	36.5
Strongly agree	17	27.0
Total	63	100.0

It is evident from the table above (Table 11) that E-commerce and technology enabled platforms are helpful for made a positive impact on sales as 36.5% and 27% agree and strongly agree respectively. On the point of whether technologies and improved production methods have aided in improving overall supply chain, 55.6% are neither in favour nor in denial. While approximately3 8% are in favour. Thus it's concluded that not much influential impact is made on the supply chain of local products which requires attention. (Table 12).

Table 12: The advent of cutting-edge technologies and improved production methods have aided you in improving overall supply chain

	Frequency	Percent
Disagree	4	6.3
Neutral	35	55.6
Agree	7	11.1
Strongly agree	17	27.0
Total	63	100.0

Table 13: Statement Valuations

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Digital transformation can help you to improve your customer experience.	0	0	25	17	21
Digitalisation helps you to have more and easy access to various finances and loans as all the financial data is available online	0	0	36	27	0
Digitalisation has helped your business to expand leading to growth in employment opportunities	3	17	27	16	0
Digitalisation has helped you to explore various government schemes as most of them are now executed through technology or e-portals.	23	33	7	0	0
Availability of your products on online selling platforms has increased your product awareness among different age groups of customers and from variety of geographical area.	0	0	14	35	14
Availability of your products on online selling platforms like Amazon, Flipkart, Pepperfry, etc has increased your customers.	0	0	25	24	14
E-Commerce has brought a level of convenience and accessibility to customers towards your product.	0	0	37	22	4
Digital technologies can help you to reach new customers, generate leads, and close deals more effectively.	0	0	29	28	6
By embracing digital transformation, organizations can improve their efficiency, productivity, customer experience, and competitive advantage.	0	0	26	22	15

From the table above it is evident that on the point of digitalization helping business to expand leading to growth in employment opportunities, 3 are in complete negation ,17 disagree and 27 are of neutral opinion. A positive response is received on the factors that availability of products on online selling platforms has increased product awareness among different age groups of customers and from variety of geographical area, Digital technologies can help to reach new customers, generate leads, and close deals more effectively, E-Commerce has brought a level of convenience and accessibility to customers towards product and Digitalization helps to have more and easy access to various finances and loans as all the financial data is available online.

CONCLUSION

The world is on a wave of advanced change. And without a question, MSMEs ought to adjust to this headway. MSMEs may be smaller scale, little, and medium businesses by classification, but the affect they have is enormous and important. They win as the spine of the economy due to their tall share of business and value-addition. In order to make ODOP programme a successful one with an aim to foster the growth of local products, it's important to accept digital reforms. The study above shows that there is a considerable positive impact of digitalization on MSME sector. Although on certain factors, the acceptance is not favorable. The sample is a blend of all sorts of players which includes 38.1% retailers, 25.4% wholesalers, 22.2% manufactures and 14.3% are performing functions of all. Majority of the respondents agree that digitalization of payments allows businesses and individuals can easily connect with others in different parts of the world and conduct transactions seamlessly. A considerable part of the respondents from the selected industry agree that new internet marketplaces which are basically

technology driven can speed up the sales of artisanal goods. While 34.9% are of no opinion that with the increase of e-markets, artisanal goods or craft items can now reach a more elaborated and variety of audience and sell even faster. Overall, the impact is on a positive note. The study is bound by a limitation that the inference is based on the responses of a selected sample size depicting the purview of the entire community of Eastern UP.

REFERENCES

1. Anand, Abhishek, Mehrotra, Akash, Gayatri, ManojNayaket.al (2020). 'ImpactofCOVID-19 pandemic on Micro, Small, and Medium Enterprises (MSMEs): India report', Microwave Consulting, Lucknow, India

2. Giyar, Moturam and Pareek, Dr Ashish (2011). 'A Study of e-commerce related practices in selected small-scale wooden handicraft enterprises.' October 2011. Retrived from SSRN. Https://ssrn. com/ abstr a c t=1948146 or http://dx.doi.org/10.2139/ssrn.1948146.

3. Goel Richa, Sahai Seema, Vinaik Anita and Garg Vikas (2019). Cashless Economy in India - Study of Consumer Perception Towards Digital Transactions. Moving From Cash to Cashless Economy International Journal of Recent Technology and Engineering (IJRTE), Volume-8, Issue-1.

4. Khan, W.A, and Amir, Z. Study of Handicraft Marketing Strategies of Artisans in [2] Uttar Pradesh and Its Implications, Research Journal of Management Sciences, Vol. 2(2), Feb. 2013.

5. Khanna, Rashmi and Singh, Dr Satyadenra P (2018). 'Status of MSMEs in India: A detailed study.' Journal of Applied Management- Jidnyasa Vol 10, Issue 2.

6. Nurrbudiyani, Lin and Sonedi and Suyati, Evdang Sri and Fadhil, Mohammad Rizaki and Pratama (2019). 'Development of Micro, Small and Medium Enterprises Rattan Woven Crafts in Central Kalimantan, Indonesia.' Anterior Journal, 2019.

7. Retrieved from https://economictimes.indiatimes. com/small-biz/sme-sector/e-commerce-digital-transformation-keys-for-growth-of-msmes/articleshow/90741524.cms?from=mdr

8. Retrieved from https://timesofindia.indiatimes.com/blogs/voices/strategies-to-boost-msmes-growth-through-digitization/

9. Retrieved from https://www.businesstoday.in/latest/economy-politics/story/up-plans-outlets-to-promote-handicrafts-indigenous-items-272689-2020-09-10

10. Retrieved from https://www.indianretailer.com/article/technology-e-commerce/digital-trends/reducing-shopping-cart-abandonment-how-rte-enables-e

11. Retrieved from https://www.pdflist.in/up-one-district-one-product-list/

12. Susmi. R, Reema. K, Ruchi. P, Rakesh. G, A Move towards Cashless Economy: A Case of Continuous Usage of Mobile Wallets in India, Theoretical Economics Letters, Vol.09 No.04(2019), Article ID:92187,15 pages https://www.scirp.org/html/38-1501825_92187

Trends and Perspectives in E-commerce and Sustainable Consumption: A Bibliometric Overview

Dileep Kumar Singh

Post Doctoral Fellow, Institute of Management &
Commerce Srinivas University, Manglore and
Assistant Professor
Narsee Monjee Institute of Management Studies
(NMIMS) Hyderabad, Telangana
✉ dileep.udai@gmail.com

P. S. Aithal

Professor
Institute of Management & Commerce
Srinivas University
Manglore, Karnataka
✉ psaithal@gmail.com

ABSTRACT

This bibliometric review explores the intricate connection between sustainable consumption and e-commerce by looking at how online platforms affect consumer behavior in a sustainable setting. Using a thorough search approach, we located and examined 720 papers from 395 sources in the Scopus database, covering a wide spectrum of academic contributions from 2000 to 2024. Within this developing discipline, our bibliometric research revealed important topics, authors, and trends. Notably, the motor topic emphasized the importance of technology and decision-making processes in changing the e-commerce environment, highlighting the value of decision support systems, e-commerce quality, trust, and service quality. With the inclusion of social sustainability, supply chain dynamics, sustainable development, neuromarketing, optimization, dependability, and online buying, the developing subject examined the relationship's multifaceted facets. The thematic analysis also uncovered a niche topic that reflected the complexities of contemporary retail operations and was centered on inventory control, omni-channel strategies, resilience, network architecture, and tabu search optimization. The study also included eminent writers, references, and papers that shed light on the state of e-commerce and sustainable consumption research throughout the world.

KEYWORDS: E-commerce, Sustainable consumption, Bibliometric analysis, Online platforms, Consumer behaviour.

INTRODUCTION

The traditional retail sector has seen disruptive components brought forth by e-commerce platforms. They provide customers with never-before-seen levels of accessibility and convenience, letting them explore, evaluate, and buy things from the comfort of their homes. Due to the shift in customer behavior toward online buying, there are now fewer geographical obstacles to entry, opening up access to a worldwide marketplace(Zhou et al., 2022). Furthermore, e-commerce's capacity to improve logistics and simplify supply chains may result in efficiencies that lessen the environmental effects of traditional brick and mortar retail. But, in addition to these advantages, there are some noteworthy drawbacks that should be taken into account. The environmental impact of e-commerce activities is one such worry(Salazar V., 2021). The packing and long-distance shipping of goods can increase trash production and carbon emissions. Important first steps in reducing these effects include putting sustainable packaging solutions into practice, streamlining delivery routes, and looking at alternate modes of transportation(Riasat & Shah, 2021). Furthermore, concerns regarding ethical production methods and responsible sourcing are brought up by the growth of e-commerce. Since the speed at which internet commerce is growing can sometimes mask product origins and production processes, supply chain transparency and traceability must be established (Rakhimberdiev, Ishnazarov, Allayarov, et al., 2022). This is especially important to make sure that products are made in an ecologically conscious manner and under fair labour circumstances (Kaluzhnova et al., 2019).

The emergence of e-commerce offers a chance to encourage and reward the purchase of sustainable goods within the framework of sustainable consumption. Products that follow ethical and ecological manufacturing criteria can be promoted and shown off on online platforms (Rakhimberdiev, Ishnazarov, Khayitova, et al., 2022). Through emphasizing these options and giving customers clear details about the products' materials and origins, e- commerce has the potential to significantly influence sustainable consumption (Shang et al., 2023). Thus, the area where e-commerce and sustainable consumption converge is dynamic and ever-changing, having the potential to have both beneficial and detrimental effects on the world's efforts to achieve sustainability (Ananova, 2018). It is crucial that we critically assess the complexities, trade-offs, and possibilities that emerge as academics and stakeholders continue to investigate this intricate relationship. We can make sure that the digital marketplace adheres to the principles of sustainable consumerism by doing thorough analysis and making educated policy decisions, which will eventually help to create a more equal and balanced global economy (Hoang & Phan, 2022).

In this study, we investigate the complex link that exists between e-commerce and sustainable consumption, with a particular emphasis on the ways that online platforms affect consumer behaviour in respect to sustainability (Hassani et al., 2019). Through a bibliometric analysis of the current literature, we aim to identify important themes, ground-breaking research, and developing trends in this rapidly developing subject (Meenar et al., 2022; Nobre & Tavares, 2021). In order to better understand the complexity of this important nexus, our bibliometric study lays the groundwork for future research directions and policy actions that will promote a more just and sustainable digital economy (Lian & Feng, 2022).

Research Questions

1. What are the predominant research themes and topics within the intersection of e- commerce and sustainable consumption, as revealed by bibliometric analysis?

2. Who are the authors driving research in the field of e-commerce and sustainable consumption?

3. What are the most influential and highly-cited publications in the field of e-commerce and sustainable consumption?

4. Are there discernible geographical patterns in research output and collaboration within the domain of e-commerce and sustainable consumption?

OBJECTIVES

1. To Conduct a bibliometric analysis to identify and analyze the predominant research themes and topics at the intersection of e-commerce and sustainable consumption, unveiling the key areas of focus within the academic literature.

2. To Identify and profile the authors who are prominently contributing to research in the field of e-commerce and sustainable consumption, elucidating their respective roles and influence within the scholarly community.

3. To Determine the most influential and highly-cited publications within the field of e-commerce and sustainable consumption through citation analysis, providing insight into seminal works and their impact on the research landscape.

4. To Investigate geographical patterns in research output and collaboration within the domain of e-commerce and sustainable consumption, discerning trends in publication distribution and the extent of international collaboration among researchers.

METHODOLOGY

For this bibliometric overview, we conducted a comprehensive search using the Scopus database (Popescu et al., 2021) to identify relevant literature at the intersection of e-commerce and sustainable consumption. The search strategy was designed to capture publications that encompassed key terms related to e-commerce (such as "e-commerce," "online marketing," "digital marketing," and "internet marketing") in conjunction with sustainability-related terms ("sustainability," "sustainable," "sustainably").

The inclusion criteria for this study focused on English-language publications to ensure consistency and

accessibility. Additionally, we limited the search to articles, conference papers, and reviews to ensure a focused and scholarly examination of the field.

To further refine the selection, we employed search string as TITLE-ABS-KEY ((("e commerce" OR online AND marketing OR "Web Marketing" OR "digital Marketing" OR "internet marketing") AND (sustainabl*)) AND (LIMIT-TO (LANGUAGE , "English") in Scopus database, which allowed us to target publications with a primary focus on the intersection of e-commerce and sustainable consumption. By ensuring that the papers that were retrieved were pertinent to our study objectives, this strategy improved the bibliometric analysis's validity and reliability.

RESULTS AND DISCUSSION

Descriptive Analysis

The dataset spans the years 2000–2024 and includes a wide range of scholarly works that explore the nexus between sustainable consumption and e-commerce. It includes 395 distinct publications, including books, journals, and conference papers, for a total of 720 items. The information shows an annual growth rate of -4.47%, which suggests that throughout the given time period, research output somewhat decreased. The documents' 3.43-year average age indicates a relatively new and active topic of study. Remarkably, an average of 10.56 citations are obtained for each paper, highlighting the importance and influence of the research conducted in this field. The dataset also includes 4,514 additional indexing phrases in addition to a wide range of keywords from the writers. There are 1,912 distinct writers overall, with 97 documents written by a single author and an average of 3.08 co-authors per document in terms of authorship. 22.36% of the partnerships are international co-authorships, highlighting the worldwide reach of this field's research. There are many different kinds of documents in the dataset; the most common ones are articles (443), which are followed by conference papers (136), book chapters (64), and reviews (35). This extensive and multifaceted dataset provides insights about collaborative behaviours, document genres, and citation effect, making it an invaluable tool for
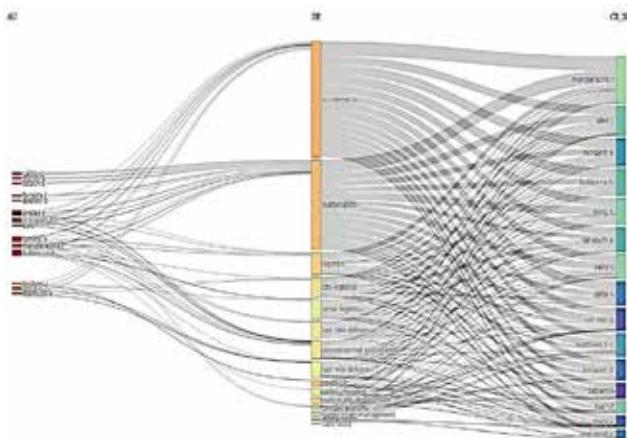
comprehending the changing field of e-commerce and sustainable consumption research.

Figure 1: Most Influential Sources

The provided figure 1 offers a comprehensive overview of the sources contributing to research in the field of e-commerce and sustainable consumption. Among the 395 identified sources, "Sustainability" based in Switzerland emerges as the most prolific, with a notable 139 articles. This journal evidently plays a pivotal role in disseminating research at the intersection of e-commerce and sustainable consumption. Following closely are "Lecture Notes in Networks and Systems," "ACM International Conference Proceeding Series," and "Environmental Science and Pollution Research," each contributing significantly with 10, 8, and 8 articles respectively. These sources, along with journals like "Journal of Cleaner Production" and "Lecture Notes in Computer Science," underscore the multidisciplinary nature of research in this domain, drawing from networks, systems, environmental science, and computer science. Additionally, the dataset encompasses a diverse range of publications, including conference proceedings, case studies, and journals, indicating the varied platforms through which research in e-commerce and sustainable consumption is disseminated. This breadth of sources reflects the dynamic and evolving nature of the field, with contributions from both specialized and interdisciplinary outlets.

Three Field Plot

Figure 2: Three Field Plot

A three-field plot, also known as a Sankey diagram, is a visual representation used to depict flows of resources, energy, or information between three different entities or categories. It consists of three columns or nodes, each representing a distinct category, and flows or arrows connecting them to illustrate the movement or distribution of a quantity from one category to another. The width of the arrows is proportional to the quantity being represented, allowing for a clear visualization of the relative magnitudes of flows between the categories. Figure 1 presents three field plot or Sankey plots which are used to show the relationship between three fields with the size of the part corresponding to the node's value. A three-field plot with the left field as authors, the middle field as keyword plus and right field as sources were configure in the mentioned three-field plot diagram.

Most Prolific Authors

The dataset presents a snapshot of prolific authors contributing to research at the intersection of e-commerce and sustainable consumption. Among the 1,912 unique authors identified, Pratap S emerges as a leading contributor with 9 articles to their name, followed closely by Prajapati D, who has authored 8 articles. These individuals have demonstrated a substantial commitment to producing valuable research in this dynamic field. Additionally, authors like Buldeo Rai H, Tumino A, Callou G, and Maciel P have each contributed significantly with 7 or 6 articles, indicating a notable level of expertise and dedication to advancing

knowledge in this domain. The presence of multiple authors with a substantial number of contributions underscores the collaborative nature of research in this field. This diversity of authorship suggests a rich and varied pool of expertise, contributing to the multidisciplinary and evolving nature of research at the nexus of e-commerce and sustainable consumption.

Figure 3: Most Prolific Authors

Table 1: Most Influential Documents

S.NO	Document	Year	Local Citations	Global Citations	LC/GC Ratio (%)
1	VELAZQUEZ R, 2019, IEEE INT CONF IND ENG ENG MANAGE	2019	4	12	33.33
2	AHMADI E, 2021, IEEE INT CONF IND ENG ENG MANAG, IEEM	2021	2	3	66.67
3	TIWAPAT N, 2018, IEEE INT CONF INTELL TRANSP ENG, ICITE	2018	2	15	13.33
4	CALLOU G, 2013, COMPUT	2013	2	31	6.45
5	SETTEY T, 2021, SUSTAINABILITY	2021	1	25	4.00
6	WANG C-N, 2021, AXIOMS	2021	1	44	2.27
7	KUMAR G, 2020, SUSTAINABLE CITIES SOC	2020	1	57	1.75
8	PATELLA SM, 2021, SUSTAINABILITY	2021	1	51	1.96
9	HAN C, 2020, SUSTAINABILITY	2020	1	9	11.11
10	XIAO L, 2019, SUSTAINABILITY	2019	1	80	1.25

The table provides a list of highly cited documents within the context of e-commerce and sustainable consumption. These documents have been influential within their respective years of publication and have garnered notable recognition both locally and globally. For instance, the work by Velazquez R, presented at the IEEE International Conference on Industrial Engineering and Engineering Management in 2019, received 4 local citations and 12 global citations, resulting in a local citation to global citation ratio of 33.33%. Similarly, Ahmadi E's contribution at the 2021 IEEE International Conference on Industrial Engineering and Engineering Management received 2 local citations and 3 global citations, resulting in a high local citation to global citation ratio of 66.67%. The data further showcases the impact of other notable documents, with varying degrees of local and global citations. Tiwapat N's work in the 2018 IEEE International Conference on Intelligent Transportation Engineering garnered 2 local

citations and 15 global citations, demonstrating a local citation to global citation ratio of 13.33%. Callou G's paper from 2013 in the journal "Comput" received 2 local citations and an impressive 31 global citations, resulting in a local citation to global citation ratio of 6.45%. These ratios provide insights into the relative influence of these documents within the academic community.

Bibliographic Coupling of Countries

The figure 4 represents bibliographic coupling(Marrucci et al., 2022) between countries in the context of e-commerce and sustainable consumption research. China emerges as a prominent contributor with 116 documents, accompanied by a substantial citation count of 1460. This highlights China's significant presence in this research domain, indicating a robust academic output and influence. Following closely, India exhibits noteworthy contributions with 71 documents and 461 citations, underlining its active engagement in this field. The United States and Italy also feature prominently, each producing 70 documents, with citation counts of 1431 and 958 respectively. This suggests a strong research presence and impact from these countries. Furthermore, the United Kingdom and Germany demonstrate substantial involvement with 50 and 37 documents, supported by citation counts of 949 and 697 respectively. These numbers indicate a considerable level of academic engagement and influence in e-commerce and sustainable consumption research. Other countries such as Indonesia, Australia, Spain, and France also make valuable contributions, showcasing a diverse global participation in this dynamic field.
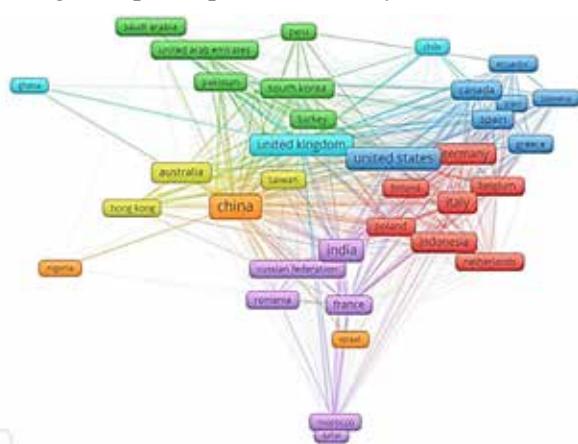
Figure 4: Bibliographic Coupling of Countries

THEMATIC MAPPING

As far as bibliometric analysis is concerned, themes are essential for identifying patterns and trends in a corpus of literature(Uyar et al., 2020). The motor theme denotes the main topic that has been thoroughly studied or investigated, signifying a dominant or major focus in a certain field. Conversely, the overarching topic suggests basic or underlying ideas that function as central themes that are often discussed in the literature. An emerging subject is a topic that is gaining scholarly attention due to its rising or increasing relevance. Even if it's not stated directly, a decline theme might point to a topic that was popular at one point but is currently getting less attention. Through the use of co-occurrence patterns, keyword analysis, and other bibliometric techniques, these themes are found, offering insightful information about the dynamics and course of research in a certain field. It's crucial to keep in mind that how these words are interpreted might change depending on the analysis's context and the bibliometric exploratory techniques used.

Motor Theme

Figure 5 presents a thematic analysis whereby the motor theme—which includes terms like decision support system, e-commerce quality, trust, and service quality—emerges as a crucial emphasis area (Dicaprio et al., 2020). This subject emphasizes how important technology and decision-making procedures are to the e-commerce industry (Thakre et al., 2022). In order to build customer trust, decision support systems are essential to improving the caliber of e- commerce platforms(Yusupova et al., 2020). The focus on service quality highlights how crucial it is to provide a dependable and smooth client experience. This main subject illustrates how technology, processes for establishing trust, and superior customer service interact dynamically to shape the changing e-commerce market and its consequences for sustainable consumption (Belov et al., 2021).

Basic theme

The subject that is emerging encompasses a wide range of terms, suggesting that the link between sustainable consumption and e-commerce is multifaceted. Supply chain, neuromarketing, social sustainability,

sustainable growth, optimization, dependability, and internet purchasing are noteworthy keywords (Duncan, 2022). The growing range of factors at the nexus of sustainability and e-commerce is reflected in this subject. A comprehensive approach to e-commerce that transcends transactional characteristics is indicated by the growing topic, which ranges from the social and environmental implications of sustainable development to the complexities of neuromarketing and optimization (Mohamed & Ali, 2018). In the end, it shapes a more mindful and environmentally friendly environment for online shopping experiences by highlighting the necessity of trustworthy and sustainable practices across the supply chain (Ghaemi Asl et al., 2021; Yawar & Shaw, 2023)
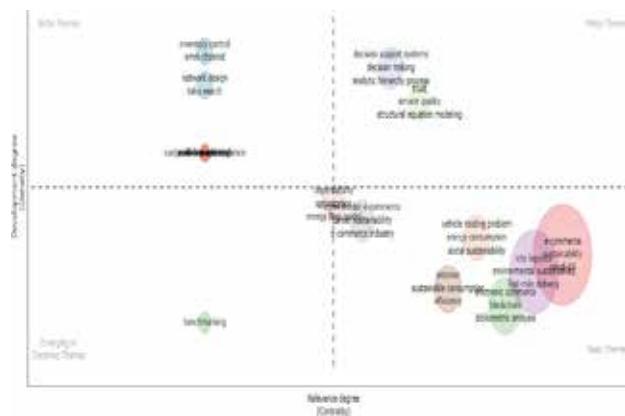
Emerging Theme

As the issue is examined in relation to e-commerce and sustainable consumption, the discussion delves into complex aspects of environmental and logistical concerns. This subject dives into the intricacies of the latter stages of product delivery, highlighting ideas like urban freight, COPERT modeling, last mile delivery, and transport externalities. The focus on last-mile logistics tackles the difficulties and solutions involved in delivering goods straight to customers (Viriyasitavat et al., 2019). The significance of sustainable transportation is further highlighted by COPERT modeling, which assesses emissions and environmental effects. Particularly in urban environments, travel externalities help to provide a thorough knowledge of the wider effects of transportation networks(Bao et al., 2020). Furthermore, the notion of urban freight clarifies the distinct obstacles and prospects presented by electronic trade in highly populated regions. As a cooperative solution, crowd shipping shows how to dynamically optimize last- mile logistics by sharing delivery services(Wilson et al., 2022). This issue is multidimensional and highlights how e-commerce is changing while highlighting how important it is to have effective last-mile delivery options in metropolitan areas (Zhang et al., 2022).

Niche Themes

The discussion dives into advanced tactics to improve resilience and streamline operations while examining a specialized topic within the larger framework of

e-commerce and sustainable consumption (Muminova et al., 2020). Using inventory management strategies denotes a careful approach to controlling stock levels and reducing the possibility of stockouts or overstock. The idea of omni-channel commerce, which emphasizes the integration of several channels for a seamless consumer experience, also touches on this issue (Ertz & Boily, 2019). Network architecture becomes a crucial strategic factor that requires careful supply chain structure planning for optimal performance. An further indication of a dedication to accuracy in decision-making processes is the application of sophisticated optimization techniques like tabu search (Dorofeyev et al., 2018). This specialty subject captures the complexities of contemporary retail operations, where smart network architecture, omni-channel strategies, resilience, and inventory control come together to support the sustainability and adaptation of e-commerce platforms (Sarfraz et al., 2022).

Figure 5 Thematic Map

CONCLUSION

To sum up, this bibliometric analysis offers a thorough grasp of the complex interactions that exist between sustainable consumption and e-commerce. While e-commerce platforms bring with them unparalleled ease for customers, they also present significant environmental issues. Promoting sustainability necessitates addressing problems including ethical production methods, responsible sourcing, and the environmental impact of e-commerce activities. Critical topics emerged from the thematic analysis, such as the rising theme that explores logistical and environmental problems and the motor theme that emphasizes

technology and decision- making. The specialty subject showcased complex methods for improving resilience and streamlining operations. Highly referenced papers, eminent sources, and prolific writers all emphasized how international and diverse this field of study is.

FUTURE RESEARCH SCOPE

Future research opportunities in the dynamic field of e-commerce and sustainable consumption are made possible by the bibliometric analysis that has been given. Academics can investigate in-depth research on particular themes that have been defined, such as the motor theme's emphasis on service quality and decision support systems. More research on the developing topic, in particular on urban freight, COPERT modeling, and last-mile delivery, might offer insightful information on sustainable logistics. Furthermore, the chosen niche issue offers potential for in-depth analyses of contemporary retail operations due to its emphasis on inventory control, omni-channel strategies, and network architecture. Future studies can also examine how patterns of collaboration are changing, how different regions are, and how regulatory changes affect sustainability and e-commerce. The foundation for further investigation and comprehension of the complex link between e-commerce and sustainable consumption is laid by this bibliometric review.

