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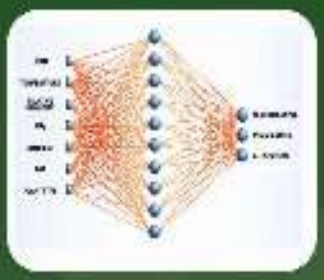


Special Issue

Proceeding of the 10th National Conference on "Emerging Trends in Computer & Information Technology" held on 15th January 2025

Editor in Chief
Prof. Dr. B.H. Barhate

|| विद्या दानम् महत् पुण्यम् ||
Tapti Education Society's
Dept. of Computer Science and Information Technology
Bhusawal Arts Science & P.O.Nahata Commerce College,
Bhusawal - 425 201 Maharashtra
NAAC Reaccredited (*Fourth Cycle*) "A" Grade with CGPA 3.17
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About Publisher of IJCRT

Bhusawal, as recalled and noted down in records has a prominent place on the map of the nation; proudly housing two ordnance factories, a thermal power station in the region, and itself being one of the major railway junctions of Central Railway from where, residents proudly say, you may visit any corner of India. A mixture of farmers, tribal people from adjoining are as with the servants from all over India, Bhusawal serves as a slice of the nation; and honorably has unity in diversity. It is 25kms away from the district, Jalgaon, famous as a city of gold; and few Kms away from Yawal and Raver tehsils, famous all over nation for bananas. It is the only "A" graded Municipal Corporation in the district. Another identification as well as benefit of thecity is that it is situated at the bank of the Tapi river, the only river that flows from east to west. The city of Bhusawal has been ahome place for the British authorities, and it is famous for railways since British rule. It is historically remarkable for the grave of Major Robert Gill, who invented world famous Ajanta caves; and for the tomb of Sant Gadgebaba, a famous and truly a leading social reformer in Maharashtra. The world famous Ajanta caves are just 60kms away from the city. It is believed that the parental home of Rani Laxmibai (famous as Queen of Jhansi) is situated at Parola, 50kms away from the city. Bhusawal is also famous for many mythological stories like that of Shravana, coming from Ramayana who is said to be killed at Hartala, which is near to the city. Besides, the city was once famous in Bollywood for film distribution companies as well known "Rajashri" pictures.

Summing up the physiognomies of the city, Bhusawal stands as a glorious city in the eyes of everyone. However, it was the time-besides all assets of the city-when Bhusawal was a degenerated city in terms of higher education even after a long time from independence. There were few schools imparting high school level education but none of the colleges. It was only in1958, under the motivation of Late Honorable Madhukar rao Chaudhari, ex-speaker of Maharashtra Legislative Assembly, a groupof social well-wishers came together and established the Tapti Education Society in 1958. Simply having the wish in mind to provide potential students higher education facilities near their home, they started the Bhusawal College of Arts and Commerce in 1963. Their philanthropic view may be seen in the motto: *Vidya danam mahat punyam.* Yet difficulties were innumerable. The college with two faculties was started in the place of rent of a high school in the city.

It is wisely said that *vidya danam* is *mahat punyam*. The dedicated faculty, the sublime view of the management soon started to produce good academicians. Inspired by the results the trust purchased a barren land of 7 acres out of the city which is soon to be developed as a centre of imparting quality higher education in the area. The barren land with sustaining hard work, and devotion was then transferred into a naturally beautiful campus. The college is then shifted to a new place in 1972 with the introduction of Science stream. The philanthropist Late Mr. Poonamchand Nahata donated to the college, hence the college is renamed and which today itself is a brand as **Bhusawal Arts, Science and Poonamchand Omkardas Nahata Commerce College, Bhusawal.**

The college is then marching forward with a goal to **creatively contribute the society through the pursuit of learning at higher level of excellence**. The institute has contributed in many ways for economic, social and cultural uplift of the society by offering quality education. Since the inception it has been known for academic excellence, inventive pursuits and athletic dynamism. The college is a multi-stream institute catering to the needs of the young minds primarily from the rural areas.Our society runs not only the college but also the Institute of Management and Career Development and much sought Tapti Public School (affiliated to CBSE Board, New Delhi) within a minimum space of 7.3 acres. The institute is developing vertically in all of the fields.

