Online ISSN : 2395-602X
Print ISSN : 2395-6011
www.ijsrst.com

IJSRST

Conference Proceedings

Two Days National Conference in Computer Science & Electronics on Multidisciplinary Innovations in Science Technology

NCMIST-2025

10th and 11th January 2025

Organized By

Department of Computer Science and
Department of Electronics
Yogeshwari Mahavidyalaya, Ambajogai. Dist. Beed, Maharashtra, India

VOLUME 12, ISSUE 9, JANUARY-FEBRUARY-2025

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN SCIENCE AND TECHNOLOGY

PEER REVIEWED AND REFEREED INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL

Scientific Journal Impact Factor : 8.627

Email : editor@ijsrst.com Website : http://ijsrst.com

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In Collaboration with

Society of Science, Technology and Humanity, Kalyan

Published By

International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 Online ISSN: 2395-602X

Volume 12, Issue 9, January-February-2025

International Peer Reviewed, Open Access Journal
Published By
Technoscience Academy

website: www.technoscienceacademy.com

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

A Study on Audio Splicing Detection and Localization Method Using Convolution Neural Network Encoder-Decoder Architecture (ASLnet)

Mrs. Shazia Farheen Shaikh
Assistant Professor, Department of Computer Science, Dayanand Science College, Latur, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
01-09

ABSTRACT

In the digital computing world, multimedia forensics is a challenging and instigative field, which is generally a branch of digital forensics. With the rapid-fire growth in the use of digital technology, moment crimes are committed using rearmost ways that do n't involve physical contact. As a result, it's delicate for forensic specialists to examine and dissect the data at the crime scene. A change in the different ways is necessary to achieve effective investigation of crimes involving advanced technology. This exploration focuses on audio forgery discovery and localization from a multimedia forensics perspective. With the wide range of availability of audio manipulating tools online, it has come easier to produce forgeries without a perceptual trace. Audio splicing, fitting an audio member at the launch, middle or at the end of another audio recording, is one of the most common types of audio forgery . The spliced audios reduce the trustability of judicial substantiation and master intellectual property protection. In addition, these spliced audios can be used for fake news spreading which will make a negative impact on society. thus, the capability to descry whether an audio recording has been spliced is a task of great interest in the audio forensics community [1].

Keywords: Splicing, Detection and Localization, Convolution Neural Network, Encoder-decoder architecture, ASLNet

I. INTRODUCTION

The extensive accessibility of online audio manipulation tools has made it simpler to produce forgeries that lack perceptual traces. One prevalent method of audio forgery is audio splicing, which involves inserting a segment of audio at the beginning, middle, or end of another recording. Such spliced audio can undermine the credibility of judicial evidence and compromise intellectual property rights. Furthermore, these altered audio files can be utilized to disseminate fake news, negatively affecting society. Consequently, detecting whether an audio recording has been altered is a significant concern within the audio forensics field.

In recent decades, various types of research have been conducted on the detection and localization of audio splicing. As the audio splice operations cause the inconsistency of the noise level, researchers have developed audio splicing detection methods based on local noise levels of audio signals [2–6]. However, when the signal-to-noise ratio between the spliced segments is either low or nearly identical, the effectiveness of noise-based detection methods sharply declines. In addition, based on the fact that inserting an audio segment into another audio recording leads to anomalous variations of the electric network frequency (ENF) signal, several kinds of research [7–9] have shown that it is an efficient way to detect spliced audio via the analysis of ENF signal. The approach for detecting spliced audio. However, due to legal constraints, obtaining simultaneous reference datasets from power systems is challenging, complicating the application of ENF-based audio splicing detection methods [10]. Recently, convolutional neural networks have been introduced for audio splicing detection [11]. Nevertheless, these neural network-based methods can only determine whether an audio file has been spliced, lacking the ability to localize the spliced content. Based on the overview provided, while certain audio splicing detection and localization methods have shown effective results, there is a need for new approaches to enhance detection and localization performance.

In this paper, we perform a review study of a novel audio splicing detection and localization system based on an encoder-decoder architecture known as ASLNet. The audio is segmented into smaller parts in accordance with the size of the lowest localization region (Lslr). Then generate the audio point matrix along with a corresponding ground truth binary mask, where the original segments are represented by black points (labeled 0) and the spliced segments are represented by white points (labeled 1) for each audio segment. Furthermore, the audio point matrices are merged from all sections of an audio clip into a comprehensive audio point matrix and input it into the encoder-decoder network, which comprises a series of convolutional, pooling, and transposed convolutional layers to produce a binary output mask. Subsequently, the binary output mask is subdivided into smaller segments based on the Lslr, and compute the ratio (ρ) of the number of elements labeled one compared to the total number of elements in each small segment. Finally, we assess whether the corresponding audio segment is spliced by comparing ρ with a predetermined threshold (T). The cross-database and intra-database evaluations produced on datasets derived from publicly available speech output verify the effectiveness of ASLNet in detecting and localizing audio splicing.

Audio Splicing Detection

The research on audio/speech forensics dates back to the 1960s, when the U.S. Federal Bureau of Investigation has conducted an examination of audio recordings for speech intelligibility enhancement and authentication. Lin and Kang [8] introduced a wavelet-filtered ENF signal designed to emphasize abnormal variations in ENF, integrating autoregressive coefficients to train their classifier within a supervised learning framework. Mao et al. [9] applied multiple ENF features as input eigenvectors for convolutional neural networks to identify spliced audio. Meng et al. [4] employed a spectral entropy technique to ascertain the duration of each syllable and measured the variance of the background noise associated with them. They then compared the variances between syllables to determine the likelihood of heterogeneous splicing tampering in the audio. Yan et al. leveraged a parameter-optimized noise estimation algorithm to extract the noise signal from the suspected speech and analyzed the Mel frequency features of this estimated noise to uncover splicing traces [6]. In light of the successful implementation of convolutional neural networks across various domains, Jadhav et al. [11] were the first to apply convolutional neural networks for audio splicing detection, feeding the spectrogram of an audio sample directly into the network for classification.

Fully Convolutional Network

The fully convolutional network (FCN) utilizes an encoder-decoder framework that includes convolutional and transposed convolutional blocks (illustrated in Figure 1), enabling it to effectively generate dense predictions for per-pixel tasks. Long et al. [12] were the first to introduce FCN for semantic segmentation by transforming all fully connected layers in traditional classification networks into convolutional layers. They examined three classification architectures: AlexNet [13], GoogleNet [14], and VGG16 [15], discovering that the FCN utilizing VGG16 as its backbone (FCN-VGG16) outperformed those based on AlexNet and GoogleNet. Subsequently, Salloum et al. [16] introduced single-task fully convolutional networks (SFCN) and multi-task fully convolutional networks (MFCN) based on the FCN-VGG16 framework to address the problem of image splicing localization. The SFCN and MFCN were trained using ground truth masks, which are binary masks that identify each pixel in an image as either spliced or authentic. Segal et al. [17] developed SpeechYOLO to localize utterance boundaries within input signals, marking the first application of FCN from the vision domain to the speech recognition field. It was demonstrated that FCN-VGG16 yielded strong performance in the context of image splicing localization. This paper draws inspiration from [16, 17] to implement the FCN-based encoder-decoder architecture from the vision domain in the realm of audio splicing detection and localization, treating the acoustic features of spliced audio segments as distinct objects.

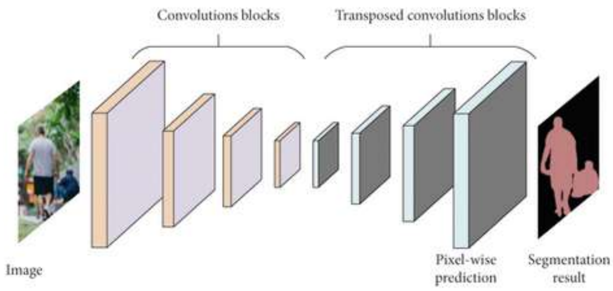

Figure 1. Convolution Blocks &Transposed Convolution blocks

II. LITERATURE REVIEW

2.1. The Framework of ASLNet

In this paper, we discuss ASLNet method for detecting and localizing audio splicing, utilizing an encoder-decoder architecture. Figure 2 illustrates the entire ASLNet procedure, encompassing both the training and testing phases. During the training phase, first the audio signal is segmented into smaller pieces based on the Lslr, which defines the minimum size of the localization region containing several sample points. For each audio segment, an acoustic feature matrix is generated and the corresponding ground truth binary mask. These acoustic feature matrices from all segments are then combined into a single matrix and submitted to an encoder-decoder architecture based on a fully convolutional network (FCN), which includes multiple convolutional, pooling, and transposed convolutional layers to produce a binary output mask. Ultimately, this binary output mask is compared to the ground truth mask to calculate the error from the current neural network weights used in the backward propagation process.

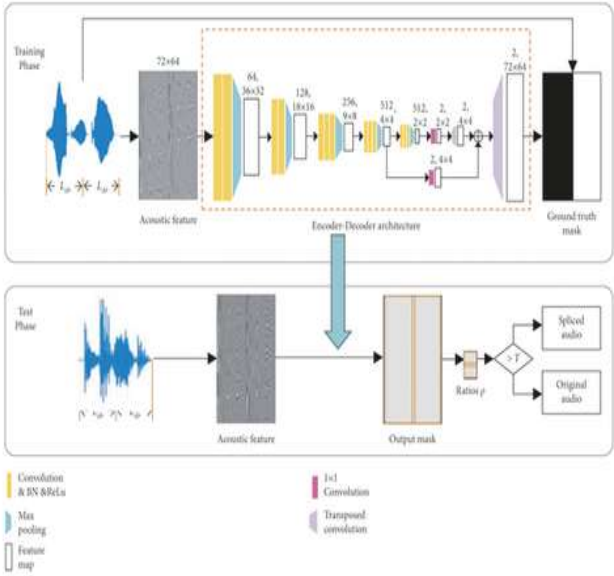

Figure 2 ASLNet Training Phase & Test Phase

During the testing phase, initial step is to generate an acoustic feature matrix from an entire audio clip, similar to the process used in the training phase. Next, we feed this acoustic feature matrix into the trained encoder-decoder model to obtain a binary output mask. This binary mask is then divided into smaller segments based on Lslr. Finally, calculate the ratio (ρ) of the number of elements equal to one to the total number of elements in each small segment. This ratio is compared to a predetermined threshold (T) to ascertain whether the corresponding audio segment is spliced. Specifically, if ρ exceeds the threshold T ($\rho > T$), we classify the audio segment as spliced; otherwise, we categorize it as original.

2.2. Acoustic Feature and Binary Ground Truth Mask.

As fake audio detection technology advances, various acoustic features have been introduced to enhance detection performance. Among these, Linear Frequency Cepstral Coefficient (LFCC) and Mel-Frequency Cepstral Coefficient (MFCC) are two of the most commonly utilized features for identifying counterfeit speech [18–20]. In this study, we derive LFCC and MFCC features from the audio signals to serve as input data for the ASLNet. The block diagrams illustrating the extraction processes for LFCC and MFCC are presented in Figure 3.

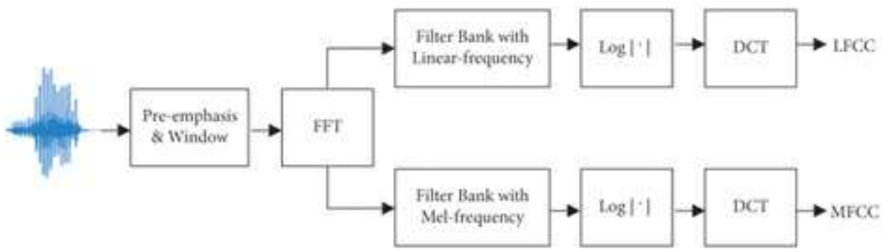

Figure 3. Extraction processes for LFCC and MFCC features

As illustrated in Figure 3, the extraction processes for LFCC and MFCC features are similar, differing only in the types of filter banks used. The LFCC feature utilizes a linear-frequency filter bank that uniformly spans all audio frequency ranges, treating each frequency as equally significant. In contrast, the MFCC employs a Mel-frequency filter bank, which takes into account the nonlinear characteristics of human hearing relative to various frequencies. The following outlines the detailed extraction procedure for MFCC. Initially, pre-emphasis is applied to boost the signal's energy at higher frequencies, subsequently computing the short-time Fourier transform (STFT) of the signal with a periodic Hamming window of 2048 samples and a 512-sample overlap. Next, mapping the spectral powers onto the Mel scale using the Mel filter bank. Then apply the discrete cosine transform to derive the transformed coefficients, which capture significant amounts of energy. In this study, the minimum length defined of the audio segments for extracting the LFCC and MFCC matrices as 16,000 samples (i.e., Lslr = 16000). We select the first 24 coefficients as static LFCC and MFCC features, while the delta and acceleration coefficients are computed and appended to the static coefficients, resulting in a feature vector comprising 72 elements. Consequently, the LFCC and MFCC feature matrices are structured as 72×32, where 72 indicates the number of coefficients and 32 represents the number of frames. Additionally, to facilitate the training of the encoder-decoder network on a per-pixel basis, we create a binary ground truth mask for each LFCC or MFCC feature matrix. This binary ground truth mask is composed of elements valued at either 0 or 1, matching the dimensions of 72×32. In the case of the original audio segment, every element in the respective ground truth mask is 0, whereas for the spliced audio segment, all elements in the corresponding ground truth mask are 1. After extracting all LFCC or MFCC matrices from the different segments of an audio clip, we further combine them to form the final LFCC or MFCC matrix for the entire audio clip.

Feature	Threshold	Spliced at the end				Spliced at the middle			
		Dataset	Ptp	Ptn	Pacc	Dataset	Ptp	Ptn	Pacc
MFCC	T=0.5	ENSet2s	0.8742	0.9295	0.9077	ENSet3s	0.8949	0.9904	0.9740
		CNSet2s	0.9698	0.9903	0.9833	CNSet3s	0.9938	0.9979	0.9965
	T=0.6	ENSet2s	0.8778	0.9269	0.9075	ENSet3s	0.9022	0.9894	0.9745
		CNSet2s	0.9712	0.9894	0.9831	CNSet3s	0.9943	0.9977	0.9965
	T=0.7	ENSet2s	0.8818	0.9219	0.9061	ENSet3s	0.9108	0.9876	0.9745
		CNSet2s	0.9725	0.9884	0.9830	CNSet3s	0.9950	0.9972	0.9964
	T=0.8	ENSet2s	0.8869	0.9206	0.9073	ENSet3s	0.9132	0.9869	0.9742
		CNSet2s	0.9743	0.9870	0.9827	CNSet3s	0.9955	0.9966	0.9962
LFCC	T=0.5	ENSet2s	0.5359	0.7588	0.6708	ENSet3s	0.0012	1.0000	0.8289
		CNSet2s	0.9129	0.9575	0.9422	CNSet3s	0.9730	0.9768	0.9755
	T=0.6	ENSet2s	0.5571	0.7479	0.6726	ENSet3s	0.0037	0.9997	0.8291
		CNSet2s	0.9155	0.9563	0.9424	CNSet3s	0.9750	0.9750	0.9750
	T=0.7	ENSet2s	0.5818	0.7357	0.6750	ENSet3s	0.0183	0.9982	0.8304
		CNSet2s	0.9187	0.9554	0.9429	CNSet3s	0.9758	0.9738	0.9745
	T=0.8	ENSet2s	0.6030	0.7061	0.6654	ENSet3s	0.0452	0.9912	0.8291
		CNSet2s	0.9219	0.9543	0.9432	CNSet3s	0.9778	0.9714	0.9736

Table 1. Methods Spliced at the end Spliced at the middle

The detection results of the ASLNet on four datasets under different thresholds T and acoustic features

2.3. The Encoder-Decoder Architecture of ASLNet

The encoder-decoder architecture is a widely used structure in contemporary semantic segmentation algorithms, consisting of two main components: an encoder and a decoder. The encoder executes convolution and down-sampling processes to gather contextual information, while the decoder handles deconvolution and up-sampling to generate pixel-wise class predictions. With notable achievements attributed to encoder-decoder frameworks, models such as FCN [12], U-Net [21], and SegNet [22] have been developed for pixel-level image segmentation. In this study, the foundational network architecture of ASLNet is based on a modified FCN-VGG16, which features a VGG16 encoder alongside a decoder that incorporates skip connections. The role of the VGG16 encoder is to capture the contextual representations of the acoustic features, whereas the decoder's function is to convert the intermediate feature maps into a binary output mask.

As described in Figure 2, a VGG16 encoder is constructed by stacking five VGG blocks. Each block comprises two or three convolutional layers, followed by a max-pooling layer, culminating in a total of 13 convolutional layers and five max-pooling layers. Each convolutional block consists of a convolutional layer, a batch normalization layer, and a rectified linear unit (ReLU) activation function. All convolutional layers utilize a uniform kernel size of 3×3, with a fixed convolution stride of 1. Additionally, a padding size of 1 is employed to maintain the output dimensions after each convolutional layer. The max-pooling layers feature a size of 2×2 and a stride of 2, effectively reducing the resolution by half after each VGG block. The decoder is designed to reconstruct the binary mask using the crucial information extracted by the VGG16 encoder, incorporating two transposed convolution layers and a softmax layer. The first transposed convolution layer has a kernel size of 4×4 and a stride of 2, while the second features a kernel size of 32×32 and a stride of 16. Furthermore, a skip connection is established from the fourth VGG block to the first transposed convolution layer, allowing for the merging of features learned at lower layers and higher layers. The softmax layer is employed to compute the probability that a given element originates from the spliced audio segment.

	Dataset	Ptp	Ptn	Pacc	Dataset	Ptp	Ptn	Pacc
Jadhav et al. [11]								
	ENSet2	0.8992	0.9191	0.9072	ENSet3	0.9229	0.9483	0.9412
	CNSet2	0.9587	0.9671	0.9614	CNSet3	0.9465	0.9591	0.9524
ASLNet								
	ENSet2	0.8742	0.9295	0.9077	ENSet3	0.8949	0.9904	0.9740
	CNSet2	0.9698	0.9903	0.9833	CNSet3	0.9938	0.9979	0.9965

Table2. The detection results of the Jadhav et al. [11] and the ASLNet with MFCC feature and T = 0.5 under the intradatabase testing scenario.

Methods	Train dataset	Test dataset	Ptp	Ptn	Pacc
Jadhav et al. [11]					
	ENSet2s	CNSet2s	0.8002	0.8512	0.8468
	CNSet2s	ENSet2s	0.8295	0.8395	0.8320
	ENSet3s	CNSet3s	0.8965	0.8620	0.8754
	CNSet3s	ENSet3s	0.8495	0.8929	0.8826
ASLNet					
	ENSet2s	CNSet2s	0.9072	0.9600	0.9420
	CNSet2s	ENSet2s	0.8990	0.8540	0.8718
	ENSet3s	CNSet3s	0.9347	0.9944	0.9740
	CNSet3s	ENSet3s	0.9474	0.9229	0.9271

Table 3. The detection results of the Jadhav et al. [11] and the ASLNet with MFCC feature and T = 0.5 under the cross-database testing scenario.

III. IMPLEMENTATION DETAILS

To train and evaluate neural networks, we partition the datasets randomly into three subsets: a training set consisting of 60% of the data, a development set comprising 20%, and an evaluation set which also accounts for 20%. In the training phase, the model is trained using the training set, while the development set is utilized to assess the model's performance. The weights of the neural networks are randomly initialized based on a Gaussian distribution, and the biases are set to zero. We select a mini-batch of 64 audio clips from the training data to estimate the actual gradient, shuffling the training dataset after each epoch. For optimization, we implement the AdaDelta algorithm, which is a stochastic gradient descent method that automatically adjusts the learning rate based on the gradient, using default parameter settings. After each epoch, the model's performance is validated on the development set. The training of the neural networks continues for 200 epochs, and the model that exhibits the highest validation performance is selected for testing.

Once the trained neural network model is established, we test it using a mini-batch of 64 audio clips that are randomly sampled from the evaluation set. The goal is to determine if each audio clip is spliced based on a pre-defined threshold. After cycling through all audio clips in the evaluation set without replacement, we compute three metrics to evaluate the detection model. To ensure robust results, we repeat the random splitting of the training, development, and evaluation sets ten times, averaging the results to obtain the final metrics: Ptp, Ptn, and Pacc.

IV. CONCLUSION

In this paper, we study a novel audio splicing detection and localization method based on an encoder-decoder architecture proposed by zhenyu zhang, xianfeng zhao, xiaowei yi. The base network architecture of ASLNet is the modified FCN-VGG16, which is composed of a VGG16 encoder and the decoder with a skip connection. The VGG16 encoder is used to extract contextual representations of the acoustic features, while the decoder transforms the intermediate feature map as the binary output mask for judging whether the audio segment is spliced. Four spliced audio datasets ENSet2s, ENSet3s, CNSet2s and CNSet3s that are produced from publicly available speech corpus are used to evaluate the performance of the proposed ASLNet. Experimental results prove the effectiveness of the proposed ASLNet for audio splicing detection and localization task, which significantly improves the detection performance compared with a current state-of-the-art approach. In addition, according to the results of the cross-database evaluation, it demonstrates the promising generalization capability of the ASLNet. In practical scenarios, the size of the smallest localization region Lslr and the threshold T can be adjusted to improve the universality of the ASLNet. In the future, we will explore more effective deep neural network based methods for audio splicing detection and localization.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Secure Data Transmission Using IoT Devices- A Review

Mr. Faheemuddin Ahmed[1], Dr. N. S. Ratnaparkhi[2]
[1]Assistant Professor, Poona College of Arts Science and Commerce, Pune, Maharashtra, India
[2]Assistant Professor, DSM College, Jintur, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
10-15

ABSTRACT

The review, emphasizing the pressing need for robust security measures in IoT environments. With the global dependence on e-communication, ensuring error-free and secure data transmission is paramount. The focus of this review lies in leveraging Raspberry Pi as an open source and widely used hardware platform for IoT devices and gateways to propose a secure communication framework. The review examine and analyze the critical aspects of secure data transmission in IoT environments, with a focus on enhancing data security, privacy, and integrity. As the IoT landscape rapidly expands, securing the communication between devices and backend services becomes crucial to prevent data breaches, eavesdropping, and tampering. This paper aims to Highlight the Importance of Secure Data Transmission in IoT and examine Devices Used for Secure Data Transmission. The paper reviews several cryptographic SHA (Secure Hash Algorithm) versions and their application to IoT environments. It also provide an in-depth review of existing IoT security methods, while proposing a robust, practical framework that addresses key challenges in securing IoT communications, ensuring privacy, and promoting data integrity.

Keywords: SHA, Algorithm, Encryption, IoT, , Authentication, cryptography, Sensor, Hashing.

I. INTRODUCTION

This review paper explores the security challenges of data transmission in IoT environments and the security mechanisms that can be employed to address these challenges. The focus is on the role of cryptographic techniques, particularly hash algorithms, in ensuring secure and authenticated communication between IoT devices and backend services (e.g., cloud-based databases and analytics platforms). The review will also examine the Raspberry Pi, an opensource, cost-effective platform commonly used in IoT applications, as a potential gateway or end device for secure data transmission. Secure data transmission refers to the process of transferring data between two or more parties in a way that ensures its confidentiality, integrity, and authentication, while protecting it from unauthorized access, tampering, or interception. It involves implementing various cryptographic techniques and security protocols to ensure that data remains private, unaltered, and only accessible to intended recipients. In the context of Internet of Things (IoT), secure data transmission is especially important because IoT devices often communicate over potentially insecure channels (such as wireless networks) and deal with sensitive or critical information, such as personal data, sensor readings, and control commands. Without proper security measures, the data being transmitted can be intercepted, altered, or manipulated by malicious actors, potentially leading to privacy violations, unauthorized control of devices, or even large-scale cyber-attacks. Secure data transmission is used in a wide range of fields, from healthcare and smart cities to autonomous vehicles and industrial automation. The need for secure transmission stems from the desire to protect sensitive information, ensure reliable operations, and prevent unauthorized access or tampering with critical systems. In IoT environments, where billions of devices exchange vast amounts of data, securing that transmission is not just a matter of privacy but also safety, operational efficiency, and trust in technology. By implementing strong encryption, authentication, and integrity verification methods, secure data transmission can protect both the data itself and the systems that rely on it. The introduction highlights Raspberry Pi as a cost-effective and versatile computing device, ideal for serving as both an IoT end node and an analytical machine. Its support for the Python programming language further amplifies its potential in facilitating IoT accessibility, particularly in developing countries. In addition, the introduction explores two prevalent IoT communication models: publish subscribe and request-response. It delineates their respective characteristics, strengths, and weaknesses in different network environments. The significance of these models in catering to diverse communication needs, from bandwidth-constrained settings to low-traffic scenarios, is underscored. Moreover, the introduction emphasizes the importance of SHA-3 as a secure authentication mechanism essential for ensuring data integrity and security in IoT applications.

II. RESEARCH METHODOLOGY

Various research papers (recent scopus, IEEE, Science direct, peer review on different search strings) have been reviewed on topics of secure data transmission, encryption and data transmissions in IoT devices. This research adds an additional layer of security on encryption with data transmission using IoT devices. The objective was to secure data transmission with in flight requests to the backend i.e. AWS Dynamo DB.

Objectives

The objective of this review paper is to critically evaluate existing research on secure data transmission in IoT environments, with a particular focus on enhancing security through the integration of TLS (Transport Layer Security) and SHA-3 (Secure Hash Algorithm) for both data encryption and authentication. The paper aims to:

Review and Analyze Current Security Protocols in IoT:

Examine various encryption and authentication methods used in IoT devices, identifying their strengths, limitations, and performance trade-offs in real-world applications.

Propose an Enhanced Security Framework: Based on insights from the literature, suggest an additional layer of security for IoT data transmission using TLS for securing communication channels and SHA-3 for ensuring data integrity and authentication during transmission to cloudbased services like AWS DynamoDB.

Highlight the Role of Secure Communication in IoT:

Emphasize the critical importance of ensuring secure, authenticated, and error-free communication between IoT devices and their cloud-based backends, particularly in environments with resource-constrained devices.

Examine Cloud Integration and Visualization Tools:

Discuss the role of cloud platforms (e.g., AWS DynamoDB) in secure data storage, and explore how Grafana and similar visualization tools can enhance the monitoring and analysis of IoT data in a secure, real-time manner.

Identify Gaps and Future Research Directions:

Identify gaps in current research and propose avenues for future studies to strengthen the security of IoT data transmission, particularly with respect to encryption and hashing algorithms in large-scale, resource-constrained environments.

The ultimate goal is to provide a comprehensive overview of existing approaches to IoT security, while proposing a robust, practical framework that leverages TLS and SHA-3 to enhance both the confidentiality and integrity of data during transmission to cloud-based storage systems.

III.LITERATURE REVIEW

The literature review critically analyzes existing research and contributions relevant to IoT security, focusing on authentication techniques, encryption methods, and the evolution of hash algorithms. Notable research papers and studies discussing lightweight encryption, OTP-based authentication techniques, and secure hash algorithms are thoroughly evaluated for their relevance to the proposed research. For instance, the study by Goel, Sharma, and Gupta on lightweight encryption and OTP- based authentication techniques sheds light on innovative approaches for securing IoT networks [2]. Additionally, the review also puts some light into the evolution and analysis of secure hash algorithms, particularly the SHA family, as documented by Khan. [3] This in-depth analysis establishes a comprehensive understanding of the current state of IoT security measures and provides a solid foundation for the methodologies chosen in this research.

The literature review for this research goes into the existing body of knowledge surrounding IoT security, particularly focusing on authentication techniques, encryption methods, and hash algorithms. It provides a comprehensive understanding of current methodologies and highlights gaps that this research aims to address.

Authentication Techniques and IoT Security

Authentication is a cornerstone of IoT security, ensuring that data is transmitted between verified entities. Several studies have explored various authentication schemes suitable for IoT environments:- Goel, Sharma, and Gupta (2021) [2] present LEOBAT, a lightweight encryption and OTPbased authentication technique. Their work addresses the challenge of securing IoT networks with constrained resources, emphasizing the need for efficient authentication methods that do not compromise performance. Their approach is particularly relevant for IoT environments where both lightweight and secure solutions are essential.

Hasan and Qureshi (2018) [8] discuss hardware-based serialization for IoT device authentication. They propose a scheme utilizing unique hardware characteristics to authenticate devices, which enhances security by exploiting the physical properties of IoT devices. This method is significant for improving authentication robustness in an ecosystem where physical device security is paramount.

3.1. Encryption Methods

Encryption is crucial for protecting data from unauthorized access and ensuring its confidentiality. Research in this area often focuses on finding a balance between security and performance, especially in resource-constrained IoT devices:- Khan et al. (2022) [3] provide an extensive analysis of the Secure Hash Algorithm (SHA) family, focusing on its evolution and security features. Their work highlights the strengths of SHA algorithms, including SHA-3, in providing robust data integrity and security. This analysis underscores the importance of advanced hash functions in maintaining secure data transmission in IoT networks.- Lightweight encryption techniques are explored by various researchers as solutions tailored to IoT constraints. The emphasis is on methods that offer security without imposing significant computational or energy overhead. This review identifies key trends and innovations in lightweight cryptography, which are crucial for developing efficient IoT security solutions.

3.2. Hash Algorithms

Hash algorithms play a pivotal role in ensuring data integrity and authenticity. The evolution and effectiveness of these algorithms have been extensively studied: Bertoni [7] offers an in-depth examination of Keccak, the cryptographic algorithm underlying SHA-3. Their research provides insights into the design and security enhancements of SHA-3 over previous SHA versions, making it a strong candidate for modern IoT security frameworks. Li (2018) [10] explores the application of hash algorithms in conjunction with real-time databases, emphasizing their importance in maintaining data integrity and security. Their work highlights the integration of hash functions with cloud-based storage solutions, relevant for IoT scenarios requiring secure data transmission and storage.

3.3. Visualization and Data Storage

In this paper, we explore various studies that utilize different data sources for securing the transmission and storage of IoT-generated data. These data sources can be broadly categorized into the following types: On-Device Data Storage: Many IoT devices, especially low-power and resource- constrained devices, store data locally before transmitting it to a central system or cloud service. In some cases, this involves storing data on the device's internal storage or using edge devices that aggregate sensor data before sending it for further processing. The security of ondevice data storage is crucial, as unauthorized access or tampering with data could compromise both the privacy and integrity of the transmitted information.

Edge Storage: In edge computing environments, data may be temporarily stored on edge nodes that sit between the IoT devices and the cloud. These edge nodes often handle preprocessing, aggregation, or filtering of the data before it is transmitted. Storing data at the edge is beneficial for reducing latency and minimizing the amount of data that needs to be transmitted over the network. However, ensuring secure communication and authentication between edge nodes and IoT devices, as well as between edge nodes and the cloud, is essential for preventing attacks and ensuring data integrity. Cloud-Based Storage: Cloud platforms are widely used in IoT environments to provide scalable storage solutions for vast amounts of sensor data. IoT devices transmit data to the cloud for centralized storage and analysis. The cloud enables real-time monitoring, data analysis, and long-term storage for IoT applications. For this type of storage, security concerns revolve around ensuring that both the data at rest and data in transit are protected against unauthorized access, tampering, and other malicious activities. While we do not directly specify a particular cloud service in this paper, it is assumed that cloud-based storage platforms can offer the required security protocols to manage large-scale IoT data securely.

Hybrid Storage Solutions: Some IoT systems may use a hybrid approach, where data is partially stored locally (on-device or at the edge) and partially in the cloud. This approach allows for a balance between reducing latency and conserving bandwidth while still maintaining centralized storage for critical data. The security challenges in this scenario include ensuring end-to-end encryption, as well as secure communication between the edge, local storage, and the cloud.

IV. IMPORTANCE OF SECURE DATA STORAGE FOR IOT

Regardless of the specific storage solution employed (whether local, edge, cloud, or hybrid), the secure transmission and storage of data is of paramount importance in IoT environments. The security of the stored data is directly linked to its integrity, confidentiality, and availability:

Confidentiality: Sensitive data such as user information, health metrics, or industrial data must be encrypted both in transit and at rest to prevent unauthorized access.

Integrity: Ensuring that the data is not altered or tampered with during transmission or while stored is critical, especially in applications like healthcare, automotive, and industrial IoT.

Availability: In many IoT applications, real-time access to data is essential. Secure storage solutions must also ensure that data is available for legitimate users and that backups are securely maintained to protect against loss or corruption.

Effective data management and visualization are essential for analyzing and interpreting sensor data:

The use of AWS DynamoDB for secure and scalable data storage is discussed, with a focus on its integration with visualization tools like Grafana. These tools are crucial for presenting timeseries data in a comprehensible manner, enabling effective monitoring and analysis of IoT data. The research demonstrates how these technologies enhance the practical application of secure data transmission frameworks.

V. COMPREHENSIVE UNDERSTANDING AND GAP ANALYSIS

The literature highlights the various advancements in IoT security, from authentication and encryption to hash algorithms and data storage. However, there remains a need for a unified approach that integrates these components into a cohesive framework suitable for diverse IoT applications. This research builds upon the existing knowledge by focusing on the implementation of SHA-3 hash algorithms for secure data transmission, combined with practical tools for data visualization and storage. The integration of these elements into a single framework aims to address current gaps and enhance the overall security of IoT systems.

In summary, the literature review establishes a solid foundation for this research, illustrating the importance of advanced encryption techniques in securing IoT environments. The identified gaps and trends guide the development of a comprehensive security framework, leveraging SHA-3 and modern visualization tools to address the evolving challenges in IoT security.

VI. CONCLUSION

This research underscores the pivotal role of secure data transmission within IoT ecosystems, emphasizing the effectiveness of SHA-3 in ensuring data encryption. The study's scope spans across various domains, including smart homes, cities, self-driven cars, and wearables, emphasizing the relevance and potential impact of the proposed secure communication framework in these diverse settings.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Advanced Malware Detection in E-Commerce SIoT Networks Using Machine Learning Techniques

Sanket Gunderao Torambekar[1], Panchakshari Madhavi Chandrashekhar[2], Kamakshi Shivajirao Bondge[3], Dr. Suraj Shankarrao Damre[4]

[1]K.P.C.Yogeshwari Polytechnic, Parali Road, Ambajogai, Maharashtra, India

[2]Assistant Professor, Department of Computer Engineering, Sandipani Technical Campus, Latur, Maharashtra, India

[3]Assistant Professor, Department of Computer Engineering, Vilasrao Deshmukh Foundations Group of Institutions, Latur, Maharashtra, India

[4]Assistant Professor, Department of Computer Science Engineering, M.S. Bidve Engineering College, Latur, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
16-27

ABSTRACT

The Internet of Things (IoT) serves a key role in each object of the next-generation people like smartphones, wearable devices as well as actuators and sensors have been provided with digital counterparts. The goal of augment the ability of physical objects and perform on behalf of communicating with third parties. The object has ability in interacting and establishing autonomous social relationships in accordance with the SIoT (Social Internet of Things). Objects such as humans have been considered to be social and intelligent. They created its Social Network (SN) to accomplish their usual goals like improvement in performance, functionality and efficiency for satisfying their needed services. Their privacy might be violated and their data can be made available to the public. IoT is unlikely to take the lead as a technology until it has proven methods to strengthen reliable connectivity between nodes. There are various preventions of malware detection have been created subsequently to hide their hazardous behaviors from analysis tools. Therefore, it's unable to use traditional malware detection techniques, and the SIoT must be secured by creative solutions against such anti- detection malware. In identifying malware attacks imposed by hostile nodes as well as separating it from the network. This proposed Autoencoder (AE) utilizes the auxiliary data for pre- trained and Machine Learning (ML) is using for fine tuning model for accurate detection of malware from the MQTT (Message

Queuing Telemetry Transport) dataset. To evaluate the proposed AE with ML method has accomplished the best performance using confusion matrix metrics such as accuracy, precision, recall, F1- score are comparing with an existing methodologies.
Keywords— Internet of Things, Social Internet of Things (SIoT), Autoencoder, malware detection, security, Machine Learning (ML).

I. INTRODUCTION

The IoT idea has currently come into existence as globalization as well as smart device connectivity with skyrocketed. Despite involving humans, IoT devices are utilized in sensing, controlling, monitoring intelligent data sharing, and other functions. The idea of the IoTs has been used in smart grids for transportation and agriculture, smart cities, smart public safety systems and smart healthcare among other smart global networks. Featuring environment and carrying out basic tasks of IoT has begun to pass and provide rise to the vision of anytime and anywhere connectivity with anything [1]. There are several areas like smart building, supply chain of logistics and transportation, industrial production plant management and e-health have developed recent applications with large amounts of data flow using IoT. In addition, there are some IoT applications that are created for an architecture of service-oriented in which each device is performed as a service requester or service provider else both activity. IoT has forwarded towards the model of things that focused on other things in providing combined services to the human being benefits. Understanding how any object's information can be effectively evaluated by any additional peer in the system is crucial when using a similar relationship model. The requester, who plays the role of the trustor in the IoT scenario, must have faith that the supplier, who then plays the role of the trustee, will deliver the requested service. However, malfunctioning devices are performed with different assaults while compared to benefits of other IoT nodes. Hence, fake suggestion or services have been provided to perform solely or organizing cooperating community devices for controlling hre service classes. Thus, the attacks as well as malfunctioning could completely negate any IoT advantages if they aren't get handled effectively [2] [3].

Consequently, mobile, web, and sensor technologies have quickly developed and are being integrated. This technology may now provide physical items including doors, home applicants that turn into "smart things" over digital era. Gartner and Cisco Systems predict that there are going to be 20 billion and 50 billion linked devices, correspondingly by the year 2020. This might raise the degree of IoT network complexity in the future. The present IoT integration techniques don't adhere to common design standards aren't economically viable, and hinder the full potential of IoT from being realized. The concept of SN and the IoT share certain commonalities [4]. The SN research is able to be utilized for tackling implementation issues in the IoT environment. As a result, social ties between items in IoT networks serve as the foundation of the new paradigm known as SIoT. Smart objects are connected using devices with occasional connections dependent on user relations using relationships with others including parental, shared facilities, co-work, ownership, and social objects. SIoT aims in maintaining the two levels of individuals as well as things separated permitting the objects to establish independent SN. This allows individuals to establish rules for safeguarding its privacy while limiting access to the autonomous results of inter- object interaction operating on the SN objects [5]. The SN for smart devices also makes it possible to do the following functions in a secure setting, network navigability, interoperability and service discovery. In addition, Ericsson researchers have suggested utilizing SN as an intellectual framework or analogy to describe the intricacy of user-thing interactions and IoT integration. It provides to SIoT which began about 2011 and is currently employed interchangeably. Despite the fact of SIoT is still early stages, extensive research has currently done to provide concepts for integration in practical applications [6]. Even though the concept of social relationships between objects initially emerged as SIoT it applied in several ways depending on the study. There are hardly any investigations that have examined various ideas of SN in SIoT and consider the growing interest in SIoT as a research issue.

The IoTs are envisioned as SN with features for collaboration as well as community engagement. Each object can explore data and share with other devices as well as computing systems using the Internet as well as additional networks using sensors, software, processors, and Various other technologies have been incorporated. These social connections facilitate interaction between devices and people, improving their social networks and simplifying data sharing. IoT applies the concepts of human social networks to solve challenges specific to IoT. The models currently employed to analyze human SNs have been used for resolving [7]. Although security solutions have evolved the issues with scalability, centralization, as well as an unclear designing. Moreover, they overemphasize the physical features of the devices while ignoring the output obtained from relationship among gadgets and consumers as social intelligence. These solutions fail to improve actual interactions between people. Devices connected to the IoTs are particularly vulnerable to network attacks such as fraud, DDoS attacks and spoofing. The methods of attack and vulnerabilities like new cyberattacks are utilized.

The SIoT paradigm makes use of arbitrary behavioral characteristics to guarantee accurate data analysis, expert services, and enhanced security [8]. There are certain research gaps that have been fulfilled through efficient scalability, object discovery and efficiency which is similar to the platform of human social networking management between network navigability and smart social devices in the phenomenom of smart world context by management intraction between reliability and objects for the user's smart devices [9]. The existing IoT technologies has combined with human social activities named SIoT system that has an opportunity to offer users ubiquitous connectivity. The objectives of SIoT systems change from distributing data to user delight, computation offloaded is crucial to speed up the execution of program [10]. Delivering excellent service in a fully protected environment becomes significantly more difficult, adding to the existing challenging responsibility of securing sensitive data. A few studies have made an effort to investigate this issue. They put forth a wide range of models that categorize trusted nodes in the IoT network using various criteria and aggregation techniques. However, the earlier efforts have failed to offer any strategies for identifying fake nodes or discriminating between assaults. Hence, the proposed AE based ML is used to improve accuracy of detecting malware attacks efficiently.

The structure of this paper is explained as follow, session 2 discusses about detecting malware attack using ML and AE methods. Session 3 illustrates the proposed AE with LGBM classifier for pre-training the MQTT input and fine tuning LGBM classifier for better classification. Session 4 illustrates the performance evaluation of AE with LGBM classifier using confusion matrix metrics with existing methods. Session 5 concluded that AE with LGBM classifier has high accuracy in detecting malware attack effectively.

II. RELATED WORKS

In SIoTs model, each node is considered as an entity that interact socially with other objects individually in accordance with established rules by their owner. This idea is quickly gaining traction due to the major advantages resulting from the SN possibilities in the IoT domain like simplifying the dynamic network navigations. The billion object efficiency in the dynamic discovery, selection, as well as services composition offered through dispersed networks and objectss, reliable management of the object's constancy while maintaining services and data.

R. Chen et al. have suggested an adaptable mechanism of decentralized trust with respect to social trust is one of the efforts taking social considerations into account. It combines collaboration and social community variables through a weighted and it utilizes two actual social IoT scenarios to illustrate the model's efficacy [11]. K. Zhao and L. Pan have presented a further trust model pertaining to social trust that suggests formalizing the trust assessment as a classification issue using a ML-based technique. In a social network, social parameters including reputation as well as centrality are used for developing the feature vector [12]. A. M. Kowshalya and M. Valarmathi have presented a trust management strategy using certain metrics of SIoT trust, such as centrality, community interest, and cooperation, to promote autonomous trustworthy decision-making that relies on smart device behavior [13]. The value of the service as well as metrics like social similarity have been taken into consideration by B. Jafarian et al. The ensuing trust management algorithm calculates the nodes trust level in a SIoT network by social relationships. A centralized trust- based system for moving items has been presented by R. Chen et al. and relationships with others are used by the system to ensure accuracy and trust among the devices. [14,15].

To elaborate on the advantages of SIoT over traditional IoT and the research team highlighted the benefits of networking "social objects" as opposed to "smart objects," that regarded as a generational shift from objects in few degree of intelligence for the objects with actual consciousness in social [16]. Khelloufi et al. have proposed a recommendation system for services that obtain advantage of the social connections among individuals of IoT devices. The recommendation depends on the various connections among service provider and service requester. It also involve detection algorithm in boundary-based community which utilized for creating communities of social connected device owners [17]. Deep learning models and ML- based malware detection techniques are the key methodologies used. Wang et al. have used five ML models to perform software classification, including SVM, NB, K-NN, RF, and CART, the methods that utilize algorithms primarily employ typical ML and classification models [18]. A feature learning model incorporating a variety of ML methods was suggested by Kumar et al. [19] to identify malware with high accuracy and minimum overhead.

W. Wang et al. [20] created a hybrid approach based on deep AE as a pre-trained technique and several CNN structures in malware identification in an effort for improving the precision of Android malware detection with large-scale. The CNN-P structure achieved the best accuracy based on experimental results. Yi Zhang et al. [21] have developed a system called DeepClassifyDroid and CNN. Three parts make up DeepClassifyDroid's structural layout: the feature extraction component, the embedding in vector space and the DL model which uses CNN for malware characterization.

III.PROPOSED METHODOLOGY

The concepts of social networking and IoTs were combined to create the SIoT paradigm. It permits communication between linked equipment and people and offers a wide range of intriguing applications. The introduction of IoT into telecommunications environments initiated an evolutionary process that resulted in SIoT. The dataset is composed by 8 MQTT sensors with different features. In table, the MQTT sensors are reported. Each sensor has a data profile, as well as a topic connected to the MQTT broker. The subject is specified by the sensor when transmitting the data to the broker, and the data profile describes the kind of data the sensors transmit. This concept is important since a temperature sensor has a periodic behavior over time, i.e. cyclically sending information retrieved from the environment periodically (defined as P). Instead, a motion sensor has a more random behavior since it sends information only when a user passes in front of the sensor (defined as R)). By analyzing also this aspect, the dataset is even more valid as a real behavior of a home automation is simulated and implemented.

A. Dataset collection

The proposed effort seeks to produce an initial dataset for the scientific and industrial communities to utilize their applications that are related to the IoT context, focusing specifically on the MQTT communication protocol. Each component of a real network is defined in the dataset, which is made up of IoT sensors based on MQTT. In precisely, the network consists of 8 sensors and the MQTT broker is created using Eclipse Mosquitto. In the scenario, sensors in a smart home environment gather data on temperature, light, humidity, CO-Gas, motion, smoke, doors, and fans over a range of time intervals because each sensor behaves differently from the others.

tcp.flags	tcp.time_	tcp.len	mqtt.con	mqtt.con	mqtt.con	mqtt.con	mqtt.conf	mqtt.conf	mqtt.conf	mqtt.conf	mqtt.conf	mqtt.conf	mqtt.conf	mqtt.conf	mqtt.dupf	mqtt.hdrf	mqtt.kaliv	mqtt.len
0x0000001	1.90E-05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x0000001	0	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	165
0x0000001	1.00E-06	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000004	0	2
0x0000001	1.00E-06	85	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	165
0x0000001	4.00E-06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x0000001	3.00E-06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x0000001	0.000448	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x0000001	6.10E-05	1460	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	172
0x0000001	9.30E-05	1460	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	166
0x0000001	0.00012	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	12
0x0000001	0.000337	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x0000001	9.10E-05	492	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	163
0x0000001	4.00E-06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x0000001	5.00E-06	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	11
0x0000001	0.001751	132	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000004	0	2
0x0000001	0.000133	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	10
0x0000001	60.0001	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0x000000c	0	0
0x0000001	2.00E-06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x0000001	1.00E-06	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000004	0	2
0x0000001	4.10E-05	684	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	169
0x0000001	0.000148	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	8
0x0000001	8.90E-05	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0x0000003	0	11
0x0000001	3.10E-05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fig.1: MQTT dataset as an input for SIoT

Fig.2: Correlation heatmap for various features in MQTT dataset

Python Code Representation for Attack Type	Attack type description as target
0	Brutforce
1	DoS
2	Flood
3	Legitimate
4	Malformed
5	Slowite

Table 1. Code representation for various attack type as target

IV. WORKING OF STACKED AUTOENCODER

One of the unsupervised Neural Network (NN) is AE that assist to learn for reducing the difference among input data as well as output data. This AE consists of two type namely encoder and decoder. The original data gets mapped with encoder code which basically deals with code dimension is lesser than an original data. In the case of decoder, the code has tried to map an original input. The dimensionality reduction is an AE application and consider input as $z \in$
Rn, the AE goal is represented as $y = z$ which tried for
learning AE function is expressed in equation 1.

$Fw,ib(x) \approx y$ (1)

Where,

W = Weight of the entire neural network ib = Image bias The basic reconstruction loss in AE loss function for Lp distance in which Stochastic Gradient Descent (SGD) has been utilized to fine tune the weight and bias in AE module shown in equation 2.

$b(w, ib) = min \parallel x - Fw,ib(x) \parallel p$ (2)

However, the better results are obtained through AE that involves various AE in which the output of each AE is assigned to the input of the succeeded AE. The given below steps are basic steps for AE training.

Step 1 - Encoder transformation

The AE with M number is represented as mth AE's encoder as well as decoder transformation functions. The function of encoder transformation in AE has evaluated using function of encoder transformation for each AE in forward order gets illustrated in equation 3.

$xencoded = xm = \alpha m, \alpha m{-}1, \ldots, \alpha 2, \alpha 1\ (x)$ (3)

Step 2 - Decoder transformation

In the case of AE decoder transformation function has been evaluated by function of decoder transformation for each AE in reverse order get illustrated in equation 4.

$xDecoded = xreconstrct = \alpha 1, \alpha 2, \ldots, \alpha 2, \alpha 1(xw)$ (4)

When one layer is trained, the other layer's parameters get fixed whereas the output of the preceding layer has been utilized as an input for the subsequent layer. Thus, it will continue till the training gets completed. The backpropagation algorithm has been utilized for reducing the reconstruction error once all the layers are trained and all the layer's weights get modified.

A. Working of Light Gradient Boosting Machine (LGBM) classifier

One of the gradient boosting framework is LGBM that completely relies on Decision Tree (DT) for improving the model efficiency and minimize the usage of memory. This method includes two novel techniques namely Gradient- based One Side Sampling (GOSS) and Exclusive Feature Bundling (EFB) in which mean of GOSS and EFB with Gradient Boosted Decision Tree (GBDT) in which GDBT is expressed in equation 5.

$F(x, w) = \sum T\alpha tht(x, w)$ (5)

Where,

F( ) = Predictive value for GBDT

$\hat{F} = \arg min \sum NL(y, F(x, w))$ (6)

$\hat{V} = 1 (L1 + L2)$ (7)

Where,

$L1$ and $L2$ = Variable for subset M and N.

Additionally, the sample with a large gradient is represented by M and N, illustrating discretionary size selection. In each iteration of gradient boosting, the loss function is derived from the negative gradient using the GBDT method. The LGBM classifier algorithm not only optimizes the training sample through GOSS but also employs EFB to extract features, improving network training speed. The data tends to be sparse due to high-dimensional, mutually exclusive features, where sparse features are grouped using feature-based EFB. This method creates new features and reconstructs them based on histogram equations, as shown in figure 3.

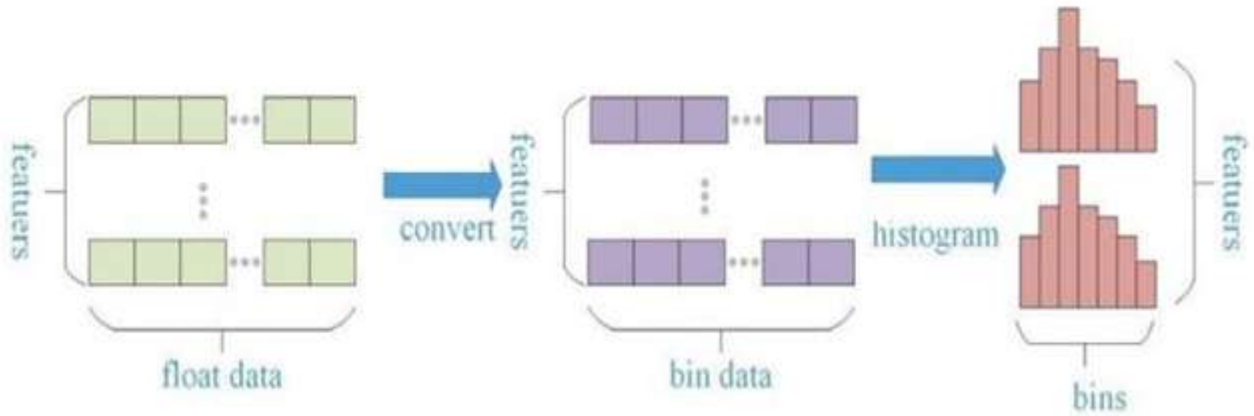

Fig.3: LGBM with histogram based reconstructed features

LightGBM employs the leaf-wise method of growth. In order to prevent fruitless node splitting and conserve computer resources, it can be understood as choosing the most advantageous leaf nodes for growth at each divisive node. In addition, the tree's growth is constrained by the maximum depth, which helps to manage the network's complexity and prevent over- fitting. The generalization capacity of the LightGBM model is also ensured by increasing the network's training speed. Therefore, the AE with LGBM has generated high accuracy through better training of data modeling the SIoT based MQTT dataset and it can be measure and compared with various classifier using a single library named lazy predict classifier. This library assist in training the data preprocessed sample that has been split as 70% as train dataset and 30% as test dataset. By importing the lazy predict library in python, the classifier model accuracy is defined and sorted in an ascending order.

V. EXPERIMENTAL RESULTS

Figure illustrates the pre-trained model of AE is utilized to determine the bias of the model and assist to train classifier model as the fine-tuned model for improving the accuracy of the classifier model in which LGBM has performed better while compared to Extra Tree (ET) classifier and Extreme Gradient Boost (XGBoost) classifier. This experimental research utilizes 500 epochs for better learning and understanding of features. The assessed results are consistent and associated with various accuracy metrics identified by the optimal LGBM Classification model. The attacks are quickly predicted by refining the models.

```
# Train the autoencoder
history = autoencoder.fit(X_train, X_train, epochs=500, batch_size=16, validation_data=(X_test, X_test

# Extract learned features from the encoder part
encoder_model = keras.Model(inputs=input_layer, outputs=encoder)
deep_learning_features_train = encoder_model.predict(X_train)
deep_learning_features_test = encoder_model.predict(X_test)
```

```
Epoch 1/500
180/180 [==============================] - 1s 3ms/step - loss: 1422976.7500 - val_loss: 68379.7578
Epoch 2/500
180/180 [==============================] - 1s 3ms/step - loss: 17806.2285 - val_loss: 42413.5391
Epoch 3/500
180/180 [==============================] - 0s 3ms/step - loss: 41497.8984 - val_loss: 2462.4470
Epoch 4/500
180/180 [==============================] - 0s 2ms/step - loss: 965.7145 - val_loss: 20768.7559
Epoch 5/500
180/180 [==============================] - 1s 3ms/step - loss: 17740.5742 - val_loss: 2365.1558
Epoch 6/500
180/180 [==============================] - 0s 2ms/step - loss: 1004.9792 - val_loss: 195108.3125
Epoch 7/500
180/180 [==============================] - 0s 2ms/step - loss: 135054.7969 - val_loss: 50624.5039
Epoch 8/500
180/180 [==============================] - 0s 2ms/step - loss: 20529.5645 - val_loss: 80681.1953
Epoch 9/500
180/180 [==============================] - 1s 3ms/step - loss: 239254.6875 - val_loss: 31300.8320
Epoch 10/500
```

Fig.4: Epochs for AE with LSTM classifier

The various performance metrics include precision, recall, F1 score, and support. The confusion matrix has four components: True Positive (TP), where the malware attack is correctly identified; True Negative (TN), where the normal type is accurately predicted. In the case of False Positive (FP), the actual type is an attack, but it is wrongly classified as normal, and in False Negative (FN), the attack type is normal but incorrectly identified. Figure 6 shows the confusion matrix of the AE with the LGBM method, where multivariable classes are provided, and the test dataset includes 1,235 sample transactions.

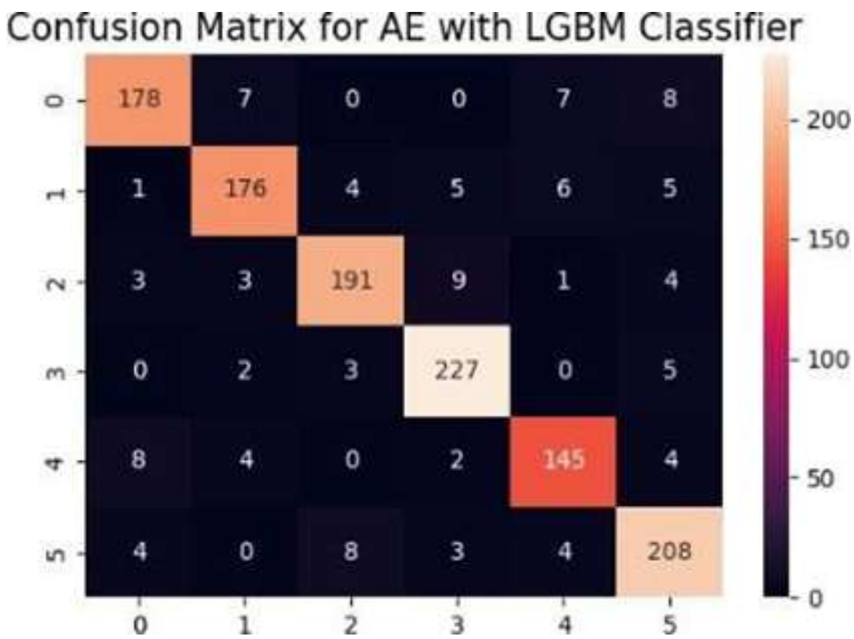

Fig.5: Confusion matrix for AE with LGBM classifier

Table 2 illustrates the confusion matrix class value for top three lazy predict with AE method in which the lable 5 as slowite has obtained the similar value for all three classifier but TP count is high AE with LGBM model while compared with ET and XGBoost classifier.

Table 2. Confusion matrix classes for various ML classification methods

ML classifier methods	**Attack type Lable**	**Confusion Matric classes**			
		TP	**TN**	**FP**	**FN**
LGBM Classifier	0	178	1019	22	16
	1	176	1022	21	16
	2	191	1009	20	15
	3	227	979	10	19
	4	145	1054	18	18
	5	208	982	19	26
ET Classifier	0	171	1019	22	23
	1	169	1020	23	23
	2	185	1002	27	21
	3	227	972	17	19
	4	145	1054	18	18
	5	208	978	23	26
XGBoost Classifier	0	171	1019	22	23
	1	169	1016	27	23
	2	185	1002	27	21
	3	217	972	17	29
	4	145	1048	24	18
	5	208	978	23	26

Figure 6 illustrates the micro and weighted metrics in which accuracy can be determined through micro precision, micro recall and micro f1-score. The value of micro f1-score is said to be accuracy in which AE with LGBM has high accuracy as 91.09% while compared with ET classifier and XGBoost classifier as 89.47% and 88.66% correspondingly. Similarly, the individual lable weight is measured and estimated through weighed precision, weighted recall and weighted F1- score. According to the experimental results, it determined weighted precision, weighted recall is 91.09% and weighted F1-score is 91.08% respectively which is better in determining the attack type accurately than ET classifier and XGBoost classifier.

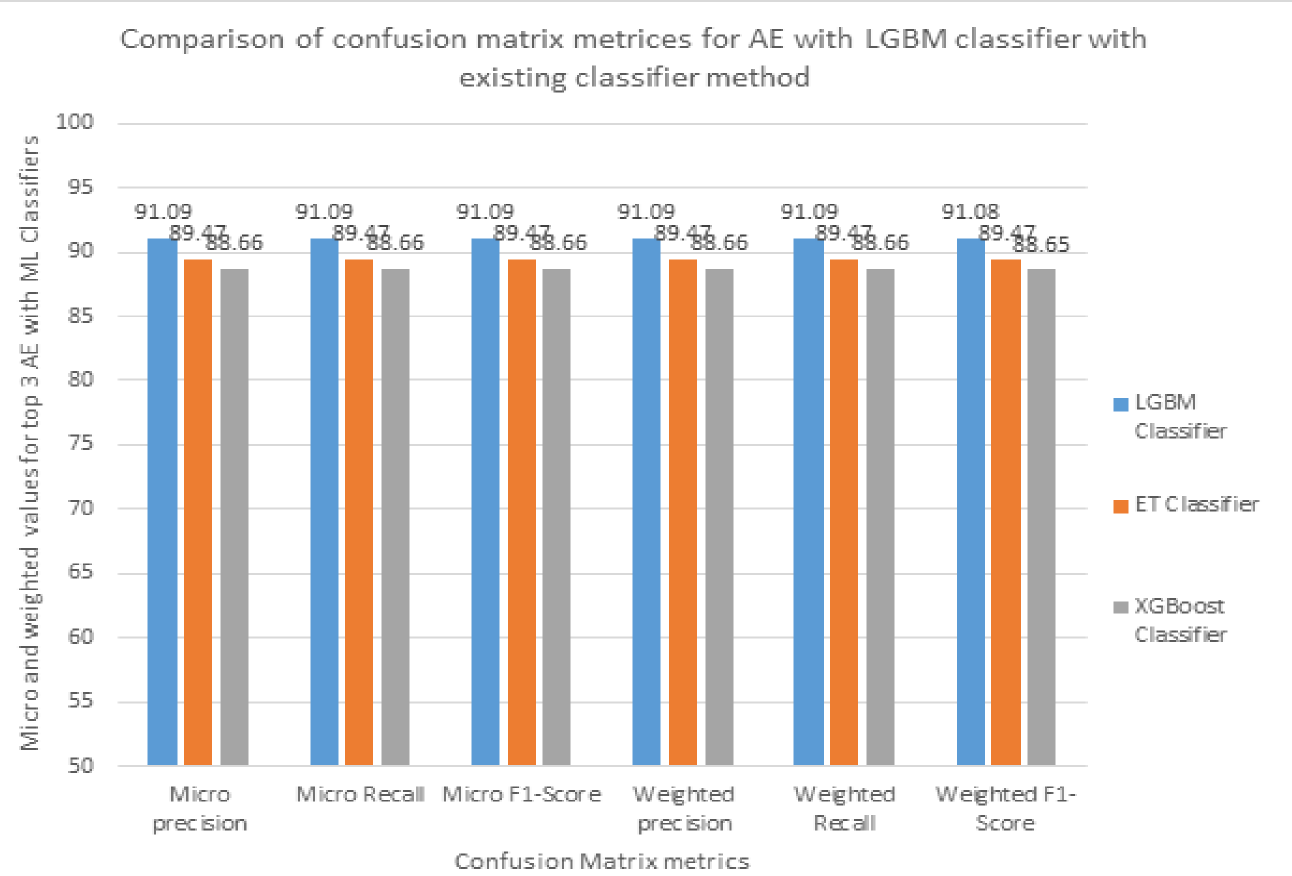

Fig.6: Micro and weighted value for various ML classifier

VI. CONCLUSION

A robust classification model is capable of identifying active malware attacks by analyzing network traffic and benign traffic in SIoT, aiding in early detection and preventing system tampering. Even a single rogue node can compromise numerous others. The proposed AE with LGBM classifier acts as a defense mechanism for SIoT by securing data packets and transmissions from vulnerable nodes. The LGBM classifier within AE improves the pre-training phase, offering an effective solution for detecting various malware attacks. This study uses a lazy predict classifier to identify attacks such as DOS, flood, Slowloris, brute force, and malformed attacks. The metrics analyzed include precision, recall, F1 score, and support. With an accuracy score of 91.09%, the model proves to be highly efficient in rapidly detecting malware attacks, making the AE with LGBM classifier a strong tool for malware detection.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Cyber Security and Its Important

Dr Kiran Chakre
Assistant Professor and Head, Department of Military Science, S.R.T.Mahavidyalaya, Ambajogai, Beed, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
28-32

ABSTRACT

Cyber security is the protection to defend internet-connected devices and services from malicious attacks by hackers, spammers, and cybercriminals. Companies use the practice to protect against phishing schemes, ransomware attacks, identity theft, data breaches, and financial losses.Look around today's world, and you'll see that daily life is more dependent on technology than ever before. The benefits of this trend range from near-instant access to information on the Internet to the modern conveniences provided by smart home automation technology and concepts like the Internet of Things.

Keywords- Research Paper, Technical Writing Security Studies

I. INTRODUCTION

Cyber security is a discipline that covers how to defend devices and services from electronic attacks by nefarious actors such as hackers, spammers, and cybercriminals. While some components of cyber security are designed to strike first, most of today's professionals focus more on determining the best way to defend all assets, from computers and smartphones to networks and databases, from attacks. Cyber security has been used as a catch-all term in the media to describe the process of protection against every form of cybercrime, from identity theft to international digital weapons. These labels are valid, but they fail to capture the true nature of cyber security for those without a computer science degree or experience in the digital industry. To gain a deeper understanding and practical skills, consider enrolling in online cybersecurity courses, which are designed to make the complexities of cyber security accessible to everyone.

Cisco Systems, the tech conglomerate specializing in networking, the cloud, and security, defines cyber security as "…the practice of protecting systems, networks, and programs from digital attacks. These cyberattacks are usually aimed at accessing, changing, or destroying sensitive information; extorting money from users; or interrupting normal business processes."

Important of Cyber security

In today's digital world, one cannot ignore cyber security. One single security breach can lead to exposing the personal information of millions of people. These breaches have a strong financial impact on the companies and also loss of the trust of customers. Hence, cyber security is very essential to protect businesses and individuals from spammers and cyber criminals. According to Cybercrime Magazine, cybercrime will cost the world $10.5 trillion annually by 2025! Furthermore, global cybercrime costs are predicted to rise by almost 15 percent yearly over the next four years.Concepts such as the pandemic, cryptocurrency, and the rise in remote working are coming together to create a target-rich environment for criminals to take advantage of. Cyber security encompasses technologies, processes, and methods to defend computer systems, data, and networks from attacks. To best answer the question "what is cyber security" and how cyber security works, we must divide it into a series of subdomains:

Application security covers the implementation of different defenses in an organization's software and services against a diverse range of threats. This sub-domain requires cyber security experts to write secure code, design secure application architectures, implement robust data input validation, and more, to minimize the chance of unauthorized access or modification of application resources. Cloud security relates to creating secure cloud architectures and applications for companies that use cloud service providers like Amazon Web Services, Google, Azure, Rackspace, etc.

1) Identity Management and Data Security

This subdomain covers activities, frameworks, and processes that enable authorization and authentication of legitimate individuals to an organization's information systems. These measures involve implementing powerful information storage mechanisms that secure the data, whether in transition or residing on a server or computer. In addition, this sub-domain makes greater use of authentication protocols, whether two-factor or multi-factor. Mobile security is a big deal today as more people rely on mobile devices. This subdomain protects organizational and personal information stored on mobile devices like tablets, cell phones, and laptops from different threats like unauthorized access, device loss or theft, malware, viruses, etc. In addition, mobile security employs authentication and education to help amplify security. Network security covers hardware and software mechanisms that protect the network and infrastructure from disruptions, unauthorized access, and other abuses. Effective network security protects organizational assets against a wide range of threats from within or outside the organization.

2) Disaster Recovery and Business Continuity Planning

Not all threats are human-based. The DR BC subdomain covers processes, alerts, monitoring, and plans designed to help organizations prepare for keeping their business-critical systems running during and after any sort of incident (massive power outages, fires, natural disasters), and resuming and recovering lost operations and systems in the incident's aftermath.

3) User Education

Knowledge is power, and staff awareness of cyber threats is valuable in the cyber security puzzle. Giving business staff training on the fundamentals of computer security is critical in raising awareness about industry best practices, organizational procedures and policies, monitoring, and reporting suspicious, malicious activities. This subdomain covers cyber security-related classes, programs, and certifications.

Cyber Security and Types of Cyber Threats

Cybercrime is defined as any unauthorized activity involving a computer, device, or network. There are three generally recognized classifications of cybercrime: computer-assisted crimes, crimes where the computer itself is a target, and crimes where the computer is incidental to the crime rather than directly related.

list of common cyber threats:

- Cyber terrorism: This threat is a politically-based attack on computers and information technology to cause harm and create widespread social disruption.
- Malware: This threat encompasses ransomware, spyware, viruses, and worms. It can install harmful software, block access to your computer resources, disrupt the system, or covertly transmit information from your data storage.
- Trojans: Like the legendary Trojan Horse of mythology, this attack tricks users into thinking they're opening a harmless file. Instead, once the trojan is in place, it attacks the system, typically establishing a backdoor that allows access to cybercriminals.
- Botnets: This especially hideous attack involves large-scale cyber attacks conducted by remotely controlled malware-infected devices. Think of it as a string of computers under the control of one coordinating cybercriminal. What's worse, compromised computers become part of the botnet system.
- Adware: This threat is a form of malware. It's often called advertisement-supported software. The adware virus is a potentially unwanted program (PUP) installed without your permission and automatically generates unwanted online advertisements.
- SQL injection: A Structured Query Language attack inserts malicious code into a SQL-using server.
- Phishing: Hackers use false communications, especially e-mail, to fool the recipient into opening it and following instructions that typically ask for personal information. Some phishing attacks also install malware.
- Man-in-the-middle attack: MITM attacks involve hackers inserting themselves into a two-person online transaction. Once in, the hackers can filter and steal desired data. MITM attacks often happen on unsecured public Wi-Fi networks.
- Man-in-the-middle attack: MITM attacks involve hackers inserting themselves into a two-person online transaction. Once in, the hackers can filter and steal desired data. MITM attacks often happen on unsecure public Wi-Fi networks.
- Denial of Service: DoS is a cyber attack that floods a network or computer with an overwhelming amount of "handshake" processes, effectively overloading the system and making it incapable of responding to user requests.