REFERENCES

1. Ananova, O. G. (2018). Digital economy, the development ways of cryptocurrency. In M. M., C. Y.G., N. T.A., M. V., G. H.-G., E. K., K. G., N. D.A., K. I., S. I.B., & K. H. (Eds.), MATEC Web of Conferences (Vol. 226). EDP Sciences. https://doi.org/10.1051/matecconf/201822604050

2. Bao, J., Geng, X., & Yu, P. (2020). An digital economy mode based on blockchain. Proceedings - 2020 International Conference on Robots and Intelligent Systems, ICRIS 2020, 391–394. https://doi.org/10.1109/ICRIS52159.2020.00102

3. Belov, M., Grishko, S., Cheremisina, E., & Tokareva, N. (2021). CONCEPT of PEER-TO- PEER CACHING DATABASE for TRANSACTION HISTORY STORAGE AS AN ALTERNATIVE to BLOCKCHAIN in DIGITAL ECONOMY. In K. V., N. A., & Z. T. (Eds.), CEUR Workshop Proceedings (Vol. 3041, pp. 494–497). CEUR-WS. https://www.scopus.com/inward/record.uri?eid=2-s2.0- 85121659497& partnerID = 40& md5 = 04ac 40935 ae 6067aaee054ce8c045c85

4. Dicaprio, A., Sokolova, M. V, & Yang, J. (2020). The Impact of Decentralization on Industrial Hubs: Blockchain and the Digital Economy. In The Oxford Handbook of Industrial Hubs and Economic Development (pp. 1069–1085). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780198850434.013.54

5. Dorofeyev, M., Kosov, M. E., Ponkratov, V., Masterov, A., Karaev, A., & Vasyunina, M. (2018). Trends and prospects for the development of blockchain and cryptocurrencies in the digital economy. European Research Studies Journal, 21(3), 429–445. https://doi.org/10.35808/ersj/1073

6. Duncan, G. (2022). Motion Planning and Remote Sensing Algorithms, Predictive Geospatial Modeling and Deep Learning Artificial Intelligence Tools, and Machine Perception and Image Recognition Technologies in the Blockchain-based Virtual Economy. Analysis and Metaphysics, 21, 193–209. https://doi.org/10.22381/AM21202212

7. Ertz, M., & Boily, É. (2019). The rise of the digital economy: Thoughts on blockchain technology and cryptocurrencies for the collaborative economy. International Journal of Innovation Studies, 3(4), 84–93. https://doi.org/10.1016/j.ijis.2019.12.002

8. Ghaemi Asl, M., Rashidi, M. M., & Hosseini Ebrahim Abad, S. A. (2021). Emerging digital economy companies and leading cryptocurrencies: insights from blockchain-based technology companies. Journal of Enterprise Information Management, 34(5), 1506–1550. https://doi.org/10.1108/JEIM-08-2020-0348

9. Hassani, H., Huang, X., & Silva, E. S. (2019). Fusing big data, blockchain and cryptocurrency: Their individual and combined importance in the digital economy. In Fusing Big Data, Blockchain and Cryptocurrency: Their Individual and Combined Importance in the Digital Economy. Springer International Publishing. https://doi.org/10.1007/978-3-030-31391-3

10. Hoang, T. G., & Phan, T. N. T. (2022). Cultural Entrepreneurship and Disruptive Blockchain Applications in Vietnam: The Status Quo and the Transition Towards a Digital Economy. In Cultural Entrepreneurship: New Societal Trends (pp. 23–38). Springer Nature. https://doi.org/10.1007/978-981-19-2771-3_3

11. Kaluzhnova, N., Kosykh, E., & Frolov, I. (2019). Institutional environment for the development of digital economy and blockchain technologies in the Russian Federation. IOP Conference Series: Materials Science and Engineering, 667(1). https://doi.org/10.1088/1757-899X/667/1/012035

12. Lian, X. S., & Feng, H. (2022). The Innovation of Enterprise Management Mode of Digital Economy Based on Blockchain Technology. IEEE International Conference on Knowledge Engineering and Communication Systems, ICKES 2022. https://doi.org/10.1109/ICKECS56523.2022.10060213

13. Marrucci, L., Corcelli, F., Daddi, T., & Iraldo, F. (2022). Using a life cycle assessment to identify the risk of "circular washing" in the leather industry. Resources, Conservation and Recycling, 185. https://doi.org/10.1016/j.resconrec.2022.106466

14. Meenar, M., Heckert, M., & Adlakha, D. (2022). "Green Enough Ain't Good Enough:" Public Perceptions and Emotions Related to Green Infrastructure in Environmental Justice Communities. International Journal of Environmental Research and Public Health, 19(3). https://doi.org/10.3390/ijerph19031448

15. Mohamed, H., & Ali, H. (2018). Blockchain, fintech, and Islamic finance: Building the future in the new Islamic digital economy. In Blockchain, Fintech, and Islamic Finance:Building the Future in the New Islamic Digital Economy. De Gruyter. https://doi.org/10.1515/9781547400966

16. Muminova, E., Honkeldiyeva, G., Kurpayanidi, K., Akhunova, S., & Hamdamova, S. (2020). Features of Introducing Blockchain Technology in Digital Economy Developing Conditions in Uzbekistan. In Z. S., S. A., D. de S. R., B. A., & M. A. (Eds.), E3S Web of Conferences (Vol. 159). EDP Sciences. https://doi.org/10.1051/e3sconf/202015904023

17. Nobre, G. C., & Tavares, E. (2021). The quest for a circular economy final definition: A scientific perspective. Journal of Cleaner Production, 314. https://doi.org/10.1016/j.jclepro.2021.127973

18. Popescu, I.-S., Hitaj, C., & Benetto, E. (2021). Measuring the sustainability of investment funds: A critical review of methods and frameworks in sustainable finance. Journal of Cleaner Production, 314. https://doi.org/10.1016/j.jclepro.2021.128016

19. Rakhimberdiev, K., Ishnazarov, A., Allayarov, P., Ollamberganov, F. F., Kamalov, R., & Matyakubova, M. Q. (2022). PROSPECTS for the USE of NEURAL NETWORK MODELS in the PREVENTION of POSSIBLE NETWORK ATTACKS on MODERN BANKING INFORMATION SYSTEMS BASED on BLOCKCHAIN TECHNOLOGY in the CONTEXT of the DIGITAL ECONOMY. ACM International Conference Proceeding Series, 592–599. https://doi.org/10.1145/3584202.3584291

20. Rakhimberdiev, K., Ishnazarov, A., Khayitova, O., Abdullayev, O. K., & Jorabekov, T. (2022). METHODS and ALGORITHMS for the FORMATION of DISTANCE EDUCATION SYSTEMS BASED on BLOCKCHAIN and ARTIFICIAL INTELLIGENCE TECHNOLOGIES in the DIGITAL ECONOMY. ACM International Conference Proceeding Series, 568–574. https://doi.org/10.1145/3584202.3584287

21. Riasat, S., & Shah, M. A. (2021). SECURING SMART CITIES: AN ANALYSIS ON USING BLOCKCHAIN FOR DIGITAL ECONOMIES. IET Conference Proceedings, 2021(4), 143–148. https://doi.org/10.1049/icp.2021.2417

22. Salazar V., A. R. (2021). Unconscionability, smart contracts, and blockchain technology: Are consumers really protected against power abuses in the digital economy? International Journal on Consumer Law and Practice, 9, 74–94. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85116937607 & partner ID = 40& md5 = 35885e35fe8341ff0f87e88901c 7452d

23. Sarfraz, M., Ivascu, L., & Abdullah, M.I. (2022). Editorial: Sustainable digital economy, entrepreneurship, and blockchain technology role in industrial-organizational psychology. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.974415

24. Shang, D., Yan, Z., Zhang, L., & Cui, Z. (2023). Digital financial asset price fluctuation forecasting in digital economy era using blockchain information: A reconstructed dynamic-bound Levenberg–Marquardt neural-network approach. Expert Systems with Applications, 228. https://doi.org/10.1016/j.eswa.2023.120329

25. Thakre, K. S., Kulkarni, G., & Deshmukh, P. S. (2022). Digital India Digital Economy Using Blockchain Technology. In Blockchain for Smart Systems: Computing Technologies and Applications (pp. 123-15Thakre, K. S., Kulkarni, G., Deshmukh, P.). CRC Press. https://doi.org/10.1201/9781003203933-12

26. Uyar, A., Karaman, A. S., & Kilic, M. (2020). Is corporate social responsibility reporting a tool of signaling or

greenwashing? Evidence from the worldwide logistics sector. Journal of Cleaner Production, 253. https://doi.org/10.1016/j.jclepro.2020.119997

27. Viriyasitavat, W., Xu, L. D., Bi, Z., & Pungpapong, V. (2019). Blockchain and Internet of Things for Modern Business Process in Digital Economy - The State of the Art. IEEE Transactions on Computational Social Systems, 6(6), 1420–1432. https://doi.org/10.1109/TCSS.2019.2919325

28. Wilson, K. B., Karg, A., & Ghaderi, H. (2022). Prospecting non-fungible tokens in the digital economy: Stakeholders and ecosystem, risk and opportunity. Business Horizons, 65(5), 657–670. https://doi.org/10.1016/j.bushor.2021.10.007

29. Yawar, S. M., & Shaw, R. (2023). Decentralising the Digital Economy: The Blockchain and Competition Remedy. In A. B., N. C. C. Middle East Technical University KKTC, via Mersin 10 , Güzelyurt, & H. A. (Eds.), Lecture Notes in Networks and Systems: Vol. 495 LNNS (pp. 1265–1274). Springer Science

and Business Media Deutschland GmbH. https://doi.org/10.1007/978-3-031-08954-1_109

30. Yusupova, L. M., Kodolova, I. A., Nikonova, T. V, Agliullina, M. I., & Agliullina, Z. I. (2020). Blockchain as a part of the digital economy in financial sphere. International Journal of Engineering Research and Technology, 13(12), 4469–4474. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85099276360 & partnerID = 40& md5 = 92859114687bb62ab328ebba5464b7da

31. Zhang, J., Li, J., Ye, D., & Sun, C. (2022). The Impact of Digital Economy of Resource- Based City on Carbon Emissions Trading by Blockchain Technology. Computational Intelligence and Neuroscience, 2022. https://doi.org/10.1155/2022/6366061

32. Zhou, C., Li, Y., Yu, H., & Dong, X. (2022). Application of blockchain technology in energy digital economy. Proceedings - 2022 International Conference on Artificial Intelligence in Everything, AIE 2022, 636–641. https://doi.org/10.1109/AIE57029.2022.00125

Muti-objective Optimization of Turning Process Parameters for AISI (M3) Tool Steel

Vijay Balaji Aher
Research Scholar
Department of Mechanical Engineering
JCOE, Kuran
Pune, Maharashtra
✉ vijay.aher 9910@gmail.com

Paresh Sudam Pawar
Assi. Professor & HOD
Department of Mechanical Engineering
JCOE, Kuran
Pune, Maharashtra

Galhe Dattatray Shankar
Professor
Department of Mechanical Engineering
JCOE, Kuran
Pune, Maharashtra

Anil Trambak Tidke
Assistant General Manager
Birla Precision Technologies Ltd.
Nashik, Maharashtra
✉ vijay.aher 9910@gmail.com

ABSTRACT

The current research is related to multi-objective optimization of turning process parameters for AISI M3 tool steel material. The turning is done on CNC machine. The turning environment is dry during experimentation. The ultimate aim of this research work is to find the turning process parameters which will give best surface finish as well as best material removal rate simultaneously. The research concluded that cutting speed (300m/min), feed rate (0.15mm/rev), depth of cut (0.75mm), and nose radius (1.2mm), this set of turning process parameters provide best Ra and MRR value simultaneously. For this stage nominal is best criterial is selected. Ra and MRR both values increase with increase in cutting speed. Ra and MRR both values decrease with increase in feed rate. Ra and MRR both values increase first then decrease. Ra and MRR both values increase with increase in nose radius.

KEYWORDS: *Ra, MRR, CNC, Multi-objective, AISI M3, Dry turning.*

INTRODUCTION

The feasibility of hard turning has been made possible by advancements in modern technologies. The process involves the fabrication of solid objects utilising advanced machinery. High-precision machining presents various obstacles, one of which involves the selection of a tool insert that offers enhanced tool longevity. Various industries, such as cutting tool manufacturing, ball bearing production, automotive manufacturing, gear production, and die making, exhibit a shared interest in the process of turning hardened materials through the utilisation of a single-point cutting tool. The utilisation of hard turning presents several advantages in comparison to conventional grinding. These advantages encompass reduced equipment expenses, decreased setup durations, and a diminished number of process stages. Consequently, these factors contribute to enhanced adaptability and the capacity to fabricate intricate geometries. The utilisation of hard turning often involves the omission of cutting fluid, hence reducing the requirements for storing, managing, and disposing of this fluid. The promotion of operators' health is beneficial.

In present time the technology of CNC turning machine has been improved significantly to meet the advance requirements in various manufacturing fields, especially in the precision metal cutting industry. Among several CNC industrial machining processes, turning is a fundamental machining operation. It is widely used in a variety of manufacturing in industries.

Material removal rate (MRR) & Surface roughness (Ra) is an important control factor of machining operation. MRR is a measurement of productivity. Ra is a measurement of quality. Effort to minimize Ra

value and maximize MRR value by optimal selection of cutting speed, feed rate, depth of cut & insert nose radius.

LITERATURE REVIEW

This section includes some selected articles for an in-depth investigation to find a research gap or further extension of research in the area of hard turning. The selected papers for the study is as follows:

Alok, A., & Das, M. (2019) [1] executed a new type of coating material, HSN2 with 12 µm thickness on carbide insert by using physical vapor deposition technique for machining hard AISI 52100 steel of hardness 55 HRC is evaluated. DSC and TGA assess coated carbide insert thermal and oxidative stability. Cutting speed, feed rate, and depth of cut affect primary cutting, radial and feed pressures, maximum flank wear, and workpiece surface quality. Statistics examine how cutting parameters affect machinability. Regression models connect input and output process features. A response surface optimisation and validation test follows. The confirmation test found percentage errors for main cutting force, radial force, feed force, surface roughness, and flank wear. Maximum tool wear is 292 m, which is ISO 3685-compliant. Cutting speed works best among output parameters. The current endeavor is unusual in that it machines AISI 52100 steel with a 55 HRC hardness at 102–287 m/min with a new 12 m-thick HSN2 coating.

Aouici, H., et al. (2012) [2] investigated experimentally the effects of cutting speed, feed rate, workpiece hardness and depth of cut on surface roughness, and cutting force components in the hard turning. Sandvik milled AISI H11 steel with cubic boron nitride (CBN 7020), a 57% CBN/35% TiCN blend. They employed ANOVA for four-factor (cutting speed, feed rate, hardness, and depth of cut) and three-level fractional experiments. This method represents surface roughness and cutting force components mathematically. The depth of cut and workpiece hardness have the greatest impact on cutting force components, while feed rate and hardness affect surface roughness statistically. Finally, industrial production cutting circumstances should be optimised.

Aouici, H., et al. (2011) [3] investigated turning

conditions of hardened AISI H11 (X38CrMoV5-1), the effects of cutting parameters on flank wear (VB) and surface roughness (Ra) using the CBN tool. The response surface method is utilised in machining experiments. This study examines how cutting speed, feed rate, and duration affect two performance outputs (VB and Ra) (ANOVA). The ideal cutting conditions for each performance level are calculated using quadratic regression. The findings show that flank wear is primarily affected by cutting time, then speed. Feed rate appears to be the key factor affecting workpiece surface roughness.

Azizi, M. W., et al. (2012) [4] investigated the effect of cutting parameters (cutting speed, feed rate, and depth of cut) and workpiece hardness on surface roughness and cutting force components. Coated Al2O3 + TiC mixed ceramic cutting tools on AISI 52100 steel. The experiment was planned using Taguchi's L27 orthogonal array. The response table and ANOVA helped us validate the linear regression model and discover surface roughness and cutting force components. The statistical investigation found that depth of cut, workpiece hardness, and feed rate affect cutting force components more than cutting speed. Empirical models linked cutting parameters, workpiece hardness, surface roughness, and cutting forces. The desired function technique for multiple response factor optimisation was used to identify the best machining settings for low surface roughness and low cutting force. The presented empirical models were validated via experiments.

Azizi, M. W., et al. (2020) [5] optimized machining parameters to achieve the desired technical parameters such as surface roughness, tool radial vibration, and material removal rate using response surface methodology (RSM). Hard turning EN19 alloy steel with GC3015) cutting tools was studied. Hard and high-precision component manufacturers face a big difficulty in surface finish quality and manufacturing rate. RSM can solve this problem using a mathematical model and tests. A face-centered central composite design (FCCD) with cutting parameters (speed, feed rate, and depth of cut) was used in the statistical analysis. Cutting parameters affected surface roughness, tool vibration, and material removal. The ideal cutting parameters for surface roughness, tool vibration, and material removal rate were found using a desirability

function and numerical and graphical optimisation. The mathematical models were validated by experiments.

Bouzid, L., et al. (2015) [6] attempted to statistically model the relationship between cutting parameters (speed, feed rate, and depth of cut), cutting force components (Fx, Fy, and Fz), and workpiece absolute surface roughness (Ra). The AISI 420 martensitic stainless steel is subjected to machining using a chemical vapour deposition (CVD)-coated carbide tool. The full-factorial design with a 4^3 configuration is used to assess experimental outcomes via the application of analysis of variance (ANOVA) and response surface methodology (RSM). The best cutting conditions are determined by the interaction of mutually responsive surfaces and desire functions, while the accuracy of the model is confirmed by the residual values. The surface roughness (Ra: 81%) is influenced by the depth of cut (Fx: 86%), dominance (Fy: 58%), and feed rate (Fz: 81%). The observed cutting force and surface roughness exhibited a strong agreement with the expected values. The results were examined for potential inaccuracies, with the following percentages of inaccuracy identified: Fx (6.51 percent), Fy (4.36 percent), Fz (3.59 percent), and Ra (5.12 percent). Ultimately, it is essential that the ranges for industrial production cutting be optimised.

Cakir, M. C., et al. (2009) [7] examined the effects of cutting parameters (cutting speed, feed rate, and depth of cut) onto the surface roughness through the mathematical model developed by using the data gathered from a series of turning experiments performed. Another research was conducted to investigate the impact of two commonly used coating layers on surface roughness. Two CNMG 120408 carbide inserts, designated according to the International Organisation for Standardization (ISO), were subjected to testing under comparable cutting circumstances. These inserts had identical geometry and substrate, but differed in terms of their coating layers. The machining process was performed using AISI P20 cold-work tool steel. Insert 2 is subjected to a physical vapour deposition (PVD) process, resulting in the application of a thin layer of titanium aluminium nitride (TiAlN) measuring 31 micrometers in thickness. On the other hand, Insert 1 undergoes a chemical vapour deposition (CVD) process, which involves the deposition of a titanium carbonitride (TiCN) underlayer, an aluminium oxide

(Al2O3) intermediate layer, and a titanium nitride (TiN) outer layer. The average error of the model was found to be 4.2 percent for Insert 1 and 5.2 percent for Insert 2, indicating a measure of dependability for the equations.

Das, D. K., et al. (2014) [8] investigated surface roughness during hard machining of EN 24 steel with the help of coated carbide insert. Testing was done in dry conditions. The Grey-based Taguchi approach optimised process parameters. The regression-based surface roughness prediction models were also evaluated. Hard machining yields 0.42micron surface roughness. The grey-based Taguchi technique's optimum depth of cut (Ra) and cutting speed (Rz) were 0.4 mm, 0.04 mm/rev, and 130 m/min. Feed matters more for Ra and Rz. The prediction models have high R2 values (0.993 and 0.934). This improves model fit and is important.

Das, S. R., et al. (2015) [9] investigated the dry hard turning of AISI 4140 steel using PVD-TiN coated Al2O3+TiCN mixed ceramic inserts. This ANOVA examines how cutting factors (cutting speed, feed, and depth of cut) affect performance variables like surface roughness and flank wear. Surface roughness is most affected by cutting feed and speed. Though not statistically significant, flank wear is a function of incision depth. The process is established by SEM studies on the machined surface and worn tool. Abrasion dominated wear throughout the range. Also examined were tool wear and surface roughness. It predicted flank wear and surface roughness. With 95% confidence, RSM-based mathematical models for surface roughness (Ra) and flank wear (VB) were created. Tool life was examined under ideal cutting conditions (obtained by response optimisation) to justify coated ceramic inserts in hard turning. TiN coated ceramic has a 51-minute tool life and a reduced anticipated machining cost per item (Rs. 12.31).

Das, S. R., et al. (2017) [10] addressed surface roughness, flank wear, and chip morphology during dry hard turning of AISI 4340 steel (49 HRC) using CVD (TiN/TiCN/Al2O3/TiN) multilayer coated carbide tool. Taguchi's L9 Orthogonal array (OA) and ANOVA examined how cutting parameters affect tool and workpiece flank wear and surface roughness. SEM was utilised to investigate machined workpiece surface topography, coated carbide tool wear, and

chip morphology. Thus, multiple regression analysis was utilised to develop a mathematical model for each response, and several diagnostic tests were done to verify its validity and utility. Finally, a Gilbert's method cost analysis (recommended by response optimisation methodology) showed coated carbide tools' economic feasibility in hard turning. Statistics show that feed and cutting speed effect surface roughness and flank wear. Faster cutting improves flank wear and surface polish. Abrasion from flank land rubbing on machined surface and high cutting temperatures damage tools. Saw-tooth chip morphology shows significant serration from cyclic fracture propagation caused by plastic deformation. Hardened AISI 4340 steel with a coated carbide tool costs $0.13 per item to machine. A multilayer TiN/TiCN/Al2O3/TiN coated carbide tool for hard turning in dry cutting circumstances is cheaper than cylindrical grinding, according to the study. Alternatives to CBN and ceramic tools are cheaper.

Davoodi, B., et al. (2015) [11] investigated the effects of cutting parameters on tool life of PVD TiAlN-coated carbide tools, and volume of workpiece material removed during the machining of the N-155 iron–nickel-base superalloy is evaluated. Cutting variables comprised five levels of feed rate and speed. RSM modelled machining parameter-output variable interactions. ANOVA tested the mathematical model and variables. Overall, model projections and actual tool life and material removed matched well. SEM was used to study cutting tool insert wear at various speeds. Adhesion caused most tool failures. Finally, the intended function approach improved tool life and material removal for productivity.

Davoodi, B., et al. (2014) [12] investigated the effects of cutting speed and undeformed chip thickness on cutting and feed force components, and tooltip temperature was experimentally investigated in order to remove the cutting fluid. AA5083-O wrought alloy with 4.5% Mg was machined dry and wet using coated carbide tools. ANOVA was employed in two-factor (cutting speed and undeformed chip thickness) and five-level fractional experiments. Cutting, feed force, and tool tip temperature (RSM) mathematical models were created using this strategy. Results show that undeformed chip thickness influences output variables. AA5083 may be machined without fluid at high speed

and low undeformed chip thickness. Cutting speed and chip thickness statistically affect cutting and feed force in dry and wet machining. We finally have industrial production-friendly turning circumstances.

Devi, K. D., et al. (2015) [13] studied an optimization problem that seeks the identification of the best process condition or parametric combination for the said manufacturing process. Single-objective optimisation involves one quality characteristic. When several characteristics are evaluated, choosing the best choice that fulfils all quality requirements is tough. This study solved a Multi-Objective Optimisation problem by straight turning brass bar using Response Surface Methodology. Research sought the best process environment for quality and productivity. Finally, the study evaluates how cutting speed, feed, depth of cut, and coolant type affect output parameters. The predicted optimal setting reduced surface roughness and increased MRR, tool life, and machinability index. The confirmatory test confirmed the perfect result.

Dureja, J. S., et al. (2009) [14] attempted to model the tool wear and surface roughness, through response surface methodology (RSM) during hard turning of AISI-H11 steel with TiN-coated mixed ceramic inserts. Using ANOVA and factor interaction graphs in the RSM, machining parameters such cutting speed, feed rate, depth of cut, and workpiece hardness were examined on flank wear and surface roughness. This model matches experiments best. A desirability function optimizes several response components. Validation trials predicted response factors within 5%. Surface roughness and flank wear depend on feed rate, workpiece hardness, and depth of cut. A toolmaker's microscope monitored tool wear, and SEM-EDX characterized typical inserts. Rubbing and impingement of hard work material particles causes tool surface abrasion, notch wear, and chipping.

On the strength of the review of work done by previous researchers, it is found that a considerable amount of work has been carried out by previous investigators for modeling, simulation and parametric optimization of surface properties of the product in turning operation. Issues related to tool life, tool wear, cutting forces have been addressed to. But no work is found on multi-objective optimization of turning process parameters for AISI M3 tool steel.

EXPERIMENTAL SETUP

Size of Sample

Nine sample of material AISI (M3) is taken for experimentation. The size of sample is Ø 17× 120.

Figure1.Taper Shank Twist Drill

Chemical Composition

The chemical composition of AISI (M3) is shown in following table:

Table 1: Chemical Composition of Sample [15]

Element	Symbol	%
Carbon	C	1.15 – 1.25
Chromium	Cr	3.75 – 4.50
Molybdenum	Mo	4.75 – 6.50
Tungsten	W	5.00 – 6.75
Vanadium	V	2.25 – 2.75
Cobalt	Co	Nil

Cutting Tool and Toolholder

The cutting tool selected for present research work is Tin Coated Tungsten Carbide inserts. The inserts used in present work are TNMG 160404, TNMG 160408, TNMG160412 Taegutec company (as per ISO coding). The tool holder used is HCLNL 2525M0904.

Experimental Unit

ACE Designer Ltd. Make CNC turning centre with Fanuc Oi-mate-TD controller is used to carry out the experimentation.

Figure 2. Experimental Unit

Table 2. Specification of CNC machine

Max.turning diameter	300 mm
Max.turning length	400 mm
Max.spinde speed	3500 rpm
Supply voltage	380 v/4.5v
Number of axis	2
Control voltage	24 VDC
Back up fuse	63
Rated current	24/22 Amps
Environment	Dry

Plysical and Mechanical Properties of Material

Table 3: Properties of AISI (M3) [15]

Properties	Value
Density	8.9 kg/m^3
Melting point	4680^0
Hardness	62-65 HRC
Compressive yield strength	3250 Mpa.
Poisson's ratio	0.27-0.30
Elastic modulus	190-210

Application of Material

AISI (M3) material is used in cutting tool industry to manufacturing twist drills, reamers, taps and cold forming tool such as extrusion rams and dies and also to prepare plastic molds with elevated wear resistance and screw.[16]

Experimental Procedure

AISI (M3) is taken for machining and their weight before machining and after machining were precisely recorded and cycle time is recorded from screen. The MRR is calculated by using formula:

MRR = Wi – Wf / ρs* t mm³/sec   (1)

Where, Wi = Initial weight of work piece in gm
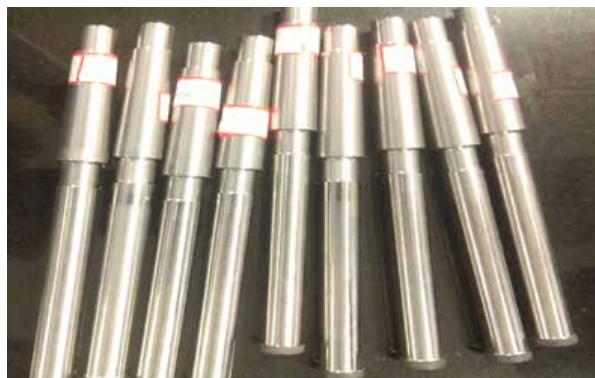
Wf = Final weight of work piece in gm

t = Machining time in seconds

ρs= Density of mild steel

= (8.028x 10^{-3} gm/mm³).

and surface roughness value is recorded with help of Make–Strumentazione, Model-RT10G, L.C.0.001μm

Figure 3. Jobs for Surface Roughness Checking

Design of Experiment

The selection of particular orthogonal matrix from the standard orthogonal array depends on:

1.   Number of control factors

2.   Nmber of levels for each control factor

3.   Total degree of freedom of factor

In present research work consists of four parameters such as cutting speed, feed rate, depth of cut and nose radius and is used three level therefore according to MINITAB software, the most suitable orthogonal array is L9(34).

Table 4: Control factors and their levels

Levels	Control factors			
	Cutting speed (m/min)	Feed rate (mm/rev)	Depth of cut (mm)	Nose radius (mm)
Level 1	150	0.15	0.5	0.4
Level 2	220	0.22	0.75	0.8
Level 3	300	0.28	0.8	1.2

After level finalization the selected orthogonal array is designed in following manner.

Table 5: Taguchi's L9 Orthogonal Array

Exp. No	Cutting speed (m/min) A	Feed rate (mm/rev) B	Depth of cut (mm) C	Nose radius (mm) D
1	150	0.15	0.5	0.4
2	150	0.22	0.75	0.8
3	150	0.28	0.8	1.2
4	220	0.15	0.75	1.2
5	220	0.22	0.8	0.4
6	220	0.28	0.5	0.8
7	300	0.15	0.8	0.8
8	300	0.22	0.5	1.2
9	300	0.28	0.75	0.4

On the basis of Table 2 experimental trials are taken to find material removal rate and their related surface roughness values. The response values of each trial along with their S/N ratio is shown in following Table 3.

Condition of S/N ratio for surface roughness: smaller is better

$$\eta = -10 \log \frac{1}{n} \sum_{i=1}^{n} y_i^2$$

(2)

Condition of S/N ratio for Material removal rate: larger is better

$$\eta = -10 \log \frac{1}{n} \sum_{i=1}^{n} 1/y_i^2$$

(3)

Where, η - Signal to Noise (S/N) Ratio, Yi – i^{th} observed value of the response, n - Number of observations in a trial, y - Average of observed values (responses) s – Variance

Table 6. Response value table for MRR

Exp. No	MRR (Trial1) mm³/sec	MRR (Trial 2) mm³/sec	Mean MRR mm³/sec	S/N Ratio dB
1	205.011	212.79	208.901	46.39
2	307.51	328.53	318.020	50.03

3	368.90	368.90	368.900	51.33
4	218.87	232.51	225.690	47.05
5	305.96	323.08	314.520	49.94
6	375.60	363.15	369.375	51.34
7	225.91	224.21	225.060	47.04
8	308.29	313.74	311.015	49.85
9	345.90	337.28	341.590	50.66

Table 7. Response Value table for Ra

Exp. No	Ra (Trial1) μm	Ra (Trial 2) μm	Mean Ra μm	S/N Ratio dB
1	2.10	2.50	2.300	-7.2673
2	2.68	2.63	2.655	-8.4817
3	2.35	2.32	2.335	-7.3659
4	0.95	0.45	0.700	2.5767
5	3.10	3.60	3.350	-10.5250
6	3.50	3.38	3.440	-10.7325
7	1.35	1.32	1.335	-2.5102
8	1.20	1.31	1.255	-1.9812
9	4.10	3.53	3.815	-11.6541

Table 8. Mean Value Table for MRR

Levels	Mean Value of MRR			
	Cutting Speed	Feed Rate	Depth of Cut	Nose Radius
Level 1	298.6	219.9	296.4	288.3
Level 2	303.2	314.5	295.1	304.2
Level 3	292.6	360.0	302.8	301.9

Table 9. Mean Value Table for Ra

Levels	Mean Value of Ra			
	Cutting Speed	Feed Rate	Depth of Cut	Nose Radius
Level 1	2.430	1.445	2.332	3.155
Level 2	2.497	2.420	2.390	2.477
Level 3	2.135	3.197	2.340	1.430

MULTI-RESPONSE OPTIMIZATION

From the utility concept, the muti-response S/N ratio of the overall utility value is given by

$$\eta_{Obs} = W_1\eta_1 + W_1\eta_1 \qquad (4)$$

Where, W_1 and W_2 are the weights assigned to the Ra and MRR. Assignment of weights to the performance characteristics are based on customer's requirements and their priorities. In the present work equal importance is given for both Ra and MRR. Therefore, W_1 and W_2 = 0.5
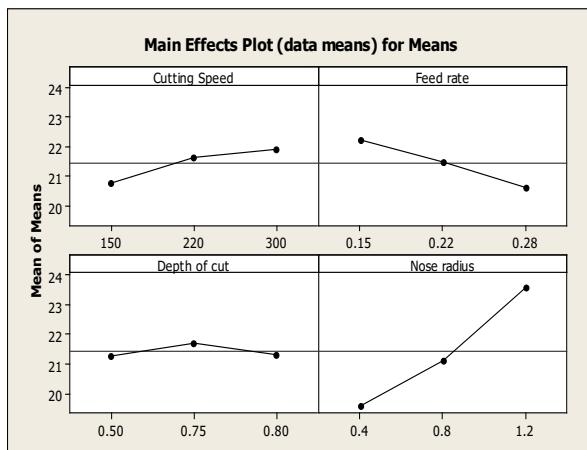
Table 10: Design matrix with multi-response S/N ratio

Exp.	A	B	C	D	η_{obs}
1	150	0.15	0.75	0.4	19.56
2	150	0.22	0.8	0.8	20.77
3	150	0.28	1.5	1.2	21.98
4	180	0.15	0.8	1.2	24.81
5	180	0.22	1.5	0.4	19.70
6	180	0.28	0.75	0.8	20.30
7	300	0.15	1.5	0.8	22.26
8	300	0.22	0.75	1.2	23.93
9	300	0.28	0.8	0.4	19.50

Table 11: mean value of η_{obs} at different levels

Levels	Mean values of η_{obs} for process parameters			
	A	B	C	D
Level 1	20.77	22.21	21.27	19.59
Level 2	21.61	21.47	21.70	21.11
Level 3	21.90	20.60	21.32	23.58

RESULTS AND DISCUSSION

Figure 4. Multi-objective Optimization Output Graph

From above graph, it is concluded that

a) Ra and MRR both values increase with increase in cutting speed.

b) Ra and MRR both values decrease with increase in feed rate.

c) Ra and MRR both values increase first then decrease.

d) Ra and MRR both values increase with increase in nose radius.

The set of turning process parameters at which both factors such as Ra and MRR are at best state is as follows:

• Cutting Speed = 300 m/min

• Feed Rate   = 0.15 mm/rev

• Depth of Cut   = 0.75 mm

• Nose Radius   = 1.2 mm

In this multi objective optimization stage, we have given equal importance to both values Ra and MRR.

CONCLUSION

After this research, it is concluded that multi-objective optimum process parameter level is A3 B1 C2 D3. The set of turning process parameters at which both factors such as Ra and MRR are at best state are Cutting Speed = 300 m/min, Feed Rate = 0.15 mm/rev, Depth of Cut   = 0.75 mm, Nose Radius = 1.2 mm.

REFERENCES

1. Alok, A., & Das, M. (2019). Multi-objective optimization of cutting parameters during sustainable dry hard turning of AISI 52100 steel with newly develop HSN2-coated carbide insert. Measurement, 133, 288-302.

2. Aouici, H., Yallese, M. A., Chaoui, K., Mabrouki, T., & Rigal, J. F. (2012). Analysis of surface roughness and cutting force components in hard turning with CBN tool: Prediction model and cutting conditions optimization. Measurement, 45(3), 344-353.

3. Aouici, H., Yallese, M. A., Fnides, B., Chaoui, K., & Mabrouki, T. (2011). Modeling and optimization of hard turning of X38CrMoV5-1 steel with CBN tool: Machining parameters effects on flank wear and surface roughness. Journal of mechanical science and technology, 25(11), 2843-2851.

4. Azizi, M. W., Belhadi, S., Yallese, M. A., Mabrouki, T., & Rigal, J. F. (2012). Surface roughness and cutting forces modeling for optimization of machining condition in finish hard turning of AISI 52100 steel. Journal of mechanical science and technology, 26(12), 4105-4114.

5. Azizi, M. W., Keblouti, O., Boulanouar, L., & Yallese, M. A. (2020). Design optimization in hard turning of E19 alloy steel by analysing surface roughness, tool vibration and productivity. Structural Engineering and Mechanics, 73(5), 501-513.