The Tapti Education Society's, Bhusawal Arts, Science and P. O. Nahata Commerce College was accredited as **four stars (****) in 2001**, reaccredited as **"A" Grade** with CGPA **3.28 in 2008 and reaccredited 3rd cycle as "A" Grade with CGPA 3.30 in 2015,** as the **first College** in Kavayitri Bahinabai Chaudhari North Maharashtra University jurisdiction. It is also the first college to get registers for the fourth cycle of accreditation in the jurisdiction of the university and reaccredited as **"A" Grade** with CGPA **3.17 in 2023 with new framework**. It is also recognized by UGC as **College with Potential for Excellence**. Recently, the society is certified as ISO 9001:2008 institute. Our institute is one of the renowned institutes in the adjoining area. We welcomed the upcoming students from rural areas who made remarkable progress and set theirs and college's image in society. Many of the students of this institute secure top position in various fields. This make us feel great. The college achieves 'A'grade in three subsequent cycles of Re-accreditations and it brings the college towards autonomous status.

Initially the college was affiliated to the Pune University, and got permanent affiliation in 1990. Since the inception of Kavayitri Bahinabai Chaudhari North Maharashtra University in 1991, the college is permanently affiliated to the same. The university spreads all over three districts: Jalgaon; Dhule; and Nandurbar, being on the boundaries of Gujrat and Maharashtra and one being the district of tribal people. The university is trying hard to uplift the downtrodden, while keeping in touch with the rapidly changing world.

Last but not least, the college has the advantages of developing youth coming from rural area, and forming them into sensible youth as they are mixed in the cosmopolitan society. The college is aware that every coin has two sides: hence students coming from rural areas have inferiority complex, their vernacular background being most disadvantage for them. The college has faced challenges to improve their communication skills, to boost their confidence to bring them into modern current while making them aware of great Indian culture. As the college has celebrated its golden jubilee, it will be a golden, in fact a platinum moment for us when the students coming from different backgrounds will be essentially Indian serving for the welfare of humanity. With this view the college is making progress towards quality excellence so that it will be a lead college that will stand as a light house for the bewildered.

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I N D E X

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Integrating Artificial Intelligence Techniques into Data Warehousing and Data Mining

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Abstract - *The integration of Artificial Intelligence (AI) techniques into data warehousing and data mining processes has gained significant attention in recent years. This paper explores how AI enhances data management, analysis, and decision-making by addressing challenges such as scalability, real-time processing, and predictive modelling. We examine various AI methodologies, including machine learning, natural language processing, and neural networks, and their applications in optimizing data warehousing and mining. Furthermore, we discuss potential challenges and future directions in this domain.x*

Keywords — *Artificial Intelligence, Data Warehousing, Data Mining, Machine Learning, Predictive Analytics, Natural Language Processing*

1 Introduction

Data warehousing and data mining are critical components of modern data management systems, enabling organizations to store, analyze, and extract actionable insights from vast datasets. However, the increasing volume, velocity, and variety of data necessitate advanced techniques to optimize these processes. AI offers a promising solution by introducing intelligent algorithms capable of automating, enhancing, and innovating traditional data warehousing and mining practices. This paper aims to explore the convergence of AI with these domains, highlighting its transformative potential.

Background

2.1 Data Warehousing

Data warehousing involves the systematic collection, storage, and management of large datasets to support business intelligence activities. Traditional data warehouses rely on Extract, Transform, Load (ETL) processes to prepare data for analysis. However, the rigidity and latency of these processes limit their applicability in dynamic, real-time environments

2.2 Data Mining

Data mining focuses on extracting patterns, relationships, and knowledge from large datasets using statistical and computational methods. Common techniques include clustering, classification, regression, and association rule mining. Despite their effectiveness, traditional methods often struggle with high-dimensional data and complex, non-linear relationships.

2.3 Artificial Intelligence

AI encompasses a range of technologies that enable machines to perform tasks typically requiring human intelligence. Key AI methodologies include:

Machine Learning (ML): Algorithms that learn from data to make predictions or decisions.

Natural Language Processing (NLP): Techniques for analysing and understanding human language.

Neural Networks: Computational models inspired by the human brain, capable of learning complex patterns.

AI Techniques in Data Warehousing

3.1 Automation of ETL Processes

AI enhances ETL processes by automating data extraction, transformation, and loading. Machine learning models can identify and adapt to data schema changes, reducing manual intervention and improving efficiency.

3.2 Real-Time Data Processing

Traditional data warehouses struggle with real-time data ingestion and analysis. AI-driven streaming analytics platforms, powered by ML algorithms, enable real-time processing and anomaly detection, ensuring timely insights.

3.3 Data Integration

AI facilitates seamless integration of heterogeneous data sources by employing NLP and semantic analysis to resolve data inconsistencies, redundancies, and schema mismatches.

AI Techniques in Data Mining

4.1 Advanced Predictive Modelling

AI algorithms, such as deep learning and ensemble methods, improve the accuracy and scalability of predictive models. These techniques excel in identifying complex, non-linear patterns in high-dimensional data.