As data breaches, hacking, and cybercrime reach new heights, companies increasingly rely on cyber security experts to identify potential threats and protect valuable data. So it makes sense that the cyber security market is expected to grow from $217 billion in 2021 to $345 billion by 2026, posting a Compound Annual Growth Rate (CAGR) of 9.7% from 2021 to 2026.

Advantages of Cyber Security

Today's cyber security industry is primarily focused on protecting devices and systems from attackers. While the bits and bytes behind these efforts can be hard to visualize, it's much easier to consider the effects. Without cyber security professionals working tirelessly, many websites would be nearly impossible to enjoy due to ever-present denial-of-service attack attempts. Imagine not having access to Simplilearn's community of experts and certified professionals — no more tips, tricks, and advice to help you achieve your professional goals!

Without solid cyber security defenses, it would be easy to destroy modern-day essentials like the power grids and water treatment facilities that keep the world running smoothly.

Simply put, cyber security is critically important because it helps to preserve the lifestyles we have come to know and enjoy.

Cyber security Myths

We are well aware that cyber attacks are continuing to grow. In today's technology era, organizations and individuals must protect themselves against most types of threats. Unfortunately, there is a handful of cyber security misconceptions that are still holding too many people back from taking the necessary action to safeguard personal sensitive information.

- Passwords alone are enough to protect you: one should not solely rely on passwords to keep the data safe. While strong passwords are essential, cybercriminals may still find ways to hack them. Hence it is necessary to implement robust cyber security measures, to have a multilayered defense.
- Deleting the file from the computer: By deleting the data from the computer, the file moves to the Recycle Bin and then empties it. Even after deleting the data, the data remains in the hard drive for example in the temporary files folder.
- Encryption solutions are not worth it: Some organizations retain the opinion that encryption software is something they can do without. It is a misconception that encryption will avoid data breaches. Encryption plays a vital role in defending against cybercriminals and ransomware attacks.
- Small and Medium-sized businesses are not targeted: It is a myth that only big companies are not secure, only those companies are targeted by cybercriminals.

II. CONCLUSION –

Key Cyber security Technologies

- Use VPN to privatize your connections
- Before clicking on links check the links
- Do not be lethargic with your passwords
- Scan external devices for viruses
- Store sensitive information in a secure place
- Enable two-factor authentication
- Double-check the HTTPS on websites
- Remove adware from the computer
- Disable Bluetooth connection when you are not using it.
- Avoid using public networks
- Invest in security upgrades
- Employ white hat hacker

Cyber Safety Tips

- Keep software up-to-date
- Avoid opening suspicious emails
- Use Antivirus and Antimalware software on the electronic devices
- Use a security file-sharing solution to encrypt data.
- Use strong passwords
- Backup your data
- Be cautious of phishing scams
- Use password manager
- Use two-factor authentication
- Don't reuse passwords

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Heavy Vehicle Driving Safety System by Analyzing Mouth Aspect Ratio using IOT

Abhishek Khonde, Mustaqeem Sayyed, Dinesh M. Barode, Seema Kawathekar
Department of Computer Science and Information Technology, Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhaji Nagar, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
33-39

ABSTRACT

Problem Statement: As driving heavy vehicles for a long period of time onto a straight road or highway can lead to deception for the driver and misinterpret the objects in the surrounding, because of a long journey of days and weeks, the driver faces many problems like weak eye vision and fatigue that significantly increases the risk of accidents. One of the key indicators is yawning which is an early sign for microsleep and loss of focus. For long haul drivers and heavy vehicle operators, detecting early signs of fatigue can be crucial in preventing accidents and ensuring road safety. Former techniques, such as physiological systems like EEG and ECG, while accurate, are costly and visible. Vehicle-based technologies like lane departure detection fail to monitor the driver directly and are scenario-dependent. Image-based techniques, however successful, often suffer in bad conditions or require expensive hardware.

Solution: The study focuses a heavy vehicle driving safety system for analyzing driver fatigue based on yawning frequency using a raspberry Pi, and Dlib libraries. By analyzing the mouth aspect ratio, it identifies yawning and records the frequency of yawns and gives an alarm to take a break when it crosses a predefined threshold.

Keywords: Yawning, Mouth Aspect Ratio, IoT Devices, Image Processing

I. INTRODUCTION

In today's world, driving has become very common as there are vehicles everywhere. Driving a vehicle comes with a lot of issues like safety of drivers as well as of the people on the road. Heavy vehicles are a mode of transportation that travels from one state to another state carrying goods and materials. Sometimes the journey is on to another countries as well. This long route journey is often on highways, for example, like Samruddhi Mahamarg, where there are no turns for many kilometers. This leads to fatigue and drowsiness to the driver [1].

As driving in drowsy state removes the focus on the road, a high risk of accidents occurs. It becomes fatal for the driver as well as for the other people that travel on the same route [2]. Many experiments have suggested that due to continuous motion in a straight path, poor judgment can arise [3]. Recently, an article published stated that 20 percent of all the road accidents are due to fatigue-related issues [4].

The accidents caused due to fatigue-related issues are less in number on a crowded road as compared to highways. Highways are mainly for the heavy-loaded vehicles that carry a large quantity of goods, so if there causes an accident, there is equal loss to the property as to the lives [5]. Another article by The Indian Express stated that Samruddhi Mahamarg witnessed more than 590 accidents between 11 December 2022 to 3 July 2023, and from them, 192 accidents were due to the driver falling asleep [6].

II. MOTIVATION

An irony in this case is that the driver may be too tired to relalize their own level of drowsiness.this main problem is often ignored by the driver .there are three main reasons of accidents on road, alcohol , distraction and fatigue. alcohol and distractions are mainly focused by the society. but what about the fatigue. so in this paper, the initivative is to deal with fatigue related issues and the solutions that will reduce the loss happening to the property as well as lives.

III.OBJECTIVE

The goal of this research paper is to build a smart safety system that will help in detecting one of the indicator of drowsiness, that is yawning. the system will detect the counts of yawning performed by the driver and generates an alert message if the count exceeds a particular count in a particular duration. the system will generate alerts in pre sleep phase and reduce further consiquences.

IV.RELATED WORK

Particularly for long-distance heavy vehicle transportation, driver sleepiness detection has been a major focus of study aiming at enhancing road safety. Among the other approaches under investigation are vehicle parameter tracking, behavioral analysis, and physiological monitoring. Among them, non-intrusive behavioral techniques including monitoring face traits like the Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR) have demonstrated encouraging results. In one such study by Abtahi et al. [5], yawning and facial expression analysis of real-time video-based surveillance helped to identify tiredness. The study successfully underlined how tired one could be indicated by yawning frequency. Still, the system lacked integration with contemporary IoT technology and was not scalable. Conversely, IoT-based solutions are becoming rather popular in this field. Using IoT, Pranav et al. [6] created a system to track driving metrics including yawning and blink rates, therefore identifying tiredness. For long-distance travel especially, the system also offered real-time alarms. But the study paid more attention to blink detection and underlined less relevance of MAR, which is a direct sign of yawning.

Recent improvements in sensor technologies and machine learning have also led to sleepiness detection systems. Kielty et al. [7] presented a neuromorphic vision system for yawning detection that decreases processing requirements, making it appropriate for low-power IoT applications. While their algorithm obtained great accuracy, it did not study MAR-specific detection thoroughly.

Subramanian et al. [8] integrated machine learning techniques with video and sensor data to detect fatigue indications as yawning and head tilts. Their work revealed the usefulness of merging different data sources but needed large processing resources, which could be a constraint for resource-constrained situations like IoT.
Although these research have provided the groundwork, there is still a paucity of solutions that combine Mouth Aspect Ratio (MAR) analysis with IoT-based frameworks specifically for heavy vehicle drivers. This research presents a method to solve this gap by establishing a MAR-driven system that functions in real-time and gives early alarms to prevent accidents due by tiredness during long-distance transportation.

V. METHODOLOGY

The study in the paper presents the approach which is followed in the development of a heavy vehicle driving safety system using internet of things and image processing techniques. the system is the integration of different devices with python libraries like OpenCV, dlib and Pi camera for real time-video capturing, by calculating the mouth aspect ratio (MAR) from facial landmark, the system identifies yawning patterns that indicates drowsy behaviour, and due to excessive yawning, an alarm is turned on to alert the driver.

Hardware:

Raspberry Pi: a compact computer that is used for the processing unit of the system, particularly selected for its ability to run python-based applications effectively. Moreover, it is affordable and also requires low power consumption.

Pi Camera: integrated with raspberry pi, used to capture real time video or actions of the driver's facial features. The camera is placed in a specific position where it monitors the mouth region.

Buzzer: to alert the driver with a sound when driver is experiencing drowsiness or pre sleep behavior. **Mounting handle:** to place the device in a proper position, flexile according to the scenario.

Software: the implementation relies on python programming and below libraries:

Dlib: python library for facial landmark detection.

OpenCV: for processing images and videos, for detecting the actions of driver's mouth region.

Imutils: for image transformations and video streams handling .

1. **Data Acquiring:** Pi camera captures the real time video of driver's face. then the video is processed on raspberry pi board, ensuring portability and efficiency.
2. **Preprocessing:** the frames that are extracted from the video are converted to grayscale that will make the processing fast. Gaussian blur is used to remove noise and enhance the captured quality.
3. **Facial landmark detection:** Dlib library detects the facial landmark points that identifies the wide space between the lips. Then mouth aspect ratio(MAR) is calculated which is the horizontal distance upon the vertical distance of the landmark points. Formula for calculating MAR is:

$$MAR = \frac{|P2-P6|+|P3-P5|}{2|P1-P4|}$$

P1 to P6 are the points surrounding the mouth. MAR value decreases when the mouth is closed and increases when the mouth is opened widely considering a yawn. A threshold value is predefined, below which the yawn is detected.

also, drowsiness is detected when the yawns exceed the count of 3 in a minute. on exceeding the 3 count of yawns, the system will generate an alert alarm. The duration is an experimental call. the threshold is updated on the situations and feedbacks.

4. **Alarm generation:** the alarm will be triggered when it crosses the threshold for a predefined duration. the alert type will be in three order, on the count of one yawn, a beep sound is generated. on second yawn, two beep sounds are generated, and on the third yawn a sound telling to take rest is generated.

The steps implemented are:

1. face detection
2. facial landmark detection.
3. mouth aspect ratio (MAR) analysis.
4. yawn detection and alert generation.

Fig1 Shows the real-time value of MAR

If MAR is more than 0.4 device generates an ALARM

Normal MAR MAR>0.4 Fig1

Steps Involved

1. Start
2. Capture video using Pi Camera
3. Detect face using OpenCV
4. Extract mouth landmarks using dlib
5. Calculate MAR
6. Detect yawns
7. Trigger an alert if necessary
8. Repeat

VI. ADVANTAGES

Low Price: Raspberry Pi is a reasonably priced tool with superior processing and results than high end gadgets.

No requirement of sensors to be positioned on the driver; non-intrusive.

Real time monitoring helps one to identify and interpret driving behaviour.

High accuracy in fatigue detection: by computing mouth aspect ratio, the system reduces false positives and false negatives while guaranteeing a precise and dependable means of identifying the tiredness.

The technology can be adjusted to fit different kinds of cars and driving situations, therefore guaranteeing public transportation's safety.
Enhances driver health: early drowsy detection helps drivers to take required breaks, which over time improves their general health.
Using OpenCV and Dlib guarantees adaptability and customizing that brings fresh ideas into the field.
Commercial: as heavy vehicles are a means of products and service transportation, such systems helps businesses avoid further losses.

VII. CHALLENGES AND SOLUTIONS

Yawning Patterns Vary by Motor Drivers: Each motor driver has its own unique yawning pattern that varies based on physical characteristics and fatigue levels.
Train the system on diverse datasets that include different age groups as part of the solution. Machine learning models to fit to driver profiles
Environmental Factors: High and Low intensity light level, and shadows present in the car can disrupt detection.
Solution (based on real practice): Red/infrared or low- light cameras & algorithms that mitigate dynamic illumination changes and temper noise from shadows.
Camera Positioning: When filming, it is important to position your camera correctly.

VIII. FLOWCHART:

figure 2 shows the flowchart for the process

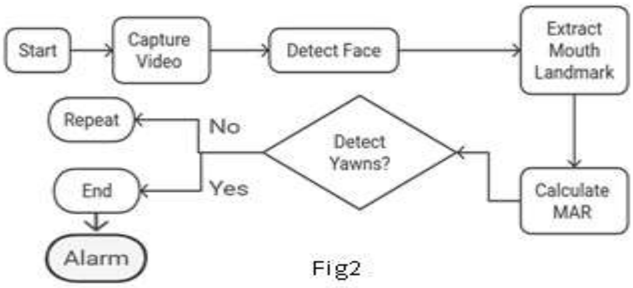

Fig2

IX. RESULT

The system is still in the conceptual part, the system proposed is designed to deliver effective real time drowsiness detection by analyzing yawning with the help of mouth aspect ratio (MAR). with the integration of raspberry pi and a pi camera, the limitations can be effectively handled in further implementations. the proposed system aims to achieve accurate monitoring or detection of the driver's mouth region under challenging environments and conditions.
the system aims to identify the yawns in a particular time that will detect the drowsiness and fatigue state and will alert the driver and avoid any future happenings and incidents.

1. detecting the mouth region in challenging conditions with real time monitoring.
2. provide timely alerts to the driver.

X. CONCLUSION

In this study, a real time heavy vehicle driving safety system by analyzing yawning mouth aspect ratio with raspberry pi a pi camera is designed to generate an alert sound for breaking the pre sleep phase of the driver. in this study, main focuses is done on the fatigue and drowsiness of a driver that becomes fatal while driving on a high way or on the road. many of the times, due to distracted focuses of the driver while driving accident occurs that makes a damage not only to property but also the lives. highways or express ways like samruddhi mahamarg that are considered long routes are witnessing huge accidents because of this reason, so the proposed system shows contribution for the issue and tried to find a solution in reducing the loss. due to its cost effective and non-intrusive solution it becomes affordable to be placed in heavy vehicles instead of placing costly devices and equipment's. as new trucks and heavy vehicles are offering smart systems, the study is mainly focused on the existing old vehicles that are in large numbers. by using python libraries like dlib and OpenCV, the system becomes more effective in processing at real time.

its integration with the buzzer mainly provides alert generation that wakes up the driver from pre sleep phase.

the system is flexible to adapt changes and updates. also, it is affordable and scalable.

by using various devices like infrared cameras, some challenges can be solved. these advancements can be addressed in further implementations.

XI. FUTURE WORK

Future implementations will include eye closure analysis and head movement to attain more exact fatigue detection.

Including heart rate sensors will help to better monitor driver behaviour and tiredness.

Advanced infrared cameras will help to detect mouth regions under low-light and nighttime environments.

The technology will be tested on several big vehicles in order to hone accuracy and performance.

The technology will be tailored for usage in automobiles including vehicles and other vehicle kinds, thereby expanding its utilization.

Efforts will be made to create a more pocket-friendly gadget so that a bigger audience may access it.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Navigation and Locomotion of Humanoid Robot

Prof. Kulkarni Kiran, Dr. Priyank Nahar
Department of Computer Science, Shri Venkateshwara University Gajraula, Uttar Pradesh, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
40-45

ABSTRACT

According to scientist Isaac a robot is a reprogrammable, multipurpose automatic manipulator programmed to work in multi-dimensions. Humanoid robots, with six senses and common sense, artificially instill human characteristics, and work like human experts, drawing conclusions and making decisions. Humanoids are expert systems with memory stored in a knowledge base, learning and programming to reassemble robots similar to human appearance and behavior, working with speed and accuracy. It shows emotions & expressions artificially. Humanoid works with fuzzy logic. Today Humanoid robots work inside known environments meaning laboratories and outside the lab with remote technology IOT and new IORT technology. These are also robots giving their best Today to expect better performance from a humanoid robot we need to consider the structure of the humanoid, its size, its environment, release platform, 3-D coordinate system, workspace, number of joints, types of joints and their degree of freedom, mobility of each joint as well as the restricted scope of the joint, speed of movement. Power is given to actuators which serve as artificial mussels that convert the energy into motion. Designing a robot involve considering its purpose and its limitations. Every robot with some fundamental level of complexity. Basically, robots being more complex due to limbs, actuators, and sensor. Modern robots have more complex microprocessors and microcontrollers. Any addition to the robot's components expands its range, and each joint increases a robot's degree of functionality. Python, an open-source language, governs robotic navigation and movement, offering pre-built modules for computer vision, machine learning, and numerical computation. It enables rapid prototyping and development, building robust, scalable, and efficient robotics applications. Sensors for humanoid performance are limited, but understanding their mechanics and developing algorithms for varying performance is crucial. Implementation is possible in future with advancements in design, smart modeling, and

control techniques.

Keywords: Sensor, Actuator, Navigation, Locomotion, Workspace.

I. INTRODUCTION

To prepare algorithms for the various performances of humanoid robots It is necessary to understand the overall mechanics of humanoid robots It means all the mechanisms that are required to move the humanoid robot from one place to another as well as to do any kind of movement made by any part or organ of humanoid robot It includes running, jumping, moving sitting, walking talking, cycling, driving, giving any expression on face everything that is programmed The Power Supply provided by batteries, hydraulic, solar power, or pneumatic power sources. Artificial mussels convert energy into work. Electric motors (AC OR DC) Motors convert electrical power into its equivalent work done. Real-time information is provided via sensors that measure various environmental parameters. One component of a robot that manages all mechanical system movements is the controller. It also gets information from its immediate surroundings via several sensors.

I] Navigation of Humanoid Robot

When an autonomous robot locates itself, it may use that information to determine a course that will take it to its destination without encountering any barriers. There are varies path for humanoid navigation namely linear ,curved, freeform, grid based, optimal, random, hybrid, spiral, etc.

II] Humanoid Locomotion:

Moving from one place to another is known as locomotion. The process that enables a robot to move among its surroundings is called robot locomotion. There are many types of locomotion some are having Wheel, some are with two or more than two Legs, and. For a robot to move leg coordination is necessary if it has several legs.

III] Liberty in Movement:

Allowing free space for a move is a difficult task. The multiple factors are necessary to define the movement of a humanoid robot in three-dimensional spaces. Six is the allowed free space which means the maximum number of degrees of freedom. The humanoid allowed workspace (DOF) is Leg= 6, Arm=4 Hand=1 Waist=2 Neck=1 TOTAL D.O.F. = 25

Workspace: It is also called work volume, work envelops. It is the volume or maximum reach within which a robot can operate namely

A) Full Liberty

A Maximum Envelope refers to the potential coordination achieved by connecting a known frame to robotic effectors, allowing the joint DOF to assume any value.

B) Reachable Liberty

The robot's effectors can achieve a specific position for a minimum of one when joint DOF assumes all permissible standards, forming a constrained space.

C) Primary Liberty / Operational Envelope or Dexterous Workplace:

The robot can cover a workspace with full manipulation capacity due to its maximal size in any direction.

II. METHODS AND MATERIAL

I] Mechanical Structure of Humanoid

The mechanical form, actuators, and sensors make up humanoid and manipulator robots. The structure is of rigid components Physical joints connect connections, which are referred to as links. These connections may be manipulated, with power-driven motors or hydraulic systems often used. Humanoids, in particular, are anthropomorphic machine robots with a humanoid look. The humanoid is depicted as an ordered form of a firm body attached by revolute joints. Statistics portray a typical situation in the Figure shows a humanoid robot

A) Rigid Frame

Joints are represented with grey circles, inflexible bodies are characterized by ellipses, and terminal bodies are characterized through black rings (end-effectors).

The rectangles represent firm frames, the arrows indicate a parental-infant relationship in the middle of bodies, R stands for proper, and L stands for the left Compared to the robotic Machiavelli, the humanoid machine is not always in the same place and time. As a result, the robot's mobility is determined by its joints and a neighbouring body, allowing humanoids to move and control objects

Figure 1: Outer Appearance of Humanoid Robot

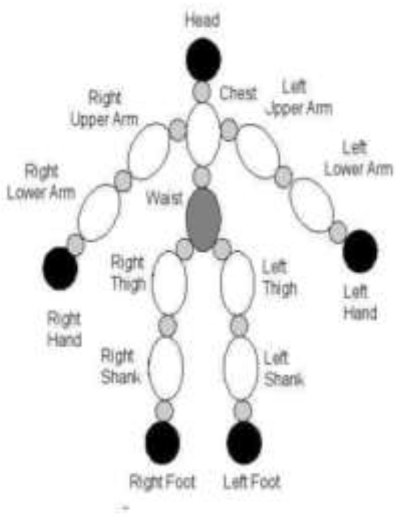

Figure 2: A Firm-Frame of Robot

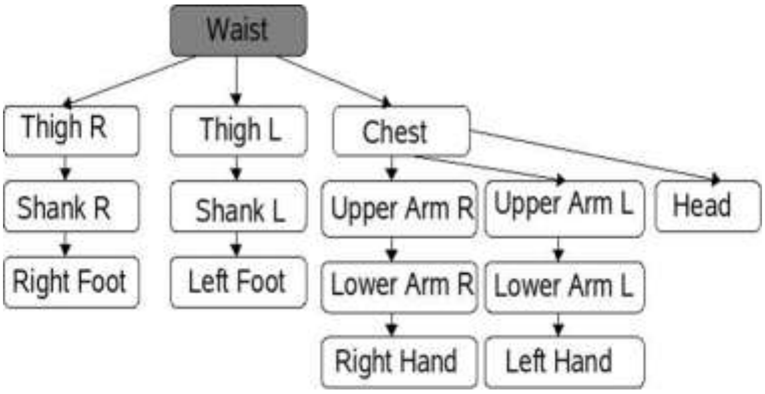

Figure 3: Ordered Illustration of the Kinematic Hierarchy of robot

Reaction powers between legs and ground maintain system balance. The hand features 34 tassels on each fingertip, providing data on forces and torques, demonstrating dexterity in

II] Gripping Techniques.

A] Dexterity: Hand dexterity involves the ability to manipulate objects from a specific configuration to another, requiring the cooperation of eye and hand. Machine dexterity can be measured using hand redundancy or complexity, allowing for arbitrary object movement in a processing workspace.

B] Re-grasping: The object geometry and environment stage in hand manipulation should ensure a fixed configuration of the item. Grasping can occur in multiple workspaces, and stability is provided by the robot's legs and centre of mass.

C] Grasp Manipulation: The device utilizes kinematics redundancy to adjust object orientation and position, ensuring no sliding or slippage, but local rolling based on finger design and Degree of Freedom.

D] Finger Gaiting: When joint limits are reached, the hungry finger is altered, forming finger switch and footswitch, replacing, clutching fingers for stability, and allowing grasping fingers to move freely.

E] Finger Pivoting / Tracking: Humanoids use arm manipulation to rotate items in two-point contacts using free fingers, repositioning objects caught between index and thumb fingers.

F] Rolling: Non-fingered end effectors are non-prehensile manipulation techniques used for non-holonomic task planning, requiring objects or fingers with specific shapes.

G] Sliding: Humanoids commonly use push greed for hand manipulation, requiring high-quality touch sensor arrays for sensitivity, reducing gripping issues, and minimizing slip.

III] Navigation and Path Planning

The Autonomous Robot must be able to extract the environmental information, to represent the surroundings as a map and use this map to plan a path and navigate. In any Autonomous Robot system, the tasks of Navigation can be segregated into three basic operations;

A) Locating one,

B) Planning the path

C) Building and interpreting the environment map.

The proposed work emphasizes designing an efficient Navigation system for Autonomous Mobile robots. The brief methodology and flow of the proposed work is as follows:

1. Intensive study is conducted on the Navigation Controller for Autonomous Robot regarding the implementation of tasks of path planning, motion controlling, and obstacle detection. For simulation and verification of the system, python is used.
2. Python is used to generate the path planning GUI.

3. The results from the simulation are verified by arithmetical modelling.
4. Hardware implementation is done on FPGA and Xilinx ISE 14.1 tool is used for hardware implementation.
5. with the help of Modalism, the timi5. With the help of Modalism, the timing diagrams and RTL design analysis are presented through simulation.
6. After completing the functional testing through simulation, the Xilinx ISE tool is used to optimize the design further and synthesize this design, so that it can be mapped onto a target FPGA.
7. The Place & Route tool of Xilinx has started to generate a bit file, which will be downloaded onto the target FPGA board.
8. The hardware system is then run to check the performance by analysing the result with power, area, and delay measures. Humanoid has two legs. When displaying leap, jump up and down or move. A leg movement uses energy. For a movement, more motors are needed to complete the process. An irregular surface needs more operational power. Stability concerns make implementations challenging. Considering that a robot has K legs, the number of alternative outcomes is N = (2K-1)! In the case of a two-legged robot (K=2), the number of possible events is

N= (2K-1)! = (2><2-1)! =3! =6 Hence, There are six possible different events:-

1) Lifting the Right leg
2) Lifting the Left leg
3) Releasing the right leg
4) Releasing the left leg
5) Releasing both legs together
6) Lifting both legs together

In case of K=4 legs, Total 5040 possible events. The more complicated the robotic system becomes if legs are more.

III.RESULTS AND DISCUSSION

All Humanoid robots are designed for humans, allowing them to navigate confined spaces, perform tasks with efficiency, and engage more naturally with humans. They have a smaller footprint, can maintain eye contact, and can perform advanced movements like jumping or running; making them ideal for dynamic environments and navigating obstacles.

IV. CONCLUSION

Humanoid mechanics presents numerous challenges, including maintaining balance, adjusting posture, developing control systems for smooth walking patterns, consuming more energy than quadrupedal robots, simulating human-like movements, designing lightweight joints and limbs, real-time computation for sensory data processing, ensuring safe operation around humans, and learning and adapting to new environments. The complexity of humanoid robots often leads to higher costs in materials, design, and technology, making it essential to address these challenges to advance their capabilities and applications.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

The Internet of Things (AIoT) and Artificial Intelligence's (AI) Impact on Education

Dr. Vyankat Vishnupant Munde
Department of Computer Science, Vaidyanath College Parli Vaijnath , Dr. Babasaheb Ambedkar Marathwada University , Sambhaji Nagar, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
46-53

ABSTRACT

Education is one of the many industries that are undergoing a transformation thanks to the combination of artificial intelligence (AI) and the Internet of Things (IoT), or AIoT. The integration of Artificial Intelligence (AI) and the Internet of Things (IoT), collectively known as AIoT, is poised to revolutionize education by fostering a more adaptive, personalized, and interconnected learning experience. The transformational function of AIoT in education is examined in this research article, with particular attention paid to how it might improve learning outcomes, promote inclusion, and tackle important issues. The study also looks at the effects of adopting AIoT and offers suggestions for successful deployment. This paper's goals are varied and include giving readers a thorough grasp of how the Artificial Intelligence of Things (AIoT) is revolutionizing education.

Keywords: AIoT, Artificial Intelligence, Internet of Things, Smart Education, Personalized Learning, Digital Transformation. Intelligent Tutoring Systems (ITS)

I. INTRODUCTION

Technological advancements have significantly influenced the education sector, leading to the emergence of innovative teaching and learning methods. The convergence of Artificial Intelligence (AI) and the Internet of Things (IoT) — known as AIoT — has the potential to redefine education by enabling smarter, data-driven systems. This paper investigates the role of AIoT in education, highlighting its applications, benefits, and challenges.

A revolutionary paradigm known as AIoT, or the Artificial Intelligence of Things, has emerged in the quickly changing field of education as a result of the convergence of artificial intelligence (AI) and the Internet of Things (IoT). This combination of smart algorithms and networked gadgets has the potential to completely transform educational technologies and learning settings. The educational environment is undergoing a

significant transition away from traditional models and towards a dynamic, adaptive, and personalized approach to learning as we stand at the nexus of these two potent technology forces. A combined fog/edge/AIoT/robotics teaching strategy based on tripled learning is proposed by Hasko et al. (2020).
This combination marks a turning point in the educational field, where the introduction of intelligent algorithms and networked gadgets is redefining and reshaping conventional pedagogical approaches. AIoT offers a synergistic approach to education that goes beyond traditional bounds by combining AI-driven analytics with the extensive network of IoT-enabled devices. Fundamentally, AIoT in education represents a dedication to
The development of intelligent learning environments, particularly smart classrooms, is another way that AIoT is being used. Online instruction and AIoT-based smart education are offered by Srivastava & Pathak (2023). These spaces are furnished with a variety of networked gadgets, such as sensors, interactive whiteboards, and instructional resources enabled by the Internet of Things. Students actively interact with the material, work together in real time, and gain knowledge via AI-driven analytics in this immersive learning environment. The abundance of data produced by AIoT drives learning analytics, which is crucial in designing instructional methods. Teachers get essential insights into student performance, preferences, and areas for growth through the ongoing collecting and analysis of data. A more proactive and responsive educational system is made possible by this data-driven approach, which allows interventions to be precisely tailored to meet the requirements of each person.

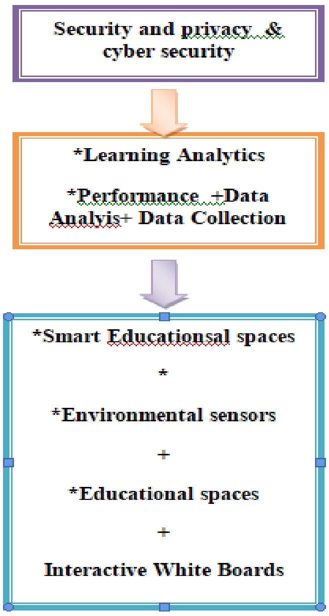

Fig. 1- AIoT in Education

AIoT's Importance in the Field of Education

The revolutionary potential of Artificial Intelligence of Things (AIoT) to rethink conventional educational paradigms and steer towards more dynamic, adaptable, and customized learning environments highlights the technology's relevance in the educational landscape. In a time when educational technology is becoming more and more important, the combination of AI and IoT signals a new age in the way that knowledge is taught and learned. The potential of AIoT to transform individualized learning experiences is at the core of its relevance. It might be difficult for traditional educational institutions to accommodate different learning styles and individual demands. By utilizing AI algorithms and IoT device connection, AIoT tackles this problem by customizing instructional information in real time. The outcome is an educational opportunity.

The importance of AIoT also extends to learning analytics, where instructors may gain a thorough grasp of student performance, engagement, and learning preferences thanks to the abundance of data produced by these networked technologies. Teachers may make well-informed judgments, pinpoint areas for development, and proactively meet the requirements of each individual student with the help of this data-driven method.

II. ILLUMINATE THE SIGNIFICANCE OF PERSONALIZED LEARNING:

Examine the Evolution of Smart Educational Spaces: Emphasizing the critical role AIoT plays in enabling individualized learning experiences is one of the main goals. A more interesting and successful learning experience may be created by dynamically tailoring educational information to each student's unique requirements, Examine the idea of smart classrooms and learning spaces that are improved by Internet of Things-connected gadgets.

Uncover the Role of Learning Analytics and Data-Driven Insights: Examine the educational value of the data produced by AIoT. The goal is to demonstrate how learning analytics, which are fueled by the abundance of data from networked systems, give teachers useful information on student performance, engagement trends, and areas in need of development.

III.FUNDAMENTALS OF AIOT IN EDUCATION

Definition and Components of AIoT

The innovative combination of two game-changing technologies—Artificial Intelligence (AI) and the Internet of Things (IoT)—is known as Artificial Intelligence of Things (AIoT) in education. Fundamentally, AIoT uses AI's analytical capabilities to analyze data produced by IoT-connected devices, resulting in an ecosystem that intelligently responds to the always changing demands of educators and students.

The fundamental elements of this creative integration are the elements of AIoT in education. Advanced machine learning algorithms that can handle massive information, provide predictions, and identify trends in student behavior and learning preferences are all part of the artificial intelligence component. The use of environmental IoT detection technologies for college students' environmental education is an intriguing idea put out by Wu, Chin, and Lai (2022). The complex system that gathers data on student interactions, engagement levels, and environmental elements in real time is made up of sensors, smart boards, wearables, and other IoT-enabled teaching technologies.

The traditional notion of technological integration is not applicable to the concept and elements of AIoT in education. It represents a paradigm change away from conventional, one-size-fits-all educational paradigms and toward a flexible, dynamic approach that customizes each student's learning experience. The data coming from IoT devices is continuously analyzed by AI-driven analytics in this ecosystem, providing a detailed insight of students' learning preferences, shortcomings, and capabilities.

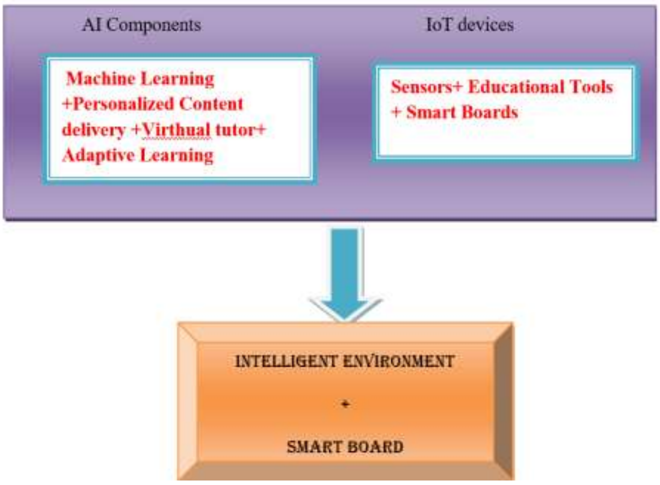

Fig. 2- AIoT in Education Architecture

Integration of Artificial Intelligence and IoT in Education

An innovative step toward a more dynamic and responsive learning ecosystem is the incorporation of artificial intelligence (AI) and the internet of things (IoT) in the classroom. Fundamentally, this integration is a symbiotic connection where the analytical capabilities of AI and the connectivity of IoT come together to reimagine the conventional educational environment. It goes beyond a simple comparison of technology. IoT, a network of connected devices, and AI, with its ability to analyze large datasets and extract insightful information, work together to create an educational synergy that can be tailored to each learner's unique requirements and preferences.

Synergies and Interactions between AI and IoT in Educational Settings

Traditional learning environments and educational technology are redefined by the revolutionary synergy created by the dynamic interaction of artificial intelligence (AI) and the Internet of Things (IoT) in educational settings. The capacity of AI to leverage the rich data fabric created by IoT-connected devices is at the heart of this synergy, resulting in a linked ecosystem that can intelligently respond to the needs of both students and instructors. These solutions use AI algorithms to give students real-time. The tutoring process is continuously improved by this feedback loop, which guarantees that interventions are properly matched to each student's needs. An essential component of ITS, virtual assistants communicate with students, providing flexible feedback and fostering an interactive learning environment outside of the confines of conventional classrooms.

IV. PERSONALIZED LEARNING EXPERIENCES

Adaptive Learning Systems

A paradigm change from traditional pedagogical models to a dynamic and customized approach, adaptive learning systems are a hallmark of innovation in the field of artificial intelligence of things (AIoT) in education. These systems' adaptable features provide a responsive and interesting learning environment that goes beyond the constraints of conventional one-size-fits-all methods. According to Tsai et al. (2021), senior high school students' learning results can be enhanced by an AIOT implementation course.

Intelligent Tutoring Systems:

A new age of individualized and adaptable learning experiences is ushered in by the merging of Intelligent Tutoring Systems (ITS), a significant development in education, with the Artificial Intelligence of Things (AIoT). The use of virtual assistants, AI-guided feedback and evaluation tools, and real-time monitoring to offer students proactive help are just a few of the many ways that AIoT is being used in intelligent tutoring systems. Following are the Intelligent Tutoring System

1. Role of AIoT in Tutoring and Mentorship
2. Virtual Assistants in Education
3. AI-guided Feedback and Assessment
4. Real-time Monitoring and Support for Students

Smart Educational Spaces

Using Internet of Things (IoT) integration to build dynamic and adaptable classrooms, smart educational spaces are a revolutionary approach to learning settings. The conceptual foundation of smart classrooms, the incorporation of interactive technologies provided by the Internet of Things, the function of networked devices and infrastructure, and the general improvement of collaboration and active learning in educational settings are all covered in this part.

Learning Analytics and Data-Driven Insights

The depth and effectiveness of data analysis in educational settings are improved by AIoT, which is emerging as a disruptive force in learning analytics. Real-time, detailed data can be gathered from a variety of sources, including smart devices, online platforms, and interactive tools, thanks to the combination of AI and IoT technology. This data is processed by AI algorithms, which reveal correlations, patterns, and trends that conventional approaches would miss at first glance. In order to maximize the teaching and learning process, AIoT-driven learning analytics enable teachers to design adaptive learning pathways, forecast student performance, and customize learning experiences.

Ethical Considerations in Data Collection

In educational contexts, ethical issues are crucial while gathering data. Ensuring privacy, security, and openness becomes crucial as educational institutions collect and examine enormous volumes of student data. Concerns like data anonymization, informed permission, and the appropriate use of AI algorithms must all be covered by ethical guidelines. Maintaining trust and ethical integrity within the educational community requires finding a balance between protecting individual privacy and utilizing AIoT's potential for educational insights.

Challenges in AIoT with Education

There are a number of obstacles and factors to take into account when navigating the AIoT environment in education. This part examines the crucial elements of privacy and security issues, the difficulties of integration and possible fixes, the needs for technical infrastructure, and the necessity of resolving moral conundrums related to AIoT in education.

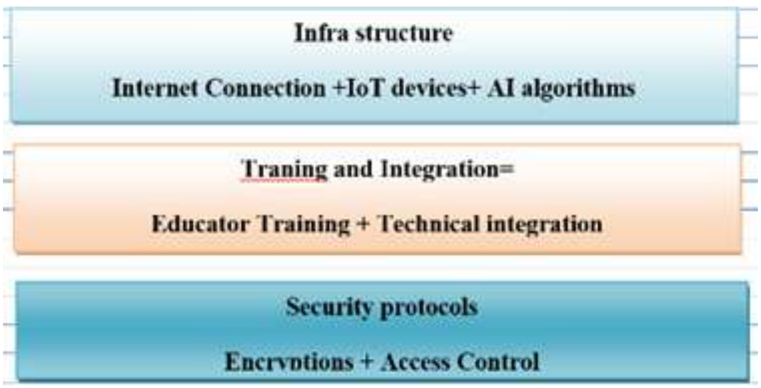

Fig.3- Challenges in AIoT with Education

V. SHOWCASE OF IMPLEMENTATIONS IN EDUCATIONAL INSTITUTIONS

Smart Campus Initiatives at a Leading University

In order to provide an intelligent and connected learning environment, a prominent institution started a Smart Campus program that included AIoT technology. IoT-enabled sensors continuously tracked the temperature, lighting, and occupancy of the classroom. This data was examined by AI systems to improve the surroundings for increased comfort and attentiveness among students. The technology also monitored student movements, which made resource allocation and security measures more effective. This initiative's success resulted in increased campus security, better energy efficiency, and a more individualized and flexible learning environment.

Demonstrated Improvements in Learning Outcomes

In a pioneering educational institution, the implementation of AIoT technologies resulted in significant and demonstrable improvements in learning outcomes. This case study focuses on how the strategic integration of Artificial Intelligence and the Internet of Things positively impacted the educational experience and academic achievements of students.

Real-time Feedback Mechanisms:

Students received instant, AI-generated feedback on their assignments and assessments, providing guidance on areas that needed improvement.

Educatorsaccessed comprehensive analytics dashboards to track individual and collective performance trends.

VI. RESULT:

Significant gains in learning outcomes were seen when AIoT technology were implemented:

Customized_Academic Development:

- The system found and filled in knowledge gaps, leading to a more thorough comprehension of subjects; students also had a more individualized learning experience, with adaptive material and evaluations that matched their individual learning preferences.

Enhanced Motivation and Engagement: Personalized challenges and real-time feedback created a sense of achievement and internal motivation, while the interactive features of AIoT-enabled learning environments enhanced student motivation and engagement.

Increased Retention Rates: As a result of students receiving individualized help and a more interesting educational experience, the institution saw an increase in retention rates.

VII. CONCLUSION

In conclusion, this study serves as an example of how learning outcomes may be shown to improve with the strategic integration of AIoT technologies. The educational institution established an atmosphere where students flourished intellectually and teachers were empowered to provide effective instruction by customizing learning paths, adopting adaptive tests, and putting in place real-time feedback mechanisms. The initiative's success highlights how AIoT has the ability to revolutionize education in the future.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Sol-Gel Synthesis and Investigation of Cation Distribution, Structural, and Vibrational Properties of $Ni_{0.3}Zn_{0.3}Co_{0.4}Fe2O_4$ Ferrites

Tanay S. Gore[1], Dilip L. Navgare[2], Vaishali S. Dhoble[3], Ramdas B.Kavade[4], Vivekanand B. Kawade*[1]

[1]Late. Laximibai Deshmukh Mahila Mahavidyalaya, ParliVaijanath, Dist. Beed, 431515, Maharashtra, India

[2]Shikshan Maharshi Dyandeo Mohekar Mahavidyalaya, Kalamb, Dist. Dharashiv, Maharashtra, India

[3]D.K.A.S.C. College, Ichalkaranji, Kolhapur, Maharashtra, India

[4]Bhagawan Mahavidyalaya, Ashti, Dist. Beed, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
54-62

ABSTRACT

The present study investigates the sol-gel synthesis of mixed transition metal oxide nanoparticles with the composition $Ni_{0.3}Zn_{0.3}Co_{0.4}Fe2O_4$ (NZC ferrites). This work aims to examine the influence of cobalt, and nickel in zinc ferrite on their crystallographic and vibrational properties. The sol-gel method, known for its precision in controlling stoichiometry and particle size, was employed to synthesize these advanced ferrite materials. The synthesized nanoparticles were systematically characterized using X-ray diffraction (XRD) to evaluate their crystal structure, lattice parameters, and phase purity. Fourier- transform infrared spectroscopy (FTIR) was utilized to identify the vibrational modes and confirm the presence of metal-oxygen bonding. Additionally, the cation distribution within the spinel structure was analyzed and deduced from XRD data, providing insights into the site occupancy of various cations. The findings highlight the significant role of cobalt, and nickel, in modulating the structural and vibrational characteristics of zinc ferrite. This study provides a deeper understanding of how cationic composition influences material properties, paving the way for tailored design of ferrite-based materials for advanced technological applications such as gas sensing, magnetic storage, and catalysis.

Keywords: Sol-gel synthesis, cation distributions, cubic spinel structure, Bohr magneton

I. INTRODUCTION

Over the past few decades, magnetic nanoparticles have garnered significant attention due to their exceptional properties compared to their bulk counterparts [1, 2]. These nanoparticles exhibit a high surface-to-volume ratio, large surface area, and strong adsorption capabilities. They find applications in diverse fields, including memory devices, microwave devices, biomedical materials, and electronic devices [3-6]. Ferrites with the general formula MFe2O4 (where Co, Fe, Cu, Ni, Zn etc.) are among the most important materials for magnetic and electrical applications. These ferrites exhibit a cubic spinel structure, where oxygen ions form a close-packed arrangement and metal ions occupy tetrahedral and octahedral interstitial sites. In normal spinel structures, divalent cations occupy the tetrahedral sites, whereas trivalent cations replace them in inverse spinel structures [7]. For instance, ZnFe2O4 adopts a normal spinel structure with Zn2+ ions in tetrahedral sites and Fe3+ ions in octahedral sites [8]. On the other hand, CoFe2O4 exhibits an inverse spinel structure, where Co2+ ions occupy octahedral sites, and Fe3+ ions are distributed between both tetrahedral and octahedral sites [9]. The cation distribution within these structures strongly influences their magnetic properties, allowing modulation of magnetic behavior through chemical composition adjustments. The growing technological, scientific, and industrial challenges necessitate the development of simple, eco-friendly, and economical synthesis methods for ferrite nanoparticles. Techniques such as chemical co-precipitation, hydrothermal reaction, microwave-assisted synthesis, microemulsion, chemical spray, and sol-gel methods have been widely used for synthesizing nanocrystalline ferrites [10-15]. Among these, the sol-gel auto-combustion method is particularly advantageous, offering bulk production, cost-effective chemicals, and homogeneous precursor materials [16]. The physical properties of ferrites can be tailored based on their size and shape. Cobalt-based nano-ferrites have attracted significant interest due to their high magnetocrystalline anisotropy, moderate saturation magnetization, large coercivity, and flexible magnetic properties [17]. The properties of ferrites can be further tailored by substituting different metal ions within the lattice. Substitutions, such as replacing Zn2+ ions with varying concentrations of Co2+, yield nanoparticles with distinct magnetic properties suitable for specific applications. Additionally, doping with trivalent ions like Al3+, Bi3+, La3+ has been shown to significantly influence coercivity and saturation magnetization of the ferrites [18-23]. The present study focuses on synthesizing mixed transition metal oxide nanoparticles of $Ni_{0.3}Zn_{0.3}Co_{0.4}Fe2O_4$ (NZC ferrites) using the sol-gel auto-combustion method. The objective is to investigate the effects of cobalt, nickel, and aluminum on the crystallographic, magnetic, and dielectric properties of these ferrites. The structural and functional properties of the synthesized materials are analyzed using techniques such as X- ray diffraction (XRD), and Fourier-transform infrared spectroscopy (FTIR).

II. SYNTHESIS OF NICKEL ZINC COBALT FERRITE ALUMINATE

The cobalt-substituted nickel zinc ferrite aluminate nanoparticles, represented by the chemical formula ($Ni_{0.3}Zn_{0.3}Co_{0.4}Fe2O_4$) (NZC ferrite), were synthesized using the sol-gel auto-combustion method. The starting materials used in this process included nickel nitrate ($Ni(NO_3)_2{\cdot}5H_2O$), cobalt nitrate ($Co(NO_3)_2{\cdot}6H_2O$), zinc nitrate ($Zn(NO_3)_2{\cdot}6H_2O$), ferric nitrate ($Fe(NO_3)_3{\cdot}9H_2O$), and citric acid ($C_6H_8O_7{\cdot}H_2O$), all with a purity of 99.9% from sd- fine chemicals. These reagents were utilized without further purification and were measured based on stoichiometric ratios, maintaining a metal nitrate-to-citrate ratio of 1:3 throughout the synthesis. All the metal nitrate salts were dissolved in 100 mL of deionized water to create a clear solution, which was then combined. Citric acid was added to the mixture, acting as a chelating agent. The solution's pH, initially around

3, was adjusted to 7 by adding ammonia solution [24]. The reaction was carried out in a neutral medium. The mixture was heated on a hot plate at 100°C with constant stirring. During evaporation, the solution gradually became viscous, forming a gel. Once all water molecules were removed, the gel spontaneously ignited, burning with bright sparks. The combustion reaction concluded as the entire citrate complex was decomposed. This auto-ignition process, which lasted less than a minute, produced black ashes known as the precursor material. The precursor powders were subsequently calcined at 600°C for 4 hours to obtain the final product. These heat-treated powders were then subjected to further characterization.

III.EXPERIMENTAL DETAILS

The powder X-ray diffraction (XRD) patterns of all the samples were recorded using a Philips (Japan) X-ray diffractometer (Model 3710) with Cu-Kα radiation (λ = 1.5418 Å). The XRD analysis was conducted over a 2θ range of 20° to 70° at a scanning rate of 10° per minute. The morphological features of the powder were examined using a transmission electron microscope (Philips CM 200). Fourier-transform infrared (FTIR) spectroscopy was employed to record transmittance spectra in the frequency range of 400–4000 cm^{-1} at room temperature.

IV.RESULT AND DISCUSSIONS

Structural Analysis

The XRD spectra of $Ni_{0.3}Zn_{0}.03Co0.4Fe2O_{4}$ (NZC) ferrite samples with varying Co concentrations are depicted in Fig. 1. The data align well with the powder diffraction standards of JCPDS card number 08-0234, confirming the formation of zinc ferrite in the synthesized samples [25]. associated with the space group Fd3M [26]. The diffraction pattern analysis confirms the samples' cubic spinel structure. The broadening of the XRD peaks indicates the formation of nanoparticles with average particle sizes of 16 nm, as determined from the data presented in Table 1. The diffraction peaks were indexed to the planes (220), (311), (400), (422), (511), and (440), characteristic of zinc ferrite. The interplanar spacing (d) values were calculated using Bragg's law, and the lattice parameters were derived from Bragg's equation.

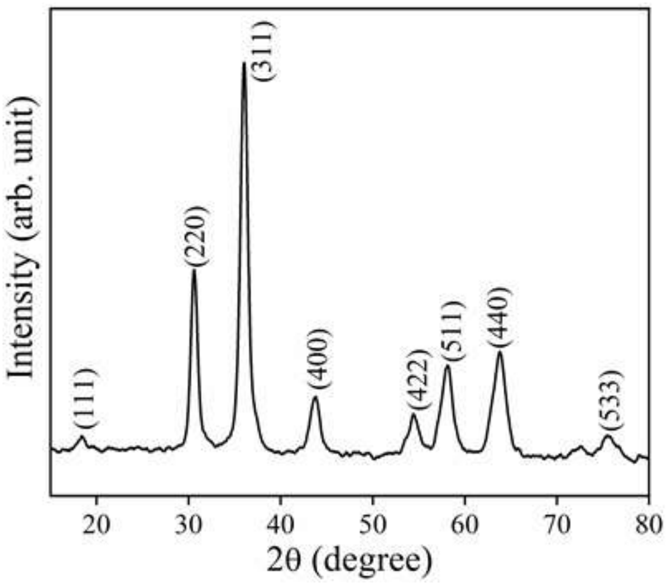

Fig.1 XRD spectra of Ni0.3Zn0.3Co0.4Fe2O4 ferrite powder sample.

The calculated lattice parameters closely matched the reported values for zinc ferrite. The crystallite size was estimated from the line broadening of the (311) peak using the Scherrer formula [27, 28]. Additional parameters, such as lattice constants, X-ray density, and bulk density, were also calculated and are presented in Table 1.

Table 1: Lattice constant (a), X-ray density (dx), bulk density (dB), porosity (P) and crystallite size (D), Oxygen parameter (u) observed, theoretical and Theoretical lattice constant (ath) of NZC samples.

‘a’ (Å)	‘d_x’(gm/cm^3)	‘d_b’ (gm/cm^3)	‘P’ (%)	‘D’ (nm)	u_{obs}	a_{th}	u_{th}
8.249	4.931	2.405	51.226	21	0.377	8.361	8.376

Density plays a significant role in determining the structural properties of ferrites. The bulk density and X-ray density values for the prepared sample is summarized in Table 1. X-ray density, also referred to as true density, was calculated using data from X-ray diffraction. It was observed that the X-ray density values were consistently higher than the bulk density values. This discrepancy is likely due to the presence of pores and voids formed during sample preparation or the sintering process [29].

The lattice parameter of NZC ferrites can also be determined using the cation radii at tetrahedral and octahedral sites. The oxygen parameter values are provided in Table 1, and in this study, the oxygen parameter values are close to the ideal values. The calculated (Ucal) and observed (Uobs) oxygen parameters, derived from cation distribution and X-ray diffraction data, show good agreement.

Table 2: Tetrahedral bond length (dAX), octahedral bond length (dBX), tetrahedral edge (dAXE), octahedral edge (dBXE), hopping length (LA, LB).

Co^{2+}	d_{AX}	d_{BX}	d_{AXE}	d_{BXE}		L_A	L_B
				shared	unshared		
0.4	1.872	2.016	3.056	2.776	2.924	3.572	2.916

These parameters confirm the bond lengths, including the A-O bond length (dAX), tetrahedral edge length (dAXE), B-O bond length (dBX), shared octahedral edge length (dBXE), and unshared octahedral edge length (dBXEU). Additionally, the magnetic hopping lengths at the tetrahedral site (LA) and octahedral site (LB) are presented in Table. 2. Changes in structural parameters, as determined from the data.

Cation distributions

The peak intensities of the (220), (422), and (400) planes are influenced by the cation distribution at the tetrahedral (A) and octahedral (B) sites, which significantly impacts the magnetic properties of ferrites. The cation distribution in $Ni0.3Zn0.3Co0.4Fe2O_4$ ferrites was determined through X-ray diffraction analysis. The X-ray intensity for different planes was calculated using a formula reported in the literature [30, 31]. Specifically, the (220), (400), (440), (422), and (511) planes were used to derive the X-ray intensity ratio. Various possible cation combinations were considered, accounting for their site preference energy, and the intensity ratios were calculated accordingly. These calculated ratios were then compared with the observed intensity ratios. Additionally, the calculated magneton numbers based on cation distribution were compared with the observed magneton numbers for different cation configurations at the tetrahedral (A) and octahedral (B) sites. The results of these calculations are presented in Table 3. For a specific cation combination, the observed and calculated intensity ratios, along with the observed and calculated magneton numbers, exhibited close agreement. The Bohr magneton number obtained from the cation distribution is presented in table 3. The results indicate that NZC ferrites exhibit a mixed spinel structure. In this structure, Zn^{2+}, Fe^{3+}, and Ni^{2+} ions predominantly occupy the tetrahedral (A) sites, while Fe^{3+}, Zn^{2+}, Ni^{2+}, and Co^{2+} ions are present at the octahedral (B) sites [32, 33].

The Ni2+ ions occupy both tetrahedral and octahedral sites. nB values 0.82 because the non-magnetic Zn2+ ions preferred octahedral B-site and Co2+ ions preferred octahedral sites which increase magnetic moment μB on B-site. Similarly magnetic moment of tetrahedral A- site is decreases due to Ni2+ ions.

Table 3: Cation distribution, Bohr Magneton (nB) and intensity ratios of the NZC ferrite.

Sites	A-site				B-site			
Cation distribution	$Zn_{0.4}Fe_{0.5}Ni_{0.1}$				$Ni_{0.2}Fe_{1.5}Co_{0.3}$			
Bohr Magneton (n_B)	n_B Obs				n_B Cal			
	0.82				0.8			
Intensity ratio	I(422/400)		I(400/440)		I(422/220)		I(220/400)	
	Obs.	Cal.	Obs.	Cal.	Obs.	Cal.	Obs.	Cal.
	1.97	0.96	1.44	0.94	0.24	0.85	5.6	120

Spectroscopic analysis of nanoparticles

Fourier Transform Infrared spectroscopy is an experimental technique for qualitative and quantitative analysis of compounds, providing specific information on molecular structure, chemical bonding and chemical environment. The FT-IR spectra of NZC ferrite nanoparticles were scanned in range of 4000-400 cm-1 [Fig. 2]. In ferrites spinel structure shows two IR spectra bands one at around 600 cm-1 which corresponds to the stretching vibration of oxygen and metal ions at the tetrahedral site Mtetra -O and the other was at around 400 cm-1 which corresponds to the stretching vibration of oxygen and metal ions at octahedral site Moct -O [34]. The frequency absorption band (1) was observed at 635 cm-1, assigned to tetrahedral Fe3+O2- stretching and the frequency absorption band (2) observed at 416 cm-1 was due to octahedral Zn2+O2- stretching indicating the formation of spinel ferrite structure. The absorption band observed at around 1017 cm-1 was attributed to the stretching vibration of nitrogen from unconsumed reagents from the O-N bond [35]. The intensive band observed at 2361cm-1 may be due to the presence of CO2 in air (C=O) [36] and 3439 cm-1 due to stretching vibration of O-H because during the preparation of KBr pellet moisture get absorbance in the sample [37]. The values of bond length (RA, RB) and ionic radii (rA, rB) of the tetrahedral and octahedral sites were calculated using the XRD data formula given by Gorter [38]. The force constant for the tetrahedral site (Kt) and octahedral site (Ko) was calculated employing the method suggested by Waldron (39) have been calculated from IR spectra are given by the molecular weight of the tetrahedral site M1 and octahedral site M2 were calculated from the cation distribution data. The values of bond length (RA and RB), ionic radii (rA and rB) and force constant (Kt and Ko) are listed in table 4.

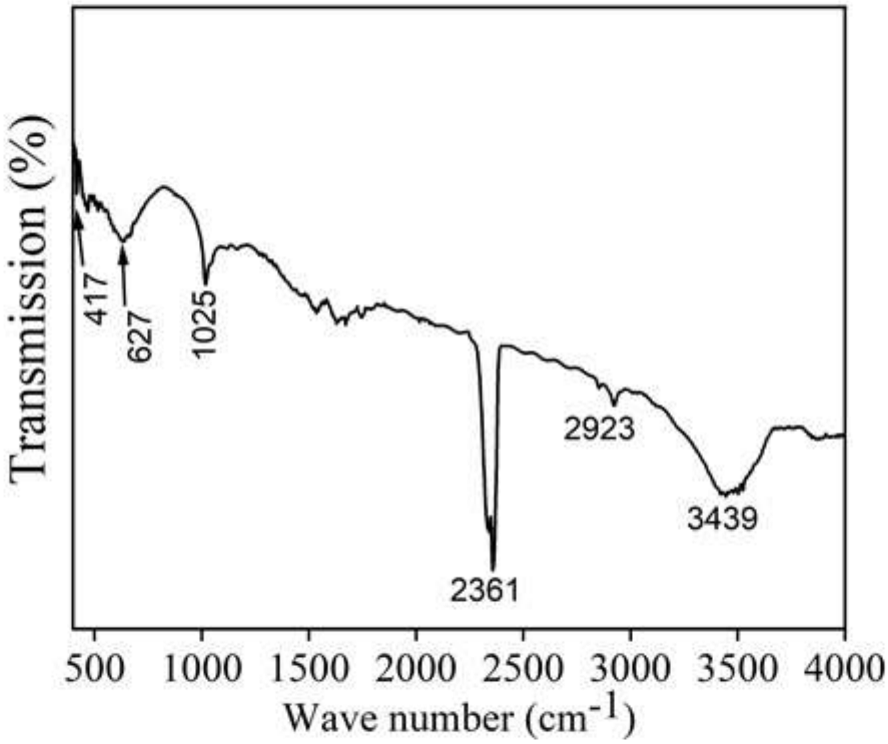

Fig. 2 FTIR spectra of NZC ferrite.

Table 4: vibrational frequency of NZC ferrites

Co^{2+}	ν_1	ν_2	ν_3	ν_3	ν_4	ν_5
0.4	416	635	1017	2361	2923	3439

Table 5: Bond length of tetrahedral (RA), octahedral (RB), radii at tetrahedral (rA), octahedral (rB) site, ionic radii (rA, rB), vibrational frequency (□1, □2) and Force constant of tetrahedral (Kt), octahedral (Ko) site.

Co^{2+}	R_A	R_B	ν_1	ν_2	r_A	r_B	K_t x10^5 dyne/cm	K_o x10^5 dyne/cm
0.3	1.874	2.008	416	635	0.742	0.633	0.794	1.80

V. CONCLUSIONS

This study successfully synthesized mixed transition metal oxide nanoparticles of $Ni_{0.3}Zn_{0.3}Co_{0.4}Fe2O_4$ (NZC ferrites) using the sol-gel auto-combustion method. The structural, magnetic, and spectroscopic properties of the synthesized ferrites were comprehensively analyzed. X-ray diffraction (XRD) confirmed the formation of a cubic spinel structure. The crystallite size was determined to be approximately 16 nm, with lattice parameters and oxygen positional parameters closely aligning with theoretical values. The cation distribution analysis indicated a mixed spinel structure, with Zn^{2+}, Fe^{3+}, and Ni^{2+} predominantly occupying the tetrahedral sites, while Fe^{3+}, Zn^{2+}, Ni^{2+}, and Co^{2+} ions were located at the octahedral sites. Observed and calculated intensity ratios and Bohr magneton numbers (nB) demonstrated close agreement, affirming the reliability of the cation distribution model. Fourier-transform infrared (FTIR) spectroscopy confirmed the spinel ferrite structure, with characteristic absorption bands at ˜635 cm^{-1} and ˜416 cm^{-1} corresponding to metal-oxygen vibrations at tetrahedral and octahedral sites, respectively.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Evaluation of Designed Convolution Neural Network in Image Classification

Dr. Rajesh S. Sarkate
Department of Computer Science, JES College, Jalna, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
63-67

ABSTRACT

Deep learning is widely used in image classification in various fields like real time scene, medical, agriculture etc. CNN with its flexibility to operate on various types of datasets are very popular among researchers. The current study describes classification of sports images using convolution neural network. In this experiment, a CNN model with five convolution layers, pooling layer and a fully connected dense layers was designed using Tensor flow keras library. A special image set of 400 images from four different classes, collected randomly from internet, was deigned. The designed CNN has shown good accuracy of 94.29% in recognising the class of given image.

I. INTRODUCTION

Image classification is traditional process but having its own importance in research. Various tools like k-means, SVM, ANN with their pros and cons are used for such purposes. Researchers are trying different tools for better results in terms of classification and low processing and memory overheads. Deep learning with Convolutional neural networks have gained wide popularity in these works. CNN is basically deep artificial neural networks that have successfully proven its applications in computer vision tasks like classify images, object recognition within scene etc. CNN with its pre-trained models like mobilenet, Yolo, VGG has made convenient to perform the said tasks.[1] These models are trained and tested for variety of image dataset like ImageNet, MNIST that contains thousands of images.

One can use these models directly or with modifications in it. Apart from these, one can design entirely new CNN model with various combinations of convolution, pool and neural network layers for processing the given image dataset.

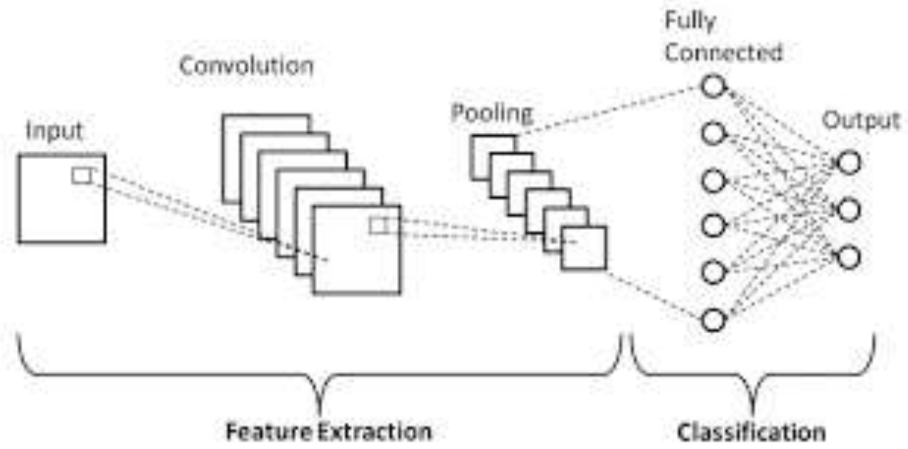


Figure. 1- Typical CNN architecture

As shown in figure 1, typical CNN architecture contains input layer for providing images to classify, convolution layer kinds of filters that are responsible for extracting the features from input images, pooling layer with max pooling or average pooling techniques are used that reduces the input size for network and finally a fully connected neural network layer that accept the reduced feature set and generate desired output after training. While training the model, different trail error combinations are used and tested till CNN produces desired output. Each trained model is evaluated for accuracy of classification and best one was selected. Though, CNN model produces good results but there is always scope for improvement for better accuracy.

Use of CNN for image classification has been increased in last few years due to its ability to extract features and sort the input images in various categories. Researcher had used to CNN in images of insect identification and classification with efficiency around 98.6%[2]. Another study [3]evaluated CNN use for classification of CIFAR-10 dataset and found the 93.47% accuracy in image classification. Multiple works has been carried out for images classification using various architectures of CNN [4][5], Use of CNN was carried out to classify COVID-19 chest X-ray images [6]. A study conducted to determine the effectiveness of image augmentations techniques in image classification process.[7]

II. METHODS AND MATERIAL

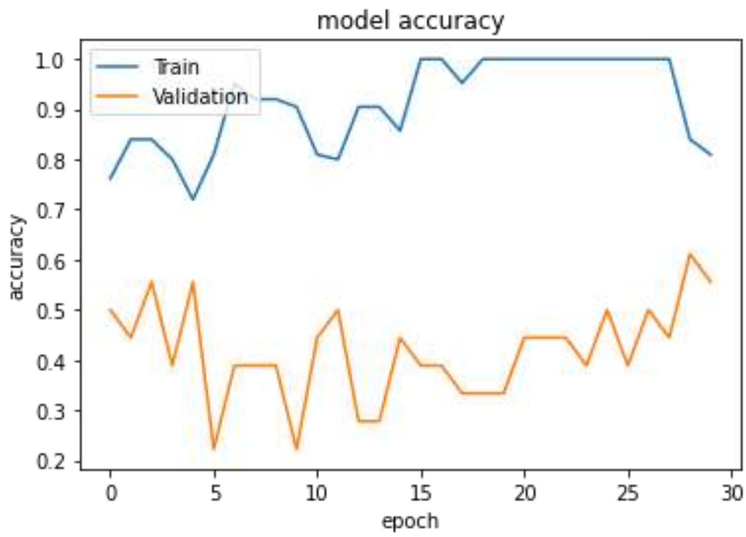
An image set of 400 images belonging to 4 classes {Cricket, Football, Swimming, Tennis} were randomly downloaded from internet. For the classification purpose, these images were pre-processed and reduced to the two sets of size of 200 x 200 and 224 x 224 pixels respectively. The dimension reduction was carried out to minimize the memory and processing overload. Image augmentation with shearing and zooming scale of 0.2 was performed before training and testing sets. Set of 360 images and 40 images were used to CNN model for training and validation purpose.

Figure 2. : Sample Image Dataset

Network Design and Training

Instead of using pre-trained CNN models, entirely new model was designed as the dataset was having randomly selected internet images with different angles and zooms. The designed model starting with input layer was used to pass the pre-processed images to five convolution and pooling layers that serves for the purpose of feature extractions and dimension reduction.

The CNN model was structured 3x3 convolution layers with number filters from 16, 32, 64, 128 and 512 and 2x2 Max pooling layers. For compilation purpose, optimizer adam and model loss was set to "sparse_categorical_crossentropy" as it was multiclass classification process and target labels were denoted by integers indicating class indices. The output of convolution layer was flattened to input it to dense layer. Finally, a fully connected network was used to classify input images into one of the targeted four classes.