6. Bouzid, L.; Yallese, M. A.; Chaoui, K.; Mabrouki, T.; Boulanouar, L. (2015). Mathematical modeling for turning on AISI 420 stainless steel using surface response methodology. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 229(1), 45–61.

7. Cakir, M. C., Ensarioglu, C., & Demirayak, I. (2009). Mathematical modeling of surface roughness for evaluating the effects of cutting parameters and coating material. Journal of materials processing technology, 209(1), 102-109.

8. Das, D. K., Sahoo, A. K., Das, R., & Routara, B. C. (2014). Investigations on Hard Turning Using Coated Carbide Insert: Grey Based Taguchi and Regression Methodology. Procedia Materials Science, 6, 1351-1358.

9. Das, S. R., Dhupal, D., & Kumar, A. (2015). Study of surface roughness and flank wear in hard turning of AISI 4140 steel with coated ceramic inserts. Journal of Mechanical Science and Technology, 29(10), 4329-4340.

10. Das, S. R., Panda, A., & Dhupal, D. (2017). Experimental investigation of surface roughness, flank wear, chip morphology and cost estimation during machining of hardened AISI 4340 steel with coated carbide insert. Mechanics of Advanced Materials and Modern Processes, 3(1), 1-14.

11. Davoodi, B., & Eskandari, B. (2015). Tool wear mechanisms and multi-response optimization of tool life and volume of material removed in turning of N-155 iron–nickel-base superalloy using RSM. Measurement, 68, 286-294.

12. Davoodi, B., & Tazehkandi, A. H. (2014). Experimental investigation and optimization of cutting parameters in

dry and wet machining of aluminum alloy 5083 in order to remove cutting fluid. Journal of Cleaner Production, 68, 234-242.

13. Devi, K. D., Babu, K. S., & Reddy, K. H. (2015). Mathematical Modeling and Optimization of Turning Process Parameters using Response Surface Methodology. International Journal of Applied Science and Engineering, 13(1), 55-68.

14. Dureja, J. S., Gupta, V. K., Sharma, V. S., & Dogra, M. (2009). Design optimization of cutting conditions and analysis of their effect on tool wear and surface roughness during hard turning of AISI-H11 steel with a coated—mixed ceramic tool. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 223(11), 1441-1453.

15. otaisteel.com/products/high-speed-steel/aisi-m3-steel-class2-2/

16. Pawar, K., & Palhade, R. D. (2015). Multi-objective optimization of CNC turning process parameters for high speed steel (M2) using Taguchi and ANOVA method. International Journal of Hybrid Information Technology, 8(4), 67-80.

An Extensive Survey on Vibration Analysis of Rotor-Bearing-Gear System for Fault Diagnosis

Rahul Ramesh Joshi
Research Scholar, S.U.,Kolhapur
Assistant Professor
Department of Engineering Sciences
International Institute of Information Technology
Pune, Maharashtra
✉ rahul.joshi719@gmail.com

S. H. Sawant
Principal
Sant Gajanan Maharaj College of Engineering
Mahagaon, Maharashtra
✉ sanjaysawant2010@gmail.com

ABSTRACT

Fault diagnosis techniques have evolved rapidly and are effectively implement in many engineering applications. Machines with relative motion of parts generate noise and vibration. Errors during operation can cause serious damage to the gearbox. Condition monitoring techniques are therefore very important for preventing and diagnosing gearbox vibrations. Damage detection and condition monitoring of gears and bearings in industrial machines is currently a focus of researchers. Several technologies such as material technology, information technology and signal processing bring modern solutions to efficiently and accurately analyze various faults and problems related to gear failure in the working environment. Many studies have been conducted on machine condition monitoring to evaluate industrial gears. Signal processing and vibration analysis techniques are well known and suitable for industrial practice. This is because the vibration signal from the transmission is temporary and not constant. Each technique has some drawbacks and may not be used in all conditions. The simple vibration method cannot detect minor faults. In the early stages, simple spectral analysis is not very successful in finding gear damage. This article represents a detailed study of the various authors for fault diagnosis of gears and bearings.

KEYWORDS: *Fault diagnosis, Gears, Bearing,failure.*

INTRODUCTION

To cope with increasing demands of mankind, companies are trying to improve and speed up their machining processes to increase productivity. To increase the productivity, companies are taking advantages of modern manufacturing techniques and methods. But a very small failure could lead to catastrophe failure. when collective faults occur in distinctive elements of the rotating machines, their functions are extremely reliant. specialists can easily expect approximately single faults but the trouble arises, while the faults blended and the separation of traits will become complicated. The facts approximately mixed fault traits is rare, at the same time as the intensity of each failure isn't clarified as it should be.

LITERATURE SURVEY

Laxmikant s Dhamande ,Carried out a Vibrational study at of a single stage spur Gear , joint impact of bearing and tools defects have been discuss. MATLAB is used for feature Extraction and prognosis accomplished with the help of ANN.[7]

Renping Shao., A novel gear damage detection and diagnosis system is developed using empirical mode decomposition in combination with MATLAB and VC++.[17]

Vikas Sharma , A case study of fixed axis gear box is discussed and 28 Condition indicators are extracted. [24]

Vakharia, have completed the failure diagnosis technology for complex rotating machines by vibration evaluation. Two functions are used for rank criteria Chisquare and ReliefF using ANN and RF. 40 statistical features are computed from time-domain, frequency-domain, and discrete wavelet transforms.[22]

Biing Wu, Vibration record analysis strategies for Helicopter Plantery gear failure forecasting were studied. look at and find that the fault of the crack in the planet plates is transmitted. The time-synchronous averaging method is compared to various techniques for preprocessing vibration records within the frequency domain. two new feature extraction techniques yielded the harmonic index in the frequency domain and the intra-revolution energy dispersion within the wavelet domain to differentiate the information received from damaged and undamaged gears.[26]

Xiaoyun Gong , Emprical Mode Decomposition for fault diagnosis and its weakness is discussed. New proposed methodology (EEMD) ensemble empirical Mode Decomposition with full vector spectrum for gear diagnosis developed. Experimentation is carried out on Ball Coal mill.[27]

Praveenkumar, Experimentation is conducted for gear defect(good gear and face wear gear) to collect vibration signals for healthy gear and fault gear. Testing is carried out for different speeds and loading condition. Use Support Vector Machine (SVM) for fault identification and efficiency of gear is compared.[28]

Yang Zhi, With the help of fault tree analysis an expert system was developed diagnosis of gear box. From fault tree analysis qualitative and quantitative analysis of the gear box is carried out. Use of C# on the .NET platform to develop expert system.

Ashish Goyal, Experimentation is carried out for healthy and faulty bearing. Testing is carried out for different speeds and loading condition. Vibration responses are acquired and analyzed for the various defects of bearing. Use of ANN for prediction of further results.[8]

Aditendra Jaiswal, Experimentation setup with Spur Gear of Kinectic Scooters for healthy and faulty gears. Testing is carried out of for different speeds using Variable frequency drive (VFD). Different defects are compared. (Wear,pitting,corrosion,crack etc.)

Mayssa Hajar, Experimentation for different cases of healthy and faulty gears and bearings are discussed. Power Spectral density parameters from the vibrations signals can be extracted.

Morsy, setup is developed for Vehicle gear box fault diagnosis for pitting defect on one tooth of pinion gear on the output shaft with different speeds same load. Comparison between two techniques are carried out. (Envelope Detection and Cepstrum Analysis).

Rabinaryan Sethi ,Develop a diagnostic model for fault detection of gearing with different defects in gear. FEA, ANSYS and ANN are used.

Devendrian , Bearning Condition Monitoring using signal processing techniques with Artifical Intelligent Diagnostics Techniques and gear condition monitoring using signal processing techniques with Artifical Intelligent Diagnostics Techniques are discussed.

Sawalhi , study is carried out for extended inner race fault in one of the rolling element bearing in a single stage gearbox with simulation. Use of Matlab and Cyclostationarity is done.

Riazl, A concise analysis of technique on vibration feature extraction and analysis for fault prognosis of rotating equipment with superior sign processing methods are tricky.

Akhand Rai , It describes some Conditioning monitoring tools used for rolling element bearings. Methods are discussed in three stages; before 2001, between 2001-2010 and from 2010 to till date. Advantages and Disadvantages are discussed.[1]

M.S.Patill, explains an overview of bearing vibration signature analysis. The measurement of vibrations in the time and frequency domain is presented. The latest trends in bearing defect detection research have been covered.

Mohamed B. Abd-Elbary discusses a Vibration is one of the maximum crucial parameters to bear in mind in rotating gadget situation monitoring. In the worst case, Small failure can result in timeout, pricey damage, harm and certainly lack of lifestyles. thus, early failure discovery is an crucial thing in icing and lengthening the lifestyles of a rotating gadget. By measuring and assaying the weather of rotating machines, you could descry and become aware of crucial disasters inclusive of mass imbalances, misalignments, bearing damage, tools disasters, and rotor cracks. This paper ambitions to manual experimenters in imposing not unusual place fault kind discovery, opinion, and shape methods the use

of vibration analysis, consisting of subspace identity and deep literacy, for rotating systems. It indicates several crucial methods used for condition monitoring.[2]

Behara santosh sagar, the paper centered on the ones strategies which have installed themselves withinside the creation and exploration network because of the huge motion of ebb and glide assessments with inside the field. In particular, failure detection techniques had been grouped into 3 fundamental classes: model-primarily based totally, hardware-primarily based totally, and historic methods. Model-primarily based totally flaw detection strategies have accompanying properties: They have the maximum dependable estimators or observers, while all multipoint fashions are up to date can exhibit practical ordinary and fault mistakes, and case grips can seem and mistakes may be displayed and merged into useless research procedures. [5]

Adnan Althubaiti, In this paper, a entire evaluation of curler bearing evaluation and prognosis has been reviewed. This evaluation showed several strategies have been utilized in mixture with vibration assessment for the prognosis and prognosis of bearings detail faults, but, maximum of those algorithms are valid for wonderful times and cannot be generalised. future research at the area of vibration evaluation will deal with the space related to prognosis functionality via device getting to know and propose a manner to lessen dependency on training data to set up lifestyles prediction.

D. H. Omar focuses on Early failure detection the usage of vibration tracking device enables the enterprise keep away from sudden device outages, thereby decreasing device downtime and preservation prices and saving time and money. Early detection of mistakes the usage of vibration measuring gadgets may be very useful in figuring out and reading the situation of rotating elements. In this article, we performed an experimental examine to are expecting misalignment mistakes in rotating equipment related to easy rigid entity entification couplings. Vibrations are recorded with the aid of using the Microlog facts collector. From the results, it's far viable to without difficulty are expecting the misalignment of the rotating device the usage of the spectral evaluation method. Vibration size and

evaluation is one of the maximum vital device condition tracking strategies for detecting and diagnosing rotating device failures. This avoids unexpected interruptions and saves price and time.[16]

S. K. Nithin This paper focuses the significance of circumstance monitoring in the mechanical subject. Many mechanical field operations have been studied and springs to concluding that Vibration analysis is an key a part of a prognostic preservation programs and is one of the most useful strategies of situation upkeep. The Vibration analysis for device health tracking is a easy, competitively priced, and effective technique for early fault detection to keep away from surprising downtime and massive repair costs. Monica Tiboni gives detailed information on monitoring vibrations in rotating equipment permits effective diagnostics, as strange functioning states are related to specific patterns that may be extracted from vibration indicators.[15]

Desavale R. G. discuss on a Theoretical and experimental studies on vibrations generated by defects in tapered roller bearings using vibration characteristic analysis. In this study, an experimental reasoning of self-alignment with different states of sin was completed. Experimental results are most appreciated as they allow us to obtain a clear intuition about the relevant signals. Before that, a reversal study, which can be modified several times, is performed to establish a clear relationship between the vibration magnitude and various additional limits.[6]

LITERATURE GAP

From the literature survey it is found that the majority of studies have developed vibration Models of fault diagnosis a separately fault diagnosis for bearings and separately for gears are carried out or for particular application is carried out. Many researchers are focus on a single stage spur gearbox, single or double stage helical gearbox for fault diagnosis and feature extraction with suitable signal processing methods. Less attention was paid towards bevel gear box with combination of taper roller bearing.

PROPOSED WORK

The Stability of a gear box has been analyzed by the signature analysis of vibration. In gear box several defects are obtained during working condition. So, Analysis of these defects is an important studies to

diagnosis the faults in system. In this proposed work a single stage bevel gear box with single row taper roller bearing gears will be used. Signal processing techniques are used to obtain characteristics information from the vibration signals. These vibration analyses will be used as a method of diagnosis of fault. In this work, healthy system will compare with faulty system. Analysis will be carried out for monitoring the status in gear and bearings. For this theoretical (Numerical) studies and results will be carried on healthy and faulty system by using suitable software, also experimental set up shall be developed. For getting vibration signature for different defects Spectrum and cepstrum analysis will be carried out, with the help of FFT Analyzer. These theoretical and experimental results will be studied with suitable analysis techniques for detection of defects and for condition monitoring.

The following faults occurred in bearing and gear will be considered for a study :-

For Bearing (Taper Roller Bearing)

In general, failure of bearing occurs not due to breakage of parts but due to damage of working surface of its parts.

a)　Wear

b)　Pitting

B)　For Gear (Bevel Gear)

a)　Wear

b)　Fatigue failure

i)　Pitting ii) Fracture

c)　Corrosion.

Developed Experimental Setup

Experimentation-

For Experimentation the following 4 conditions will be consider

1.　Healthy gear and Healthy Bearing

2.　Faulty gear and Healthy Bearing

3.　Healthy gear and Faulty Bearing

4.　Faulty gear and fault Bearing

By using two vibrational signal processing techniques: Spectrum and Cepstrum analyses with the help of a FFT Analyzer and comparison between two vibrational signal processing techniques will be done.

Experiment trials for above each mentioned conditions will be performed as detailed below:-

Influence of speed

In steps of 250 rpm, the speed of the rotor varied between 500rpm and 3000rpm. For each speed, the amplitude of vibration is measured. The vibration amplitude and frequency variations with speed will be illustrated.

Influence of load

Using the experimental setup the load on the system can be changed. The testing are varied by changing the load between 50N to 500N in steps of 50N while keeping the rotor speed constant at 2500rpm. Each load's amplitude and Load is determined.

CONCLUDING REMARKS-

For a rotor-bearing-gear system, vibrations initiated by the combined damages in gears and bearings usually cannot be recognized readily without special treatment to the vibration signature. As such, the aim of this research detects the defect of a rotor-bearing-gear system to avoid the resulting great loss by vibration signature analysis.

REFERENCES

1. Akhand Rai et.al. ,(2015), " A Review on Signal Processing Techniques Utilized in the Fault Diagnosis of Rolling Element Bearings." , Tribology International (www. Elesvier.com/locate/jtri) pp. 01-51

2. Abd-Elbary Mohamed B. (2021), "Fault Diagnosis in Rotating System Based on Vibration Analysis", ERJ, PART 3, Prod. Eng., Vol. 44, No. 3, July 2021, pp. 285 – 294

3. Adnan Althubaiti (2020), " Fault diagnosis and health management of bearings in rotating equipment based on vibration analysis – a review" , JOURNAL OF VIBRO ENGINEERING. FEBRUARY 2022, VOLUME 24, ISSUE 1, PP46-74

4. BEHARA SANTOSH SAGAR (2020), "A REVIEW ON VIBRATION ANALYSIS OF ROTOR SHAFT SYSTEM BY VARIOUS FAULT DIAGNOSIS TECHNIQUES" International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) ISSN (P): 2249– 6890; ISSN (E): 2249– 8001 Vol. 10, Issue 3, Jun 2020, 13441–13450

5. Dennis Hartono et.al. (2016), "Bevel Gearbox Fault Diagnosis using Vibration Measurements,MATEC Web of Conferences ICFST 2016

6. Desavale R.G et.al., (2014), "Theoretical and Experimental Studies on Vibrations Produced by Defects in Taper Roller Bearing using Vibration Signature",International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 5, May – 2014 pp. 2279-2283

7. Dhamade Laxmikant etal. (2016), "Detection Of Combined Gear –Bearing Fault In Single Stage Spur Gear Box Using ANN", 12th International Conference on Vibration Problems(ICOVP 2015) pp.759-766

8. Goyal D.(2018) et.al, "Condition monitoring of rotating machines: A review", An International Scientific Journal, WSN 113(2018)98-108, 2018

9. IlhanAsilturket.al. (2017) " Machinery Monitoring using Vibration Signal Analysis", International Journal of Mechanical and Production Engineering, Volume 5 pp.21-25

10. Jayaswal Pratesh et.al, (2008) "Review Article: Machine Fault Signature Analysis", International Journal of Rotating Machinery, Volume 2008 pp.01-10.

11. Mouleeswaran, Senthilkumar, et.al. (2015) "Vibration Monitoring for Defect Diagnosis on a Machine Tool: A Comprehensive Case Study", International Journal of Acoustics and Vibration,Vol.20 pp. 04-09

12. Mohamad, T.H (2020), "A Review of Phase Space Topology Methods for Vibration-Based Fault Diagnostics in Nonlinear Systems". J. Vib. Eng. Technol. 2020, 8, 393–401.

13. Malla, C.; Panigrahi (2019) , "Review of Condition Monitoring of Rolling Element Bearing Using Vibration Analysis and Other Techniques" . J. Vib. Eng. Technol. 2019, 7, 407–414.

14. Mobley K(1999)., Vibration fundamentals. Elsevier, 1999.

15. Nithin, S.K (2022), "Importance of condition monitoring in mechanical domain". Mater. Today Proc. 2021, in press.

16. Omar D.H. (2021), "Early Fault Detection by Vibration Measurement", International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249-8958 (Online), Volume-10 Issue-5, June 2021, PP358-365

17. Renping Shao. Etl. (2011), "Gear Damage Detection And Diagnosis System Based On COM Module", Advanced in Control Engineering and Information Science, pp. 2301-2307

18. Sumitkumar Sar, et.al. (2015), " Techniques of Vibration Signature Analysis", International Journal of Advanced Research in Computer and Communication Engineering, Vol. 4 pp.240- 244

19. Tiboni Monica (2022) , "A Review on Vibration-Based Condition Monitoring of Rotating Machinery", Appl. Sci. 2022, 12, 972. https://doi.org/10.3390/app12030972 https://www.mdpi.com/journal/applsci, PP 01- 44

20. Tenali N,(2017) "Vibrational analysis in condition monitoring and faults diagnosis of rotating shaft overview" , International Journal of Advanced Engineering Research and Science (IJAERS), Vol. 4, Issue-1, Jan 2017

21. Thomson(2018), Theory of vibration with applications. CRC Press, 2018.

22. V. Vakaharia, et.al. (2016), " Bearing Fault Diagnosis Using Feature Ranking Methods and Fault Identification Algorithms", 12th International Conference on Vibration Problems(ICOVP 2015) pp.343-350 23. Vernekar Kiran et.al. (2015), " Fault Detection Of Gear Using Spectrum And Cepstrum Analysis",Proc Indian Natnsciacad81 No. 5 December 2015 Pp. 1177-1182

24. Vikassharma, et.al (2016) "A review of gear fault diagnosis using various condition indicators", 12th International Conference on Vibration Problems(ICOVP 2015) pp.253-263.

25. Zakuddinet K.S., et al. (2013) "Fault Diagnosis of Gear by Vibration Analysis", International Journal of Latest Trends in Engineering and Technology, Vol 3 pp.26-32.

26. Biqing Wu (2005), VIBRATION MONITORING FOR FAULT DIAGNOSIS OF HELICOPTER PLANETRY GEARS, https://doi.org/10.3182/20050703-6-CZ-1902.00127IFAC Proceedings Volumes Volume 38, Issue 1, 2005, Pages 755-760.

27. Xiaoyun Gong (20170, Gear Fault Diagnosis Using Dual Channel Data Fusion and EEMD Method,https://doi.org/10.1016/j.proeng.2017.01.242, Procedia Engineering Volume 174, 2017, Pages 918-926

28. T. Praveenkumar (2014) a Fault Diagnosis of Automobile Gearbox Based on Machine Learning Techniques, https://doi.org/10.1016/j.proeng.2014.12.452 Procedia Engineering Volume 97, 2014, Pages 2092-2098.

Textile Industry Effluent Component Recovery by Ultrafiltration Followed by Nanofiltration

Pragati A. More
Avinash B. Pawar*
Department of Chemistry
BVDU, Y M College
Pune, Maharashtra
✉ ssapmore@gmail.com
✉ abpower@yahoo.com*

Yogesh J. Chendake
Department of Chemical Engineering
BVDU, College of Engineering
Pune, Maharashtra

Sachin J. Mane
Department of Civil Engg.
D Y Patil CoE, Akurdi
Pune, Maharashtra

ABSTRACT

The textile industry effluent is analyzed and found that it is highly contaminated, has dark color, BOD/COD ratio is low and TSS and TDS is high (concentrated salts). Heavy metals are also observed considerable, BOD and COD values are high. This is due to dyes stuff, chemicals like caustic soda, salts and detergents. This paper optimizes membrane characteristics for separating the important components from the textile wastewater. The parameters such as high energy utilization, low output volume, fouling of membrane and the generation of concentrated wastewater as secondary pollutant were analyzed and attempt to optimize. Formed membranes showed excellent removal of impurities, validated from ICPMS. Further 7 to 20 % clarified alkali solution concentration was recovered alkali can be reused techno-economically in various applications. Thus, the process provides an economically attractive and environmentally benign process.

KEYWORDS: Textile industry effluent, Nanofiltration, Ultrafiltration, Membrane, Recovery of alkali.

INTRODUCTION

The waste water from textile industry contains huge quantities of chemical substances in complex form like dyes, unused materials during various stages of textile manufacturing or processing. In the textiles production and in the colour application process, the textile industry effluent becomes highly concentrated with chemical and hence pollute water stream. Approximately 200-250 liter of water is used to produce 1 kg of textile and therefore the quantity of wastewater generated is also very high. Water and chemical recovery have become a major problem due to economic and ecological concern as well as strict regulations act for wastewater discharge of textile effluent. After studying literature, we observed that the conventional methods for treating textile effluent are not sufficient.

The coagulation/flocculation is associated with large volumes of sludge production, also unable to treat reactive dyes, inorganic coagulants pose toxicity and health hazard, large amount of toxic sludge is produced, heavy metals removal is not effective. Major concern of Adsorption method is safe disposal of secondary pollutant produced and the adsorbent regeneration, not an economic method. Advanced treatment is essential for the biologically treated wastewater to meet the standards for discharge, non-biodegradable contaminants cannot be removed, capital, operating as well as maintenance cost is very high. Advanced oxidative processes having high cost perhaps the most significant disadvantage and the chemistry of the process is tailored to specific contaminant only. The lifespan of oxidants is significantly short, the precipitates produced

during oxidation process require secondary treatment. The most sustainable methods for industrial effluent is Membrane separation. Membrane treatment and recovery does not involve phase change It involves pores of the membrane deliver separation mechanically and concentrate the impurities. Textile wastewater can be treated using various membrane processes so that it can be reused. MF can be potentially used to remove colloidal impurities from exhausted dye baths and RO to concentrate exhausted dye bath as proposed by Buckly.

To overcome the above problems, new technologies such as membrane separation can be used to treat wastewater. The advantage of the membrane is that it can remove organic as well as inorganic pollutants from effluent, this reduces the COD, BOD and color of wastewater. Different technologies such as 'membrane bioreactor (MBR), ultrafiltration (UF), nanofilter (NF), reverse osmosis (RO) and membrane distillation (MD)' are used in wastewater treatment. The objectives of this work are to select parent material, to define the membrane properties, to formulate the membrane, to remove the effluent components like heavy metals, ions starch, colour by ultrafiltration and nanofiltration for the recovery of Caustic, suitability of membrane for transport and rejection properties. This paper fulfills the above objective with the steps as defining of membrane material and material properties, selection of backing material, preparation of membrane, membrane optimization, stream characterization and instruments, experimental setup, measurement of membrane, and rejection analysis.

MATERIALS AND METHODS

The wastewater samples were collected from selected textile industries and different locations and at different time in regent bottles as per standard sampling method. Conductivity is with a conductivity meter. Turbidity meter analysed for turbidity of the sample. The colour mixture of feed and filtrate samples analysed with Perkin Elmer Lambda 20 spectrometer. Colour is measured with the help of the absorbance value curve over the entire 'visible range (400-800nm)'. Total dissolved solids (TDS) of all samples were measured by drying at 105^0C using hot air oven. The COD reflux apparatus is used to measure the oxygen consumed (COD). Determination of Anions were carried out by

ion chromatography using a Met Rohm 751 Compact Ion Chromatography of known performance. Anion chromatography was measured with antibiotics using the Metrosep anion dual column. The pH is neutral, the electrical conductivity rages from 6750 to 10500 $\mu s.cm^{-1}$. The wastewater contains total dissolved solids in high quantity due to which the wastewater becomes viscous. The TDS of the textile industries were found 8461 mg/l. The BOD is 750 mg/l and COD is 2550 mg/l. The concentration of anions for Ca^{2+} is 587.0 mg/l, K^+ is 157.9 mg/l, Mg^{2+} is 41.8 mg/l and Na^+ is 3310.5 mg/l. After waste water analysis the formation, casting and analysis of membrane were carried out.

Formation of Solution: 82 gm of moisture free PSF crystal was added with 200 ml of N, N- Dimethyl acetamide and mixed using agitator. Ensure complete dissolution for 46 hours preventing dust and moisture to enter the system. Centrifuge for 30 minutes after degassing.

Casting of Ultrafiltration Membranes: Formulated solution was poured on the casting plate with extruded polypropylene as backing. Three tanks filled with water setup in series with first "gelation tank "at 8°C, 2nd "rinsing tank" at room temperature and 3rd "curing tank" at 40°C. Adjust the gap between backing and doctor knife with the around knife setting and maintain air gap with the help of stepper meter control system.

Casting of Nanofiltration Membrane: Clean the tray plate and fill with water around 60%. After cleaning the glass plate well, set the cellulose paper on it with the help of the tape. Now slowly drop 21% solution on the glass plate. Now start the machine by pressing the button. The solution is spread on the cellulosic support in the form of layer. Let the glass plate slide into the tray filled with water, and the membrane is obtained.

Analysis of Membranes: In dead end cell analysis, we add the material in enclosed cell. This assembly is mounted on membrane placed on the porous sheet and a collector. It is sealed with tie rods duly supported by O-rings. This has made an arrangement to apply desired pressure in controlled form, and we measure the transport properties. Crossflow analysis includes three tank, two pumps, supervisory control, data acquisition system and other necessary equipment. Here we select the UF and NF sequence. The wastewater is collected in

the first tank and then passes through the ultrafiltration membrane.

Fig 1: Formulation

Fig 2: Casting

Fig 3: Analysis

The ultrafiltration filtrate enters the second tank. The filtrate in the second tank passes through the nanofiltration membrane and is collected in third tank. The membranes used in the system have been tested and each has 1 UF and 1 NF. Membrane Characterization:

As per results of analysis, membrane from Polysulfone is one of the best materials to treat textile wastewater, considering the properties like thermal stability, chemical resistance to bases, acids and chlorine, mechanical strength, processibility etc. Pilot scale polymeric UF and NF membrane system was prepared with our basic objectives.

Table 1: Properties Ultra and Nano Filtration

Parameter	Ultrafiltration		Nanofiltration
Support layer	Cellulose	Polypropylene	Polyester
Active layer	Polysulfone	Polysulfone	Polysulfone
Channel dia (μm)	26	265	14
Membrane area (mm)	50	50	50

Membrane Optimization

Membrane fouling (pore clogging and/or filter cake) can cause a decrease in flux and reduced performance. The study on combination of two membranes was carried to reduce the fouling of membrane: effect caused due to clogging of particles present in textile effluent. Nanofiltration process is followed by Ultra Filtration (UF used as a pretreatment). Comparisons were made between direct NF and UF.

RESULTS AND DISCUSSION

Selection of membrane material and its properties: The commonly used polymer in textile industries is Polyacrylonitrile, Polyvilidene fluoride (PVDF), Styrene–Butadiene Polymers, and Polysulfones. In our study, we preferred Polysulfone (PSF) over other polymers due to their reaction with NaOH and hence affecting the stability and strength of the polymer. PSF (high performance thermoplastics) known for their durability and stability at high temperatures. They are hydrolytically resistant to aqueous and alkaline environments, chemically inert, mechanically stable in solvents, but insoluble in water and therefore contribute to phase separation. PSF membranes are widely used because of high mechanical strength great stability, more over modification of PSF membranes very easy. Performance can be improved with modification which increases applicability of membrane in wastewater treatment, as shown in Table 1, Properties Ultra and Nano Filtration.

Selection of backing material: The nature of the water system is an important consideration when choosing a recovery device. Understanding the required liquid rate, pore size and porosity, and water transport properties leads directly to the correct recovery configuration and geometry. Some familiar backing materials used in membrane separation are as

1) Polyester: NaOH hydrolyses polyester breaking its ester bonds and hence affecting its mechanical strength. Due to this reason, polyester is not a good choice for backing material in this situation. 2) Polypropylene: Polypropylene as backing material cannot be a suitable backing here due to adhesion of Polysulfone which will affect the membrane stability since the polypropylene can be easily peeled off. 3) Cellulose: Due to its high tensile strength, insolubility in water and its plant-based nature and high porosity, cellulosic membrane is the suitable and preferred backing material in our experiment. It is both a chemically and mechanically stable natural polymer.

Bubble point Analysis: For each 1 ml of solution, bubble point observed at different time intervals at different pressures for each membrane is mentioned below in the Figure 4.