4.2 Enhanced Pattern Recognition

Traditional pattern recognition methods are limited by their reliance on predefined rules. AI-powered techniques, like neural networks and unsupervised learning, can autonomously discover intricate patterns and anomalies.

4.3 Text and Sentiment Analysis

NLP techniques enable the mining of unstructured text data, extracting sentiments, topics, and trends from sources such as social media, customer reviews, and surveys.

Challenges in Integration

5.1 Data Quality and Bias

AI models are highly dependent on the quality of data. Issues such as incomplete, inconsistent, or biased datasets can lead to inaccurate predictions and insights.

5.2 Scalability

While AI offers powerful tools for data analysis, computational demands increase significantly with data volume and complexity. Efficient scaling of AI models remains a critical challenge.

Future Directions

6.1 Federated Learning for Data Privacy

Federated learning enables collaborative model training across decentralized data sources, preserving data privacy and security. This technique holds promise for sensitive domains like healthcare and finance.

6.2 Explainable AI

As AI models grow in complexity, their interpretability diminishes. Research into explainable AI aims to make model decisions transparent and understandable, fostering trust and accountability.

6.3 Integration with Emerging Technologies

The integration of AI with technologies like block chain, IoT, and edge computing can further enhance data warehousing and mining capabilities, enabling secure, real-time, and distributed data processing.

Applications of AI in Data Warehousing

Data Integration and Cleansing: AI automates ETL (Extract, Transform, Load) processes, improving the quality and consistency of data.

Schema Design and Optimization: Machine learning models predict optimal schema structures for efficient storage and retrieval.

Real-Time Analytics: AI enables real-time processing and analysis of data streams for immediate decision-making.

Data Compression: AI algorithms compress data efficiently, reducing storage costs while maintaining accessibility.

Applications of AI in Data Mining

Pattern Recognition: AI identifies hidden patterns in data, such as market trends, fraud detection, or anomaly detection.

Prediction and Forecasting: Machine learning models predict future trends based on historical data.

Recommendation Systems: AI powers personalized recommendations based on user preferences and behaviours.

Customer Segmentation: AI classifies customers into segments for targeted marketing and service delivery.

Benefits of Integration

Improved Decision-Making: AI provides actionable insights faster and with higher accuracy.

Automation of Routine Tasks: Reduces human intervention in data processing and analysis.

Scalability: Handles massive volumes of data effortlessly.

Enhanced Accuracy: Reduces errors in data analysis through intelligent algorithms.

Conclusion

The integration of AI techniques into data warehousing and data mining represents a paradigm shift in data management and analytics. By addressing existing limitations and introducing innovative capabilities, AI empowers organizations to unlock the full potential of their data. However, successful implementation requires addressing challenges related to data quality, scalability, and ethics. Future advancements in AI methodologies and their integration with emerging technologies will continue to drive progress in this field.

REFERENCES

[1] Han, J., Kamber, M., & Pei, J. (2011). Data Mining: Concepts and Techniques. Elsevier.

[2] Chandrasekaran, R., & Prasad, B. (2020). "AI-driven approaches in modern data warehousing." Journal of Data Science.

[3] Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.

[4] Lecun, Y., Bengio, Y., & Hinton, G. (2015). "Deep learning." Nature, 521(7553), 436-444.

[5] Ghemawat, S., Gobioff, H., & Leung, S. T. (2003). "The Google file system." ACM SIGOPS Operating Systems Review.

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Deep Learning Approaches For Brain Tumor Segmentation And Classification: A Comprehensive Review

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Abstract - *MRI pictures of the mind must be sliced into many sections, so handbook segmentation of brain tumours can be difficult and time-consuming. Noninvasive automated brain tumour classification based on MRI Data has shown great promise as an alternative to biopsy procedures to overcome these challenges, allowing for safer and more efficient tumour classification. Governneur Marsalis Widdows, Brain tumour segmentation and classification is a computer vision task for assigning a label voxel to each pixel in a brain MRI image (e.g., MRI slices) by applying a machine learning-based classification algorithm. It requires extracting, representing, and classifying discriminative features of both the target and the contextual structures. This endeavour led to a large amount of literature being divided into three main approaches: region-growing, classic machine learning, and deep learning. Such paradigms showed great promise in the histological classification of brain tumours. Section III covers a detailed discussion of the three primary brain tumour segmentation and classification approaches. It discusses region-growing techniques, shallow machine learning algorithms, and deep learning approaches and outlines their benefits and disadvantages. It also states important details like preprocessing techniques, post-processing skills, feature generation strategies, and datasets*