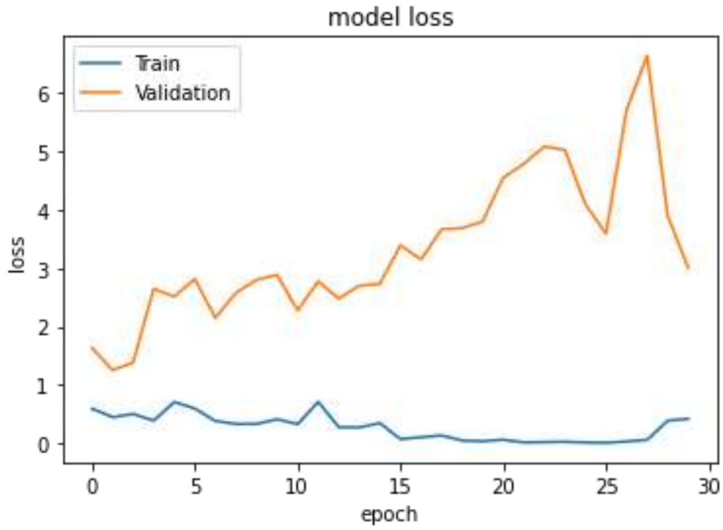


Figure 3:- Sample training accuracy and loss

Model was trained with various combinations of batch size and epochs. The designed model with batch size 3, 5, 10 and number of epochs 15, 20, 30, 40 respectively were experimented. Finally, model of 30 epochs with batch size of 5 was settled that gives accuracy of 94.29% and loss of 0.47. The whole model was designed and trained in python Jupyter notebook using tensorflow-keras library. Other libraries like numpy and matplotlib were also used for image pre-processing operations and display purposes.

III.RESULTS AND DISCUSSION

Total 100 images from each of the four categories forming 400 images were used in the experiment. Initially, the model was trained and tested for two sets of 200 x 200 and 224 x 224 image resolutions. Results found that images set of 200 x 200 resolution produced good accuracy. The designed model was trained and tested with various combinations of epochs and batch size. Results were fluctuating. Best results with average accuracy of 92% were achieved using batch size = 10 and epoch 30. Result accuracy was found varying among the categories. The best result of classification was observed in the swimming and tennis images, whereas classification of cricket class was found low. Features similarities in cricket and tennis classes may have affected the result of cricket class images.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Load Capacity and Time-Height Relations for Squeeze Films Between Porous Plates with Couple-Stress Fluids

S. Santosh[1], N.B.Naduvinamani[2]
[1]Department of Mathematics, Government First Grade College, Shahapur, Maharashtra, India
[2]Department of Mathematics, Gulbarga University, Gulbarga-585106, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
68-80

ABSTRACT

In this paper, a theoretical analysis of hydrodynamic couplestress squeeze film lubrication with various plane geometries viz; circular, annular, elliptic and rectangular are studied. The Stoke's couplestress fluid model is used to characterize the rheological behaviour of the lubricant with polymer additives. The modified Reynolds equation for the squeeze film lubrication is derived on the basis of Stokes micro-continuum theory for couple stress fluids. Squeeze film characteristics for various geometries under consideration are derived. The effect of couple stresses, shape of plate and porosity on the squeeze film characteristics are analyzed and are illustrated graphically. It is observed that, for all the lubricant film shapes under consideration, the effect of couple stress fluid is to increase the load-carrying capacity and to lengthen the squeeze film time as compared to the corresponding Newtonian case.

Keywords: Porous bearings, Squeeze films, Couple-stress fluids.

I. INTRODUCTION

Squeeze film phenomena play an important role in many areas of engineering and thus have received considerable interest. Studies of squeeze film behaviors are of practical significance in lubrication of machine tools, automotive engines, aircraft engines, turbo-machinery and skeletal joints. Traditionally, analysis of squeeze film performance assume that the lubricant behaves essentially as a Newtonian viscous fluid. However, to stabilize the flow properties and to increase the lubricating qualities, the use of various additives has been emphasized. Experimental results show that the addition of small amounts of additives to a Newtonian fluid provides beneficial effects on the frictional characteristic and the wear due to friction [1]. Since the classical theory cannot accurately describe the rheological behaviour of a Newtonian lubricant blended with various additives, a number of microcontinuum theories have been proposed [2,3]. Among them, the microcontinuum theory proposed by Stokes [4] is the simplest theory of fluids which allows for polar effects such as the presence of couple stresses and body couples. Essentially, this theory describes the peculiar behaviour of fluids containing substructure and is intended to account for particle size effects. Couple stress effects are considered as a results of the action of one part of a deforming body on its neighborhood. Since the additives are generally long chain organic compounds, couple stresses may appear particularly in problems where thin films exit. Many researchers have applied this couple stress fluid model to study various hydrodynamic lubrication problems [5-9]. These investigations have resulted in predictions such as larger load-carrying capacity, lower co-efficient of friction and delayed time of approach in comparison with the Newtonian case. The purpose of this paper is to predict the rheological effects of couple stress fluids on the various types of plane geometries. To take into account the couple stress effects due to the lubricants containing long chained additives or suspended particles, the most general modified Reynolds equation is derived by using the Stokes [4] constitutive equations.

The solutions for film pressure distribution, load carrying capacity and squeeze film time of various bearing configurations have been obtained. The plane geometries considered are those relevant to circular, annular, elliptic and rectangular boundaries. Comparison is made between the squeeze film behaviors of various geometries of equivalent surface area. It is found that, the circular plates have the highest transient load capacity compared to all other geometries.

II. BASIC EQUATIONS

The momentum and continuity equations of an incompressible couplestress fluid derived by Stokes [4] in the absence of body forces and body couple are

$$\rho \frac{D\vec{V}}{Dt} = -\nabla p + \mu \nabla^2 \vec{V} - \eta \nabla^4 \vec{V}, \tag{1}$$

$$\nabla \bullet \vec{V} = 0 \tag{2}$$

where $\vec{V}$ is the velocity vector, ρ is the density, p is the pressure, μ is the material constant with dimension of viscosity and η, the material constant with dimension of momentum. The ratio (η / μ) has the dimension of length square and hence, characterizes the the size of microstructure additives present in the lubricant.

III.MATHEMATICAL FORMULATION OF THE PROBLEM

The physical configuration of geometry and co-ordinates of the flow domain considered in the present paper are as shown in the fig.1. The squeezing flow of couplestress fluid between two rectangular and circular plates is considered. The upper rectangular / circular plate is approaching a lower porous plate with a given velocity $\left({\partial h}/{\partial t}\right)$. It is assumed that the porous matrix and the bearing gap are filled with a fluid containing microstructure additives (i.e. a couplestress fluids).

The lubricant in the film region is considered to be an incompressible Stokes [4] couplestress fluid. It is also assumed that the body forces and the body couple are absent. Under the usual assumptions of hydrodynamic lubrication applicable to thin films, the equations of motion are derived by Stokes take the form,

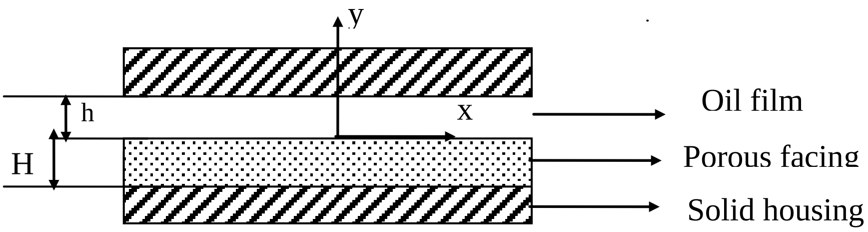
$$\mu \frac{\partial^2 u}{\partial y^2} - \eta \frac{\partial^4 u}{\partial y^4} = \frac{\partial p}{\partial x} \tag{3}$$

$$\mu \frac{\partial^2 w}{\partial y^2} - \eta \frac{\partial^4 w}{\partial y^4} = \frac{\partial p}{\partial z} \tag{4}$$

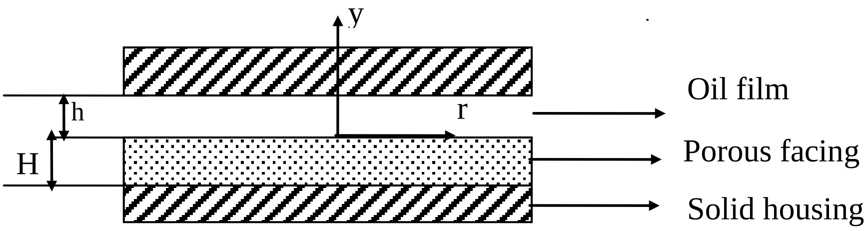
$$\frac{\partial p}{\partial y} = 0 \qquad (5)$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \qquad (6)$$

where *u, v* and *w* are the velocity components of the lubricants in the *x, y,* and *z* direction respectively.



Rectangular



Circular

Fig.1. physical configuration of the problem

The relevant boundary conditions for the velocity components are

$$u = 0, v = v^{*}, w = 0 \quad at \quad y = 0 \qquad (7a)$$

$$\frac{\partial^2 u}{\partial y^2} = 0 \quad at \quad y = 0, h, \text{ (Vanishing of couple stresses)} \qquad (7b)$$

$$\frac{\partial^2 w}{\partial y^2} = 0 \quad at \quad y = 0, h, \text{ (Vanishing of couple stresses)} \qquad (7c)$$

$$u = 0, v = \frac{\partial h}{\partial t}, w = 0 \quad at \quad y = h \qquad (7d)$$

IV. SOLUTION OF THE PROBLEM

The solution of equation (3) and (4) subject to the boundary condition (7a)-(7d) are obtained in the form

$$u = \frac{1}{2\mu}\frac{\partial p}{\partial x}\left[y^2 - yh + 2l^2\left\{1 - \frac{Cosh[(2y-h)/2l]}{Cosh(h/2l)}\right\}\right] \qquad (8)$$

$$w = \frac{1}{2\mu}\frac{\partial p}{\partial z}\left[y^2 - yh + 2l^2 \left\{ 1 - \frac{Cosh[(2y-h)/2l]}{Cosh(h/2l)} \right\} \right] \tag{9}$$

where $l = \sqrt{\frac{\eta}{\mu}}$ is the couplestress parameter.

The modified Reynolds type equation for the pressure in the film region is obtained by using equation (8) and (9) for u and w respectively in the continuity equation (6) and then integrating over the film thickness and also using the boundary conditions for v given in Eqn (7a), and Eqn, (7d) as

$$\frac{\partial}{\partial x}\left[(f(h,l))\frac{\partial p}{\partial x} \right] + \frac{\partial}{\partial z}\left[(f(h,l))\frac{\partial p}{\partial z} \right] = 12\mu \frac{\partial h}{\partial t} + 12\mu [v^*]_{y=0} \tag{10}$$

where $f(h,l) = h^3 - 12l^2 h + 24l^3 \tanh\left(\frac{h}{2l}\right)$

The flow of a couplestress fluid in the porous region is governed by modified form of Darcy's law which accounts for the polar effects in porous region given by

$$\vec{q}^{\,*} = \frac{-k}{\mu(1-\beta)}\nabla p^* \tag{11}$$

where $\vec{q}^{\,*} = (u^*, v^*, w^*)$, k is the permeability of porous matrix and β (=(η/μ)/k) represents the ratio of microstructure size to the pore size. If $\left(\eta/\mu\right)^{1/2} \approx \sqrt{k}$. i.e. $\beta \approx 1$, then the microstructure additives present in the lubricant block the pores in the porous layer and thus reduce the Darcy flow through the porous matrix. When the microstructure size is very small compared to the pore size, i.e. β <<1, the additives percolate in to the porous matrix. In the limit as $\beta \to 0^+$, the bearing conditions tend to the case of the Newtonian flow in the porous matrix. The pressure p^* in the porous region, due to continuity, satisfies the Laplace equation

$$\frac{\partial^2 p^*}{\partial x^2} + \frac{\partial^2 p^*}{\partial y^2} + \frac{\partial^2 p^*}{\partial z^2} = 0 \tag{12}$$

Integrating with respect to y over the porous layer thickness, δ and using the boundary condition of solid baking $\left(\frac{\partial p^*}{\partial y} = 0\right)$ at $y = -\delta$ we obtain

$$\left(\frac{\partial p^*}{\partial y}\right)_{y=0} = -\int_{-\delta}^{0}\left(\frac{\partial^2 p^*}{\partial x^2} + \frac{\partial^2 p^*}{\partial z^2}\right)dy \tag{13}$$

Assuming the porous layer thickness, δ to be very small and using the condition of continuity of pressure $(p = p^*)$ at the porous interface $(y = 0)$, equation (13) reduce to

$$\left(\frac{\partial p^*}{\partial y}\right)_{y=0} = -\delta\left(\frac{\partial^2 p}{\partial x^2} + \frac{\partial^2 p}{\partial z^2}\right) \tag{14}$$

Then the velocity component v^* at the interface $(y = 0)$ is given by

$$(v^*)_{y=0} = -\frac{k\delta}{\mu(1-\beta)}\left(\frac{\partial^2 p}{\partial x^2} + \frac{\partial^2 p}{\partial z^2}\right) \tag{15}$$

Substituting equation (15) in equation (12), the modified Reynolds equation is obtained in the form

$$\frac{\partial}{\partial x}\left[\left(f(h,l)+\frac{12k\delta}{(1-\beta)}\right)\frac{\partial p}{\partial x}\right]+\frac{\partial}{\partial z}\left[\left(f(h,l)+\frac{12k\delta}{(1-\beta)}\right)\frac{\partial p}{\partial z}\right]=12\mu\frac{\partial h}{\partial t} \quad (16)$$

Where $f(h,l)=h^3-12l^2h+24l^3\tanh\left(\frac{h}{2l}\right)$,

Introducing the following non-dimensional scheme into equation (16)

$$\bar{l}=\frac{2l}{h_0},\quad \bar{h}=\frac{h_1}{h_0},\quad \psi=\frac{k\delta}{h_0^3},\quad \bar{x}=\frac{x}{h_0},\quad \bar{z}=\frac{z}{b},\qquad \bar{p}=\frac{h_0^3\,p}{\mu\left(\frac{dh}{dt}\right)A}.\quad \lambda^2=\frac{b^4}{A^2}$$

The non-dimensional form of equation (16) is

$$\frac{\partial^2\bar{p}}{\partial\bar{x}^2}+\frac{1}{\lambda^2}\frac{\partial^2\bar{p}}{\partial\bar{z}^2}=\frac{\left(d\bar{h}/dT\right)}{g\left(\bar{h},\bar{l},\psi\right)} \quad (17)$$

where $.\ g\left(\bar{h},\bar{l},\psi\right)=f\left(\bar{h},\bar{l}\right)+12\psi/(1-\beta)$

$$f\left(\bar{h},\bar{l}\right)=\bar{h}^3-12\bar{l}^2\bar{h}+24\bar{l}^3\tanh\left(\frac{\bar{h}}{2\bar{l}}\right)$$

Hence the problem reduces to the solution of eqn (17) with appropriate boundary conditions.

4.1. Annular Discs

If the plates are annular, the problem becomes axi-symmetric and the solution of equation (17) with ambient boundary conditions is obtained in the form

$$\bar{p}=-\frac{3}{\pi g\left(\bar{h},\bar{l},\psi\right)}\left[\frac{\log\left(r/b\right)}{\log\left(a/b\right)}-\frac{\left(r/b\right)^2-1}{\left(a/b\right)^2-1}\right] \quad (18)$$

with r being the radial co-ordinate and a, b are the dimensions of the annular plates.

The non-dimensional load carrying capacity is obtained in the form

$$\bar{W}=-\frac{3}{2\pi g\left(\bar{h},\bar{l},\psi\right)}\left[\frac{\left(a/b\right)^2+1}{\left(a/b\right)^2-1}-\frac{1}{\log\left(a/b\right)}\right] \quad (19)$$

The time-height relation is obtained by integrating equation (19)

$$T=-\frac{3}{2\pi}\left[\frac{\left(a/b\right)^2+1}{\left(a/b\right)^2-1}-\frac{1}{\log\left(a/b\right)}\right]\int_1^{\bar{h}_1}\frac{1}{g\left(\bar{h},\bar{l},\psi\right)}d\bar{h} \quad (20)$$

Where $\bar{h}_1=h_1/h_0$

4.2. Circular Plates

For circular plates the differential equation (17) reduces to

$$\frac{1}{\bar{r}}\frac{d}{d\bar{r}}\left(\bar{r}\frac{d\bar{p}}{dr}\right) = \frac{d\bar{h}/dT}{g\left(\bar{h},\bar{l},\psi\right)} \tag{21}$$

The relevant boundary conditions are

$$\bar{p}(1) = 0 \text{ and } \left.\frac{\partial\bar{p}}{\partial\bar{r}}\right|_{\bar{r}=0} = 0 \tag{22}$$

The expression for non-dimensional pressure distribution is obtained by solving (21) with boundary conditions (22)

$$\bar{p} = -\frac{h_0^3 p}{\mu\left(\frac{d\bar{h}}{dt}\right)\pi a^2}$$

$$= \frac{3\left(1-\left(r/a\right)^2\right)}{\pi g\left(\bar{h},\bar{l},\psi\right)} \tag{23}$$

The non-dimensional load carrying capacity is obtained in the form

$$\bar{W} = \frac{w h_0^3}{\mu\left(\frac{dh}{dt}\right)a^4\pi^2}$$

$$= \frac{3}{2\pi g\left(\bar{h},\bar{l},\psi\right)} \tag{24}$$

The time-height relation is obtained by integrating equation (24)

$$T = -\frac{w h_0^2 t}{\mu\pi^2 a^4}$$

$$= \frac{3}{2\pi}\int_{h}^{\bar{h}_1}\frac{1}{g\left(\bar{h},\bar{l},\psi\right)}d\bar{h} \tag{25}$$

4.3. Elliptic plates

The differential equation (17) is

$$\frac{\partial^2\bar{p}}{\partial\bar{x}^2} + \frac{1}{\lambda^2}\frac{\partial^2\bar{p}}{\partial\bar{z}^2} = \frac{d\bar{h}/dT}{g\left(\bar{h},\bar{l},\psi\right)} \tag{26}$$

The relevant boundary conditions are $\bar{p}\,(x_1, z_1) = 0$

$$\text{Where } \frac{x_1^2}{a^2} + \frac{y_1^2}{b^2} = 1 \tag{27}$$

The pressure distribution and load carrying capacity is obtained by solving equation (26) by using the boundary conditions are (27)

The expression for pressure distribution and load capacity are obtained either by solving equation (26) with boundary conditions (27) thus,

$$\bar{p} = -\frac{h_0^3 p}{\mu\left(\frac{d\bar{h}}{dt}\right)\pi a b}$$

$$= \frac{6\left(a/b\right)}{\pi g\left(\bar{h},\bar{l},\psi\right)\left(\left(\frac{a}{b}\right)^2+1\right)}\left(1-\frac{x_1^2}{a^2}-\frac{z_1^2}{b^2}\right) \tag{28}$$

The non-dimensional load carrying capacity is obtained in the form

$$\bar{W} = -\frac{w h_0^3}{\mu\left(\frac{d\bar{h}}{dt}\right)\pi^2 a^2 b^2}$$

$$= -\frac{3\left(a/b\right)}{\pi\left(\frac{a^2}{b^2}+1\right)}\int_1^{\bar{h}_1}\frac{1}{g\left(\bar{h},\bar{l},\psi\right)}d\bar{h} \tag{29}$$

The time-height relation is obtained by integrating equation (29)

$$T = \frac{w h_0^2 t}{\mu \pi^2 a^2 b^2}$$

$$= -\frac{3}{\pi}\left[\frac{\left(a/b\right)}{\left(a/b\right)^2+1}\right]\int_1^{\bar{h}_1}\frac{1}{g\left(\bar{h},\bar{l},\psi\right)}d\bar{h} \tag{30}$$

4.4. Rectangular Plate

The differential equation (17) reduces to

$$\frac{\partial^2\bar{p}}{\partial\bar{x}^2}+\frac{1}{\lambda^2}\frac{\partial^2\bar{p}}{\partial\bar{z}^2}=\frac{d\bar{h}/dT}{g\left(\bar{h},\bar{l},\psi\right)}$$

The relevant boundary condition are

$$\bar{p}\left(1/2,\bar{z}\right)=0\ ;\ \text{and}\ \bar{p}\left(\bar{x},1/2\right)=0 \tag{31}$$

The pressure distribution is obtained by using the boundary condition (31), we get

$$\bar{p} = -\frac{h_0^3 p}{\mu\left(\frac{d\bar{h}}{dt}\right)ab}$$

$$= \frac{6}{\left(a/b\right)}\left[\left\{\frac{1}{4}-\left(\frac{z}{b}\right)^2\right\}-\frac{8}{\pi^3}\sum_{n=1}^{\infty}\left[\frac{(-1)^n\cosh\left(\frac{2n+1}{b}\right)\pi\cos\left(\frac{2n+1}{b}\right)\pi z}{(2n+1)^3\cosh\left(\frac{2n+1}{2b}\right)\pi a}\right]\right]\left[g\left(\bar{h},\bar{l},\psi\right)\right]^{-1} \tag{32}$$

The load carrying capacity is obtained by integrating equation (32), we get

$$\overline{W} = -\frac{w h_0^3}{\pi\left(\frac{d\overline{h}}{dt}\right)a^2 b^2}$$

$$= \frac{192}{\left\{\pi^4\left(a/b\right)^2\right\}}\left[\left\{\frac{\pi^4}{192}\left(\frac{a}{b}\right)\right\} - \frac{1}{\pi}\sum_{n=1}^{\infty}\left[\frac{\tanh\left(\frac{2n+1}{2b}\right)\pi a}{(2n+1)^5}\right]\right]\left[g\left(\overline{h},\overline{l},\psi\right)\right]^{-1}$$

(33)

The time-height relation is obtained by

$$T = \frac{w h_0^2 t}{\mu a^2 b^2}$$

$$= -\frac{1}{\left\{\pi^4\left(a/b\right)^2\right\}}\left[\left\{\frac{\pi^4}{192}\left(\frac{a}{b}\right)\right\} - \frac{16}{\pi}\sum_{n=1}^{\infty}\left[\frac{\tanh\left(\frac{2n+1}{2b}\right)\pi a}{(2n+1)^5}\right]\right]\int_1^{\overline{h}_1}\left[g\left(\overline{h},\overline{l},\psi\right)\right]^{-1} d\overline{h}$$

(34)

V. RESULTS AND DISCUSSIONS

Dimensionless parameters

In the present study, three dimensionless parameters $\overline{l}$, β , ψ are of importance. The parameter $\overline{l} = \left(\sqrt{\eta/\mu}\Big/h_0\right)$ arises due to the couple stress present in the lubricant. The dimensions of η/μ are length squared and this length may be identified as the chain length of the polar additives in the lubricant. Hence, the parameter $\overline{l}$ provides the mechanism for the interaction of the fluid with the bearing geometry. The couplestress effects are more prominent when either the molecular size of the polar additives is larger or the minimum film thickness is small i.e. when $\overline{l}$ is larger. The couplestress effects are not prominent for smaller values of $\overline{l}$, i.e. when the chain length of the polar additives is small or the film thickness is larger. In the present paper the squeeze film characteristics are studied for intermediate values of $\overline{l}$. The effect of presence of lubricant additives in the porous matrix can be observed from the β dependence of the squeeze film characteristics, where β is the dimensional parameter defined by $\beta = \left(\eta/\mu\right)/k$. The effect of isotropic permeability is observed through the dimensionless permeability parameter $\psi = \left(kH/h_0^3\right)$.

a. Load carrying capacity

The figures 2 and 3 show the variation of non-dimensional load carrying capacity $\overline{W}$ versus the permeability parameter, ψ for different values of the couplestress parameter $\overline{l}$. It is observed that the load carrying capacity $\overline{W}$ increases for the decreasing values of permeability parameter.

Figure.4. depicts the variation of non-dimensional load-carrying capacity $\overline{W}$ with the film thickness $\overline{h}$ for different bearing geometries. It is observed that, the circular plate geometry produces the largest load carrying capacity as compared to the other geometries.

b. Time-height relationship

In designing the bearing, a significant factor is the response time of squeeze films. This response time represents the time that will elapse for a squeeze film to be reduced to some minimum permissible height for the sake of safe operation. Figures 5 to 7 show the variation of nondimensional time, T with $\overline{h}$ for different values of couplestress parameter $\overline{l}$. It is observed that, as the values of couplestress parameter $\overline{l} \to 0$, the non-dimensional response time T approaches the Newtonian lubricant case. Moreover, since the couplestress effects $(\overline{l} > 0)$ give a high film pressure such that the bearing is capable of supporting high loads, the response time T is expected to be increased. According, the time taken in reducing a given height for the couplestress fluid lubricant is significantly more as compared to the Newtonian lubricant case. These results also reveal that the response time increases with the increases in value of couplestress parameter.

VI. CONCLUSIONS

On the basis of the stokes microcontinuum theory, the effect of the couplestress on th e performance chacteristics of porous squeeze film bearings with couplestress fluids is presented. The present analysis exhibits couplestress effects through the parameter $\overline{l}$. As $\overline{l} \to 0$, and $\psi \to 0$, the expressions obtained for the squeeze film characteristics reduce to those of the corresponding Newtonian case studied by Prakash and Vij [11].

The presence of microstructures in the lubricant causes an enhancement of load carrying capacity and a delayed time of approach as a result, the performance of the porous squeeze film bearing is improved.

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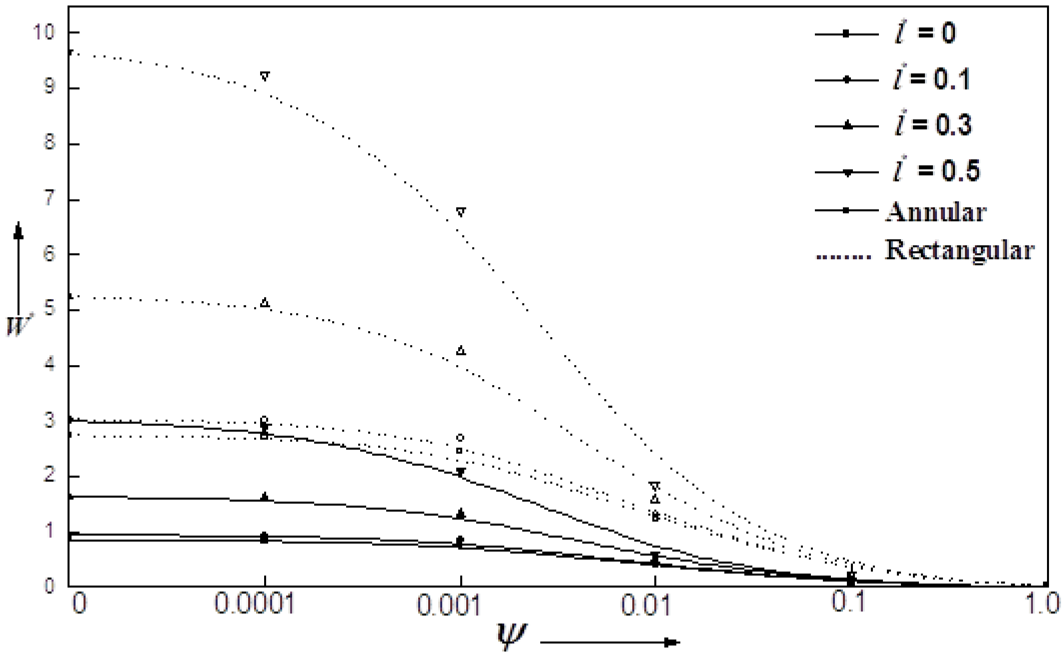

Fig.2 Variation of non-dimensional W^* with ψ for different geometries with different values of l^* and $a/b = 2$, $h^* = 0.5$, $\beta = 0.2$.

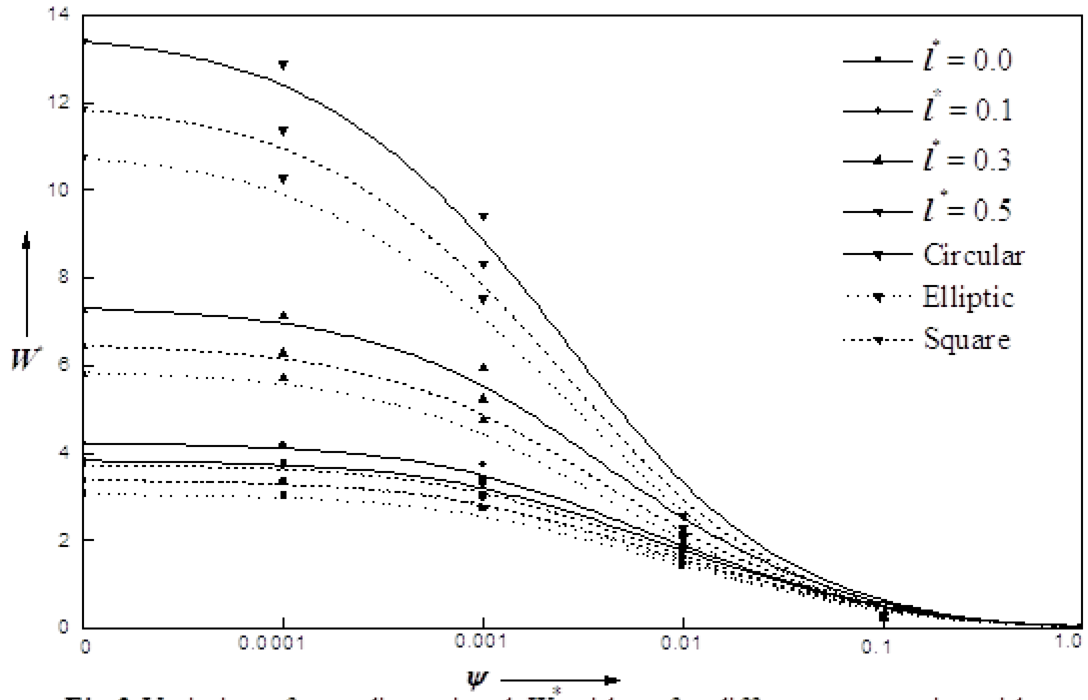

Fig.3 Variation of non-dimensional W^* with ψ for different geometries with different values of l^* and $a/b = 2$, $h^* = 0.5$, $\beta = 0.2$.

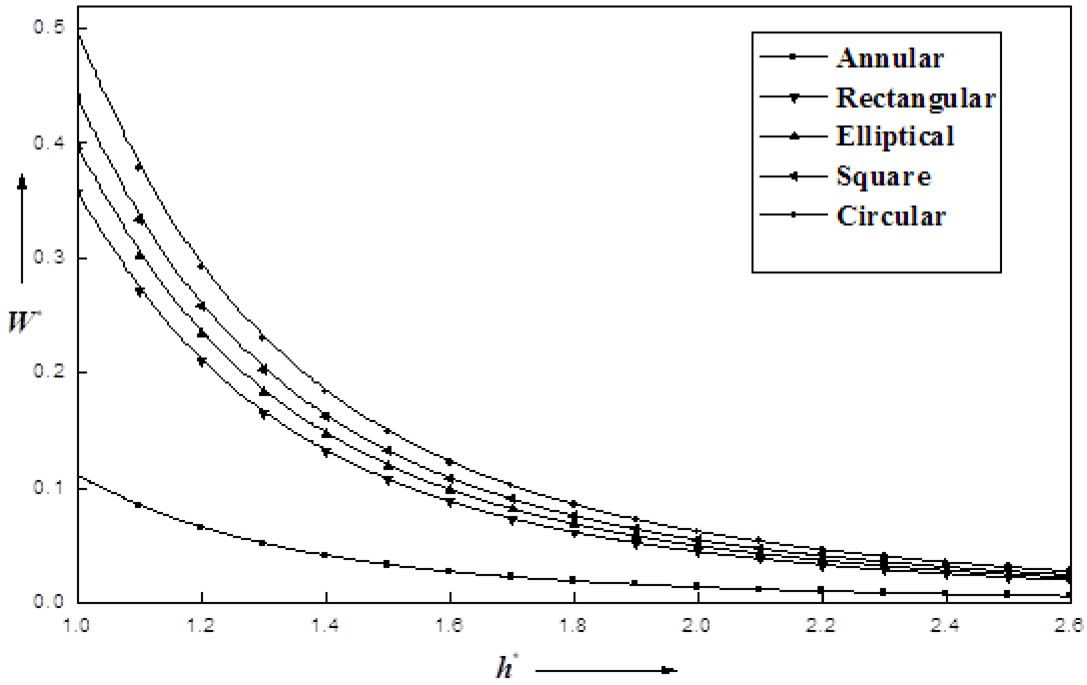

Fig.4 Variation of non-dimensional W^* with h^* for different geometries with $l^* = 0.3$, x = 2, $\psi = 0.01$, $\beta = 0.2$.

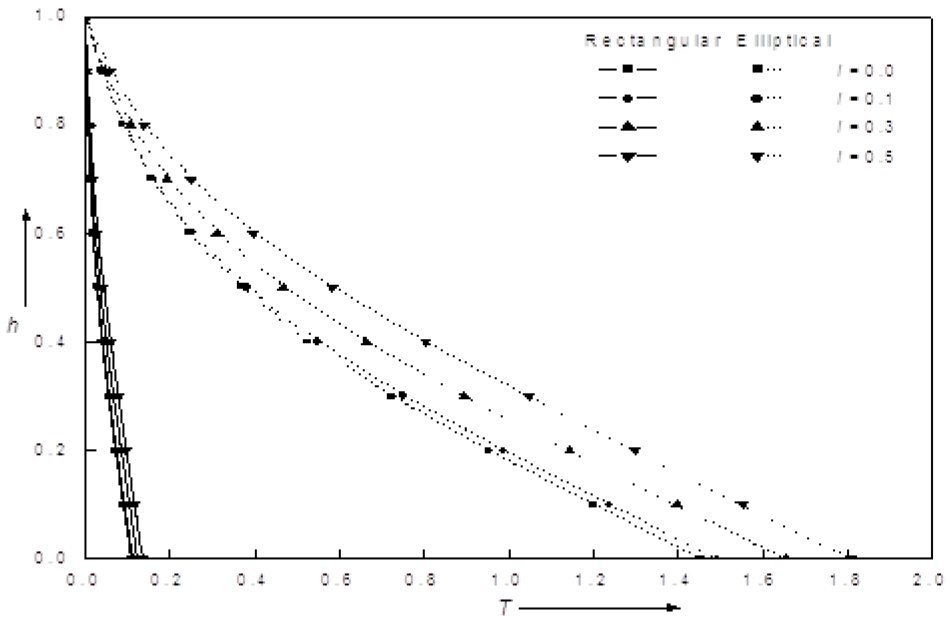

Fig.5. Variation of non-dimensinal film thickness h with T for different values of l with a/b = 2.0, ψ = 0.01, and β = 0.2.

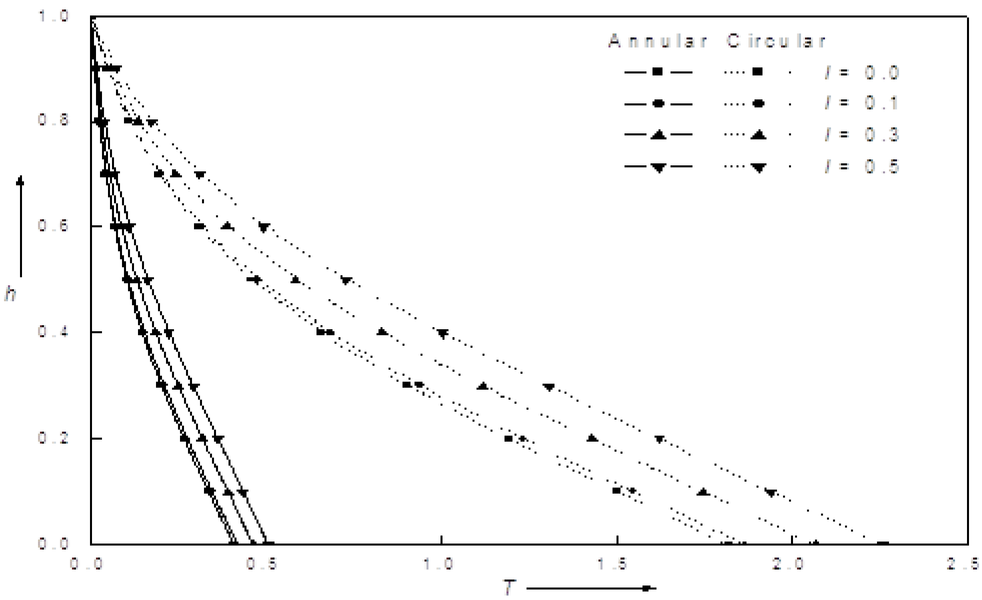

Fig.6. Variation of non-dimensinal film thickness h with T for different values of l with a/b=2.0, ψ = 0.01, and β = 0.2.

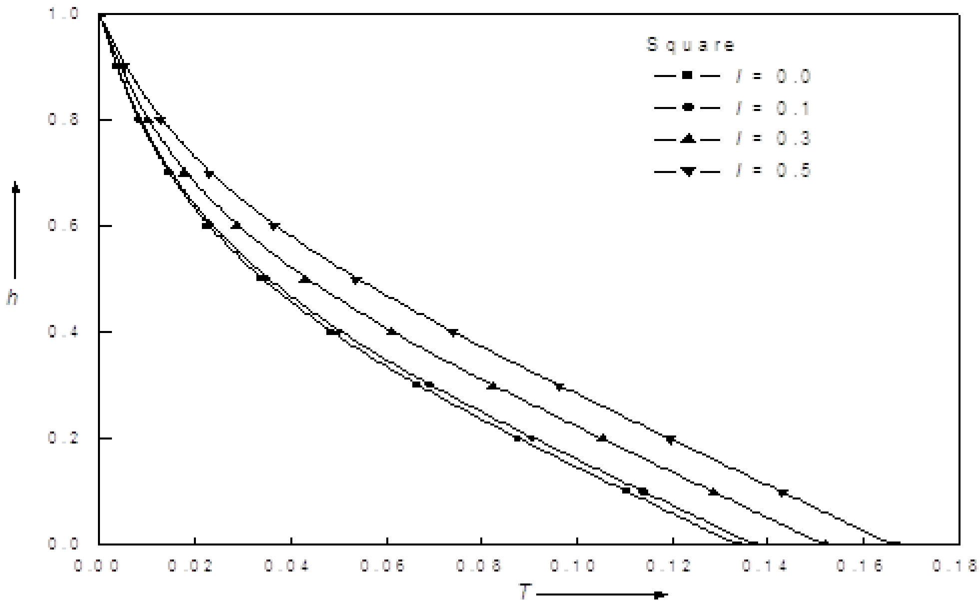

Fig.7. Variation of non-dimensinal film thickness h with T for different values of l with a/b=2.0, ψ = 0.01, and β = 0.2.

Nomenclature

A	area of the bearing surface
a, b	dimensions of the bearing
h	film thickness
h_o	initial film thickness
h_1	film thickness after time Δt

$\bar{h}$	non-dimensional film thickness $\left(= \bar{h_1} / \bar{h_o} \right)$
δ	thickness of porous facing
k	permeability of the porous matrix
l	couple stress parameter $\left(= \left(\eta / \mu \right)^{1/2} \right)$
$\bar{l}$	non-dimensional form of couple stress parameter $\left(= 2l / h_0 \right)$
L	bearing length
p	lubricant pressure in the film region
$\bar{p}$	non-dimensional film pressure $\left(= h_0^3 p \Big/ \left(\mu \left(\frac{\partial \varepsilon}{\partial t} \right) A \right) \right)$
p^*	pressure in the porous region
$\vec{q}^*$	darcy velocity vector $\left(= \left(u^*, v^*, w^* \right) \right)$
r	radial co-ordinate
t	time
Δt	time required for the film thickness to decreases to a value h_1
T	non-dimensinal time $\left(= \frac{w h_o^2}{\mu A^2} \Delta t \right)$
u	tangential velocity of the bearing surface
V_h	normal velocity of bearing surface
W	load capacity
$\bar{W}$	non-dimensional load carrying capacity
x, y, z	Cartesian co-ordinates
x_1, z_1	co-ordinates of a point on the boundary of an elliptic plate
V	velocity vector
u, v, w	components of fluid velocity in x, y, z directions, respectively
u^*, v^*, w^*	modified Darcy velocity components in x, y, z directions, respectively
μ	absolute viscosity of the lubricant
ψ	permeability parameter $(= k\delta / ho^3)$

International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

A Deep Learning Model based White Blood Cell Image Classification

Dr. Suryakant Baburao Ummapure[1], Dr. Satishkumar Mallappa[2]
[1]Department of Computer Science, Govt First Grade College Afzalpur, Kalaburagi-585301, Karnataka, India
[2]Department of Mathematical and Computational Sciences, Sri Satya Sai University for Human Excellence, Kamalapur, Kalaburagi, Karnataka, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
81-89

ABSTRACT

This is paper explores the classification of four types blood cells (Eosinophil, Lymphocyte, Monocyte, and Neutrophil). The diagnosis and treatment of many illnesses depend on the classification of blood cells. Various types of blood cells can be recognized by one another based on factors such as size, shape, function, and other attributes. The total of 12,506 augmented images of blood cells from BCCD dataset are considered for the experiment. For process of classification the widely GoogleNet deep learning model has been efficiently used and it shown a good classification accuracy of 99.47%. This model compared with Alexnet and Googlnet is outperformed with Alexnet Model.

Keywords: Deep Learning, GoogleNet, Alexnet, Image classification.

I. INTRODUCTION

This is essential to gain knowledge about the blood cells types and importance then is made task easy to develop an efficient medical image classification model. In the connection, the following section is all about blood cell types and all are belongs to white blood cell.

White Blood Cell (WBC) image classification is an important task in medical diagnostics, particularly in the context of hematological analysis and the detection of diseases such as leukemia, infections, and other immune-related conditions. White blood cells play a crucial role in the body's immune response, and their abnormal count or morphology can indicate various health issues. Consequently, accurate classification of WBCs based on microscopic images is essential for disease diagnosis and treatment planning.

Blood is a fluid that flows throughout the body to supply oxygen, nutrition, and other essential elements to the tissues and organs [1]. Blood cells are the specialized cells that make up blood. The four types blood cell were used to make classification those are Eosinophil, Lymphocyte, Monocyte, and Neutrophil. Following section gives the brief details of these blood cells.

1.1 **Eosinophil:** White blood cells called eosinophils are a subset of the immune system that aid in the body's defense against allergic reactions and parasitic infections [2].

1.2 **Lymphocyte:** White blood cells known as lymphocytes are essential to the body's immune system[3]. B cells and T cells are the two primary subtypes of lymphocytes.

1.3 **Monocytes:** White blood cells known as monocytes are an essential part of the immune system[4]. They are made in the bone marrow and circulate in the bloodstream.

1.4 **Neutrophil:** White blood cells known as neutrophils are essential for the immune system's response to infection[5]. They make up between 57% to 70% of all circulating white blood cells, making them the most prevalent kind there.

Classifying blood cells can also help healthcare providers to monitor the progression of certain diseases, such as leukemia, which affects the production and function of white blood cells. By monitoring changes in the number and type of blood cells, healthcare providers can tailor treatment plans and adjust medications to improve patient outcomes.

1.5 Traditional Methods for WBC Classification

Historically, WBC classification has been performed manually by pathologists, who analyze blood smear slides under a microscope. This process is time-consuming and subject to human error, as it depends heavily on the expertise of the observer. Traditional computational approaches have been used to aid this process, relying on feature extraction techniques such as edge detection, texture analysis, and color-based segmentation to differentiate between the types of WBCs.

However, these methods often require significant domain knowledge to define the features and are sensitive to variations in image quality and staining. As a result, they may not always be reliable, particularly when analyzing large volumes of data or dealing with subtle differences between cell types.

It is crucial to have the experiment technological knowledge, and which is used in this experiment. Hence, this part explores some insight details of the GoogleNet. To develop efficient classification system this proposed experiment is considered the GoogleNet pretrained CNN model [6], and it has given highest recognition accuracy after examining other pretrained CNN models. The other methods like SIFT[22][23], LBP[24][25][26],SFTA[27] and so on, are not considered for this experiment.

This paper has been setup in the manner. Section 2 is all about the previous implementation details. Section 3 gives information about the proposed method. The discussion on the outcome of the experiment is done in the result and discussion in section 4. Finally the conclusion of this experiment along with the future directions for the improvements.

II. RELATED WORK

The medical field has a vital space to do the research, due to its essentiality of the society.

This is not ending phenomena of the human race, more and more experiments are taking place to improve the health conditions of the humans. Henceforth, there be many works are done in this area and few of them are mentioning in this section.

The end-to-end recognition of blood cell images is accomplished using three convolutional neural network models in [8], and they have reported the accuracy of 0.894 and precision 0.916, respectively. The work of [9], they have proposed a new model named it as a White Blood Cell Hematological Diseases Classification (WBC_HDC) by using Deep learning network model, and after undergoing several testing of network layer settings for eight separate stages, the WBC_HDC network attained an accuracy of 90.86%. [10], have constructed the model which is enhanced hybrid methodology for accurate WBC subtype classification and used the entropy controlled deep feature optimization with this method they have achieved the 99.99% accuracy result. The work of Classification of Atypical White Blood Cells in Acute Myeloid Leukemia by developing a Hybrid Model Based on Deep Convolutional Autoencoder and Deep Convolutional Neural Network is by [11], from this their model achieved an average accuracy of 97%, a sensitivity of 97%, and a precision of 98%. AUC of 99.7% and a class-wise range of 80% to 100%. [12] are developed the system to classify a White Blood Cell Leukemia with Improved Swarm Optimization of Deep Features. The classification of white blood cell by using a deep features extracted by using the CNN models is developed by [13] and this is based on combination of feature selection methods, they have extracted features from these CNN models named as AlexNet, GoogLeNet, and ResNet-50 and quadratic discriminant analysis was used as a classifier, they have reported overall recognition accuracy as a 97.95%. The shape and deep features based white blood classification is reported by [14], and as for result they achieved shape based features based is 80.0% accuracy, deep features obtain 82.9% accuracy. When both shape and deep features are concatenated, 85.7% accuracy is obtained. The two models; traditional and deep learning approach based white blood classification is given in [15], they have applied these two approaches and obtained the recognition accuracy of 99.8% for handcrafted features and 99% accuracy for the full training CNN. In the work of [16] the white blood cell classification is carried out by utilizing deep features of proposed 4B-AdditionNet-based CNN network with ant colony optimization, from this method they have able to achieve 98.44%. These are the few works to name, still there are a many works are carried out to classify the white blood cells.

III.PROPOSED METHOD

To carry out this experiment, the GooglNet model have been utilized, due to its robustness it is chosen. For this experiment the BCCD standard dataset [17], it contains the 12,506 images belongs to four categories; (Eosinophil, Lymphocyte, Monocyte, and Neutrophil) in that Eosinophil has 3,132, Lymphocyte have the 3,108 images, Monocyte contains 3095 and Neutrophil contains the 3171 images and this makes total of 12,506 images. Following figure shows the sample images all four categories of blood cells.

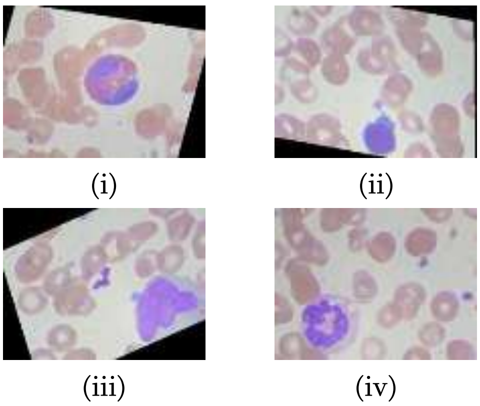

Figure 1. sample images of (i) Eosinophil (ii) Lymphocyte (iii) Monocyte (iv) Neutrophil blood cell types

The sample images made size normalization of 224x224 and these images are feed to the GoogleNet cnn model to obtain the result. The description of this model is given above section I. The GoogleNet[19][20][21] has been used as mode for classification from this model the experiment has received a highest recognition accuracy of 99.47%.

GoogleNet: Convolutional neural network (CNN) researchers at Google created GoogleNet, commonly referred to as Inception-v1, as a model in 2014. Its goal was to make image classification tasks more accurate and efficient. The GoogleNet model is unique by its deep architecture, which has 22 layers and a special "Inception module" that enables more accurate and efficient computing. The Inception module is made up of a number of different-sized convolutional layers that are then joined together via in parallel concatenation to build an single output. With this method, the network can capture features at various scales with the least amount of computational work. The inclusion of auxiliary classifiers, which are tiny classifiers added into the network at different levels, is a further important component of the GoogleNet method. The model's overall accuracy is increased by using these classifiers to give additional supervision during training.

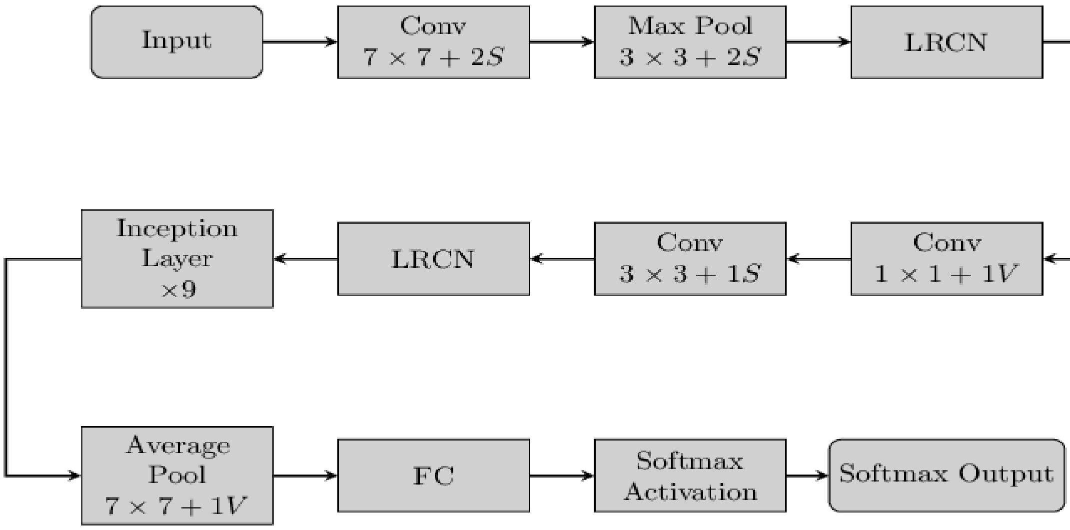

Figure 2. A simplified block diagram of the GoogleNet Architecture[7].

Inception-v2, Inception-v3, and Inception-v4 have all been developed as a result of the success of the GoogleNet model, considerably enhancing both the efficiency and the accuracy of image classification tasks. Applications of these models include object identification, face recognition, and image analysis for medical purposes.

The following figure 3. Shows the white blood cell image classification using Googlenet architecture.

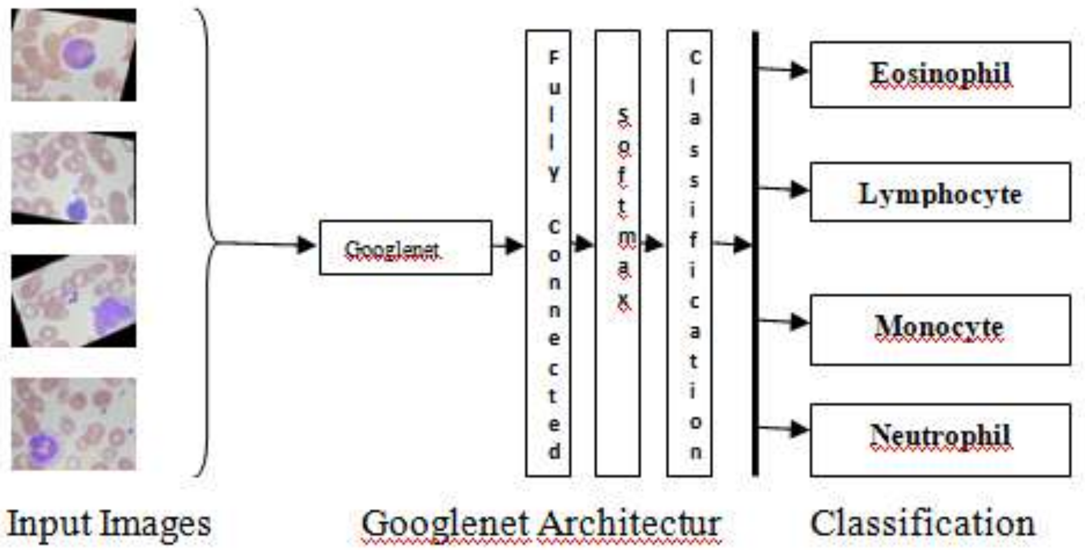

Figure 3. White blood cell image classification using Googlenet architecture.

3.1. Main functions of Googlenet

Inception Modules: The Inception module is designed to capture spatial hierarchies across different filter sizes. Each module consists of parallel convolutional layers with different kernel sizes (e.g., 1x1, 3x3, and 5x5), along with a 3x3 max-pooling layer. These layers are concatenated to create a rich feature map that captures information at multiple scales [28]

Dimensionality Reduction: GoogLeNet uses 1x1 convolutions to reduce the dimensionality of feature maps before applying larger convolutions (3x3 and 5x5), which helps reduce the computational cost and memory footprint [28]

Deeper Network, Fewer Parameters: Despite having 22 layers, GoogLeNet has significantly fewer parameters compared to earlier deep networks like AlexNet. This is due to the use of smaller filters and 1x1 convolutions to maintain computational efficiency [28].

Auxiliary Classifiers: To prevent the vanishing gradient problem in deep networks, GoogLeNet introduces auxiliary classifiers that branch out of the middle layers of the network. These classifiers provide additional supervision during training and improve gradient flow [28].

Global Average Pooling: Instead of fully connected layers used in previous architectures, GoogLeNet employs global average pooling at the end of the network, which reduces overfitting and the number of parameters [29].

3.2. Challenges and Limitations

While deep learning models have demonstrated significant improvements in the classification of WBC images, there are still challenges:

- **Data Imbalance**: WBC datasets are often imbalanced, with some cell types (like neutrophils) being more common than others (like basophils). This can lead to biased models that perform poorly on underrepresented classes.
- **Small Datasets**: Medical image datasets are generally small due to the difficulty in acquiring and labeling data, which can limit the generalization capabilities of deep learning models.
- **Interpretability**: Deep learning models, especially CNNs, are often criticized for their "black-box" nature. While they achieve high accuracy, it is difficult to understand how they make decisions, which can be a barrier to clinical adoption.
- **Variability in Staining and Imaging Conditions**: Variations in how blood samples are prepared, stained, and imaged can introduce noise, making it harder for models to generalize across different datasets or clinical settings.

IV. RESULT AND DISCUSSION

This section provided the performance of the GoogleNet model to make the efficient classification of the white blood cells.

Figure 4. GoogleNet training model.

The parameters are used to train this model are; the learning rate is set to 0.01, mini batch size 128, learner is adam, with 10 epochs includes 680 iterations, 68 iteration per epoch. With these parameters the model was able to achieved the considerably 99.47% recognition accuracy.

To check its performance, the other CNN model Alexnet was employed on same BCCD dataset. The Alexnet was given poor result. Following figure shows its result.

Figure 5. AlexNet training model.

From the above figures it is clearly observed that the GoogleNet was given highest results as compare with the AlexNet. The AlexNet able to get only 24.74% accuracy, and the GoogleNet has given 99.47% accuracy this is an exponentially bigger than AlexNet.

The high accuracy of GoogleNet comes from its Inception Module, which allows for multi-scale feature extraction, along with efficient use of resources through 1x1 convolutions. It minimizes the number of parameters while maximizing the network's depth, and the use of auxiliary classifiers aids in faster convergence and regularization. This combination of deep, efficient architecture enables the model to handle complex images more accurately than other architectures.

(a) Comparative analysis

This proposed method was made compared with other with other methods. Following table 1. Summarizes the proposed method with other methods.

Table 1. Comparative analysis

Method	Accuracy
WBC_HDC [9]	90.86%.
Deep features with combination of feature selection methods [13]	97.95%.
shape and deep features [14]	85.70%
Proposed GoogleNet	99.47%

V. CONCLUSION AND FUTURE SCOPE

The proposed method is performed well with the blood cell images. The common man cannot make discrimination between the different class of blood cell images, due to its look alike nature, here it needs the medical field known person' s intervention to make this job easy. With this developed system also is very helpful in making discrimination of blood cell images, so this may be helpful to medical field experts to take an decision to make recognition. The classification accuracy was achieved at greater height it is very nearer to 100%.

In the future, integrating WBC classification models with broader clinical decision support systems could enhance diagnostic accuracy and speed. For example, these models could be used in conjunction with other diagnostic tools to provide real-time assistance to clinicians, potentially revolutionizing how blood-related diseases are diagnosed and treated.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

A Role of Nanorobot in Medical Science

Prof. Kulkarni Kiran Prakashrao
Department of Computer Science, Yogeshwari Mahavidyalaya, Ambajogai, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
90-95

ABSTRACT

Today varieties of robots are found. These are classified based on configuration, function, mobility, control, and application. The components of all types of robots are nearly the same. Nanobots are unlike all these as they are very small and capable of entering inside the human body too. Nano robots are very small ranging from 1 to 100 nanometers. It means much smaller than a human cell. Nano-robots play an important role in medical science for targeted drug delivery repairing damaged tissue or diagnosing diseases at an early stage. As blood gets thick results in blood clots. The blood clots in blood vessels result in deep vein thrombosis (D.V.T.), pulmonary embolism or stroke. A Stroke is not good for our health it affects our mobility and decreases the speed of movement and number of limitations in day-to-day activities. Brain stroke is due to poor blood circulation and due to any reason blood cannot reach the brain and stroke occurs. A few hours after the stroke is important for patients during this golden time if they get treatment properly better recovery is possible. Medicines to make the blood thin are available but it gives temporary relief. Blood tends to make a clot. I suggest yoga, exercises, and clapping of hands; a healthy diet along with vitamin C will normalize blood circulation and protect us from stroke. Less blood circulation and blockages in arteries increases the chances of heart attack Prevention is better than cure. Nano robots also called nanobots have tiny mechanical tools or spikes to break the clot and reset blood flow. After the treatment nanobots either biodegrade or dissolve inside the body or in some cases removed by the immune system. The nanobot is self-destructive and after destruction, no harmful residue or foreign material remains in the blood The best option for open operation is the nanobot as it reaches the place where it is exactly required inside the human body carrying medicine as well as tools. Nanobot works with speed and great accuracy. Thus nanobots emerge as a new ray of hope for patients. This technology needs to come into existence as early as possible for mankind. Great scientist Hon

Stephen Hawking proves that will power, modern technology and medicines make us comfortable and overcome these type of difficulties with confidence. All the need is that we have to look this matter positively.
Keywords: Stroke, Nanobot, Sensor, Nano-medicine, Nano scale.

I. INTRODUCTION

I] Nature of Nanobot

A nanorobot or nanobot, is a tiny robot built at the scale of nanometers (billionths of a meter). These robots are part of the field of nanotechnology, which involves working with materials and devices at a microscopic scale, typically between 1 to 100 nanometers. The design of Nanobots often consists of the combination of nanomaterials like carbon nanotubes, proteins, and DNA to create machines capable of performing complex tasks on a microscopic scale. Nano-robots hold great promise in medicine. They could be used for targeted drug delivery, repairing damaged tissues, or even diagnosing diseases at an early stage. Nanobots could be programmed to carry out specific tasks, such as moving through the bloodstream to target particular areas of the body, sensing and reacting to environmental conditions, or performing construction tasks at a microscopic level. Nanobots are still largely in the research and development phase, challenges include their size limitations, energy requirements, and the complexity of programming them to work in dynamic and unpredictable environments like the human body.

II] Structure of Nanobot

The structure of nanobot is typically designed at the Nano scale (1 to 100 nanometers) and consists of various components that enable it to perform specific tasks. Since nanobots are still largely experimental, their structures can vary depending on the intended application.

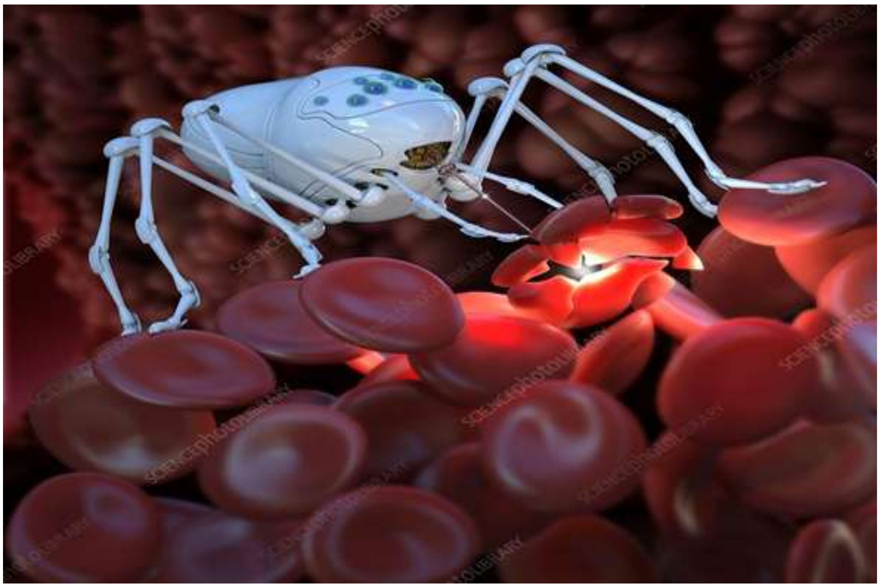

Figure 1: Nanobot for removal of blood clot

However, most nanobots are designed with a combination of biological and synthetic components. Below is a breakdown of the general structure of typical nanobot

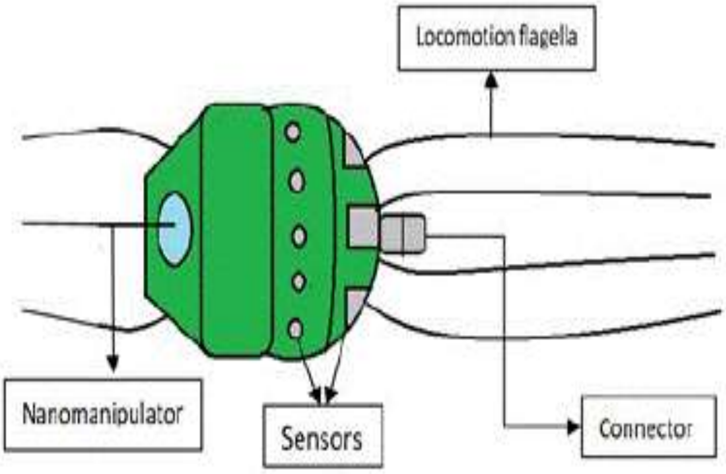

Figure 2: General structure of typical Nanobot

It is made of a Core, Motors, Sensors, an Energy source Control system, an Outer Shell, and Communication. The core of nanobot is typically the central part that holds all of its functional components. The core may be composed of carbon nanotubes or DNA-based structures. To move, Nano robots require actuators or motors, which allow them to carry out tasks like movement or changing shape These are either molecular motors or magnetic motors. Sensors help the nanobot detect its environment and respond accordingly. These are either Chemical or temperature sensors for detection Nanobots require an energy source to function. Given their small size, this is a significant challenge, and several power mechanisms are being explored these are either Chemical fuel or external power.

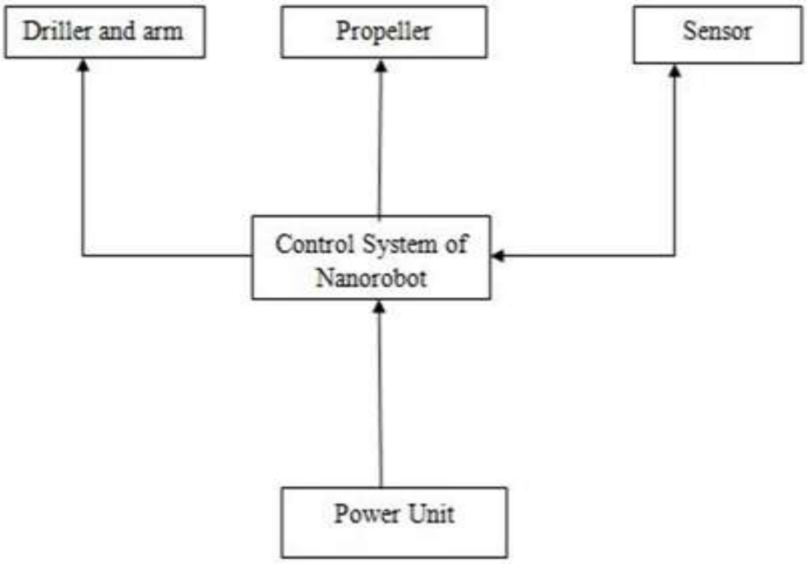

Figure 3: A control system of nanobot

A control system helps guide the actions of the nanobot. Since nanobots are so small, controlling them requires precise methods these are either Pre-programmed DNA or AI algorithms or biocompatible coating or lipid membrane. The outer shell of nanobot provides protection and can also aid in communication with its environment. Optical or radio communication is used to interact with other systems or humans. Some advanced nanobots are designed with communication capabilities, enabling them to send and receive information.

II. METHODS AND MATERIAL

Nano Robots Could Cure Blood Clots in the following way.

A] *Targeted Delivery:* Nanobots could be designed to precisely navigate to the site of the blood clot. Once in the bloodstream, they would be programmed to identify the clot and distinguish it from healthy tissue. The nanobots would have sensors to detect specific markers or changes in the blood chemistry associated with the clot. For example, they could identify the unique proteins found in the clot (like fibrin) and be attracted to it, ensuring that they target only the clot and not healthy tissue.

B] *Breaking Down the Clot:* Once at the site of the clot, the nanobots could perform several functions to help dissolve the clot. The nanobot could carry or trigger the release of enzymes that break down the fibrin in the clot. These enzymes (like plasminogen activators) are already used in thrombolytic therapy but would be delivered directly to the clot by the nanobot, increasing efficiency and reducing side effects. The nanobot might have tiny mechanical components (like nano blades or probes) that can physically break apart the clot, helping to restore normal blood flow. Some nanobots could carry drugs that dissolve the clot, such as clot-dissolving drugs like TPA (Tissue plasminogen activator), and release them only when they are in the vicinity of the clot.

C] *Controlled and Timely Action: Self-Regulation:* Nanobots can be controlled or programmed to stop their activity once the clot is dissolved. This would prevent unnecessary disruption of the blood vessel walls or healthy tissue. To avoid harming healthy tissue, the nanobots could be equipped with mechanisms to detect healthy blood vessel cells and avoid interacting with them, ensuring that only the clot is affected.

D] *Guidance and Navigation: Magnetic Navigation:* One way to guide nanobots through the bloodstream is by using external magnetic fields. Magnetic nanobots could be steered by doctors to precisely reach the clot site. In some designs, nanobots could be guided using ultrasound waves, which can also help physicians track the location and activity of the nanobots.

E] *Biocompatibility and Safety & Biocompatible Materials*: Nanobots would need to be made from materials that do not trigger an immune response or cause harm to the body. These could include lipid coatings, biodegradable polymers, or carbon-based materials like carbon nanotubes. The materials and drugs used by the nanobots would need to be safe for human tissues. After performing their task, the nanobots would ideally degrade and be eliminated by the body, leaving no harmful residues behind. The advantages of nanobot treatment are Precise Treatment, Reduced Side Effects, Faster Recovery, and Reduced Risk of Complications.

III.RESULTS AND DISCUSSION

I] Treatment by Nanobot

While nanobots specifically designed to break blood clots have not yet been widely implemented in clinical practice, there are promising examples in Nano-medicine research

Ex: Magnetic Nanoparticles for Drug Delivery: Research is exploring how magnetic nanoparticles can be used to deliver clot-dissolving drugs directly to the site of a clot, offering a more targeted and efficient treatment. Magnetic particles could be used to steer drug-loaded nanoparticles precisely where they're needed. DNA Nanobots: DNA-based nanobots have been proposed as highly versatile tools for targeted therapies. These DNA machines can be programmed to bind to specific molecules, such as those found in blood clots, and can be triggered to release therapeutic agents like thrombolytics (clot-dissolving drugs). Microbubbles and Ultrasound:

Another approach involves using microbubbles (tiny gas-filled spheres) and ultrasound waves to break apart blood clots. Researchers are investigating whether nanoparticles can work in tandem with ultrasound to deliver high levels of energy to the clot while minimizing damage to surrounding tissue. These treatments are not always effective or suitable for every patient. A nanorobot could provide a more precise and targeted solution by interacting directly with the clot to break it down or dissolve it. Nanobots could prevent the formation of embolisms (secondary clots that break loose and cause further blockage) by carefully managing the dissolution of the clot.