The tests were carried out at pressures between 0.5 bar and 6 bar. Samples and filtrate were analyzed at different flow rates and the effect of membrane pressure on filtrate flow was evaluated. As shown in Figure 5, the permeate flow varies linearly with membrane pressure, indicating the high efficiency and good stability of the membrane.
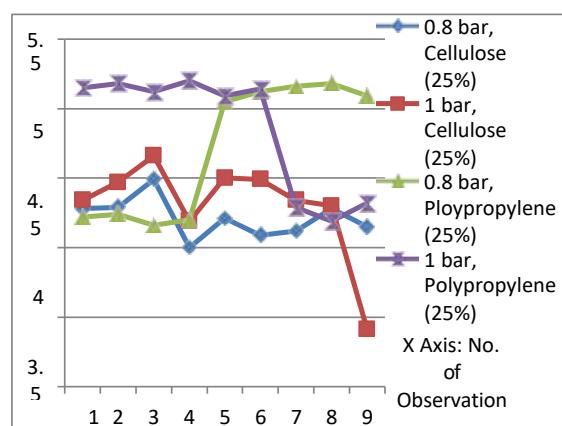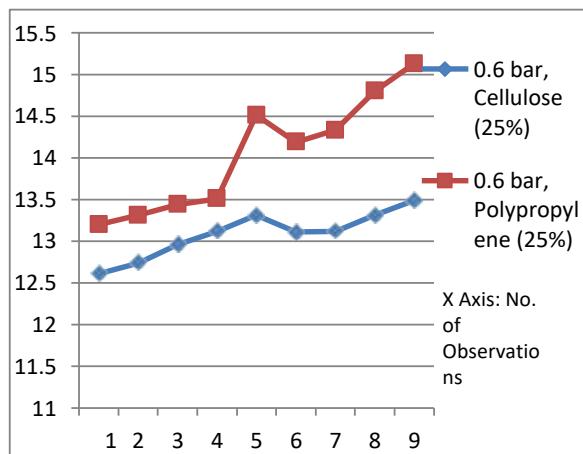
Fig. 4: Bubble point at different time intervals at different pressures (0.6, 0.8 and 1 bar)
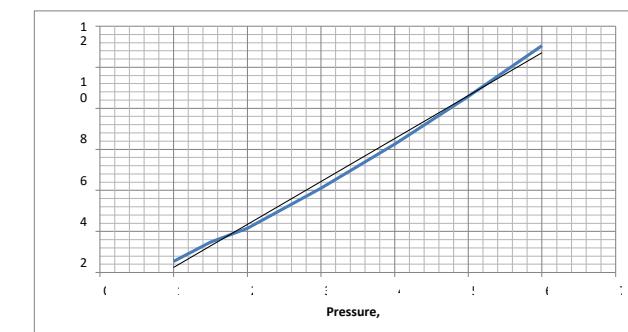
Fig 5: Comparison between flux rate vs pressure (25%)

Flux calculation

$$\text{Membrane flux,} = \frac{\text{Vol}}{\text{Area} \times \text{Time}} \ (\text{lit} / \text{m}^2 / \text{hr})$$

Clarification analysis

The filtration will remove most particles, sediments, oils, organic matter and colour of the water to provide clarity. The clarification step is the first part of the routine wastewater treatment.
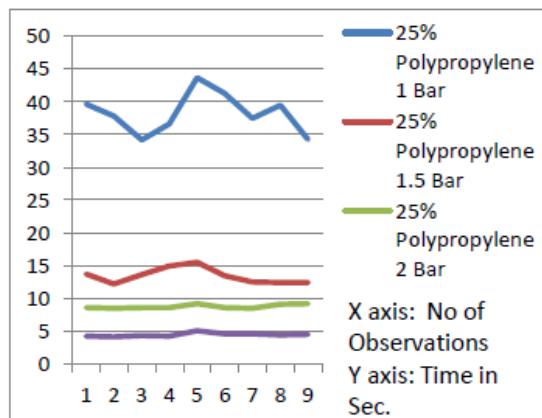
Fig 6: Before clarification
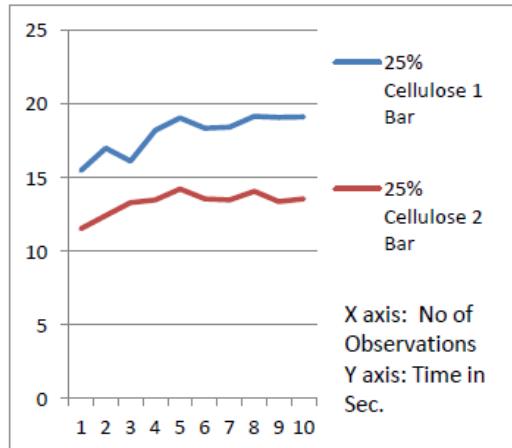
Fig 7: After clarification

For the clarification process we used two UF membrane with backing of polyester and polypropylene at different pressures and results were satisfactory. Large amounts of heavy wastewater containing contaminants such as dyes, dissolved solids, suspended solids and toxic metals are removed.

Fig 8: Time for different pressures for 25% Polypropylene

Fig 9: Time for different pressures for 25% Cellulose

Molecular Weight Cut-off

The molecular weight limit (MWCO) is the lowest molecular weight solute (in Daltons) at which 90% of the solute is retained by the membrane. Ultrafiltration membranes are generally characterized by molecular weight cutoff values (MWCO), meaning that the membrane rejects more than 90% of the smallest species. Retention is defined as 1 minus the CP solution in the filtrate divided by the solvent concentration in the bulk solution,

$$\text{“CB : σ”} = (1-\text{CP})/\text{CB}$$

Because the molecular weight cutoff value depends on the type and activity of the solute, it is used only for tests performed by the manufacturer. We generally choose a molecular weight limit that is 3 to 6 times smaller than the molecular weight of the product to be stored. When our main concern is flow rate, we choose membranes with a molecular weight cutoff (MWCO) at the lower end of this range (3x). In the next step fuse is our main concern and we chose a thin layer (6x). Solute retention and selectivity will vary depending on many factors such as pressure, molecular shape, presence of other solutes, and ionic conditions. Current work of removal of components and recovery of alkali would facilitate its reuse. This would lead to additional economic benefits. As per the assessment 1 Kg of textile requires 210 liters of water. Now these 210 liters of water with 7% of alkali would makes 14 kg of caustic.

The commercial cost of caustic soda range in the range of Rs 30 to 60/- kg. Each recovery and recycle would lead to economic benefits of Rs 420 to 840/- kg of textile fabric. Now to the amount of Rs 420/- kg seems smaller but in industrial production would make it huge with per day production in tons. The results show that the second treatment improves the quality of data entry, ensuring that most of the analyzed results are retained. In fact, the color retention rate is about 95%, the conductivity and total dissolved salt retention rate is about 80%, and the divalent ion value is more than 95%. After combining the ultrafiltration and nanofiltration methods, stable permeate flow was observed until the reduced volume (VRF) reached 2.77. The results showed that using ultrafiltration as a pretreatment for the nanofiltration process improved the textile wastewater treatment performance by increasing

the working time of the membrane. Other important points to consider when optimizing membrane functionality: 1) Pore size optimization: The separation of materials from a membrane depends on the pore size and molecular size. Pore geometry strongly affects flux. We focus on the hydrodynamic interaction and consider the electric field between the surface and the pores. 2). Increase in rejection of solution material was observed with decrease in pore size and porosity. The formation of negative films with no significant difference in pore size from transport properties was observed. To improve the selection, the pore size remains unchanged as can be seen from the bubble point, rejection and pore size analysis. Considering the waste information, it is very important to add transportation with a high selection.

CONCLUSION

Model textile waste water purified using two membrane filtration processes i.e., Nanofiltration and Ultrafiltration. In the first stage, the possibility of treating textile wastewater containing various contaminants like starch, waxes, grease, soda ash, fibers, surfactants, hydrochloride, dyes, soaps, oils, mordents, etc., was investigated through the ultrafiltration membrane. Formed membranes showed excellent removal of impurities, clear permeate solution was obtained and given for ICPMS to confirm their removal. Further the clarified alkali solution concentration was investigated and an increase in concentration from 7 to 20 % was possible which can be recycled back or used in other application. It would avoid disposal of alkaline effluent, while other components can be easily undergoing further treatment or disposal, without need for extreme conditions required at high pH. The recovered alkali can be reused techno-economically with a huge benefit. Thus, the process provides an economically attractive and environmentally benign process for recovery of alkaline and its reuse. While other components can be treated at less stringent conditions thus providing added benefits.

REFERENCES

1. A E Ghaly, R Ananth Shankar, M Alhattab, W Ramakrishna (2014), Production, Characterisation and Treatment of Textile Effluent: a critical review, Chemical Engineering and Process Technology, Volume 5, Issue 1, pp 1-18.

2. Cheima Fersi, Lassad Gzara, Mahmoud Dhabbi (2005), Treatment of Textile Effluent by Membrane Technologies, ELSEVIER, Desalination, Volume 185, Issues 1–3, pp 399-409

3. Srebrenkoska Vineta, Zhezhova Silvana, Risteski Sanja, Saska Golomeova (2014), Methods for Wastewater Treatment in Textile Industry, Unitech, International Scientific Conference, Gabrovo

4. Deepa Chandran, a review of the Textile Industries Wastewater Treatment Methodologies (2016), International Journal of Scientific & Engineering Research, Volume 7, Issue 1, pp 392-403

5. Sana Khan, Abdul Malik, Environmental and Health effects of Textile Industry Wastewater (2013) Environmental Deterioration and Human Health, pp 55- 71.

6. T. Marimuthu, S Rajendran, M Manivannan (2013), Decolourisation of Reactive Textile Dye Effluent by Using Bacterial Strain, International Journal of Scientific & Engineering Research, Volume 4, Issue 5, pp 1646-1657.

7. Sudevi Basu (2016), Colour Removal of Textile Industry Effluent using Waste Pea Pods as Adsorbent, International Research Journal of Engineering and Technology (IRJET), Vol. 3, No. 12, pp 190 – 192.

8. M Joshi, R Bansal, R Purwar (2004), Colour Removal from Textile Effluents, M Joshi, R Bansal, R Purwal, (IIT, Delhi), Colour Removal from Textile Effluents, Indian Journal of Fiber and Textile Research, Vol 29, pp 239-259.

9. Nouman Rafique Mirzaa, Ray Huanga, Erdeng Dub, Mingguo Pengb, Zhigang Panc, Hui Dingc, Guocheng Shanc, Ling Lingc, Zongli Xiea (2020), A review of the textile wastewater treatment technologies with special focus on advanced oxidation processes (AOPs), membrane separation and integrated AOP-membrane processes, pp 83-107.

10. Pei Sean Goh, Nidal Hilal, Innovative and sustainable membrane technology for wastewater treatment and desalination application (2020), Science Direct, Innovation Strategies in Environmental Science, pp 291-319.

11. Cheima Fersi, Mahmoud Dhabbi, Treatment of textile plant effluent by ultrafiltration and/or nanofiltration for water reuse (2008), ELSEVIER, Desalination, Volume 222, Issues 1–3, pp 263-271

12. Mishra S, Kharkar P S, Pethe A M, "Biomass and Waste Materials as Potential Sources of Noncrystalline Cellulose-Comparative Review of Preparation Methods, Carbohydrate Polymer, 2019, vol 207, pp418-427.

13. Pallavi Mahajan-Tatpate, Supriya Dhume1 and Yogesh Chendake, "Removal of Heavy Metals from Water: Technological Advances and Today's Lookout Through Membrane Applications", International Journal of Membrane Science and Technology, Cosmos Scholars, 2021, v 8, pp 1-21.

14. Kupnik K, Primozic M, Kokol V, Leitgeb M, "Nanocellulose in Drug Delivery and Antimicrobially Active Materials", Polymers, ACS OMEGA, 2020, 12, 2825.

Groundwater NO$_3$ Concentration And Potential Health Implications In Lower Krishna Basin

Bharthavarapu Srikanth
Research Scholar
Civil Department
Vel Tech Rangarajan Dr.sagunthala R&D Institute of Science and Technology
Avadi,Chennai, Tamil Nadu
✉ vtd589@veltech.edu.in

A. Geetha Selvarani
Professor
Civil Department
Vel Tech Rangarajan Dr.sagunthala R&D Institute of Science and Technology
Avadi,Chennai, Tamil Nadu
✉ geethacivil1201@gmail.com

G. Maheswaran
Dean - Research
Shanmuganathan Engineering College
Pudukkottai, Tamil Nadu

ABSTRACT

This research studied nitrate concentrations in water from an irrigated area in the lower Krishna basin and evaluated the health risks for humans of different ages. The findings showed that the average nitrate concentration in the groundwater was 39.79 mg/L, with a range of 0.6 to 93.9 mg/L. These levels were largely caused by human activities such as manufacturing and home wastewater penetration into the deep aquifer. The study found that 171 out of the sampled wells had varying levels of water quality, ranging from poor to excellent, based on Indian standards. Infants were identified as the group most susceptible to the effects of high nitrate levels, followed by females, males, and children. Ingesting nitrate through the mouth seems to be the primary way that people are exposed to it, which leads to a high non-cancer risk for those exposed. The level of risk, as measured by the hazard index (HI), varies depending on human activities and how densely populated an area is. These findings can be used to progress operative approaches for refining groundwater quality and ensuring safe drinking water. Additionally, these results could be used to establish drinking water quality standards for the study area and to guide decisions on the management of nitrate pollution in the area.

KEYWORDS: *Groundwater, NO$_3$ Contamination, Public health risks, Assessment.*

INTRODUCTION

Agriculture plays a critical role in ensuring a harmless, nutritive, and plentiful food supply for an emergent world population, making it a vital part of the global economy. However, it also consumes large amounts of fresh water, which can prime to the degradation of both external and groundwater resources (Sekhon 1995). In order to meet the demand for food, agricultural practices often involve heavy consumption of fertilizers and pesticides. If not properly coped, these practices can result in the adulteration of external and .groundwater with nutrients and insecticides. Consumption of water is one of the utmost intimidations to human wellbeing, and encompassing water has been found to have thru damage to human health in several parts of the world (Hodges 2017). In addition to this, there have been alarmingly high reports of other health issues in this region, such as impulsive hair greying, changing delay, sterility, aging, neurological and cardiac diseases, interactive disorders, generative abnormalities, and miscarriages (Halder and Research 2007). High nitrate levels in water can cause a variety of health problems, including disrupting the balance of both surface and groundwater environments (Vitousek, Cassman, et al. 2002). The foremost sources of nitrate in water are human activities, specifically agricultural

practices that involve the widespread use of nitrogen fertilizers and manure from livestock. Nitrate can also come from sewage discharge, but to a slighter level (Bednarek, Zalewski, et al. .2007). Nitrate, due to its great solubility in water and squat preservation by soil, can easily leach into the subsurface soil and reach groundwater when it is not operated by flora. High intensity of nitrate in drinking water can pose significant environmental and health risks, especially for newborn children. Studies have shown that nitrate pollution is a growing concern and there have been reports of dramatic increases in nitrate concentrations in groundwater in intensive agricultural areas around the world in recent years (Serio, Miglietta et al. 2018). With agriculture contributing 18% of India's GDP and employing 50% of the workforce, it is a vital sector of the Indian economy. India is a major creator of pulses, rice, wheat, spices, and spice foodstuffs. However, attention has been drawn to the issue of nitrogen cycling due to the high intensity of nitrates originating in groundwater. Studies have shown a strong correlation between nitrate levels in water and methemoglobin levels in the blood of infants in Namibia, further supporting the idea that nitrate-contaminated drinking water can cause methemoglobinemia in infants, as has been reported in other countries (Super, Heese et al. 1981). To the finest of our familiarity, there is an imperfect number of studies that have investigated the effects of nitrate contamination in groundwater on both human wellbeing and the atmosphere. (Barakat, Mouhtarim et al. 2019). The contemporary research, steered in 2020, aimed to ascertain the geographical distribution and fluctuation of nitrate levels in shallow groundwater in the Krishna Basin area and identify areas susceptible to nitrate contamination. The research also aimed to deliver orientation info on consumption water safety and assess the potential health risks associated with nitrate exposure through digestion and dermal alleyways for folks of dissimilar age groups. To accomplish this, a human wellbeing risk valuation was conducted, and the spatial deliveries of nitrate attentiveness and Hazard-Index (HI) were analyzed using GIS which represents Non-Carcinogenic risk.

STUDY AREA

Small reservoirs (tanks) were mostly used to control water in the lower Krishna basin before massive irrigation systems were developed by British engineers in the mid-1800s. Following India's independence, the Krishna delta project was transformed, and various irrigation and hydroelectric projects, notably Nagarjuna Sagar and Srisailam, were built. The rate of irrigation development, however in the in the 1990s, India's economy underwent liberalization . State assets in agriculture were weakened, whereas groundwater-related isolated and communal creativity rapidly increased. Between 1987 and 2001, the Krishna basin's well count expanded from 0.6 to 1.7 million, and in the early twenty-first century, the combined storage capacity of its foremost and intermediate reservoirs reached 54 billion cubic metres. Small-scale groundwater and surface irrigation systems grew as well, however, it is unclear how much water they can store altogether. As a result, the Krishna River's is discharging to ocean gradually declined starting in the 1960s, signalling to river basin closure, and the net irrigated area in the Krishna basin more than doubled since the 1950s. In the years 1996 to 2000, groundwater irrigation was responsible for 37% of the loss from irrigated areas, which resulted in decreased base flow and groundwater resource depletion.

SAMPLING AND ANALYSIS

The Central Ground Water Board (CGWB) developed a monitoring grid and sampling strategy to comprehensively research the groundwater quality in the Lower Krishna Basin. This program involved collecting 170 samples from bore wells within the irrigated perimeter during the years 2015-2016. The sampling wells were strategically placed using GPS, as showned in Figure 1.
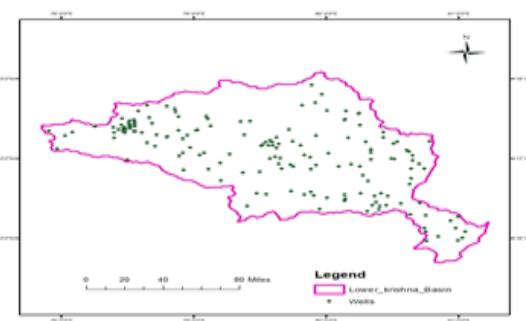
Figure 1 Studys area and sample collected map

The Central Ground Water Board (CGWB) analyzed 170 samples collected from the Lower Krishna Basin irrigated perimeter for nitrates, pH, electrical conductivity (EC), and piezometric level (PL) (NO3). The CGWB chose these metrics based on the area's known environmental processes (such nitrate pollution and salinization) and potential dangers related to agricultural practises The logical excellence was safeguarded by using consistent techniques and following normal methods (Rodier and Legube 2009). The outcomes were presented as regular annual values in meters for PL, dS/cm for EC, and mg/L for NO$_3$.

METHODS

Nitrate pollution assessment

The Central Ground Water Board (CGWB) database used in this research evaluated the eminence of groundwater in Lower Krishna Basin area with regard to latent nitrate pollution. Elementary evocative data .All leisurely variables in each well were examined for, such as minimum, maximum, mean, and standard deviation (SD). To assess if groundwater is suitable for drinking and to categorize polluted wells, the groundwater eminence structures were also contrasted with the 2008 and BIS 2012 water quality standards. Based on nitrate content, the CGWB groundwater evaluation grid divides groundwater into four quality classes: bad (more than 50 mg/L), fair (20–50 mg/L), good (10–20 mg/L), and excellent (less than 10 mg/L). The correlations between several leisurely restrictions were assessed using Pearson's correlation analysis

RISK ASSESSMENT FOR HUMAN HEALTH

Characterization of exposure

Elevated concentrations of nitrate's in water can pose health risks to humans who are bare over drinking and straight interaction. To measure human contact with this contaminant, replicas have been established by the USEPA, taking into account the attentiveness and delivery of chemical contaminants, the intensity, frequency, and duration of exposure. In this research, an empirical model proposed by Karunanidhi et al. (2020) stayed pragmatic to evaluate the latent non-oncogenic impacts of groundwater nitrates. Over oral ingestion,

nitrates' chronic daily intake (CDI) was intended in this model.

$$CDI = \frac{C_W \times IR \times EF \times ED}{BW \times AT_Z} \quad (1)$$

The risk of harm from oral intake and cutaneous contact with water was calculated using the hazard quotient approach in the study. The formula used to calculate the oral hazard quotient is as follows: HQ = CDI / Rfd, where IR stands for the ingestion rate (L/d), EF is the subjection of frequency (day/year), ED is average of acquaintance period (year), BW is the average body weight (kg), AT is the average contact time. CDI of groundwater is expressed as mg/kg/d. (The formula used to get the dermal hazard quotient is DAD = (Cw * IR * EF * ED) / (BW * AT), DAD is dermal absorbed dose. (Mutlu and Assessment 2020).

$$CDI = \frac{C_W \times K_i \times CF \times EF \times ED \times EV \times SA}{BW \times AT} \quad (2)$$

where CDI of nitrate over oral intake, taking into account the dermal absorbed dose (DAD), the dermal permeability coefficient (Ki), a conversion factor (CF), the contact time during bathing and showering (EV) and the area of skin that can be touched (SA). The area of the skin is calculated using an equation that takes into account a person's height (H).

$$SA = 239 \times H^{0.417} \times BW^{0.517} \quad (3)$$

n its analysis, it takes into account newborns (under 5 years old), children (ages 5 to 17), and adult males and females. The values utilised in the formulae for the health risk assessment parameters are based on the subjection factor value advised by the USEPA. (as listed in Table 1).

Table 1 shows the values for the human exposure parameters used to calculate the hazard index (HI)

	Male	Female	Children	Infant
IR	2.5	2.5	1.5	0.78
EF	365	365	365	365
ED	30	30	12	0.65
BW	70	65	45	16
AT	10,950	10,950	4,380	237.25
Ki	0.001	0.001	0.001	0.001

CF	0.001	0.001	0.001	0.001
EV	1	1	1	1
H	165	152	150	100
SA	18,071	16,807	13,821	6,838

Non-carcinogenic risk estimation

This research aimed to estimate the potential non-carcinogenic risks associated with water contamination by nitrates in the Lower Krishna Basin. Nitrate contamination of groundwater can cause public concern due to its potential to cause adverse health effects. The research used the hazard quotient (HQ) method to calculate the risk of harm from oral ingestion and dermal contact of water.

$$HQ_o = \frac{CDI}{RfD_o} \tag{4}$$

$$HQ_d = \frac{DAD}{RfD_d} \tag{5}$$

In the lower krishna basin, stream flow reduction is probably aided by groundwater irrigation, although the amount of this relationship is unclear. Although excessive groundwater usage can temporarily offset the loss of surface water, it eventually makes the problem of excessive water use worse.

where RfDo (1.6 mg-daykg) and RfDd (0.8 mg-daykg) are the reference doses of NO$_3$ for oral intake and dermal absorption, respectively. The hazard thresholds for oral ingestion and dermal concern to water, &,respectively, are HQo and HQd. Aravinthasamy, Karunanidhi, and others 2020). Equation (6)'s quantities of iHQo and iHQd are correlated with the hazard index (HI),

$$HI = HQ_o + HQ_d \tag{6}$$

HI implies non-carcinogenic risk is tolerated, however HI > 1 shows that the potential health risk exceeds the permissible level for exposed human. 2016; Chen, Teng, et al.

RESULTS & DISSCUSSION

Spatio-temporal distribution of nitrate's in groundwater

Table 2 displays descriptive data for PL and physico-chemical restrictions (pH, EC, and NO$_3$) of groundwater in the lower Krishna basin.

The PL research's findings revealed that the depth of the groundwater in the area was between 0.48-30m, with an average depth of 7.9m. The pH of the analyzed groundwater samples was found to be between 6.63-8.92, indicating a weakly acidic to basic nature. The electrical conductivity (EC) of the groundwater was found to be between 0.21-7.25 ds/m, on an average 1.48 ds/m. These values are below the permissiible limit. According to the EC values, 13.33% of the groundwater wells had very poor water quality, 4.44% had poor water quality, 62.22% had fair water quality, and 20% had decent water excellence. The comparatively high EC values are likely due to soil quality and human activities.

The examined groundwater samples had NO$_3$ concentrations ranging 0.6 to 93.9 mg/L.with average of 78.79 mg/L (as shown in Table 2 and Figure 2). Of the samples, 17.78% had poor quality, 40.00% had fair quality, 37.78% had good quality and 4.44% had excellent quality in terms of NO3 content. These high proportions of tasters with poor to fair quality indicate that the nitrates in groundwater are likely from human sources.
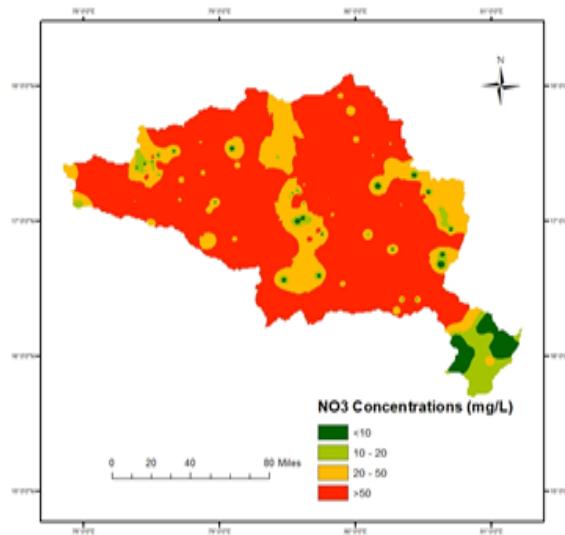
Figure 2 NO$_3$ concentration map

The variations in NO$_3$ levels among the studied wells may be influenced by multiple factors, including the proximity of the NO$_3$ source, recharge rate of the groundwater, precipitation levels, changes in the water table, evapotranspiration, soil texture and permeability

Table 2 data of the examined strictures of groundwater tasters in the study area, Indian standard and WHO standard.

	Min	Max	Mean	SD	N	Indian Standard	WHO Standard
					Wells		
PL(m)	0.48	30	7.96	5.64	208		
pH	6.63	8.29	7.79	0.38	230	6.5–8.5	7.0–8.5
EC (dS/m)	0.21	7.25	1.48	1.13	230	2.8	0.6
NO3 − (mg/L)	0.6	93.9	39.79	10.91	230	45	50

Non-carcinogenic risk assessment

The majority of nitrates in the human body come from drinking water. However, prolonged exposure to high nitrate levels in drinking water without taking protective measures can be harmful to human health. Some of the investigated wells were utilised for both home and agricultural irrigation, and the high nitrate levels found there could be hazardous to human health through different exposure routes like oral and cutaneous. Therefore, it is important to conduct a risk assessment of nitrates on human health.

For adults, females, children, and newborns, the hazard quotient (HQo) for nitrate was determined to be 1.75, 1.89, 1.64, and 2.4, respectively. These findings show 40% of wells had an HQo above 1, indicating that the untreated use of water from wells is not advised. The HQo of nitrate was found to be highest in babies and lowest in females, as shown in Table 3. In all wells under study, the HQd of nitrates for newborns, women, men, and kids was less than 1. Infants and kids had the greatest HQd levels. Among instances, the HQd ranged from 0.001 to 0.5 for infants, kids, women, and men (Table 3). These findings demonstrate that cutaneous exposure poses a lower non-carcinogenic risk than oral consumption.

In order to assess the non-carcinogenic risk, the HI was adopted. Its values ranged from 0.01 to 30.78, with clear differences amongst the receptors (as shown in Table 4). Because of their greater susceptibility to developing toxicity, newborns in the study region are more likely to be impacted by higher nitrate levels in groundwater, as shown in Table 4 and Table 3 (a-d). The spatial distribution of HI investigated by GIS in order to lessen groundwater contamination, and HI maps were generated for each site under study using the IDW method of interpolation. These maps revealed a distinct variation in the HI values' spatial distribution (as shown in Figure 3).
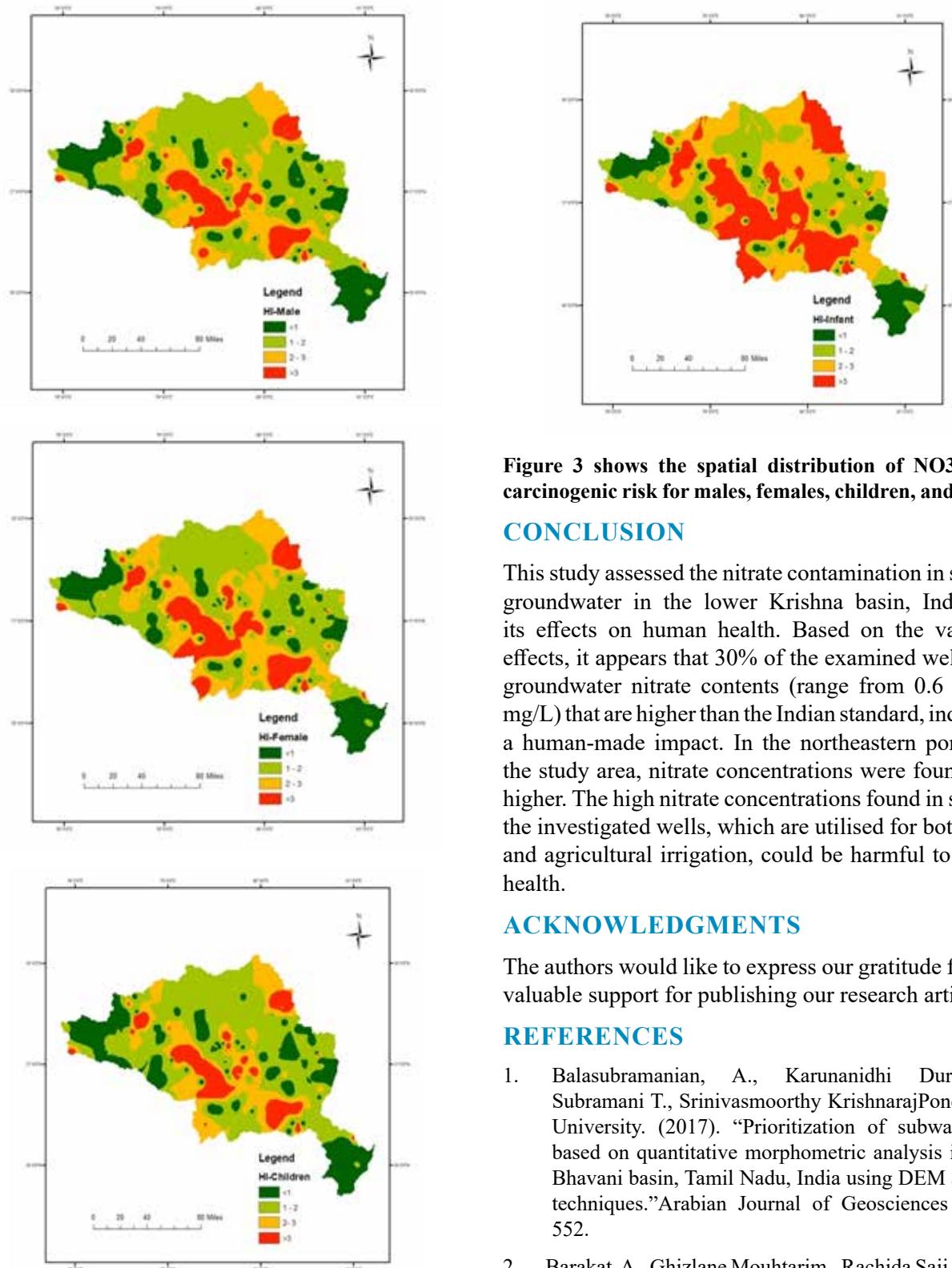
Table 3 Statistics of Results for NO$_3$ in Groundwater from HQo, HQd, and HI

	Male	Female	Children	Infant
		HQo		
Min	0.013393	0.014423	0.0125	0.018281
Max	22.16518	23.87019	20.6875	30.25547
Mean	1.75881	1.894103	1.641556	2.400775
SD	2.436678	2.624115	2.274233	3.326066
		HQd		
Min	0.000196	0.000197	0.00023	0.000321
Max	0.324463	0.326181	0.381229	0.530479
Mean	0.025746	0.025883	0.030251	0.042094
SD	0.035669	0.035858	0.04191	0.058317
		HI		
Min	0.013589	0.01462	0.01273	0.018602
Max	22.48964	24.19637	21.06873	30.78595
Mean	1.784556	1.919985	1.671806	2.442869
SD	2.472347	2.659973	2.316143	3.384383

Table-4 provides statistics on HI for NO3 in the groundwater under study

	Male	Female	Children	Infant
		HI		
Min	0.013589	0.01462	0.01273	0.018602
Max	22.48964	24.19637	21.06873	30.78595
Mean	1.784556	1.919985	1.671806	2.442869
SD	2.472347	2.659973	2.316143	3.384383

Figure 3 shows the spatial distribution of NO3's non-carcinogenic risk for males, females, children, and infants

CONCLUSION

This study assessed the nitrate contamination in shallow groundwater in the lower Krishna basin, India, and its effects on human health. Based on the valuation effects, it appears that 30% of the examined wells have groundwater nitrate contents (range from 0.6 to 93.9 mg/L) that are higher than the Indian standard, indicating a human-made impact. In the northeastern portion of the study area, nitrate concentrations were found to be higher. The high nitrate concentrations found in some of the investigated wells, which are utilised for both home and agricultural irrigation, could be harmful to human health.