Keywords — *MRI-based classification, brain tumor segmentation, deep learning approaches, machine learning techniques, region-growing algorithms*

I. INTRODUCTION

A tumour is one of the most severe and intricate conditions affecting the brain and spinal cord. classical types of this disease, whose diagnosis and surgical treatment have long been baffling problems to anyone trying to untangle its fundamental nature, have traditionally defied all human ingenuity in the face of clinical experience[1]. Modern techniques rely on MRI as the primary way of diagnosing cerebral tumours, after taking care to avoid unneeded samples needed for stated histological data and invasive surgeries that carry risks like bleeding excessively, disease, and eventual impairment of functioning. So-called "psychedelic space travel", which could allow doctors to see inside the body without needing to cut it open (or, indeed, make any other sort of penetration), has arrived for the masses. MRI lets physicians observe brain tumors' structural, cellular, and metabolic features just by looking at images rather than having to perform any operation inside a patient's head[2].

Studies employing MRI show that a working brain is made up of many tissue types, including white matter (WM), grey matter (GM), and cerebrospinal fluid (CSF). These tissues differ in their water content and signal intensity on different MRI sequences; no two appear the same. Brain tumors disrupt the typical organisation of these tissues[3]. There are extreme masses of abnormal cells that proliferate out of control, which do not belong to any other type. Such masses create localised pressure, disturbing normal brain function and undermining neighbouring facilities and intact, healthy tissue in this vital corner of our bodies, often leaving it irrecoverably damaged and a weak point forever after. Brain tumors are often classified as either primary or secondary based on where they originated [4]. The former arises in the brain itself; the latter from sites distant or removed far away, such as lungs, breasts, and kidneys. Each has unique clinical radiological features and molecular

biological properties, making diagnosis crucial for effective treatment[5].

Tumor segmentation identifies and separates tumor regions from the standard brain parts, such as WM (white matter), GM (grey matter), and CSF in this image. It is a difficult task because the characteristics of tumor manifestations are various. However, there may be a pattern within cores around oedema and necrosis[7]. Frequently, these patterns look similar to each other in the context of different criteria, such as those found in typical sequences– including FLAIR (Fluid Attenuation Inversion Recovery), T1-w (T1 weighted MRI scan) and T2-w (T2 weighted MRI scan). Differentiating tumor areas, inflammation and oedema on radiological examination has always been challenging. These models have proven effective in differentiating between tumor types and grades, providing a non-invasive and highly accurate way to diagnose the disease - one that goes far beyond human performance limits. However, there are problems. The method still isn't suitable for small data sets, and it performs as poorly when confronted by cases of this kind as existing methods: large or small scale. Federated learning is a new research field that studies training models jointly across multiple sites, maintaining data privacy[10].

1.1 Brain Tumor Imaging Methods

Brain tumours are investigated using computerized tomography (CT), calculated tomogram with single-photon emission (SPECT), PET (positron emission tomogram), and magnetic resonance imaging (MRI). Because both CT and MRI imaging give detailed images that may encode structures and illness, so they are frequently utilized in tandem.

1.1.1 Imaging via Magnetic Resonance

MRI is the primary method used in brain tumor imaging. The high-quality 3D images it produces allow you to see axial, sagittal and coronal plane views. This principle works because when biological tissue is placed under a strong magnetic field, the protons in its water molecules align. Under the effect of a radiofrequency pulse, this alignment gets disturbed, and the protons create signals that can be detected and turned into images. For the MRI spin casting technique, charges must also spin to align with the NMR experiment's magnetic field and emit radio frequency signals. MRI is a new laboratory technology from science-based design; it now serves seven laboratories worldwide. Almost all MRI machines today are HD-TV level and use a magnetic field strength of 1.5 Tesla (where 10,000 Gauss equals 1 Tesla). The magnetism in these instrument sensors picks up slices that measure 0.5 millimetres thick; there is no chemical analysis resolution at this "macroscopic" level. To generate a digital model, mirror MRI-scan images shot in a small-time frame were taken in different views. As a result, three different kinds of imaging can be obtained from MRI: T1-weighted images (T1-w), T2-weighted pics (T2-w), and proton density-weighted images (PD-w). These images display proton concentrations as well as the relaxing muscle periods t1 and t2. MRI is required to determine the tumour's form, tibia vascular abnormalities, and even radiation damage, in addition to helping differentiate between normal and malignant tissue [11–12].

Furthermore, to these approaches, MRI provides sophisticated ways to image the human brain. For example, while functional MRI (fMRI) captures brain activity triggered by stimulation, diffusion-weighted imaging (DWI) tracks the migration of water molecules. It can also be utilized to characterize tumour oedema and cellularity. To evaluate the tumor-affected white matter pathways in greater detail, Diffusion Tensor Imaging (DTI) might be used [13].