II] Future Scope

In the future, as nanotechnology advances, we could see fully functional nanobots that are capable of: Autonomously detecting blood clots in real time, and thereby delivering highly targeted treatments to the exact location. Breaking down the clot with minimal disruption to surrounding tissues, offering significant improvements over current methods like clot-busting drugs or invasive surgeries. While nanobots for blood clot treatment are still in the research and development phase, several promising technologies are being explored DNA-based nanobots are being developed to perform medical tasks, such as delivering drugs or repairing cells. Magnetic nanoparticles have already been tested for targeted drug delivery and clot disruption in preclinical studies. Nano-medicine is an expanding field that explores how nanoparticles can be used to deliver treatments directly to the site of disease, such as blood clots.

IV. CONCLUSION

In conclusion, nanorobot has the potential to revolutionize how blood clots are treated, offering a targeted, efficient, and minimally invasive solution. However, further research and development are needed before they can become a mainstream treatment option. Nanobots designed to break blood clots would likely combine several advanced technologies to target and dissolve clots effectively within the human bloodstream. While still in the research and development stage, the concept of nanobot draws inspiration from both nanotechnology and medical treatments. In the case of DNA-based nanobot is a combination of cutting-edge materials and technologies, from molecular motors to DNA programming, with an emphasis on minimizing size while maximizing function. Though the field is still in its infancy, the combination of these elements promises to lead to incredible advances in medicine, technology, and various other fields. These are as follows.

A) *Safety*: As with any new technology, nanobots must be thoroughly tested to ensure they are safe for humans and do not cause unforeseen side effects or complications, such as immune reactions.

B) *Regulation:* The introduction of nanobots in medical treatments would require stringent regulation by health authorities to ensure their effectiveness and safety.

C) *Energy Supply:* Since nanobots are extremely small, finding efficient ways to power them during their journey through the body remains a challenge.

D) *Cost and Scalability:* Developing Nanobots for widespread use in medical treatments might be expensive, especially in the initial stages

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Communication Technology for Cloud Data Communications Network

Dr. Shaikh Amjad Riyaz

Assistant Professor Department of Computer Science, Mrs. K.S.K. Alias Kaku Arts, Science & Commerce College, Beed, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
96-101

ABSTRACT

This paper emphasizes the indispensable role of information and Communications Technologies (ICTs), particularly recent cloud computing technologies, in achieving higher efficiency, increase productivity, and improved education outcomes in the teaching and learning process. It delves into the origins of ICTs, tracing the combination of 'Cloud Computing' and 'Communication' that gave rise to these transformative technologies. The perspectives of various authors and experts on the essence of ICTs are examined, along with a discussion of their unique characteristics and key types employed in education today. Furthermore, the paper highlights the tangible impacts of ICTs on educational planning, police-making and their influence on both teachers and students in the classrooms. Cloud Computing is an excellent alternative for educational institutions which are especially under budget shortage in order to operate their information systems effectively network device. Cloud Computing brings the revolutionary changes in the words of information technology & communication technology because of its potential benefits, such as reduced cost accessible any where any time, as well as its elasticity & flexibility.

Keyword: Cloud Computing, Information and Communication Technologies (ICTs), Educational Outcomes, Teaching and Learning Process, Cloud Services Models

I. INTRODUCTION

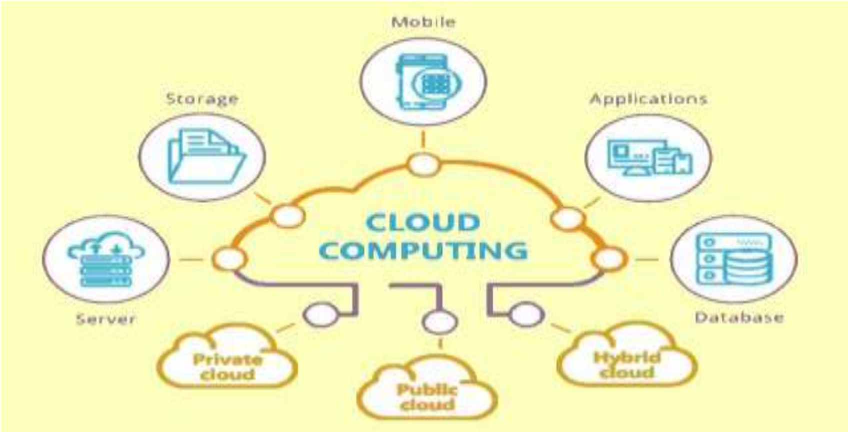
Today there are important transformations tied to the use of technological approaches in teaching and learning the world over. Modern Information and Communication Technologies (ICTs) facilities are making teaching and learning easier and better in developed and some developing countries. Every aspect of life from education, leisure, work, environment to social interactions is being propelled and influenced by information and communication technologies. According to Adedeji (2012), it is generally accepted today that basic knowledge and skills in the use of technological facilities should form part of the minimum educational standard that a person requires to live a meaningful and self-fulfilling life as well as be a productive member of the society. The new world order of ICTs has drastically altered the norms and paradigms of the social order, bringing in its wake an entirely new way of seeing and doing things. It has altered, for instance the way people relate, teach, learn and communicate (Egbule, 2013).

Cloud computing has several applications; traditional mass storage media such as floppy discs, hard drives, CDs, and USBs are no longer popular. Both large corporations and individuals use it as a medium for exchanging files and data. Thanks to these essential elements, sharing files and resources is now quick and straightforward. People might keep sensitive information safe by using the internet and software that allows them to enter virtual spaces. Cloud Computing is a web-based service, where a user (client) can access and manipulates files available in data servers. The Gartner group defines cloud computing as “A style of computing in which massively scalier and elastic IT enabled capabilities are delivered as a service to a external customers using internet technologies”. The core concept of cloud computing is quite simple that the vast computing resources that we need will reside somewhere. Cloud computing represents an exciting opportunity to bring on services & models.

II. CLOUD COMPUTING AS A CONCEPT:

Cloud computing is receiving a great deal of attention, both in publications and among users, from individuals at home (Lewis, 2009). Yet it is not always clearly defined cloud computing is subscription-based service where you can obtain networked storage space and computer resources. Cloud computing is a technology that enables users to access computing resources and services over the internet (see figure 1). It encompasses a wide range of offerings, such as development tools, business applications, data storage, and networking solutions. As stated by Knorr and Gruman (2008), the significance of cloud computing becomes apparent when considering the perpetual requirements of IT: the need for scalability, additional capabilities, and flexibility without the need to invest in new infrastructure, train new personnel, or acquire new software licenses. Essentially, cloud computing enables the extension of existing IT capabilities through subscription-based or pay-per-use services delivered in real time over the internet. These cloud services are hosted at a software vendors' data center and managed by the cloud services provider or onsite at a customer's data center. In simple terms, cloud computing allows you to rent instead of buy your IT. Rather than investing heavily in databases, software, and hardware, companies opt to access their computer power via the internet, or the cloud, and pay for it as they use it. These cloud services now include, but are not limited to, servers, storage, databases, networking, software, analytics, and business intelligence. Cloud computing provides the speed, scalability, and flexibility that enables teachers/ students and businesses to develop, Type of cloud computing Deploying cloud computing can differ depending on requirements and the following four deployment models have been identified each with specific characteristics that support the need of the service and uses of the cloud in particular ways. innovate, and support teaching/learning and businesses. When an organization/school chooses to “move to the cloud,” it means that its IT infrastructure is stored offsite, at a data center that is maintained by the cloud computing provider. An industry-leading cloud provider has the responsibility for managing the organizational IT infrastructure, integrating applications, and developing new capabilities and functionality to keep pace with information stored offline and market demands.

Figure 1: Cloud



III. TYPES OF CLOUD COMPUTING:

There are three types of clouds: public, private, and hybrid. Each type requires a different level of management from the organization and provides a different level of security.

- **Public Cloud:** The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.
- **Private Cloud:** The cloud infrastructure is operated solely for a single organization. It may be managed by the organization or a third party and may exist on-premises or off-premises.
- **Community Cloud:** The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns e.g. mission, security requirements, policy, or compliance considerations. It may be managed by the organizations or a third party and may exist on-premises or off-premises.
- **Hybrid Cloud:** The cloud infrastructure is a composition of two or more clouds e.g. private, community, or public that remains unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).
- **Managed Cloud:** It is important to note that there are derivative cloud deployment models emerging due to the maturation of market offerings and customer demand.

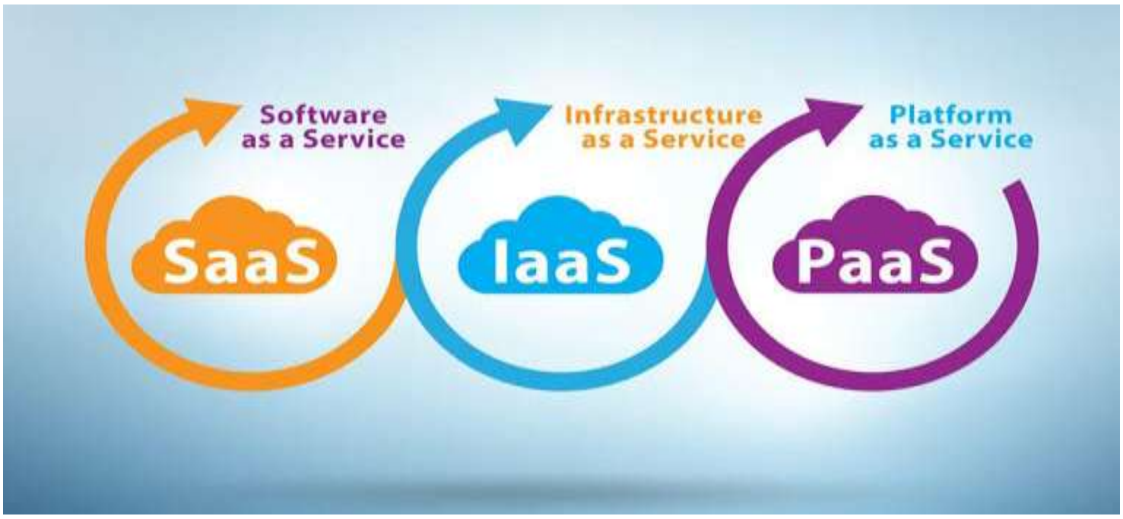
IV. CLOUD SERVICES MODELS:

Cloud service delivery is divided among three architectural models and various derivative combinations. The three fundamental classifications are often referred to as the "**SPI Model**" where 'SPI' refers to Software, Platform or Infrastructure as a Service respectively. We are defining these terms below.

(i) **Cloud Software as a Service (SaaS).** The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser e.g., web-based email. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities

(ii) **Cloud Infrastructure as a Service (IaaS).** The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer can deploy and run arbitrary software, which can include operating systems and applications.

(iii) **Cloud Platform as a Service (PaaS).** The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations.



V. CHARACTERISTICS OF INFORMATION AND COMMUNICATION TECHNOLOGY:

1. ICT can be applied to the full range of human activity from personal use to business and government. It is multifunctional and flexible, allowing for tailored solutions – based on personalization and localization to meet diverse needs.
2. ICT is a key enabler in the creation of networks and thus allows those with access to benefit from exponentially increasing returns as usage increases (i.e network externalities).
3. ICT foster the dissemination of information and knowledge by separating content from its physical location. This flow of information is largely impervious to geographic boundaries – allowing remote communities to become integrated into global networks and making information, knowledge and culture accessible, in theory to anyone.
4. The digital and virtual nature of many ICT products and services allows for zero or declining marginal costs. Replication of content is virtually free regardless of its volume and marginal costs for distribution and communication are near zero. As a result, ICT can radically reduce transaction costs.
5. ICTs power to store, retrieve, sort, filter, distribute and share information seamlessly can lead to substantial efficiency gains in production, distribution and markets. ICT streamlines supply and production chains and makes many business processes and transactions learner and more effective.
6. The increase in efficiency and subsequent reduction of costs brought about by ICT is leading to the creation of new products, services and distribution channels within traditional industries, as well as innovative business models and whole new industries.
7. ICT facilitates disintermediation, as it makes it possible for users to acquire products and services directly from the original provider, reducing the need for intermediaries.
8. ICT is global through the creation and expansion of networks; ICT can transcend cultural and linguistic barriers by providing individuals and groups the ability to live and work anywhere, allowing local

communities to become part of the global network economy without regard to nationality and challenging current policy, legal and regulatory structures within and between nations.

VI. TYPES OF ICTS COMMONLY USED IN EDUCATION:

- **E-Learning:** E-learning encompasses learning at all levels, both formal and non-formal that uses an information network – the internet, an internet (LAN) or extranet (WAN) – whether wholly or in part, for course delivery, interaction, evaluation and or facilitation.
- **Blended Learning:** This refers to learning models that combine traditional classroom practice with e-learning solutions. For example, students in a traditional class can be assigned both print-based and online materials, have online mentoring sessions with their teacher through chat and are subscribed to a class email list or a web-based training course can be enhanced by periodic face-to-face instruction. "Blended" was prompted by the recognition that not all learning is best achieved in an electronically mediated environment particularly one that dispenses with a live instructor altogether.
- **Open and Distance Learning:** Open and distance learning is defined by the Commonwealth of learning as "a way of providing learning opportunities that is characterized by the separation of teacher and learner in time or place, or both time and place; learning that is certified in some way by an institution or agency; the use of a variety of media, including print and electronic; two-way communications that allow learners and tutors to interact; the possibility of occasional face-to-face meetings and a specialized division of labour in the production and delivery of courses (Commonwealth online).
- **Learner-Cantered Environment**: The National Research Council of the U.S. defines learner- centred environments as those that pay careful attention to the knowledge, skills, attitudes and beliefs that learners bring with them to the classroom. The impetus for learner centeredness reives from a theory of learning called constructivism, which views learning as a process in which individuals "construct" meaning based on prior knowledge and experience.

VII. CONCLUSION

The efficacy and effectiveness of Information and Communication Technologies (ICTs) in education are no longer a subject of doubt. Cloud computing has gained significant credibility as a valuable tool for educational purposes. However, a crucial challenge lies before policymakers, educators, administrators, and stakeholders in education: ensuring that their educational systems are technologically up to date. Any country, institution, system, or organization that has not yet embraced or integrated ICTs into its operations is considered outdated and lagging behind the current age. Nowadays, cloud computing is an essential aspect of the computer industry. Customers of these cloud services are not privy to the physical location of the servers or data storage facilities, but rather receive IT support over the internet. Customers of cloud services are often in the dark about the origin and method of service delivery. Software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS) are three paradigms that can work for Nepal's data protection needs in the cloud. Security, storage, data center operations, pricing, service level agreements, location, integrity, access, segregation, breaches, and confidentiality are just a few of the cloud computing issues that Nepal is clearly encountering. According to the research, the three main areas of cloud computing security are storage, virtualization, and networks. They are aiming for data security. As one of the world's emerging nations, Nepal has to start making use of its own servers and satellites for data cente and connectivity.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Application of AI in Agriculture: An Overview

Mr. Sanjay R. Kale
Assistant Professor, Department of Computer Science, Swa. Sawarkar Mahavidyalaya, Beed, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
102-104

ABSTRACT

This research Paper Present an overview of an AI application and role of various application in development of agriculture food production. This paper provides an overview of the applications of AI in agriculture, highlighting more beneficial its potential to transform the sector. Farming and Agriculture is very important role .it is backbone of human civilization and its importance cannot be overstated.

With the global population projected to reach 9.6 billion by 2050, the pressure on agriculture to produce more food while minimizing environmental impact is increasing. Artificial Intelligence (AI) has most important role as a game-changer in agriculture, it offering innovative solutions to, reduce waste, improve crop yields, and promote sustainable farming practices.

AI is becoming more prevalent every day in agriculture, and AI-based devices are elevating the current farming system. Agriculture is dependent on a number of variables, including soil nutrient content, moisture, crop rotation, rainfall, temperature, etc. Products based on artificial intelligence can use these variables to track crop productivity. In order to improve a wide range of agriculture-related tasks throughout the entire food supply chain, industries are turning to AI technologies.

Keywords: AI, Agriculture, Crop diseases, Precision Farming, Automated Farming Skylark, Airpix, Consort Digitals Drones

I. INTRODUCTION

Agriculture is a complex and dynamic field that faces numerous challenges, including climate change, soil degradation, water scarcity, and crop diseases. Traditional farming practices often rely on manual labor, intuition, and trial-and-error methods, which can lead to inefficiencies and reduced productivity. AI has the potential to revolutionize agriculture by providing data-driven insights, automating tasks, and optimizing decision-making processes.

Applications that use AI in agriculture have been created to assist farmers in precise and regulated farming by giving them the right advice on water management, crop rotation, timely harvesting, the type of crop to be cultivated, optimal planting, pest attacks, .

Objectives :

1. To find use of AI technology for farming to improve crop production
2. To find food security using AI technology Applications
3. To find to **Skills and Training**

II. APPLICATIONS OF AI IN AGRICULTURE

1. **Precision Farming**: AI-powered precision farming involves using sensors, drones, and satellite imaging to collect data on soil conditions, crop health, and weather patterns. This data is then used to optimize irrigation, fertilization, and pest control, reducing waste and improving crop yields.
2. **Crop Yield Prediction**: AI algorithms can analyze historical climate data, soil conditions, and crop genetics to predict crop yields. This information can help farmers make informed decisions about planting, harvesting, and pricing.
3. **Disease Detection and Prevention:** AI-powered computer vision can be used to detect crop diseases, such as fungal infections or pests, at an early stage. This enables farmers to take prompt action to prevent the spread of disease and reduce the use of chemical pesticides.
4. **Automated Farming:** AI can automate farming tasks, such as, pruning, and harvesting, planting ,using autonomous vehicles and robotics. This can enhance crop quality improve efficiency, AI enabled system reduce labor costs,
5. **Supply Chain Optimization:** AI can optimize supply chain logistics managing inventory, and streamlining transportation. This can help reduce food waste, improve freshness,
6. **Farm Robotics:** AI-powered farm robots can perform tasks, such as weeding, pruning, and harvesting, with precision and accuracy. This can improve crop quality, reduce labor costs,
7. **Decision Support Systems**: AI-powered decision support systems can provide farmers with data-driven insights and recommendations on crop management, soil health, and weather forecasting.

III.BENEFITS OF AI IN AGRICULTURE

1. **Improved Crop Yields:** AI can optimize crop growth, reduce waste, and improve yields.
2. **Increased Efficiency:** AI can automate tasks, reduce labor costs, and enhance farm productivity.
3. **Enhanced Sustainability:** AI can promote sustainable farming practices, reduce chemical use, and conserve water.
4. **Better Decision-Making:** AI can provide data-driven insights, enabling farmers to make informed decisions.
5. **Reduced Food Waste:** AI can optimize supply chain logistics, reducing food waste and improving freshness.

IV. CHALLENGES AND LIMITATIONS

1. **Data Quality and Availability:** AI requires high-quality and relevant data, which can be challenging to obtain in agriculture.
2. **Interoperability:** AI systems may not be compatible with existing farming systems and infrastructure.
3. **Cyber security :** AI systems can be vulnerable to cyber threats, which can compromise farm data and operations.
4. **Regulatory Frameworks:** There is a need for regulatory frameworks to govern the use of AI in agriculture.
5. **Skills and Training:** Farmers may require training and support to effectively use AI-powered systems.

V. CONCLUSION

AI has the potential to transform agriculture, improving crop yields, reducing waste, and promoting sustainable farming practices. While there are challenges and limitations to be addressed, the benefits of AI in agriculture are undeniable. As the global population continues to grow, AI can play a critical role in ensuring food security, sustainability, and productivity. Drone technology has had a lasting effect on the productivity of India's agriculture sector. The Indian companies like **Skylark,Airpix, Consort Digitals** Drones help to farmers with drone-powered solutions to boost productivity in a variety of farming operations, including precision farming, pesticide application, crop stress identification, treatment planning, plant growth monitoring and crop health.
The Future of Agriculture in India is undoubtedly technology driven.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Advances in Sentiment Analysis: Techniques, Applications, and Challenges

Bharti B. Balande*[1], Dinesh M. Kolte[1], Ramesh R. Manza[1], Suryakant S. Revate[2]
*[1]Department of Computer Science & IT, Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar, Maharashtra, India
[2]Department of Computer Science & IT, Shri Chhatrapati Shivaji College, Omerga, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
105-108

ABSTRACT

Opinion mining, which is additionally known as sentiment analysis, is a computational method that extracts, evaluates, and quantifies subjective information from text data. The paper provides an outline of sentiment analysis, covering the approach, applications, and challenges. The report discusses the key methodologies, including lexicon-based approaches and machine learning, and analyzes their merits. The report ends with a consideration of sentiment analysis' potential directions.

Keywords: Sentiment analysis, opinion mining, natural language processing, machine learning, lexicon-based methods, hybrid approaches, text classification

I. INTRODUCTION

Textual data generated by social media, reviews, forums, and news sites is an important resource for assessing public opinion in the digital age. Sentiment analysis helps to categorize feelings indicated in a text as neutral, negative, or positive. This functionality is crucial for applications that require business analytics, determining user feedback, and monitoring public mood.

II. METHODOLOGIES

A. Machine Learning-Based Approaches

Machine learning algorithms use labeled datasets for training classifiers that categorize text based on sentiment.
Support Vector Machines (SVM) are an effective text categorization method that excels in high-dimensional environments.
Naïve Bayes is a statistical technique for analyzing independent features.
Deep Learning Models: Architectures such as transformers (e.g., BERT) and recurrent neural networks (RNNs) offer cutting-edge performance.

B. Lexicon-Based Approaches

Lexicon-based techniques make use of readily available sentiment word dictionaries. To determine the overall impression of the written content, dictionaries include SentiWordNet and VADER determines polarity scores to phrases and words.

C. Hybrid Approaches

The advantages of lexicon-based and machine learning methods are integrated in hybrid systems. Lexicones can be used to enhance feature sets in machine learning models, enhancing their performance.

III. APPLICATIONS

A. Business Intelligence

Sentiment analysis can help firms forecast market trends, monitor brand reputation, and comprehend customer input.

B. Social Media Monitoring

Sentiments in social media posts might show popular opinion on politics, new product launches, and social issues.

C. Healthcare

Sentiment analysis of patient reviews helps to determine patient happiness and the quality of medical care.

IV. LITERATURE REVIEW

1. "Sentiment Analysis: Current State and Future Research Perspectives" (2023): This paper provides a general overview of sentiment analysis, particularly in the context of product reviews.
2. "A Review of Sentiment Analysis: Tasks, Applications, and Deep Learning Techniques" (2023): This review delves into the intricate landscape of sentiment analysis, exploring its significance, challenges, and evolving methodologies.
3. "The Many Applications of Sentiment Analysis: A Literature Review" (2023): This research identifies current articles and themes in sentiment analysis, uncovering three main themes: applications, experiments, and vulnerabilities, with vulnerabilities as an emerging area calling for further research.
4. "Sentiment Analysis Based on Machine Learning Algorithms": This study assesses the reliability of Yelp's review sentiment algorithm by constructing a specific sentiment analysis algorithm using data from Yelp.
5. "Contextualized Sentiment Analysis Using Large Language Models": This study explores the capabilities of large language models (LLMs) in employing economic reasoning to predict industry-specific news impacts.
6. "Challenges and Future in Deep Learning for Sentiment Analysis": This paper provides an in-depth investigation into sentiment analysis, categorizing prevalent data, pre-processing methods, text representations, learning models, and discusses the challenges and future directions in deep learning for sentiment analysis.
7. "Sentiment Analysis in the Era of Large Language Models: A Reality Check" (2023): This study provides a comprehensive investigation into the capabilities of large language models in performing various sentiment analysis tasks, comparing their performance against smaller language models trained on domain-specific datasets.

8. "SentimentGPT: Exploiting GPT for Advanced Sentiment Analysis and its Departure from Current Machine Learning" (2023): This study presents a thorough examination of various Generative Pretrained Transformer (GPT) methodologies in sentiment analysis, revealing their unique strengths and potential limitations.
9. "Exploring Sentiment Analysis Techniques in Natural Language Processing: A Comprehensive Review" (2023): This paper offers a systematic review of sentiment analysis techniques, identifying existing gaps, and suggesting possible improvements to enhance the efficiency and accuracy of sentiment analysis processes.
10. "The Sentiment Problem: A Critical Survey towards Deconstructing Sentiment Analysis" (2023): This inquiry examines the sociotechnical aspects of sentiment analysis by critically reviewing 189 peer-reviewed papers, proposing an ethics sheet to guide practitioners in ensuring equitable utilization of sentiment analysis.

V. CHALLENGES

A. Context and Sarcasm

Sarcasm recognition and context interpretation remain significant challenges in sentiment analysis.

B. Multilingual Texts

Accurate analysis is complicated by the lack of significant sentiment resources for multiple languages.

C. Domain-Specific Language

Modifying sentiment analysis models for specific domains requires more labeled data and domain knowledge.

VI. FUTURE DIRECTIONS

Advances in natural language processing (NLP) and artificial intelligence (AI) are opening the door to more accurate and complex sentiment analysis.

The following are new areas of interest:

- Aspect-Based Sentiment Analysis (ABSA): This approach looks at how readers feel about specific textual elements.
- Multimodal Sentiment Analysis: Combining textual, visual, and auditory data improves sentiment comprehension.
- Explainable AI: Improving the simplest aspects of sentiment categorization models.

VII. CONCLUSION

Sentiment analysis is an ever growing, prominent, and diverse field. Despite the challenges of domain development and environmental perception, current breakthroughs in NLP offer prospective for improvements in the future. Sentiment analysis capabilities can be greatly improved by using developing approaches and a hybrid approach.

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International Journal of Scientific Research in Science and Technology
Available online at : **www.ijsrst.com**
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Design and Development of Custom AI CHATBOT #Ask Me

Sonali Ramrao Gaware
Department of Computer Science, Mrs. K.S.K. College, Beed, Dr. BAMU Sambhajinagar, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
109-113

ABSTRACT

In the contemporary digital landscape, chatbots have emerged as indispensable tools for facilitating human-computer interaction across various domains. This project presents the design and implementation of a custom chatbot to enhance user engagement and satisfaction. Leveraging natural language processing (NLP) techniques and machine learning algorithms, the chatbot is capable of understanding user queries, generating appropriate responses, and adapting to user preferences over time. The development process involved several key stages, including data collection, preprocessing, model training, and integration into a user-friendly interface. By utilizing a combination of supervised and unsupervised learning approaches, the chatbot achieved robust performance in understanding and generating responses to diverse user performance in understanding and generating responses to diverse user inputs.

Furthermore, the chatbot incorporated personalized features to tailor interactions based on individual user profiles and historical interactions based on individual user feedback mechanisms and reinforcement learning techniques, the chatbot continuously refines its response to provide increasingly accurate and relevant information. Evaluation of the chatbot's performances involved rigorous testing across various scenarios and user demographics. Results demonstrate the efficacy of the chatbot in handling a wide range of queries while maintaining a high level of user satisfaction. The practical implications of this project extend to numerous domains, including customer service, education, healthcare, and e-commerce. By automating routine interactions and providing timely assistance, the chatbot contributes to improved efficiency, cost savings, and enhanced user experiences. Overall, this project contributes to the advancement of conversational AI technologies by presenting a comprehensive framework for developing custom chatbots tailored to specific user needs. The insights gained from this endeavor pave the way for future research and innovation

in the field of human-computer interaction and natural language processing.

Keywords: AI Technology, Natural Language Processing, Digital assistance and chatbot.

I. INTRODUCTION

In today's digital age, where technology continues to revolutionize how we interact with and engage with information, the emergence of chatbots has significantly transformed the landscape of human-computer interaction. These conversational agents offer a unique platform for users to communicate, seek assistance, and access services in a manner that mimics natural language conversations. The development of chatbots has garnered immense attention across various domains, ranging from customer service and healthcare to education and entertainment, owing to their potential to enhance user experiences and streamline operations.

The focus of this project is to design and implement a custom chatbot solution tailored to meet specific user needs and preferences. Unlike off-shelf chatbots, which often lack personalization and fail to address unique requirements, our approach emphasizes the customization of conversational interaction to deliver more meaningful and efficient user experiences. By leveraging natural language processing (NLP) techniques machine learning algorithms and advanced dialogue management strategies, our custom chatbot aims to provide intelligent responses that anticipate user intent and adapt to evolving conversation contexts seamlessly.

Chatbots are generally smart machines. Chatbots are intelligent. It understands the user request and then it formulates the solution or provides requested data. Chatbots are very successful because they provide quick and accurate information. It's not only chatbot but also your digital personal assistant. Chat boats become more popular nowadays.

II. OBJECTIVES:

A. **Understanding User Requirements:** Conducting compressive user research and analysis to identify specific needs, preferences, and pain points that the chatbot can address.

B. **Designing Conversational Flows:** Creating intuitive conversational flows and dialog structure to facilitate smooth interactions between users and the chatbot ensuring a user-friendly experience.

C. **Implementing NLP Capabilities:** Integrating advanced natural language processing capabilities to enable the chatbot to understand and interpret user queries accurately, even in the presence of ambiguity or variations in language.

D. **Personalizing User Experiences:** Developing mechanisms to personalize interactions based on user preferences, past interactions, and contextual information thereby enhancing engagement and satisfaction.

E. **Ensuring Scalability and Robustness:** Building a scalable and robust architecture to support concurrent users, handle varying levels of complexity in conversations, and maintain high reliability and performance.

F. **Evaluating performance and user satisfaction:** Conducting evaluations and usability tests to assess the performance of the chatbot in terms of accuracy, efficiency, and user satisfaction and incorporating feedback for continuous improvement.

III.SOFTWARE REQUIREMENTS:

- **Visual Code Studio:**

The Visual Studio uses to run, compile, and coding. It is the standard editor and debugger that most IDEs provide, Visual Studio provides features like compilers, code completion tools, graphical designers, etc. to software implementation process.

IV. LANGUAGES:

A. HTML5:

HTML is the markup language. It is used for developing web pages and web apps. HTML interpreted by a browser. It designs the structure and content of a web page by using a system of tags and elements to define various elements such as headings, paragraphs, images and more. It creates web documents. HTML documents are composed of a hierarchy of nested elements forming the backbone of web content. Following are key aspects:

i. **Structure:** HTML documents are hierarchical element structure. These are paragraphs, headings, links, images, tables etc.

ii. **HTML Tags:** HTML tags give signal to web browsers. These are embedded in a document. Tags write in angular brackets (< >). Some tags are singular, and some are paired. Singular tag does not have a closing tag. Paired tag has opening and closing tag. Like that <p>…. </p>.

iii. **Attributes:** Attributes provide additional information about the element. Attributes appear within the opening tag and are used to customize the behavior or appearance of an element. For instance, the <body> tag has attributes like bgcolor, image.

B. CSS:

CSS is a style sheet language used to describe the presentation of a document return in HTML. It allows wave developers to control the layout, styling, and appearance of multiple web pages simultaneously. CSS enables web designers and developers to style HTML elements by specifying properties such as color font, size, facing and positioning. With CSS you can create visually appealing and consistent designs across multiple web pages or an entire website.

C. JAVASCRIPT:

JavaScript is an object oriented language. JavaScript is a interpreted programming language that allows creation of webpages. It allows dynamic behavior to web pages.[3] It primarily used for client-side scripting, but it can also be used for server-side development in (Node.js). It allows developers to create responsive and interactive elements such as animations form validations interact to maps and more. JavaScript is executed on the client side enabling real time manipulation of web page elements without the need for server interaction.

V. HISTORY:

The history of chatbots dates back to about 70 years before the beginning of computing.

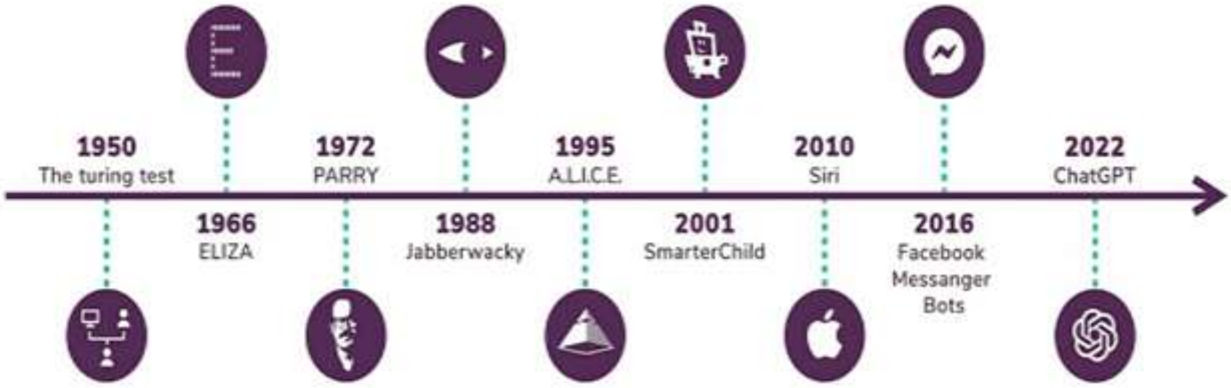

Fig 1: History of Chatbot

Table1: Timeline of Chatbot

Year	Chatbot	Developers
1960	ELIZA	Joseph Weizenbaum
1972	PARRY	Kenneth Colby
1984	RACTER	William Chamberlain and Thomas Etter
1995	A.L.I.C.E.	Richard Wallace
2001	Smarter Child	Active Buddy
2006	IBM Waston	IBM'S DeepQA Project
2011	SIRI	Apple iOS
2014	CORTANA	Microsoft 2014
2014	ALEXA	Amazon
2016	Microsoft Tay	Microsoft's technology
2016	Google Assistant	Google
2022	CHATGPT	Open AI 2022

VI. STEPS FOLLOW FOR DEVELOPING CUSTOM CHATBOT:

i. Identify the chatbot's purpose: Consider the chatbot's functionality, use cases, and how it will align with customer needs.
ii. Select a platform: Choose the platforms where the chatbot will operate, such as websites, apps, or Messenger.
iii. Select a technology stack: Choose the framework or platform for development, and consider whether to use open-source or proprietary options.
iv. Design the conversation: Map out the chatbot's interaction flow and user experience.
v. Test the chatbot: Evaluate the chatbot's performance with real users.
vi. Deploy and maintain: Deploy the chatbot to various digital channels and maintain it.

VII. ARCHITECTURE OF CHATBOT:

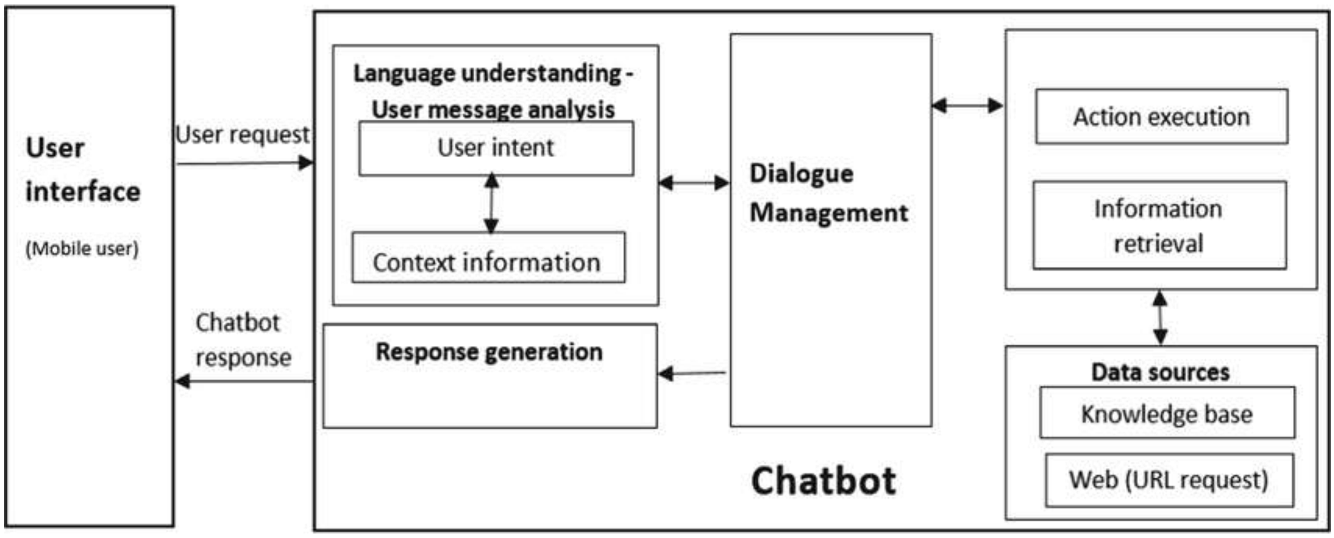

Fig 2: Architecture of Chatbot [3]

VIII. CONCLUSION:

The development of custom chatbots website represents a significant milestone in the realm of digital interaction and artificial intelligence integration. Through the amalgamation of HTML CSS, JavaScript and API integration we have created a dynamic platform that facilitates seamless communication between users and driven conversational agent.

Custom chartbots not only show cases our proficiency in web development technology but also demonstrate our ability to liver is API to enhance functionality and user experience. By harnessing the power of JavaScript we have crafted an intuitive future winter face that ensures smooth navigation across the website

Moreover the incorporation of AI through the chart board feature adds earlier of inter activity and intelligence to the website enabling users to engage in meaningful conversations and receive relevant assistant in real time.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

A Comprehensive Overview of Association Rule Mining in Data Science and Its Applications

Renuka R Londhe
Department of Computer Science, Rajarshi Shahu Mahavidyalaya, Latur, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
114-121

ABSTRACT

Association rule mining is a widely used technique in data analytics and machine learning for discovering hidden relationships between variables in large datasets. This method has a broad range of applications, including market basket analysis, customer segmentation, and fraud detection. In this article, we explore the concept of association rule mining and its implementation in R. We begin by introducing the technique, its common use cases, and its importance in uncovering valuable insights from data. We then examine key algorithms for association rule mining, including the Apriori, FP-Growth, and ECLAT algorithms, highlighting their principles, strengths, and weaknesses. The article further discusses the essential metrics for evaluating association rules, such as support, confidence, and lift, and provides an overview of popular R libraries that facilitate association rule mining. Finally, we conclude by summarizing the practical applications of association rule mining in real-world developments, emphasizing its value for data-driven decision-making across various industries.

Keywords: Association Rule, Apriori, FP-Growth

I. INTRODUCTION

Association rule mining is a technique used to uncover patterns and relationships within big datasets. By identifying associations between different variables, this method provides valuable understandings that can inform predictions, decisions, and strategic actions. The primary objective of association rule mining is to reveal rules that describe how items of datasets are related to one another [1].

Consider, example, a dataset representing transactions in a grocery store. Association rule mining identifies relationships between items that are often purchased together. A common rule mined from such a dataset could be, "If a customer buys bread, they are likely to also buy milk." These rules can drive decisions related to store layout, product placement, and marketing strategies, ultimately enhancing customer experience and business performance [1].

The process of association rule mining typically involves using algorithms that analyze data to detect relationships between variables. These algorithms, which may be based on statistical methods or machine learning techniques, generate rules that are often expressed in the form of "if-then" statements. The antecedent (the "if" part) represents the condition being tested, while the consequent (the "then" part) denotes the outcome that follows when the condition is met [2].

Association rule analysis plays a vital role in data analysis by helping identify hidden patterns that may not be directly apparent. By revealing associations among variables, it aids in understanding the connections between them, thereby providing insights into market trends, customer behaviors, and other critical factors. In addition, association rule analysis serves as a foundation for more advanced data analysis techniques, such as outcome prediction and the identification of key drivers behind various phenomena. As a versatile and valuable tool, association rule mining is integral to extracting meaningful insights and comprehending the underlying structure of data across diverse applications.

Association Rule Algorithms:

Association rule analysis involves identifying patterns in large datasets by discovering relationships between items. A number of algorithms have been developed to perform this task, each with its own strengths and techniques for generating association rules [3]. Some of the most commonly used algorithms are:

1. Apriori Algorithm

It is one of the most widely utilized methods for association rule analysis. It operates by identifying frequent itemsets within a dataset—combinations of items that appear together in a given number of transactions. Once these frequent itemsets are determined, the algorithm generates association rules that describe the likelihood of items being purchased together. For example, a rule might state, "If item A is purchased, and then item B is likely to be purchased as well." The Apriori algorithm employs a bottom-up method, by examining individual items and progressively combining them into itemsets that are more complex. This iterative process helps uncover associations among multiple items, making it effective for market basket analysis and other similar applications. While powerful, the Apriori algorithm can become computationally expensive for very large datasets due to its need to evaluate numerous combinations of items [4].

2. FP-Growth Algorithm

Frequent Pattern Growth algorithm is another widely used method for association rule mining. Unlike Apriori, which generates candidate itemsets and prunes them based on support thresholds, FP-Growth uses a more efficient technique by constructing a tree-like structure known as an FP-tree. This tree encodes the frequent itemsets of the dataset, and the FP-tree is then used to extract the association rules. This algorithm is quicker than Apriori, particularly when dealing with large datasets, because it avoids the need for generating candidate itemsets explicitly. This makes FP-Growth more scalable and suitable for handling data with a big number of items or complex relationships [5].

3. ECLAT Algorithm

Equivalence Class Clustering and bottom-up Lattice Traversal algorithm is a variation of the Apriori algorithm that utilizes a top-down approach for identifying frequent itemsets. ECLAT works by first dividing items into equivalence classes based on their support, which is the frequency with which items appear in transactions. These equivalence classes are then combined in a lattice structure, which helps generate association rules by exploring all possible combinations of itemsets. ECLAT is more efficient than Apriori because it uses a vertical data format and avoids generating candidate itemsets in a bottom-up manner. This makes it particularly useful for big datasets, as it is both faster and more scalable compared to traditional algorithms [6], [7] .

Each of these algorithms has its strengths and is chosen based on the size and nature of the dataset being analyzed. While Apriori remains the most well - known method, FP-Growth and ECLAT offer more efficient alternatives for handling large and complex data sets.

Association Rules Evaluation Metrics:

In association rule, support, confidence, and lift are important metrics used to evaluate the quality and strength of the association rules [8] . These metrics help to quantify the relationships between items in a transaction database. Below is an explanation of each:

1. Support

Support refers to the frequency or proportion of transactions in the dataset that contain a specific item or itemset. It is a measure of how frequently an itemset appears in the database.

Support of an itemset X is calculated as the fraction of transactions that contain the itemset X.

$$Support(X) = \frac{Number\ of\ transactions\ contating\ X}{Total\ Number\ of\ Transactions}$$

A high support value indicates that the itemset occurs frequently in the dataset, while a low support value indicates that the itemset is rare.

2. Confidence

Confidence measures the likelihood that a rule holds true, given that the left-hand side (antecedent) of the rule is present in a transaction. It represents the probability that item B appears in a transaction given that item A is present.

Confidence of an association rule A → B is the probability of finding item in a transaction given that item A is already in the transaction.

$$Confidance\ (A \rightarrow B) = \frac{Support(AUB)}{Support(A)}$$

where A ∪ B represents the set of transactions that contain both A and B, and A represents the set of transactions containing only A.

Confidence quantifies the strength of the implication of the rule. A high confidence value means that, if item A is present, item B is likely to be present as well. A confidence value of 1 means that item B is always bought when item A is bought.

3. Lift

Lift is a metric used to measure the strength of a rule, considering how much more likely the items are to co-occur than if they were independent. It compares the observed support of a rule with the expected support if A and B were independent.

Lift is the ratio of the observed support to the expected support under the assumption of independence.

$$Lift(A \rightarrow B) = \frac{Support(A \cup B)}{Support(A) X\ Support(B)}$$

A lift value of 1 indicates that there is no association between the items, i.e., they are independent. A lift value greater than 1 indicates that A and B are positively correlated and appear together more often than expected by chance. A lift value less than 1 indicates a negative correlation, meaning that the items tend to appear together less often than expected [9] .

Association Rule Analysis using R:

In R, a variety of libraries is available to facilitate the process of association rule mining, each catering to different aspects of the task. Some of the most commonly used R libraries for this purpose [10] .

1. arules

The arules package in R is a fundamental tool for mining association rules and frequent itemsets. It is widely used for analyzing transactional data, such as sales data, where it can uncover patterns and relationships between items. The package provides comprehensive functionality for reading and manipulating transaction data, as well as generating association rules. Additionally, arules includes features for evaluating the quality of generated rules through metrics such as support, confidence, and lift, making it a versatile library for association rule mining.

2. arulesViz

To complement the arules package, arulesViz is a visualization tool specifically designed for displaying association rules and frequent itemsets. It provides functions that allow users to create a range of plots and charts that aid in the interpretation and understanding of the mining results. By using arulesViz, users can visualize complex relationships and patterns in an intuitive way, which is essential for deriving actionable insights from the data.

3. arulesSequences

The arulesSequences package extends the functionality of arules by enabling the mining of association rules from sequential data. Sequential data refers to data in which the order of transactions matters, such as customer purchasing patterns over time. This package provides tools for handling sequential data, generating sequential association rules, and evaluating their quality. It is particularly useful in contexts such as time-series analysis, web usage mining, and market basket analysis where the temporal sequence of events is important.

Implementing Association Rules in R:

Using R and the arules and arulesViz packages, we can generate frequent itemsets by implementing Apriori algorithm.

install.packages('arules')
install.packages('arulesViz')
library ('arules')
library ('arulesViz')

Above commands install R Packages and import them in current R workspace.

Groceries Dataset:

data(Groceries)
Groceries

Transactions in sparse format with 9835 transactions (rows) and 169 items (columns)

The summary shows that the most frequent items in the dataset include items such as whole milk other vegetables, rolls/buns, soda and Yogurt. These items are more purchased more often than the others.

Summary(Groceries)

```
> summary(Groceries)
transactions as itemMatrix in sparse format with
 9835 rows (elements/itemsets/transactions) and
 169 columns (items) and a density of 0.02609146

most frequent items:
      whole milk other vegetables       rolls/buns             soda
            2513             1903             1809             1715
          yogurt          (Other)
            1372            34055

element (itemset/transaction) length distribution:
sizes
   1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16
2159 1643 1299 1005  855  645  545  438  350  246  182  117   78   77   55   46
  17   18   19   20   21   22   23   24   26   27   28   29   32
  29   14   14    9   11    4    6    1    1    1    1    3    1

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.000   2.000   3.000   4.409   6.000  32.000

includes extended item information - examples:
       labels  level2           level1
1 frankfurter sausage meat and sausage
2     sausage sausage meat and sausage
3  liver loaf sausage meat and sausage
> 
```

Generation of Frequent Itemset:

The apriori ( ) function from the arule package implements the apriori algorithm to create frequent itemsets. We considered minimum support threshold is set to 0.02 based on management discretion.

The following code identifies 59 frequent 1 itemset that satisfy the minimum support

```
> itemsets <- apriori(Groceries, parameter=list(minlen = 1, maxlen = 1, support=0.02, t
arget = "frequent itemsets"))
Apriori

Parameter specification:
 confidence minval smax arem  aval originalSupport maxtime support minlen maxlen
         NA    0.1    1 none FALSE            TRUE       5    0.02      1      1
            target   ext
 frequent itemsets TRUE

Algorithmic control:
 filter tree heap memopt load sort verbose
    0.1 TRUE TRUE  FALSE TRUE    2    TRUE

Absolute minimum support count: 196
```

```
> summary(itemsets)
set of 59 itemsets

most frequent items:
frankfurter     sausage         ham        meat     chicken     (Other)
          1           1           1           1           1          54

element (itemset/transaction) length distribution:sizes
 1
59

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
      1       1       1       1       1       1

summary of quality measures:
    support            count
 Min.   :0.02105   Min.   : 207.0
 1st Qu.:0.03015   1st Qu.: 296.5
 Median :0.04809   Median : 473.0
 Mean   :0.06200   Mean   : 609.8
 3rd Qu.:0.07666   3rd Qu.: 754.0
 Max.   :0.25552   Max.   :2513.0
```

Inspect function is used to display the top 10 frequent 1-itemsetssorted by their support.

```
> inspect(head(sort(itemsets, by = "support"), 10))
     items               support    count
[1]  {whole milk}        0.25551601 2513
[2]  {other vegetables}  0.19349263 1903
[3]  {rolls/buns}        0.18393493 1809
[4]  {soda}              0.17437722 1715
[5]  {yogurt}            0.13950178 1372
[6]  {bottled water}     0.11052364 1087
[7]  {root vegetables}   0.10899847 1072
[8]  {tropical fruit}    0.10493137 1032
[9]  {shopping bags}     0.09852567  969
[10] {sausage}           0.09395018  924
```

```
> itemsets <- apriori(Groceries, parameter=list(minlen = 2, maxlen = 2, support=0.02, target = "frequent itemsets"))
Apriori

Parameter specification:
 confidence minval smax arem  aval originalSupport maxtime support minlen maxlen
         NA    0.1    1 none FALSE            TRUE       5    0.02      2      2
            target   ext
 frequent itemsets TRUE

Algorithmic control:
 filter tree heap memopt load sort verbose
    0.1 TRUE TRUE  FALSE TRUE    2    TRUE

Absolute minimum support count: 196
```

```
> inspect(head(sort(itemsets, by = "support"), 10))
     items                                support    count
[1]  {other vegetables, whole milk}       0.07483477 736
[2]  {whole milk, rolls/buns}             0.05663447 557
[3]  {whole milk, yogurt}                 0.05602440 551
[4]  {root vegetables, whole milk}        0.04890696 481
[5]  {root vegetables, other vegetables} 0.04738180 466
[6]  {other vegetables, yogurt}           0.04341637 427
[7]  {other vegetables, rolls/buns}       0.04260295 419
[8]  {tropical fruit, whole milk}         0.04229792 416
[9]  {whole milk, soda}                   0.04006101 394
[10] {rolls/buns, soda}                   0.03833249 377
> 
```

II. USE CASES OF ASSOCIATION RULE ANALYSIS:

Association rule mining is a powerful technique commonly applied across a wide range of industries and applications. Below are some key use cases that demonstrate its versatility:

Market Basket Analysis

One of the most prevalent uses of association rule mining is in market basket analysis, where businesses analyze the items customers frequently purchase together. This analysis helps in understanding consumer purchasing behavior and preferences.

For example, a retailer might uncover a pattern where customers who purchase diapers are also likely to buy baby formula. With this insight, the retailer can strategically optimize product placements and design targeted promotions, thereby increasing sales and enhancing customer satisfaction.

Customer Segmentation

Association rule mining can effectively utilized to segment customers based on their purchasing habits. For example, a business might find that younger customers are more inclined to buy specific product categories, or that certain product combinations are more common among customers from particular geographic regions.

These findings can help companies craft personalized marketing strategies and product recommendations tailored to different customer segments.

Fraud Detection

By analyzing transaction patterns, businesses can identify suspicious or anomalous behavior that might indicate fraudulent activity. For example, a credit card company could use association rule mining to detect patterns such as multiple transactions from the same merchant within a short period, a behavior that could signal fraud. This information enables companies to flag potential fraud and take proactive measures to protect their customers.

Social Network Analysis

Association rule analysis helps uncover patterns in social media and other network data.

For example, analyzing Twitter data might reveal that users who engage with a specific topic are also likely to engage with related topics, providing insights into the formation of groups or communities within the network. This analysis is valuable for businesses or researchers aiming to understand social dynamics and behavior in digital environments.

Recommendation Systems

By analyzing past purchases or browsing history, businesses can recommend products or services that a customer is likely to be interested in. For example, a music streaming platform might use association rule mining to recommend artists or albums to a user based on their previous listening patterns. This helps create personalized user experiences, increasing engagement and customer retention.

III.CONCLUSION:

Association rule analysis proves to be an essential tool for data analysis, offering significant value in uncovering patterns and relationships within datasets. R provide a range of libraries that enable efficient implementation of various algorithms, along with features for visualizing results. The versatility of association rule mining allows it to be applied across different contexts to extract meaningful insights and reveal the underlying structure of data. However, careful selection of the appropriate algorithm and fine-tuning of parameters, such as minimum support and confidence thresholds, are essential for obtaining accurate and meaningful results.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

On Some Properties of Laplace Transform and Applications

Changdev Jadhav[1], N. G. Patil[2], Sonali R. Deshmukh[1]
[1]Department of Mathematics, Deogiri Institute of Engineering & Management Studies, Chhatrpati Sambhajinagar Maharashtra, India
[2]Department of Mathematics, M. S. Bidve Engineering College, Latur, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
122-129

ABSTRACT

In this work we study the action of the fractional Laplace transform [6] on the fractional derivative of Riemann-Liouville. The properties of the transformation of the convolution product, defined as MIANA, were also presented. As an example, we solve the differential equation.

Keywords: Integral Laplace Transform, Convolution products, Fractional derivative.

I. INTRODUCTION

In 1695, the concept of fractional derivatives first appeared in a famous letter between L'Hospital and Leibniz. Many great mathematicians have further developed this field. We can mention Euler, Lagrange, Laplace, Fourier, Abel, Liouville, Riemann, Hardy, Littlewood and Weyl. Over the past decades, fractional calculus has been considered one of the best tools for describing long-term memory processes. Such models are of interest to physicists, engineers and mathematicians. Fractional calculus has important applications in various fields such as physics, mechanics, electricity, biology, economics, control theory, etc. An introduction and application of fractional calculus may refer to [7-15]. Fractional calculus includes derivatives and integrals of any real or complex order. There is no specific definition of fractional derivative and integral. Common definitions include Riemann Liouville (R-L) fractional derivative, Caputo fractional derivative, Grunwald Letinikov (G-L) fractional derivative and Jumarie's modified R-L fractional derivative [1-4].

II. PRELIMINARIES

We begin by recalling some basic definitions of fractional derivatives and integral transforms.

Definition 1. [7] Let $f = f(t)$ be a function of R. The Laplace transform $f(s)$ is given by the integral

$$\tilde{f}(s) = \mathfrak{L}[f(t)]_{(s)} = \int_0^{\infty} e^{-st} f(t)dt \qquad (1.1)$$

Definition 2. Let A(R_0^+) a function of the space:

i) f is piecewise continuous in the interval 0 ≤t≤ T for any T ∈ R_0^+.

ii) f it is of exponential order,

$$|f(t)| \leq Ke^{at}$$

for t> M where M, K y a are real positive constants.

The parameter a is called the abscissa of the convergence of the Laplace transform. So, we have next classic definition of Laplace transform.

Definition 3. Let f = f(t) a function defined in R_0^+.

The incomplete Laplace transform $\check{f}$(s) is given by the integral

$$\mathfrak{L}[f(t), b]_{(s)} = \int_0^{b} e^{-st} f(t)dt \qquad (1.2)$$

for b, s ∈ R

Definition 4 [6] Let f = f(t) by a function of R_0^+. The $\alpha -$ Integral Laplace Transform $\check{f}$ α(s) of order α ∈ R+ is given the integral

$$\tilde{f}_{\alpha}(s) = \mathfrak{L}_{\alpha}[f(t)](s) = \int_0^{\infty} e^{-s^{1/\alpha}t} f(t)dt \qquad (1.3)$$

for s ∈ R

The $\alpha -$ Integral Laplace Transform it is a generalization of the Laplace transform so that when $\alpha \to 1$. That is to say

$$\mathfrak{L}_1[f(t)](s) = \mathfrak{L}[f(t)](s) \qquad (1.4)$$

Then we can generalize

Theorem 2. If f(t) ∈ A(R_0^+), then there $\tilde{f}$α(s) = $\mathfrak{L}_\alpha$[f(t)](s) for s > a^{α} Note that it is natural to enunciate the following

Lemma 2. *Let f be a function running sufficiently and let α be a real number, 0 < α < 1. The fractional Laplace transform of the function f is given by*

$$\mathfrak{L}_{\alpha}[f](s) = \mathfrak{L}[f](\mu), \mu = s^{\frac{1}{\alpha}}$$

Proof: Follow from the definition (1.3)

If $f^{(k)}$(t) ϵ A(R_0^+) con k = 1, 2, ...n y n ∈ N then

$$\mathfrak{L}_{\alpha}\left[\left(\frac{df(t)}{dt}\right)^{n}\right](s) = s^{\frac{n}{\alpha}}\mathfrak{L}_{\alpha}[f(t)](s) - \sum_{k=1}^{n} s^{\frac{n-k}{\alpha}} f^{k-1}(0) \qquad (1.5)$$

Recall

$$\mathfrak{L}\left[\left(\frac{df(t)}{dt}\right)^{n}\right](\mu) = \mu^{n}\mathfrak{L}_{\alpha}[f(t)](s) - \sum_{k=1}^{n} \mu^{n-k} f^{k-1}(0) \qquad (1.6)$$

and

$$\mathfrak{L}_{\alpha}[f](s) = \mathfrak{L}[f](\mu), \mu = s^{\frac{1}{\alpha}}$$

we obtained

$$\mathfrak{L}_{\alpha}\left[\left(\frac{df(t)}{dt}\right)^{n}\right](s) = s^{\frac{n}{\alpha}}\mathfrak{L}_{\alpha}[f(t)](s) - \sum_{k=1}^{n} s^{\frac{n-k}{\alpha}} f^{k-1}(0)\blacksquare \qquad (1.7)$$

Now, we are able to find the inversion formula for the k-TL.

$$\mathfrak{L}_\alpha[f](s) = \mathfrak{L}[f](\mu) = g_1(\mu), \mu = s^{\frac{1}{\alpha}}$$

then

$$f(t) = \mathfrak{L}_\alpha^{-1}[\mathfrak{L}_\alpha[f](s)] = \mathfrak{L}^{-1}(g_1(\mu))(t)$$

applying the Laplace inverse transform gives

$$\mathfrak{L}^{-1}(g_1(\mu))(t) = \frac{1}{2\pi i}\int_{a-i\infty}^{a+i\infty} e^{\mu t} g_1(\mu) d\mu = \frac{1}{2\pi i}\int_{a-i\infty}^{a+i\infty} e^{\mu t}\mathfrak{L}[f](\mu) d\mu (1.8)$$

and making the change of variable μ =$S^{\frac{1}{\alpha}}$, where dμ = $\frac{1}{\alpha}s^{\frac{1}{\alpha}-1}$

$$\mathfrak{L}^{-1}(g_1(\mu))(t) = \frac{1}{2\pi i}\int_{a^\alpha-i\infty}^{a^\alpha+i\infty} e^{s^\alpha t}\mathfrak{L}_\alpha[f](s)\frac{1}{\alpha}s^{\frac{1}{\alpha}-1} ds \qquad (1.9)$$

From this expression we have the following

Definition 5. Let f be α sufficiently well-ordered function and a real number, 0 < α < 1. The inverse α -integral Laplace transform is given by

$$\mathfrak{L}_\alpha^{-1}[\bar{f}_\alpha(s)](t) = \frac{1}{2\pi i\alpha}\int_{a^\alpha-i\infty}^{a^\alpha+i\infty} e^{s^\alpha t}\bar{f}_\alpha(s)s^{\frac{1-\alpha}{\alpha}} ds \qquad (1.10)$$

Remark. By changing the variable μ = $S^{\frac{1}{\alpha}}$, and noting the formulas establishing the relationship between the conventional and fractional Laplace transforms, we can easily prove that

$$\mathfrak{L}_\alpha[\mathfrak{L}_\alpha^{-1}] = \text{Id}$$

where Id denotes the identity operator.

Definition 6. Let *f* and g functions belonging to $L^1(R^+)$, the usual or classic convolution product is given by

$$(f * t)(t) = \int_0^t f(\tau)g(t-\tau)d\tau \ , \ t > 0 \qquad (1.11)$$

Definition 7. Let *f* and g functions belonging to $L^1(R^+)$, Miana in [2] introduce the convolution product o as the integral

$$(f \circ g)(t) = \int_t^\infty f(\tau - t)g(\tau)d\tau \ , \ t > 0 \qquad (1.12)$$

III.MAIN RESULT

Let $\lambda \in R^+$, *f* and g functions belonging to $L^1(R^+)$ and the exponential function $e_{\lambda 1/\alpha} = e^{\lambda 1/\alpha t}$ then:

i) $f \circ e_{\lambda^{1/\alpha}} = \mathfrak{L}_\alpha[f](\lambda).e_{\lambda^{1/\alpha}}$

ii) $e_{\lambda^{1/\alpha}} \circ f = \mathfrak{L}_\alpha[f](\lambda^\alpha)e_{-\lambda^{1/\alpha}} - (e_{-\lambda} * f)(t)$

iii) $\mathfrak{L}_\alpha(f \circ g)(s) = \mathfrak{L}_\alpha(g\mathfrak{L}_\alpha(f,.)(-s^{1/\alpha}))(s)$

Proof

i) From definition 7 we have

$$(f \circ e_{\lambda^{1/\alpha}})(t) = \int_t^\infty f(\tau - t)e^{-\lambda^{1/\alpha}\tau} d\tau$$

if $u = \tau - t$, then $du = d\tau$

$$\begin{aligned}(f \circ e_{\lambda^{1/\alpha}})(t) &= \int_0^\infty f(u) e^{-\lambda^{1/\alpha}(u+t)} du \\ &= \left[\int_0^\infty f(u) e^{-\lambda^{1/\alpha} u} du\right] .e_{\lambda^{1/\alpha}} \\ &= \mathfrak{L}_\alpha[f](\lambda).e_{\lambda^{1/\alpha}}\end{aligned}$$

ii) From definition 7 we have

$$(e_{\lambda^{1/\alpha}} \circ f)(t) = \int_t^\infty e^{-\lambda^{1/\alpha}(\tau - t)} f(\tau) d\tau \qquad (2.1)$$

as f y $e_{-\lambda 1/\alpha}$ are functions belonging to $L^1(R^+)$, then $e_{-\lambda 1/\alpha} * f \in L^1(R^+)$ we obtain

$$\begin{aligned}(e_{\lambda^{1/\alpha}} \circ f)(t) &= \left(\int_0^\infty e^{-\lambda^{1/\alpha}(\tau-t)} f(\tau) d\tau\right) - (e_{-\lambda} * f)(t) \\ &= \left(\int_0^\infty e^{-\lambda^{1/\alpha}\tau} f(\tau) d\tau\right) e_{-\lambda^{1/\alpha}} - (e_{-\lambda} * f)(t) \\ &= \mathfrak{L}_\alpha[f](\lambda) e_{-\lambda^{1/\alpha}} - (e_{-\lambda^{1/\alpha}} * f)(t)\end{aligned}$$

iii) Let f and g functions belonging to $L^1(R^+)$, from definition 7 we have

$$(f \circ g)(t) = \int_t^\infty f(\tau - t) g(\tau) d\tau \ , \ t > 0$$

applying definition 4 we obtain

$$\begin{aligned}\mathfrak{L}_\alpha[(f \circ g)(t)](s) &= \int_0^\infty e^{-s^{1/\alpha}t} (f \circ g)(t) dt \\ &= \int_0^\infty e^{-s^{1/\alpha}t} \left(\int_t^\infty f(\tau - t) g(\tau) d\tau\right) dt\end{aligned}$$

Applying Fubini's Theorem we have

$$\int_0^\infty e^{-s^{1/\alpha}t} \left(\int_t^\infty f(\tau - t) g(\tau) d\tau\right) dt = \int_0^\infty g(\tau) \left(\int_0^\tau e^{-s^{1/\alpha}t} f(\tau - t) dt\right) d\tau$$

If T < t < ∞, 0 < T < ∞ and we consider changing the variable u = 7 — t, then 7 = u+t, 0 < u < ∞ and the differential dt = du

$$\begin{aligned}\mathfrak{L}_\alpha[(f \circ g)(t)](s) &= \int_0^\infty g(\tau) \left(\int_0^\tau e^{-s^{1/\alpha}(\tau - u)} f(u) du\right) d\tau \\ &= \int_0^\infty e^{s^{1/\alpha}\tau} g(\tau) \left(\int_0^\tau e^{s^{1/\alpha}u} f(u) du\right) d\tau \\ &= \mathfrak{L}_\alpha(g\mathfrak{L}(f,.)(-s^{1/\alpha}))(s)\end{aligned}$$

α-Laplace Transform of Fractional Riemann- Liouville Operator

In this last section we consider Riemann-Liouville fractional operators and we show the results of applying our α-Laplace transform to them.

First, we need some preliminary definitions and results.

Definition 8. Let f be a locally integrable function on (a, +∞). The Riemann-Liouville integral of order α, of the function f is given by

$$I_x^\alpha f(t) \doteq \frac{1}{\Gamma(\alpha)} \int_a^x (x - t)^{\alpha - 1} f(t) dt \qquad (3.1)$$

here (a) denotes the Gamma function of Euler

$$\Gamma(z) = \int_0^\infty e^{-t}t^{z-1}dt \quad (3.2)$$

For $\alpha > 1$, and t > 0, let $j\alpha(t) = \frac{t^{\alpha-1}}{\Gamma(\alpha)}$, be the singular kernel of Riemann-Liouville.

It can be proved that the Riemann–Liouville fractional integral convolution can be expressed as

$$I_x^\alpha f(t) = \left(\frac{t^{\alpha-1}}{\Gamma(\alpha)} * f\right)(x) \quad (3.3)$$

A Riemann-Liouville fractional derivative inverse of order a is defined

$$D_x^\alpha I_x^\alpha = id$$

Another way to define this fractional derivative is as follows.