ACKNOWLEDGMENTS

REFERENCES

1. Balasubramanian, A., Karunanidhi Duraisamy., Subramani T., Srinivasmoorthy KrishnarajPondicherry University. (2017). "Prioritization of subwatersheds based on quantitative morphometric analysis in lower Bhavani basin, Tamil Nadu, India using DEM and GIS techniques."Arabian Journal of Geosciences 10(24): 552.

2. Barakat, A., Ghizlane Mouhtarim., Rachida Saji., Fatima Touhami. (2019). "Health risk assessment of nitrates

in the groundwater of Beni Amir irrigated perimeter, Tadla plain, Morocco." Human and Ecological Risk Assessment, 1-15.

3. Bednarek, A., (2007). "Management of lowland reservoir littoral zone for enhancement of nitrogen removal via denitrification." Taylor & Francis Group, pp. 293-299.293-299.

4. Haiyang Chen., Yanguo Teng., Sijin Lu., Yeyao Wang., Jin Wu., J. S. Wang (2016). "Source apportionment and health risk assessment of trace metals in surface soils of Beijing metropolitan, China." Chemosphere 144: 1002-1011.

5. Dorin, B. and F. Landy (2002). Agriculture et alimentation de l'Inde: les vertes années (1947-2001), Editions Quae, Development durable et territoires

6. Etienne, G. . (2003). "F. Landy, L'Union indienne." Programme National Persée, ISSN 1293-8882. - Vol. 44.2003, 44(173): 233-233.

7. Gunningham, N. and . Sinclair (2005). "Policy instrument choice and diffuse source pollution." Journal of Environmental Law., 17(1): 51-81.

8. Halder, A. and D. Research (2007). "Premature greying of hairs, premature ageing and predisposition to cancer in Jajjal, Punjab: a preliminary observation." Journal of Clinical and Diagnostic Research 6: 577-580.

9. Hanumantha Rao, (2006). "Integrated Water Resources Development in Andhra Pradesh-Problems faced in "Jalayagnam" & Solutions."

10. Hodges, K. (2017). Arsenic-contaminated drinking water, American Association for the Advancement of Science.

11. Karunanidhi, D., (2020). "Evaluation of non-carcinogenic risks due to fluoride and nitrate contaminations in a groundwater of an urban part (Coimbatore region) of south India." Environ Monit Assess., 192(2): 102.

12. Mittal, S., Ravishankar Kumar, Prafulla Kumar Sahoo., Sunil Sahoo. (2020). "Geochemical assessment of groundwater contaminants and associated health risks in the Shivalik region of Punjab, India." Toxin Reviews, 1-17.

13. Mutlu, A. (2020). "Air quality impact of particulate matter (PM 10) releases from an industrial source." Environmental Monitoring and Assessment, 192(8): 1-17.

14. Rodier, J. and B. Legube (2009). Assessment of Ground Water Quality in Baba I Village, North-West Cameroon, L'analyse de l'eau, Dunod.

15. Sekhon, G. (1995). "Fertilizer-N use efficiency and nitrate pollution of groundwater in developing countries." Journal of Contaminant Hydrology,20(3-4): 167-184.

16. Francesca Serio a, PierPaolo Miglietta, Lucrezia Lamastra, Salvatore Ficocelli, Francesca Intini, Federica De Leob, Antonella De Donno (2018). "Groundwater nitrate contamination and agricultural land use: A grey water footprint perspective in Southern Apulia Region (Italy)." Sci Total Environ, 645: 1425-1431.

Simplified Method for Computing Attainments in the OBE Framework

Kanmani Buddhi   **C Gururaj**   **Shreenivas B**

Department of Electronics and Telecommunication Engineering
BMS College of Engineering
Bengaluru, Karnataka
✉ bkanmani.tce@bmsce.ac.in

ABSTRACT

Outcomes Based Education (OBE) is being practiced by all institutions across the country. OBE is the development of the Program Outcomes (POs) defined by the National Board of Accreditation (NBA). OBE is significantly addressed through the Course Outcomes (COs) of various courses of the Curriculum. Well-defined COs, together with relevant assessments, becomes the core parameter for academic quality of OBE. However, in addition to defining the COs, there is also a need to measure the attainments of the COs. This computation is elaborate and there exists a micro-level analysis, resulting in the task of analyzing large volumes of small numbers. While this method is an exact measurement of the attainment, we propose an alternate and simplified method that provides reasonable attainments. If the proposed method is adopted for CO attainment, it shall result in huge saving of faculty time, which can be used for other academic responsibilities. In this work, we present details of CO computations by the usually adopted method and as well the proposed method, for three different courses. In addition, summary of online faculty survey conducted on OBE processes is included.

KEYWORDS: *Outcome based education, Program outcomes, Course outcomes, Attainments, Assessments.*

INTRODUCTION

The Washington Accord is an International agreement between bodies responsible for accrediting engineering degree programs [1]. In 2014, India was recognized as one of the Signatories with full rights of participation in the Accord, with India being represented by the National Board of Accreditation (NBA) [2, 3]. This recognition ensures that the engineering degree of students graduating from NBA accredited programs of autonomous Institutions is valid by all countries who are signatories of the Washington Accord. This is possible because NBA has included the expected Graduate Attributes [4, 5, 6] through the Program Outcomes (POs), for Undergraduate engineering programs, to ensure global competence of our engineering graduates. Hence, to ensure global recognition and acceptance of our engineering graduates, there is a need to develop the twelve POs defined by NBA in all students through the engineering program. The POs are significantly addressed through the Course Outcomes (COs) of various courses in the curriculum and further though the co-curricular and extra-curricular activities on campus. The POs defined by NBA are common for all engineering disciplines, and hence, NBA requires programs to define two to four additional outcomes, known as Program Specific Outcomes (PSOs) [7, 8]. This academic process of consciously planning to develop the POs in all students is known as Outcomes Based Education (OBE). Towards ensuring an effective implementation of OBE, there has been sincere efforts in framing COs; mapping the COs to the POs/PSOs; assigning strength to the CO-PO mapping; designing assessments that help measure the defined COs; followed by the computation of attainments towards continuous improvement [9, 10]. These OBE processes required huge change in the type of assessments, together with suitable changes in course delivery methods. Effective implementation of OBE, witnessed an improvement in student performance like: quality of student projects; student awards; performance in national/international

competitive examinations; on-campus placements; off-campus placements; the average salary; the highest salary; the entrepreneurs and securing admissions in premier institutions for higher education. This visible improvement in student performance, enhanced the peer perception of the program in the region, and resulted in improvement in the quality of students getting admitted to the program. Improvement in the quality of students admitted, further enhanced the performance of students graduating from the program. Programs that effectively implemented OBE eventually got accredited by NBA. While the benefits of OBE are evident, there has been an undue emphasis on the computation of attainments.

In this work we propose an alternate and simplified method for computing the attainment of Course Outcomes (COs), leading to the computation of the Program Outcomes (POs) defined by NBA for the under graduate Engineering program. The typical method, that is usually adopted by most institutions, for computing the attainments, involves: mapping of every question in all assessments to the CO; tabulating the details of every student performance, in every question of every assessment; computing the number of students who have achieved a set target (based on a formula decided by the program); arriving at the contribution to PO attainment through the Course. This process is repeated for all courses of the curriculum, and the cumulative contribution by all courses leads to the overall attainment of a graduating Batch. We recognize the purpose of computing attainments is towards incorporating improvements in academic processes (changes in Pedagogy and the quality of Assessments) to enhance student learning. Hence, it is sufficient to have meaningful statistical parameters of required data through a faster procedure, than an accurate procedure with huge investment of faculty time. The saved faculty time can then be used for other academic improvements. The program can then focus on correlating the attainments the student performance at the time of graduation. The paper provides examples of computing the attainments of COs using the established conventional method and the proposed method, for three sample courses.

In the next Section, we shall discuss the course in the OBE framework: the COs, the CO-PO mapping strength and method of computing the CO attainment.

In Section III, we have examples of CO attainment for three courses. Section IV has our concluding remarks.

THE COURSE IN THE OBE FRAMEWORK

We shall now discuss about the contribution of a course in the curriculum towards the development of the POs defined by NBA, as listed by their key words in Table 1. The Self-Assessment-Report (SAR) for engineering programs by NBA, clearly states that the number of expected COs for a course is six, for both affiliated and autonomous institutions [7, 8].

Table 1: The key words of the POs defined by NBA

Program Outcomes (POs) defined by NBA	
PO1	Apply Knowledge
PO2	Problem Analysis
PO3	Design/Development of Solution
PO4	Conduct Investigations
PO5	Use Modern Tool
PO6	Engineer and Society
PO7	Environment and Sustainability
PO8	Professional Ethics
PO9	Individual and Team work
PO10	Communicate Effectively
PO11	Project Management and Finance
PO12	Life-Long Learning

Since, NBA recommends, around six COs for a course, let us consider an example of a course with six COs, and all COs aligned to PO1, as shown in Table 2. In this example, by observing the CO-PO mapping, we can conclude that all assessments of the course, shall include application of an engineering concept/theorem/law to compute and obtain a desired parameter, and hence all COs are mapped to PO1. It is possible to address this CO in the conventional written examination. If all courses in the curriculum have similar course articulation matrix, then we do not have an effective implementation of OBE. Since, the course maps to just one PO, we need to avoid such types of course articulation matrices, and we need to explore addressing more POs through the COs of the course.

Table 2: A Course Articulation Matrix that addresses one PO through six COs

The Course Articulation Matrix

Course	Program Outcome (PO)											
CO	1	2	3	4	5	6	7	8	9	10	11	12
CO1	3											
CO2	2											
CO3	3											
CO4	1											
CO5	2											
CO6	3											

Let us consider another example of the Course articulation matrix as given by Table 3. Here, once again we have six COs for the course, and the COs are aligned to application of knowledge (PO1), analysis (PO2) and design skills (PO3). In this example, we expect the assessments to include the application of an engineering concept/theorem/law to compute and obtain a desired parameter; and assessments to apply the knowledge leading to a conclusion; and assessments that address the design skill. Once again these COs can be addressed and measured in the conventional written examination. Usually, this type of mapping is observed when the COs are defined based on the course content; and the COs are an abridged version of the course content. Hence, on reading the six COs of the course, it is possible to arrive at the course content, and not the intended POs. Hence, this type of CO-PO mapping needs to be avoided.

Table 3: A Course Articulation Matrix that addresses three POs through six COs

The Course Articulation Matrix

Course	Program Outcome (PO)											
CO	1	2	3	4	5	6	7	8	9	10	11	12
CO1	3	2	1									
CO2	2	3	1									
CO3	3	1	2									
CO4	1	2	3									
CO5	2	1	3									
CO6	3	1	2									

The two examples of course articulation matrices considered in Table 2 and Table 3, need to be avoided, and we need to define COs so as to ensure larger number of POs are addressed through the six COs of the course. We now have an example of the course articulation matrix, with five COs addressing eight POs, as given in Table 4. In this example, we observe the first CO is aligned to PO1, and hence is related to assessments that involve application of a formula/concept to obtain the desired parameter. Similarly, CO2 is mapped to PO2, and hence is related to assessments that include application of knowledge leading to a conclusion. CO3 is mapped to PO3, and hence addresses all assessments that include design and development of solutions. CO4 is mapped to PO4 and PO5, and is likely to include assessments that use an engineering tool, and involves conduction of investigation of data/results, including design of experiments. CO5, on the other hand is mapped to PO6, PO10 and PO12. Hence, this CO involves the students to engage in independent learning of application of the concepts of the course for society, followed by the presentation of the details through a written report/oral seminar. It can be observed that the CO-PO mapping strength is different. In this example, the COs are clearly aligned to the intended PO(s), and hence, it is possible to identify the type of assessments for every CO. In this example, the COs are mapped to the intended POs and are not an abridged version of the course content. If all courses of the curriculum define COs such that the course maps to around 6 POs, then definitely, there shall be an effective implementation of OBE.

Table 4: A Course Articulation Matrix that addresses eight POs through five COs

The Course Articulation Matrix

Course	Program Outcome (PO)											
CO	1	2	3	4	5	6	7	8	9	10	11	12
CO1	3											
CO2		3										
CO3			2									
CO4				1	1							
CO5						1				1		1

Let us consider the POs defined by NBA, with regard to the assessments. The first three POs, can be

assessed in the conventional written examination. It is possible to design laboratory assessments to address and measure PO4 and PO5. The higher POs, PO6 through PO12 can be addressed through: (i) course projects; (ii) course seminars; (iii) programming based assignments; (iv) projects; (v) technical seminars; (vi) internship based seminars; (vii) reproduction of research work; (viii) abstract for a technical document; (ix) development of a tool-box using the engineering tool. Hence, purely through careful design of the COs together with corresponding assessments, it is possible to address PO4 through PO12. Typical assessments for a course include two major components: (i) the Continuous Internal Examination (CIE) and (ii) the Semester End Examination (SEE), as shown in Fig. 1. Towards addressing the POs defined by NBA, there is a requirement to include alternate assessments, in addition to the conventional written examination, as indicated in Fig. 1. The weightage for the alternate assessment depends on the institute policy.

The method of allocating the mapping strength in the course articulation matrix is not defined by NBA. Hence, stakeholders of the program can arrive at suitable justifiable methods. One possible method of arriving at the CO-PO mapping strength is based on the marks awarded for various COs of the course, as shown in Fig. 2. This method is measurable, and justifiable, and is not subjective or dependent on the interpretation of the course instructor. The thresholds are typical and can be changed based on the experts of the course, however it is suggested to have a uniform method across all courses in the department.

Fig. 2: The method for arriving at the CO-PO mapping strength

At the end of the course, students are awarded letter Grades, based on the cumulative performance in the CIE and the SEE, as indicated in Fig. 3. The weightage for each of these components is governed by the guidelines of the Academic Body of the Institute. At the end of the course, there is a need to compute the attainment of the COs of the course, and the contribution to the POs through the course. The tools for computing the attainment of the COs, together with typical weightage, is given in Fig 4. It can be observed that we have a higher weightage for the CIE component, as the CIE includes alternate/additional assessments, beyond the conventional written assessments, to address higher POs. The weightage for various assessment tools for CO attainment can be arrived through a consultative process with the stakeholders of the program.
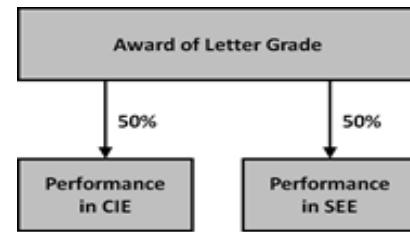
Fig. 3: Assessment tools for award of letter Grade

Fig. 1: The assessments for a course
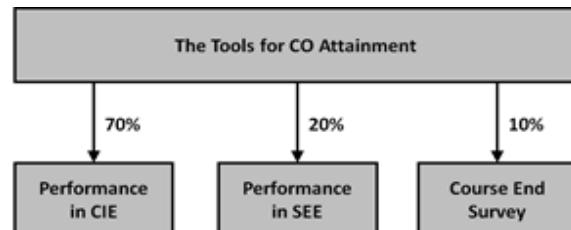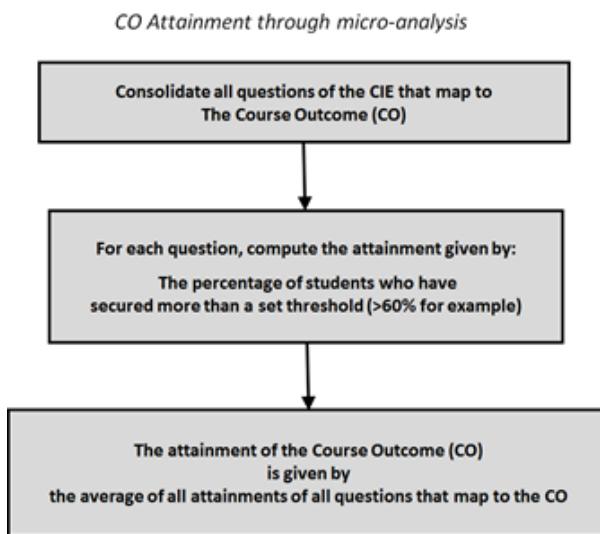
Fig. 4: Assessment tools for computing CO attainment
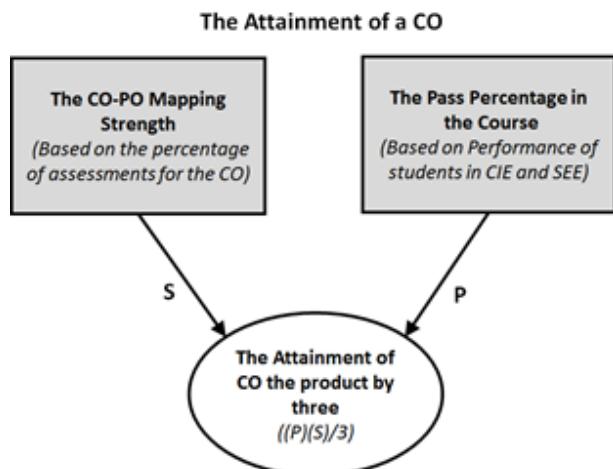
Fig. 5, has the method usually adopted for computing the CO attainments, wherein every assessment and student performance in every assessment is considered [10, 11]. This method is computationally intensive. To consider a typical situation: with 60 students in a class, 25 core courses in the curriculum, each course having 5 assessments, each assessment having 15 questions (on an average, including sub-divisions); there is a need to engage in the arriving at meaningful statistical parameters from huge data (112,500 values), including attainment of COs and POs. This elaborate exercise involving a large sized data has resulted in the emergence of commercial tools to compute attainments, together with the misconception that the Outcomes Based Education (OBE) process involves huge numbers.

CO Attainment through micro-analysis

Fig. 5: Micro-level analysis of assessments and student performance leading to CO attainment

We propose an alternate and simplified method of arriving at the CO attainment, based on the performance in the SEE and quality of all assessments of the course, leading to the CO-PO mapping strength, as given in Fig. 6. This method is a simpler algorithm to compute the attainments that eliminates the need to enter student wise performance in all the assessments, but requires mapping the assessments to the COs, and the attainment is based on the overall pass percentage in the course. Hence, the proposed method, considering the identical situation: with 60 students in a class, 25 core courses in the curriculum, each course having 5 assessments, each assessment having 15 questions, requires the pass percentage in each of the 25 courses, together with the CO-PO mapping strength; which is typically around 10 values per course. Hence, we can arrive at all desired statistical parameters from reduced data, of just 250 values. The purpose of computing attainments is towards continuous improvement. This In the next Section, we shall consider a specific example of few courses.

Fig. 6: The simplified method of arriving at the CO attainments

EXAMPLES OF COURSES

In this Section, we shall consider specific examples of few courses. For each course, we have the COs, the CO-PO mapping, the attainments. Specifically, we compute the attainment with different methods and compare the results. The aim is to arrive at alternate and simple method of CO attainment.

Example I: Signals and Systems: Analog

Our first Example, is the III semester core course on, 'Signals and Systems: Analog' [12], with 63 students registered for the course. The course has five modules. The first module deals with the definition and classification of Continuous Time Signals and Analog Systems. The second module deals with the time domain representation of continuous time signals, while the third module deals with the frequency domain representation of continuous time signals. The fourth module deals with the representation and analysis of Linear Time Invariant (LTI) analog systems. The fifth module deals with the design, implementation and analysis of analog

Butterworth filters. The COs for this course is given in Table 5. It can be observed, that the COs are aligned to the intended POs, and are not an abridged version of the course content. In this example, CO1, is aligned to the lower Bloom's Taxonomy, Remember/Understand, and hence is not mapped to any PO (since the POs defined by NBA start from Bloom's level 3).

Eventually this type of CO needs to be avoided. The Course articulation matrix is given by Table 6.

Table 5: The COs for the Course on, 'Signals and Systems: Analog'

At the end of the course on, the students will have the ability to:	
CO1	define and explain continuous time signals and systems
CO2	obtain the specified parameter of the given continuous time signal/system
CO3	analyse the given signal/system
CO4	Develop and Analyse the Python code; design, implement and analyse analog Butterworth filters on Multisim live
CO5	make an oral presentation on the application of concepts of the course for the benefit of society
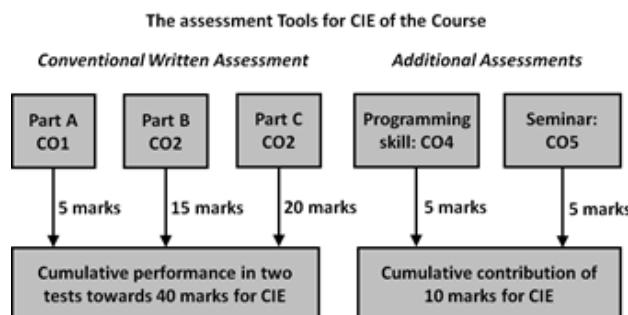
Table 6: The course articulation matrix for the Course on, 'Signals and Systems: Analog'

The Course Articulation Matrix

Course	Program Outcome (PO)											
CO	1	2	3	4	5	6	7	8	9	10	11	12
CO1												
CO2	3											
CO3		3										
CO4			1		1							
CO5						1				1		1
	3	3	1		1	1				1		1
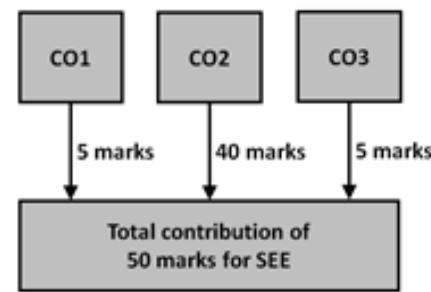
There is equal weightage for the CIE and SEE component towards award of letter Grade, as indicated in Fig. 7. Both CIE and SEE are evaluated for 50 marks. The CIE component includes: 40 marks from performance in the written tests; 5 marks from the assessment based on programming using Python/Multisim Live; and 5 marks from the seminar based on application of concepts for benefit of society. As per the academic calendar of the

institute, three internal assessments are conducted, and the best two of the three are considered towards CIE. The assessment tools for the course are given in Fig. 7. It can be observed that the weightage for CO-PO mapping is in accordance to the suggested method of Fig. 2. The SEE question paper is from a pool of question papers available in the office of the Controller of Examinations, and is a random pick of one of the question papers. The analysis of the SEE paper is given in Fig. 8, with 10% questions mapped to CO1, 80% mapped to CO2, and 10% mapped to CO3. It can be observed that CO4 and CO5 cannot be assessed in the SEE, which is of conventional written examination, and hence the weightage for the SEE component is reduced in Fig. 4. The course has a pass percentage of 81%, considering the student performance in both CIE and SEE, with equal weightage for both.

Fig. 7: The assessment tools for CIE of the course on, 'Signals and Systems: Analog'

Fig. 8: The mapping of SEE assessments to COs

We now compute the attainment of COs, based on student performance in CIE and SEE. Table 7, has the attainment of COs, computed as the percentage of students who have secured more than a set threshold in the CO. Let us consider the attainment of CO2, with

a mapping strength of 3. Here, with threshold of 40%, we have the attainment as 72%; while the threshold of 60% has reduced the attainment to 50%; and the threshold of 80% has further reduced the attainment to 40%. On the other hand, the attainment of CO5, with a mapping strength of 1, has the attainment of 32% (threshold 40%); and 31% (threshold of 60%) and 22% (threshold of 80%). Mapping strength of 3 indicates higher weightage of assessments; while a mapping strength of 1, indicates, less weightage of assessments. There is significant variation in the attainment with the set threshold, when mapping strength is 3, while, the variation is less, when the mapping strength is 1. Also the CO attainment cannot exceed 33%, when the mapping strength is 1.

Table 7: The attainment of COs with different thresholds for the Course on, 'Signals and Systems: Analog'

Attainment through mapping of every Question in every Assessment

Threshold: 40%	CO1	CO2	CO3	CO4	CO5
Students secured more than Threshold	82%	72%	50%	82%	96%
The CO-PO Mapping Strength	-	3	3	1	1
The Attainment of the CO		72%	50%	27%	32%

Threshold: 60%	CO1	CO2	CO3	CO4	CO5
Students secured more than Threshold	66%	50%	33%	54%	93%
The CO-PO Mapping Strength	-	3	3	1	1
The Attainment of the CO		50%	33%	17%	31%

Threshold: 80%	CO1	CO2	CO3	CO4	CO5
Students secured more than Threshold	51%	40%	20%	36%	66%
The CO-PO Mapping Strength	-	3	3	1	1
The Attainment of the CO		40%	20%	12%	22%

Every internal written test has minimum two questions each for CO1, CO2, and CO3, and with performance in two tests being considered towards CIE, the total entries is the product of: number of questions, the number of students, and the number of students; which is 756 values for the conventional assessment component. In addition, there are entries through the assessment of CO4 and CO5; which is twice the number of students; and is 126 values in this example. Hence, total number of entries of the CIE component, is 882. Once, we have these values entered, in an excel file, we can apply the formula for CO attainment: computing the percentage of students above the set threshold for every CO. This computation is then multiplied by the mapping strength to have the overall attainment of the CO, through the

CIE component. For discussion purpose, let us set the total computations for CO attainment of the course to be around 900 values, for a class of strength close to 60 students.

The attainment for the same course, using the alternate and simplified method of Fig. 6, is given below in Table 8. Here, the computation of the CO attainment is based on the pass percentage in the course: a single value. Based on the assessments, we have the overall attainment. In this method, there is huge saving of faculty time. In this example, there is a small difference in the attainments; however, this variation is insignificant, as the emphasis is on design of assessments and addressing the POs through the COs of the course.

Table 8: The CO attainments by simplified method for the Course on, 'Signals and Systems: Analog'

Attainment through Pass Percentage of the Course

Parameter	CO1	CO2	CO3	CO4	CO5
Students Passed the Course			81%		
The CO-PO Mapping Strength	-	3	3	1	1
The Attainment of the CO		81%	81%	27%	27%

Example II: VLSI Design

Our next example is the IV semester core course on, 'VLSI Design' [12], with 67 students registered for the course. The course has five modules. The first module deals with CMOS fundamentals including circuit implementations, basic fabrication techniques and Stick diagrams of CMOS circuits. The second module deals with the specialized CMOS implementations, while the third module deals with the fundamentals electronics concepts necessary for effective VLSI realizations. The fourth module deals with important Sub-system design implementations and their challenges. The fifth module deals with the design of various memory elements and various Testing methodologies. The COs for this course is given in Table 9, and the Course articulation matrix is given in Table 10. It can be observed, that the COs are aligned to the intended POs, and are not an abridged version of the course content. Although this is a theory based course, laboratory component has been introduced to achieve better pedagogy.

The CIE component includes: 40 marks from performance in the written tests; 5 marks from the

assessment based on programming using Multisim; and 5 marks from the Mini project. The analysis of the SEE paper has 10% questions mapped to CO1, 60% mapped to CO2, and 30% mapped to CO3. It can be observed that CO4 and CO5 cannot be assessed in the SEE. The course has a pass percentage of 88%.

Table 9: The COs for the Course on, 'VLSI Design'

At the end of the course on, the students will have the ability to:	
CO1	Define, understand and explain concepts of nMOS and CMOS technology.
CO2	Apply the knowledge of VLSI to fabricate the MOS circuits, illustrate different CMOS logic structures, subsystems and memory elements, calculate rise time and fall time estimations.
CO3	Analyse the monochrome layout and stick diagrams of MOS technology and CMOS logic structures and subsystems, deduce appropriate testability vectors for the given parameters.
CO4	Analyse the given VLSI simulation block and arrive at the application/problem statement.
CO5	Implement a mini-project to develop the specified application using VLSI tools

Table 10: The course articulation matrix for the Course on, 'VLSI Design'

The Course Articulation Matrix

Course	Program Outcome (PO)											
CO	1	2	3	4	5	6	7	8	9	10	11	12
CO1												
CO2	3											
CO3		3										
CO4		1			1							
CO5			1		1							

We now compute the attainment of COs, based on student performance in CIE and SEE. Table 11, has the attainment of COs, computed as the percentage of students who have secured more than a set threshold in the CO. Let us consider the attainment of CO2, with a mapping strength of 3. Here, with threshold of 40%, we have the attainment as 64%; while the threshold of 60% has reduced the attainment to 50%; and the threshold of 80% has further reduced the attainment to 29%. On the other hand, the attainment of CO5, with

a mapping strength of 1, has the attainment of 25% (threshold 40%); and 20% (threshold of 60%) and 18% (threshold of 80%). Mapping strength of 3 indicates higher weightage of assessments; while a mapping strength of 1, indicates, less weightage of assessments. There is significant variation in the attainment with the set threshold, when mapping strength is 3, while, the variation is less, when the mapping strength is 1. Also the CO attainment cannot exceed 33%, when the mapping strength is 1.

Table 11: The attainment of COs with varying thresholds for the Course on, 'VLSI Design'

Threshold: 40%	CO1	CO2	CO3	CO4	CO5
Students secured more than Threshold	67%	64%	59%	74%	74%
The CO-PO Mapping Strength	-	3	3	1	1
The Attainment of the CO		64%	59%	25%	25%

Threshold: 60%	CO1	CO2	CO3	CO4	CO5
Students secured more than Threshold	54%	50%	43%	60%	60%
The CO-PO Mapping Strength	-	3	3	1	1
The Attainment of the CO		50%	43%	20%	20%

Threshold: 80%	CO1	CO2	CO3	CO4	CO5
Students secured more than Threshold	37%	29%	15%	53%	53%
The CO-PO Mapping Strength	-	3	3	1	1
The Attainment of the CO		29%	15%	18%	18%

Every internal written test has minimum two questions each for CO1, CO2, and CO3, and with performance in two tests being considered towards CIE, the total entries is the product of: number of questions, the number of students, and the number of students; which is 756 values for the conventional assessment component. In addition, there are entries through the assessment of CO4 and CO5; which is twice the number of students; and is 126 values in this example. Hence, total number of entries of the CIE component, is 882. Once, we have these values entered, in an excel file, we can apply the formula for CO attainment: computing the percentage of students above the set threshold for every CO. This computation is then multiplied by the mapping strength to have the overall attainment of the CO, through the CIE component.

The attainment for the same course, using the alternate and simplified method of Fig. 6, is given below in Table 12. Here, the computation of the CO attainment is based on the pass percentage in the course: a single value. Based on the assessments, we have the overall attainment. In

this method, there is huge saving of faculty time. In this example, there is a small difference in the attainments; however, this variation is insignificant, as the emphasis is on design of assessments and addressing the POs through the COs of the course.

Table 12: The attainment of COs using the simplified method for the Course on, 'VLSI Design'

Attainment through Pass Percentage of the Course

Parameter	CO1	CO2	CO3	CO4	CO5
Students Passed the Course			88%		
The CO-PO Mapping Strength	-	3	3	1	1
The Attainment of the CO		88%	88%	29%	29%

Example III: Computer Communication Networks

VI semester core course on, 'Computer Communication Networks ' [12], with 68 students registered for the course. The course has five modules. The first module deals with the basics of network along with layer structures. The second module deals with the data link layer functions and its responsibilities, while the third module deals with the network layer and IP address mechanism.. The fourth module deals with the transport layer and Congestion control along with quality control. The fifth module deals with the application layer functionalities along with few protocol functions. The COs for this course is given in Table 13. The Course articulation matrix is given by Table 14.