Definition 9. Let be a real number and let i be an integer. Then the Riemann-Liouville fractional derivative of order a is given by

$$D_x^\alpha f(t) = \left(\frac{d}{dx}\right)^m I_x^{m-\alpha} f(t) \quad (3.4)$$

Lemma 1. *Let f be a sufficiently well-behaved function and let α be a real number, 0 < α < 1. The Laplace transform of the Riemann-Liouville fractional integral of a function f is given*

$$\mathfrak{L}[I^\alpha f](s) = (s)^{-\alpha}\mathfrak{L}[f](s) \quad (3.5)$$

Lemma 2. *Let f be a sufficiently well-ordered function and let α be a real number, 0 < α <1. The Laplace transform of the Riemann–Liouville fractional derivative of a function f is given by*

$$\mathfrak{L}[D^\alpha f(t)](s) = s^\alpha \mathfrak{L}[f(t)](s) - I^\alpha f(t)|_{t=0} \quad (3.6)$$

Lemma 3. *Let f be a sufficiently well-ordered function and let α be a real number, 0 < α <1. The Laplace transform of the Riemann-Liouville fractional integral of a function f is given*

$$\mathfrak{L}_\alpha[I_x^\beta f](s) = (s)^{\beta/\alpha}\mathfrak{L}_\alpha[f](s) \quad (3.7)$$

Proof: For t > 0 and y $\beta \in R$ [6]

$$\mathfrak{L}_\alpha[t^\beta] = \frac{\Gamma(\beta+1)}{s^{\frac{\beta+1}{\alpha}}} \quad (3.8)$$

From definition 4 and (3.8) we have

$$\mathfrak{L}_\alpha[j_\beta(t)](s) = s^{-\beta/\alpha} \quad (3.9)$$

recall (3.3)

$$I_x^\alpha f(x) = j_\beta(t) * f(t) \quad (3.10)$$

applying definition 4 to (3.10) and (3.8) properties

$$\begin{aligned} \mathfrak{L}_\alpha(I^\beta f(x)) &= \mathfrak{L}_\alpha[j_\beta(t) * f(t)](s) \\ &= \mathfrak{L}_\alpha[j_\beta(t)](s).\mathfrak{L}_\alpha[f](s) \\ &= s^{-\beta/\alpha}.\mathfrak{L}_\alpha[f](s) \end{aligned}$$

Lemma 4. *Let f be a sufficiently well-ordered function and let α be a real number, 0 < α <1. The Laplace transform of the Riemann–Liouville fractional derivative of a function f is given by*

$$\mathfrak{L}_\alpha[D^\alpha f(t)](s) = s^{\beta/\alpha}\mathfrak{L}_\alpha[f(t)](s) - I^{1-\alpha} f(t)|_{t=0} \quad (3.11)$$

Proof by definition 9 we have that if 0 < β ≤ 1, m = 1 y

$$\mathfrak{L}_\alpha[D_x^\beta f(t)](s) = \mathfrak{L}_\alpha[\frac{d}{dx} I_x^{1-\beta} f(t)](s) \quad (3.12)$$

by Lemma 2 we have

$$\begin{aligned}\mathfrak{L}_\alpha[\frac{d}{dx}I_x^{1-\beta}f(t)](s) &= s^\beta\mathfrak{L}_\alpha[I_x^{1-\beta}f]-I_x^{1-\beta}\\ &= s^{1/\alpha}s^{-(1-\beta)/\alpha}\mathfrak{L}_\alpha[f]-I_x^{1-\beta}|_{t=0}\\ &= s^{1/\alpha}s^{-(1-\beta)/\alpha}\mathfrak{L}_\alpha[f]-I_x^{1-\beta}|_{t=0}\\ &= s^{\beta/\alpha}\mathfrak{L}_\alpha[f]-I_x^{1-\beta}|_{t=0}\end{aligned}$$

Mittag-Leffler

Mittag-Leffler type functions play an important role in the theory of fractional differential equations (FDEs). First, we introduce the two-parameter Mittag-Leffler function defined by formula (4.1).

$$E_{\alpha,\beta}(\lambda t^\alpha)=\sum_{k=0}^{\infty}\frac{(\lambda t^\alpha)^k}{\Gamma(\alpha k+\beta)} \qquad (4.1)$$

As we will see later, solutions of FDES appear to have classical derivatives of the Mittag-Leffler function. Since the series (4.1) is uniformly convergent, we can differentiate term by term and obtain

$$E_{\alpha,\beta}^{(m)}(\lambda t^\alpha)=\sum_{k=0}^{\infty}\frac{(k+m)!}{k!}\frac{(\lambda t^\alpha)^k}{\Gamma(\alpha k+\alpha m+\beta)} \qquad (4.2)$$

Theorem 6. Let γ, β ∈ C, R(γ) > 0, R(β) > 0, λ ∈ R. Then hold

$$\mathfrak{L}_\alpha\left(t^{\gamma m+\beta-1}E_{\gamma,\beta}^{(m)}(\lambda t^\gamma)\right)=\frac{s^{\frac{\gamma-\beta}{\alpha}}}{(s^{\gamma/\alpha}-\lambda)^{m+1}} \qquad (4.3)$$

Proof : Remember the next series convergence

$$\sum_{k=0}^{\infty}\frac{(k+m)!}{k!}x^k=\frac{m!}{(1-x)^{m+1}} \qquad (4.4)$$

Then

$$\begin{aligned}\mathfrak{L}_\alpha\left(t^{\gamma m+\beta-1}E_{\gamma,\beta}^{(m)}(\lambda t^\gamma)\right) &= \sum_{k=0}^{\infty}\frac{(k+m)!\lambda^k}{k!}\frac{\mathfrak{L}_\alpha[t^{\gamma k+\gamma m+\beta-1}]}{\Gamma(\gamma k+\gamma m+\beta)}(s)\\ &= \sum_{k=0}^{\infty}\frac{(k+m)!\lambda^k}{k!}\frac{\Gamma(\gamma k+\gamma m+\beta)}{\Gamma(\gamma k+\gamma m+\beta)s^{\frac{\gamma k+\gamma m+\beta-1+1}{\alpha}}}\\ &= \sum_{k=0}^{\infty}\frac{(k+m)!}{k!}\frac{\lambda^k}{s^{\frac{\gamma k+\gamma m+\beta}{\alpha}}}\\ &= s^{\frac{-\gamma m-\beta}{\alpha}}\sum_{k=0}^{\infty}\frac{(k+m)!}{k!}(\lambda s^{-\gamma/\alpha})^k\\ &= s^{\frac{-\gamma m-\beta}{\alpha}}\frac{m!}{(1-\lambda s^{-\gamma/\alpha})^{m+1}}\\ &= s^{\frac{-\gamma m-\beta}{\alpha}}\frac{m!}{s^{-(m+1)\gamma/\alpha}(s^{\gamma/\alpha}-\lambda)^{m+1}}\\ &= \frac{s^{\frac{\gamma-\beta}{\alpha}}}{(s^{\gamma/\alpha}-\lambda)^{m+1}}\end{aligned}$$

Example

A slight generalization of an equation solved in [4]

$$D^{\frac{1}{2}}f(t)+af(t)=0; \qquad I^{\frac{1}{2}}f(t)|_{t=0}=C \qquad (5.1)$$

applying the α-Integral Laplace Transform, with $\alpha=\frac{1}{2}$, we obtained

$$\mathfrak{L}_{\frac{1}{2}}\left(D^{\frac{1}{2}}f(t)+af(t)\right) = 0 \quad (5.2)$$

$$s\mathfrak{L}_{\frac{1}{2}}[f(t)](s) - I^{\frac{1}{2}}f(t)|_{t=0} + a\mathfrak{L}_{\frac{1}{2}} = 0 \quad (5.3)$$

$$\mathfrak{L}_{\frac{1}{2}}[f(t)](s) = \frac{C}{s+a} \quad (5.4)$$

$$(5.5)$$

and applying definition (1.10) gives the solution of (5.1)

$$\mathfrak{L}_{\frac{1}{2}}^{-1}\left(\mathfrak{L}_{\frac{1}{2}}[f(t)](s)\right) = \mathfrak{L}_{\frac{1}{2}}^{-1}\left(\frac{C}{s+a}\right) \quad (5.6)$$

$$f(t) = Ct^{-\frac{1}{2}}E_{\frac{1}{2},\frac{1}{2}}(-at^{\frac{1}{2}}) \quad (5.7)$$

is identical to solution obtained in [8]

IV. CONCLUSION

Fractional Laplace transform is used to solve fractional differential equations. In fact, the method we use is a generalization of the Laplace transform of analytic functions. Additionally, the new multiplication we defined is a natural operation in fractional calculus and plays an important role in this article.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Literature Review: Developing an Attendance Management System using Face Recognition Technology

Shireeshkumar Sharadkumar Rudrawar
Dyanopasak Shikshan Mandal's Arts, Commerce & Science College, Jintur, Parbhani, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
130-134

ABSTRACT

Attendance management systems are integral to organizations and educational institutions for tracking participation. Traditional methods, such as manual roll calls or ID card systems, are time-consuming and prone to errors. Face recognition technology has emerged as an efficient and automated alternative, leveraging advancements in computer vision and artificial intelligence

Keywords: Attendance Management System, Face Recognition Technology.

I. INTRODUCTION

Overview of Face Recognition Technology

Face recognition involves identifying or verifying individuals using facial features extracted from images or video frames. Techniques such as Convolutional Neural Networks (CNNs), deep learning, and feature extraction algorithms like Local Binary Patterns Histograms (LBPH) have improved accuracy and speed. According to Parkhi et al. (2015), deep learning-based models, such as FaceNet, have significantly enhanced recognition performance in complex environments.

1.1 How Face Recognition Works

The process of face recognition generally involves the following steps:

1. **Face Detection**: The system detects the presence of a face in an image or video. Algorithms such as Viola-Jones or modern deep learning models like YOLO (You Only Look Once) are commonly used.
2. **Feature Extraction**: Key features, such as the distance between eyes, nose shape, or jawline, are extracted from the detected face. Feature extraction techniques include:
    - **Histogram of Oriented Gradients (HOG)**
    - **Scale-Invariant Feature Transform (SIFT)**
    - **Deep Learning models like Convolutional Neural Networks (CNNs)**

3. **Face Matching**: Extracted features are compared to a database of known faces to find a match. Methods like **Euclidean distance** or **cosine similarity** are used to measure the similarity between facial embeddings.

1.2 Algorithms and Techniques

Modern face recognition relies heavily on deep learning for accuracy and scalability. Popular approaches include:

- **Convolutional Neural Networks (CNNs)**: CNNs, such as those used in FaceNet and DeepFace, are the backbone of modern face recognition. They create high-dimensional feature vectors (embeddings) to uniquely represent each face.
- **Local Binary Patterns Histograms (LBPH)**: A simpler algorithm often used for smaller applications. LBPH captures texture information and works well in controlled environments.
- **Deep Metric Learning**: Techniques like triplet loss in FaceNet allow models to distinguish between similar faces more effectively.

1.3 Advantages of Face Recognition

- **Non-Intrusive**: Does not require physical contact, unlike fingerprint scanners.
- **Automation**: Speeds up tasks like attendance tracking or identity verification.
- **Scalability**: Works efficiently for both small-scale and large-scale applications.

1.4 Technological Advancements

The field has seen significant improvements with:

- **3D Face Recognition**: Uses depth information for higher accuracy in varying lighting or angles.
- **Live Detection**: Differentiates between real faces and images to prevent spoofing.
- **Edge AI**: Processes face recognition on devices, reducing latency and enhancing security.

1.5 Applications

Face recognition is widely applied in:

- **Security**: Surveillance systems and access control.
- **Healthcare**: Patient identification and monitoring.
- **Retail**: Customer analytics and personalized services.
- **Education**: Attendance tracking and behavior analysis.

This technology continues to evolve, driven by the need for greater accuracy and ethical concerns like privacy protection and algorithmic fairness.

II. APPLICATIONS IN ATTENDANCE MANAGEMENT

Automated attendance systems using face recognition minimize human intervention, reduce fraud, and improve efficiency. Gill et al. (2019) demonstrated a system that utilizes face recognition for real-time attendance in classrooms, showing a reduction in errors compared to RFID-based systems. Similarly, Sharma et al. (2020) highlighted the scalability and adaptability of cloud-based systems for large-scale deployments.

2.1. Education Sector

In schools, colleges, and universities, attendance plays a significant role in ensuring student participation and academic accountability. Face recognition systems streamline this process by:

1. **Automating Roll Call**: Cameras installed in classrooms capture students' faces and automatically mark their attendance, eliminating the need for manual registers.

2. **Real-Time Monitoring**: Administrators can monitor student presence in real time, improving classroom discipline and attendance rates.
3. **Enhanced Accuracy**: By reducing errors such as proxy attendance, these systems ensure fairness and integrity in tracking attendance.
4. **Integration with Learning Management Systems (LMS)**: Attendance data can be directly linked to LMS platforms for performance analytics and reporting.

2.2. Corporate Workplaces

In workplaces, accurate attendance tracking is crucial for payroll processing, productivity analysis, and compliance with labor laws. Face recognition systems offer:

1. **Seamless Check-In/Check-Out**: Employees can clock in and out without physical interaction, improving convenience and hygiene.
2. **Fraud Prevention**: By verifying identity through facial features, the system prevents buddy punching or other fraudulent practices.
3. **Flexibility**: These systems can be integrated with remote work policies, allowing organizations to track attendance during virtual meetings or work-from-home setups.

2.3. Event Management

In conferences, workshops, or public events, managing attendee lists is a challenge. Face recognition technology simplifies this by:

1. **Quick Registration**: Attendees are registered and verified within seconds, reducing queues and waiting time.
2. **Access Control**: Only verified attendees are allowed into specific areas, enhancing security.
3. **Analytics and Insights**: Organizers can track attendance trends, such as peak times and crowd distribution, to improve future planning.

2.4. Government and Public Sector

Face recognition technology is also used in public sector programs to ensure transparency and accountability:

1. **Citizen Attendance in Welfare Programs**: Beneficiaries of government schemes can be verified using face recognition, ensuring resources reach the right individuals.
2. **Attendance in Public Offices**: Civil servants' attendance is monitored efficiently, enhancing productivity and discipline.

2.5. Advantages of Face Recognition in Attendance Management

- **Time-Saving**: Automating attendance eliminates delays caused by manual processes.
- **Contactless Process**: Particularly useful during pandemics or in hygienic environments.
- **Scalability**: Can handle large numbers of users simultaneously, making it ideal for institutions and events of all sizes.
- **Data Integration**: Attendance data can be integrated with HR, payroll, or academic systems for seamless operations.

2.6. Case Studies

1. **Educational Institutions**: A study by Sharma et al. (2020) implemented face recognition in classrooms and reduced the time spent on attendance by 75%, with an accuracy rate of over 90%.
2. **Corporate Sector**: Gill et al. (2019) showcased how real-time facial attendance tracking in offices improved employee accountability and streamlined payroll management.

III.CHALLENGES AND LIMITATIONS

Despite advancements, face recognition systems face challenges, such as variations in lighting, pose, occlusion, and ethnicity biases (Nguyen et al., 2018). Privacy concerns also arise due to the storage and processing of biometric data. Addressing these challenges is crucial for widespread adoption in sensitive environments like educational institutions.

3.1. Accuracy and Environmental Conditions

One of the biggest challenges in face recognition is maintaining high accuracy under varying environmental conditions. Factors affecting accuracy include:

1. **Lighting Variations**: Poor or uneven lighting can distort facial features, reducing recognition accuracy. This is a significant issue in real-world scenarios like outdoor environments or dimly lit classrooms (Nguyen & Nguyen, 2018).
2. **Pose Variability**: Faces turned away from the camera or captured at extreme angles can make feature extraction difficult. Even advanced deep learning models like FaceNet struggle with extreme pose variations.
3. **Occlusions**: Objects such as glasses, masks, or hats can obstruct key facial features, leading to recognition failures. The use of masks during the COVID-19 pandemic highlighted this limitation (Kumar et al., 2020).

3.2. Privacy and Ethical Concerns

The use of face recognition technology raises significant privacy and ethical concerns:

1. **Data Security**: Biometric data, once compromised, cannot be reset like passwords. Data breaches pose severe risks, including identity theft (Suo et al., 2021).
2. **Consent and Misuse**: Many individuals are unaware their facial data is being collected, violating privacy rights. Organizations must comply with regulations such as GDPR to ensure user consent.
3. **Surveillance Risks**: The use of facial recognition in public spaces raises concerns about mass surveillance and potential abuse by governments or organizations.

3.3. Bias and Fairness Issues

Face recognition systems can exhibit biases based on race, gender, or ethnicity due to unbalanced training datasets:

1. **Algorithmic Bias**: Studies show that recognition accuracy can differ across demographic groups, with higher error rates for darker-skinned individuals and females (Buolamwini & Gebru, 2018).
2. **Dataset Diversity**: Many systems are trained on datasets lacking diverse representation, leading to skewed results and reduced fairness.

3.4. Scalability and Processing Limitations

1. **High Computational Requirements**: Real-time recognition systems require substantial computational power, especially for large-scale deployments (e.g., tracking attendance in universities or workplaces with thousands of users).
2. **Latency Issues**: On-device or cloud-based systems may experience delays, particularly in systems with suboptimal network infrastructure.

3.5. Cost and Implementation Challenges

1. **High Costs**: The initial setup of cameras, servers, and software is expensive, especially for small institutions or businesses.

2. **Maintenance**: Systems require regular updates to stay secure and compatible with evolving technology.

3.6. Legal and Regulatory Barriers

1. **Data Protection Laws**: Strict regulations like GDPR in Europe and CCPA in California impose stringent requirements on the collection, storage, and use of biometric data.
2. **Legal Uncertainty**: Many jurisdictions lack clear legal frameworks, leaving organizations uncertain about compliance and exposing them to potential lawsuits.

3.7. Spoofing and Security Threats

Face recognition systems are vulnerable to spoofing attacks, such as using printed photos, videos, or 3D masks to fool the system. Anti-spoofing techniques, such as liveness detection, are improving but are not yet foolproof (Nguyen et al., 2020).

3.8. User Acceptance and Adoption

Users may resist adopting face recognition due to concerns about privacy, misuse, and reliability. Educating users and ensuring transparency in the system's operation are critical for acceptance.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Nano Science and Nano Technology in Agriculture and Food Processing

Dr. Hemawati
Associate Professor of Mathematics, Government First Grade Colleg Bhalki-585328, Karnataka, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
135-143

ABSTRACT

Nanotechnology has great potential, as it can enhance the quality of life through its applications in various fields like agriculture and the food system. Around the world it has become the future of any nation. There is a growing demand for healthy and safe food, strategy against an increasing risk of biotic factors such as disease, and threats to agricultural and food production from changing global climate condition. Nanotechnology is a new discipline and developed innovative tools to revolutionize the agricultural and food industry through diagnosis and treatment of diseases, enhancing the ability of plants to absorb nutrients, combat microbial and pest infections, increase the efficiency of biocides, reduce pollution and clean-up existing pollutants. Nanotechnology has been extensively used in food production, plant protection, processing, packaging, transportation of agricultural products and quality control and environmental management with this technological development, societal issues associated with nanotechnology and to improve public awareness are emerging. There is great potential in nanoscience and technology in the provision of state-of-the-art solutions for various challenges faced by agriculture and society today and in the future.

Keywords: Nanotechnology, Agriculture, food processing, food security, Nanoscience.

I. INTRODUCTION

Agriculture sector in India contributes significantly to the national economy. Science and technology has played a significant role in increasing agricultural productivity over the years. Farmers throughout the world will focus on using new innovations and technologies for enhancing the production of crops through intensive and extensive agriculture.

For developing countries, agriculture sector is backbone of their economy including more than 60% of the population which depends upon agriculture to earn their livelihood directly or indirectly [1-3]. But even in 21st century it has to deal with concerns like sustainable use of natural resources, depleting nutrients in soil and environmental issues like runoff and accumulation of fertilizers and pesticides. So, the key is to adopt such a technology that can shape the modern agriculture in a more productive fashion that would ultimately lead to precision farming in a cost-effective way with the delivery of just the right amount of input at the right time [4]. Nanotechnology is a branch of science which deals with various aspects of research and technology. Nanotechnology deals with the matter at nanoscale (1-100 nm) dimensions. These materials when reduced to the nanoscale show some properties which are different from what they exhibit on a macro scale, enabling unique applications. Nanoscience has brought revolution in different fields by helping develop processes and products that are hardly possible to evolve through conventional methods.

Thanks to nanotechnology that the future food will be designed according to consumer's choice with a better taste, texture, nutrient contents and a longer shelf life. It can offer compelling value and prove to be the "the next big thing" in future agriculture. The food will be wrapped in smart safety packaging that can detect contaminants and spoilage agents. Nanotechnology works with the smallest particles, which raises hope for better agricultural productivity and for trying to solve unsolved problems conventionally. Nanotechnology is a cutting-edge, advanced interdisciplinary field based on the use of materials at the nanoscale, contributing to every science field, such as biomedicine, engineering, chemistry, and physics. The integration of nanotechnology in the field of agriculture has overcome many challenges related to crop productivity, plant diseases, soil fertility, food security, waste restoration, and environmental protection. The use of hazardous chemicals in conventional agriculture has substantially reduced with the use of nano formulated pesticides and fertilizers originating from biological sources. The application of nanotechnology in the agriculture and food industries is receiving attention nowadays. In this study we explore the potential of fundamental nanotechnology and its progress in the agricultural sector, with a brief historical background. We focus on the applications of nanotechnology, the sustainability of agri-nanotechnology, and their future challenges. Nanotechnology has a great impact on the agricultural sector and will help improve agri- nanotechnology in the future.

Recently, innovative nanotechnology has revolutionized the food industry [5,6].There is progressive improvement in use of nanoparticles in food industry especially on food processing, packaging, storage and development of innovative products. Nanoparticles aimed at enhancing bioavailability of nano-sized nutraceuticals and health supplements, improving taste and flavor, consistency, stability and texture of food products. Due to antimicrobial characteristics of nanoparticles it can be incorporated into the food packaging materials to increase shelf life and keep it safe for human consumption. It is predicted that the invasion of the food production market with nanoparticles will be significantly increased in the near future[7]. Moreover, the use of encapsulated nanoparticles enable the development of nano-formulated agrochemicals such as pesticides, fertilizers, biosides, veterinary medicine, additives, antimicrobials and detoxifying compounds. In human food processing, nanocapsules have been used as nano-sized ingredients, additives, nutritional supplements, and in functional foods [8,9]reported that nanoencapsulation of food ingredients and additives have been carried out to provide protective barriers, flavor and taste masking, controlled release, and better dispensability for water insoluble food ingredients and additives. There is developing public concern regarding the toxicity and adverse effect of nanoparticles on human health and environment. Therefore, establishment of regulatory system capable of managing risks associated with the use of nanoparticles is recommended.

The difference between nanoscience and nanotechnology (N&N) is the same as the difference between science and technology, but in N&N ultra-high precision is required[10]. N&N as defined by the United States National Foundation[11,12] is the study that relies on various key parameters to control the synthesis procedure for the fabrication of materials with dimensions ranging from 1 to 100 nm. These materials have properties to form layered, large, and novel structures by combining with each other in very different ways. The important feature of N&N is the drastic change in properties of materials (i.e., chemical, physical, mechanical, thermal) from their bulk counterparts as the size of materials approaches to nanoscale. These nanomaterials show drastically enhanced properties compared to bulk materials when used in similar applications. The applications of nanotechnology in different fields like electronics, biology, and environmental applications are increasing rapidly [13,14]

II. CURRENT AND FUTURE TRENDS

Recently, a wide range of potential applications of nanotechnology has been envisaged also in agriculture, leading to intense research at both academic and industrial levels . Indeed, the unique properties of materials at nanoscale make them suitable candidates for the design and development of novel tools in support of a sustainable agriculture. Some of the main applications of these nanotools in agriculture are reported in the following paragraphs, and schematically drawn in Figure 1.

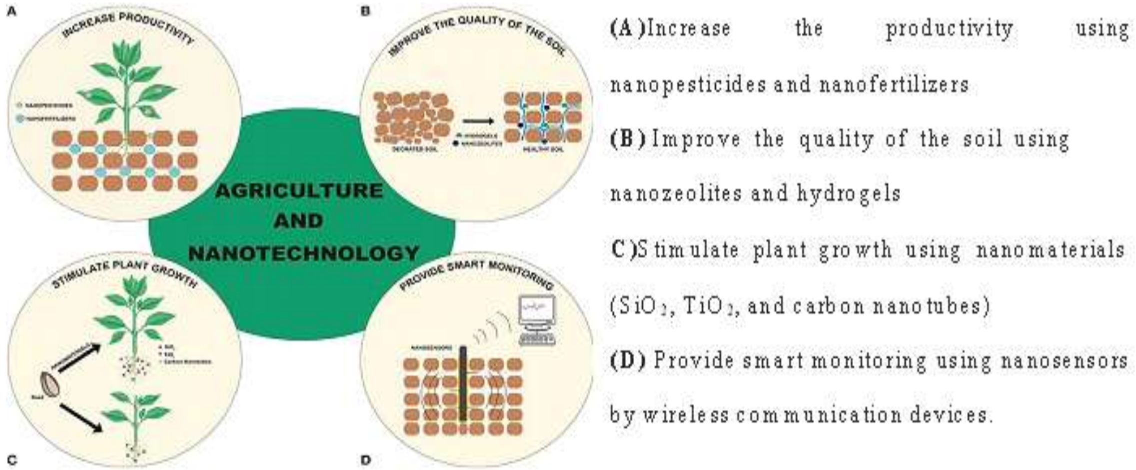

Figure 1. Potential applications of nanotechnology in agriculture.

Nanoparticles In Crop Improvement

There are numerous reports revealing the use of nano-particles in crop improvement. Mostly carbon and metal-oxides based engineered nano-particles have been subject of studies [15] has reported the effect of penetrated carbon nanotubes (CNTs) in tomato seeds as their germination efficiencies increased several times. The water uptake ability of CNTs enhanced the seed germination dramatically [16]. Ti02 nano-particles have been found to accelerate spinach growth by enhancing Rubisco activase activity and improving light absorbance[17]. Nano-particles of TiO2 improved spinach growth by enhancing nitrogen metabolism [18]. DeRosa et al, reported that ZnO nanoparticles showed inhibition of seed germination in corn and rye grass. But these left porous domains in plant roots, hence letting a potential nutrient delivery system to be explored[19]. Silicon NPs are absorbed by plants and they lead to increased disease and stress resistance [20]. A product by Syngenta under the brand name Primo MAXX® is being used as plant growth regulator, it allows turf grass to withstand against drought, heat and disease stress.

Nanotechnology in Agricultural Production

Nanotechnology application here makes farming more targeted and scientific. Precision farming makes use of computers, global satellite positioning systems, and remote sensing devices to measure various parameters.

Accurate information through applications of Nanotechnology for real time monitoring of soil conditions, environmental changes and diseases and plant health issues. Precision agriculture means that there is a system controller for each growth factor such as nutrition, light, temperature, etc. Available information for planting and harvest time are controlled by satellite systems. This system allows the farmer to know, when is the best time for planting and harvesting to avoid of encountering bad weather conditions. Best time to achieve the highest yield, best use of fertilizers, irrigation, lighting and temperature are all controlled by these systems. An important nanotechnology role is the use of sensitive nuclear links in GPS systems controller. This includes the fine-tuning and more precise micromanagement of soils; the more efficient and targeted use of inputs; new toxin formulations for pest control; new crop and animal traits; and the diversification and differentiation of farming practices and products within the context of large-scale and highly uniform systems of production.

Nanotechnology for detecting plant diseases

A need for detecting plant disease at an early stage so that tons of food can be protected from the possible outbreak; has tempted nanotechnologists to look for a nano solution for protecting the food and agriculture from bacteria, fungus and viral agents. A detection technique that takes less time and that can give results within a few hours, that are simple, portable and accurate and does not require any complicated technique for operation so that even a simple farmer can use the portable system. If an autonomous nanosensors linked into a GPS system for real-time monitoring can be distributed throughout the field to monitor soil conditions and crop, it would be of great help. The union of biotechnology and nanotechnology in sensors will create equipment of increased sensitivity, allowing an earlier response to environmental changes and diseases.

Nano-particles controlling the plant diseases

Some of the nano particles that have entered into the arena of controlling plant diseases are nanoforms of carbon, silver, silica and aluminosilicates. Pesticides inside nanoparticles are being developed that can be timed-release or have release linked to an environmental trigger. Combined with a smart delivery system, herbicide could be applied only when necessary, resulting in greater production of crops and less injury to agricultural workers. Leading chemical companies are now formulating efficient nanopesticides and nanohericides at nano scale. One of such effort is use of Alumino-Silicate nanotubes with active ingredients. Pesticides via Encapsulation, Pesticides containing nano-scale active ingredients are already on the market, and many of the world's leading agrochemical firms are conducting research on the development of new nano-scale formulations of pesticides, Nanopesticides. The use of nanomaterials in plant protection and production of food is under-explored area in the future. It is well known that insect pests are the predominant ones in the agricultural fields and also in its products, thus NPs may have key role in the control of insect pests and host pathogens [21]. The recent development of a nanoencapsulated pesticide formulation has slow releasing properties with enhanced solubility, specificity, permeability and stability [22].These assets are mainly achieved through either protecting the encapsulated active ingredients from premature degradation or increasing their pest control efficacy for a longer period. Formulation of nanoencapsulated pesticides led to reduce the dosage of pesticides and human beings exposure to them which is environmentally friendly for crop protection

Application of nanotechnology in food processing

The food market demands technologies, which are essential to keep market leadership in the food processing industry to produce fresh authentic, convenient and flavourful food products and nanotechnology is the answer to it [23] Food processing methods that involve the nanomaterials in their contents include incorporation of nutraceuticals, gelation and viscosifying agents, nutrient delivery, mineral and vitamin fortification and nanoencapsulation of flavours [24].

Nanotechnology in Food Packaging

Using inorganic nanoparticles, a strong antibacterial activity can be achieved in low concentrations and more stability in extreme conditions. Therefore, in recent years, it has been a great interest of using these nanoparticles in antimicrobial food packaging. An antimicrobial packaging is actually a form of active packaging which contacts with the food product or the headspace inside to inhibit or retard the microbial growth that may be present on food surfaces Many nanoparticles such as silver, copper, chitosan, and metal oxide nanoparticles like titanium oxide or zinc oxide have been reported to have antibacterial property.The application of nanoparticles is not limited to antimicrobial food packaging but nanocomposite and nanolaminates have been actively used in food packaging to provide a barrier from extreme thermal and mechanical shock extending food shelf-life. In this way, the incorporation of nanoparticles into packaging materials offers quality food with longer shelf-life. The purpose of creating polymer composites is to have more mechanical and thermostable packing materials. Many inorganic or organic fillers are being used in order to achieve improved polymer composites. The incorporation of nanoparticles in polymers has allowed developing more resist packaging material with cost effectiveness . Use of inert nanoscale fillers such as clay and silicate nanoplatelets, silica (SiO2) nanoparticles, chitin or chitosan into the polymer matrix renders it lighter, stronger, fire resistance, and better thermal properties.

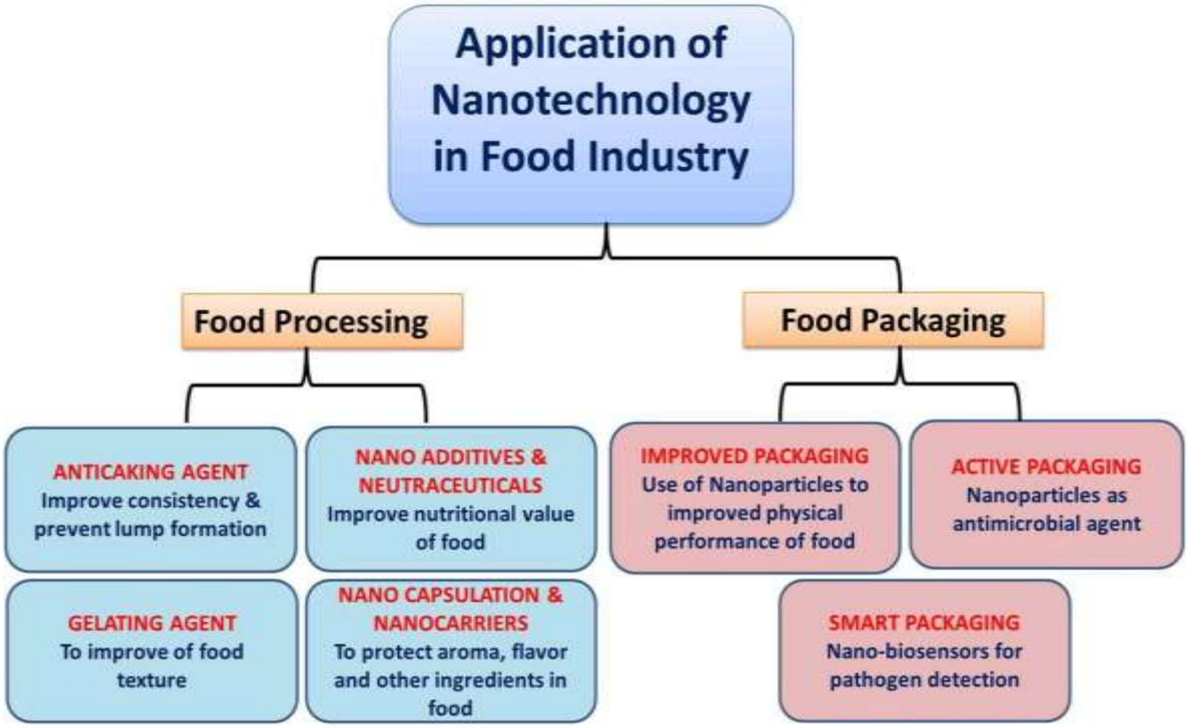

Figure 2. Schematic diagram showing role of nanotechnology in different aspects of food sectors.

Nanoencapsulation

Nanoencapsulation is defined as the technology of packaging of nanoparticles of solid, liquid or gas, also known as the core or active, within a secondary material, named as a matrix or shell, to form nanocapsules [25]. The core contains the active ingredient (e.g., drugs, perfumes, biocides, vitamins, etc.) while the shell isolates and protects the core from the surrounding environment. This protection can be permanent or temporal, in which case the core is generally released by diffusion or in response to a trigger, such as shear, pH or enzyme action, thus enabling their controlled and timed delivery to a targeted site [26].

Nanoencapsulations mask odours or tastes, control interactions of active ingredients with the food matrix, control the release of the active agents, ensure availability at a target time and specific rate, and protect them from moisture, heat, chemical, or biological degradation during processing, storage and utilization and also exhibit compatibility with other compounds in the system [27]. The protection of bioactive compounds, such as vitamins, antioxidants, proteins and carbohydrates may be achieved using nanoencapsulation for the production of functional foods with enhanced functionality and stability [28].

Nano lamination

Other significant factors include moisture, gases and lipids accumulation that cause the food to be perished. To protect the food from these agents, another workable option is nano-lamination. Nano-lamination is applied by coating foods with nanolaminates or simply by spraying it on the food surface. Along with preservation of food they can improve the texture, preserve flavour and colour of the food [29]. Nanolaminates are thin, harmless food grade protective films which are prepared from edible polysaccharides, proteins, and lipids [30]. These have proven to be a good barrier against carbon dioxide and oxygen. While against moisture lipid based nano-laminates are effective protectors.

Nanotechnology and Safety Issues

Nanotechnology has brought revolution in food industry as has several applications in all areas of food science, from agriculture to food processing including packaging [31]. Although the hazards and risks of nano-technology are not known but can be assumed that like any other technology this may also have associated hazards and risks. Environmentalists are afraid that nano-technology may produce contaminants, which because of their nano-size, may pose to be ultrahazardous[32]. Even if these particles are not harmful, their interaction with products may be harmful[33]. The interaction of nanoparticles with living cells is not yet understood completely. Consumers are exposed to nanomaterials by consumption of food and beverages containing these extremely small particles of large reactive surface area of unknown safety. The small size of these nanomaterials may increase the risk for bioaccumulation within body organs and tissues. The nanoparticles are more reactive, more mobile, and likely to be more toxic. The ingredients in these nanoparticles must undergo a full safety assessment by the relevant scientific advisory association before these are permitted to be used in food industry.

Future perspectives and challenges of nanotechnology and Nanoscience in Agriculture and Food Sustainable agriculture must be taken as an ecosystem method, where abiotic–biotic-living beings live in accord with a co-ordinated stability of food chains and their related energy balances. New technologies, modernization, increased in use of nano-chemicals, specialization and government policies are adapted to maximize the production in agriculture. To overcome the situation, it is mandatory to establish the recent technology in the food industry. Therefore, the new and future technology is nanotechnology that possesses very unique property in food supply chain (from the field to table: crop production, use of agro-chemicals such as nanofertilizers, nanopesticides, nanoherbicides, etc., precision farming techniques, intelligent feed, enhancement of food texture and quality, and bioavailability/nutrient values, packaging and labeling, etc.) round the world agricultural sector. Some focused areas may need more attention in near future researches in the field of agricultural nanotechnology or nanofoods:

- New environmental and safety delivery systems for carrying special food/feed compounds, plant nutrients, etc. These systems also can have pharmaceutical application potentials.
- The (bio)sensors related nanotechnology have effective role in insect pest control and food products of agriculture. Consumers always can get actual information of the state of certain food product via intelligent food packaging corporated with nanosensors.

- The properties of nanomaterials such as size, dose, exposure time, surface chemistry, structures, immune response, accumulation, retention time, etc., and other effects should be accessed carefully. New analytical methods are needed to develop to detect, validate and access the effects of each nanomaterials/nanofoods in whole ecosystems. Life-cycle analysis of nanomaterials/nanofoods should be done. Improvement of wide-ranging databank as well as international collaboration for policy, idea and regulation are needed for manipulation of this knowledge. Additionally, the authorities should provide clear guidelines and roadmaps for reducing risks of the use of nanotechnological products.
- New communication channels and debates should be opened with participation of different sides such as consumers, researchers, authorities, industrial sectors, etc. to discuss impacts of this technology in human life, economy, and science.

This technology in the long term may provide innovative and economical development routes for human nutrition worldwide

III.CONCLUSION

In agriculture sector, Nanotechnology has phenomenal potential to facilitate and frame the next stage of precision farming techniques. It will increase agricultural potential to harvest higher yields in ecofriendly way even in challenging environment. Globally many countries have recognized the potential of nanotechnology in the agri-food sector and are investing a significant amount on it. The adoption of nanotechnology would play a crucial/ unparalleled role to feed the ever increasing population with declining natural resources. Over past years the popularity of the uses of structures on the nanometer scale in the food sector is increasing, therefore, interest and activities in this research area have greatly focused. Additionally, promising results have been achieved in food preservation using nanomaterial where they might protect the food from moisture, lipids, gases, off-flavors, and odors. Nanotechnology is emerging as a rapidly growing field with its wide application in food science from primary production of food at farming level to food processing and their packaging. With intelligent innovations it will positively affects the food quality, safety and security of food to meet the consumer demands. However, more research is required regarding the migration behavior of nanoparticles from the packaging materials to food and their potential health implications. The nanoparticles must undergo a specific safety assessment before they are incorporated into the food products and the packaging materials.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Application of Machine Learning Algorithms in Predicting Quality and Production of Milk in Dairy Farming

R.V. Kulkarni[1], R. G. Joshi[2]

[1]Assistant Professor and Head, Department of Dairy Science and Technology, Yogeshwari Mahavidyalaya Ambajogai, Maharashtra, India

[2]Assistant Professor and Head, Department of Computer Science, Yogeshwari Mahavidyalaya Ambajogai, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
144-147

ABSTRACT

An important part of the world's agricultural and food production is the dairy business. Maintaining profitability and sustainability requires maximizing output and ensuring consistent milk quality. Conventional techniques for keeping an eye on milk output and quality are labor-intensive, resource-intensive, and frequently reactive. Predictive analysis and optimization in dairy farming are made possible by machine learning (ML) algorithms, which offer a creative solution. This study gives information about the use of machine learning algorithms to forecast milk output and quality, stressing the possible advantages, difficulties, and opportunities for the future. The effectiveness of these algorithms in practical situations is illustrated with the help of case studies and current research findings.

I. INTRODUCTION

security and the global economy both greatly benefit from dairy production. However, producers deal with issues like variable milk yields, quality variances, and production-affecting environmental conditions. Profitability, animal welfare, and decision-making can all be improved by generating accurate predictions about milk production and quality. With its capacity to examine enormous datasets and spot intricate patterns, machine learning has become a game-changing instrument in this field. An algorithm is a process used to carry out a calculation or solve a problem. An algorithm is a precise set of instructions that, in hardware- or software-based routines, carry out predetermined operations step by step.

1. Key Factors Affecting Milk Production and Quality:

1.1 Genetics and Cow Health

Dairy cows' genetic mix has a significant impact on milk production, affecting characteristics including output, milk content, and illness resistance. Based on past breeding data, machine learning models can be used to forecast cows' genetic potential. By examining trends in cows' activity levels, dietary patterns, and even early disease indicators, these models can also forecast health problems.

1.2 Diet and Nutrition

The amount and quality of milk produced by dairy cows are largely determined by the diet they are fed. The amount of fat in milk, protein levels, carbohydrates and many other significant substances are closely related to nutrient intake. In addition to creating customized diets to increase milk production, machine learning algorithms can determine feed composition data, cow weights, and milk volumes that would be best suited for scheduling the right feeding times.

1.3 Environmental Conditions

Among the elements influencing dairy cow productivity are climate, temperature, humidity, and farm infrastructure. It is possible to train machine learning models to ascertain the relationships between various environmental factors and milk production. These models can assist farmers in making adjustments to maximize cow comfort and milk yield when combined with historical data and real-time environmental sensors.

Objectives

1) To study the use of machine learning algorithms used in dairy farming to forecast milk production and quality.
2) To study how well these algorithms work to enhance dairy farming methods.

II. MACHINE LEARNING IN DAIRY FARMING

2.1. Overview of ML Algorithms

There are several uses for machine learning algorithms in dairy farming, including supervised learning, unsupervised learning, and reinforcement learning. Typical algorithms are as follows:

1) Linear Regression: Using past data to forecast milk yield.
2) Decision Trees and Random Forests: Determining the main elements influencing the quality of milk.
3) Support Vector Machines (SVM): Using compositional data to classify the quality of milk.
4) Using neural networks to extract non-linear relationships from data on milk production.
5) Clustering Algorithms: Dividing cows according to trends in productivity.

2.2. Data Sources

1) On-Farm Sensors: Tracking health indicators, feed consumption, and cow activity.
2) Analysis of the Fat, Protein, Lactose and Minerals content of Milk.
3) Temperature, humidity, and seasonal fluctuations are examples of environmental data.
4) Historical Documents: Reproductive cycles, milk production, and veterinary care.

III.APPLICATIONS OF ML ALGORITHMS

3.1. Predicting Milk Quality

1) Prediction of Fat and Protein Content: Regression models use past data to forecast shifts in the composition of milk.
2) Contamination Detection: Milk sample anomalies are found using classification methods.
3) Somatic Cell Count Analysis: One important measure of milk quality is the probability of mastitis, which may be predicted using machine learning models.

For dairy producers, forecasting and guaranteeing high-quality milk is essential. Anomalies in the fat, protein, and lactose content of milk that result from nutrition and cow health can be detected using machine learning algorithms. Furthermore, early warning indicators of mastitis or other illnesses that may compromise the quality of milk can be found using machine learning approaches, enabling prompt interventions.

3.2. Forecasting Milk Production Yield: Time-series analysis methods use historical trends to predict milk yield. Milk production is frequently predicted using machine learning algorithms, which assist farmers in modifying management strategies to maximize yield. ML models can accurately forecast daily, weekly, and monthly milk output by examining variables including cow age, lactation stage, and feeding schedule. This enables improved resource allocation and management planning.

3.3. Feed Optimization: To improve output, ML models optimize the composition of feed.

3.4. Behavior Analysis: To determine the stressors influencing yield, algorithms examine cow behavior.

3.5. Monitoring of Animal Health

Real-time dairy cow health monitoring is becoming more and more common thanks to machine learning algorithms. Wearable sensor data, including that using radio frequency identification tags and accelerometers, can reveal important information on cow behavior, activity levels, and even early disease symptoms. Farmers can improve animal wellbeing by using machine learning models to analyze this sensor data and anticipate health problems before they result in decreased milk output.

IV. CASE STUDIES AND RESEARCH FINDINGS

4.1. Predictive Analytics for Milk Yield

Using genetic and environmental data, Random Forest algorithms were utilized in a European study to forecast milk yields. With a 92% accuracy rate, the model assisted farmers in making well-informed choices on feeding and breeding practices.

4.2. Enhancing the Quality of Milk

SVM algorithms were used in India to categorize milk samples according to somatic cell counts, and they were quite successful in identifying inferior quality. Participating farms experienced a 25% decrease in mastitis incidence as a result of this application.

V. CHALLENGES AND LIMITATIONS

Data Quality: Model performance may be hampered by inaccurate or lacking data.

Scalability: It's still difficult to apply ML solutions on small farms.

Integration: Training farmers and investing in infrastructure are necessary when integrating ML tools with conventional farming methods.

Ethical Issues: Preserving animal welfare while maximizing output is still a top concern.

VI. FUTURE DIRECTIONS

IoT and ML integration: Using smart sensors to improve data collection.

Hybrid models: combining machine learning with conventional statistical techniques to produce reliable forecasts.

Creating models that give farmers comprehensible information is known as explainable AI.

Sustainability: Reducing environmental impact and increasing resource efficiency through machine learning

VII. CONCLUSION

By offering data-driven solutions to forecast milk production and quality, machine learning algorithms have the potential to drastically change the dairy industry. By integrating various machine learning algorithms, farm management can be improved through optimal practices, improved dairy animal health, and increased milk production overall. Therefore, despite the challenges brought forth by technological development and its underutilization in contemporary farming methods, this region appears to have a bright future.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Impact of ICT on Library and Information Centers

Dr. Bhagyashri Yeshwantrao keskar
Librarian, Yogeshwari Mahavidyalaya, Ambajogai , Dist. Beed 431124, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
148-151

ABSTRACT

In the contemporary era, Information and Communication Technology (ICT) has revolutionized the way information is created, shared, and consumed. Libraries and information centers have undergone significant transformations due to the rise of digital information systems. This paper explores the impact of ICT on libraries, library services, and library professionals. The role of emerging technologies like open-source software, institutional repositories, and cloud-based services in transforming library functions is also discussed. The shift from print to digital formats and the evolving demands of library users necessitate constant professional development in the library sector.

Keywords: ICT, Library services, Subject gateways, professionals, Digital libraries, Institutional repositories, Cloud services.

I. INTRODUCTION

The rapid evolution of Information and Communication Technology (ICT) has profoundly altered the landscape of library and information centers. Libraries, once primarily print-based repositories of knowledge, have embraced the digital age, transitioning into hybrid or fully digital institutions. The proliferation of the internet has created an immense shift in how information is disseminated and accessed. Today, libraries are no longer just passive holders of information but active participants in facilitating access to knowledge globally.

Libraries are utilizing ICT to enhance their services, offering new ways for users to access information, collaborate, and manage resources. With the advent of technologies like open-source software, institutional repositories, and cloud-based services, libraries are evolving beyond traditional paradigms. However, this shift brings with it new challenges, including the need for constant updates in professional skills, the rise of user expectations, and the integration of new tools to stay relevant in a fast-paced, information-driven world.

This paper aims to delve into the various impacts that ICT has had on libraries and information centers, focusing on library services and the professional skills required to navigate this new landscape.

Impact of ICT on Libraries:

The integration of ICT in libraries has led to a fundamental transformation in how information is managed, processed, and made accessible to users. The impact of ICT is most evident in several key areas, including the automation of library functions, digital resource management, and user access.

1. **Shift from Print to Electronic Resources:** One of the most significant changes brought about by ICT is the shift from print to electronic resources. Digital formats like eBooks, online journals, and databases have largely replaced physical books and paper-based periodicals in many libraries. This transformation has expanded the accessibility of resources, allowing users to access a wide variety of materials from anywhere, at any time.
2. **Library Automation:** The introduction of automation in libraries has streamlined many operational tasks such as cataloging, acquisitions, circulation, and resource management. Software applications designed for library management systems (LMS) have replaced manual processes, making library services faster and more efficient.
3. **Global Access and Seamless Information Sharing:** ICT has facilitated seamless access to global resources. Libraries can now provide access to digital repositories, subject-specific portals, and databases that were once unavailable to users outside of a particular region. This global connectivity has bridged the gap between library users and information resources worldwide.
4. **Consortia Approach:** Libraries have increasingly adopted the consortia model, wherein groups of libraries share resources and services. This collaborative approach maximizes resource utilization and enhances access to digital resources, offering a broader range of materials without the need for individual libraries to acquire every resource independently.

ICT-Based New Library Services:

ICT has not only transformed the internal workings of libraries but has also introduced new services that significantly enhance user experience and access to information.

1. **Internet Services:** The internet has become an indispensable tool for communication and information dissemination. Libraries have embraced internet technologies to offer web-based services, enabling users to access library resources remotely. However, the digital divide remains a challenge, with some user groups still lacking access to personal internet facilities.
2. **Online Public Access Catalog (OPAC):** OPACs have replaced traditional card catalogs, offering users the ability to search for books and other resources through a computer interface. OPACs provide faster, more efficient search capabilities and allow users to browse and check the availability of resources in real-time.
3. **Subject Gateways:** Subject gateways are specialized tools designed to provide access to resources within a specific subject area. They allow users to quickly navigate relevant digital resources such as journals, articles, and databases in their field of interest, improving the efficiency of research and learning.
4. **Subject Portals:** Portals represent a unified access point for multiple library services. They aggregate various information resources, including digital archives, e-books, and multimedia content, and present them in a user-friendly interface. Integration services such as authentication, search protocols, and loan systems ensure seamless access to the library's offerings.
5. **Ask a Librarian Services:** This internet-based service connects users with librarians who possess specialized knowledge in certain areas. Users can ask questions online and receive expert advice on information retrieval, research strategies, or even subject-specific queries. This service has expanded the traditional role of the librarian, making them more accessible and efficient in aiding users.

Impact of ICT on Library Professionals:

The rapid technological advancements in libraries have transformed the role of library professionals. Traditional skills related to information storage and retrieval are no longer sufficient in an ICT-driven environment. Library professionals must continuously adapt to new technological tools and systems.

1. **Technological Proficiency:** Library professionals must develop a solid understanding of technological tools such as downloading and installing programs, understanding system settings, and resolving hardware and software issues. A basic knowledge of troubleshooting is essential to ensure smooth library operations.
2. **Familiarity with Electronic Resources:** Librarians need to be proficient in navigating, managing, and utilizing electronic resources, including digital archives, databases, and e-books. Understanding how these resources are structured and how they can be accessed remotely is critical in providing quality service to users.
3. **Library Systems Integration:** Modern libraries operate using multiple interconnected systems (e.g., cataloging systems, circulation management, e-resource management). Library professionals must understand how these systems work together and how they can be used to provide a seamless user experience.
4. **Digital Literacy and Content Creation:** With the rise of social media, library professionals must be proficient in creating and managing online content. This includes writing for the web, developing multimedia content, and using platforms like Facebook, Twitter, and Instagram for communication and outreach. The ability to generate QR codes and create videos is also becoming increasingly important.
5. **Mobile Technology:** As mobile technology becomes more widespread, library professionals must understand the implications of mobile devices in library services. This includes optimizing library websites for mobile access, using apps to improve user experience, and understanding the unique needs of mobile users.
6. **Professional Development:** The continuous evolution of ICT demands that library professionals engage in ongoing professional development. This includes staying updated on new technologies, understanding digital copyright issues, and adapting to emerging trends in information science.

II. CONCLUSION:

Information and Communication Technology (ICT) presents both opportunities and challenges for libraries. As libraries continue to integrate digital tools and systems into their operations, they must remain responsive to the evolving needs of their users. The shift from traditional print-based resources to digital content has fundamentally altered the way information is accessed, shared, and managed.

Library professionals must adapt to these changes by acquiring new skills and staying abreast of emerging technologies. The professional development of librarians is critical to ensuring that libraries can provide high-quality services in this ICT-driven era.

In conclusion, ICT is transforming libraries into dynamic centers of information access and sharing. By embracing these changes and adapting to new technological advancements, libraries can continue to serve the information needs of future generations, ensuring greater accessibility and satisfaction for users across the globe. As libraries become more digital and interconnected, the role of ICT will only continue to grow, shaping the future of library services for years to come.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Impact on Everyday Life of AI: - Advantages and Disadvantages

Datta V. Sarwade
Assistant Professor, Vaishnavi Mahavidyalya, Wadwani. Dist. Beed, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
152-158

ABSTRACT

In recent years, artificial intelligence (AI) has become embedded in our daily lives in ways that we may not even be aware of. It has become so pervasive that many people are unaware of both its impact and its reliance on it.

From morning to night, in our daily activities, AI technology drives everything we do. When we wake up, most of us use our mobile phones or laptops to start our day. Doing so has become automatic and an integral part of how we work, in terms of making decisions, planning, and finding information.

I. INTRODUCTION

When we turn on our devices, we immediately plug in AI functionality such as:
Face ID and image recognition, Email, Apps, Social media, Google search, Digital voice assistants like Apple's Siri and Amazon's Alexa, Online banking, Driving aids – route mapping, traffic updates, weather conditions , Shopping, Leisure like Netflix and Amazon for movies and programs.

AI touches every aspect of our personal and professional online lives today. Global communication and interconnectivity has been and continues to be a hugely important area in business. The use of artificial intelligence and data science is essential and its potential growth is limitless.[2]

What is artificial intelligence?

AI is the intelligence demonstrated by machines, as opposed to the natural intelligence displayed by both animals and humans.

The human brain is the most complex organ, controlling all the functions of the body and interpreting information from the outside world. Its neural network consists of approximately 86 billion neurons, which are woven together by approximately 100 trillion synapses. Even today, neuroscientists have yet to unravel and understand many of its effects and capabilities.

Humans are constantly evolving and learning; this reflects how AI works at its core. Human intelligence, creativity, knowledge, experience, and innovation are the drivers for the expansion of current and future machine intelligence technologies.[1]

When was artificial intelligence invented?

During World War II, Alan Turing's work on code-breaking German messages at Bletchley Park marked a significant scientific turning point. His revolutionary work helped develop some of the fundamentals of computer science.

By the 1950s, Turing had proposed that machines could think for themselves. This radical idea, along with the growing impact of machine learning on problem solving, led to many advances in the field. Research explored the fundamental possibilities of whether machines could be directed and directed: to think, understand, learn, and apply their own 'intelligence' to solve problems like humans.[5]

Computer and cognitive scientists such as Marvin Minsky and John McCarthy recognized this potential in the 1950s. Their research, based on Turing's ideas, fueled the exponential growth of the field. Attendees at a 1956 workshop at Dartmouth College in the United States laid the foundation for what we now consider the field of AI. Regarded as one of the world's most prestigious academic research universities, many of those in attendance became leaders and innovators in artificial intelligence in the decades to come. As a testament to his groundbreaking research, the Turing test – in its updated form – is still applied to today's AI research and is used to measure the success of AI development and projects.[2]

How does artificial intelligence work?

AI is built by capturing large amounts of data. This data can be used to determine knowledge, patterns, and insights. The goal is to build and build on all of these building blocks, applying the results to new and unfamiliar situations.

Such technology relies on advanced machine learning algorithms and very high-level programming, datasets, databases, and computer architecture. Success at specific tasks depends, among other things, on computational thinking, software engineering, and a focus on problem solving.[2]

Artificial intelligence comes in many forms, from simple tools like chatbots in customer service applications to complex machine learning systems for large business organizations. The field is broad, encompassing technologies such as:[5]

Machine learning (ML). Using algorithms and statistical models, ML refers to computer systems that are able to learn and adapt without following explicit instructions. In ML, inference and analysis are identified in data patterns, divided into three main types: supervised, unsupervised, and reinforcement learning.

Narrow AI. This is inherent to modern computer systems that are taught or learned to perform specific tasks, without being explicitly programmed. Examples of narrow AI include: virtual assistants on mobile phones, such as those found on the Apple iPhone and the Android personal assistant on Google Assistant; and recommendation engines that provide suggestions based on search or purchase history.

Artificial General Intelligence (AGI). Sometimes, the worlds of science fiction and reality seem to blur. In fiction, AGI - exemplified by robots in shows like West world, The Matrix, and Star Trek - refers to the ability of intelligent machines to understand and learn any task or process normally undertaken by humans.

Strong AI. However, some AI academics and researchers believe that machines should only be able to sense or be aware of things once they are used.

Natural Language Processing (NLP). This is a challenging area of AI in computer science, as it requires vast amounts of data. It requires expert systems and data interpretation to teach intelligent machines how to understand how humans write and speak. For example, NLP applications are increasingly being used in healthcare and call center settings.

Deep Mind. As large technology companies try to capture the machine learning market, they are developing cloud services to enter areas such as leisure and entertainment. For example, Google's Deep Mind created Alpha Go, a computer program to play the board game Go, while IBM's Watson is a supercomputer that famously competed in the televised Watson & Jeopardy! Challenge. Using NLP, Watson answered questions with recognizable speech recognition and responses, which has sparked public awareness of the potential future of AI.

II. ADVANTAGES OF ARTIFICIAL INTELLIGENCE

1. Reduction in Human Errors:- The most important benefit of artificial intelligence is that it can significantly reduce errors and increase accuracy and precision. The decisions made by AI at each stage are made using previously collected information and a set of specific algorithms. When properly programmed, these errors can be reduced to zero.
2. Decision Making:- One of the notable benefits of artificial intelligence is decision making. AI enhances decision-making capabilities by using big data to identify patterns and trends that are often invisible to humans. AI's ability to process information at high speed reduces the time it takes to make decisions, thus providing a competitive advantage in dynamic environments.
3. Zero Risk:- Another important benefit of artificial intelligence is that humans can overcome many risks by letting AI robots do it for them. Whether it's defusing bombs, going into space, or exploring the deepest parts of the oceans, machines with metal bodies are resilient and can survive in harsh environments. Moreover, they can provide precise work with greater responsibility and do not tire quickly.
4. 24x7 availability:-A key advantage of AI is its availability around the clock. Several studies have shown that humans are only productive for 3 to 4 hours a day. Humans also need rest and vacations to balance their work and personal lives. But AI can work endlessly without breaks. With the help of AI algorithms, they can easily handle even boring, repetitive tasks.
5. Digital assistance:-Digital assistants are employed by some of the most advanced companies to interact with users, reducing the need for human employees. Many websites use digital assistants to deliver content based on user requests, allowing us to perform conversational searches. Some chatbots are so sophisticated that it is difficult to tell whether we are interacting with a human or a machine.
6. New discoveries:- AI brings numerous innovations in almost every field that help humans tackle the most challenging problems. For example, recent advances in AI-based technology have enabled doctors to detect breast cancer in women at an early stage.
7. Unbiased decisions:- While emotions naturally drive humans, AI works without emotional influence, maintaining an efficient and rational approach. One of the key benefits of artificial intelligence is the lack of biased views, which allows for more accurate and objective decision-making.
8. Automation:- Another well-known benefit of AI is the automation it brings! In our daily work, we perform many repetitive tasks, such as checking documents for errors and sending thank-you notes.
9. Everyday Applications:- Today, our daily lives are completely dependent on mobile devices and the internet. We use various apps on Windows like Google Maps, Alexa, Siri, Cortana, OK Google, taking selfies, making calls, responding to emails, etc. Using various AI-based techniques, we can even predict the weather today and the days to come.

10. AI in Dangerous Situations:- One of the main benefits of artificial intelligence is: by creating AI robots that can perform complex tasks on our behalf, we can overcome many dangerous constraints that humans face. Whether it is going to Mars, defusing bombs, exploring the deepest regions of the oceans, or mining for coal and oil, it can be effectively used in any natural or man-made disaster.[3]
11. Medical Applications:- AI has also made significant contributions to medicine, with applications ranging from diagnostics and treatment to drug discovery and clinical trials. AI-powered tools can help doctors and researchers analyze patient data, identify potential health risks, and develop personalized treatment plans.
12. Increased Efficiency and Productivity:- Another benefit of AI is efficiency! AI significantly increases efficiency and productivity by optimizing processes and reducing the time and resources required to complete tasks. This results in faster production cycles, lower operational costs, and higher output quality.
13. Increased Security and Fraud Detection:- Another benefit of AI is its ability to detect fraud! It increases fraud detection and prevention by analyzing transaction patterns and identifying anomalies that indicate fraudulent activity.. AI's ability to learn from new data continuously improves its accuracy in detecting and preventing fraud.
14. Improving human workflows:-. By examining how tasks are performed, AI can identify areas where time and resources are wasted, making recommendations to streamline operations. This helps organizations optimize workflows, improve employee productivity, and reduce operational costs.
15. Enhancing customer experience:- AI enhances the customer experience by providing personalized recommendations based on individual preferences and behavior. By analyzing past purchases, browsing history, and demographic information, AI can predict which products or services a customer might be interested in, increasing customer satisfaction and loyalty.
16. Smarter monitoring:- The next notable benefit of AI is the monitoring capabilities it brings! AI improves security and monitoring by monitoring and analyzing large amounts of data from various sources such as video feeds, sensors, and network traffic. AI systems can detect unusual activity, recognize faces, and identify potential security threats in real time, enabling rapid responses to prevent incidents and enhance security.
17. Bias and Fairness:- AI can help identify and reduce bias in decision-making processes, promoting fairness and equality. By analyzing large datasets, AI can detect patterns of bias and provide insights into how they affect outcomes. In addition, AI algorithms can be designed to reduce bias, ensuring that decisions are based on objective criteria rather than subjective or discriminatory factors.
18. Cost Savings:- Another benefit of AI is cost savings! Businesses can automate repetitive tasks such as data entry, scheduling, and customer service by implementing AI technology. This reduces the need for a large workforce to handle these tasks, leading to significant savings in salaries, benefits, and training.
19. Increased Workforce Productivity:- Another point on the list of 'benefits of AI' is increased employee productivity. This allows employees to focus on more strategic and creative tasks, which increases their productivity.
20. Personalization:-. Using this data, AI can create content recommendations, targeted ads, and customized user interfaces, ensuring a more engaging and satisfying user experience.[3]
21. Better Decisions:- AI enhances decision-making by quickly and accurately analyzing large amounts of data, identifying patterns and insights that humans miss. This enables businesses to make more informed, data-driven decisions, improve efficiency, reduce errors, and ultimately achieve better results.

22. Advanced Data Analytics:- AI technologies can process and analyze larger datasets than traditional methods.
23. Problem Solving:- AI technologies excel at identifying patterns in large datasets and can be used to solve complex problems across a variety of domains. Businesses and researchers can use AI to develop innovative solutions and improve decision-making processes.

III.DISADVANTAGES OF ARTIFICIAL INTELLIGENCE

1. **Creativity:** - Artificial intelligence (AI) often lacks the intrinsic creativity of humans, which stems from emotional depth, abstract thought, and imaginative processes. AI can mimic creativity by creating art, music, or writing based on existing patterns, but it lacks true originality or the ability to think outside the box.[1]

AI's creative output essentially recombines pre-existing data, limiting its potential for true innovation. This reliance on patterns and data limits AI, making it challenging to match the nuanced and unpredictable nature of human creativity, which thrives on intuition and emotional intelligence.

2. Emotional intelligence:- A further disadvantage of AI is that it lacks emotional intelligence, as it involves recognizing and managing one's own emotions, as well as empathizing with others and handling interpersonal relationships with prudence and empathy.

AI can be programmed to recognize specific emotional cues and respond in a predetermined manner, but it lacks true empathy or the ability to navigate complex human emotions. This limitation can hinder AI's effectiveness in roles that require emotional sensitivity, such as counseling, human resources, or any field where interaction is important.

3. Promoting human laziness:- The increasing reliance on AI for tasks ranging from mundane tasks to complex decision-making can lead to human laziness. As AI systems take on more responsibilities, individuals may become less motivated to develop their skills and knowledge, relying more on technology.

This reliance can lead to a decline in critical thinking and problem-solving abilities, as people may turn to AI solutions without questioning their validity or exploring alternatives. Over time, this can create a less competent workforce.

4. Privacy concerns:- AI systems often require large amounts of data to function effectively, which can raise significant privacy concerns. Personal data collection, storage, and analysis can be intrusive, revealing sensitive information without the consent of individuals.

AI-powered surveillance systems and data mining methods can undermine personal privacy, making data misuse by corporations, governments, or cybercriminals possible. In addition, there is a risk of data breaches and leaks, which can compromise personal and financial information, leading to identity theft and other forms of exploitation.

5. Job Displacement:- The rise of AI and automation technologies poses a major threat to employment, particularly in industries that rely on routine and repetitive tasks.

Jobs in specific professional sectors such as manufacturing, retail, customer service, and legal research or medical diagnostics are increasingly being automated, leading to large-scale job displacement. AI can create new job opportunities, but the transition period can be challenging, with many workers requiring retraining and up skilling. The economic and social impact of widespread job displacement could increase unemployment rates and social inequality if not managed effectively.[4]

6. Overreliance on technology:- As society becomes increasingly dependent on AI, the risk of technological dependency is increasing. This dependency can erode human skills and capabilities as individuals and organizations rely more on automated systems to make decisions and solve problems. In critical situations, if the system fails or produces inaccurate results,

Overreliance on AI can be beneficial. Furthermore, the complexity of AI systems can make it difficult for users to understand or question AI-driven decisions, potentially leading to a loss of autonomy and control over essential processes.

7. Algorithm Development Concerns:- The rapid development of AI algorithms raises concerns about the pace and direction of technological progress. There is a risk that algorithms are being developed and deployed faster than regulatory frameworks and ethical guidelines can sustain.

This can lead to unintended consequences such as misuse of AI technologies, lack of accountability, and inadequate protection against harmful applications.

8. Environmental Issues:- Training large AI models often requires a large amount of computing power, which requires a large amount of energy consumption. This can increase carbon emissions and contribute to climate change.

Data centers that house the infrastructure for AI systems require constant cooling and maintenance, further increasing their environmental footprint.

9. Lack of common sense

Despite their advanced capabilities, AI systems often require more common sense reasoning.

They can process and analyze large amounts of data but need help understanding context, making intuitive decisions, or adapting to new and unexpected situations. This limitation can lead to mistakes or inappropriate actions in situations that require fine-grained understanding and flexibility.

Unlike humans, AI lacks the innate ability to understand everyday knowledge and social norms, which can lead to decisions that are logically correct but practically or ethically flawed.[4]

10. Interpretability and transparency

Many AI and ML models, especially deep learning algorithms, act as "black boxes," meaning that their decision-making processes are not easily interpretable or transparent.[1]

This can be problematic in critical applications that require interpretation and understanding of the reasoning behind AI decisions.

11. Following norms and experience

AI is based on pre-loaded facts and experience and is adept at performing the same task repeatedly. It cannot be used and manipulated like human intelligence, but it can store unlimited data.

Machines can only complete the tasks for which they are developed or programmed. If asked to complete something else, they often fail or produce useless results, which can have adverse consequences. In this way, we can only make something conventional.

IV. CONCLUSIONS

Now that you understand the pros and cons of AI, one thing is certain: AI has enormous potential to create a better world. However, humans must ensure that the development and implementation of AI remains in check. Despite the ongoing debate about its benefits and drawbacks, AI's impact on global industries is undeniable. It is increasing sustainability for businesses, underscoring the importance of AI literacy and skill development for thriving in a number of emerging job roles. A master's degree program in AI and Machine Learning can help you launch your career in AI, preparing you for one of the most exciting fields in the world. This program covers both fundamental and advanced topics and everything you need to succeed in the AI field. The widespread integration of AI into our daily lives brings both unparalleled convenience and ethical considerations.[5] From healthcare to education, the workplace, and social interactions, the impact of AI is profound. Balancing the benefits with privacy concerns and job displacement challenges us to navigate this technological landscape responsibly. As AI evolves, the opportunities for innovation are immense, promising a future where collaboration and creativity flourish. To capitalize on these opportunities, individuals are actively acquiring skills through AI and data science courses, preparing themselves to contribute to and shape the exciting path of artificial intelligence.[6]

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Fuzzy Based Technology for Sustainable Development of Employee and Progression

Rohini B. Shinde, Sangita A. Jaju
Department of Computer Science, Dayanand Science College, Latur, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
159-169

ABSTRACT

Since a nation's strength is derived from its people such as students, warriors, farmers, doctors, teachers, employees and others. Personal growth is essential to advancing the country. Finding and developing each person's potential is crucial for sustainable growth and innovation, enabling them to make valuable contributions to the advancement of society. Finding a person's actual potential, however, is difficult because it requires addressing many different and intricate aspects.

Using fuzzy logic, a state-of-the-art soft computing technology, this study suggests a novel way to tackle this problem. By analyzing ambiguous and imprecise data, fuzzy logic makes it possible to represent human potential and successfully capture qualitative elements like creativity, critical thinking, and inventions, Teamwork, communication skill, problem solving ability etc. The system offers a comprehensive study of individual capacities by utilizing membership functions and language characteristics, supporting a data-driven approach to identifying and enhancing personal improvement. The results of this study are intended to provide a scalable method for evaluating human potential, aiding in the growth of a knowledgeable and capable populace and promoting comprehensive national development.

Index Terms: FIS: Fuzzy Inference System. Mamdani fuzzy, Triangular membership function, Trapezoidal Membership function

I. INTRODUCTION

In today's dynamic work environments, organizations face significant challenges in ensuring the sustainable development of employees while maintaining steady progression in individual performance and organizational growth. Human resource management plays a critical role in achieving these objectives by identifying, evaluating, and addressing employee performance and developmental needs effectively. Traditional evaluation methods often struggle with the inherent uncertainty, subjectivity, and imprecision associated with human behavior and organizational contexts. This is where **fuzzy-based technology** offers a promising solution. [1]

Fuzzy logic, a mathematical framework introduced by Lotfi Zadeh, is designed to handle vagueness and ambiguity, making it ideal for decision-making processes in complex systems. By integrating fuzzy-based technology, organizations can model imprecise and subjective factors, such as employee performance, skills, satisfaction, and potential, in a structured manner. This approach enables more robust evaluations and personalized development plans tailored to individual employees, fostering a sustainable pathway for their growth.

The concept of **sustainable development of employees** focuses on creating an environment where employees can enhance their skills, achieve career progression, and contribute meaningfully to organizational success over the long term. [2] Fuzzy-based technology aligns with this vision by providing a flexible and adaptive tool to measure, monitor, and guide employee growth, ensuring their progression is in harmony with the organization's goals.[9]

This research paper explores the application of fuzzy logic in employee evaluation and progression. It highlights how fuzzy systems can incorporate multiple dimensions of performance, such as technical skills, soft skills, and leadership potential, along with subjective metrics like adaptability and teamwork. By employing fuzzy-based techniques, organizations can identify not only high-performing employees but also those with untapped potential, enabling equitable growth opportunities and a more sustainable workforce.

II. OBJECTIVES

1. Developing Teachers (teaching quality) analysis system which removes the lacuna of traditional Analysis System.
2. Applying different ability checking parameter for personalized analysis system.
3. Helping teachers for taking decision about improvement in the skill of teaching.
4. To help the governing body of organization for taking decision about the candidate.
5. Also helpful for finding the potential of candidates in respective skill and interest area.

III.LITERATURE REVIEW

Analyzing capability of individuals' to finds skills, potential, caliber of the individual which make easy to take appropriate decisions for the decision committee.[19]

Many researchers studied on the analyzing employees Behavior, Performance, Honesty [24] etc. and gives the conclusion for betterment. Some studies works on employees' job performance through work environmental variables and leadership behaviors [25] etc.

Many researchers have used fuzzy logic to determine and update learner's knowledge level model for each domain concept. Masfer Al Duhayyim and Paul New burry in their "Concept based and fuzzy Adaptive e-learning" [23] study evaluates the learner's knowledge level for each concept and produced ranked concept list of learning material to point out weakness in the understanding of the learner's. In this proposed research work we are applying fuzzy logic technic for analyzing employees potential, caliber etc.

IV. CONCEPTUAL BACKGROUND

As per literature Review, we observed that there is lot of study has been done on employees' analysis. In which different techniques were used. The conventional method of analyzing (Teachers)employes is based on a Performance Based Appraisal System (PBAS) approach, which uses some parameters for analyzing teachers' performance. Where employee have to respond his self to the appraisal proforma. As self-appraisal report always gives positive result after analysis which may differ from reality. For true analysis one should use the student feedback for respective teacher. Hence in proposed paper we are using feedback proforma which has many parameters like, how much of syllabus covered in class, how the teacher prepares for class, can teacher identify strength and weakness of student, Teaching Methodologies, Internal Assessment by teacher, Class Control and Personal Attention, Teacher Promoting for Extra Curricular activity.

V. RESEARCH METHODOLOGY

The objective of this study is to propose effective and recommend technology for the analyzing employes performance for governing body of institution. It will be effective for sustainable growth & progression of employees as well as institution.

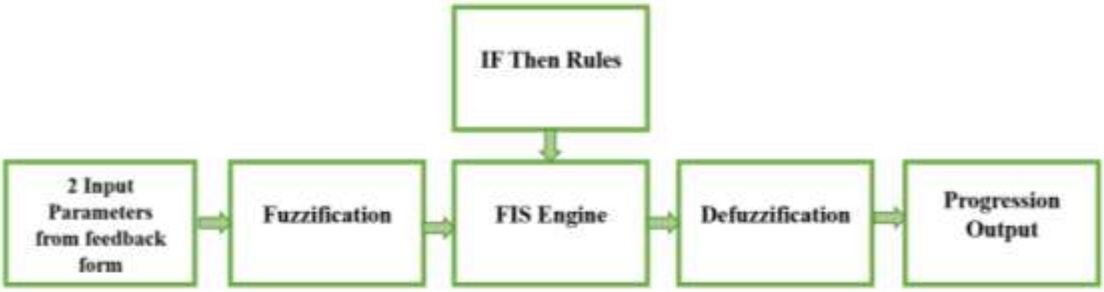

Fig. 1 Fuzzy System: For Proposed Model

Fuzzy logic is one of the soft computing tools to work on range of data. It helps to remove uncertainty in result. Fuzzy logic is not solution to the problem but it solves the problem with new method. Fuzzy Logic allows you to model complex dynamic systems in a more intuitive way [12].

In proposed work we use feedbacks from students. Which has parameters like subject depth, presentation of subject, involvement in subject as well as in the student, live example for concept i.e. conceptual example, social and moral awareness, team work etc. Proposed Method uses two factors i.e. 1) syllabus completion and 2) Teachers Preparation of subject among 8 factors as we discussed in conceptual background.

Fuzzy logic system removes the lacuna found in traditional analysis system and can deal with such factors due to which individuals Analysis can efficiently possible. [13]

***Fuzzy Inference System*:**

A Fuzzy inference system is a way of mapping an input space to an output space using fuzzy logic. A fuzzy inference system tries to formalize the reasoning process of human language by means of fuzzy logic (i.e. by building fuzzy IF-THEN rules) [11].

Ex. "IF Action as an Input THEN Result as an Output". Or "If antecedent Then consequent"

Each inference stage or inference engine has its own set of rules or rule base. It combines certain input indicators into composite output indicator. In order to give better results, decisions or action fuzzy data is processed by fuzzy inference engine as shown below in fig.(1).

Proposed Research Model is categorized in following stages

1. Data Set
2. Classifying input in 3 linguistic variables and applying membership function
3. Fuzzification
4. Decision Unit
5. Defuzzification

1. Data set:

The experimental study involved a dataset 50 students gives feedback to 1 teacher. Where a specially designed feedback form was created and filled from 60 students. Feedback form has the fields like how much of syllabus covered in class, how the teacher prepares for class, can teacher identify strength and weakness of student, Teaching Methodologies, Internal Assessment by teacher, Class Control and Personal Attention, Teacher Promoting for Extra Curricular activity etc. For the practical work only 2 parameters were used.

To analyse the data, it was classified into **input** and one **output** for the **Fuzzy Inference System (FIS)**. The classification used the following approach:

Input Parameters: Two **linguistic variables** (e.g., Syllabus, Teachers Preparation). Syllabus parameter was categorized into four ranges: **Poor, Average, Good, Very Good** And Teachers Preparation parameter was categorized into four ranges: **Unsatisfactory, Poorly, Satisfactory, Thoroughly.** based on the ranks given by student in feedback. The score range for each variable was between **0 and 10.** These outputs were mapped using **Trapezoidal Membership Functions**, with values ranging from **0 to 10**.

Output Parameters: Five **linguistic values** were defined for the outcome **Excellent, Very Good, Good, Average and Below Average.** These outputs were mapped using **Triangular Membership Functions**, with values ranging from **0 to 10**.

The data was analysed based on these classifications, allowing a student by understanding and filling feedback form for a teacher. This approach provided a more detailed analysis than traditional scoring methods, aligning with the finding a performance of teacher by a governing or selection committee for sustainability of that teacher.

2. Linguistic variables

Teachers performance with various parameters is regarded as a linguistic variable in the suggested module. These linguistic variables have four linguistic values for Syllabus parameter are **<40%, between 40% to 80%,between 80% to 100%, &100%** as indicated in Table I. For Teachers Preperarion parameters are **Unsatisfactory, Poorly, Satisfactory, Thoroughly** as indicated in Table II. For Output Progression used values are **Excellent, Very Good, Good, Average and Below Average** as indicated in Table III

Table I Linguistic values for Syllabus Parameter

Linguistic Values	Range of Syllabus Parameter
< 40%	[0 0.8333 1.66 2.5]
Between 40% to 80%	[2.5 3.333 4.163 5]
Between 80% to 100%	[5 5.8333 6.666 7.5]
100%	[7.5 8.333 9.166 10]

Table I Linguistic values for Teachers Preparation Parameter

Linguistic Values	Range of Teachers Preparation Parameter
Unsatisfactory	[0 0.8333 1.66 2.5]
Poorly	[2.5 3.333 4.163 5]
Satisfactory	[5 5.8333 6.66 7.5]
Thoroughly	[7.5 8.333 9.166 10]

Trapezoidal Function: This function computes fuzzy membership values using trapezoidal membership function which is defined by a lower limit **a**, an upper limit **d**, a lower support limit **b**, and an upper support limit **c**, where **a < b < c < d** as shown in fig. (2)[10]

$$\mu_A(x) = \begin{cases} 0, & (x < a) or (x > d) \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \end{cases} \quad \text{……….equation 1}$$

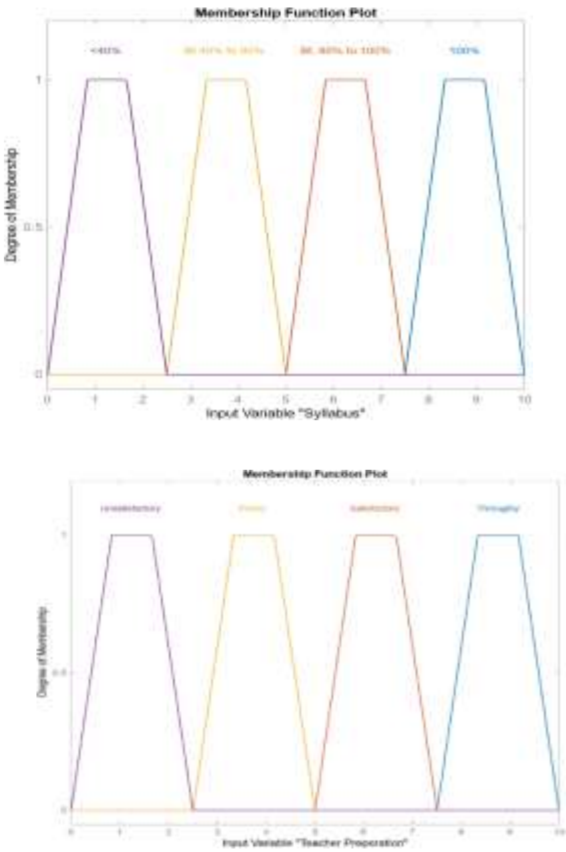

Fig 2: Trapezoidal Membership Function for Input Variable Syllabus & Teacher Preparation

Triangular Function: This function computes fuzzy membership values using triangular membership function which is defined by Lower limit **a**, an upper limit **b**, and a value **m** is a peak value, where **a<m<b** as shown in fig. (3).

$$\mu_A(x) = \begin{cases} 0, & x \le a \\ \frac{x-a}{m-a}, & a < x \le m \\ \frac{b-x}{b-m}, & m < x < b \\ 0, & x \ge b \end{cases} \quad \text{...... equation 2}$$

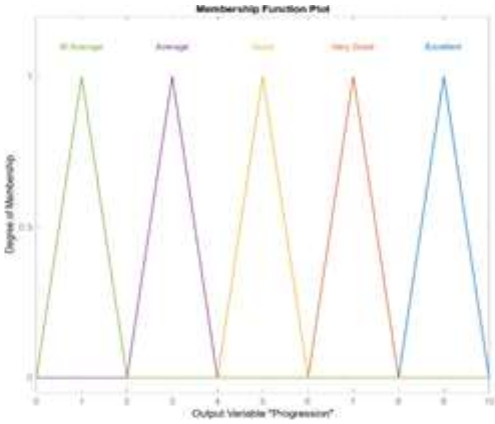

Fig 3: Triangular Membership Function Output Variable Progression.

3. Fuzzification:

Fuzzification is the process of changing a real scalar value into a fuzzy value. This is achieved with different types of fuzzifiers (membership functions). In other words it can says that Fuzzification module: transforms the system inputs, which are crisp numbers, into fuzzy sets. This is done by applying a fuzzification function. Linguistic variables are used to represent qualities spanning a particular spectrum [8].

For calculating spectrum for Syllabus & Teacher's Preparation parameter using Trapezoidal membership function, divide minimum to maximum marks in four group as per four linguistic term. For Each term again there is lower limit **a**, an upper limit **d**, a lower support limit **b**, and an upper support limit **c**.

Applying Trapezoidal Membership function for syllabus & Teacher's Preparation:

(i) $\mu_{>40\%}(x)$

$$= \begin{Bmatrix} = 0 \ \text{if}\, x \le 0 \\ = 1 \ \text{if}\, 0 < x < 0.833 \\ = 1 \ \text{if}\ \ 0.833 < x < 1.66 \\ = 0 \ \text{if}\, x > 2.5 \end{Bmatrix}$$

(ii) $\mu_{BT\ 40\%-80\%}(x)$

$$= \begin{Bmatrix} 0 \ \text{if}\, x \le 2.5 \\ 1 \ \text{if}\, 2.5 < x < 3.33 \\ 1 \ \text{if}\, 3.33 < x \le 4.16 \\ 0 \ \text{if}\, x > 5 \end{Bmatrix}$$

(iii) $\mu_{BT\ 80\%-100\%}(x)$

$$= \begin{Bmatrix} 0 \ \text{if}\, x \le 5 \\ 1 \ \text{if}\, 5 < x < 5.833 \\ 1 \ \text{if}\, 5.833 < x \le 6.66 \\ 0 \ \text{if}\, x > 7.5 \end{Bmatrix}$$

(iv) $\mu_{100\%}(x)$

$$= \begin{Bmatrix} 0 \ \text{if}\, x \le 7.5 \\ 1 \ \text{if}\, 7.5 < x < 8.33 \\ 1 \ \text{if}\, 8.33 \le x \le 9.66 \\ 0 \ \text{if}\, x > 10 \end{Bmatrix}$$

Applying Triangular Membership function for Output

(i) $\mu_{Bl\ Average}(x) = \frac{(x-0)}{(1.5-x)}$ Where 0<=x<=2

(ii) $\mu_{average}(x) = \frac{(x-3)}{(3.3-x)}$ Where 2<=x<=4

(iii) $\mu_{Good}(x) = \frac{(x-4.5)}{(5.5-x)}$ Where 4<=x<6

(iv) $\mu_{Very\ Good}(x) = \frac{(x-6.5)}{(7.5-x)}$ Where 6<=x<=8

(v) $\mu_{excellent}(x) = \frac{(x-8)}{(9-x)}$ Where 8<=x<=10

4. Decision Unit: Applying rules and Evaluation of rules.

Fuzzy Rule Base:

Finding the teachers progression for there improvement in syllabus completion and teachers preparation factor which can also handle uncertain information fuzzy rule base is used. To facilitate experimental evaluation a rule base has been constructed which uses input and output fuzzy rules. The teachers feedback scores were carefully monitored and recorded for analysis with respect to parameters for progression.

The membership of antecedent is usually called firing strength of rule to a given input value. Fuzzy system often has a set of fuzzy rules that represent the behavior of the system, known as fuzzy rule base. To obtain the fuzzy output of each rule, the Mamdani method is applied which propagate the degree of membership of antecedent of the rule to consequent of the rule [8].

Knowledge base: It stores IF-THEN rules provided by experts. For the proposed research work there are two inputs for each analysis and divide these marks in 4 linguistic variables. The rules are formed by considering each linguistic value of one input with each linguistic value of another variable and obtain the output using If-Then rules. This is nothing but mapping between input spaces to output space using fuzzy logic. In this way we form 16 different rules for 2 inputs; one is syllabus with 4 linguistic values mapped with 4 linguistic values of another input teacher's progression. Following Table II shows the output of mapping using 16 rules for a given input ranges are divided into 5 categories as shown below

Table II Rule Mapping Of 2Input Parameters and one Output Parameter

	Rule	Weight	Name
1	If Syllabus is 100% and Teacher Preperation is Throughly then Progression is Exc...	1	rule1
2	If Syllabus is 100% and Teacher Preperation is Satisfactory then Progression is Ex...	1	rule2
3	If Syllabus is 100% and Teacher Preperation is Poorly then Progression is Average	1	rule3
4	If Syllabus is 100% and Teacher Preperation is Unsatisfactory then Progression is ...	1	rule4
5	If Syllabus is Bt. 80% to 100% and Teacher Preperation is Throughly then Progres...	1	rule5
6	If Syllabus is Bt. 80% to 100% and Teacher Preperation is Satisfactory then Progr...	1	rule6
7	If Syllabus is Bt. 80% to 100% and Teacher Preperation is Poorly then Progressio...	1	rule7
8	If Syllabus is Bt. 80% to 100% and Teacher Preperation is Unsatisfactory then Pro...	1	rule8
9	If Syllabus is Bt 40% to 80% and Teacher Preperation is Throughly then Progressi...	1	rule9
10	If Syllabus is Bt 40% to 80% and Teacher Preperation is Satisfactory then Progres...	1	rule10
11	If Syllabus is Bt 40% to 80% and Teacher Preperation is Poorly then Progression i...	1	rule11
12	If Syllabus is Bt 40% to 80% and Teacher Preperation is Unsatisfactory then Progr...	1	rule12
13	If Syllabus is <40% and Teacher Preperation is Throughly then Progression is Good	1	rule13
14	If Syllabus is <40% and Teacher Preperation is Satisfactory then Progression is Av...	1	rule14
15	If Syllabus is <40% and Teacher Preperation is Poorly then Progression is Bl Aver...	1	rule15
16	If Syllabus is <40% and Teacher Preperation is Unsatisfactory then Progression is ...	1	rule16

5. Defuzzification

Defuzzification module:

It transforms the fuzzy set obtained by the inference engine into a crisp value. It is the process that maps fuzzy set to crisp set [10]. Therefore the defuzzification is to convert the information in vague into quantitative magnitudes. Several techniques are present in practice for defuzzification such as

- Defuzzification by calculating center of gravity or
- Defuzzification by calculating maximum [15].

Following Table depicts Output per score range between 0 and 10. The proposed model uses Mamdani interface and defuzzification by gravity center. In the proposed model Triangular membership function is used for finding fuzzy set output category. Formula for Triangylar membership function is shown in equation 2

Where a and b are lower and upper limit respectively and mis center point. By considering values for each variable calculate membership value by Triangular formula as shown in Table III.

Table III Linguistic variable for Progression and their respective range

Linguistic Variables Indicated in Grades	Below Average	Average	Good	Very Good	Excellent
Range	0 – 2	2 – 4	4 – 6	6 – 8	8 - 10

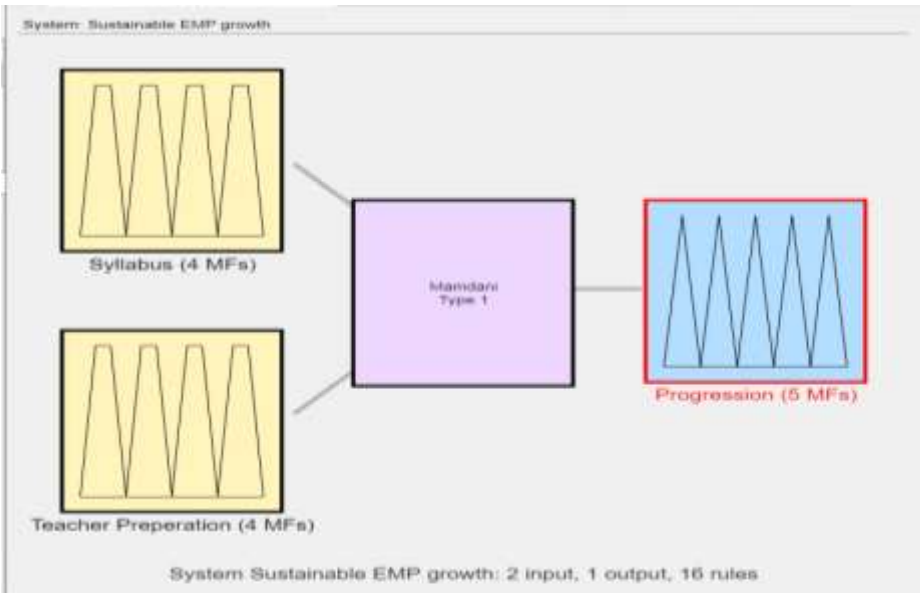

Fig.3 showing two Input in Trapezoidal and one Output in Triangular Membership form

VI. RESULT & DISCUSSION:

Result analysis plays measure role in deciding the features & skill of teacher. As in proposed work result analysis is done by using Syllabus Completion and Teacher's Preparation as input parameter from feedback. When scores of these parameters are analyzed through a classical method it represents two dimensional graphs only. Using this two dimensional graph it is quite difficult to predict range of Progression. So proposed work uses FIS for analysis of results, which is helpful for predicting the following results.

Result is categorized in 5 grades depending on combination of linguistic variables and its values which is shown in following table IV.

Table IV Obtained grade and its prediction

Syllabus	Teachers Preparation	Prediction Output Grade
100 %	Thoroughly	Excellent
100 %	Satisfactory	Excellent
100 %	Poor	Average
100 %	Unsatisfactory	Average
Bt 80% -100%	Thoroughly	Very Good
Bt 80% -100%	Satisfactory	Very Good
Bt 80% -100%	Poor	Average
Bt 80% -100%	Unsatisfactory	Below Average
Bt 40% -80%	Thoroughly	Good
Bt 40% -80%	Satisfactory	Good
Bt 40% -80%	Poor	Average
Bt 40% -80%	Unsatisfactory	Below Average
>40%	Thoroughly	Good
>40%	Satisfactory	Average
>40%	Poor	Below Average
>40%	Unsatisfactory	Below Average

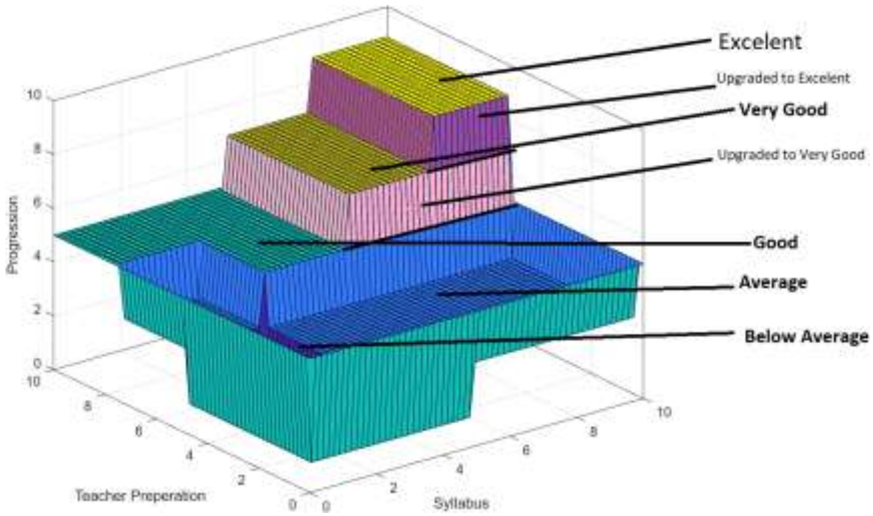

Fig 4. Surface Graph of Creativity & Critical Thinking showing obtained grades of learners

This image illustrates a **3D surface graph** used to evaluate and visualize teacher progression based on two factors: **Teacher Preparation** and **Syllabus**. The third dimension, **Progression**, represents the overall performance or evaluation metric. **Teacher Preparation** Represents the level or quality of preparation by teachers. This could include factors like lesson planning, subject mastery, or resource utilization. **Syllabus.** Indicates the completeness or quality of syllabus coverage. This might consider how well teachers adhere to the syllabus, pace of teaching, and depth of topics covered. **Progression** Reflects the progression or evaluation of teachers' performance based on the combination of **Teacher Preparation** and **Syllabus**. The surface graph is divided into coloured zones with labels indicating progression levels:

- **Below Average (Blue):** Represents areas where both teacher preparation and syllabus coverage are low, leading to minimal progression.

- **Average (Light Blue):** Indicates moderate performance.
- **Good (Green):** Reflects improved progression with better preparation and syllabus coverage.
- **Very Good (Pink):** Represents high levels of performance. Teachers in this zone may receive feedback to "upgrade to excellent."
- **Excellent (Yellow):** The highest progression level, achieved with exceptional preparation and syllabus delivery.

VII. CONCLUSION:

- Based on Teacher Preparation and Syllabus Coverage, the 3D surface graph offers an organized and transparent assessment of teacher development. It is possible to reach the following conclusions:
  1. Performance Categories: Teachers are divided into five advancement categories: **Excellent, Very Good, Good, Average and Below Average.** These classifications make it possible to pinpoint both areas of strength and opportunities for development.
  2. Improvement Potential: To improve their preparation and delivery of the syllabus, teachers in the **Below Average** and **Average** zones require targeted interventions. Higher performance is regularly correlated with better preparation and syllabus covered, as the graph illustrates.
  3. High Achievers: Teachers in the **Very Good** category are on course, but with focused instruction and guidance, they can aim to advance to the **Excellent** level.

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AUTHORS PROFILE

Ms. R. B. Shinde received Ph.D. (Computer) degree from S. R. T. M. University Nanded (MS), India. She is currently working as assistant professor in Dayanand Science College Latur (MS). Her Research area is Human Computer Interaction and published 20 research papers in different national and international conferences and journals.

Ms. S. A. Jaju received M.Phil.(Computer Science) degree from S. R. T. M. University Nanded (MS), India. She is currently working as assistant professor in Dayanand Science College Latur (M.S.). Her Research area for M. Phil is in cryptography and published 12 research papers in different national and international conferences and journals. She was awarded Ph.D. degree in S. R. T. M. University, Nanded in Fuzzy logic domain.

International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Detecting Plant Leaf Diseases Using Non-Imaging Techniques

Rupali Deshmukh, Dr. S.S. Revate sir, Dr. Jaypalsingh Kayte

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
170-177

ABSTRACT

Plant health monitoring plays a vital role in ensuring global food security and sustainable agricultural practices. With plant diseases accounting for significant crop losses annually, innovative detection methods are crucial. Non-imaging techniques, including spectroscopy, hyperspectral analysis, and thermal sensing, have emerged as precise and reliable tools for early disease detection. These methods are particularly valuable for their ability to identify plant stressors and infections before visible symptoms appear. This review focuses on the application of non-imaging techniques for disease detection in key crops such as citrus, rice, wheat, soybean, and mango. The study highlights advancements in integrating machine learning with field-based sensors, including FieldSpec devices, to enhance real-time monitoring capabilities. Key techniques and their impact on precision agriculture are discussed, offering insights into improving disease management strategies and reducing economic losses. By bridging technology and agriculture, non-imaging approaches pave the way for sustainable and efficient farming practices.

I. INTRODUCTION

Agriculture forms the backbone of global food security and economic stability, supporting livelihoods and ensuring sustenance for billions of people. However, plant diseases pose a significant threat to crop yield, quality, and overall agricultural productivity. According to the Food and Agriculture Organization (FAO), plant diseases account for nearly 20-40% of global crop losses annually, translating to billions of dollars in economic losses (FAO, 2020). Early detection and management of plant diseases are, therefore, critical for sustainable agriculture and global food security.

Traditional methods for plant disease detection often rely on visual inspection by experts, which is time-intensive, subjective, and often limited by the human eye's ability to detect subtle signs of stress or disease (Sankaran et al., 2010). These limitations have driven the development and adoption of advanced techniques that leverage technological innovations for precision agriculture. Among these advancements, non-imaging techniques have emerged as powerful tools for detecting and diagnosing plant diseases. Unlike imaging-based methods, non-imaging approaches focus on analyzing spectral, thermal, or fluorescence data from plants to identify stressors, infections, or nutrient deficiencies (Wahabzada et al., 2015).

Non-imaging techniques are especially valuable for their ability to detect diseases at early stages, even before visible symptoms appear. This early detection capability is essential for mitigating the spread of diseases and minimizing yield losses (Mahlein et al., 2010). Spectroscopy, for instance, analyzes the interaction of light with plant tissues to detect characteristic spectral signatures associated with specific diseases. Hyperspectral and multispectral analyses delve deeper into the narrow spectral bands to identify subtle variations in plant health (Huang et al., 2019). Similarly, thermal imaging measures temperature differences in plant canopies, which can indicate stress caused by pathogens or environmental factors (Jones et al., 2013). Fluorescence spectroscopy adds another dimension by measuring chlorophyll fluorescence, a key indicator of plant vitality and stress (Lu et al., 2011).

FieldSpec devices have become integral to these advancements, offering high-resolution spectral data for precise disease detection. These portable devices are particularly suited for field-based applications, providing real-time insights into crop health (Zhang et al., 2018).

The integration of these non-imaging techniques with machine learning and artificial intelligence has further revolutionized the field. Machine learning models can process vast amounts of spectral data, identify patterns, and classify diseases with high accuracy (Rumpf et al., 2010). This integration not only enhances detection capabilities but also enables scalability for field applications. For instance, portable devices equipped with reflectance or fluorescence sensors allow real-time monitoring of plant health, making these technologies accessible to farmers and agricultural stakeholders (Alchanatis et al., 2010).

Figure 1. Citrus Leaf Dataset: Visual Representation of Healthy and Diseased Leaves (Canker, Greening, and Black Spot)

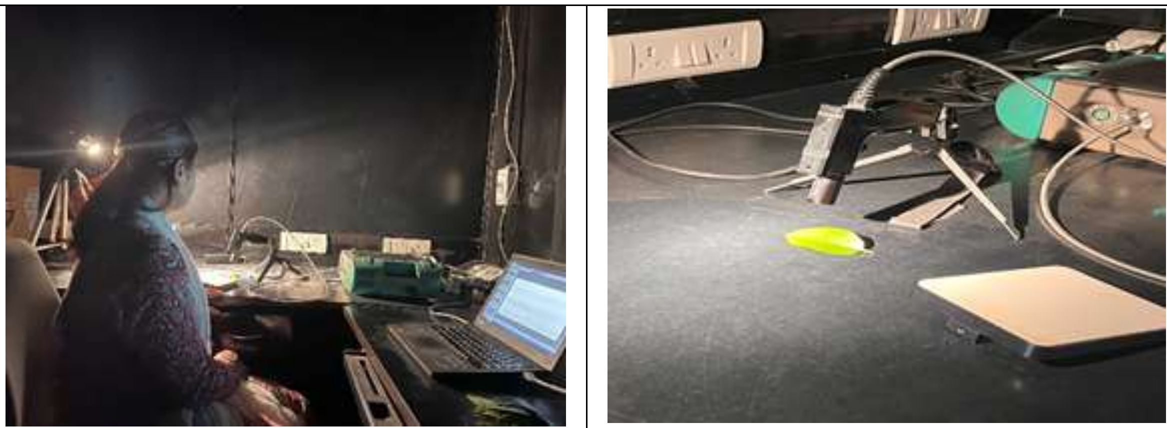
Crops such as citrus, rice, wheat, soybean, and mango are particularly susceptible to diseases that can devastate yields if not managed promptly. For example, citrus greening (Huanglongbing) has caused widespread damage to citrus orchards globally, while fungal infections like rice sheath blight and wheat rust continue to challenge cereal production (Zhang & Zhang, 2018; Huang et al., 2019). Non-imaging techniques have shown significant promise in addressing these challenges. Research has demonstrated that spectral reflectance can accurately detect citrus greening, while hyperspectral indices have proven effective in identifying wheat rust and rice fungal infections (Moshou et al., 2005; Xie et al., 2017).

Despite their potential, the adoption of non-imaging techniques is not without challenges. High equipment costs, complex data processing requirements, and limited accessibility in resource-constrained regions are notable barriers (Niu et al., 2014). However, ongoing advancements in sensor technology, machine learning algorithms, and cost-reduction strategies are steadily overcoming these limitations. Furthermore, the integration of Internet of Things (IoT) technologies and cloud-based platforms is enabling real-time, large-scale disease monitoring, further enhancing the practicality of these approaches (Wang et al., 2016).

This literature review aims to provide a comprehensive overview of the current state of non-imaging techniques for plant disease detection. By examining key studies, methods, and results, the review highlights the potential of these technologies to transform precision agriculture. The focus is on understanding how non-imaging techniques can be effectively applied across different crops, including citrus, rice, wheat, soybean, and mango, to achieve early detection and sustainable disease management.

II. TECHNIQUES FOR NON-IMAGING DISEASE DETECTION

2.1. Spectroscopy Spectroscopy involves analyzing the interaction of light with plant tissues to identify spectral signatures associated with disease. For instance, reflectance spectroscopy has been widely used for early disease detection in citrus, rice, and mango trees (Zhao et al., 2005). The introduction of FieldSpec devices has further enhanced the resolution and accuracy of spectral measurements in field conditions (Lu et al., 2011).



A	B

Figure 2. Portable FieldSpec4 Device for Spectral Data Collection (A and B)

2.2. Hyperspectral and Multispectral Analysis Hyperspectral imaging enables the detection of diseases by analyzing narrow-band spectral data. Studies have shown that hyperspectral vegetation indices can effectively diagnose fungal infections in rice and wheat rust (Huang et al., 2019). The FieldSpec system's hyperspectral capabilities have proven instrumental in mapping disease spread with high precision (Zhang et al., 2005).

2.3. Thermal Imaging Thermal imaging detects variations in leaf temperature, which often indicate stress or disease. This method has been successfully applied to monitor drought and fungal infections in mango and soybean plants (Jones et al., 2013). Advanced thermal sensors integrated into portable devices provide real-time data for effective disease management (Niu et al., 2014).

2.4. Fluorescence Sensing Fluorescence spectroscopy measures chlorophyll fluorescence changes, a key indicator of plant stress or infection. Real-time fluorescence sensing has shown high accuracy in detecting citrus canker and mango anthracnose (Lu & Lu, 2018). Combining fluorescence data with spectral indices enhances the robustness of disease detection models (Wang et al., 2016).

III.SUMMARY OF KEY STUDIES

A comprehensive table summarizing the literature on non-imaging techniques for disease detection in plants is provided below.

Sr. No	Title of Subject	Crop	Techniques Used	Methods	Results (Accuracy, Sensitivity, etc.)	Author Name(s)
1	Early detection of citrus huanglongbing using spectroscopy and machine learning	Citrus	Spectroscopy, machine learning	Feature selection and supervised learning	Early HLB detection accuracy: **90%**	Zhang & Zhang (2018)
2	A non-destructive method for detecting citrus canker using fluorescence spectrometer	Citrus	Portable fluorescence spectrometer	Real-time fluorescence sensing	Early citrus canker detection accuracy: **91%**	Lu et al. (2011)
3	Multi-spectral sensors for monitoring stress in citrus	Citrus	Multi-spectral sensors	Sensor-based stress detection	Stress detection accuracy: **89%**	Alchanatis et al. (2010)
4	Spectral analysis of rice diseases and stress using hyperspectral data	Rice	Hyperspectral analysis	Field spectral analysis	Disease detection accuracy: **89%**	Huang et al. (2019)
5	Hyperspectral vegetation indices for detecting fungal infections in rice	Rice	Hyperspectral vegetation indices	Vegetation index analysis	Infection detection sensitivity: **87-91%**	Zhang et al. (2005)
6	Detection of diseases in wheat crop using spectral reflectance and discriminant analysis	Wheat	Spectral reflectance, discriminant analysis	Discriminant analysis for spectral features	Disease classification accuracy: **87%**	Moshou et al. (2005)
7	Automated detection of wheat rust using reflectance spectroscopy and machine learning	Wheat	Reflectance spectroscopy, machine learning	Automated classification	Wheat rust detection accuracy: **94%**	Xie et al. (2017)
8	Portable non-imaging	Soybean	Non-imaging	Handheld	Nitrogen stress	Zhao et al.

Sr. No	Title of Subject	Crop	Techniques Used	Methods	Results (Accuracy, Sensitivity, etc.)	Author Name(s)
	sensors for detecting nitrogen stress in soybean		sensors	sensor-based detection	detection accuracy: **85%**	(2005)
9	Chlorophyll fluorescence and spectral indices for monitoring fungal infections	Soybean	Chlorophyll fluorescence, spectral indices	Combined fluorescence and spectral data	Fungal infection detection accuracy: **89%**	Wang et al. (2016)
10	Detection of fungal infections in mango trees using near-infrared spectroscopy	Mango	Near-Infrared Spectroscopy	Spectral-based infection monitoring	Early fungal infection detection accuracy: **88%**	Lu & Lu (2018)
11	Stress detection in mango leaves using portable spectral sensors	Mango	Portable spectral sensors	Reflectance-based stress monitoring	Stress detection rate: **86-89%**	Niu et al. (2014)
12	Detection of early plant stress responses in hyperspectral images	General	Hyperspectral imaging	Image-based feature analysis	Stress detection accuracy: **86-90%**	Behmann et al. (2014)
13	Combining spectral indices for monitoring leaf diseases in sugarcane	Sugarcane	Narrow-band spectral indices	Spectral index monitoring	Disease detection sensitivity: **88%**	Chivasa et al. (2020)
14	Spectral reflectance analysis of peanut plants under different levels of water stress	Peanut	Reflectance spectroscopy	Reflectance measurement	Water stress detection accuracy: **84-87%**	Zhao et al. (2005)
15	Early stress detection in soybean leaves caused by fungal infection using reflectance and fluorescence	Soybean	Reflectance and fluorescence	Dual-sensor analysis	Fungal stress detection accuracy: **87-90%**	Wang et al. (2016)
16	Hyperspectral imaging for early detection of rust disease in wheat	Wheat	Hyperspectral imaging	Spectral rust-specific indices	Detection accuracy: **91%**	Singh et al. (2020)

Sr. No	Title of Subject	Crop	Techniques Used	Methods	Results (Accuracy, Sensitivity, etc.)	Author Name(s)
17	Detection of mango anthracnose using fluorescence spectroscopy	Mango	Fluorescence spectroscopy	Real-time fluorescence-based monitoring	Disease detection accuracy: **89%**	Qin et al. (2019)
18	Detection of rice sheath blight using reflectance spectroscopy	Rice	Reflectance spectroscopy	Spectral feature extraction	Disease detection accuracy: **88%**	Wahabzada et al. (2015)
19	Monitoring fungal infections in maize using hyperspectral vegetation indices	Maize	Hyperspectral vegetation indices	Fungal-specific vegetation index development	Detection accuracy: **89%**	Zhang et al. (2005)
20	Thermal imaging for monitoring drought stress in mango trees	Mango	Thermal imaging	Leaf temperature-based stress monitoring	Stress detection accuracy: **85-88%**	Jones et al. (2013)

IV. DISCUSSION

The reviewed studies highlight the transformative potential of non-imaging techniques in the domain of precision agriculture. By utilizing spectroscopy, hyperspectral analysis, thermal imaging, and fluorescence sensing, these techniques have demonstrated remarkable accuracy and efficiency in detecting plant diseases across diverse crops.

One significant advantage is their capability for early detection, often identifying stress and disease before visible symptoms manifest. This feature is crucial for mitigating the economic and environmental impacts of plant diseases. For example, spectroscopy, combined with advanced machine learning algorithms, has shown the ability to distinguish between healthy and diseased leaves with over 90% accuracy (Zhang et al., 2018). Hyperspectral indices have proven particularly effective in diagnosing fungal infections, such as wheat rust and rice sheath blight, which can devastate yields if not controlled (Moshou et al., 2005).

Thermal imaging, though traditionally used for drought monitoring, has also emerged as a reliable method for detecting biotic stress. Variations in canopy temperature often correlate with pathogen-induced stress, providing an indirect but effective metric for early disease detection (Jones et al., 2013). Combining thermal imaging with spectral data has further enhanced its diagnostic accuracy, particularly in crops like mango and soybean.

Fluorescence sensing has demonstrated unique strengths in detecting chlorophyll-related changes associated with stress and disease. This method's non-invasive nature, coupled with real-time data acquisition capabilities, makes it an indispensable tool for modern agriculture (Lu & Lu, 2018). However, integrating fluorescence data with other spectral indices or machine learning models has shown the greatest promise in achieving comprehensive diagnostic capabilities.

Despite these successes, the adoption of non-imaging techniques faces challenges. Equipment costs and the complexity of data analysis remain significant barriers, particularly for resource-constrained regions (Niu et al., 2014). Furthermore, field conditions, such as varying light levels and environmental factors, can introduce noise into spectral data, complicating disease detection.

Future research should focus on overcoming these limitations through the development of cost-effective, portable devices that leverage advancements in IoT and cloud computing. The integration of these tools with remote sensing platforms could enable large-scale monitoring of plant health, significantly enhancing the scalability of non-imaging techniques (Wang et al., 2016).

V. CONCLUSION

Non-imaging techniques have established themselves as powerful tools in the fight against plant diseases, offering high accuracy, early detection, and scalable solutions. By combining spectral, thermal, and fluorescence data with machine learning algorithms, these methods provide unparalleled diagnostic capabilities. The reviewed studies underscore their applicability across a wide range of crops, including citrus, rice, wheat, soybean, and mango, highlighting their transformative potential in precision agriculture.

While challenges such as cost and field applicability persist, ongoing technological advancements are steadily addressing these barriers. The integration of non-imaging techniques with IoT and cloud-based systems promises to revolutionize plant disease management, enabling real-time, large-scale monitoring. As these technologies continue to evolve, they hold the potential to pave the way for more sustainable and efficient agricultural practices, ultimately contributing to global food security.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Artificial Intelligence: Tool for Newer Technologies

Dr. Vinod Wamanrao Gangane
Department of Computer Science, Yogeshwari Mahavidyalaya, Ambajogai, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
178-181

ABSTRACT

As a governance framework for emerging technologies, the responsible research and innovation (RRI) approach faces some fundamental conflicts, particularly between "inclusivity" and "agility". When we try to apply RRI principles to the development of AI, we also encounter similar difficulties. Therefore, it may be helpful to change the approach by not only seeing AI as the object of ethical governance but also as an effective tool for it. This involves mainly three levels: first, using AI directly to solve general ethical problems; second, using AI to solve the ethical problems brought about by AI; and third, using AI to upgrade the RRI framework. By doing something at these three levels, we can promote the fusion of AI and technology ethics and move towards ethical engineering, thus pushing ethical governance to new heights. In traditional ethical governance approaches, ethics is external, brought in by external actors, and the focus is on actors. However, in this new approach, ethics must be internalized in technology, with the focus not only on actors, but also on technology itself. Its essence lies in the invention and creation of technologically ethical tools..

Keywords: RRI; artificial intelligence; ethical governance; ethical engineering.

I. INTRODUCTION

Due to their novel, variable, and uncertain development prospects, emerging tech-nologies cannot have clear measurement standards at the outset. Therefore, innovators face inescapable uncertainty and can only move forward. Once emerging technologies are intro- duced, they will nonlinearly interact with various economic and social elements, constantly undergoing "translation" by other actors, inevitably leading to unforeseeable economic and social consequences, including uncontrollable risks and resulting in governance dilemmas that are difficult to solve [1]. People either allow these emerging technologies to develop freely and only address negative consequences after they occur, in which case the harm has already been carried out, or strictly regulate them from the outset, which might stifle their development—this is known as the Collingridge dilemma [2]. There have been many studies on how to overcome this dilemma, and "responsible research and innovation" (RRI) has become the most popular approach in recent years.

As a new concept that has emerged in recent years in European and American coun- tries, RRI requires attention to social, ethical, and legal issues in the research and innovation process; emphasizes the participation and collective negotiation of stakeholders as early as possible; and encourages the early intervention and real-time evaluation of humanists such as ethicists [3]. However, the RRI framework faces some problems, and the most serious one is that there is an inherent contradiction between the inclusiveness of stake- holders and the agility of collective action. This framework requires as many stakeholders as possible to participate. Due to the different interests and values of each stakeholder, there will be many internal conflicts, which will cause the collective action to be slow and make it difficult to conduct innovative activity effectively.

II. METHODS AND MATERIAL

Turning Artificial Intelligence into a Tool for Ethical Governance

To address this problem, we should shift our thinking mode. Rather than treating artificial intelligence solely as a subject of ethical governance, we should explore how we can turn it into a tool for ethical governance, thereby promoting RRI frameworks to be upgraded. This consists of three levels. Firstly, we could use artificial intelligence directly to solve general ethical problems. Secondly, we could use artificial intelligence to address the ethical problems that it itself has caused. Thirdly, we could use artificial intelligence to enhance RRI frameworks. By taking action on these three levels, we may be able to develop a new field of ethical engineering.

2.1. Using AI to Solve General Ethical Issues in Science and Technology The first step is to use artificial intelligence to solve general ethical problems in science and technology. For example, there are lots of academic misconduct cases in the research field, including plagiarism. It used to be difficult to detect plagiarism, but now things are different. There are plagiarism detection tools available, and in general, the first step after a journal receives a paper submission is to check for duplicates. However, this retrieval system still has problems. Basically, it can only detect textual duplications and not semantic duplications. In other words, the expression can be changed and passed, but the idea itself may still be plagiarized. Moreover, most plagiarism detection tools can only work for documents in a certain language and cannot detect plagiarism with cross-language retrieval. As a result, there may be a situation where published articles in a foreign language are copied and assembled in the home country, or overseas students translate publications in their native language into foreign languages to apply for their degrees. Through natural language processing technologies, especially large language models (LLM) [5], new technologically ethical tools can be developed to achieve cross- language retrieval and semantic duplication detection. With this, academic misconduct will be difficult to hide.

Actually, an ethical AI machine can function as a universal tool for ethical discussions with researchers and innovators, a conversational partner in people's daily ethical decision- making processes. Current efforts are underway to develop a range of digital thinkers, including digital philosophers, ethicists, and even common citizens. By engaging in real-time conversations, these machines can prompt researchers, innovators, and the public to consider ethical issues and remain vigilant about ethical considerations. Individuals can seek guidance from an AI-based tool like ChatGPT or digital ethicists whenever confronted with ethical issues. This ethical AI has the potential to expand its reach throughout society and provide support in addressing a multitude of ethical concerns.

2.2. Using AI to Solve Ethical Issues Caused by AI The second aspect is to use AI to solve ethical issues related to Artificial Intelligence. The basic idea is to use AI to counter AI. When we try to govern AI, we should not forget that AI is also a tool for governing AI. This actually represents a kind of reflexivity—AI is used to control AI, and by doing so, a cycle is formed where AI develops along an ethical development trajectory through iterative learning. For instance, we can develop an AI ethics verification machine to check AI ethics during the AI development process. In general, the ethical principles can be converted into industry standards on which the ethical monitoring machine can be built. Such an ethical machine can penetrate all aspects of AI applications so as to serve as a supporting platform, which could be used by AI developers, customers, and even third parties. In this way, AI ethics can be transformed into a concrete technical tool. This kind of technical tool is a distributed platform, a real-time operational tool, and can be understood as a kind of ethical machine.

Combating AI is a complex task that requires consideration of multiple factors such as data security, network security, and algorithm security. The overarching method for leveraging AI in this pursuit involves: Using AI algorithms to identify abnormal activities such as threats, attacks, and malicious programs that steal data from the network; Using AI to simulate attacks so potential vulnerabilities and

security risks of AI-based systems can be identified and corresponding preventive measures can be taken; Using AI to establish a secure network area to prevent unauthorized access and other threats. In short, to address the ongoing threats posed by AI, creative and innovative AI-based strategies should be continuously developed.

2.3. Using AI to Upgrade the RRI Framework

The third point is to upgrade the RRI framework by using artificial intelligence. Utiliz-ing AI can help alleviate the contradiction between inclusiveness and agility, promoting both inclusiveness and agility simultaneously. According to the AI framework, many stakeholders should be included, but there is a coordination problem after they are brought in. If coordination is only carried out in person, the cost will be very high. If a network platform based on AI is established, an auditable stakeholder network can be formed, and coordination among stakeholders can be more convenient and efficient. This approach can not only include more stakeholders but also greatly reduce coordination costs, thus simultaneously enhancing the inclusiveness and agility of responsible innovation.

As we know, typical RRI procedures include four dimensions: anticipation, reflexiv-ity, engagement, and feedback. The anticipation dimension requires the combination of scientific evidence and future analysis to enable innovators to better understand the oppor-tunities and challenges they face; the reflexivity dimension requires innovators to reflect on their own behavior and innovation process; the engagement dimension requires placing visions, purposes, problems, and difficulties in a larger social context and achieving collec-tive deliberation through participation; and the feedback dimension refers to adjusting the framework and direction of innovation activities in a timely manner based on voices from stakeholders [6]. When discussing these four dimensions in the past, people never considered the issues of “cost” and “feasibility” of implementation. Based on artificial intelligence, all four dimensions can be upgraded to become AI-based anticipation, AI-based reflexivity, AI-based engagement, and AI-based feedback. AI tools can be applied in each dimension, allowing for digital philosophers, digital ethicists, digital sociologists, digital lawyers, and even digital citizens to participate. With the increasing use of digital stakeholders, the process of communication and dialogue is moving towards real-time automation, which can significantly reduce operational costs. Nonetheless, it is not an indicator that real actors’ involvement is dispensable; rather, it is the first step in implementing RRI. This approach effectively addresses the conflict between inclusivity and agility and ensures responsible innovation is not merely rhetoric but is practiced in reality.

III.RESULTS AND DISCUSSION

In conclusion, the solution to resolving ethical concerns associated with technology, such as those related to artificial intelligence, lies in using artificial intelligence to create governance tools that prioritize ethics, specifically AI-based ethics tools. This represents a significant ethical responsibility for researchers, engineering professionals, and manage- ment teams at various levels.

Although science and technology management has made significant contributions to promoting ethics by establishing ethical guidelines and monitoring the ethical behaviors of scientists and innovators, it is not enough to stop at this level. AI should be regarded as an opportunity to proactively address ethical concerns and aggressively pursue research on AI-based ethics. This endeavor will require substantial support to materialize.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Environmental Studies with the Sensor Mesh: Essence and Execution

Mahendra D. Acharya*[1], Mahajan Sachin Pandurang[2]
*[1]Department of Computer Science, Yogeshwari Mahavidyalaya, Ambajogai, Maharashtra, India
[2]Department of Computer Science, Padmashri Vikhe Patil Arts, Science & Commerce College, Pravaranagar, Ahmednagar, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
182-190

ABSTRACT

In 1997, the Sensor Mesh was conceived at the /Jet Propulsion Laboratory (JPL) to take advantage of the increasingly inexpensive, yet sophisticated, mass consumer-market chips for the computer and telecommunication industries and use them to create platforms that share information among themselves and act in concert as a single instrument. This instrument would be embedded into an environment to monitor and even control it. The Sensor Mesh's purpose is to extract knowledge from the data it collects and use this information to intelligently react and adapt to its surroundings. It links a remote end-user's cognizance with the observed environment. Here, we examine not only current progress in the Sensor Mesh technology, but also its recent application to problems in hydrology to illustrate the general concepts involved.

Keywords: Sensor Mesh, network, wireless, hydrology, flood.

I. INTRODUCTION

In its most general form, the Sensor Mesh is a macro-instrument comprised of spatially-distributed sensor platforms [1]. As shown in Level 1, these platforms, or shells, can be orbital or terrestrial, fixed or mobile. Coordinated communication and interaction among the shells provides a local fusion of the dispersed data and results in a spatio-temporal understanding of the environment. Specific portal shells provide end-user access points for command and information flow into and out of the Sensor Mesh. Sensor Meshs Project is currently focused on in-situ Sensor Meshs, with the resulting instrument accessible, in real-time, via the Web.

II. METHODS AND MATERIAL

Level 1. Generalized concept of the Sensor Mesh, including both orbital and terrestrial platforms.

The Sensor Mesh's capabilities are useful in a diverse set of outdoor applications ranging from precision agriculture to perimeter security to effluent tracking. Wireless networks of sensors are often marketed as replacements for running wire to sensing points. Naturally this holds true for the Sensor Mesh as well, with the individual shells communicating among themselves wirelessly. However, it is more significant that the Sensor Mesh, with its unique global information sharing protocol, forms a sophisticated sensing tapestry that can be draped over an environment. This Sensor Mesh approach allows for various complex behaviors and operations such as on-the-fly identification of anomalous or unexpected events, mapping vector fields from measured scalar values and interpreting them locally, and single-pod detection of critical events which then triggers changes in the global behavior of the Sensor Mesh.

Wireless networks are not a new approach to environmental monitoring and it is common to find systems where remote sensors in the field communicate to central points for data processing in a star- network formation. The Sensor Mesh, however, is a temporally synchronous, spatially amorphous network, creating an embedded, distributed monitoring presence which provides a dynamic infrastructure for sensors. By eschewing a central point on the network, information flows everywhere throughout the instrument (see Level 2).

So far, this sounds like a typical ad hoc, self-configuring, mesh network. Often, the ideas of hopping information around such a network are framed in terms of the power advantage gained by doing so. While this advantage certainly exists, the Sensor Mesh concept goes one step further: the individual shells comprising a Sensor Mesh are not just elements that can communicate with one another; they are elements that must communicate with one another. Whereas wireless networks are typically discussed as confederations of individual elements (like computers connected to the Web), the Sensor Mesh is a single, autonomous, distributed instrument. The shells of a Sensor Mesh are akin to the cells of a multi-cellular organism; the primary purpose for information flow over a Sensor Mesh is not about getting data to an end-user, but rather to the rest of the Sensor Mesh itself.

Level 2. The Sensor Mesh forms an informational backbone that creates a dynamic infrastructure for the sensors in the Sensor Mesh shells.

By design, the Sensor Mesh spreads collected data and processed information throughout its entire network. As a result, there is no design criterion for routing as in more typical wireless systems. Routing, by definition, is a focused moving of information from one point to another. In contrast, information collected by a Sensor Mesh is spread everywhere, rendering meaningless the concept of routing on it. Instead, the communication protocol on a Sensor Mesh is relatively simple and is structured for both omni- and bi-directional information flows. Omni-directional communication implies no directed information flow, while bi-directional communication lets individual shells (and end-users) command other shells as well as receive information from them. Consequently, information on the Sensor Mesh can result from four types of data: (a) raw data sensed at a specific pod, (b) post- processed sensed data from a pod or group of shells, (c) commands entered into the distributed instrument by an external end-user, and (d) commands entered into the distributed instrument by a pod itself. The Sensor Mesh processes this internal information, draws knowledge from it, and reacts to that knowledge.

Since there is no specific routing of information, all shells share everything with each other. After each measurement is taken, both raw and processed information from each pod are moved throughout the Sensor Mesh to all other shells before the next measurement is taken. Because the Sensor Mesh is a single, distributed instrument, its internal operations are synchronous from pod to pod (again in contrast to more common wireless networks). In this way, the total snapshot associated with that instant in time is available to all shells on the Sensor Mesh. This global data sharing allows each pod to sense phenomena beyond its specific location. shells may therefore, combine data across the Sensor Mesh to identify a moving front and determine its speed and direction, a task that a single-point measurement can not accomplish. shells may also use neighbours to examine the stochastic nature of their local measurements to determine whether or not the data collected are well-behaved. Such macroscopically coordinated data processing would not be as straightforward if each pod were semi- autonomous on the network, as in typical wireless sensor systems. There is a degree of stiffness to the information flow over the Sensor Mesh compared to the individually directed node-to-node information threads on more typical wireless systems. The Sensor Mesh shells may be thought of as individual, synchronized pixels in a much larger instrument that can take snapshots at regular intervals of the entire environment in which it is embedded and each pixel is simultaneously aware of the overall picture as well as its local readings.

Sensor Mesh shells

A Sensor Mesh pod consists of five basic modules:

(1) The radio, which links each pod to its local neighborhood. The Sensor Mesh shells use radios operating in the 700 MHz license-free Industrial, Science and Medical (ISM) band with an upper range of ~100 m or more.

(2) The microcontroller, which contains the system's protocols, communicates with the attached sensors, and carries out data analysis as needed.

(3) The power system. The system uses a battery pack with solar panels to keep the batteries charged. The combination of solar panels and micropower electronic design have kept Sensor Mesh shells operating in the field for years without requiring maintenance.

(4) The pod packaging. This key module is often overlooked, especially for Sensor Mesh applications in the wild. The package must be light, durable, inexpensive, and sealed against such elements as rain, snow, salty sprays, dust storms, and local fauna. In addition, it must provide for easy and rapid mounting.

(5) The sensor suite. This module is completely determined by the specific application. Ideally, the sensor suite will, in fact, be the prime-determining factor for the size, cost, and power requirements of a Sensor Mesh pod, making the Sensor Mesh infrastructure attractive for any application. What is considered an inexpensive or small Sensor Mesh pod in one application may not be viewed as such in another.

We have been conditioned by decades of experience with Moore's Law (and the technology revolution associated with it) to think that smaller is always better. There are certainly practical reasons for limiting the size of a Sensor Mesh pod. In an outdoor environment, smaller and lighter shells are easier to deploy since more can fit into, say, a backpack. However, shrinking shells to infinitesimal sizes is undesirable for a typical outdoor Sensor Mesh system. Consider the impact of size with respect to three key Sensor Mesh pod design issues: power, antenna size, and transducers.

An important design requirement for typical outdoor Sensor Meshs is pod longevity. In many cases, deployment is only practical during certain seasons and therefore, intra-season maintenance must be avoided. As a result, maximizing the available power, by cleverly using batteries and/or energy harvesting, is critical. Batteries are often rated in terms of their energy density (watt-hours per unit volume). This is because cells can be added serially to increase total available voltage. The larger the volume of the Sensor Mesh pod, the more volume is available for power from any particular battery technology.

There are only two ways to maintain a given amount of battery power level available while allowing the pod volume to shrink: improve the battery technology or reduce energy use within the pod. While there are numerous efforts to provide higher energy-density power sources than are typically available (e.g,. lithium ion batteries), none are yet commercially available for consumer use. In addition, many experimental batteries have limited lifetimes. Moreover, any suitable battery technology must be essentially zero-maintenance and environmentally robust (especially to changes in temperature, both seasonal and diurnal). As for improving energy efficiency, the laws of physics require a certain power output to broadcast a given distance. Therefore, although one can lower the energy per bit involved in computation, the wireless communication puts a hard limit on how much energy will be required for the system to operate for a given pod-to-pod distance.

Now, consider energy harvesting which is typically accomplished via solar power charging secondary batteries. Here, too, the smaller the platform, the smaller the solar panels used to re-energize the system, and the smaller amount of energy that can be harvested for a given panel. Clearly, beyond a certain size, the smaller one designs a Sensor Mesh pod for a given set of operating parameters, the more one gives up in terms of longevity with respect to available power.

Antennas are also directly related to platform size. Again, the laws of physics dictate the appropriate antenna geometry for a given operating frequency to ensure a proper impedance match into the radiated space. As a result, while the on-board processor and radio electronics may shrink, the antenna may not if a particular communication range is required. Without proper coupling, radiation efficiency is reduced and power must be increased to the radio to maintain range. We therefore find that since most outdoor Sensor Meshs required pod-to-pod ranges of at least tens of meters, indiscriminate shrinking of the individual antennas clearly compromise the telecommunication subsystem.

Lastly, consider the sensors themselves. many sensors used in outdoor field applications, though compact and inexpensive, are not micro-electromechanical system (MEMS) devices and therefore cannot be integrated into the Sensor Mesh pod at the chip level. As a result, for a wide variety of Sensor Mesh applications in an outdoor environment, the sensors will be additional components added to the basic pod platform. Clearly, there is little to be gained by continually shrinking the platform if the sensors themselves remain the limiting size element. Moreover, shrinking the platform may actually complicate the design if it becomes difficult to integrate the sensors into the pod.

As shown in Level 3, the Sensor Mesh shells have been developed in several sizes, including that of a gumball and that of a couple of decks of playing cards. Significantly, the gumball-sized pod dates back to 1998 [1], demonstrating, even then, that it was relatively easy to make small platforms so long as only simple measured parameters (i.e., temperature, humidity, etc.) and short pod-to-pod communication distances (i.e., order of meters) were required. Such small shells are ideal for building or factory monitoring, but less practical for outdoor environments for reasons discussed above. From this discussion, it is apparent that, while smaller shells are desirable, shrinking shells beyond a certain point leads to diminishing returns.

Fielding a Sensor Mesh

With the objective to do real in-situ environmental work, the Sensor Meshs Project has been aggressive about fielding instruments. Sensor Meshs have been deployed in a large variety of demanding real-world locations for many months or even years. For example, Sensor Meshs have been at the Huntington Botanical Gardens in San Marino, CA, starting with the deployment of Sensor Mesh 2.0 in June 2000 and continuing with Sensor Mesh 3.0, the first permanent wireless sensor network system to provide continuous real-time streaming data to users over the Web, in October 2001. The Gardens continue to remain a significant test site for Sensor Mesh technology [1]. Information about other deployments in a variety of environments as well as real-time, streaming data from several present deployments, is available on the Web [2].

From the experience of deploying the Sensor Mesh in a multitude of environments with varying conditions, it is apparent that the ease with which the system is deployed is just as critical for acceptance by end-users as are its technological aspects. With the exception of applications in battlefield theaters, most outdoor Sensor Mesh applications require the system to be deployed in manner that does not harm the monitored environment. For example, end users have expressed concerns that if Sensor Mesh shells are too small, local fauna may try to ingest them and choke. End- users also want to avoid littering their environment with hundreds of pieces of microelectronic gear.

Most applications require tracking specific pod location and it is therefore highly unlikely that shells will simply be sprinkled over large areas. In addition, coupling sensors into the environment will usually prevent such a passive deployment. For example, neither subterranean nor seismic sensors can be deployed by a sprinkling technique, as both require laborious efforts for appropriate sensor mounting. Consequently, the mounting and placement of Sensor Mesh shells will be an active operation and likely to be done by hand in most instances.

The methods used to mount the Sensor Mesh shells depend not only on the application but also the particular field site. Pod placement very close to the ground can limit transmission distance.

Nevertheless, while the Huntington Garden shells are within 10 inches of the ground, they have sufficient communication power to keep an adequate pod-to-pod distance. Often, for logistical reasons, the Sensor Mesh shells tend to be mounted higher off the ground with the attendant benefit of increasing the wireless distance. Local terrain is rarely level which also tends to increase transmission distances.

We have typically used posts (for horizontal surfaces) and brackets (for vertical surfaces) to mount the shells. These types of mounts are both small enough and light enough to bring into the field yet are sturdy enough for fixing the Sensor Mesh shells rigidly in place for long durations.

Level 3. Various Sensor Mesh shells. Top: Functioning Sensor Mesh 1.0 pod, circa 1998. Note the small size which includes antenna, battery, and temperature and light sensors. Bottom Left: Sensor Mesh 3.1 pod deployed at the Huntington Botanical Gardens, circa 2002. It is about the size of two decks of playing cards. The pod is mud spattered from rain and watering and has a chewed antenna. Subterranean sensors (soil moisture and temperature) can be seen going into the ground. Bottom Right: A Sensor Mesh 5.0 pod, circa 2004. This new generation of Sensor Mesh shells is more compact and more power efficient than previous ones, a direct result of exploiting Moore's Law in its design.

Sensor Mesh deployment at a recharge basin facility

Each year, large-scale flooding affects millions of people around the world with attendant losses of property and life. A major limitation in the mapping and characterization of catastrophic floods is an inability to monitor them in real-time. For instance, it has been historically difficult to study transient hydrologic phenomena such as storm-induced flooding, surface water movements, water infiltration, and soil moisture conditions. This limitation has had a direct impact on accurate flood prediction systems. The Sensor Mesh can address this deficiency by providing real-time detection and monitoring of both surface water conditions and water infiltration.

We have deployed a Sensor Mesh at the Central Avra Valley Storage and Recovery Project (CAVSARP) facility located west of Tucson, AZ [2,3] and shown in Level 4. The facility is located in a desert environment of the semi-arid Southwest United States where the artificial recharge basins experience repeated flood cycles. The controlled flooding conditions at the CAVSARP facility are ideal for the investigation of various hydrologic processes. Common geomorphologic features related to flood inundation observed at the site are analogous to features often found in ancient paleolakes on both Earth and Mars and include wave-cut terraces, polygonal-patterned ground, and ridges related to drying of basin floor materials. Algal mats are also visible in some of the basins during the drying period of the flood cycle. Thus, the flood-related phenomena at the facility are of great interest to both hydrologists and terrestrial and planetary geologists.

There are several technology-related reasons for this site choice as well. The CAVSARP facility, with its controlled flood conditions, allows us to continue our efforts to develop the Sensor Mesh as a tool for the study of spatio-temporal phenomena. For example, the Sensor Mesh can track the moving flood front, follow the infiltration of water into the ground, and provide information to map and characterize the lateral and vertical extent of the floodwaters. Moreover, the extreme temperature variations of the Arizona desert (both diurnal and seasonal) provide yet another test of the Sensor Mesh's robustness. The deployed Sensor Mesh had essentially identical hardware to those of previous installations [4] and no special provisions were made for the new environment.

The recharge basins are operated cyclically to allow for routine maintenance of the surface conditions. These operations lead to periodic infilling, with a water front progressing across the basin. Once the inflow of water is shut off, the floodwaters continue to infiltrate into the ground and the drying portion of the cycle begins with the drying front reversing the original flood pattern. The basins were constructed to have a smoothly varying elevation, which declines from south to north. As a result, the north ends of the basins fill first during flooding and dry last during draining. Existing instruments in each basin provide for continuous monitoring of inflow rate at the inlet pipe and water height at the deep end. These instruments are connected to a Supervisory Control And Data Acquisition System (SCADA), allowing for remote monitoring of basin operations. A visual staff gauge is regularly read to confirm the accuracy of the water level sensors.

A single basin (102), measuring approximately 700×2400 ft2, was strategically outfitted with 13 Sensor Mesh 3.2 shells, the number and placement of shells being determined by science requirements, rather than technological limitations. As shown in Level 5, the shells were mounted on stakes to elevate them above the flood waters which can rise as high as 7 ft. (While the shells themselves are water-tight, pod-to-pod radio communication would not be possible if they were submerged.) Each pod, in addition to collecting air temperature, humidity, and light levels also collects two soil moisture readings (one at the surface and one 0.5 m below) and a surface soil temperature reading. This is accomplished by wires that run from the pod into the ground. Measurements are made at 5 minute intervals with the results being fed to the Web in real-time (via the portal pod 0). Level 6 shows the deployed Sensor Mesh during a flooding event.

Level 4. Aerial view of a portion of CAVSARP facility showing the location of the Sensor Mesh shells in recharge basin 102. The portal pod (pod 0) is connected to a computer which transfers the data to the Web. In this photograph, recharge basin 103 is drying out, with the wetter soil in the northern portion of the basin. In contrast, basin 102 is being flooded with the moving water advancing southward. The basins immediately north of 103 and south of 102 are fully flooded.

Level 5. team members deploy a Sensor Mesh 3.2 pod in recharge basin. Extended stands allow the shells to stay operational above water during a flooding event. Note polygon patterns in soil, indicative of previous flooding/drying cycles.

Level 6. View looking north with recharge basin 102 fully inundated. Pod 11 is clearly visible above the rising water.

Flooding Event Flooding Event

Level 7. Screen-capture of Web data from CAVSARP facility. Graphs (top to bottom): surface temperature (◦C), surface moisture, and soil moisture at 0.5 m depth (relative units; lower values imply wetter soil). Diurnal cycles in soil water potential measurements are largely artifacts that can be corrected using the soil temperature at the same location and depth. Sensor Mesh pod 1 (southwest basin corner) is in blue, pod 6 (basin inlet, northwest corner) in red, pod 10 (basin center) in green, pod 11 (southeast basin corner, diagonal from pod 6) in light blue. Data correlate with water discharge into basin, inundation, infiltration, drying, and the beginning of another cycle.