Table 13: The COs for the Course on, 'Computer Communication Networks'

At the end of the course on, the students will have the ability to:	
CO1	Ability to understand, define and explain the fundamental concepts of computer network
CO2	Ability to apply the knowledge of communication and networks to computer communication
CO3	Ability to analyse the given network systems parameters and arrive at suitable conclusions
CO4	Ability to conduct experiments to demonstrate networking concepts using the hardware and software engineering tool: Qualnet / Matlab/ Packet tracer
CO5	Ability to implement and demonstrate the specified mini-project using suitable computer communication network parameters

Table 14: The course articulation matrix for the Course on, 'Computer Communication Networks'

The Course Articulation Matrix

Course	Program Outcome (PO)											
CO	1	2	3	4	5	6	7	8	9	10	11	12
CO1												
CO2	2											
CO3		1										
CO4	3				3							
CO5		2			2				1			

The CIE component includes: 25 marks from performance in the written tests and Quiz; 15 Marks from the laboratory component; 10 marks from the assessment based on mini-project;   The course has a pass percentage of 77%. We now compute the attainment of COs, based on student performance in CIE and SEE. Table 15, has the attainment of COs, computed as the percentage of students who have secured more than a set threshold in the CO. Let us consider the attainment of CO2, with a mapping strength of 2. Here, with threshold of 40%, we have the attainment as 48%; while the threshold of 60% has reduced the attainment to 25%; and the threshold of 80% has further reduced the attainment to 3%. On the other hand, the attainment of CO4, with a mapping strength of 3, has the attainment of 90% (threshold 40%); and 79% (threshold of 60%) and 24% (threshold of 80%). Mapping strength of 3 indicates higher weightage of assessments; while a mapping strength of 1, indicates, less weightage of assessments. There is significant variation in the attainment with the set threshold, when mapping strength is 3, while, the variation is less, when the mapping strength is 1. Also the CO attainment cannot exceed 33%, when the mapping strength is 1.

Every internal written test has minimum two questions each for CO1, CO2, and CO3, and with performance in two tests being considered towards CIE, the total entries is the product of: number of questions, the number of students, and the number of students; which is 756 values for the conventional assessment component. In addition, there are entries through the assessment of CO4 and CO5; which is twice the number of students; and is 126 values in this example. Hence, total number of entries of the CIE component, is 882. Once, we have

these values entered, in an excel file, we can apply the formula for CO attainment: computing the percentage of students above the set threshold for every CO. This computation is then multiplied by the mapping strength to have the overall attainment of the CO, through the CIE component.

Table 15: The attainment of COs with varying thresholds for the Course on, 'Computer Communication Networks'

Attainment through mapping of every Question in every Assessment

Threshold: 40%	CO1	CO2	CO3	CO4	CO5
Students secured more than Threshold	71%	72%	75%	90%	82%
The CO-PO Mapping Strength	-	2	1	3	2
The Attainment of the CO	-	48%	25%	90%	54%

Threshold: 60%	CO1	CO2	CO3	CO4	CO5
Students secured more than Threshold	60%	38%	49%	79%	82%
The CO-PO Mapping Strength	-	2	1	3	2
The Attainment of the CO	-	25%	16%	79%	54%

Threshold: 80%	CO1	CO2	CO3	CO4	CO5
Students secured more than Threshold	32%	4%	6%	24%	50%
The CO-PO Mapping Strength	-	2	1	3	2
The Attainment of the CO	-	3%	2%	24%	33%

The attainment for the same course, using the alternate and simplified method of Fig. 6, is given below in Table 16. Here, the computation of the CO attainment is based on the pass percentage in the course: a single value. Based on the assessments, we have the overall attainment. In this method, there is huge saving of faculty time. In this example, there is a small difference in the attainments; however, this variation is insignificant, as the emphasis is on design of assessments and addressing the POs through the COs of the course.

Table 16: The attainment of COs using simplified method for the Course on, 'Computer Communication Networks'
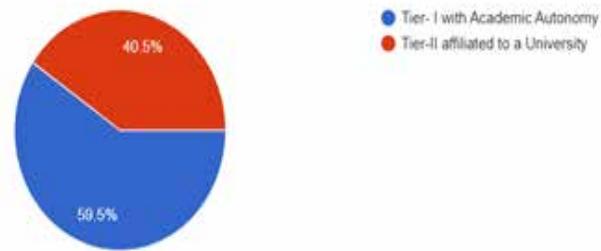
Attainment through Pass Percentage of the Course

Parameter	CO1	CO2	CO3	CO4	CO5
Students Passed the Course			77%		
The CO-PO Mapping Strength	-	2	1	3	2
The Attainment of the CO		51%	26%	77%	51%

FACULTY SURVEY ON OBE

An online survey was launched during August 2023, to obtain feedback on OBE processes (https://forms.gle/N5CbsN2kmbn9vwjU9) from faculty. The survey was taken by 126 Faculty from 42 colleges. Included

below is an extract from the survey response. From Fig. 9, it can be observed that close to 60% of the faculty are from Tier-I Institutions with academic autonomy, while the others are from Tier-II Institutions, who are affiliated to an University.

Fig. 9: The distribution of faculty from Tier-I and Tier-II Institutions
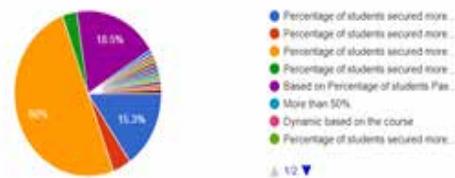
From Fig. 10, it can be observed that most Institutions are computing the CO attainment, as a percentage of students more than a set threshold; and the most commonly used threshold is 60%.
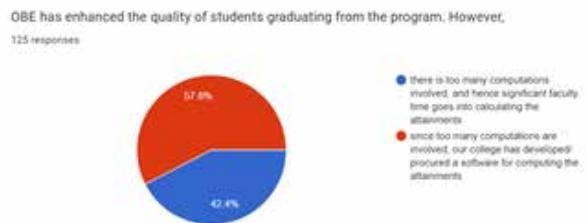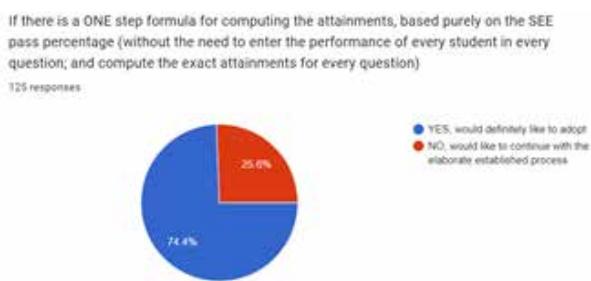
Fig. 10: The method adopted for computing the CO attainment

From Fig. 11, it can be observed that all faculty agree to the enhanced performance of students due to OBE practices; however close to 57% of them feel the computations take too much time; and 43% of faculty are from institutions having dedicated software to compute the attainments.

Fig. 11: The response to benefits from OBE

From Fig. 12, it can be observed that 75% of faculty looks forward to a simplified method of CO attainment based on performance in SEE and quality of assessments.

Fig. 12: 75% of faculty looks forward to a simplified method of CO computation

he response of the survey describing one Best practice, in Teaching Learning Process being followed because of OBE: Project based learning; Introduced Experiential Learning; Designed assessments to measure higher order POs; Partial reproduction of research work; Including the questions from Competitive Examinations in the internal Question Papers; Open Ended Experiment in laboratory courses; Activity Based learning; Enhanced quality of question paper; Introduced Open Book Examination in few courses; Focused on mini projects and MOOC to map it to PO6 to PO12; Activity based learning / project based learning / open ended questions; comparative learning of outcomes with respect to preceding and succeeding years; introduced Video presentation in group; hands-on session in programming based courses.

The response of the survey describing one practice in the OBE that needs to be changed: The process of calculation of CO attainment needs amendment; Too much stress on computations than practices; Attainment Calculation can be made simpler; Method of computing CO attainment; Procedure should be simple and more precise; Simplified methods can

be explored for computation; Too much emphasis on quantitative assessment of outcomes; Typing marks obtained by each student to each question in internal assessment; unnecessary time consuming attainment computations and clerical work burden on faculty in preparing document files, which are of no use in engineering education curriculum; CO-PO attainment process should be simplified; More weightage to Course Instructor.

Hence, it can be observed that most Institutions are practicing OBE, and have benefited through the OBE processes, however, they look forward to simplified methods for computing the attainments.

CONCLUSIONS

In the present OBE framework, faculty have the responsibility of delivering the course during the semester; design assessments; complete evaluations, and then enter the values and finally compute the attainments. As evident from the faculty survey, significant amount of faculty time goes into CO attainments. Faculty need to focus on changing delivery methods, enhancing quality of assessments, enhancing the number of POs being addressed through the course, and reduce the time in computing attainments. In this work, we have proposed an alternate and simplified method for computing the attainments. Through the three examples, considered, with an alternate and simplified method, there is a small difference between the exact attainment and the attainment obtained through the alternate method. However, attainments are not included in student grade cards, attainments do not fetch accreditation. Attainments are purely for continuous improvement in academic processes in the department. Hence, the proposed method can be adopted for computing the CO attainment of COs. The significant advantage of the proposed method is the emphasis on the quality of assessments. The shift in emphasis from attainments to assessments, shall take the OBE processes further.

ACKNOWLEDGMENT

REFERENCES

1. International Engineering Alliance, Washington Accord, https://www.ieagreements.org/accords/washington/

2. National Board of Accreditation (NBA), for promoting International quality standards for Technical Education in India, https://www.nbaind.org/

3. https://www.mhrd.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

4. Accreditation Board for Engineering and Technology (ABET), ISO 9001 non-profit organization that accredits Universities and programs, https://www.abet.org/

5. Criteria for accrediting Engineering Programs (Academic year 2023-24), by ABET Engineering Accreditation Commission, https://www.abet.org/wp-content/uploads/2023/03/23-24-EAC-Criteria_FINAL2.pdf

6. Stephen Hundley, Lynn G. Brown, Alan Jacobs, Patricia Fox, Catherine Didion, Daniel R. Sayre, and Hans J. Hoyer, 'Attributes of a Global Engineer', ASEE 2011, Annual Conference & Exposition, pp. 22-266. 2011.

7. Manual for Accreditation of Undergraduate Engineering Programs (Tier-I Institutions), by NBA, https://www.nbaind.org/files/NBA_UGEngg_Tier_I_Manual.pdf

8. Manual for Accreditation of Undergraduate Engineering Programs (Tier-II Institutions), by NBA, https://www.nbaind.org/files/NBA_UGEngg_Tier_II_Manual.pdf

9. Buddhi, K. (2023). A Pedagogy for Engineering Concepts Focusing on Experiential Learning. In: Guralnick, D., Auer, M.E., Poce, A. (eds) Creative Approaches to Technology-Enhanced Learning for the Workplace and Higher Education. TLIC 2023. Lecture Notes in Networks and Systems, vol 767. Springer, Cham. https://doi.org/10.1007/978-3-031-41637-8_8

10. 'Effective implementation of OBE leading to accreditation', through the Working Professionals Learning Project (WPLP), an AICTE Project, of ISTE (Indian Society for Technical Education), 10th September 2020, ISBN: 978-81-89731-23-6

11. B. Shreenivas, H. R. Archana, C. Gururaj and K. Ambika, 'Leveraging the Assessment Methods for Outcome Based Education', Journal of Engineering Education Transformations, Year: 2015, Volume: 28, Issue: Special Issue, Pages: 331-334. DOI: 10.16920/jeet/2015/v0i0/59827

12. The Curriculum for the Undergraduate Electronics and Telecommunication Program, https://bmsce.ac.in/Syllabus/TE/UG/UG%20Syllabus%202018-22.pdf

Employee Attrition and Employee Retention-Challenges & Suggestion at Private Hospitals in Bengaluru

L. V. Vishnu Priya
Research Scholar (PhD)
ISBR Research Centre
University of Mysore, Karnataka
✉ lvvishnupriya@gmail.com

M R Jhansi Rani
Professor and Director
ISBR Research Centre
University of Mysore
Karnataka
✉ dr.jhansirani@isbr.in

ABSTRACT

Employee attrition and retention have become critical challenges for private hospitals in Bengaluru, India, affecting organizational stability, service quality, and overall performance. This study investigates the factors contributing to employee attrition and explores effective retention strategies within the context of Bengaluru's private healthcare sector. Through a comprehensive literature review, this research identifies key challenges such as high job stress, inadequate work-life balance, insufficient recognition, and limited career growth opportunities. The study employs a mixed-methods approach, combining quantitative surveys and qualitative interviews, to gather data from healthcare professionals, administrators, and human resources personnel in various private hospitals across Bengaluru. Statistical analyses provide insights into the primary reasons behind employee turnover, while qualitative data offer nuanced perspectives on the experiences and expectations of hospital staff. Findings reveal that factors such as competitive salary packages, robust career development programs, a positive work environment, and recognition for achievements significantly influence employee retention. Furthermore, the research highlights the importance of effective leadership, transparent communication, and fostering a supportive organizational culture in retaining healthcare professionals. Based on the analysis, this study proposes a set of practical suggestions to address the challenges of employee attrition in private hospitals in Bengaluru. Recommendations include the implementation of mentorship programs, flexible work schedules, continuous professional development initiatives, and regular feedback mechanisms. Additionally, promoting a culture of employee well-being, providing avenues for skill enhancement, and recognizing and rewarding outstanding performance are emphasized as vital strategies for enhancing employee retention in the healthcare sector. This research contributes valuable insights to hospital administrators, policymakers, and human resources professionals, enabling them to develop targeted strategies that mitigate employee attrition, enhance retention rates, and ultimately improve the overall healthcare services in private hospitals in Bengaluru.

KEYWORDS: *Employee attrition, Employee retention, Challenges in private hospitals, Employee engagement, Professional development opportunities.*

INTRODUCTION

Employee attrition and retention have become critical challenges faced by private hospitals in Bengaluru, as they strive to maintain a skilled and motivated workforce amidst a highly competitive healthcare landscape. Attrition refers to the rate at which employees leave an organization, while retention focuses on strategies to keep valuable employees engaged and committed to the organization [1]. In the context of private hospitals in Bengaluru, these challenges are further complicated by factors such as increasing demand for healthcare services, a shortage of skilled professionals, and evolving patient expectations [2]. This comprehensive analysis explores the nuances of employee attrition and retention in the private healthcare sector of Bengaluru, shedding light on the root causes, consequences, and potential solutions.

CAUSES OF EMPLOYEE ATTRITION IN PRIVATE HOSPITAL

Explore the various aspects of healthcare jobs leading to dissatisfaction, such as long working hours, high stress levels, and lack of work-life balance. Discuss the limited opportunities for career advancement and professional development within the healthcare sector, especially in smaller private hospitals.

Analyze the role of competitive salaries, benefits, and incentives in retaining healthcare professionals. Examine how factors like inadequate facilities, lack of recognition, and ineffective leadership contribute to a negative work environment [3].Discuss the impact of job-role mismatches, where employees find themselves in positions that do not align with their skills and expertise.

CONSEQUENCES OF HIGH ATTRITION RATES

Explore how frequent staff turnover affects the quality of patient care, patient satisfaction, and overall hospital reputation. Discuss the financial repercussions of high attrition rates, including recruitment costs, training expenses, and lost revenue due to decreased productivity. Analyze the impact on the morale of remaining staff and the overall organizational culture in hospitals with high attrition rates.

CHALLENGES IN EMPLOYEE RETENTION

Identifying Retention Challenges Specific to Bengaluru's Private Hospitals. Discuss the scarcity of skilled healthcare professionals in Bengaluru and how it affects the ability of private hospitals to retain talent. Analyze the competitive landscape among private hospitals in Bengaluru, exploring how they often engage in bidding wars for experienced professionals. Explore how the preferences and expectations of the younger workforce, particularly millennials and Generation Z, impact retention strategies.

RETENTION STRATEGIES IMPLEMENTED BY PRIVATE HOSPITALS

Discuss the role of competitive salaries, bonuses, and benefits in attracting and retaining healthcare professionals [4].Explore the importance of continuous learning, training programs, and skill development initiatives in retaining staff.Discuss strategies for fostering a positive workplace culture, including employee recognition, mentorship programs, and team-building activities.Explore the implementation of flexible working hours, remote work options, and policies promoting a healthy work-life balance.Analyze the role of regular feedback mechanisms, employee surveys, and engagement initiatives in understanding employee needs and addressing concerns.

CASE STUDIES

Case Study 1

Successful Retention Strategies in Bengaluru Hospitals

Provide a brief introduction to the hospital, including its size, specialties, and workforce composition.

Discuss the specific retention challenges faced by Hospital and how they impact their operations.

Detail the unique retention strategies implemented by Hospital, such as mentorship programs, skills enhancement workshops, and wellness initiatives.

Analyze the outcomes of these strategies, including improved employee satisfaction, reduced attrition rates, and enhanced patient care.

Case Study 2

Provide a brief overview of ABC Hospital, highlighting its services, reputation, and employee demographics.

Discuss the challenges that are specific to ABC Hospital, which might differ from other hospitals in Bengaluru.

Detail the unique retention approaches adopted by ABC Hospital, such as career progression pathways, cross-functional training, and community engagement programs.

Discuss the tangible benefits achieved by ABC Hospital due to these retention strategies, including improved employee loyalty, reduced turnover, and enhanced hospital performance.

Recommendations and Future Strategies

A. Recommendations for Private Hospitals in Bengaluru

Emphasize the importance of developing customized retention strategies based on the specific needs and challenges faced by each hospital.

Advocate for partnerships between hospitals and educational institutions to bridge the skills gap and ensure a pipeline of trained professionals.

Discuss the role of government policies and initiatives in supporting the healthcare sector, including subsidies for training programs and incentives for hospitals providing quality working conditions.

Explore how hospitals can leverage technology for workforce management, training, and communication, enhancing both employee experience and patient care.

Future Strategies for Long-Term Retention

Discuss the potential of predictive analytics in identifying attrition patterns and enabling proactive retention efforts.

Emphasize the importance of mental health support, stress management programs, and employee wellness initiatives in ensuring long-term retention.

Advocate for leadership development programs within hospitals to ensure that managers and supervisors are equipped with the skills to create positive work environments.

Discuss the implementation of continuous feedback systems, allowing employees to voice concerns and suggestions anonymously, fostering a culture of open communication.

Related Works

"Health-promoting leadership: An integrative review and future research agenda"

Authors: Akerjordet, K., Furunes, T., & Haver,

A Health-promoting leadership in nursing, as synthesized from the literature review, emphasizes leaders who prioritize nurses' well-being and create supportive environments. Attributes include promoting employee health, accountability, open communication, and fostering competence. Critical conditions involve empowering nurses in change, transparent communication, and building organizational capacity.

"Employee Retention: A Review of Literature"

Authors: Das, B. L., & Baruah, M

This article offers a systematic review of various retention strategies employed across industries, providing insights into their effectiveness. Understanding general retention techniques can provide a foundation for devising industry-specific strategies in the context of private hospitals in Bengaluru.

"The impact of leadership styles on staff nurses' turnover intentions"

Authors: Naseer, A., Perveen, K., Afzal, M., Waqas, A., & Gillani, S. A

The study investigated how different leadership styles of head nurses affect turnover intentions among staff nurses at a private hospital in Lahore, Pakistan. Results indicated that transactional leadership correlated positively with higher turnover intentions, while transformational leadership showed a negative association, suggesting that adopting a transformational leadership style could reduce nurse turnover in the hospital.

Industry Reports and White Papers

"Trends and Insights in Healthcare Workforce Attrition"

Published by a reputable consulting firm the 2018 NHS workforce trends report identifies ongoing challenges: modest staff growth, high vacancies, varied clinical staff increases, declining GP numbers, nurse shortages, and challenges in shifting care. Urgent actions are needed to address staffing shortages and retention issues, emphasizing the need for coherent policies aligning funding and staffing.

"Employee Turnover and Strategies Health Care Administrators Use to Improve Employee Retention: An Exploratory Case Study"

This white paper explores successful retention practices implemented by leading hospitals globally. Case studies and real-world examples can offer practical ideas for private hospitals in Bengaluru to consider while devising their retention strategies.

Case Studies and Practical Guides

"Reducing Turnover in Healthcare: A Case Study Approach"

Authors: Jane Smith, Michael Johnson ,This book presents in-depth case studies of healthcare organizations that successfully reduced employee turnover. The insights gained from these cases can be applied to private hospitals in Bengaluru, providing actionable strategies and implementation techniques.

"Employee Retention Strategies in the Healthcare Industry: A Practical Guide"

Published by a healthcare HR association Practical guides tailored to the healthcare sector often offer specific, actionable strategies. This guide would likely contain insights into employee retention techniques that have proven successful in healthcare settings, including private hospitals in Bengaluru.

Surveys and Research Papers from Local Universities

"Workplace Satisfaction and Turnover Intentions among Healthcare Professionals in Bengaluru"

Conducted by [Local University] researchers Local surveys conducted by universities often provide unique insights into the challenges faced by professionals in specific regions. This survey can shed light on the specific challenges healthcare professionals in Bengaluru face, providing valuable data for crafting targeted retention strategies.

"Impact of Work-Life Balance on Retention: A Study of Healthcare Workers in Bengaluru"

Conducted by [Local University] researchers Work-life balance is a critical factor in employee retention. This research paper could offer insights into the work-life balance preferences and challenges faced by healthcare workers in Bengaluru, guiding hospitals in creating policies that promote retention.

By consulting these related works, private hospitals in Bengaluru can gain a holistic understanding of the challenges associated with employee attrition and draw from a rich pool of strategies and insights to develop effective retention initiatives tailored to their specific needs and circumstances.

DISADVANTAGES OF EXISTING WORK

- Frequent changes in healthcare providers can lead to inconsistencies in patient care, negatively impacting patient satisfaction. Patients might prefer continuity in their healthcare providers, which attrition disrupts.

- When employees leave, the workload often falls on the remaining staff, leading to burnout and reduced job satisfaction. This can create a cycle of attrition as overburdened employees may also choose to leave.

- High turnover rates can affect the quality of care due to the loss of experienced staff. New employees may take time to acclimate to the hospital's procedures, potentially leading to errors or delays in patient care.

- Hospitals with a reputation for high attrition rates may struggle to attract patients and skilled professionals. A negative public perception can harm the hospital's standing in the community and among potential employees.

- Constant recruitment, training, and onboarding of new employees come with significant costs. Moreover, lost productivity during the transition period can lead to financial losses for the hospital.

- High attrition rates make long-term planning challenging. Hospitals may struggle to implement and sustain initiatives when the workforce is continuously changing, making it difficult to achieve organizational goals and objectives.

Addressing these challenges and leveraging the advantages of effective employee retention strategies is crucial for private hospitals in Bengaluru to maintain a stable, motivated, and skilled workforce while ensuring high-quality patient care and financial sustainability.

PROPOSED WORK

Employee attrition and retention are pressing concerns faced by private hospitals in Bengaluru. This proposed research aims to comprehensively investigate the challenges related to employee attrition and retention in the context of Bengaluru's private healthcare sector. The study will delve into the underlying causes of attrition, assess the impact on hospitals, and propose tailored retention strategies for implementation.

- Conduct in-depth interviews and surveys among healthcare professionals and administrators to

identify the root causes of attrition within private hospitals in Bengaluru.

- Analyze the consequences of high attrition rates on patient care, financial stability, and organizational culture within private hospitals in the region.

- Develop targeted retention strategies based on the identified causes of attrition, industry best practices, and innovative solutions from global healthcare institutions.

- Conduct a feasibility analysis of the proposed retention strategies, considering factors such as budget, resources, and organizational culture.

- Create a comprehensive implementation framework outlining step-by-step guidelines for hospitals to adopt and adapt the proposed retention strategies effectively.

Proposed Timeline

Months 1-2: Conduct literature review and design research methodologies.

Months 3-4: Collect primary data through surveys, interviews, and focus group discussions.

Months 5-6: Analyze the collected data and develop preliminary retention strategies.

Months 7-8: Validate strategies through expert consultations and case study analysis.

Months 9-10: Finalize the research findings, develop the implementation framework, and draft the research report.

Month 11: Present research findings to stakeholders and obtain feedback.

Month 12: Revise the research report, incorporating feedback, and prepare the final research document for submission.

EXPECTED OUTCOMES

- A detailed report outlining the causes of attrition, its impact, and proposed retention strategies specifically tailored for private hospitals in Bengaluru.

- A practical, step-by-step guide for hospitals to implement the proposed strategies effectively,

considering their unique organizational structures and requirements.

- A contribution to the academic and practical knowledge base regarding employee attrition and retention in the healthcare sector, with a focus on the private hospital context in Bengaluru.

- This proposed research aims to provide actionable insights and practical solutions to the challenges faced by private hospitals in Bengaluru, enabling them to enhance employee retention, improve patient care, and maintain a positive organizational culture.

ADVANTAGES OF PROPOSED SYSTEM

- A stable workforce leads to consistent and improved patient care. Well-retained healthcare professionals tend to develop better relationships with patients, leading to enhanced patient satisfaction and trust in the hospital's services.

- Implementing effective retention strategies fosters a positive work environment. Satisfied employees are more likely to engage in their work, collaborate with colleagues, and contribute positively to the hospital's culture, creating a harmonious workplace atmosphere.

- High attrition rates incur significant costs related to recruitment, training, and on boarding of new employees. By retaining experienced staff, hospitals can reduce these costs and allocate resources more efficiently, ultimately improving the hospital's financial stability.

- Experienced healthcare professionals possess valuable institutional knowledge and skills. Retaining these employees ensures that the hospital retains essential expertise, which is critical in maintaining high standards of care and responding effectively to complex medical situations.

- Lower attrition rates and effective retention strategies boost staff morale. Satisfied employees are more likely to stay motivated, leading to increased productivity, teamwork, and overall job satisfaction.

- Frequent turnover disrupts workflow and team

dynamics. By reducing attrition, hospitals can maintain stable teams, allowing for better coordination and seamless patient care delivery.

OBJECTIVE

- Investigate the specific factors contributing to employee attrition within private hospitals in Bengaluru, understanding the nuanced reasons why healthcare professionals choose to leave their positions.

- Evaluate the impact of high attrition rates on patient care, hospital finances, and overall organizational performance. Understand how employee turnover affects the hospital's reputation and the quality of healthcare services provided.

- Research existing employee retention strategies employed by private hospitals globally and identify successful case studies within the healthcare sector. Evaluate the relevance and effectiveness of these strategies in the Bengaluru context.

- Recognize the unique challenges faced by private hospitals in Bengaluru, including local talent shortages, competitive pressures, and changing workforce demographics. Understand how these factors influence attrition and retention efforts.

- Propose customized retention strategies that cater to the specific needs and challenges of private hospitals in Bengaluru. These strategies should address local constraints and leverage the unique strengths of the healthcare sector in the city.

- Conduct a feasibility analysis of the proposed retention strategies, considering factors such as budget constraints, available resources, and the scalability of initiatives. Ensure that the suggested strategies are practical and realistic for implementation.

- Emphasize the importance of employee well-being by considering work-life balance, mental health support, and stress management programs as integral components of retention strategies. Prioritize the holistic wellness of healthcare professionals.

- Investigate the role of leadership in retention efforts. Assess the leadership qualities and skills required to create a positive work environment and retain employees. Develop recommendations for leadership development programs.

- Develop a detailed implementation framework that outlines the step-by-step process for private hospitals to adopt and adapt the proposed retention strategies. Provide actionable guidelines for HR managers and hospital administrators.

- Define key performance indicators (KPIs) to measure the effectiveness of the implemented strategies. Develop a monitoring and evaluation framework to assess the impact of retention initiatives over time and make necessary adjustments for continuous improvement.

- Disseminate research findings through publications, seminars, and workshops. Share insights with the healthcare community, policymakers, and relevant stakeholders to foster a collective understanding of employee attrition and retention challenges in the private hospital sector in Bengaluru.

MOTIVATIONS BEHIND EMPLOYEE ATTRITION IN PRIVATE HOSPITALS

- Employees may leave due to dissatisfaction with their job roles, working conditions, or lack of recognition and appreciation. Dissatisfaction can arise from a mismatch between expectations and reality regarding their roles and responsibilities.

- Employees might seek opportunities for career advancement and professional development that their current organization cannot provide. A lack of clear career progression pathways can lead to frustration and prompt them to explore other options.

- Competitive salaries and benefits are essential for retaining skilled healthcare professionals. If employees perceive that their compensation is not commensurate with their skills and workload, they might consider opportunities offering better financial rewards.

- Long working hours, frequent shifts, and high-stress levels can disrupt work-life balance, leading

to burnout. Employees may seek positions with better work-life balance, especially if they have family or personal commitments.

- A negative work environment, including lack of teamwork, ineffective leadership, and limited opportunities for skill development, can demotivate employees. Workplace conflicts, harassment, or a toxic organizational culture can drive employees away.

- Employees need recognition and appreciation for their efforts and achievements. When their contributions go unnoticed or unacknowledged, they may lose motivation and consider leaving for organizations where they feel valued.

MOTIVATIONS FOR EMPLOYEE RETENTION IN PRIVATE HOSPITALS IN BENGALURU

- Implement employee recognition programs, awards, and incentives for outstanding performance. Recognizing employees' efforts publicly can boost morale and motivation, encouraging them to stay with the organization.

- Offer competitive salaries, bonuses, and benefits packages. Regularly review compensation structures to ensure they align with industry standards and acknowledge employees' skills and experience.

- Provide opportunities for continuous learning, training, and skill development. Support employees in pursuing further education or certifications, enabling them to enhance their skills and advance their careers within the organization.

- Implement policies that promote work-life balance, such as flexible working hours, telecommuting options, and paid time off. Encourage employees to take breaks and vacations to prevent burnout.

- Foster a positive and inclusive workplace culture. Encourage teamwork, open communication, and mutual respect among employees. Provide avenues for employees to voice concerns and suggestions, ensuring they feel heard and valued.

- Invest in leadership development programs for managers and supervisors. Effective leadership can create a supportive work environment, inspire employees, and provide clear direction, contributing to higher retention rates.

- Implement wellness initiatives, including mental health support, stress management workshops, and fitness programs. Healthy and happy employees are more likely to stay committed to their roles and the organization.

- Celebrate employees' personal and professional milestones, such as birthdays, work anniversaries, and achievements. Small gestures of acknowledgment can significantly impact employee morale.

FINDINGS ON EMPLOYEE ATTRITION AND RETENTION CHALLENGES IN PRIVATE HOSPITALS IN BENGALURU

- Many healthcare professionals in private hospitals in Bengaluru experience high levels of stress due to demanding work schedules, long hours, and challenging patient cases. Job dissatisfaction is prevalent, especially concerning work-life balance and recognition.

- Employees perceive a lack of clear career advancement pathways within private hospitals. Limited opportunities for skill development and professional growth contribute to dissatisfaction and attrition.

- Salary disparities and inadequate benefits packages compared to competitors in the industry lead to attrition. Healthcare professionals seek better compensation, especially considering the demanding nature of their roles.

- The demanding nature of healthcare jobs often leads to a significant imbalance between work and personal life. Employees value organizations that provide flexibility and support for maintaining a healthy work-life balance.

- Poor leadership, lack of communication, and a negative organizational culture contribute to dissatisfaction. Employees feel demotivated when they perceive a lack of support, recognition, and transparent communication from management.

SUGGESTIONS FOR ADDRESSING EMPLOYEE ATTRITION AND ENHANCING RETENTION IN PRIVATE HOSPITALS IN BENGALURU

- Conduct regular market research to ensure salaries and benefits are competitive. Implement performance-based incentives and bonuses to recognize and reward employees for their contributions.

- Establish comprehensive career development programs, including training, workshops, and mentorship opportunities. Encourage employees to pursue further education and certifications, aligning their growth with organizational needs.

- Introduce flexible work hours, remote work options, and job-sharing programs. Providing flexibility can significantly improve work-life balance, reducing stress and enhancing job satisfaction.

- Foster a positive and inclusive culture through leadership training, communication workshops, and team-building activities. Implement regular feedback mechanisms to address employee concerns and foster a sense of belonging.

- Implement robust employee recognition programs that celebrate achievements and milestones. Recognize not only professional accomplishments but also personal events like birthdays and work anniversaries, creating a sense of belonging.

- Provide leadership training for managers and supervisors to improve communication skills, conflict resolution, and team management. Effective leadership can create a supportive work environment and inspire employees.

- Introduce comprehensive well-being programs, including mental health support, stress management workshops, and fitness programs. Prioritize employee health and well-being to create a holistic work environment.

- Organize regular training sessions and skill enhancement workshops, keeping employees updated with the latest medical technologies and procedures. Encourage continuous learning to boost confidence and job satisfaction.

- Foster open and transparent communication channels within the organization. Regularly update employees about organizational goals, changes, and achievements. Transparent communication builds trust and engagement.

- Provide resources and support for employees to balance work and personal life effectively. Offer resources such as counseling services, childcare facilities, and concierge services to alleviate personal stressors.

LIMITATION

- Research studies investigating employee attrition and retention challenges in private hospitals in Bengaluru may face several limitations that can impact the depth and scope of the research findings. It's essential to acknowledge these limitations to ensure a realistic interpretation of the study outcomes. Some of the potential limitations could include:

- Findings from a specific region or a group of hospitals in Bengaluru might not be universally applicable to all private hospitals in the city or in other regions. Factors contributing to attrition and retention can vary significantly across different hospital sizes, specialties, and locations.

- Access to comprehensive and updated data from private hospitals, especially regarding employee turnover rates, compensation structures, and internal policies, might be restricted due to privacy concerns or organizational policies. Limited access to relevant data can constrain the depth of the analysis.

- Surveys and interviews conducted to gather data might suffer from response bias. Employees might hesitate to express their true opinions or concerns, leading to skewed or incomplete data. Additionally, employees who have recently left the organization might be less likely to participate, affecting the accuracy of attrition-related data.

- Healthcare, as an industry, has unique complexities, including compliance regulations, patient care responsibilities, and demanding schedules. These industry-specific challenges might not have direct

analogs in other sectors, making it challenging to apply generic retention strategies from different industries.

- The healthcare industry is continuously evolving, with new technologies, policies, and patient expectations shaping the work environment. Strategies effective today might not be as relevant or successful in the future. A study conducted over a specific period might not capture the impact of future changes adequately.

- Private hospitals in Bengaluru can vary significantly in terms of management styles, organizational culture, and HR practices. Strategies that work for one hospital might not be suitable for another due to these internal differences. A one-size-fits-all approach might not be applicable.

- Bengaluru, like any other city, has a unique cultural and social context that influences the dynamics of the workplace. These factors, including cultural norms, social expectations, and regional values, can significantly impact employee attitudes and behaviors, making it challenging to generalize findings to other cultural contexts.

- Implementing certain retention strategies might require substantial financial investments. Smaller private hospitals, in particular, might have limited budgets, affecting their ability to adopt certain high-cost retention initiatives.

- Research studies often operate within specific timeframes. The limited duration of the study might restrict the depth of data analysis or the ability to observe long-term effects of implemented retention strategies.

- Economic fluctuations, market demands, and healthcare policies can impact the financial stability of private hospitals. These external factors can influence the hospitals' ability to implement certain retention strategies or invest in employee benefits and incentives.

CONCLUSION:

In conclusion, the challenges of employee attrition and retention in private hospitals in Bengaluru are complex but surmountable with strategic and compassionate approaches. The findings underscore the multifaceted nature of attrition, stemming from factors such as high stress levels, limited career growth opportunities, competitive compensation concerns, work-life imbalance, and leadership issues. These challenges, when left unaddressed, not only jeopardize the well-being of healthcare professionals but also impact patient care, hospital finances, and overall organizational stability.However, the research has illuminated several effective strategies that private hospitals in Bengaluru can adopt to enhance employee retention and mitigate attrition. Competitive compensation packages, robust career development programs, flexible work arrangements, positive organizational cultures, transparent communication, and comprehensive well-being initiatives emerged as key pillars in building a supportive work environment. Additionally, recognizing and appreciating employees' efforts, investing in leadership development, and providing opportunities for continuous learning have been proven methods to foster a sense of belonging and loyalty among healthcare professionals.

By implementing these strategies, private hospitals can create workplaces where employees are not just valued for their skills but are also supported in their personal and professional growth. Such environments not only retain experienced staff but also attract new talent, contributing to a positive cycle of growth and stability. Moreover, a content and motivated workforce directly translates into improved patient care, higher patient satisfaction, and enhanced hospital reputation.

REFERENCES

1. Theivanayaki M (2022) "A Conceptual Review of Microfinance For Street Vendors: A Desi (Indian) Perspective", AUT-AUT Research Journal, UGC Care approved Group 2 Journal Vol XIII, Issue II1, ISSN No: 0005-0601. PG NO: 19-22 IF 5.1 March 2022

2. Theivanayaki M (2022) "A study on self - funding Women owned small businesses in Coimbatore", AUT-AUT Research Journal, UGC Care approved Group 2 Journal Vol XIII, Issue 1, ISSN No: 0005-0601. PG NO: 34-40 IF 5.1 January 2022 DOI:10.0001865.Aut Aut.2022.V13I1.463782.01154

3. Theivanayaki M (2020) "Linkages between Stock Market and Foreign Exchange Market in BRICS",

International Journal of Psychological Rehabilitation, Vol 24, Issue 7, ISSN No: 1475-7192. PG NO: 5748-5754 IF 1.12

4. Theivanayaki M (2020) "An empirical study on Financial Performance Analysis of Selected Private Sector Banks", The International journal of analytical and experimental modal analysis, Vol 12, Issue 2, ISSN: 886-9367.

5. Akerjordet, K., Furunes, T., & Haver, A. (2018). Health-promoting leadership: An integrative review and future research agenda. Journal of advanced nursing, 74(7), 1505-1516

6. Das, B. L., & Baruah, M. (2013). Employee retention: A review of literature. Journal of business and management, 14(2), 8-16

7. Naseer, A., Perveen, K., Afzal, M., Waqas, A., & Gillani, S. A. (2017). The impact of leadership styles on staff nurses' turnover intentions. Saudi J Med Pharm Sci, 4929(10B), 1133-8

8. Buchan, J., Charlesworth, A., Gershlick, B., & Seccombe, I. (2019). A critical moment: NHS staffing trends, retention and attrition. London: Health Foundation

9. Sharp, K. N. (2022). Employee Turnover and Strategies Health Care Administrators Use to Improve Employee Retention: An Exploratory Case Study (Doctoral dissertation, Northcentral University)

Teaching and Learning Process in the VUCA World- Challenges and Opportunities

Sanjay K Deshpande, Vanishri Hundekar

Associate Professor
Dept of MBA KLS
Gogte Institute of Technology
Belagavi, Karnataka
✉ sanjaydeshpande@git.edu

✉ vrhundekar@git.edu

M M Munshi

Professor & Chairman
Dept of Management Studies (MBA) Jnana Sangama
Visvesvaraya Technological University (VTU)
Macche, Belagavi, Karnataka
✉ mmmunshi@rediffmail.com

ABSTRACT

VUCA world a term coined by the US army in 1990 has also found relevance in all spheres of business and social world inter-alia education. Ever since the turn of the 21st century, countless disruptions have occurred across the globe. No wonder the education sector has also been confronting the challenges of a rapidly changing world. This research paper accentuates the saga of the changing educational landscape in the VUCA world besides delineating the future strategies to be embraced by educational institutions to sustain and thrive in the VUCA world. The educational sector has undergone a tectonic shift in general and higher education in particular the responsibility of the educational sector in the VUCA world is akin to that of a cradle to nurture and foster the future workforce to face the challenges of the VUCA world. This empirical research paper tries to highlight "Design thinking" as a way forward approach to be adopted in the teaching-learning process. SPSS 22.0 has been use for Data Analysis and Hypothesis tested, revealing that, B schools located in Tier II and III cities need to revamp their pedagogy and modus operandi, thus paving the way for nodal bodies and apex organizations to introduce the needed policy interventions to address the areas of concern, mentioned thereto.

KEYWORDS: *VUCA world, Teaching-learning process, Higher education, Business atmosphere, Design thinking.*

INTRODUCTION TO THE VUCA WORLD

Since the flip of the century the chaotic, turbulent, and expediently dynamical situations inside which we tend to live got to be the 'new normal' (Lawrence 2013). Detonating mechanical improvements, emotional statistic development, migration, biological catastrophes, and related government patterns disturb our lives at an ever-expanding pace and breadth. These circumstances, quickened by a wave called "VUCA" are Volatile (Fast-Changing and Rapid changes or Sweeping changes at a rapid pace); Uncertain (difficulty to predict); complex (Difficult to interpret the situation and take a well-defined course of action); and Ambiguity (the fogginess or fuzziness or vagueness in all business aspects).

Looking at the VUCA world through the educational lens gives new perspectives and insights into several immediate & future challenges to be tackled. A few challenges are worthy to be considered as equipping and preparing a future workforce with a competitive and holistic mindset. VUCA world not only poses challenges but also presents immense opportunities to learn and embrace contemporary ways in all domains. Education is a bedrock for the VUCA world to rely on, the Business world needs a well-educated workforce equipped with social- emotional and domain skills to flourish and sustain. Hence the role of educational institutes in ensuring grooming the future.

Ever since the Second World War, the story of higher education has been an incredible one, this growth trajectory has immensely contributed to the enrichment of life, nation-building, societal well-being, and technological, and academic progress. Higher

education growth has had a rapid pace of growth. The future epoch of expansion and diversification will bank higher education to get a new crop of talented and multidimensional individuals, hence it is important to bring about radical changes in the way higher education is taught and learned.

VUCA world not only poses immense challenges but also presents new opportunities to learn and embrace new ways of life, however challenges and opportunities are sector-specific. VUCA for the educational sector can be defined as Volatile (Fast-Changing Academic content and framework due to technological, industrial growth, and development).Uncertainty (difficulty in predicting the wave of employment, domain, and future opportunities) Complex (Difficulty in interpreting academic sequence and steps to be followed to move to higher Academic grade). VUCA world necessities the academic framework and pedagogy to develop cognitive, intrapersonal, and interpersonal competencies.

Design Thinking

Design thinking aims to nurture novelty or innovative thinking by uplifting the participants' ability to think creatively. It focuses on problem-solving ability and improves the ability to resolve intricate problems, achieved through collaborative and human-centered activities. Many world-class and top-notch B schools offering higher education have incorporated design-thinking in their curriculum as specific skills that need to be taught in the 21st century.

Design thinking empowers organizations to move away from existing options to contemplate what new alternatives can be created. Design thinking goes beyond root cause analysis to understand why the problem is occurring and the impact of the problem on people (Dina Chesson 2017)

Since the bygone decade, the design thinking approach has become popular across various sectors and domains and has found its application in many sectors like manufacturing, business management, healthcare, social sciences, innovation, library services, and many others. This method aims to provide world-class products and services, worthy solutions for the benefit of society, business, and mankind. Design thinking and practices are worthy to be incorporated in academic curricula and

facilitate students to succeed in the 21st century (Leila Aflatoony 2015).

Figure 1 - Chesson Design Thinker Process Model

Source: Chesson, D (2018)

CRAIS

CRAIS represents concrete–representational – abstract instructional strategy (CRAIS) and involves the active participation of students in the process of learning, It provides a framework using which lessons can be designed and imparted effectively to assist students in cultivating an abstract way of thinking to learn intricate concepts and topics. CRAIS encompasses three parts namely reinforcing previous instructions, promoting student learning and retention, and improving the conceptual knowledge of students. CRAIS is an appropriate tool to teach students with learning difficulties. The better side and effectiveness of the CRAIS over the conventional teaching strategy is the fact that CRAIS is more learner-centered and offers learners the opportunity to be highly active learners. This high level of involvement of learners enables the students to develop a problem-solving approach. CRAIS method is worthy to be implemented in management education.

Problems of the educational sector in the current disruptive world

Access to higher education is riddled with economic status and financial problems, a seemingly dwindling return on education is concurring with mounting tuition fees, and a lack of employable skills results in spiraling student debt as students are unable to repay the loan. There have been instances of intensely competed 'arms race' to provide state of art student amenities, the most-inviting campus experience. Thus, the skyrocketing tuition fee structure. This is no doubt that teaching-learning to world-class, however, has made

it not affordable and not reachable to all segments of society. The probability of poorer students to enroll and pay tuition fees is too low. OECD in June 2020 in its report provides an insight that by and large the student expenditure on higher education doubled between 1995 and 2015 owing to inflation.

The new openings will require basic scholars, social logicians, and multi-disciplinary generalists who can disentangle complex issues and provide creative solutions. Hence the current result of the scholarly community, prepared in a conventional setting, who may have secured positions in the past would be out of profundity in the future world. Accordingly, the objectives of education must move. The new setting requires an exhaustive arrangement of education, equipped to set up the student for deftness, flexibility, importance, insight, and an endurance sense of a 'transient'.

While Higher Education in India has made immense progress in terms of volume and number of enrolments, it lags significantly w.r.t to global relevance and ability to produce competitive individuals. Thus, paving the way for the employability gap to rise even higher. Lower employability of graduates can be attributed to factors like the sabre-toothed tiger curriculum, the dearth of eminent faculty, the low research output of faculty, the unscientific ratio between students and teachers, weaker industry interface, and the inability to introduce novel and advanced courses. (FICCI and EY survey 2014).

Evolution and timeline of higher education in India per se

It traces back to the late 1940s during the Nehruvian period which witnessed an enormous focus on nation-building action through the establishment of factories and manufacturing units thus it led to the introduction of IITs to impart technical education and upgrade technical skills and thereby spurring the need to have a regulating body in the name of AICTE.

The late 1980s witnessed a massive growth of engineering and management colleges as management skills were in demand and desired, which led to the opening up of professional education to the private sector. During the 1990s when the IT wave made its presence and demand of education in the IT domain,

many educational institutions aligned to this emerging trend and started offering courses in IT specialization inter-alia conventional institutes.

The proclamation of NEP 2020 after three decades, at a time when the business world is riddled with challenges, is a prudent initiative and a striking reminder that education must equip students to face the VUCA world. Covid 19 pandemic is one such testament to checking the readiness of educational institutions to handle volatility, uncertainty, complexity, and ambiguity given unforeseen situations like the current pandemic. NEP 2020 can be a game- changer and dwells on an integrated strategy to offer professional education along with content cultural and humanities studies to prepare holistic future citizens.

Holistic grooming of Graduates and postgraduates will help them become topical across the industry for multiple roles, in numerous sectors domains such as FMCG, telecom manufacturing media, banking, and many others.

Challenges faced by Higher Education in the VUCA world

Higher education has grown 6.12 times between 1970 and 2013, the world over, However, this mega growth not only depicts numbers but brings many challenges with its expansion. Higher education confronts three major challenges first being, the need to have a coherent learning ecosystem in which learners will move in and move out over a lifetime with a wide spectrum of education providers offering quality learning experiences. Secondly, transit from a perception of size fits approach to well-curated and customized learning fine-tuned during student engagement supported by robust technology, rethinking education and curriculum for a world of human-machine work underpinning the need to reorient the academic curriculum and to be done in educational campuses. (Paul J. LeBlanc 2018). It simply means that quite a lot of jobs in conventional domains that we see and the majority of the workforce is in today, will disappear and many new opportunities in asynchronous fields that we had not imagined, will surface and manifest the current business situation and climate.

Many traditional universities offering conventional

education are finding it to be a daunting task and also culturally unwilling, to participate in the digital platform of education, hence many competitors virtually offering digital education are becoming stronger and stronger (KPMG report 2020).

Higher education orbit was once regarded as the most sought-after access point to acquire new novel information and higher knowledge, however with the disruption of the Internet world and the advent of the social networking platform. Better and seamless interrupted access to information and knowledge is at the fingertips thus making the classrooms appear outdated. Awakened by this fact, flexibility, alertness, and dissemination of new knowledge instead of predefined solutions become imperative more than ever. In a bid to stay relevant, accepted supreme universities, irrespective of their size, age, and legacy, are attempting to contest the challenges of globalization and VUCA through many technology-based interventions.

HEI- Higher Educational Institutes are required to make a transition from formal and conventional ways of teaching and learning and reorient their mission statements by including innovation, entrepreneurship, creativity, and marketing. And are further required to anticipate the upcoming changes in the near/distant future and to acclimatize to them through the most befitting processes (Waller, 2019)

Keeping in view a fast-moving world, teachers have to be oriented about the changing world not only by self-training but also through faculty development programs (FDPs) and hands-on sessions organized by either the parent Institution or apex bodies or universities. Up-gradation of Digital skills and revamping course content is a must to improve teaching quality (Bhatia & Mohsin 2020).

Opportunities to be Grabbed

NEPs' razor-sharp focus on vocational education aims at skilling and up-skilling the Indian student segment to brace them for future job opportunities in the 21st century. VUCA world offers an opportunity for teachers and learners to operate in a global space

Opportunities to build their repertoire of skills through industry-integrated, innovative vocational courses, and entrepreneurial skills. For preparing their learners to

work in the VUCA world, the schools could additionally develop in them the 4Cs of 21st-century skills -Critical thinking, Communication, Collaboration, and Creativity.

Benson and Lunt (2011) have suggested a few key initiatives to be incorporated into pedagogy to encourage the intellectual and holistic development of students: Initiatives such as 1) highlighting and emphasizing improving creativity in students and 2) encouraging students to develop a sense of ownership by exploring things out of free will 3) providing hands-on experience 4) avoiding too much focus on activities that induce time pressure 5) Encouraging teamwork, collaborative projects, and interaction of students.

Skill-oriented sectors such as manufacturing and services are anticipated to contribute more than 90% to India's GDP by 2030. Hence, the trend of employment is likely to swing towards the services sector and manufacturing as well. Multiple jobs are expected to be created in the said sector.

Teachers in the VUCA world

Teachers in the VUCA world have an incredible role to play, they could become change- makers sculptors, and architects of the success of students. Teachers are expected to be ahead of time and improve their quality of interaction with students. Stay relevant and abreast with the latest trends is a prerequisite. Teachers can be torchbearers in the dark world of VUCA if they can improve some grey areas as FICCI indicates and raises concern about missing research focus and culture in most of the institutions offering higher education. Without research quality of teaching will degrade.

Although the number of patents filed with WIPO (World Intellectual Property Office Organization) across the globe is up by 5.2%, the share of India is not very encouraging, with the USA leading the race, followed by China leading the list. Teachers are expected to in the stream of IPR,

The advanced and implied duty of teachers will now be, to go beyond the realm of academic curriculum and teach with real-time sense, changing the mindset of students from meager academic orientation to problem-solving and decision-making and the like will be most

desired. Change in the ideology and shift from teaching only concepts to the way of actually doing it is called upon, for instance, although creativity is inbound and intrinsic and cannot be taught externally, creative thinking can be taught should be the teacher's resolve and belief.

Looking around our teachers in schools, colleges, and universities appear to be keeping their fingers crossed in a state of helplessness. Only a few private institutions are believed to have taken recourse to online education. It is gathered that the majority of our teachers are either not suited to offer online education that requires meticulous preparation and excellent articulation for communication or have no appetite for orientation and relearning (Deccan Herald).

Students in the VUCA World

Gen Z has grown up using technology in the routine of their everyday life instant and seamless access to laptops, computers, Tabs, cell phones, online games, and social media has made them united to the world of technology. Hence expect some technology in almost everything they do, so with education and learning.

VUCA education means students should prepare for jobs that don't exist hitherto, it also involves learning in myriad ways. Exercises like Case study discussion and scenario analysis will churn in opportunities for the students to speak, collaborate, critically think, and be creative. Multi-skilled students get themselves placed well, 21st-century skill sets are very different from conventional skills.

Keeping in view the rising expectations from the industry, Students may assimilate the fact that, meager academic degree certificates and tags issued by the Universities may fail to fetch jobs in the VUCA world, in case they fetch such jobs may not assure lifetime guarantee and success. Hence being highly adaptable, developing a quest to learn new sets of skills is indispensable.

REVIEW OF LITERATURE

Ever since the Second World War, Higher education has seen astonishing growth. 'Human capital theory' vindicates from an economic perspective by extrapolating the fact that spending on higher education is essentially an investment in economic growth for individuals and society. Higher education will become more diverse, integrated, and customized. Different educational institutors will proliferate. A fine blend of actual campuses, extended campuses flipped classrooms and virtual learning environments will be the order of the day, Education will see more permutations and combinations with content and delivery (KPMG report 2020). It is suggested that one of the key goals of the academic institution, tutors is to prepare students to become flexible learners through meta-learning skills. Hence the students can combat disruptions and transition to become a robust and versatile future workforce. Meta-learning strategies are to be imparted to students as it is the most called-upon intervention to embrace the ever-present uncertainty. To succeed in this turbulent and uncertain world multiple learning opportunities are to be provided and make students become lifelong learners. The standing challenge that educational institutes face today in the turbid world is to develop social, emotional, and intellectual competencies else they may succumb to the VUCA world. An imminent test lying before educational institutes is to prepare the students to become inquisitive, exploratory, and socially responsible (OECD Report 2020).

VUCA times involve and call for a transition from off-line to a new online system of education, which is quite abrupt, and least calibrated, with no buffer time for either students or faculty to comprehend the situation (Bhatia & Mohsin 2020). Hence the heat of VUCA is percolated to the teaching sector too, Left attended and unheeded, the teaching sector as a whole could become redundant and fail to meet its very purpose. The exacerbation of the future workforce will be inevitable.

The focus of higher education in the 21st century will be more on Creativity, innovation, critical thinking, Decision making and problem-solving, communication skills, soft skills, and collaborative working. Design thinking will find relevance in implementation in curricula. For higher effectiveness, the pedagogical structure also needs a complete makeover. Emphasis on the field, project-based learning, problem-solving approach, and inquiry-method of teaching and learning in classroom activities will be imperative (Leila Aflatoony 2015).

PROBLEM STATEMENT

From the literature review, it can be deciphered that the hackneyed phrase which reads "Product of Academia is not employable, Industry needs creative problem solvers, socially sensitive and responsible individuals" is very relevant and an awakener for all the stakeholders in the teaching community. The onus to prepare future workforce possessing before mentioned skills lies on educational institutions. VUCA world poses supreme challenges and golden opportunities at the same time. The prudence lies with the educational institutes to surge ahead by taking calculated steps in the desired directions. Teaching- The learning process is the heart of educational institutes, and needs active cooperation from its direct stakeholders like faculty and indirect stakeholders like parents, management, and other pertinent external forces.
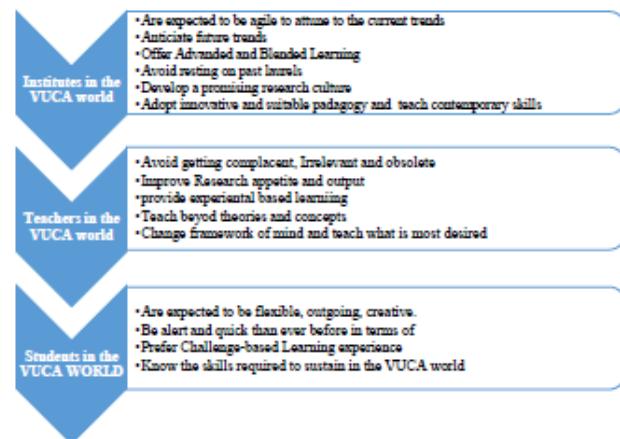
Construct Validity for Data collection Instrument (Questionnaire)

Table 1:

Parameter	References
• Decision Making, • Self-Management • Communication skills • Problem Solving • Creativity • Innovation • Soft Skills • Group Learning • Team Work As per the literature survey, these are the skills needed for the students to survive in the VUCA world	1. PTI. (2016, April 30). A report by Indian Express. 2. Culpin, V. (n.d.). 5 Skills in A VUCA World: Ashridge Executive Education. Retrieved November 26, from https://www.hult.edu/en/executive-education/insights/five-essential-skills-to-learn-in-a-vuca-world/ 3. OECD. (2020). OECD Teaching and Learning International Survey (TALIS). The Netherlands: International Project Consortium:

Conceptual model for the study: Based on the Review of Literature, the following model is developed

Figure 2

RESEARCH METHODOLOGY

Data collection: The data collection instrument was circulated online (Google form online Survey)

Data: Primary Data was collected through a self-structured questionnaire through the Internet platform (Note: The responses were extracted using a Google form and were administered to the faculty of B schools)

Sampling Frame: Teaching faculty and students of postgraduate management colleges across the country.

Sample Size: Students – 231 Faculty- 82

Sampling Method: Convenient sampling,

Research tools used: Cronbach Alpha, Chi-Square Test, Correlation Analysis (Bivariate)

Confidence Level: 95%

Objectives of this research

1. To find out the challenges faced by teachers in the teaching profession

2. To find out the awareness of VUCA amongst the B school faculty

3. To know the areas to be considered for teaching beyond the curriculum.

4. To determine the correlation between student experience and academic curriculum

Hypothesis

H1o- B-School Faculty are unaware of the best teaching method to prepare the future workforce

H1a – B-School Faculty are aware of the best teaching method to prepare the future workforce

H2O – There is no correlation between student experience and curriculum H2a - There is a correlation between student experience and curriculum.

DATA ANALYSIS

Reliability Statistics for Student Sample

Table 2

Cronbach's Alpha	N of Items
.877	11
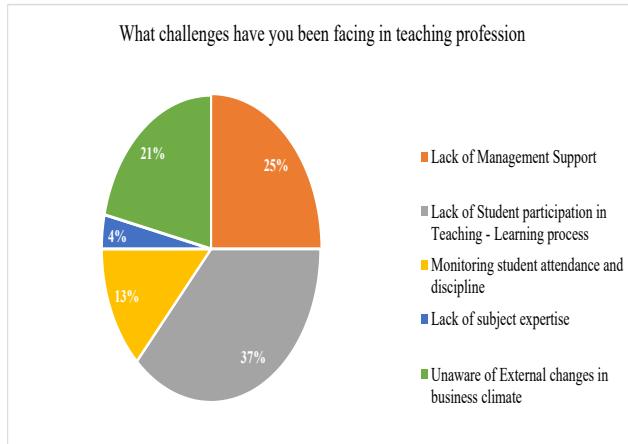
Reliability Statistics for Faculty Sample

Table 3

Cronbach's Alpha	N of Items
.857	6

Descriptive Statistics
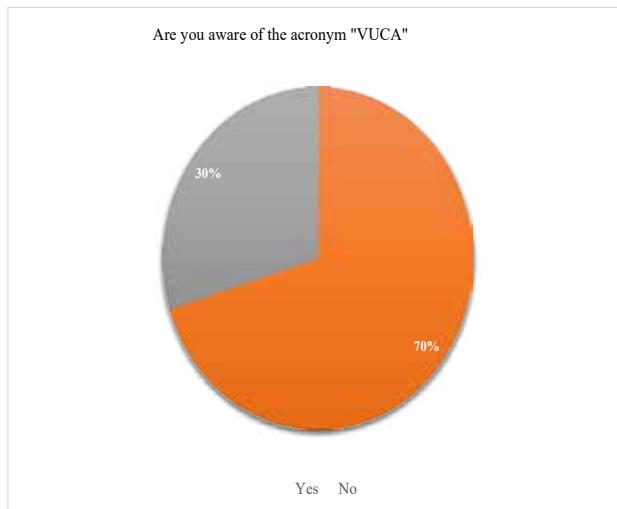
Chart 1- Challenges Faced by Teachers of B Schools

Inference: From the above pie chart it can be inferred that more than 36% of the faculty respondents have expressed that lack of student participation in the teaching-learning process is a major challenge faced by faculty followed by lack of management support as
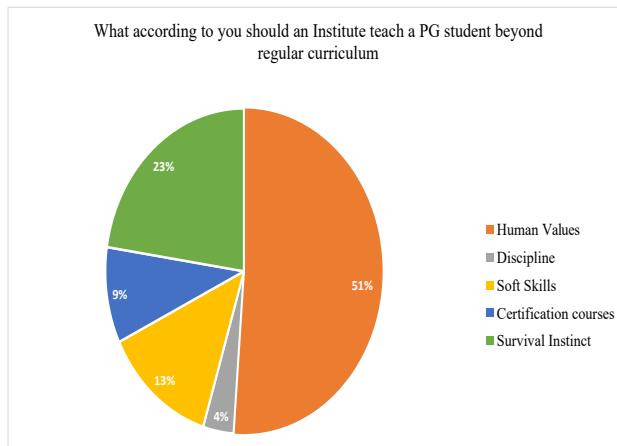
a second major challenge as expressed by 25% of the faculty respondents.

Chart 2 - Awareness of VUCA amongst faculty

Inference: From the above pie chart it can be inferred that more than 70% of the faculty are aware of the VUCA world followed by 29.76 % of them being unaware.

Chart 3 - To know the areas to be considered for teaching beyond the curriculum

Inference

From the above pie chart, it can be inferred that more than 51% of the faculty respondents have expressed that Human values to be taught beyond the curriculum followed by 22% of them saying survival techniques to be taught, 13 % of them saying soft skills to be taught in B schools beyond the curriculum.

Inferential Statistics

Testing of Hypothesis

H1o- B-School Faculty are unaware of the best teaching method to prepare the future workforce.

H1a- B-School Faculty are aware of the best teaching method to prepare the future workforce.

Table 4: Chi-Square Table

Chi-Square Tests			
Pearson Chi-Square	Value	df	Asymptotic Significance (2-sided)
Likelihood Ratio	20.402a	16	.203
Linear-by-Linear			
Association	20.725	16	.189
N of Valid Cases	3.726	1	.054

Description: A chi-square test was employed to ascertain if the teachers are aware of the best teaching method to prepare the future workforce, to test the hypothesis "B School Faculty are unaware about the best teaching method to prepare the future workforce". To test this hypothesis, the association between two items namely what according to is necessary to prepare the future workforce and which According to you is the best method of teaching in the current times were chosen and tested using the Chi-square test.

Inference: The result reveals that both the items tested have no association with each other as significant by the P-value .203(.203 > 0.05) of the Pearson Chi-Square test, Hence Null hypothesis is accepted to claim that, the assumed statement B School Faculty are unaware of the best teaching method to prepare the future workforce is the inference.

H2O -There is no correlation between student experience and curriculum

H2a - There is no correlation between student experience and curriculum

Table 5: Correlation between Student experience and curriculum

Correlations			Student experience	Curriculum
Student experience	Pearson Correlation		1	.120
	Sig. (2-tailed)			.278
	N		231	84
Curriculum	Pearson Correlation		.120	1
	Sig. (2-tailed)		.278	
	N		84	84

Description: Bi-variate correlation analysis was employed to ascertain if the student experience has any correlation with the curriculum of B schools. To test this hypothesis, the correlation between two items namely curriculum taught by faculty and student experience. The mean values of the said parameters were correlated against each other.

Inference: Table 6 reveals that there is no or negligible correlation ship between curriculum and student experience and also P-value. 278 (.278 > 0.05), The null hypothesis is accepted therefore the assumed statement "There is no correlation between student experience and curriculum" is the inference.

RESULTS AND DISCUSSION

Findings from descriptive statistics

Descriptive statistics of this particular research study unveil that the predominant challenges faced by management faculty are a lack of student participation in the teaching-learning process and a lack of management support. This study gives a view of the awareness level of the VUCA world that rules the roost now, Faculty members who cannot catch up with the pace of VUCA could become obsolete and helpless. A further novel finding indicates that there is an urgent need to teach the students in areas like Human values, Soft skills, Sustainability, and Survival to make them encounter the challenges posed by the VUCA world.