Preliminary use of Sensor Mesh in hydrologic studies

This Sensor Mesh has been collecting data since its deployment in November 2003. The real-time, streaming output from this system was made available via the Web; a sample screen-capture is shown in Level 7. Unlike remote techniques, which can only observe the basins for relatively short durations on finite schedules, the Sensor Mesh's data stream provides continuous information for tracking surface water motion and ground infiltration. The spatial and temporal patterns of wetting and drying can thus, be fully monitored and results incorporated into hydrological models and compared with space- and airborne-based investigations [5]. This analysis is ongoing. As a result, this Sensor Mesh can both augment and ground-truth the remote data traditionally used in hydrologic studies.

The repeatable nature of the flooding/drying dynamics is apparent in Level 7. The soil moisture measurements are made with Watermark sensors [6], where electrodes embedded in a granular matrix yield a lower resistance when the surrounding soil is wetter. As a result, the raw data reveals the motion of the flooding water as sharp drops in resistance. (The diurnal cycles seen in the raw data are sensor artifacts and can be corrected with soil temperature measurements [7].) It only takes a few hours for the flood front to traverse the basin from the inlet in the northwest corner to the basin center but a much longer time (about 20 hours) to reach the basin's southwest and southeast corners. Note, too, that the water reaches the southern border relatively evenly (as indicated by shells 1 and 11), which is expected from both basin construction and the photographic evidence shown in Level 4. Moreover, it is also clear from Level 7 that the drying front traverses the reverse route, albeit at a much slower speed. Not surprisingly, the surface dries more thoroughly than the deeper portions of the ground.

The raw data can be downloaded using the Sensor Mesh's graphical user interface so that these initial observations can be further refined into more meaningful hydrologic terms. Soil moisture can be described in terms of the forces that retain the water in the soil. At equilibrium, the energy status of the water in the sensor's granular matrix is equal to the energy status of the water in the surrounding soil. The electrical resistance measured is then related to the soil water potential by the sensor-specific calibration:

The inlet flow is also plotted. The maximum inflow rate was approximately 22800 gal/min with the water rising, in this case, to 5.7 ft. The shells examined are on the basin's western border and, again, it is clear that a finite time is required for the moving water front to travel south from the inlet (pod 6) to the near corner (pod 1). In contrast, note how rapidly the soil moisture at depth increases at pod 6. The slight difference in the temporal aspects of soil wetting between the two flood events (most notably at pod 6) is attributable to the fact that the soil moisture sensors were planted just prior to the first flood event and therefore, the surrounding soil was disturbed and not as compacted as before sensor insertion. The second flooding event therefore, provides data for more accurate modeling. Again, the Sensor Mesh provides a continuous embedded monitoring presence which leads to a more refined picture of events.

Level 8. Soil water potential at 0.5 m deep along the west basin border during the first two flooding events after deployment. Traveling from north to south, the shells are positioned: 6 (inlet), 15, and then

1. Also shown is the inlet water rate.

Level 9 increases the time-scale of observation. Included now is a third flooding event occurring late on January 1, 2004. Notice, however, that this time the inflow is not left on long enough to allow the water front to reach the southern side of the basin and the soil at pod 1 continues to dry out. Level 10 reveals that, in general, soil water potential at the surface is more responsive than that at depth. This type of subterranean measurement, the inferred vertical tracking of water movement and soil drying as a function of time, is not possible using remote measurement techniques. Coupled with the large spatial extent of the Sensor Mesh, this temporal vertical tracking will provide a powerful tool for understanding transient hydrologic phenomena.
These preliminary results clearly demonstrate several new methodologies for hydrology created by the Sensor Mesh. Both transient and subterranean hydrologic phenomena can be captured to better model and understand percolation in different soil types, and can be captured in native environments on a long-term basis. Unlike the information obtained by remote measurements, the data from the Sensor Mesh are continuous and not restricted by orbital paths, flight schedules, or local weather conditions. Moreover, the in-situ Sensor Mesh data can also be compared to remote measurements to provide ground-truth. The Sensor Mesh deployed in the recharge basin is therefore more than just a functioning technological test. It is a functioning scientific instrument for hydrologic use.

Level 9. Soil water potential at 0.5 m deep along the west basin border. Note that the third flooding event did not last long enough to affect pod 1.

Level 10. Comparison of pod 6 soil water potential at two depths.

III.RESULTS AND DISCUSSION

The primary focus of Sensor Mesh development thus far has been to demonstrate that the technology is stable, robust, and attractive to potential end-users. For a user community to adopt it, however, the Sensor Mesh needs to be more than just well-engineered; it must also be easily deployed and maintained and provide valuable output. The overall simplicity of the Sensor Mesh system as an operational instrument is demonstrated by the fact that most Sensor Meshs are deployed and operated in a variety of environments (including Antarctica [8]) without requiring assistance from the team.
As shown by our case study, the Sensor Mesh can provide important spatio-temporal data needed to track transient phenomena. In our hydrology example, these phenomena include flooding and infiltration. The simultaneous measurements of temperature and soil moisture at different locations and depths make it possible to monitor the changes in soil moisture in different strata. The results also provide an excellent opportunity to develop a mechanism for the study of flood dynamics in a controlled and well-instrumented environment. The Sensor Mesh, therefore, has a great potential to change our way of monitoring and understanding hydrologic processes on Earth and beyond. Similar examples can be found in other environmental studies.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Leveraging Information Technology for Financial Inclusion in India: Transformative Advancements and Opportunities

Dr. Arvind Rayalwar[1], Mr. Bhargavram Choudhary[2]

[1]Associate Professor, Department of Commerce, Swa Sawarkar Mahavidyalaya, Beed, Maharashtra, India

[2]Assistant Professor, Department of Computer Science, Swa. Sawarkar Mahavidyalaya, Beed, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
191-197

ABSTRACT

Financial inclusion is essential for fostering inclusive economic growth and reducing inequality, particularly in a diverse and populous nation like India. Technology has emerged as a critical driver in bridging the gap between underserved communities and essential financial services. India's fintech sector, expected to contribute $400 billion to the national economy in the coming years, exemplifies the transformative potential of information technology in addressing financial exclusion. This paper explores how advancements such as mobile banking, digital payment systems, and biometric authentication have significantly enhanced access to financial services. Additionally, it examines case studies, statistical data, and the socio-economic impact of these developments. While highlighting the challenges such as digital literacy gaps, infrastructure limitations, and cybersecurity threats, the article presents actionable policy recommendations to foster sustainable and inclusive growth. By leveraging technology effectively, India can lead global efforts in financial inclusion and economic empowerment.

Keywords: Financial inclusion, information technology, fintech, digital payments, India

I. INTRODUCTION

Financial inclusion is the process of providing affordable, accessible, and effective financial services to individuals and businesses, particularly those in underserved or marginalized communities. In a diverse and populous nation like India, financial exclusion has long been a challenge, with millions lacking access to formal banking systems due to geographic, economic, and social barriers. Over the past decade, information technology has emerged as a transformative force in addressing these challenges, fundamentally reshaping the financial landscape.

Technological advancements such as mobile banking, digital wallets, and biometric authentication systems like Aadhaar have revolutionized how financial services are delivered, significantly enhancing access and convenience. Programs like the Unified Payments Interface (UPI) and Pradhan Mantri Jan Dhan Yojana (PMJDY) exemplify the integration of technology into financial inclusion strategies, contributing to significant milestones, such as the rise in adult account ownership from 53% in 2013 to 88% in 2025. These developments not only support economic empowerment but also contribute to reducing poverty and fostering inclusive growth.

This paper explores the multifaceted role of information technology in advancing financial inclusion in India. It highlights key technological innovations, assesses their socio-economic impacts, and examines the challenges and opportunities they present. By doing so, it aims to provide a comprehensive understanding of India’s journey toward building a more inclusive financial ecosystem.

Research Question:

How is information technology driving financial inclusion in India, and what are the advancements, challenges, and opportunities associated with this transformation?

Objectives

1. To analyze the role of information technology in expanding financial services access in India.
2. To evaluate the socio-economic impacts and challenges of leveraging technology for financial inclusion.

II. METHODOLOGY:

This research employs a mixed-methods approach, combining quantitative and qualitative analyses. Primary data sources include government reports, financial inclusion indices, and fintech adoption surveys. Secondary data sources comprise peer-reviewed articles, industry white papers, and case studies. Statistical tools are used to interpret trends, while thematic analysis is applied to qualitative data to derive actionable insights.

III.CASE STUDIES:

1. **Unified Payments Interface (UPI):** Launched in 2016 by the National Payments Corporation of India (NPCI), UPI has become a cornerstone of India’s digital payment ecosystem. As of 2025, UPI processes over 8 billion transactions monthly, with rural and semi-urban areas accounting for a significant share. Its success lies in its ease of use, interoperability, and cost-effectiveness.
2. **Pradhan Mantri Jan Dhan Yojana (PMJDY):** The PMJDY scheme, launched in 2014, aims to provide universal banking access. By 2025, it has facilitated over 500 million accounts, many linked with Aadhaar and mobile numbers to enable seamless digital transactions and direct benefit transfers (DBTs).
3. **M-Pesa and Mobile Wallets:** Mobile wallets like Paytm and PhonePe replicate the success of M-Pesa, enabling cashless transactions and micro-credit access for unbanked populations. Paytm alone reported over 400 million active users in 2024.
4. **Digital Lending Platforms:** Companies like BharatPe and KreditBee leverage big data and AI to offer small-ticket loans to micro-enterprises, addressing the credit needs of underserved markets. BharatPe disbursed loans worth ₹35,000 crore in 2024.

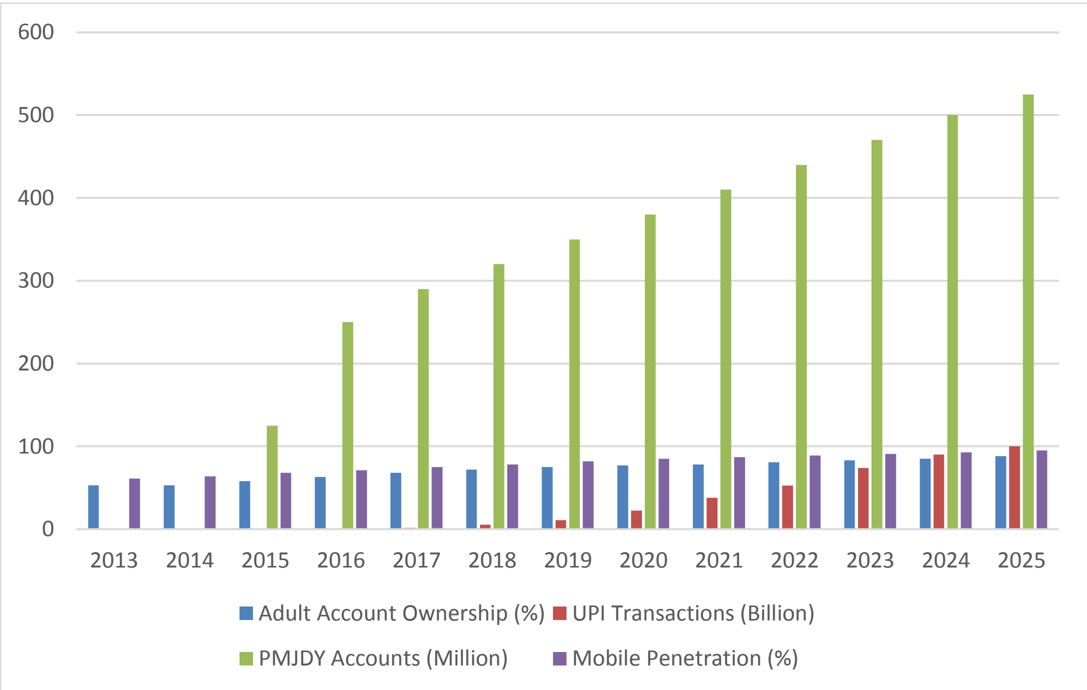
IV. INTERPRETATION, ANALYSIS, AND DISCUSSION

The transformative role of information technology in expanding financial services access in India is evident through its ability to overcome traditional barriers and foster inclusivity. Innovations like mobile banking, digital payment platforms such as UPI, and biometric authentication systems have proven instrumental in addressing challenges such as geographical isolation, socio-economic disparities, and limited infrastructure.

1. Statistical Analysis of Financial Inclusion Indicators:

The table below highlights key indicators over the last decade:

Year	Adult Account Ownership (%)	UPI Transactions (Billion)	PMJDY Accounts (Million)	Mobile Penetration (%)
2013	53	-	-	61
2014	53	-	0	64
2015	58	-	125	68
2016	63	0.1	250	71
2017	68	1.5	290	75
2018	72	5.5	320	78
2019	75	10.8	350	82
2020	77	22.3	380	85
2021	78	38.0	410	87
2022	81	52.8	440	89
2023	83	74.0	470	91
2024	85	90.0	500	93
2025	88	100.0	525	95



- **Adult Account Ownership:** The steady increase from 53% in 2013 to 88% in 2025 indicates the growing access to financial services in India, driven by government initiatives like PMJDY and technological advancements.

- **UPI Transactions:** From its inception in 2016, UPI has seen exponential growth, reaching 100 billion transactions in 2025, highlighting its role in digitalizing India's payment ecosystem.
- **PMJDY Accounts:** The increase from 0 accounts in 2014 to 525 million in 2025 underscores the success of targeted financial inclusion programs.
- **Mobile Penetration:** The rise from 61% in 2013 to 95% in 2025 reflects improved infrastructure and affordability, which have been pivotal in enhancing access to digital financial platforms.

These advancements have empowered underserved populations, bridging financial gaps across socio-economic sections and paving the way for a more inclusive financial ecosystem.

2. Socio-Economic Impact:

- Technology-driven financial inclusion has empowered women, with 55% of PMJDY account holders being female. This has led to improved financial independence and increased participation in entrepreneurial activities, especially in rural and semi-urban areas.
- Rural adoption of digital payments has significantly enhanced market access for farmers and small businesses. Digital platforms like UPI and mobile wallets have reduced dependency on intermediaries, increasing income and reducing transaction costs.
- The rise in adult account ownership from 53% in 2013 to 88% in 2025 reflects a transformative shift in access to banking services, bridging financial gaps across socio-economic strata.
- Mobile penetration reaching 95% in 2025 has been a catalyst for the adoption of digital financial services, especially in remote areas, enabling previously excluded populations to participate in the formal economy.
- Government programs like Direct Benefit Transfers (DBTs), powered by Aadhaar-linked accounts, have streamlined subsidies and welfare benefits, reducing leakages and ensuring timely disbursal to beneficiaries. This has directly impacted poverty reduction and enhanced financial stability among vulnerable groups. Technology-driven financial inclusion has empowered women, with 55% of PMJDY account holders being female. This has led to improved financial independence and entrepreneurial activity.
- Rural adoption of digital payments has enhanced market access for farmers and small businesses, boosting incomes and reducing dependency on intermediaries.

3. Challenges:

- Digital literacy remains a barrier, with only 38% of rural Indians proficient in using digital platforms.
- Infrastructure limitations, particularly in remote areas, impede consistent access to digital financial services.
- Cybersecurity concerns and digital fraud pose significant challenges to the adoption of fintech solutions, eroding user trust and creating barriers to widespread acceptance. Issues such as data breaches, phishing attacks, and identity theft compromise the security of digital transactions, particularly affecting first-time and less digitally literate users. These challenges underscore the importance of implementing robust cybersecurity measures, enhancing user awareness, and fostering industry-wide collaboration to create secure and reliable digital financial ecosystems.

V. POLICY IMPLICATIONS AND RECOMMENDATIONS:

1. **Infrastructure Development:**
   - Expand Broadband and Mobile Connectivity: Ensure universal internet coverage, particularly in remote and rural areas, through robust public-private partnerships. This involves deploying fiber-optic cables, increasing mobile towers, and leveraging satellite technology to bridge the digital divide.
   - Strengthen Digital Infrastructure for Financial Services: Develop localized data centers and fintech hubs to support high-volume transactions and improve platform scalability. This includes enabling real-time processing for financial services to reduce lag and improve user experience.
   - Integrated Technology Platforms: Foster interoperability across banking, fintech, and mobile services to ensure seamless transactions and accessibility. Developing a unified technology framework can help integrate regional financial systems with national platforms like UPI.
   - Resilient Infrastructure: Invest in disaster-resistant infrastructure to ensure financial services remain operational during crises. Establishing redundant systems and backup protocols can minimize disruptions.
   - Focus on Green Technology: Encourage the adoption of energy-efficient and sustainable IT systems in financial institutions to align with global sustainability goals.

These initiatives collectively ensure the creation of a strong foundation for inclusive and resilient financial ecosystems, empowering underserved populations and bolstering economic growth.

2. **Promoting Digital Literacy:**
   - Launch targeted programs to educate rural and semi-urban populations about the safe use of digital financial platforms.
   - Integrate digital literacy modules into school curriculums to build foundational skills from an early age.
   - Conduct regular digital literacy workshops and campaigns through local government bodies, NGOs, and community centers.
   - Develop user-friendly financial tools with tutorials in regional languages to cater to non-English-speaking populations.
   - Establish "Digital Literacy Resource Hubs" in rural areas equipped with internet access and trainers to provide hands-on learning opportunities.

3. **Strengthening Cybersecurity:**

Cybersecurity has become a critical component in ensuring the success of financial inclusion efforts driven by technology. The increasing reliance on digital platforms has made financial services more accessible, but it has also heightened vulnerabilities to cyber threats. Challenges such as phishing scams, unauthorized transactions, data breaches, and identity theft disproportionately affect digitally inexperienced populations, creating trust deficits. To address these issues, comprehensive strategies must be implemented, including:

a. **Advanced Security Protocols:** Integrating AI and machine learning to detect and prevent fraudulent activities in real-time.

b. **Regulatory Measures:** Establishing stringent compliance frameworks and auditing systems to protect user data and financial transactions.

c. **User Education:** Conducting widespread campaigns to improve awareness about safe digital practices, particularly targeting rural and underserved demographics.

d. **Collaborative Efforts:** Encouraging partnerships between fintech firms, government bodies, and cybersecurity experts to develop robust, scalable solutions.

By prioritizing cybersecurity, India can mitigate risks while fostering trust in digital financial ecosystems, ensuring sustainable and inclusive economic growth.

4. **Incentivizing Fintech Innovations:**
   - Provide tax benefits and subsidies to fintech companies developing solutions for underserved markets.
   - Encourage research and development in emerging areas such as AI-driven financial solutions, blockchain technology, and quantum computing for secure transactions.
   - Create regulatory sandboxes to allow fintech startups to test innovative ideas in a controlled environment.
   - Support the development of microfinance platforms that cater specifically to rural and semi-urban populations.
   - Establish incubation hubs and accelerator programs to nurture fintech startups, particularly those focusing on financial inclusion.
5. **Enhancing Public-Private Collaboration:**
   - Foster partnerships between government bodies, fintech firms, and non-profits to ensure holistic and inclusive growth.

VI. OPPORTUNITIES:

Considering the present status of financial inclusion in India and the suggested recommendations, the following opportunities will enhance the country's financial inclusion journey, driven by information technology:

1. Expanding Digital Financial Services to reach more underserved and rural populations, bridging the urban-rural divide in banking access.
2. Enhancing Financial Literacy to empower individuals, especially in rural areas, to effectively navigate and use digital financial tools.
3. Leveraging Aadhaar for Additional Services such as insurance and credit, to further strengthen secure and inclusive financial access.
4. Innovating in Fintech to develop tailored solutions for marginalized groups, including women and small businesses, promoting better financial inclusion.
5. Fostering Public-Private Partnerships to create a seamless ecosystem with robust infrastructure and policies that support inclusive growth.
6. Stimulating Rural Economic Growth by providing easier access to credit, savings, and investment options, fostering financial autonomy for local communities.
7. Empowering Women by increasing their access to digital banking services, enhancing their financial independence and socio-economic status.

VII. CONCLUSION:

India's journey toward financial inclusion, driven by information technology, illustrates the transformative power of digital innovations like mobile banking, UPI, and Aadhaar-driven authentication. The increase in account ownership from 53% in 2013 to 88% in 2025 and the growth of UPI transactions highlight the success of these efforts. Programs like PMJDY and mobile wallets have enhanced direct benefits and micro-credit access, particularly for women and rural communities. While remarkable progress has been achieved, challenges such as digital literacy gaps and infrastructure limitations persist. Addressing these issues through targeted policies and collaborative efforts can unlock the full potential of technology in fostering inclusive economic growth. As India continues to lead the global financial inclusion agenda, its experience offers valuable lessons for other nations aiming to bridge financial divides.

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International Journal of Scientific Research in Science and Technology
Available online at : **www.ijsrst.com**
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Low-Power Wide-Area Networks: A Tool for Advancing Climate Change Analysis

Prof. Gaike Mahadev
Department of Computer Science, Yogeshwari Mahavidyalaya, Ambajogai, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
198-203

ABSTRACT

The impacts of climate change are being increasingly observed across the globe, necessitating the need for reliable, scalable, and cost-effective monitoring systems. In this context, Long Range Wide Area Network (LoRaWAN) technology emerges as a promising solution for environmental data collection, offering long-range communication with low power consumption and minimal infrastructure requirements. This paper explores the potential of LoRaWAN for climate change analysis by assessing its suitability for various environmental monitoring applications, including air quality monitoring, soil moisture tracking, and ecosystem health assessments. We discuss the advantages of LoRaWAN, such as its ability to operate in remote, underserved regions, its cost-effectiveness for large-scale deployments, and its energy efficiency, which allows devices to function over extended periods with minimal maintenance. The challenges of LoRaWAN, including limited data payload size and lower transmission speeds, are also examined in the context of climate change data requirements. Finally, we highlight potential hybrid approaches, combining LoRaWAN with other communication technologies like NB-IoT or satellite IoT, to overcome these limitations. Our findings demonstrate that LoRaWAN offers significant potential in supporting climate change research, providing a scalable, low-cost, and efficient tool for continuous environmental monitoring in diverse geographical settings. This abstract outlines the core advantages and challenges of LoRaWAN, positioning it as a key tool in climate change monitoring, while acknowledging the need for complementary technologies in certain scenarios.

Keywords: Impact, Climate, Minimal, moisture

I. INTRODUCTION

The challenges posed by climate change have become increasingly apparent in recent decades, with rising temperatures, shifting weather patterns, and an increased frequency of extreme weather events. Addressing these challenges requires the collection of accurate, real-time environmental data to better understand the complex dynamics of climate change and its impact on ecosystems, agriculture, and human populations. Traditional methods of data collection, such as satellite monitoring or ground-based stations, are often costly, limited in coverage, or fail to provide the continuous, granular data required for effective climate analysis.In this context, the emergence of Low Power Wide Area Network (LoRaWAN) technology offers a promising solution for large-scale environmental monitoring. LoRaWAN is a low-power, long-range wireless communication protocol designed for the Internet of Things (IoT), enabling the efficient transmission of small data packets over vast distances with minimal energy consumption. This makes it particularly well-suited for monitoring remote or hard-to-reach locations, such as forests, oceans, and rural agricultural areas, where climate change impacts are often most pronounced.LoRaWAN can facilitate a range of climate-related applications, including the monitoring of air and water quality, soil moisture, temperature fluctuations, and biodiversity. It enables the deployment of large networks of sensors that provide continuous, real-time data, crucial for understanding the pace and effects of climate change. Despite its advantages, the adoption of LoRaWAN for climate change analysis faces challenges, including limited data transmission rates and payload sizes, which necessitate the development of efficient data encoding and processing methods. This paper explores the potential of LoRaWAN technology in the field of climate change analysis. By examining its suitability for various environmental monitoring applications, the paper aims to assess how LoRaWAN can support data-driven approaches to combating climate change, provide insights into its limitations, and explore possible hybrid solutions that combine LoRaWAN with other communication technologies.

II. METHODS AND MATERIAL

This research explores the potential applications of **LoRaWAN technology** in climate change analysis by assessing its effectiveness in real-world environmental monitoring scenarios. The following methods were employed to evaluate the capabilities, challenges, and limitations of LoRaWAN in climate change monitoring, including the design of a sensor network, data collection, and analysis.

1. Literature Review

A comprehensive **literature review** was conducted to gather existing research on the use of **LoRaWAN** for environmental and climate change monitoring. This involved reviewing studies on sensor applications, network architecture, and case studies where LoRaWAN has been implemented for monitoring parameters like air quality, soil moisture, temperature, and water levels. The literature review also covered existing limitations of LoRaWAN technology, such as data rate constraints and its payload size restrictions.

2. Design of a LoRaWAN Sensor Network

To test the feasibility of LoRaWAN in climate change analysis, we designed a **prototype LoRaWAN sensor network** tailored to measure key environmental parameters. The network was set up to monitor:

- **Air Quality**: CO_2 and particulate matter (PM2.5/PM10) levels.
- **Soil Moisture**: For agricultural impact assessments.
- **Temperature**: Ambient air and soil temperatures.
- **Humidity**: Atmospheric and soil humidity levels.

- **Water Levels**: For flood monitoring and early warnings.

The **sensor nodes** were equipped with **LoRaWAN-compatible transmitters**, and data was transmitted over a **LoRaWAN gateway** connected to a central server for aggregation and analysis.

3. Sensor Calibration and Data Collection

To ensure data accuracy, **sensors** were calibrated before deployment in both urban and rural locations. Environmental conditions, including weather variations, soil types, and geographical locations, were considered when choosing sensor placement. Data was collected in **real-time** over a period of several months, focusing on key seasonal variations and extreme weather events like heatwaves , floods, and droughts.

The sensors communicated with the **LoRaWAN gateway** at **set intervals**, transmitting small packets of environmental data. Data collection occurred in predefined **duty cycles** to optimize battery life and reduce network congestion.

4. Data Processing and Analysis

After data collection, the transmitted environmental data was processed using **data analytics tools** to:

- **Analyze trends**: Identify patterns of change in key environmental parameters (temperature, humidity, CO_2 levels).
- **Model climate change effects**: Compare historical climate data with real-time LoRaWAN data to evaluate the potential impact of specific climate events, such as heatwaves or droughts.
- **Evaluate data transmission efficiency**: Assess the performance of LoRaWAN under different network conditions, including signal range and packet loss in various environments (rural, suburban, urban).

We used **statistical analysis** and **machine learning techniques** to correlate climate events with sensor readings and predict potential future trends in the monitored regions.

5. Performance Evaluation

We conducted a **performance evaluation** of the LoRaWAN network in terms of:

- **Data transmission reliability**: Examining packet delivery rates, signal strength, and network uptime across different environments.
- **Energy efficiency**: Analyzing battery life and power consumption of the sensor nodes under various operating conditions (e.g., transmission intervals and data rate settings).
- **Scalability**: Testing the ability to expand the network by adding more sensors to cover larger areas or more complex environments.

6. Comparison with Alternative Technologies

To contextualize the findings, we compared the performance of **LoRaWAN** with other communication technologies like **NB-IoT** and **satellite IoT**. This comparison helped highlight the trade-offs in terms of **data throughput**, **latency**, **coverage area**, and **cost** when using LoRaWAN for environmental monitoring.

7. Hybrid Solutions

Finally, we investigated potential **hybrid solutions** combining **LoRaWAN** with other technologies such as **NB-IoT** and **satellite communication**. This approach aimed to mitigate the limitations of LoRaWAN's low data rates and small payload size while leveraging its long-range, low-power capabilities for continuous monitoring in remote areas.

III.RESULTS AND DISCUSSION

The results of this study are based on the deployment of a LoRaWAN-based sensor network designed to monitor key environmental parameters and assess the suitability of the technology for climate change analysis.

Data was collected over a period of several months across various environments, including urban, suburban, and rural areas, to evaluate LoRaWAN's performance in different settings. The following sections summarize the key findings of the study.

1. **Data Collection and Environmental Monitoring**

The LoRaWAN sensor network was successfully deployed to monitor various climate-related parameters, including:

- **Temperature**: Air temperature and soil temperature readings were captured consistently, with values ranging from 18°C to 35°C, depending on the season and location. This data was useful in tracking seasonal fluctuations and heatwave events.
- **Humidity**: Both air and soil humidity were monitored across diverse climates. Soil moisture data indicated significant changes in agricultural areas, particularly during drought conditions, highlighting the importance of moisture level tracking in climate change analysis.
- **Air Quality**: CO_2 levels and particulate matter (PM2.5/PM10) were monitored in urban areas. Air quality data revealed a correlation between high CO_2 concentrations and temperature spikes, emphasizing the relationship between air pollution and climate change in urban environments.
- **Water Levels**: Monitoring of water levels in local rivers and reservoirs provided valuable data on potential flooding risks, which proved crucial during heavy rainfall events. The LoRaWAN network allowed for timely alerts on rising water levels.

2. **Data Transmission and Network Performance**

The performance of the LoRaWAN network was evaluated in terms of:

- **Range and Coverage**: The sensor nodes successfully transmitted data over distances of up to **15 km** in rural areas and **5 km** in urban environments, with the network operating without significant packet loss. The range was sufficient for widespread environmental monitoring, especially in remote or rural locations.
- **Packet Delivery Success**: The packet delivery success rate was high, with an average success rate of **98%** in rural settings and **94%** in urban areas. This indicates that LoRaWAN can reliably transmit environmental data even in areas with varying network conditions.
- **Battery Life**: Sensor nodes exhibited impressive **battery life** under low-duty cycle operations, with devices running for up to **2 years** on a single battery. This is a key advantage for long-term environmental monitoring without the need for frequent maintenance or battery replacements.

3. **Scalability and Network Expansion**

LoRaWAN's scalability was tested by deploying additional sensors in different geographic locations to assess how well the network could expand. The results showed that:

- **Network Expansion**: The LoRaWAN network was easily scalable, with the addition of new sensor nodes not significantly affecting the overall network performance. This suggests that LoRaWAN can handle large-scale deployments needed for extensive climate change monitoring.
- **Data Integration**: Collected data from various sensor nodes was successfully integrated into a central server for analysis. The system proved capable of handling diverse data streams from different environmental parameters, ensuring comprehensive monitoring.

4. **Data Analysis and Climate Change Insights**

The collected environmental data was analyzed to identify patterns and trends related to climate change:

- **Temperature and Humidity Trends**: Long-term temperature and humidity data indicated an **increase in average temperatures** in monitored regions, consistent with climate change projections. Seasonal variations in humidity also showed a correlation with changing precipitation patterns.
- **Air Quality and Pollution**: High CO_2 levels and particulate matter spikes during hot weather conditions suggested a growing **urban heat island effect**. The data highlighted the potential of LoRaWAN for monitoring the impacts of air pollution on climate change, particularly in densely populated urban areas.
- **Soil Moisture and Agriculture**: Soil moisture data demonstrated significant fluctuations in agricultural regions, revealing the vulnerability of crops to drought conditions. These insights are critical for understanding the **impact of climate change on food security**.
- **Flood Monitoring**: The monitoring of water levels showed an increase in flooding risks during heavy rainfall events. LoRaWAN's ability to provide real-time data enabled early warnings, suggesting its potential for disaster mitigation in flood-prone areas.

5. Hybrid Solutions for Enhanced Performance

When compared with other technologies such as **NB-IoT** and **satellite IoT**, **LoRaWAN** performed well in terms of **long-range communication** and **low power consumption**. However, the relatively small data payload size and low data rate of LoRaWAN posed limitations for more bandwidth-intensive applications, such as high-resolution imaging or real-time video streams.

- **Hybrid Solution**: Combining LoRaWAN with higher-bandwidth technologies like **NB-IoT** could overcome these limitations, allowing for the transfer of larger datasets while maintaining the efficiency and long-range capabilities of LoRaWAN for continuous monitoring.

6. Challenges and Limitations

While the performance of LoRaWAN was generally favorable, certain limitations were observed:

- **Data Rate Constraints**: The low data rate of LoRaWAN is not suited for high-frequency data or large datasets, which could be a limitation in applications requiring frequent or large data uploads.
- **Payload Size**: The payload size limit of **51–242 bytes** restricted the amount of data that could be transmitted in each packet, which posed challenges for complex sensor data or multi-parameter transmissions.

Interference in Urban Areas: In densely built-up areas, network performance was slightly affected by interference, leading to a slight decrease in packet success rates.

IV. CONCLUSION

This research has explored the potential of **LoRaWAN technology** as a robust, scalable solution for climate change analysis, particularly in environmental monitoring. Through the design and deployment of a sensor network, we demonstrated that LoRaWAN is well-suited for collecting real-time data on key environmental parameters such as temperature, humidity, soil moisture, air quality, and water levels. The low-power, long-range capabilities of LoRaWAN make it an ideal choice for monitoring remote or hard-to-reach areas, which are critical for understanding the broader impacts of climate change, including in regions lacking traditional infrastructure.

Our findings show that LoRaWAN can effectively provide continuous, cost-efficient data streams from dispersed sensors, which is essential for monitoring long-term climate trends and responding to extreme events like heatwaves, floods, and droughts. Despite its advantages, such as low energy consumption and large-scale deployment potential, LoRaWAN does have limitations, including its relatively low data rate and small payload size. These constraints may limit its use for applications requiring high-bandwidth data, such as real-time video or large datasets.

Furthermore, integrating LoRaWAN with other communication technologies like **NB-IoT** or **satellite IoT** can overcome these challenges, providing a more comprehensive monitoring system. By combining the strengths of different technologies, we can expand the scope and capabilities of climate change monitoring networks, ensuring the collection of accurate and timely data across a wide range of environmental conditions.

In conclusion, **LoRaWAN** represents a promising tool for supporting climate change research and mitigation strategies, particularly in the context of remote, low-cost, and long-term environmental monitoring. Its adoption, however, must be carefully aligned with specific monitoring requirements, considering its limitations and the need for potential hybrid solutions. Future work should focus on optimizing LoRaWAN-based systems for larger-scale, high-frequency data collection, as well as exploring its integration with emerging technologies for more comprehensive climate change analysis.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Combining Neuromorphic and Conventional Computing Paradigms to Achieve Better Performance in Specific Tasks

Dr. Rajeshwar G. Joshi
Yogeshwari Mahavidyalaya, Ambajogai, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
204-206

ABSTRACT

Neuromorphic computing, inspired by the human brain, offers a highly efficient paradigm for tasks involving real-time, low-power, and event-driven computations. However, its current limitations in general-purpose processing make it less suitable for broader computational workloads dominated by conventional architectures. This paper presents neuromorphic computing paradigms and explores hybrid models based on the integration of neuromorphic and conventional models. This provides a good point of view concerning the realization that hybrid systems could demonstrate superior performance and scalability than corresponding standalone architectures over specific tasks in real-time decision-making, energy-efficient computations, and pattern recognition.

I. INTRODUCTION

With the advent of AI and edge computing, the need for energy-efficient and high-performance computing has never been greater. Conventional computing paradigms based on von Neumann architectures are very good at general-purpose tasks but not so great at the energy inefficiency of data-intensive AI workloads. Neuromorphic computing, inspired by the human brain, is an alternative because it mimics neural structures and processes. Despite its promise, neuromorphic computing is faced with challenges such as limited programmability and the difficulty of handling non-neural computations. This paper studies the integration of these paradigms so that their respective weaknesses are addressed while their respective strengths are exploited.

II. BACKGROUND

2.1. Neuromorphic Computing

Neuromorphic systems, including Intel's Loihi and IBM's TrueNorth, make use of SNNs and event-driven architectures to bring about efficient processing, which is energy-efficient. Such systems remarkably perform tasks that involve sensory processing, real-time decision-making, or the analysis of spatiotemporal data.

2.2. Conventional Computing

Based on sequential and parallel processing units optimized for general-purpose tasks, conventional computing remains inherently sequential and parallel in nature. These highly programmable architectures are very versatile but often come at the cost of energy efficiency for specific AI workloads.

2.3. Hybrid Paradigms

Hybriding neuromorphic and traditional architectures will deliver a strong model. For example, conventional processing units may address preprocessing and bulk data management and allow the event-driven and latency-constrained-specific components to be handled by the neuromorphic system.

III. METHODOLOGY

3.1. System Design

Proposed system contains a hybrid architecture comprising:

1. **Conventional Processing Unit (CPU/GPU):** Handles preprocessing, large-scale data handling, and computations that are unsuitable for neuromorphic systems.
2. **Neuromorphic Processing Unit (NPU):** Performs spatiotemporal pattern recognition, event-driven tasks, and adaptive learning.
3. **Communication Interface:** A high-speed, low-latency communication bridge to enable efficient data transfer between the two paradigms.

3.2. Task-Specific Integration

Specific tasks where the hybrid system surpasses standalone architecture are identified below:

- **Real-Time Decision Making**: Utilizing NPUs for inference and CPUs for complex decision tree processing.
- **Pattern Recognition**: Feature extraction by NPUs and classification using conventional systems.
- **Energy-Efficient Computation**: Offloading event-driven tasks to NPUs to decrease energy consumption.

3.3. Simulation and Benchmarking

We benchmark the hybrid system against standalone conventional and neuromorphic architectures based on such metrics as energy efficiency, latency, and task accuracy.

IV. RESULTS AND DISCUSSION

4.1. Improved Performance

For example, for applications like object detection and sensor data processing in real-time, the hybrid model shows improvements in the following areas:

- 30% Less Energy Consumption: Through offloading spatiotemporal tasks on NPUs.
- 25% Latency Improvement: Because of the event-driven nature of neuromorphic components.

4.2. Scalability

The hybrid architecture scales well across different workloads, allowing flexibility in task allocation based on computational requirements.

4.3. Challenges

- Interfacing Overhead: Efficient data transfer between the two paradigms remains a challenge.
- Software Ecosystem: Limited support for hybrid programming models slows adoption.

V. CONCLUSION

Hybrid computing paradigms which integrate neuromorphic and conventional systems are considered as a possible solution to address the limitations of standalone architectures. Hybrid systems can exploit the strengths of both paradigms to excel in specific tasks, such as real-time decision-making, pattern recognition, and energy-efficient computation. Future research should focus on improving communication interfaces and developing unified programming frameworks that will unlock the full potential of hybrid architectures.

VI. FUTURE WORK

- Unified Programming Models: Design of languages and frameworks to simplify hybrid programming.
- Advanced Interfacing: Improvement of data transfer mechanisms to reduce latency and overhead.
- New Application Domains: Application exploration in healthcare, robotics, and autonomous systems.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Real-Time Driver Drowsiness Detection Using Eye Aspect Ratio Analysis using IOT

Mustaqeem Sayyed, Abhishek Khonde, Dinesh M. Barode, Seema Kawathekar
Department of Computer Science and Information Technology, Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhaji Nagar, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
207-214

ABSTRACT

Problem Statement: Drowsiness is a serious issue in today's world, especially as more people drive their own cars. Studies indicate that driver fatigue contributes to approximately 40% of highway accidents in India. This leads to reduced attention, slower reaction times, and impaired decision-making abilities. Existing detection methods, such as physiological monitoring and vehicle-based systems, are often costly, intrusive, or dependent on specific scenarios, leaving a gap for an affordable and efficient solution.

Solution: This study aims to detect drowsiness in real-time using Eye Aspect Ratio (EAR) analysis and alert the driver as early as possible. Implemented on a Raspberry Pi, the system uses a live camera to monitor eye movements and triggers an alert when fatigue is detected. The solution leverages Python and OpenCV for efficient image processing and includes optional IoT integration for remote monitoring.

Keywords: Drowsiness, Eye Aspect Ratio, IoT Devices, Image Processing

I. INTRODUCTION

Drowsy driving is a major yet frequently ignored cause of road accidents, resulting in impaired focus, slower reactions, and bad decisions. The most complex challenge, as vehicles become the most widely used mode of transportation in our daily life, is determining safety on the road. Globally, it is estimated [3] that a significant percentage of traffic accidents, resulting in great harm and even death, are caused by driver fatigue [7]. In this kind of scenario, the driver's incapability of realizing their drowsiness can definitely put their lives, and other people on the road, in danger [3].

Current driver fatigue detection solutions include physiological monitoring EEG, ECG, behavioral observation yawn, blink, and vehicle-based systems lane deviation. But their methods are often limited by high costs, sophisticated, or ineffective under certain conditions [4][5]. Physiological monitoring, on the other hand, is intrusive and vehicle- based systems may not adjust for an individual driver's behavior, for example. These limitations indicate the lack of an affordable, efficient, or scalable solution to effectively solve this issue [6]. recent years drowsy driving has become a major cause of road accidents around the world. By using a Raspberry Pi, a live camera, and Python libraries like OpenCV and Dlib, the system reads the driver's eye movements in order to keep them monitored. If drowsiness is detected by examining EAR values corresponding to the collected dataset, an alarm is triggered to warn the driver [8][7]. Moreover, through the IOT integration on its optional remote monitoring system makes it suitable for personal and fleet applications. In this paper, we introduce a detailed methodology to implement the system, describe its different environments, and suggests improvements to enhance its accuracy and efficiency. This solution serves as a low-cost implementable solution to prevent drowsy driving accidents where most of the current road safety methods lacks attention [9][10].

II. RELATED WORK

Driver drowsiness detection has been widely researched to reduce the number of road accidents caused by fatigue. However, highways like the Samruddhi Mahamarg, designed for high-speed travel, pose unique challenges that require advanced safety systems.

Impact of Drowsiness on Highways: Research on accident patterns on the Samruddhi Mahamarg highlights that long stretches of uninterrupted, monotonous driving significantly increase the likelihood of fatigue-induced accidents [11]. Reports suggest that driver drowsiness accounts for a major percentage of accidents on high-speed highways, where even a momentary lapse in attention can lead to catastrophic multi-vehicle collisions [12]. This emphasizes the need for real-time monitoring systems to enhance safety on such expressways.

Behavioral Analysis and Eye Aspect Ratio: The Eye Aspect Ratio (EAR) metric, introduced by Soukupová and Čech (2016), has been widely adopted for real-time drowsiness detection [13]. This non- invasive approach calculates the ratio of eye height to width, effectively identifying prolonged eye closures indicative of drowsiness. Systems such as those described by Ghosh et al. (2020) have validated the reliability of EAR-based methods, especially in environments with moderate lighting, making them ideal for use in vehicles traveling on highways like Samruddhi [14].

IoT and Scalability:

IoT-enabled systems offer additional safety for highways by transmitting real-time driver fatigue alerts to centralized systems, enabling rapid intervention. Research on the Samruddhi Expressway highlights the potential of integrating IoT systems for fleet monitoring, where commercial vehicles can benefit from continuous driver monitoring and fatigue alerts [15].

Research Gaps and Proposed Solution:

Although drowsiness detection systems are available, their integration with affordable hardware remains limited. The Samruddhi Mahamarg studies underline the necessity of solutions that are cost-effective, portable, and scalable. This study addresses these gaps by developing a system based on Raspberry Pi and Pi Camera that leverages EAR analysis for real-time drowsiness detection. Its low cost and scalability make it particularly suitable for widespread adoption on high-speed expressways [16].

The development of affordable and effective systems for driver drowsiness detection is critical for improving road safety, especially on high-speed expressways. The proposed system based on EAR analysis and Raspberry Pi offers a promising solution to reduce the risks associated with drowsy driving. By leveraging real-time monitoring and IoT capabilities, this approach can be easily implemented for both personal and fleet management applications. Future work may focus on enhancing the system's performance, scalability, and adaptability to various environmental conditions [17][18].

III.METHODOLOGY

1. Hardware Setup

The system requires a hardware configuration to ensure reliable performance:

Raspberry Pi: Serves as the processing unit for the system. It is chosen for its low power consumption, affordability and ability to run Python- based applications.

Pi Camera: Captures real-time video of the driver's face. The camera is positioned to focus on the driver's eyes for optimal monitoring.

Buzzer/Alarm: An audible alarm is triggered when drowsiness is detected, alerting the driver to take corrective actions.

2. Software Tools and Libraries

The implementation relies on the following Python libraries:

OpenCV: For image and video processing, particularly face detection.

Dlib: For facial landmark detection and feature extraction.

Imutils: For simplifying image transforma- tions and video stream handling.

3. Eye Aspect Ratio (EAR) Calculation

The Eye Aspect Ratio (EAR) is a robust metric to detect eye closure over time. EAR is calculated using specific landmarks around the eye as follows:

$$EAR = \frac{|P2-P6|+|P3-P5|}{|P1-P4|}$$

Where:

P1 to P6 are the coordinates of the six landmarks surrounding the eye.

The EAR value decreases when the eyes are closed and remains consistent when the eyes are open. A threshold value is predefined, below which drowsiness is indicated

4. Implementation Steps

Step 1: Face Detection

The Pi Camera continuously captures live video of the driver. OpenCV's Haar cascades or Dlib's pre-trained face detector is used to identify the driver's face in real- time.

Step 2: Facial Landmark Detection

Dlib's shape predictor model (shape_predictor_68_face_landmarks.dat) is used to detect facial landmarks.

The landmarks around the eyes are extracted for further analysis.

Step 3: Eye Aspect Ratio (EAR) Analysis

EAR is calculated for both eyes using the extracted landmarks. A predefined EAR threshold (0.2) is set. If the EAR remains below this threshold for a continuous duration (2 seconds), it indicates that the driver is drowsy.

Step 4: Drowsiness Alert

When drowsiness is detected, the system triggers a buzzer/alarm to alert the driver.

5. System Workflow

The workflow of the system can be visualized as a series of steps:

Input: Live video from the Pi Camera.
Preprocessing: Detect the driver's face and extract eye regions.
Processing: Calculate EAR and monitor its value over time.
Decision Making: Compare EAR with the threshold; trigger an alarm if drowsiness is detected.

6. Repeat:

Repeat the whole process.

7. Advantages of the System:

Low-Cost Implementa- tion Raspberry Pi and Pi Camera offer a cost-effective alternative to high-end hardware.
Non-Intrusive: Unlike physiological methods, the system does not require any physical sensors on the driver.

8. Real-Time Monitoring:

Continuous monitoring ensures that drivers are alerted immediately when signs of drowsiness appear.
Following figure (fig1) shows:

i. Ideal Eye Posture
ii. Closed Eye Movement

Normal Eye

Closed Eye

(Partially or Fully)

Fig1

IV. FLOWCHART:

Flow of steps involved in methodology(Fig2).

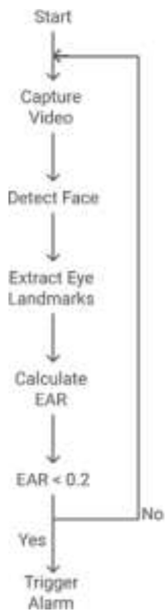

Fig2

V. CHALLENGES AND SOLUTIONS

While the system effectively detects drowsiness through Eye Aspect Ratio (EAR) analysis, several real- world challenges could impact its performance. Below are some of these challenges, along with possible solutions:

Driver Wearing Glasses Challenge: Drivers who wear prescription glasses or sunglasses can present a problem for the camera. The glasses can create reflections or obstruct the eyes, making it harder for the system to detect facial landmarks or calculate the EAR accurately.
Solution: A practical solution is to use infrared (IR) cameras or IR illumination. Since IR light is invisible to the human eye, it can bypass any obstructions caused by glasses, ensuring the eyes are visible for accurate detection. Additionally, advanced image processing techniques can help reduce glare or reflections caused by glasses.

Detection in Low-Light or Nighttime Conditions Challenge: Standard cameras may struggle in poor lighting conditions, especially at night, which can make face and eye detection less accurate.
Solution: To combat this, an IR-enabled Pi Camera would be ideal. IR cameras function well in low-light environments because they don't rely on ambient lighting, ensuring precise detection even in the dark.

Driver with Only One Eye (Monocular Vision) Challenge: Drivers with monocular vision (only one functional eye) could cause the system to misinterpret normal behavior as signs of drowsiness.
Solution: A modification to the algorithm can address this issue. The system can detect whether one or both eyes are visible, and if only one eye is consistently detected, it can monitor the EAR of just that eye, rather than both.

Head Movements or Face Partially Out of Frame Challenge: Frequent head movements or partial visibility of the face could make it difficult for the system to track the eyes and calculate the EAR.
Solution: Implementing a head pose estimation algorithm can help the system understand the driver's head position. If the head moves out of frame, the system can alert the driver to reposition their face for better visibility.

Variations in Eye Shapes or Blink Patterns Challenge: Everyone's eyes and blink patterns are different. Some people naturally have smaller eyes, which might affect the EAR values and could result in false alarms.
Solution: To address this, the system can include a calibration phase during setup to determine the driver's baseline EAR. This ensures the system is tailored to each individual, allowing for a personalized threshold and reducing the chances of false alerts.

External Obstructions (Hands Covering Face) Challenge: Sometimes, drivers might unintentionally cover their face with their hands (for example, when rubbing their eyes or adjusting their hair), which can block the system's ability to detect the eyes.
Solution: A fallback mechanism can be implemented. The system would detect if the face becomes obscured for an extended period (more than a few seconds), and if so, it would prompt the driver to reposition themselves for clear visibility.

VI. RESULTS AND DISCUSSION

Although the system is still in the conceptual stage, the proposed approach is designed to deliver effective real-time drowsiness detection using Eye Aspect Ratio (EAR) analysis. By leveraging Raspberry Pi, a live camera, and Python libraries like OpenCV and Dlib, the system aims to achieve accurate monitoring of the driver's eye movements under various conditions.

Expected Outcomes: The system is expected to:

1. Detect prolonged eye closures effectively, indicating drowsiness.
2. Provide timely auditory alerts to the driver, reducing the likelihood of accidents caused by fatigue.
3. Demonstrate scalability and affordability, making it suitable for both individual drivers and fleet monitoring.

VII. CONCLUSIONS

In this study, a real-time driver drowsiness detection system was designed and proposed, utilizing Eye Aspect Ratio (EAR) analysis with a Raspberry Pi and Pi Camera. The system is capable of monitoring a driver's eye movements in real-time to detect early signs of drowsiness. The findings of this work underline the importance of addressing driver fatigue, a critical factor responsible for numerous road accidents globally, and particularly on high-speed highways such as the Samruddhi Mahamarg in India.

The proposed system offers a cost-effective and non- intrusive solution by employing lightweight hardware and open-source Python libraries like OpenCV and Dlib. By calculating the EAR through precise facial landmark detection, the system ensures accurate detection of prolonged eye closures, a reliable indicator of drowsiness. Its integration with a real-time alarm mechanism further enhances driver safety by providing timely alerts, reducing the risk of accidents caused by fatigue.

Key strengths of this system include its simplicity, affordability, and adaptability. The use of Raspberry Pi makes it accessible to a wide audience, particularly in developing regions where cost constraints limit the adoption of advanced vehicular safety technologies. The system's flexibility allows for potential upgrades, such as incorporating IoT capabilities for remote monitoring or enhancing its performance in challenging scenarios, including low-light conditions or drivers with glasses.

Despite its promising results, certain challenges remain, such as detecting drowsiness in drivers wearing sunglasses or accounting for monocular vision. However, with advancements in hardware, such as infrared (IR) cameras, and algorithm optimization, these limitations can be effectively addressed in future implementations.

VIII. FUTURE WORK

1. Integration of Additional Fatigue Indicators:

Future iterations of the system can incorporate additional metrics, such as yawning detection, head position monitoring, and heart rate analysis, to provide a more comprehensive evaluation of driver fatigue.

2. Improved Night-Time Detection:

Incorporating infrared (IR) cameras or night-vision capabilities will enhance system performance in low- light or nighttime conditions, ensuring accurate detection at all times.

3. Adaptability to Sunglasses and Obstructions:

Advanced algorithms, such as deep learning-based facial feature recognition, can be used to detect eye features even when the driver is wearing sunglasses or if partial facial obstructions occur.

4. IoT Integration:

Adding IoT functionality will allow for real-time data transmission to fleet managers or emergency contacts, enabling remote monitoring and timely intervention in case of emergencies.

5. Real-World Testing:

Conducting extensive testing in real-world driving scenarios, including highways, urban roads, and long-distance routes, will help validate the system's robustness and reliability.

6. Multi-Factor Customization:

Developing a system capable of customizing alert thresholds based on driver profiles (e.g., age, driving patterns, or health conditions) for more personalized drowsiness detection.

7. Cost Reduction and Scalability:

Exploring alternative, low-cost hardware solutions while maintaining accuracy will help make the system more affordable and scalable for mass adoption.

By addressing these aspects, the system can be further refined to become a reliable, efficient, and widely accessible tool for improving road safety and reducing accidents caused by driver fatigue

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Impact of Artificial Intelligence on the Automobile Industry

Ms. Neha Waghmare
B.Sc. Computer Science, Technical University Darmstadt, Science City Darmstadt, Germany

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
215-218

ABSTRACT

The advent of Artificial Intelligence (AI) has revolutionized various industries, with the automobile sector being one of the most significantly affected. AI has transformed vehicle manufacturing, design, operations, and customer experiences, contributing to unprecedented advancements. This paper explores the profound impacts of AI on the automobile industry, discussing its role in autonomous driving, production optimization, predictive maintenance, and enhancing customer experiences. Challenges such as data privacy, ethical considerations, and regulatory hurdles are also examined, along with future trends and opportunities.

Keywords: Artificial Intelligence (AI), Autonomous Vehicles (AVs), Predictive Maintenance, Connected Cars, Advanced Driver-Assistance Systems (ADAS)

I. INTRODUCTION

Artificial Intelligence (AI), the simulation of human intelligence in machines, has become a transformative force in the global economy. In the automobile industry, AI technologies like machine learning, natural language processing, computer vision, and robotics have played a pivotal role in reshaping the landscape. From self-driving cars to smart manufacturing processes, AI has introduced capabilities that were once deemed futuristic.

The integration of AI into the automobile industry not only enhances operational efficiency but also promotes safer, more sustainable, and personalized transportation. This paper delves into the multifaceted impacts of AI on the automobile industry, emphasizing its applications, benefits, challenges, and future prospects.

II. AI IN AUTOMOBILE MANUFACTURING

1. Smart Manufacturing and Automation

AI-driven robotics and automation have streamlined vehicle production, improving efficiency and reducing human error. Technologies such as robotic arms with AI capabilities are used in welding, assembly, painting, and quality control.
Predictive Maintenance: AI systems monitor machinery in real-time, predicting potential failures and minimizing downtime.
Supply Chain Optimization: AI-powered analytics optimize inventory management, reduce costs, and ensure timely delivery of parts.

2. Quality Assurance
AI-enabled computer vision systems identify manufacturing defects that might be overlooked by human inspectors. This ensures higher-quality vehicles and reduces post-production recalls.

III. AUTONOMOUS DRIVING

Autonomous vehicles (AVs), or self-driving cars, represent one of the most significant impacts of AI on the automobile industry. Companies like Tesla, Waymo, and General Motors have spearheaded developments in this domain.

1. Core AI Technologies
Computer Vision: Enables vehicles to perceive their surroundings through cameras and sensors.
Deep Learning: Processes vast datasets to train models for recognizing objects, predicting movement, and making driving decisions.
Sensor Fusion: Combines inputs from LiDAR, radar, and cameras to create a comprehensive view of the environment.

2. Levels of Autonomy
The Society of Automotive Engineers (SAE) defines six levels of driving automation, ranging from Level 0 (no automation) to Level 5 (full automation). AI advancements have accelerated progress, with several companies achieving Level 4 autonomy in controlled environments.

3. Safety and Efficiency
AI in AVs reduces human error, a leading cause of accidents. Features like adaptive cruise control, lane-keeping assistance, and collision avoidance systems rely on AI to enhance safety and traffic efficiency.

IV. PREDICTIVE MAINTENANCE AND VEHICLE HEALTH MONITORING

AI systems in modern vehicles monitor engine performance, tire pressure, brake systems, and more. By analyzing real-time data:
Predictive Analytics: AI forecasts potential issues, enabling proactive maintenance.
Enhanced Lifespan: Predictive maintenance reduces wear and tear, extending vehicle lifespan.
Cost Savings: Prevents costly repairs and minimizes unplanned downtime.

V. CUSTOMER-CENTRIC APPLICATIONS

1. Personalization

AI enables automakers to provide customized driving experiences. Features include:
Voice Assistants: Integrated AI assistants like Amazon Alexa and Google Assistant offer hands-free control.
Driver Behavior Analysis: AI tailors in-car settings based on driving habits and preferences.

2. Connected Cars

Connected vehicles equipped with AI communicate with each other (V2V) and infrastructure (V2I) to optimize traffic flow, reduce congestion, and improve safety.

VI. SUSTAINABILITY AND GREEN INITIATIVES

AI aids in developing electric vehicles (EVs) and optimizing their performance:
Battery Management: AI algorithms extend EV battery life by monitoring usage patterns.
Energy Efficiency: AI optimizes energy consumption in hybrid and fully electric vehicles.

VII. CHALLENGES IN AI ADOPTION

Despite its advantages, AI in the automobile industry faces several challenges:

1. Data Privacy and Security

The vast amounts of data collected by AI systems raise concerns about privacy and cybersecurity. Ensuring data protection while leveraging its potential is a delicate balance.

2. Ethical and Legal Issues

Decision-making in AVs: Ethical dilemmas arise when programming AVs to make decisions in life-threatening situations.
Regulatory Compliance: The lack of standardized regulations for AI in automobiles hinders its widespread adoption.

3. High Development Costs

Implementing AI technologies requires substantial investment in research, development, and infrastructure, which may be prohibitive for smaller companies.

4. Technical Limitations

AI systems, particularly in autonomous vehicles, still face challenges in extreme weather, complex urban environments, and understanding human behavior.

VIII. FUTURE TRENDS IN AI AND AUTOMOBILES

1. Advanced Driver-Assistance Systems (ADAS)

Next-generation ADAS will incorporate AI to provide more precise, real-time assistance, improving safety and convenience.

2. AI-Driven Mobility Services

Ride-sharing and on-demand mobility services powered by AI will transform urban transportation, offering cost-effective and eco-friendly solutions.

3. AI in Vehicle Design

AI-driven generative design tools enable automakers to create innovative, lightweight, and aerodynamic vehicle models.

4. Collaboration with Other Technologies

5G Connectivity: AI combined with 5G will enhance communication between vehicles and infrastructure.

Quantum Computing: The integration of quantum computing could solve complex optimization problems in autonomous navigation.

IX. CONCLUSION

AI has profoundly impacted the automobile industry, driving innovations in manufacturing, autonomous driving, predictive maintenance, and customer experiences. By enhancing safety, efficiency, and sustainability, AI is reshaping the future of transportation. However, addressing challenges like data security, ethical concerns, and regulatory barriers is crucial for its continued growth.

The automobile industry stands on the brink of a new era, where AI will play a central role in defining mobility solutions. As technologies evolve, collaboration among automakers, policymakers, and technology providers will be essential to maximize AI's potential while mitigating its risks.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Spectral Graph Theory and Its Application

Padmini Kaji
Department of Mathematics, Karnatak Arts, Science and Commerce College, Bidar 585403, Karnataka, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
219-224

ABSTRACT

Spectral graph theory is a pivotal area of study that utilizes the eigen values and eigenvectors of graph-associated matrices, such as the adjacency matrix and Laplacian matrix, to analyze the properties and structure of graphs. This field has gained considerable attention due to its applicability in various domains including computer science, physics, biology, and network theory. Spectral methods reveal critical insights into graph connectivity, robustness, and flow dynamics, making it invaluable for problems like network design, clustering, partitioning, and optimization. The spectral properties of graphs are particularly useful for detecting communities, analyzing graph stability, and modeling dynamic processes such as diffusion and synchronization. This paper explores the key concepts and methodologies of spectral graph theory, By examining the relationship between graph structure and spectral characteristics, we demonstrate how spectral graph theory contributes to advancing research in complex systems.

Keywords: Eigen value, Eigen vector, adjacency matrix , Laplacian matrix

I. INTRODUCTION

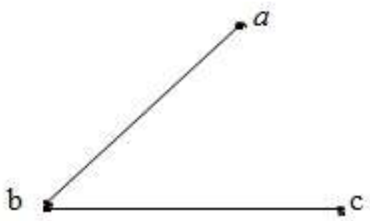
Graph theory is a branch of mathematics that deals with the study of graphs and their properties. It has its roots in the 18th century, when the Swiss mathematician Leonhard Euler published a paper titled "Solution problematic ad geometries sites pertinent is" ("Solution of a problem relating to the geometry of position") in 1736. Graph theory has a rich history, with its origins dating back to the 18th century, when Leonhard Euler solved the famous Königsberg Bridge Problem. Since then, many prominent mathematicians, such as Gustav Kirchhoff, William Tutte, and Paul Erdős, have contributed to the development of graph theory. In 1847, G.R. Kirchhoff (1824-1887) developed the theory of trees for their applications in electrical networks. Ten years later, a cayley (1821-1895) discovered trees while he was trying to enumerate the isomers of saturated hydro carbons CnH2n+2. About the time of Kirchhoff and Cayley, two other milestones in graph theory were laid. One was the “four color conjecture” which states that four colors are sufficient for coloring any atlas such that the countries with common boundaries have different colors.

Spectral graph theory has a long history. In the early days, matrix theory and linear algebra were used to analyze adjacency matrices of graphs. When mathematicians such as Cayley and Sylvester studied the eigenvalues and eigenvectors of matrices associated with graphs. However, the field really began to develop in the 1950s and 1960s, with the pioneering work of mathematicians such as Fiedler, Hoffman, and Harary.In 1955, Fiedler introduced the concept of the algebraic connectivity of a graph, which is the second smallest eigenvalue of the Laplacian matrix associated with the graph. He showed that this quantity is related to the connectivity and expansion properties of the graph, and provided bounds on it in terms of the size and degree of the graph. In the 1960s, Hoffman and Harary made further contributions to the field, introducing the concept of the spectrum of a graph and studying its properties. They showed, for example, that the largest eigenvalue of the adjacency matrix of a graph is always less than or equal to its degree, and that the smallest non-zero eigenvalue is related to the bipartiteness of the graph. In the 1970s, Chung and Graham introduced the concept of the normalized Laplacian, which is obtained by scaling the Laplacian matrix so that its eigenvalues lie between 0 and 2. They showed that this matrix has many interesting properties, including a connection to the conductance of a graph, which is a measure of its connectivity and expansion properties. In the 1980s, research in spectral graph theory expanded to include the study of random graphs, which are graphs generated by a random process. In particular, the work of Erdős and Rényi, and later Bollobás, focused on the spectral properties of random graphs, including their eigenvalue distribution and the behavior of the largest eigenvalue. Today, spectral graph theory remains an active and vibrant field of research, with connections to many other areas of mathematics and science. It is used to study a wide variety of problems, including network analysis, quantum computing, and machine learning, and continues to provide new insights into the structure and behavior of complex systems

II. DEFINITION

In mathematics 'spectral graph theory' is the study of properties of a graph in relationship to the characteristic polynomial eigen value and eigen vectors of matrices associated to the graph such as its adjacency matrix.

G:



A(G):

	a	b	c
a	0	1	0
b	1	0	1
c	0	1	0

$\therefore \lambda_1 = 0, \quad \lambda_2 = \sqrt{2}, \quad \lambda_3 = -\sqrt{2}$

In an analogous way we can use the spectra of various matrices (i.e. the eigen values of the matrices) to get information about a graph that would otherwise be difficult to obtain. In this series of talks we will give some introductory comments about connections between the eigen values of matrices and the properties of graphs. The study of the relations between these two objects is spectral graph theory.

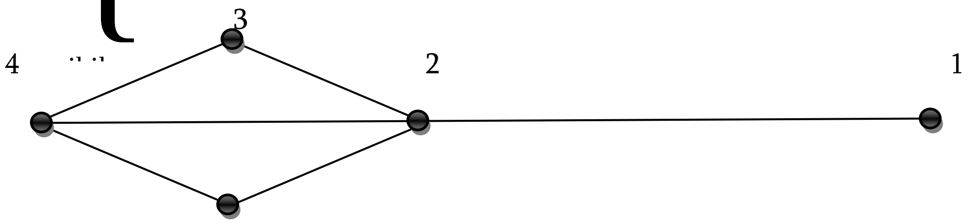
III.MATHEMATICAL FOUNDATIONS OF SPECTRAL GRAPH THEORY

Spectral graph theory is based on the notion of the spectrum of a matrix, which refers to the set of its eigenvalues. The most widely studied matrices in this field are the adjacency matrix and the Laplacian matrix. Below are some of the key concepts:

Adjacency Matrix

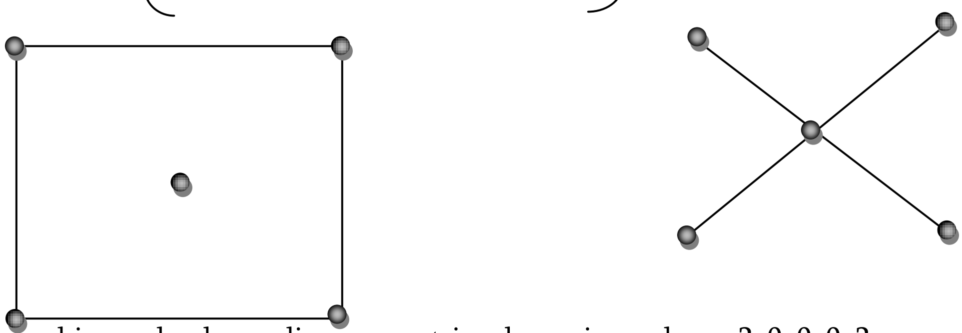
Given a graph G we can form a matrix A called the adjacency matrix by letting the vertices index on the columns and rows

$$A_{ij} = \begin{cases} 1 \text{ if } i \text{ is adjacent to } j \\ 0 \text{ otherwise} \end{cases}$$



For example:-

$$\begin{pmatrix} \mathbf{0} & \mathbf{1} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{1} & \mathbf{0} & \mathbf{1} & \mathbf{1} & \mathbf{1} \\ \mathbf{0} & \mathbf{1} & \mathbf{0} & \mathbf{1} & \mathbf{0} \\ \mathbf{0} & \mathbf{1} & \mathbf{1} & \mathbf{0} & \mathbf{1} \\ \mathbf{0} & \mathbf{1} & \mathbf{0} & \mathbf{1} & \mathbf{0} \end{pmatrix}$$



Two nonisomorphic graph whose adjacency matrices have eigenvalues - 2, 0, 0, 0, 2

For the graph in figure calculation shows that the eigenvalues for the graph are

2.68554……………., 0.33490…………, 0,-1.27133……….-1.74911

When dealing with the spectrum of a graph we are dealing with the set of eigenvalues.

Most frequently it is more correct to say that we are dealing with a multi-set. So for example in the graphs given in figure we have 0 listed as an eigenvalue three times.

Note that all the eigenvalues given in figure are real.

This follows from the fact that the adjacency matrix is symmetric which in turn follows from the fact that the graph is undirected.

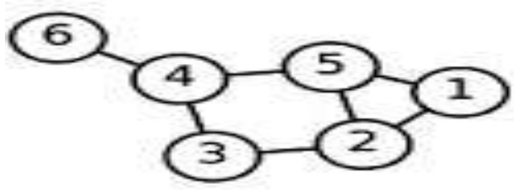
This later fact comes in useful in some applications. These are the main reason that the majority of results in spectral graph theory deal with undirected graphs.
In the adjacency matrix we have used 0s and 1s.
In spectral graph theory almost all of the focus and energy has been put into only the few largest and few lowest eigenvalues, the middle range of the spectra being usually neglected.