Findings from inferential statistics

The inferential output of this particular study uncovers the fact that management teachers are unsure and unaware of the best teaching methods or pedagogy to be deployed to teach management education in a bid to prepare and groom the future workforce. This finding gives food for thought to all the readers and faculty members to be very precise in choosing the best pedagogical tools to impart management lessons, students prefer to learn through experiential learning, however, to use this method for the entire curriculum is a daunting task.

Limitations of the study

Given the COVID-19 situation, circumstances did not permit the researcher to physically interact with the respondents and collect the data. Which otherwise could have given more insights through non-verbal communication, like body language and the like.

Speculations

It appears from the current standpoint that, faculty students and all other stakeholders of the educational domain need to be reoriented about the VUCA world. It is expected that the teaching-learning process needs a reboot to make it more relevant in the current times. A new set of practices, methods, ways, and means are to be discovered and implemented by Institutes, Faculty

Scope for further research

The findings of this research study throw open many new areas to be researched upon, as the study revealed that many management faculty are unaware of the best teaching methods and techniques. Interested researchers can study the efficacy of different teaching methods of teaching in detail and develop a matrix that will guide the faculty to use the appropriate teaching method to teach a particular topic from a specific domain

CONCLUSION

As it is evident from the research, preparing a future workforce using predefined tools and techniques is nothing else than embracing obsolescence and may turn futile. Owing to the constant flux, skills, and abilities become outdated, and to ride on the wave of change calls for a balancing act between resources, demand,

and strategies of educational institutes. Resting on past laurels does not yield any progress, hence management faculty should be awakened to the fact that the rate of obsolesce is faster than ever. The time is ripe to leverage new approaches like Design Thinking and CRAIS to make the education pillar more strong, relevant, and acceptable. All the possibilities become possible by engrossing in the best possible research, without research output and catering to the needs, the danger of redundancy lurks and stalks.

REFERENCES

1. Aflatoony, L. (2015). Development, Implementation, and Evaluation of an Interaction Design Thinking Course in the Context of Secondary Education (Unpublished master's thesis). SIMON FRASER UNIVERSITY.

2. Akinoso, S. O., Dr. (2015). Teaching mathematics in a volatile, uncertain, complex and ambiguous (vuca) world: the use of concrete – representational – abstract instructional strategy. JISTE, 9(1), 97-107.

3. Benson, C., Lunt, J. (2011). We're Creative on a Friday Afternoon: Investigating Children's Perceptions of their Experience of Design & Technology concerning Creativity, J Science Education Technology, 20 (1), 679-687.

4. Bhatia, A., & Farhat, M., Dr. (2020). Measuring Happiness of University Teachers during Challenging Times. International Journal of Advanced Science and Technology, 29(105), 7805-7817.

5. Chesson, Dani, "Design Thinker Profile: Creating and Validating a Scale for Measuring Design Thinking Capabilities" (2017). Dissertations & Theses. 388.

6. Culpin, V. (n.d.). 5 Skills In A VUCA World: Ashridge Executive Education. Retrieved November 26, from https://www.hult.edu/en/executive-education/insights/five-essential-skills-to-learn-in-a-vuca-world/

7. Dym, C.L., Agoging, A.M., Eris, O., Frey, D., Leifer, L.J. (2005). Engineering Design Thinking, Teaching, and Learning, Journal of Engineering Education, 94 (1), 103- 120.

8. Lor, Rex. (2017). Design Thinking in Education: A Critical Review of Literature.

9. OECD. (2020). OECD Teaching and Learning International Survey (TALIS). The Netherlands: International Project Consortium:

10. Paul J. LeBlanc (2018) Higher Education in a VUCA World, Change The Magazine of Higher Learning, 50:3-4, 23-26,

11. PTI. (2016, April 30). Only 7% of MBA graduates are employable, the rest earn 8-10k: Study. Retrieved November 26, 2020, from https://indianexpress.com/article/education/only-7-of-indias-b-school-graduates-employable-rest-earn-8-10k-study/

12. Saraswathy, M. (2014, November 13). Employability of graduates big concern, says FICCI-EY report. Retrieved November 21, 2020, from https://www.business-standard.com/article/management/

employability- of-graduates-big-concern-says-ficci-ey-report-114111301099_1.html

13. Tatiana V. Korsakova, 2019. "Higher Education in VUCA-World: New Metaphor of University," European Journal of Interdisciplinary Studies Articles, European Center for Science Education and Research, vol. 5, EJIS May

14. The future of higher education in a disruptive world (Publication). (2020). Australia: KPMG.

15. Waller, R. E., Lemoine, P. A., Mense, E. G., Garretson, C. J., & Richardson, M. D. (2019). Global Higher Education in a VUCA World: Concerns and Projections. Journal of Education and Development, 3(2), 73.

A Study on Implementing the House of Quality as a Quality Measure in Higher Education Institutes

Khimya S Tinani
Sardar Patel University
Vallabh Vidyanagar
✉ tinani.khimya-stat@spuvvn.edu

ABSTRACT

Emphasizing excellence has consistently been a fundamental focus for the management of products and services. Countless years have been dedicated to investigating methods to measure and improve quality. Enhancing the standard of higher education establishments is a top priority and these institutions are constantly seeking novel approaches to elevate the standard of their teaching. QFD stands for Quality Function Deployment, which is a technique used in Total Quality Management (TQM) to enhance designs and processes. This research uses QFD to ameliorate teaching quality and also to enhance the overall excellence of education. Additionally, the investigation has explored the utilization of the house of quality (HOQ) technique in higher education. The research is based on primary data collected from students at Sardar Patel University in Vallabh Vidyanagar. A self-created questionnaire was utilized to gather information from 338 students. The QFD analysis was performed using the data to determine which requirements the students valued the most. Using Sigma XL software, a house of quality that highlights the main areas in need of teaching quality improvements has been constructed based on the data that was gathered.

KEYWORDS: House of quality (HOQ), Total quality management (TQM), Relationship matrix.

INTRODUCTION

Human beings are the social animals. The basic difference between animals and humans is intelligence, skills and knowledge. We get skills and knowledge through education. Education of an individual begins from home. Basic education of knowledge to read, calculate and write is essential for every individual. Skills and knowledge acquired by education determines the quality of life of an individual. As the main customer in the new educational paradigm, students and teachers must work together during the process of discovery and learning. For better product and service, quality is most important criteria. Many efforts have been done in research for quality betterment and to develop methods to improve it. Globally, higher education institutions like to work upon the improvement of their teaching quality that enhances the competence of their students and to provide better ecosystem of infrastructure and necessary facilities. While considering the better quality in the higher education, many challenges emerge. First and foremost, requirement for improvement in quality in education is competent and passionate faculties who provide value addition to the knowledge of students. Other requirement for quality in education is relevant syllabus and material that prepare students so that they provide value addition to the world. According to Bordia (2001), students will use their knowledge in a variety of contexts and for an unspecified amount of time. Assessment factors are frequently arbitrary and challenging to measure, as stated by Cloutier and Richards (1994). Assessing customer satisfaction at an educational institution may be viewed by the relevant management as one of the most difficult issues of quality concerns.

According to Norris (1978), a university education should not just prepare students for the workforce but also for intellectual growth that will benefit them for the rest of their lives. The global competitiveness has been primarily determined by quality, which has increased demand for high-quality goods and services. In order to overcome these problems, a lot of firms have implemented whole quality management

systems. Quality across the entire organization is the aim of TQM. TQM implies total quality management, which includes bringing together efforts across all departments in order to achieve company excellence in terms of customer satisfaction. TQM focuses on improving the level of goods and services provided by businesses, healthcare institutions, and government bodies. To improve the level of education, universities are also adopting TQM concepts. QFD, a technique of Total Quality Management (TQM), is one tool for improving designs and processes. The development and implementation of features, qualities, or functions that raise the high quality of a good or service is done through a process known as quality function deployment. QFD is a useful tool to examine how to produce high-quality goods and services based on customer feedback or expectations. The QFD's origin is mainly started in Japanese industry. The Japanese book Deployment of the Quality Function, which was published in 1978, provided evidence that QFD was becoming a more and more popular tool for quality management in Japan. The study on QFD utilization by Akao et al. (1987) was conducted in Japan in 1986 by the Japan Quality Control Association's quality research branch. According to Akao (1990), QFD is an approach to creating high-quality goods and services with the motto of meeting customer needs and translating those needs into desired outcomes while preserving quality throughout the manufacturing process. A popular tool for customer-driven product design across several industries is quality function deployment, or QFD. Its goal is to translate client expectations into equal engineering attributes in order to enhance customer satisfaction. Bolt and Mazur (1999) studied that QFD considers delivering favourable results by seeking both expressed and unexpressed needs of customers. In a chain where the customer is the ultimate benefactor, it can be applied to designs and behaviors and communicated to all the organizations involved.

As stated by Clausing and Hauser (1988), the House of Quality (HOQ) is the basic design tool for management. It provides a way to communicate and plan across functional boundaries while developing new products or services. Bernal et al. (2009) stated that the creation of a series of matrices known as the House of Quality is the foundation of the QFD approach and process for

developing products and services. Applied competitive benchmarking was described by Keegan and O'Kelly (2004) as a procedure that allows firms to undertake objective evaluations in order to understand their current condition and take initiatives to enhance performance. Accordingly, benchmarking is described as a continuing analytical process that compares an organization's, function's, or processes' effectiveness to the best in the world with the goal of not only matching but exceeding those performance levels.

REVIEW OF LITERATURE

Since universities are the primary source of higher education, they have a great deal of interest in providing high-quality services that will enable them to produce high-quality goods for the market. Universities aim to enhance the quality of their educational systems, putting them apart from the competition. Several authors and academicians have taken advantage of QFD's applicability in several sectors of product and service creation, as well as in education. Clayton (1993) initiated the application of QFD in the field of education. At Aston University, he carried out a case study primarily centered on comprehensive quality management. The three domains where the successful applications of QFD in different education sector schemes are classified as engineering education, curriculum redesign, and management education. Demand for institutions to offer attractive curriculum ideas is currently rising. An outstanding curriculum is one of the most crucial components in creating a program that is appealing and interesting. One useful approach to developing a curriculum that will be beneficial is to use Quality Function Deployment (QFD). According to Brackin and Rosers (1999), the QFD approach offers an organized method to identify, prioritize, and convert consumer needs into product design criteria. In order to enhance the curriculum development procedure at the University of Portsmouth, Seow and Moody (1996) focused on identifying the VOC. The application of QFD principles and software to prioritize planning objectives for the development of engineering laboratories at the University of Missouri-Rolla was demonstrated by Benjamin and Pattanapanchai (1993). In the same way, Owlia and Aspinwall (1998) used QFD concepts to classify processes into broad groups that are associated

with quality attributes. They also discussed about the differences in viewpoints among employers, employees, and students. When developing engineering programs at the University of Cincinnati, Krishnan and Houshmand (1993) employed QFD to meet customer goals. A course on basic statistics was designed and taught using QFD by Duffuaa et al. (2003) at the King Fahd University of Petroleum and Minerals in Saudi Arabia. Wholistic considerations of faculty members, organizations, students' needs were taken into account. According to Wiklund & Wiklund (1999), QFD was employed at the Lulea University of Technology in Sweden to increase student satisfaction and learning. To better serve the needs of the students, a graduate course on quality technology was designed with several components. In order to find solutions to enhance the teaching and advising processes at West Virginia University, Jaraiedi and Ritz (1994) employed QFD. In order to assess the quality of teaching at the City University of Hong Kong's Department of Management Science, Lam and Zhao (1998) combined the QFD correlation matrix with an approach known as the analytical hierarchy process (AHP). In order to develop the MBA program at Grand Valley State University, Motwani et al. (1996) outlined a three-house method that took the accrediting standards of the American Assembly of Collegiate Schools of Business (AACSB) under consideration. From the same university, Pitman et al. (1995) used QFD to evaluate customer satisfaction of their MBA program. Using TQM and QFD concepts, Chang and Ku (1995) identified areas for improvement in Taiwan's engineering and technical education. They highlighted the need of fulfilling both the educational demands of students and the industry's personnel requirements. At the Department of Mechanical Engineering, University of Wisconsin-Madison, Ermer (1995) highlighted the design characteristics required to satisfy each type of customers. Based on the results, it seems that QFD can help minimize cycle times and improve workflow in educational institutions. Multiple matrices, such as society versus students, students versus university education, and society versus university education, were presented by Akao et al. (1996) to show the relations between VOC and design needs. Both internal and external consumers' viewpoints were taken into consideration while evaluating quality.

OBJECTIVES

In essence, universities strive to deliver top-notch education and effective administrative processes. The academic staff is dedicated to serve students promptly and in line with university standards. Higher education institutions can enhance the quality of their processes by implementing Quality Function Deployment (QFD), which also helps them know the various needs and expectations of their students, map the students' requirements into specific attributes and characteristics of the educational offerings, including curriculum, teaching methodologies, student support services, infrastructure, and learning resources. Encouraging the education sector to adopt Quality Function Deployment (QFD) contributes to the improvement of educational services and when necessary, recommends the addition of new tools and methods for raising educational quality.

RESEARCH METHODOLOGY

The study is done by survey methods, based on the questionnaire which aims to gather valuable insights regarding students' satisfaction levels and priorities across different aspects of the University. The information collected has been used for research purpose to enhance the quality of the academic environment and support continuous improvement efforts in higher education institutes. Before preparing the questionnaire, group discussions and interviews were done with students to gather qualitative insights and to understand students' perspective of their needs. Based on this, the questionnaire was designed in four parts in such a way that each part consists of twelve different needs of the students. Part I is about students' requirements regarding campus facilities and resources. It demonstrates students' satisfaction with respect to the facilities provided by the University. Some of the needs considered under this category are classroom quality and integration of technology, safety and security measures, health and wellness facilities, availability of help desk services, etc. Part II helps to know students' satisfaction levels with respect to support services in the institution. The requirements considered here include academic guidance, career counselling, earning facilities while learning, financial aid assistance and scholarship opportunities, etc. Teaching and learning aspects are considered in Part III. This category is about

the students' satisfaction levels related to teaching and learning experiences in the institution. Here students' needs include satisfaction regarding communication skills of faculties, faculties' expertise, motivation from teachers, innovative teaching methods, hands-on practical sessions, etc. Part IV reveals students' satisfaction levels with respect to academic programs and curriculum implemented in the institution. This includes alignment of curriculum with industry requirements, flexibility in selecting elective courses, research opportunities for students, interdisciplinary studies, etc. In this questionnaire students had to rate their satisfaction regarding their experience at the University using a 5-point scale. Additionally, the students were asked to rank their needs to be prioritised in each part from 1 to12, with 1 indicating the highest priority and 12 representing the lowest priority. A population is the total number of P.G. (semester-III) and semester-I students currently studying in all the departments of Sardar Patel University Vallabh Vidyanagar. Due to the impracticality of gathering data from the entire population, this study opted for a sample or subset of the population instead. The main survey study had a sample size of 338 participants. For the collection of samples, two stage sampling was used. In the first stage, stratified sampling was used and strata was made based on department from all faculties. Proportional allocation method was used in every stratum and obtained ni as number of sample point to be collected from each department.

where, ni = sample size of each department based on proportion $=(n/N)*Ni$.

N= Total number of P.G. (semester-III) and semester-I students of all the department in the academic year 2022-23.

Ni= Total number of P.G. (Semester-III) and semester-I students from each department in the academic year 2022-23.

The proportional allocation method was utilized to distribute the sample size among different department, as shown in the table 1 below.

Table 1: Sample size distribution by department in proportion

Department	Ni	ni=(n/N)*Ni	Round off
English	154	12.5421	13
Economics	143	11.6462	12
Gujarati	108	8.7958	9
Hindi	73	5.9422	6
History	36	2.9304	3
Library & Information science	23	1.8722	2
Political science	33	2.6862	3
Psychology	119	9.6866	10
Sanskrit	110	8.954	9
Social Work	96	7.8144	8
Sociology	145	11.803	12
Bioscience	246	20.0244	20
Computer science	271	22.0594	22
Chemistry	411	33.4554	33
Electronics	38	3.0932	3
Mathematics	257	20.9198	21
Material science	37	3.0118	3
Physics	289	23.5246	24
Statistics	129	10.5006	11

Pharmaceutical sciences	10	0.814	1
Home science	107	8.7098	9
Education	109	8.8726	9
Business Management	204	16.6142	17
Law	275	22.385	22
Business studies	546	44.4444	44
Total	N=3966		n=338

This research paper focuses solely on the teaching and learning aspects of 338 university students when constructing the house of quality.

DATA VISUALIZATION
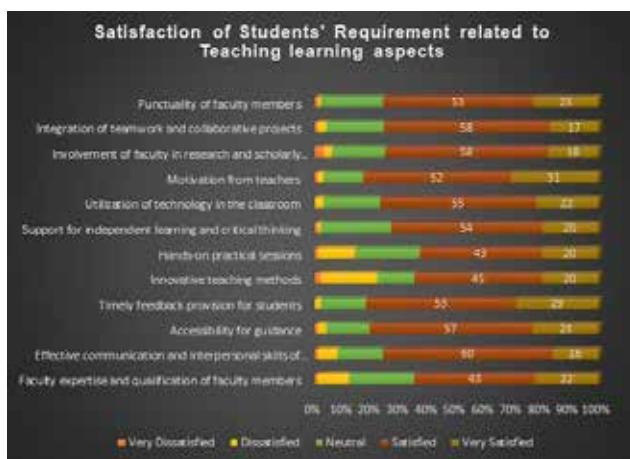
Figure 1: Student Feedback: Requirement, Teaching learning satisfaction

After analyzing the collected feedback on various teaching and learning aspects, the majority of students appear to be satisfied with motivation from teacher, timely feedback provision, accessibility for guidance, etc. This suggests that the institution's efforts to maintain a competent teaching staff, and maintaining punctual learning environment are contributing to a positive learning experience for majority of students.

THE HOUSE OF QUALITY BASIC MODEL

The main element involved in building QFD is the House of Quality (HOQ). The HOQ comprises of several standard main components. The following is a typical HOQ chart showing the step-by-step methods in the following figure 2.

Step 1: Conduct a preliminary survey of client needs.

Methods like as interviews, focus groups, questionnaires, and other approaches can be used.

Step 2: Technical requirements are established in response to the customer requirements known as Quality characteristic. The product or service must have these certain qualities and attributes.

Step 3: Draw a two-dimensional matrix, often in the shape of a house, with customer needs listed on the left side and technical requirements on the top. Technical requirements will be represented by columns in the matrix, while customer needs will be represented by rows.

Step 4: Analyze the connections between the technical specifications and the needs of the customers.

Step 5. Determine the importance ratings for customer needs. Assign numerical values to represent the relative importance of each customer need.

Step 6. Multiply the relationship values by the corresponding importance ratings for each cell in the matrix. This will measure of how well each technical requirement satisfies the overall customer needs.

Step 7. Analyse the calculated values to identify the technical requirements that have the highest impact on meeting customer needs. These are the critical areas where improvements or focus should be given.
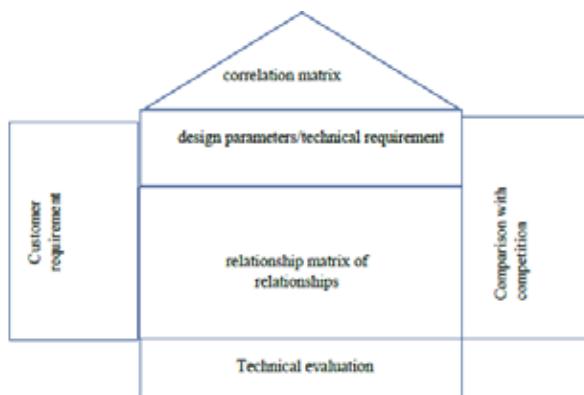
Figure 2: The House of Quality's basic model

HOQ MODEL FOR TEACHING AND LEARNING ASPECTS

The result of the HOQ matrix for teaching and learning aspects is presented in the following Figure 3.\

	Qualified and experienced faculties	Availability of faculty	Assessment feedback mechanism	Interactive learning tools	Personalized learning options	Collaborative learning opportunities	Practical learning opportunities	Supportive learning environment
1 — Faculty expertise and qualifications of faculty members	⊙			○				
3 — Effective communication and interpersonal skills of faculty	○							⊙
4 — Accessibility for guidance		⊙						○
10 — Timely feedback provision for students			⊙		△			
2 — Innovative teaching methods				⊙		○		△
9 — Hands-on practical sessions						○	⊙	
5 — Support for independent learning and critical thinking					⊙	○	○	○
6 — Utilization of technology in the classroom				⊙				
12 — Motivation from teachers		○	△					⊙
7 — Involvement of faculty in research and scholarly activities	⊙	△				○		
8 — Integration of teamwork and collaborative projects						⊙	○	○
11 — Punctuality of faculty members		⊙						○
Design characteristics importance value	114	162	90	75	55	177	126	215

Figure 3: House of Quality (HOQ) for teaching and learning aspects

CONCLUSIONS

The study aimed to assess the teaching learning aspects at university and understand the priority needs of students. To achieve this, we employed a comprehensive data collection process that involved gathering feedback from students. The data encompassed the most important students' requirements for teaching and learning aspects that included faculty expertise and qualification of faculty members, innovative teaching methods, effective communication and interpersonal skills of faculty, accessibility for guidance, support for independent learning and critical thinking etc. According to this study, the design characteristics is classified into 8 categories: Qualified and experienced faculties, availability of faculty, assessment feedback mechanism, interactive learning tools, etc. Figure 2 shows a matrix illustrating the relationship between students' priority demands and design attributes. The symbols indicate 9 strong relationships, 3 moderate relationships, and 1 weak relationship. In this context of the House of Quality (HOQ), a higher score for a design characteristic means that it is high priority characteristic that needs to be addressed or improved to meet the students' need. The result of the QFD application shows very high score for supportive learning environment; it can be attributed to the fact that supportive learning environment is the most important aspect from the students' point of view. It means fostering an atmosphere where learners are encouraged to ask questions, explore concepts and actively participate in the educational process and teachers play a vital role in providing guidance, feedback and resources to facilitate effective learning.

ACKNOWLEDGEMENTS

REFERENCES

1. Akao, Y., Ohfuji, T. and Naoi, T. 1987. Survey and reviews on quality function deployment in Japan. Proc. Int. Conf. Quality Control, Tokyo, Japan.

2. Akao, Y. 1990. Quality Function Deployment QFD, Integrating Customer Requirements into Product Design. Productivity Press, Cambridge.

3. Akao, Y., Nagai, K. and Maki, N. 1996. QFD concept for improving higher education. 50th Annual Quality Congress Transactions, ASQC Press, Milwaukee, WI, 12-20.

4. Benjamin, C.O. and Pattanapanchai, S. 1993. A QFD framework for developing engineering laboratories. International Journal of Applied Engineering Education, 9(5), 422-9.

5. Bernal, L., Byrnes, T., Dornberger, U. and Suvelza, A. 2009. Quality function deployment (QFD) for services. Leipzig: University of Leipzig.

6. Bolt, A. and Mazur, G.H. 1999. Jurassic QFD integrating service and product quality function deployment. The Eleventh Symposium on Quality Function Deployment. Novi, Michigan.

7. Bordia, S. 2001. Problems of accreditation and quality assurance of engineering education in developing countries. European J. Eng. Educ., 26(2), 187-193.

8. Brackin, P. and Rosers, G.M. 1999. Assessment and Quality Improvement Process in Engineering Education. ASEE/IEEE Frontiers in Education Conference. San Juan, Puerto Rico, 21-25.

9. Chang, I. F. and Ku, A.C. 1995. Engineering and technical education in Taiwan: an observation based on TQM concept. ASEE Annual Conference Proceedings, 2, 2414-19.

10. Clausing, D. and Hauser, J. R. 1988. The house of quality. Harvard Business Review, 63-73.

11. Clayton, M. 1993. Towards Total Quality Management in Higher Education at Aston University-a Case Study. Higher Education 25(3), 363-71.

12. Cloutier, M. and Richards, J. 1994. Examining customer satisfaction in a big school. Quality Progress, 117-19.

13. Duffuaa, S.O., Al-Turki, U.M. and Hawsawi, F.M. 2003. Quality function deployment for designing a basic statistics course. International Journal of Quality and Reliability Management, 20(6), 740-50.

14. Ermer, D.S. 1995. Using QFD becomes an educational experience for students and faculty. Quality Progress, 131-6.

15. Jaraiedi, M. and Ritz, D. 1994. Total quality management applied to engineering education. Quality Assurance in Education, 2(1), 32-40.

16. Keegan, R. and O'Kelly, E. 2004. Applied benchmarking for competiveness: A guide for SME owner/managers. Cork: Oak Tree Press.

17. Krishnan, M. and Houshmand, A. A. 1993. QFD in academia: addressing customer requirements in the design of engineering curricula. Fifth Symposium on Quality Function Deployment, ASI.

18. Lam, K. and Zhao, X. 1998. An application of quality function deployment to improve the quality of teaching. International Journal of Quality and Reliability Management, 15(4), 389-413.

19. Motwani, J., Kumar, A. and Mohamed, Z. 1996. Implementing QFD for improving quality in education: an example. Journal of Professional Services Marketing, 14(2), 149-59.

20. Norris, G. 1978. The Effective University: A Management by Objectives Approach. Saxon House, Farnborough.

21. Owlia, M. S. and Aspinwall, E. M. 1998. Application of quality function deployment for the improvement of quality in an engineering department. European Journal of Engineering Education. 23(1), 105-15.

22. Pitman, G., Motwani, J., Kumar, A. and Cheng, C.H. 1995. QFD application in an educational setting: a pilot field study. International Journal of Quality and Reliability Management, 12(6), 63-72.

23. Seow, C. and Moody, T. 1996. QFD as a tool for better curriculum design. 50th Annual Quality Congress Transactions, ASQC Quality Press, Milwaukee, WI, 21-8.

24. Wiklund, P.S. and Wiklund, H. 1999. Student focused design and improvement of university courses. Managing Service Quality, 9(6), 434-43.

GENERAL GUIDELINES FOR PREPARING AND SUBMITTING PAPERS

First Author*, Second Author†

*Institution and Country of first author's affiliation

†Institution and Country of second author's affiliation

Abstract

It should consist of a concise summary of the material discussed in the article below. It is preferable not to use footnotes in the abstract or the title. The acknowledgement for funding organizations etc. is placed in a separate section at the end of the text.

Keywords

Maximum 3 keywords may be placed after the abstract.

Introduction

Provide a historical perspective regarding the subject of your paper.

Background

Provide broad definitions and discussions of the topic and incorporate views of others (literature review) into the discussion to support, refute or demonstrate your position on the topic.

Main Thrust of the Paper

Present your perspective on the issues, controversies, problems, etc., as they relate to theme and arguments supporting your position. Compare and contrast with what has been, or is currently being done as it relates to your specific topic and the main theme of the volume.

Future Trends

Discuss future and emerging trends. Provide insight about the future of the topic from the perspective of published research on the topic. If appropriate, suggest future research opportunities within the domain of the topic.

Conclusion

Provide discussion of the overall coverage of the topic in your manuscript and conclusion should include key findings of the paper & concluding remarks.

References

References should follow the conclusions. The references should be listed in numerical order with the corresponding number cited inside the printed manuscript within square brackets at appropriate places [1, 2].

For example:

1. Hake, Richard R. 1998. Interactive-engagement versus traditional methods. A six-thousand student survey of mechanics test data for introductory physics courses. American Journal of Physics 66(1): 64-74

2. Steif, Paul S., and Anna dollar, 2003. A new approach to teaching and learning statics. In Proceedings of the ASEE Annual Conference and Exposition. Nashville, TN

GENERAL GUIDELINES FOR PREPARING AND SUBMITTING PAPERS

Acknowledgement

The acknowledgement for funding organizations etc. should be placed in a separate section at the end of the text.

Biodata

Please include brief bio data of the author (s) within 300 words and also attached a scanned copy of the latest passport size colour photograph of author (s)

Style

Manuscript should be printed on A4 size good white paper. Papers must be typed in English using MS Word. Kindly follow the instructions given below for all the pages

Margins:	:	Top	1.2"
		Bottom	1.2"
		Left	1.2"
		Right	1.2"
Orientation:	:	Portrait	
Font	:	Arial / 12 pt	
Heading	:	14 point	
Sub Heading	:	13 pt	
Spacing	:	Single line spacing	
Para Indent	:	6 point	

Length of Paper

The length of manuscript should not exceed 15 pages, including, figures/ photographs and references. The minimum number of pages should be 7 pages

Figures

All figures should be captioned and printed / pasted in appropriate place of the paper. Caption for the figures should be printed below the figures and numbered consecutively throughout the text. Tables should be placed closest to the text of citation and the title of the table to be printed on top of the table.

All figures, tables, drawings, screen shots are to be sent in a separate file preferably in an editable form.

Submission of the full paper

The final paper(s) may kindly be submitted to at the following address by post or to email : **editor@isteonline.org**

> **The Editor**
> (Indian Journal of Technical Education)
> Indian Society for Technical Education
> IIT Campus, Shaheed Jeet Singh Marg,
> Near Katwaria Saria, New Delhi - 110 016
> Phone : +91-11-26963542,26963431

Subscription details:

For subscribing the IJTE kindly visit our website www.isteonline.in and download the necessary forms.

ABOUT THE JOURNAL

Periodicity : Quarterly   **Subject :** Multidisciplinary

Indexed in the UGC-Care Journal list

The Indian Journal of Technical Education is published by the Indian Society for Technical Education on quarterly basis with the aim to provide an appropriate platform presenting well considered, meaningful, constructively thought provoking, non-political and non-controversial but critically analyzing and synthesizing present and future aspects of Technical Education System with particular reference to our country. The contributors are expected to highlight various issues of Technical Education (a broad outline of the journal objective is to promote the theory and practice of Engineering, Science, Technology, Management, Architecture, Pharmacy, Applied Arts and Crafts, Hotel Management and Computer Applications) along with meaningful suggestions for solution, refinement and innovations.

The following guidelines must be carefully followed.

1. IJTE is a peer reviewed Journal.

2. Manuscripts submitted to the journal will be initially screened by the editors. Those considered inappropriate will be returned to the sender.

3. The Authors are fully responsible for the contributions.

4. The Authors should be the Life Member of ISTE, if not, while submitting the paper they can apply for the membership by clicking https://membership.isteonline.in

5. The Copyright clearance will be the sole responsibility of authors for their papers. Enough precaution should be taken to make the manuscript error free.

6. Upon acceptance of a paper, the author(s) will be requested to provide an electronic copy of the paper, compatible with Microsoft Word.

7. The selection of papers for publication will be based on their relevance, clarity, topicality and originality.

8. The manuscript should be submitted and author's details should be mentioned in the beginning. The author should not be identified anywhere else in the article. The authors details should include full name, affiliation, e-mail address etc.

9. Manuscripts should not exceed 7,500 words (about 15 A-4 size pages, typed one and half space only)

10. Submit an abstract of about 200 words. The articles should be in clear, coherent and concise English language. Author/s should upload manuscript in MS-Word,

11. Tables should be numbered and referred to in the text as Table 1, Table 2, etc. Tables should not duplicate results in graphs. The minimum amount of descriptive text should be used on graphs and drawings (label curves, points, etc. with single letter symbols). The tables and figures should be clearly visible, readable and monochromatic in nature. Avoid inserting pictures of tables and figures in the manuscript.

12. In view of the large responses from Technical Education fraternity and limited space available in the Journal, the publication may take usually 3 months to 6 months from the date of receipt of the manuscript subject to approval by the reviewers.

13. All contributors are requested to please co-operate by observing the above mentioned Guidelines strictly while sending the paper for publication in the Indian Journal of Technical Education.

Note : Articles will be selected by the Editorial Board and are subject to editorial modification, if necessary