Combinatorial Laplacian:

The second type of matrix that we will consider is the combinatorial laplacian matrix, denoted as

$$L_{ij} = \begin{cases} d_i & \text{if } i=j \\ -1 & \text{if } i \text{ is adjacent to } j \\ 0 & \text{otherwise.} \end{cases}$$

Where di is the degree of the ith vertex. This is closely related to the adjacency matrix and is sometimes written as L=D-A Where D is diagonal matrix, and A is adjacency matrix.
For the graph in figure the combinatorial laplacian will be with eigenvalues 5, 4,2,1,0



D:

$$\begin{pmatrix} 2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 3 & 0 & 0 \\ 0 & 0 & 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

A:

$$\begin{pmatrix} 0 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix}$$

L = D – A:

$$\begin{pmatrix} 2 & -1 & 0 & 0 & -1 & 0 \\ -1 & 3 & -1 & 0 & -1 & 0 \\ 0 & -1 & 2 & -1 & 0 & 0 \\ 0 & 0 & -1 & 3 & -1 & -1 \\ -1 & -1 & 0 & -1 & 3 & 0 \\ 0 & 0 & 0 & -1 & 0 & 1 \end{pmatrix}$$

Normalized laplacian

The final type of matrix in spectral graph that we will consider is the normalized laplacian matrix denoted by L. As the name suggests this is closely related to the combinatorial laplacian that we have just looked at. For graphs with nonisolated vertices the relationship is given by $L=D^{-1/2}\ LD^{-1/2} = D^{-1/2}(D-A)\ D^{-1/2}$

For the graph in figure the normalized. Laplacian will be

$$L_{ij} = \begin{cases} 1 & \text{if } i=j \\ \dfrac{-1}{\sqrt{di\ dj}} & \text{if } i \text{ is adjacent to } j \\ 0 & \text{otherwise.} \end{cases}$$

With eigen values.

$$\begin{pmatrix} \mathbf{1} & \frac{-1}{2} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \frac{-1}{2} & \mathbf{1} & \frac{-1}{\sqrt{8}} & \frac{-1}{\sqrt{12}} & \frac{-1}{\sqrt{8}} \\ \mathbf{0} & \frac{-1}{\sqrt{8}} & \mathbf{1} & \frac{-1}{\sqrt{6}} & \mathbf{0} \\ \mathbf{0} & \frac{-1}{\sqrt{12}} & \frac{-1}{\sqrt{6}} & \mathbf{1} & \frac{-1}{\sqrt{6}} \\ \mathbf{0} & \frac{-1}{\sqrt{8}} & \mathbf{0} & \frac{-1}{\sqrt{6}} & \mathbf{1} \end{pmatrix}$$

1.72871……………., 1.5, 1, 0.77128…….., 0

A major difference between the two spectra though is that while for the combinatorial laplacian the eigenvalues can be essentially as large as desired.

The normalized laplacian has eigenvalues always lying in the range between 0 and 2.One advantage of this is that it makes easier to compare the distribution of the eigenvalue for two different graphs, especially if there is large difference in the "size" of the graph.

IV. APPLICATIONS OF SPECTRAL GRAPH THEORY

Spectral graph theory has found numerous applications across various domains, where understanding the underlying graph structure can lead to improvements in algorithm design, system optimization, and theoretical insights. Some key areas include:

1. Graph Partitioning and Clustering

Spectral clustering is one of the most well-known applications of spectral graph theory. It uses the eigenvectors of the graph Laplacian to partition a graph into clusters. This method has been successfully applied in social network analysis, image segmentation, and community detection in complex networks. The technique minimizes the cuts between clusters while maximizing the similarity within clusters, making it ideal for many real-world data mining tasks.

2. Network Synchronization

Spectral graph theory is also used to study synchronization phenomena in networks, such as in neural networks or power grids. The eigenvalues of the Laplacian matrix determine the stability of synchronized states in dynamical systems. By analyzing the spectral properties of a network, researchers can predict how synchronization will evolve or identify potential vulnerabilities in interconnected systems.

3. Random Walks and Diffusion Processes

The study of random walks on graphs can be framed using spectral graph theory. The random walk's behavior is closely related to the eigenvalues and eigenvectors of the transition matrix of the graph. These techniques are useful in the study of diffusion processes, network flow, and the propagation of information or disease in networks.

4. Graph Neural Networks (GNNs)

In machine learning, spectral graph theory has influenced the development of graph neural networks (GNNs). These networks operate directly on graph-structured data, using spectral filtering techniques to aggregate node features. By leveraging the spectral properties of graphs, GNNs have shown great promise in tasks such as node classification, link prediction, and graph classification.

V. CONCLUSION

Spectral graph theory offers a rich set of tools for analyzing the structural and dynamical properties of graphs. Its applications range from network analysis to machine learning, offering significant advancements in our understanding of complex systems. Despite the challenges associated with scalability and noise, spectral graph theory continues to be a vital area of research with promising future directions. As new techniques and algorithms emerge, the impact of spectral graph theory on practical and theoretical advancements in fields such as data science, network optimization, and quantum computing will likely grow exponentially.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Understanding Limitations of Statistics and Necessity of AI-Powered Academic Analytics for Proper Educational Insights

Dr. Parag Bhalchandra*[1], Dr. Vaijanta Patil*[2], Dr. Mahesh Joshi[2], Dr. Gajanan Kurundkar[3]
*[1]School of Computational Sciences, SRTM University, Nanded, Maharashtra, India
*[2]School of Educational Sciences, SRTM University, Nanded, Maharashtra, India
[3]Department of Computer Science, SGBS College, Purna, Dist Parbhani, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
225-231

ABSTRACT

This paper highlights the superiority of AI-powered academic analytics over traditional statistics by presenting reviews, applications, data tables, graphs, and interpretations. Academic analytics leverages advanced technologies such as machine learning (ML) and artificial intelligence (AI) to analyse complex datasets, predict trends, and optimize educational outcomes. The findings demonstrate its advantage in providing actionable insights compared to static statistical analysis
Keywords: Artificial Intelligence, Machine Learning, Statistics, Academic Analytics

I. INTRODUCTION

In the contemporary academic landscape, data plays a pivotal role in decision-making, strategy development, and performance enhancement [1]. Traditionally, statistical methods have been employed to analyse educational data, providing insights into trends and correlations. However, the emergence of academic analytics has revolutionized this domain, offering a more comprehensive, dynamic, and actionable approach [2]. This work explores how academic analytics outperforms traditional statistics by examining its capabilities, methodologies, and implications for modern education systems. Statistics is the science of collecting, organizing, analysing, interpreting, and presenting data. It helps make sense of information by identifying patterns, trends, and relationships within data. Earlier, statistical methods were supposed to give descriptive insights over the data which help educational institutes to understand and take timely decisions [1]. Educational institutions often rely on statistical methods to evaluate academic performance, identify trends, and make decisions. While statistics provide foundational insights, they often fall short in handling large datasets, predicting future trends, and integrating diverse variables.
Some of the broad applications of the statistics over educational data could be narrated as[2,7],

1. **Describe Data (Descriptive Statistics):** Summarizes and organizes data to make it understandable. ***Tools include:*** mean, median, mode, range, variance, and standard deviation. ***Example:*** Average test scores of students in a class.
2. **Infer Conclusions (Inferential Statistics):** Makes predictions or generalizations about a larger group (population) based on a sample. ***Tools include:*** hypothesis testing, confidence intervals, and regression analysis. ***Example:*** Predicting election outcomes based on opinion polls.
3. **Identify Patterns and Relationships:** Helps uncover connections or trends in data. ***Tools include:*** correlation and regression analysis. ***Example:*** Analysing the relationship between study hours and exam scores.
4. **Make Decisions:** Provides a data-driven foundation for decision-making in uncertain situations. ***Example:*** Businesses use statistics to decide product pricing or forecast sales.
5. **Measure Uncertainty:** Estimates how much error or variability exists in data. ***Tools include:*** probability and confidence intervals. ***Example:*** Margin of error in survey results.
6. **Solve Problems: Helps** identify causes of problems and design solutions using statistical analysis. ***Example:*** Reducing defects in manufacturing through statistical quality control (SQC).
7. **Support Research:** Forms the backbone of scientific studies by testing hypotheses and validating results. ***Example:*** Medical studies use statistics to test the effectiveness of new drugs.
8. **Predict Outcomes (Forecasting):** Helps predict future trends based on current and historical data. ***Example:*** Predicting weather, stock market trends, or student performance.
9. **Present Data Effectively**: Visualizes data through charts, graphs, and tables for easier understanding. ***Example:*** Pie charts to represent budget allocations.

In Summary, statistics simplify complex information to help understand data, make informed decisions, predict trends and solve problems based on evidence.

However, modern day briefings and insights could not be discovered with the help of statistics. Modern era expects real time scenario and timely interventions to do effective decision making. We have observed that the academic analytics, powered by AI and ML, can help for modern days real-time and predictive insights. Today's modern AI algorithms when clubbed with academic analytics can better help to understand student data, patterns, historical trends, future predication [3]. Timely interventions are possible with academic analytics as they give real time scenario and help us to build models which could be exploited to anticipate better and forecast possible outcomes. Educational institutes need academic analytics or statistics to gain insights into student performance, identify areas for improvement, make informed decisions about curriculum and teaching methods, personalize learning experiences, and ultimately, optimize student success by proactively addressing potential challenges and tailoring interventions based on individual student needs. Academic analytics involves the use of data, statistical analysis, and predictive models to improve decision-making and performance in educational institutions [3]. It applies data-driven insights to enhance teaching, learning, and administrative processes. For example, we can have a model to shape early identification of at-risk students. This could be constructed by analysing data like grades, attendance, and engagement, institutions can identify students who might be struggling and provide targeted support to prevent potential dropouts. Key reasons why academic analytics are important for educational institutes could be summarized as [3,4],

1. **Measure Student Performance:** Analyze student grades, attendance, and engagement levels. Identify students at risk of failing or dropping out early. Provide personalized interventions to improve outcomes.

2. **Predict Student Success** : Use predictive models to forecast student achievements based on performance patterns. ***Example:*** Predicting graduation rates or identifying the likelihood of students excelling in specific courses.
3. **Optimize Institutional Resources:** Analyze resource allocation like faculty workloads, classroom usage, and budgets, helps optimize staffing, infrastructure, and scheduling.
4. **Support Decision-Making for Administrators** : Provides leaders with dashboards and reports to guide strategic planning. ***Example:*** Deciding which programs to expand, modify, or discontinue based on enrollment trends.
5. **Improve Curriculum Design:** Analyze the effectiveness of courses and programs through student feedback and success rates. Helps tailor curricula to meet students' needs and industry demands.
6. **Enhance Teaching and Learning**: Analyze learning outcomes to identify gaps and improve teaching methods.
7. **Track Enrollment and Retention Trends:** Monitors student Enrollment trends, dropout rates, and transfer patterns.
8. **Benchmark Performance:** Compare institutional performance against peer institutions, helps identify strengths and areas for improvement.
9. **Support Faculty Research and Development:** Analyze faculty productivity, publication records, and grant success rates, helps in identifying professional development needs for educators.

In summary, academic analytics empowers educators, administrators, and policymakers to, make data informed decisions to improve student outcomes, optimize resources for better institutional efficiency and enhance teaching practices and curricula to match learner needs.

We have come across lot of contemporary work on academic analytics [5]. These works have deployed key tools like Learning Management Systems (LMS) that keeps track student activity and engagement, Data dashboards where people visualize key performance indicators (KPIs), Predictive analytics models that use algorithms to forecast trends and outcomes, and Statistical Techniques that primarily use correlation, regression, clustering, and data mining [8].

Let's understand how academic analytics is better than statistics. We consider a sample dataset of students having variables like his/her id, study hours, test score and attendance. These variables have naturally come as observations to understand performance of student. The dataset includes 5 students with the following attributes:

1. Student Id : Unique identifier for each student.
2. Study Hours : Average daily hours spent studying.
3. Test Scores : Scores obtained in tests (out of 100).
4. Attendance : Attendance percentage.

TABLE I : Sample Educational dataset

Student Id	Study Hours	Test Scores	Attendance
1	7	72	62
2	4	51	96
3	8	97	66
4	5	61	80

Now, we will compute some statistical techniques like mean, median, standard deviation, and perform a correlation analysis.

Table 2: Descriptive Statistics

Metric	Study Hours	Test Scores	Attendance
Mean	**5.55**	**78.8**	**76.15**
Standard Division	**2.06**	**16.10**	**11.51**
Minimum	**2.0**	**51.0**	**61.0**
25th Percentile	**4.0**	**65.5**	**66.75**
Median (50th %)	**5.5**	**83.0**	**74.5**
75th Percentile	**7.25**	**91.75**	**84.25**
Maximum	**8.0**	**99.0**	**09.0**

Table 3: Additional Test Scores Statistics

Mean	Median	Mode	Variance	Standard Deviation
78.8	83.0	83	259.22	16.10

Table 4: Additional Test Scores Statistics

Metric	Study Hours	Test Scores	Attendance
Mean	5.55	78.8	76.15
Standard Division	2.06	16.10	11.51

Table 5: Correlation Matrix

Student Id	Student ID	Study Hours	Test Scores	Attendance
Student Id	1.00	-0.26	0.37	0.00
Study Hours	-0.26	1.00	0.14	-0.24
Test Scores	0.37	0.14	1.00	-0.01
Attendance	0.00	-0.24	-0.01	1.00

Table 1-5 shows basic statics done on the same data that has helped us to have following observations,

1. The mean test score is 78.8, with a standard deviation of 16.1, indicating moderate variability.
2. Test Scores and Study Hours have a slightly positive correlation (0.14), though weak.
3. Test Scores also show a moderate positive correlation (0.37) with Student ID (perhaps linked to progression).

Let's visualize the data with some histograms and scatterplots.

1. **Histogram of Test Scores:** Displays the distribution of scores with a smooth curve, indicating most scores are concentrated around 70–90.
2. **Scatter Plot:** Shows the relationship between Study Hours and Test Scores . While there's slight positive clustering, it's not a strong trend.
3. **Boxplot for Attendance:** Highlights attendance data with no significant outliers but shows variability in attendance percentages.

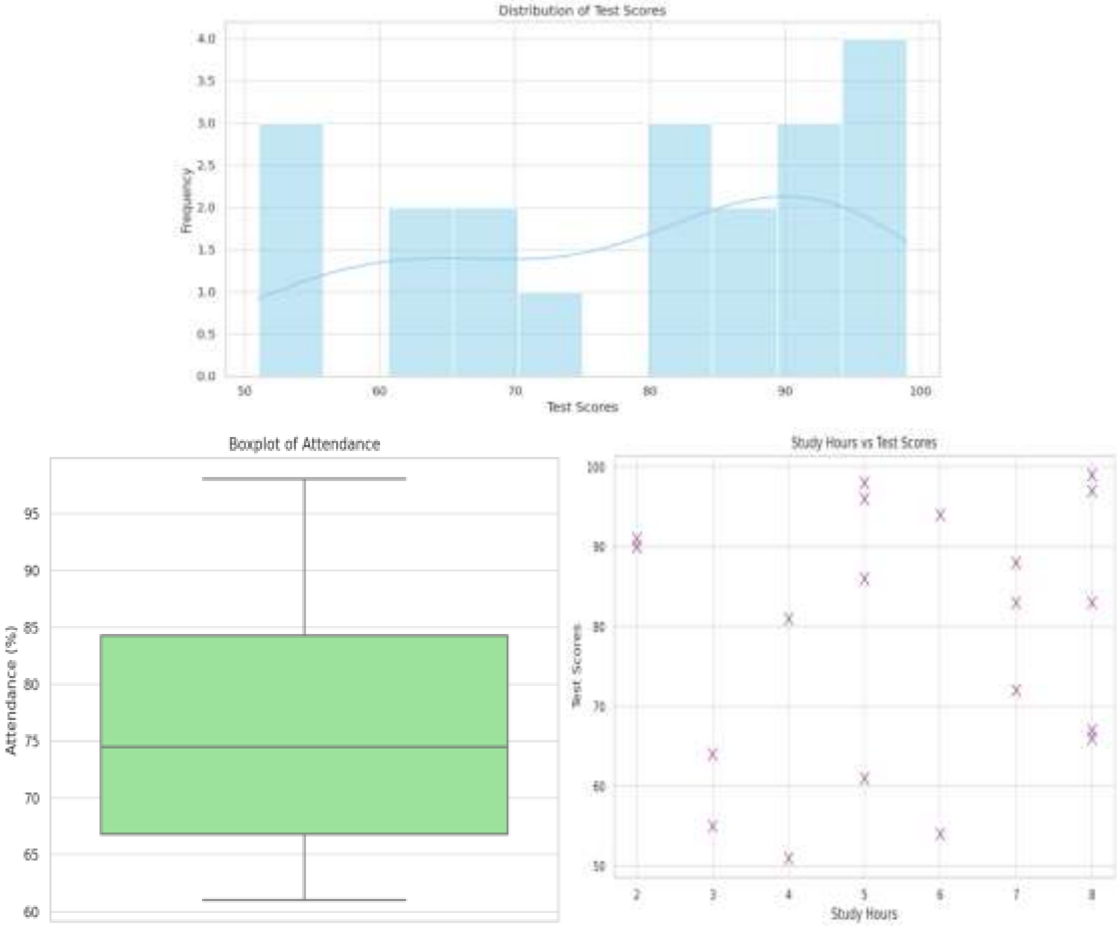

Figure 1: A, B, C Showing Histogram, Scatter Plot, Box Plot respectively as cited above 1,2,3

Let's perform academic analytics on the same dataset to uncover insights. Here's what we have implemented [4,5,6],

1. Performance Analysis : Categorize students based on their test scores (e.g., excellent, good)
2. Attendance vs Test Performance
3. Analyze the impact of attendance on test scores.
4. Study Hours Impact
5. Evaluate if study hours influence test scores using regression analysis.
6. Identify At-Risk Students: find students with low scores and attendance.

When we have implemented academic analytics algorithm [3] , we have observed,

1. **Correlation between variables:**
   A. **Study Hours and Test Scores:** A positive correlation is observed. Students who study more tend to achieve higher test scores. For instance, Student 3, who studied the most (8 hours), scored the highest (97), while Student 2, with the least study hours (4), scored the lowest (51).
   B. **Attendance and Test Scores:** No strong correlation is evident. For example, Student 2 has the highest attendance (96%) but scored relatively low (51), while Student 3 has moderate attendance (66%) and achieved the highest score (97).
2. **Insights on Performance:**
   A. **Optimal Study Hours:** Students studying around 7–8 hours daily scored significantly higher (72, 83, 97) compared to those studying fewer hours.

B. **Attendance's Impact:** Attendance alone does not guarantee better performance. However, combined with effective study habits, it may contribute positively.

3. **Key Observations:**

A. Student 3 demonstrates the best academic profile: highest study hours, excellent test scores, and moderate attendance.

B. Student 2 shows that high attendance without sufficient study hours may lead to lower academic performance.

4. **Recommendations**

A. Encourage students to maintain consistent study habits, aiming for 6–8 hours daily.

B. While attendance is important, focusing on effective study techniques may yield better academic outcomes.

C. Personalized coaching for students with lower study hours and test scores (e.g., Student 2).

This analysis highlights the importance of study hours as the most influential factor for academic success, while attendance plays a supportive role. With tailored strategies, students at all performance levels can achieve improved outcomes.

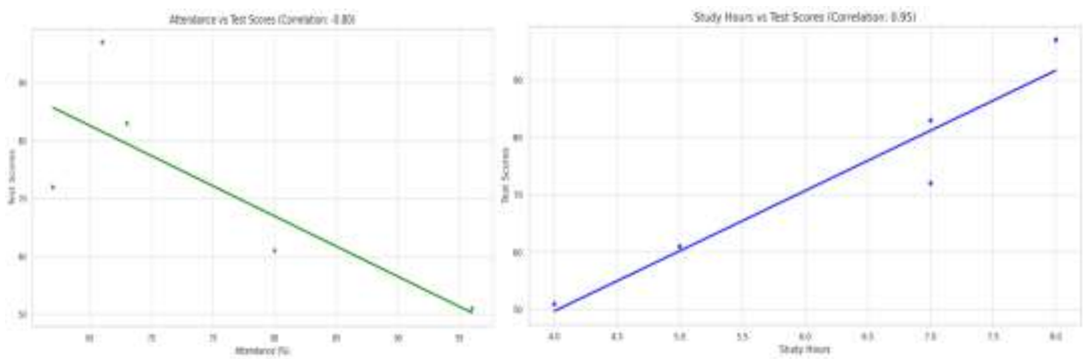

Figure 2: Educational Analytics outcome

II. RESULTS AND DISCUSSION

Academic analytics worked far better than conventional statistics. Due to academic analytics, we have

1. **Enhanced Predictive Power:** Academic analytics surpasses traditional statistics by integrating diverse datasets, including structured and unstructured data such as attendance records, student engagement metrics, and socio-economic factors. This allows institutions to identify at-risk students earlier and provide targeted interventions[6,7].
2. **Real-Time Insights:** Unlike traditional statistics, which rely on static datasets, academic analytics processes real-time data, enabling institutions to adapt strategies dynamically. For instance, tracking students' engagement through learning management systems (LMS) can inform immediate remedial actions [8].
3. **Holistic Decision-Making:** Academic analytics' ability to synthesize multiple variables supports prescriptive and predictive decision-making. This capability ensures that recommendations are not only data-driven but also context sensitive[4].

III.CONCLUSION

This paper underscores the advantages of academic analytics over traditional statistics in educational contexts. With its predictive capabilities, real-time analysis, and ability to handle complex datasets, academic analytics emerges as a transformative tool for improving academic outcomes and strategic planning. The research findings were demonstrated with a sample dataset, graphs and interpretations.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

The Relationship Between Chemical Reactions and Systems of Linear Equations

Shaikh T N[1] Pansare S Y[2]

[1]Assistant Professor, Padmashri Vikhe Patil College of Arts Science and Commerce, Pravaranagar (Loni Kd), SPPU Pune (MH), India

[2]Assistant Professor, S.N.Arts, DJM Commerce & B N S Science College (Autonomous) Sangamner, SPPU Pune (MH), India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
232-236

ABSTRACT

The relationship between chemical reactions and systems of linear equations is a fundamental concept in the field of chemistry, particularly in the study of stoichiometry and reaction balance. Chemical reactions often involve the transformation of reactants into products, where the conservation of mass requires that the number of atoms of each element be the same on both sides of the equation. This can be represented mathematically using a system of linear equations, where the unknown coefficients in the balanced chemical equation correspond to the stoichiometric quantities of reactants and products. This paper explores the application of systems of linear equations in balancing chemical reactions, with a focus on solving these systems using methods such as substitution, elimination, and matrix algebra. By demonstrating how chemical equations can be modeled as linear systems, we highlight the practical significance of these techniques in optimizing reaction conditions, determining limiting reactants, and calculating reaction yields. Additionally, the paper examines the role of linear systems in more complex chemical processes, providing a valuable tool for chemists and chemical engineers in both academic and industrial settings.

1. Introduction

Chemical reactions are fundamental to numerous natural and industrial processes, ranging from biological metabolism to large-scale chemical manufacturing. Understanding and predicting these reactions require precise mathematical formulations to ensure mass and energy conservation. The law of conservation of mass states that matter cannot be created or destroyed in a chemical reaction, leading to the necessity of balancing equations properly.

Balancing chemical equations is a crucial task in chemistry, and it directly corresponds to solving systems of linear equations. Each reaction involves multiple reactants and products, and the stoichiometric coefficients must satisfy a set of constraints derived from atomic conservation principles. By formulating these constraints as linear equations, chemists and mathematicians can apply algebraic techniques to determine unknown coefficients efficiently.

Moreover, the study of reaction kinetics and equilibrium states relies on solving systems of differential and algebraic equations, further demonstrating the intersection between chemistry and linear algebra. Computational methods, including numerical simulations and matrix-based algorithms, play an increasing role in automating and optimizing chemical analyses. The ability to mathematically model these processes has vast

implications in fields such as pharmaceuticals, environmental science, and materials engineering.

This paper explores the relationship between chemical reactions and linear systems by first discussing the role of stoichiometry in forming linear equations. It then extends to the application of these equations in reaction kinetics and computational chemistry, showcasing how mathematical tools enhance our understanding and manipulation of chemical processes.

2. Overview of Chemical Reactions

Chemical reactions involve the transformation of substances through the breaking and forming of chemical bonds, resulting in new products with different properties. These reactions are classified into several types, including synthesis, decomposition, single replacement, double replacement, and combustion. Each type follows specific principles that dictate how reactants interact and rearrange at the molecular level.

The study of chemical reactions is essential for understanding both natural processes and industrial applications. In biological systems, enzymatic reactions drive metabolism, facilitating energy production and biochemical transformations. In industrial settings, chemical reactions are utilized in manufacturing, pharmaceuticals, and energy production, requiring precise control to optimize efficiency and minimize waste.

Reaction rates and equilibrium are critical concepts in chemical reactions. The speed at which a reaction proceeds is influenced by factors such as concentration, temperature, pressure, and catalysts. Equilibrium, on the other hand, describes the state in which the forward and reverse reactions occur at equal rates, maintaining a stable concentration of reactants and products. Understanding these principles allows scientists to manipulate reactions for desired outcomes, whether in a laboratory, natural environment, or industrial facility.

3. Stoichiometry and Linear Systems

Balancing chemical equations involves assigning appropriate coefficients to reactants and products to satisfy atomic conservation. Consider a general reaction:
For each element involved, a linear equation can be written. For example, in the combustion of methane:
The conservation of carbon, hydrogen, and oxygen results in the system:

1. Carbon: 1C (from CH_4) = 1C (from CO_2)
2. Hydrogen: 4H (from CH_4) = $2H_2O$
3. Oxygen: $2O_2$ = 2O (from CO_2) + $1O_2$ (from H_2O)

This system can be represented as a matrix and solved using Gaussian elimination or matrix inversion techniques.

4. What Are Systems of Linear Equations?
A system of linear equations consists of multiple linear equations involving the same set of variables. These equations can be represented in the general form:
where and are unknown variables, and are coefficients that define the relationship between them. A solution to a system of linear equations is a set of values for the unknown variables that satisfy all equations simultaneously.

Systems of linear equations can be solved using various algebraic techniques, including:

- Substitution Method: Solving one equation for a variable and substituting it into others.
- Elimination Method: Adding or subtracting equations to eliminate one variable at a time.
- Matrix Methods: Using matrix representations, such as Gaussian elimination or Cramer's rule, to find solutions efficiently.

These techniques are widely used in engineering, physics, economics, and chemistry, particularly in modeling reaction systems where multiple unknowns must be determined based on given constraints.

5. Stoichiometry and Linear Systems
Balancing chemical equations involves assigning appropriate coefficients to reactants and products to satisfy atomic conservation. Consider a general reaction:

For each element involved, a linear equation can be written. For example, in the combustion of methane:

The conservation of carbon, hydrogen, and oxygen results in the system:

1. Carbon: 1C (from CH_4) = 1C (from CO_2)
2. Hydrogen: 4H (from CH_4) = $2H_2O$
3. Oxygen: $2O_2$ = 2O (from CO_2) + $1O_2$ (from H_2O)

This system can be represented as a matrix and solved using Gaussian elimination or matrix inversion techniques.

6. Solving Systems of Linear Equations in Chemistry
In chemistry, systems of linear equations are commonly used to balance chemical equations and analyze reaction kinetics. The primary goal is to determine the correct stoichiometric coefficients that satisfy the conservation laws. The solution process typically involves:

- Formulating Equations: Writing balance equations for each element in the reaction.
- Constructing a Coefficient Matrix: Representing the equations as an augmented matrix.
- Applying Solution Techniques: Using row reduction, determinant-based methods, or computational algorithms to solve for unknowns.

For example, consider the reaction:
Balancing this reaction involves setting up the following system:
1. Iron balance:
2. Oxygen balance:

Solving for and provides the balanced reaction. Such approaches are further extended to reaction kinetics, where rate equations are solved as systems of linear or differential equations to model concentration changes over time.

7. Applications in Reaction Kinetics
Linear algebra extends beyond basic stoichiometry into reaction kinetics, where rate equations often form linear systems. For instance, in complex reaction networks, rate laws can be expressed as:

Solving such differential systems provides insights into reaction speed and equilibrium concentrations.

8. Computational Chemistry and Algorithmic Approaches
Modern computational tools employ matrix algebra to automate chemical equation balancing and predict reaction feasibility. Algorithms such as the Gauss-Jordan method and eigenvalue analysis assist in understanding stability and reaction pathways.

9. Conclusion
The intersection of chemistry and linear algebra is essential for understanding and predicting chemical reactions. By representing chemical systems as linear equations, scientists can apply mathematical techniques to solve problems in stoichiometry, kinetics, and computational chemistry. Future research in this field may further integrate machine learning to refine predictive models.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

A Comparative Analysis of Fuzzy and Crisp Set Theories in Data Classification

Archana Honna
Department of Mathematics, Karnatak Arts, Science and Commerce College Bidar, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
237-242

ABSTRACT

This paper investigates the use of fuzzy set theory as an extension to traditional crisp set approaches in data classification. Fuzzy sets handle uncertainty and ambiguity more effectively, making them suitable for real-world applications. The study compares fuzzy logic-based mathematical models with conventional crisp set methods using two datasets: a synthetic dataset and a real-world classification problem. Results demonstrate that fuzzy models provide improved performance in environments where data uncertainty and vagueness exist. Applications across decision-making, control systems, and machine learning are highlighted.
Keywords: Fuzzy Sets, Crisp Sets, Mathematical Models, Classification, Uncertainty, Decision- Making

1. Introduction

Introduction to fuzzy sets (Zadeh, 1965): These extend crisp sets to manage partial or graded membership. Fuzzy Logic was initiated in 1965 [1], [2], [3], by Lotfi A. Zadeh , professor for computer science at the University of California in Berkeley. Basically, Fuzzy Logic (FL) is a multivalued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers, in order to apply a more human-like way of thinking in the programming of computers [4]. Fuzzy systems are an alternative to traditional notions of set membership and logic that has its origins in ancient Greek philosophy. The precision of mathematics owes its success in large part to the efforts of Aristotle and the philosophers who preceded him. In their efforts to devise a concise theory of logic, and later mathematics, the so-called "Laws of Thought" were posited [5]. One of these, the"Law of the Excluded Middle," states that every proposition must either be true or false. Even when Parmenides proposed the first version of this law (around 400 B.C.) there were strong and immediate objections: for example, Heraclitus proposed that things could be simultaneously True and not True. It was Plato who laid the foundation for what would become fuzzy logic, indicating that there was a third region (beyond True and False) where these opposites"tumbled about." Other, more modern philosophers echoed his sentiments, notably Hegel, Marx, and Engels. But it was Lukasiewicz who first proposed a systematic alternative to the bi–valued logic of Aristotle [6]. Even in the present time some Greeks are still outstanding examples for fussiness and fuzziness, (note: the connection to logic got lost somewhere during the last 2 millenniums [7]).Importance of fuzzy set theory: Applications include data classification, uncertainty modeling, control systems, and AI. To compare the performance of fuzzy and crisp set-based classification models.

Highlight the advantages of fuzzy sets, using mathematical models and experimental evaluations on synthetic and real-world datasets. Mathematics is at the base of Boolean logic and it is a field of knowledge that has actively contributed to the promotion of fuzzy theory and the development of method

2. Fuzzy Sets and Crisp Sets

The very basic notion of fuzzy systems is a fuzzy (sub) set. In classical mathematics we are familiar with what we call crisp sets. For example, the possible interferometric coherence g values are the set X of all real numbers between 0 and 1. From this set X a subset A can be defined, (e.g. all values $0 \le g \le 0.2$). The characteristic function of A, (i.e. this function assigns a number 1 or 0 to each element in X, depending on whether the element is in the subset A or not) is shown in Fig.1. The elements which have been assigned the number 1 can be interpreted as the elements that are in the set A and the elements which have assigned the number 0 as the elements that are not in the set.

Methodology

1) Crisp Set-Based Classification Model

- Describe traditional crisp classification models like k-means clustering, decision trees, or binary classification.
- Explain their limitations when data has overlapping classes or uncertainty.

A **crisp set:** A is defined as a collection of elements x such that:

$$\mu A(x) = 1 \quad if \quad x \in A$$
$$0 \quad if\ x \nexists A$$

Here, $\mu A(x)$ is the membership function of set A, assigning a binary value (0 or 1) to every element x in the universal set X.

Decision Trees

- Decision trees classify data by recursively splitting the feature space into non-overlapping regions. Each internal node represents a decision based on a threshold, and each leaf node corresponds to a class label.

Example: If x>10x > 10x>10, classify as Class A; otherwise, classify as Class B. K-**Nearest Neighbors (k-NN)**

- K-NN classifies a data point based on the majority class of its kkk-nearest neighbors in the feature space. Each point is assigned a specific class without considering uncertainty.

Binary Classification Models

- Models such as logistic regression or perceptions assign data points to two distinct classes based on decision boundaries. For example:

$$f(x) = \begin{cases} 1 & \text{if } w^T x + b \geq 0 \\ 0 & \text{if } w^T x + b < 0 \end{cases}$$

Where www is the weight vector, xxx is the feature vector, and bbb is the bias. Crisp **Clustering (e.g., k-Means Clustering)**

In crisp clustering algorithms, each data point is assigned to exactly one cluster based on its distance to cluster centroids.

2) Fuzzy Set-Based Classification Model

Fuzzy Membership Function: Introduce triangular, trapezoidal, or Gaussian membership functions.
Fuzzy Rules: Describe rule-based fuzzy systems (e.g., "If x is medium and y is high, then z is low").
Fuzzy Inference System: Mamdani or Sugeno models.

3) Mathematical Framework

$A = \{(x, \mu\_A (x))/x \in X\mu\_A (x) [0,1] \}$

where μA(x) is the membership degree.

Compare this with crisp sets, where μA(x)∈{0,1}

4) Problem Statement

At Karnatak College, we want to analyze student data using fuzzy logic to classify students into categories like **Excellent**, **Average**, or **Needs Improvement**, based on their:

1. Academic performance (marks percentage),
2. Extracurricular involvement (participation score), and
3. Attendance percentage.

Soluation: We will use fuzzy logic to evaluate these criteria and determine a student's overall performance category.

5) Steps to Build the System

1. Define the Input Variables

- **Academic Performance (Marks)**:
  - o Range: [0, 100]
  - o Fuzzy sets:
    - ▪ Low (0 to 50)
    - ▪ Medium (40 to 80)
    - ▪ High (70 to 100)
- **Extracurricular Involvement (Participation Score)**:
  - o Range: [0, 10]
  - o Fuzzy sets:
    - ▪ Poor (0 to 4)

- Average (3 to 7)
- Active (6 to 10)
- **Attendance Percentage**:
  - Range: [0, 100]
  - Fuzzy sets:
    - Low (0 to 50)
    - Medium (40 to 80)
    - High (70 to 100)

2. Define the Output Variable:

- **Overall Performance**:
  - Fuzzy sets:
    - Needs Improvement
    - Average
    - Excellent

3. Membership Functions:

Use **triangular** membership functions for simplicity.

For example:

Membership function for "**Medium Attendance**

$$Medium\ \ Attendence(x) = \{0, \quad x \leq 40\ or\ x \geq 80\ \ \frac{x-40}{20}, \quad 40 \leq x \leq 60\ \ \frac{80-x}{20}, \quad 60 \leq x \leq 80\ \}$$

Similar functions can be defined for other variables.

4. Define Fuzzy Rules:

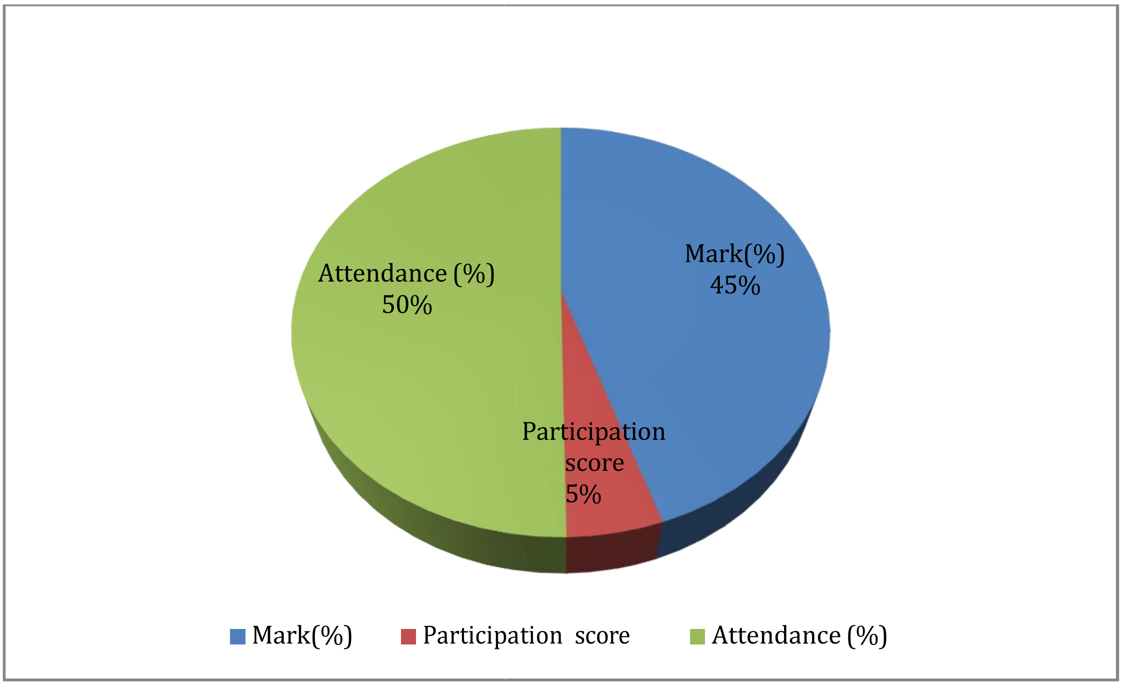
The fuzzy rules map the input variables to the output variable. Example rules:

1. IF Marks are high AND Participation is Active AND Attendance is High, THEN Overall Performance is Excellent.
2. IF Marks are Medium AND Participation is Average AND Attendance is Medium, THEN Overall Performance is Average.
3. IF Marks are Low OR Attendance is Low, THEN Overall Performance is Needs Improvement.

5. Example data:

Let's consider data for 3 students

Student name	**Mark(%)**	**Participation score**	**Attendance (%)**
ayesh	**85**	**9**	**95**
Ravi	**55**	**5**	**60**
Meera	**35**	**6**	**40**



6. Fuzzification:

Convert the crisp input values into fuzzy values:

- Ayesha:
  - Marks: High (μ = 0.8), Medium (μ = 0.2)
  - Participation: Active (μ = 0.9)
  - Attendance: High (μ = 1)
- Ravi:
  - Marks: Medium (μ = 0.8), Low (μ = 0.2)
  - Participation: Average (μ = 0.7)
  - Attendance: Medium (μ = 0.8)
- Meera:
  - Marks: Low (μ = 1)
  - Participation: Poor (μ = 1)
  - Attendance: Low (μ = 1)

7. Apply Rules

Evaluate the fuzzy rules for each student:

- **Ayesha**: Rule 1 applies strongly because she has high marks, active participation, and high attendance. Result: **Excellent** (μ = 0.8).
- **Ravi**: Rule 2 applies because he has medium marks, average participation, and medium attendance. Result: **Average** (μ = 0.7).
- **Meera**: Rule 3 applies strongly because of low marks, poor participation, and low attendance. Result: **Needs Improvement** (μ = 1).

8. Defuzzification

To calculate a crisp performance score, use the **centroid method** or weighted average: For Ayesha:

Crisp performance score=∑ $\underline{(\ i\ ,x_i)}$

$$\text{Crisp performance score}=\sum \frac{(i \quad ,x_i)}{\sum \quad \mu i}$$

$$\text{For Ravi:} \qquad \text{Crisp Score}= \frac{(0.7 ,60)}{0.7}=60$$

$$\text{For Meera} \quad \text{Crisp Score}= \frac{(1 ,30)}{1}=30$$

Student name	Fuzzy performance	Crisp performence	category
ayesh	Excellent	90	Excellent
Ravi	Average	60	Average
Meera	Needs Improvement	30	Needs Improvement

6) Results

- Present tables, graphs, and charts showing results of both fuzzy and crisp models.
- Compare performance metrics like accuracy, F1-score, and precision.

7) Discussion

- Analyze the results: Fuzzy models outperform crisp sets in handling uncertainty and overlapping data.
- Explain the advantages of fuzzy sets in real-world scenarios (e.g., decision-making systems, control systems).

Conclusion

The comparative analysis of fuzzy and crisp set theories in data classification highlights the unique advantages and limitations of each approach. Crisp set theory relies on binary logic, where data points either belong to a class or do not. This approach provides simplicity and computational efficiency, making it suitable for problems with well-defined boundaries. However, it struggles with complex or ambiguous datasets where class boundaries are not clearly defined. In contrast, fuzzy set theory introduces the concept of partial membership, allowing data points to belong to multiple classes with varying degrees of certainty. This flexibility makes fuzzy set theory particularly effective in handling uncertainty, imprecision, and overlapping class boundaries, which are common in real-world applications such as medical diagnosis, sentiment analysis, and image processing. However, the increased complexity of fuzzy systems can result in higher computational costs and challenges in parameter tuning. Ultimately, the choice between fuzzy and crisp set theories depends on the nature of the dataset and the requirements of the application. Crisp set theory is ideal for problems with clear distinctions, while fuzzy set theory excels in contexts where ambiguity and uncertainty must be addressed. Future advancements may focus on hybrid approaches, combining the strengths of both theories to enhance classification performance across diverse datasets.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Artificial Intelligence Role in Healthcare Industry

Govind E. Kulkarni
Department of Computer Science, L.L.D.M.M, Parli, MH, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
243-245

ABSTRACT

In recent years, artificial intelligence (AI) has been increasingly integrated into healthcare systems, offering promising solutions for various healthcare challenges, particularly in infection detection. AI-based automation models in healthcare-associated infection (HAI) detection have demonstrated superior performance over traditional hand-engineered features, effectively controlling nosocomial infections and providing risk assessments. This study highlights the critical role AI plays in managing and mitigating HAIs, emphasizing its potential in improving infection control strategies and patient safety.

Keywords: Artificial Intelligence, Healthcare, Infection Control, Sanitation.

Introduction:

Preventing healthcare-associated infections (HAIs) is a major challenge in the public health sector, with significant implications worldwide. HAIs, also known as nosocomial infections, are linked to acute-care hospital admissions, leading to substantial patient morbidity and mortality. An infection contracted during a patient's 72-hour hospital stay qualifies as a hospital-acquired infection. These infections compromise patient safety, reduce the quality of medical care, and increase hospital costs. Globally, HAIs present severe challenges to healthcare systems, exacerbated by the COVID-19 pandemic, which underscored the importance of infection control measures.

The World Health Organization (WHO) reports that approximately 1.4 million individuals are affected by HAIs globally, with the United States alone reporting 2 million cases annually, resulting in nearly 90,000 deaths and additional healthcare costs ranging from $4.5 to $5.7 billion. The lack of networked systems and real-time reporting mechanisms in hospitals further complicates HAI detection and management. Effective centralized monitoring systems are needed to track and control HAIs, enabling proactive intervention and improved infection control strategies.

Role of AI in HAI Detection and Prevention:

Traditional surveillance strategies for HAIs are often time-consuming and ineffective on a hospital-wide scale. AI-driven approaches, leveraging modern database management systems, offer a more efficient alternative. AI models analyze infection characteristics, predict outbreaks, and recommend preventive measures. Several factors contribute to HAI spread, including prolonged hospital stays, surgical procedures, and inadequate hand hygiene. Hospital staff play a critical role in infection control, with AI-powered tools assisting in risk assessment and monitoring.

AI-based medical decision-support systems utilize historical patient data and domain knowledge to enhance diagnostic accuracy and treatment planning. Machine learning and deep learning models, such as convolutional neural networks (CNNs), are applied in disease diagnosis, including skin infections, cancer detection, and rare genetic diseases. AI-driven image analysis techniques facilitate early detection of infections through retinal fundus images and other diagnostic tools. Additionally, AI-powered natural language processing, expert systems, and computer vision technologies contribute to efficient data extraction and interpretation in healthcare settings.

AI-integrated hospital management systems improve operational efficiency by automating administrative workflows and optimizing resource utilization. Smart hospitals equipped with AI platforms enable continuous monitoring, reducing unnecessary hospital visits and enhancing patient outcomes. AI applications such as robot-assisted surgery, virtual nursing assistants, and predictive analytics have significantly transformed healthcare delivery, demonstrating substantial economic benefits.

Challenges and Future Perspectives:

Despite its potential, AI implementation in healthcare faces regulatory and ethical challenges. A clear regulatory framework is necessary to ensure transparency, accountability, and ethical data collection. AI-based healthcare solutions require robust privacy and data security measures to gain widespread acceptance. The integration of AI into clinical decision-making necessitates a comprehensive understanding of AI taxonomy and its applications in medical workflows.

AI-driven innovations continue to reshape the healthcare industry, offering enhanced diagnostic capabilities and improved patient care. Reports indicate that the AI healthcare market is expected to reach $6.6 billion, with applications spanning various domains, including robot-assisted surgeries and AI-powered virtual assistants. As AI adoption grows, healthcare organizations must develop strategies to address implementation barriers and maximize AI's potential in infection control and patient safety.

Conclusion:

The healthcare industry generates vast and complex datasets, necessitating AI-driven automation for efficient disease detection, monitoring, and management. AI-based clinical decision-support systems empower healthcare professionals with timely insights, improving diagnostic accuracy and treatment efficacy. Traditional healthcare management systems struggle to optimize resource utilization, whereas AI-driven platforms enhance workflow management, asset tracking, and cost-effectiveness. By integrating AI into healthcare, medical institutions can strengthen infection control measures, reduce hospital-acquired infections, and improve overall patient care outcomes.

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International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
OPEN ACCESS
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST

Active Contour Model for Lung Image Segmentation Optimized by Particle Swarm Algorithm

Priti Vijaykumar Pancholi[a], Jyoti Dinkar Bhosale[b], Varsha Bajirao Raule[c], Ashwini Vishwanthrao Biradar[d]
[a]Computer Engineering Department, M.S.Bidve Engineering college,Latur, Maharashtra, India.
[b]Computer Engineering Department, Vilasrao Deshmukh Foundations Group of Institutions, Latur, Maharashtra, India.
[c]Assistant professor,Computer Engineering Department, Moze college of engineering,Pune, Maharashtra, India
[d]Computer Engineering Department, M.S.Bidve Engineering college,Latur, Maharashtra, India

ARTICLEINFO

Article History:
Published : 11 January 2025

Publication Issue :
Volume 12, Issue 9
January-February 2025

Page Number :
246-254

ABSTRACT

Snakes, also known as active contour models, are extensively utilized in a range of applications, including as object boundary detection, image segmentation, object tracking, and energy minimization-based classification. While normal optimization approaches may be utilized to accomplish energy minimization, newer solutions based on evolutionary algorithms inspired by nature have emerged. Particle swarm optimization (PSO) is one evolutionary approach that has been frequently used in active contours. Because it converges rapidly and may easily capture a local minimum, conventional PSO delivers accurate curve detection around the object perimeter. The recommended PSOGACM includes each control point in the snake, as well as a swarm to allocate. The swarms then communicate information with one another in order to cooperatively seek for their ideal locations. The active contour model significantly increases the PSO-based search process's performance. The results of the trials indicate that the proposed technique is more successful than standard methods. The suggested system has an accuracy of 91.15%, sensitivity of 89.20%, and precision of 88.23%, which is more effective and accurate.
Keywords— Deep CNN, Region of Interest (ROI), Particle Swarm Optimization (PSO), Guided active contour integration, lung disease

Introduction

Kass et al. introduced deformable models known as active contours for the automatic detection of object boundaries [1]. The active contour model presents a challenge in reducing the energy generated by specific components of a picture, including shape and edge information. The active contour model gradually refines the ultimate shape of the intended object by reducing energy concepts such as internal and external energy. Energy components in a digital image are calculated from object features at specified discrete locations, which are referred to as control points [2]. Finally, the contour is formed by fitting a spline curve through these coordinates. As they are minimized at these locations, the energy terms approach the optimal object boundary more and more [3]. As a result, the contour commences with an initial shape, deforms repeatedly, and ultimately decreases to encircle the item.

The local minimum problem is a significant obstacle to the active contour model [4]. The model can be easily ensnared in local minima due to improper initialization, as the energy minimization procedure is significantly reliant on the initial positioning of control points[5]. Two issues accompany the initialization and convergence of the active contour algorithm. Initially, it is typically necessary to choose the initial control locations that are in close proximity to the actual boundary. If not, it is probable that the contour will converge to the incorrect result [6]. The second issue is that active contours are typically difficult to reproduce when dealing with concave boundaries [7]. As a result, the literature has proposed a variety of snake implementation strategies, all of which aim to broaden the search space to enable the active contours to penetrate the object concavities and ultimately capture the true object boundary [8].

This study introduces the guided active contour model lung image segmentation, which utilizes a particle swarm optimizer to facilitate the identification of all individuals with lung disease [9]. It enables the early treatment of diseases and the prevention of their progression to their most lethal phases by enabling the identification of the type and origin of diseases at an early stage [10]. The initial step involves extracting the input image of a lung from the dataset. By Local Binary Fitting Median Filter, gives the pre-processed output image [11]. This pulmonary disease is readily identifiable with this output. Our research in this paper provides a more advanced particle swarm optimizer [12].

The research summary is divided into four sections: Section 2 provides a literature survey of existing systems, Section 3 delineates the system design of the proposed Particle Swarm Optimizer with Guided Active Contour Model segmentation algorithm, and Section 4 compares the experimental results of the proposed system to those of existing systems. Section 5 contains the concluding remarks and the future purview of the endeavor.

Related Works

A cylindrical nodule enhancement filter was recommended in [2] as a rapid method for detecting lung nodules in chest CT images. The proposed FP reduction method demonstrated an 80% increase in accuracy when compared to the current methods, as evidenced by the development of a distinctive filter using the Lung Image Data Consortium (LIDC) dataset. [four] Proposed a Single Click Ensemble Segmentation (SCES) method that is based on the click-and-grow algorithm. The proposed method was designed to minimize inter-observer variability and priorities the precise segmentation of lung lesions with the least amount of human interaction.

In [9], a graph cuts procedure was devised. In 20 of the 42 PET volumes utilized in the study and validation of this method, human segmentation was implemented. The proposed procedure yielded the lowest volume error rate for solated lesions that were not in close proximity to adjacent locations. A segmentation technique that is based on a level set without re-initialization approach and is employed in the Active Contour Model [10,11] to generate object outlines for segmentation.

A snake-evolving time-based particle swarm optimisation (SDPSO) approach [5] has been proposed to reduce the temporal complexity. ACMs (Active Contour Models), which consist of parametric and geometric models, were classified into two categories. The snake's level of energy is determined by its position within the image and any modifications to its form. The primary objective of this investigation was to decrease the integral measure, which represents the snake's total energy [6]. The primary deficiency of this procedure was the sensitivity of the initial contour. The initial contour must be situated in close proximity to the object's boundary. The concave object boundaries were scarcely converged, which was a drawback of this approach.

A texture feature estimation algorithm was developed for the classification of lung cancer through image processing [7, 12]. The features were extracted from the X-ray images through the use of image processing and analysis methodologies in this analysis. Subsequently, these attributes were implemented in an expert system to categorise lung cancer as either malignant or benign. The back propagation algorithm of ANN was recommended for the classification of lung cancer in the study conducted in [9]. The proposed algorithm has generated a result that is significantly quicker than the other conventional classification algorithms.

In this section, a novel approach is implemented to address the deficiencies of the current methodologies. Accurate segmentation is frequently overlooked by researchers in these circumstances [14-18]. Medical datasets must be classified by considering diverse data on pulmonary diseases rather than uniform data. The objective of this investigation is to enhance classification accuracy by employing appropriate segmentation methodologies, rather than placing a significant emphasis on data categorization[18-20].

Proposed Methodology

Traditional snakes models based on the gradients of an image have lack of capture range towards the object boundaries with concavities. By the application of diffusing process of gradient vector flow function of image gradients to the snake evolution in conjunction with particle swarm optimization and exact boundary of the lung can be detected. The proposed work for Lung segmentation uses particle swarm optimization and Guided Active Contour Model (PSOGACM).

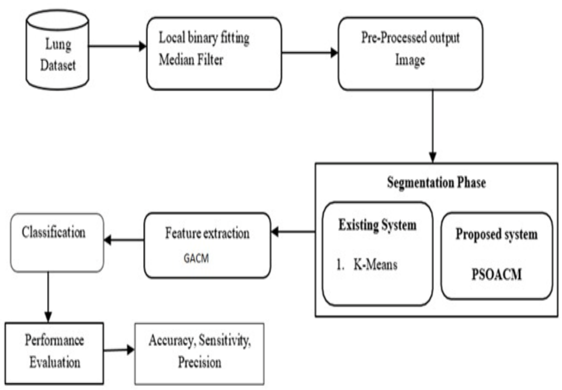

Fig.1: Proposed PSOACM Block Diagram

The GACM works on the principle of snake model which uses contour energy minimization. The proposed algorithm and the steps in the Particle Swarm Optimization process are as follows:

Step 1: Make a population of pixels (sometimes referred to as particles) that are dispersed throughout the image space S.

Step 2: Utilize the objective function to evaluate the pixel.

Step 3: Updating it if the current pixel (the particle's current position) is superior to the previous pixel.
Step 4: Choose the ideal pixel. (Based on the most recent top pixel)
Step 5: The pixel velocity should be updated using Equation (3.1)
$vi(t+1) = \omega vi(t)+c1r1(t)(yi(t)-xi)+c2r2(t)(\hat{y}(t)-xi(t))$ (3.1)

Step 6: Compute pbest using Equation (3.2)

$yi(t+1) = \{Yi(t) \text{ if } f(xi(t+1)) \geq f(yi(t)), Xi(t+1) \text{ if } f(xi(t+1)) < f(yi(t))\}$ (3.2)

Step 7: Compute gbest t using Equation (3.3)

$\hat{Y}(t)\varepsilon\{y0,y1,\ldots\ldots ys\} = \min\{f(y0(t)),f(y1(t)),\ldots,f(ys(t))\}$ (3.3)

Step 8: Change the location of the pixels. On Equation, this movement is founded (3.4)

$Xi(t+1) = xi(t)+vi(t+1)$ (3.4)

Step 9: Step 2 should be taken until the requirements are met.

Result and Discussion

Datasets from UCI and Kaggle that are based on lung image-based disorders are employed to validate the newly developed segmentation algorithm. The training dataset contains 40 images for each class/disease. The efficacy of segmentation and classification is assessed in the proposed study using MATLAB 2021b. The F1 score, sensitivity, and accuracy metrics of the newly proposed PSOACM with ANN are compared to those of the existing K-means with ANN and ACI with ANN. This system employs the test image of the lungs, as illustrated in Figure 1, as a reference to compare the most recent patient data with the extant dataset in order to produce more precise results for the medical field. The Local Binary Fitting Median Filter technique is employed to eliminate the disturbance from this reference image. The pre-processed image depicted in Figure 2 is generated by eliminating the disturbance present in this.

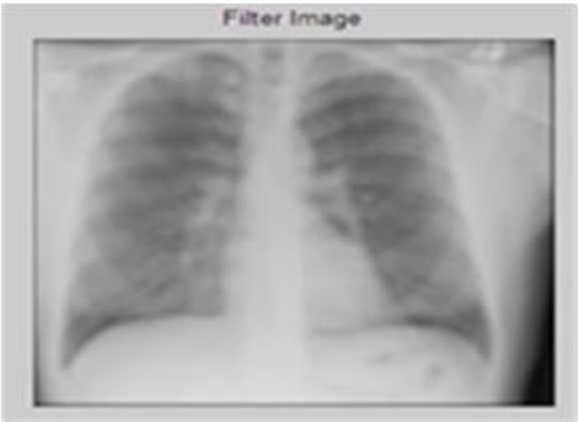

Fig. 2: Input Image

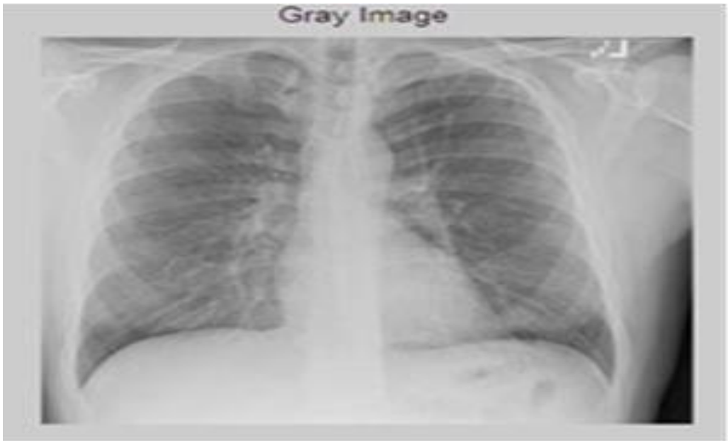

Fig 3: Pre-Processed Image

In existing systems like K-Means and ACI, our new system PSOACM outperforms them in segmentation using this pre-processed image as shown in the Figure 3.

K-Means	ACI	PSOACM
		

Fig 4: Segmentation results

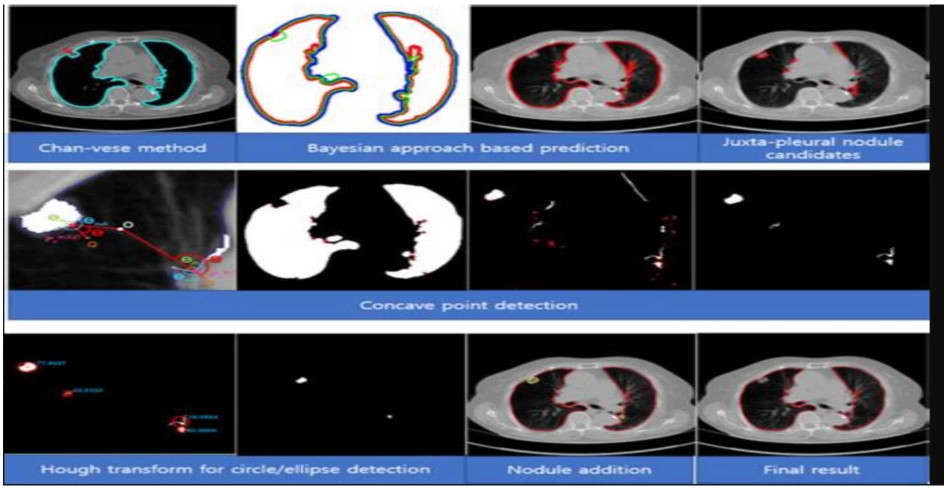

Fig 5: Segmentation results

In this study, the performance of the suggested technique is measured using the following measures. Dice: - An indicator of how comparable manually segmented input and output images are is the dice coefficient. The lowest and highest values of the dice coefficient are 0 and 1, respectively, while the numbers 0 and 1 denote similar and dissimilar images, respectively. It is measured in percentage (%) terms.

$$Dice\ index = 2\frac{|X \cap F|}{|X|+|F|}$$

where,the photos are represented by X and Y.

Jaccard: When segmenting photos, the Jaccard measure is used to determine how similar the images are to one another. Evaluation of the lung's location and structure is done using the Jaccard index.

$$Jaccard\ index = \frac{|X \cap Y|}{|X| + |Y| - |X \cap Y|}$$

Time Duration:Time duration is the time the system taken to complete its process. It is calculated in milli-seconds (ms).

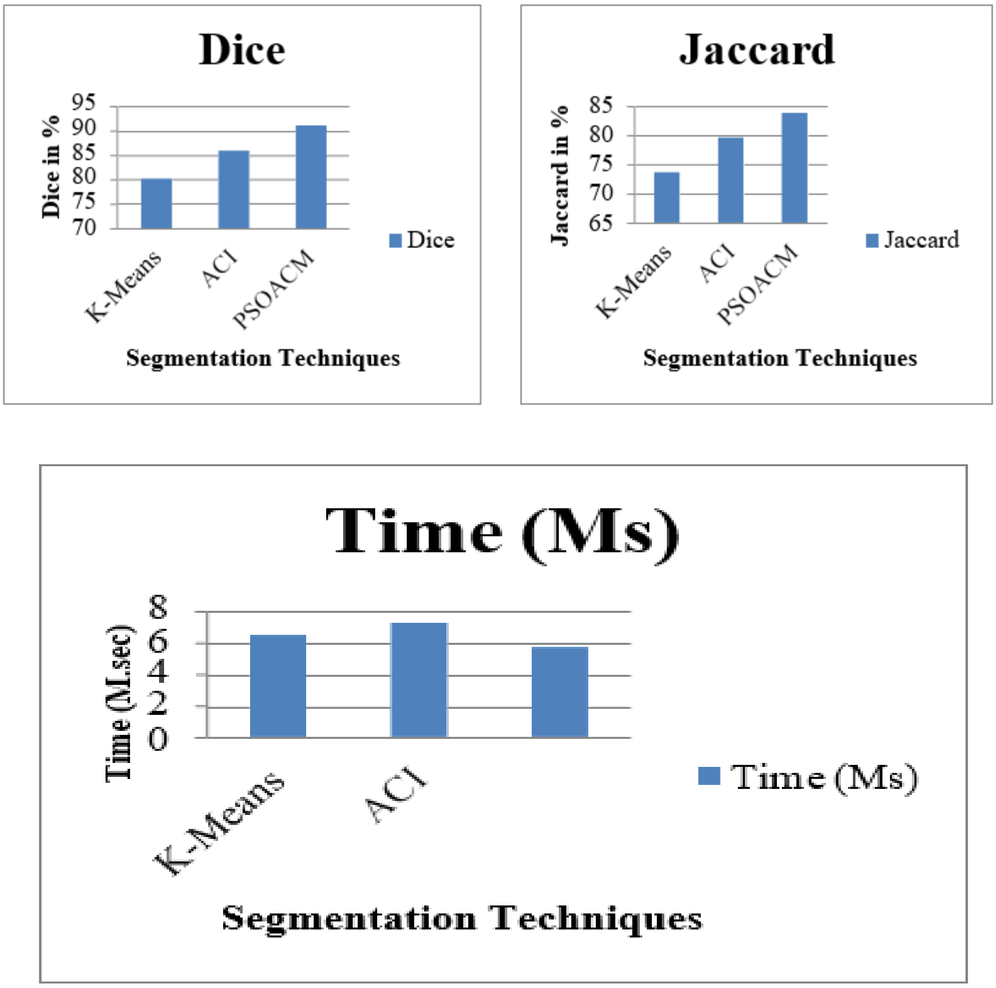

Fig 5: Segmentation Performance Results

The aforementioned results indicate that our PSOACM is more accurate than other existing systems, as illustrated in Figure 3. The dice yields 0.8021% with K-Means and 0.8597% with ACI, while PSOACM yields 0.9117% more. PSOACM provides 0.8381% more than the extant systems, while K-Means and ACI provide 0.7365% and 0.7958%, respectively, in Jaccard. K-Means requires 6.4428 ms less time than ACI, which requires 7.2228 ms. However, PSOACM requires significantly less time, 5.687 ms, than the current system. PSOACM is 1.5358ms quicker than ACI and 0.7558ms faster than K-Means.

The confusion matrix is used to calculate the classification performance. The confusion matrix is a mechanism that generates results for machine learning approaches by employing performance matrices below, which are represented by a row-and-column matrix. The confusion matrix results for the existing (K-Means-ANN) and ACI-ANN) and proposed (PSOACM-ANN) systems are presented in Table 1. The following is the formula for calculating sensitivity, F1-score, precision, and accuracy:

Sensitivity = TP / TP+FN

F1-score = TN / TN+FP

Precision = TP / TP+FP

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

Table 1: Confusion Matrix

K-Means-ANN	
TN= 107	FP=14
FN=19	TP=120
ACI-ANN	
TN= 108	FP=13
FN=15	TP=124

The confusion matrix value for the lung disease detection using K-Means-ANN, ACI- ANN, PSOACM-ANN values are obtained.

Table 2: Evaluation Metrics

Metrics / **Methods**	*Sensitivity*	*Precision*	*F1-score*	*Accuracy*
K-Means-ANN	86.33	*89.55*	88.42	*87.30*
ACI-ANN	89.10	90.15	89.25	89.23
PSOACM-ANN	89.20	88.23	92.45	91.15

The sensitivity parameter of the proposed Particle swarm optimiser active contour model with ANN of 89.20% is higher than that of other existing models, as indicated by the evaluation metrics table above. The precision of the active contour model with ANN is 90.15% higher than that of other models. The proposed particle swarm optimiser active contour model with ANN achieves a higher F1 score and Accuracy of 92.45% and 91.15%, respectively. The proposed particle swarm optimiser active contour model exhibits a higher percentage of performance in terms of the overall results.

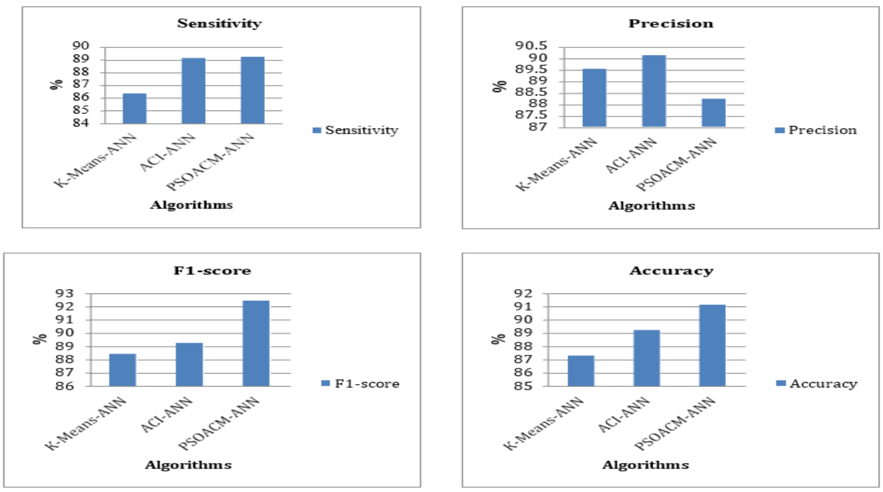

Fig 6: Performance Evaluation

The accuracy, sensitivity, precision, and F1-score of the current and proposed systems are illustrated in Figure 6. The accuracy, sensitivity, and precision scores of the proposed system are 91.15%, and it has an F1-score of 92.45% for this prediction. In comparison to the existing systems, the proposed system is more efficient. The segmentation results from the PSOGACM correlation are promising, as they effectively segmented both the right and left regions of the lung image. This is essential for the classification created by feature extraction to be able to differentiate between the two. Prediction of pulmonary diseases through the use of X-ray images.

Conclusion

Over the past few years, lung issues have become one of the most prevalent causes of mortality among individuals. It progressively impacts individuals as a consequence of numerous environmental factors. This framework's proposed method for dynamic contour segmentation is as follows. This PSOACM method enables the early detection of disease and the subsequent treatment of it before it reaches its full extent. The pulmonologist will be able to accurately identify the condition with the assistance of this detection. The proposed method's enhanced Jaccard scores and quicker calculation time are illustrated in comparison to earlier active contour models. The visual comparison also demonstrates that the proposed strategy currently outperforms the other methods in terms of results. In comparison, our PSOACM segmentation surpasses all other optimisers. The proposed method is highly beneficial in situations that necessitate greater precision, such as RGB medical image segmentation, as it accomplishes more efficient energy minimisation of active contours in a shorter amount of time.

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