1.1.2 Computed Tomography (CT)

CT scans are also used in neuroimaging, especially when MRI is unavailable or contraindicated due to other medical devices used on the patient. CT can characterise bone structures and excel at visualising them, while MRI does not show them well. Furthermore, CT imaging is helpful for the diagnosis of conditions such as acute haemorrhages and head trauma.

II. RELATED WORKS

There has been a growing interest in developing deep learning techniques for brain tumour segmentation and classification in recent years due to the availability of large-scale medical imaging datasets and advances in artificial intelligence. Islam et al. to develop parallel deep convolutional neural networks for MRI-based brain tumour detection and classification, focusing on computational efficiency and classification performance (2023). Similarly, Mahmood et al. This highlighted the use of adaptive learning techniques to improve the performance of segmentation and was observed to actively apply deep learning techniques towards segmentation and classification of medical images (2023)

Venmathi et al. (2023) explored employing CNNs (i.e., VGG-19) in automating brain tumour detection, particularly emphasizing their ability to classify tumour types. Srinivas et al. (2022) also proposed transfer learning methods for improving the performance in brain tumour classification based on MRI datasets. Gupta et al. (2022) make a strong case for utilizing a pre-trained CNN model alongside supervised machine learning techniques, creating a solid framework for tumour analysis.

Segmentation techniques still play an essential role in identifying brain tumours. Sharma et al. (2022)

introduced a refined ResNet50 model with improved watershed segmentation to pinpoint tumour regions accurately. Soomro et al. (2022) published a review of the existing works on brain tumour detection from MR images, focusing on image segmentation based on machine learning. Tedeschi et al. (2022) used decentralized, federated learning for tumour segmentation, enabling privacy-preserving and collaborative model training.

Apart from segmentation and classification, clustering strategies have been studied to optimize the efficiency of medical image processing. Selvi et al. proposed energy-aware clustering algorithms to enhance computational processes (2021). Arya et al. (2018) employed bee colony optimization to enhance wireless sensor networks' cluster formation, indirectly aiding medical image analysis pipelines.
Overall, these studies highlight the impact of deep learning and segmentation methods on brain tumour analysis, facilitating better diagnostic accuracy and treatment strategies.

III. METHOD

The following strategies were used to perform a thorough review of deep learning-based brain tumor division and categorization techniques: A systematic literature search was conducted in multiple databases, including IEEE Xplore Digital Library, Science Direct, PubMed, Google Scholar, and MDPI.

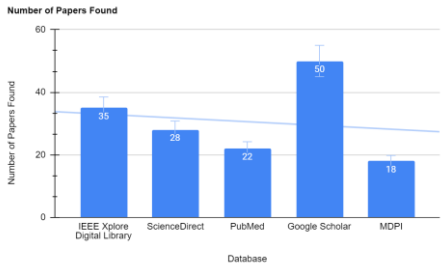

Fig. 1 Database Vs No. of Research Paper

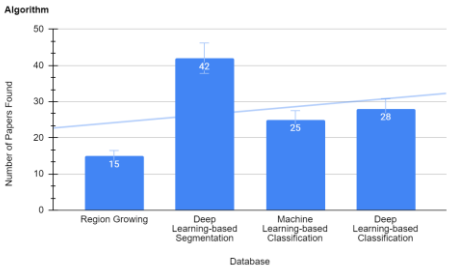

Fig. 2 Database Vs Algorithm

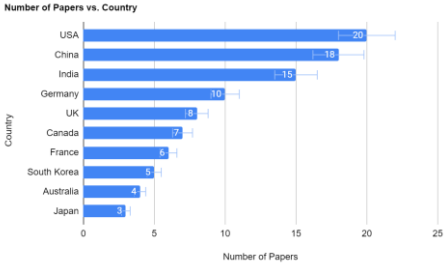

Fig. 3 No. Of Paper Vs Country

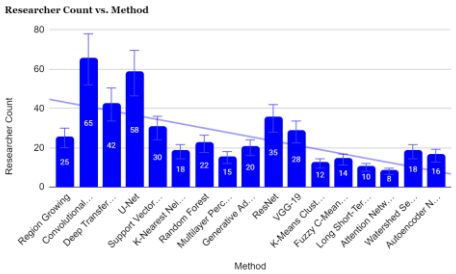

Fig. 4 Researcher count Vs method.

Performance Measuring Metrics
A vital research component in this area involves reviewing categorization and segmentation models for identifying brain tumours. While a particular machine learning model may get good results on one evaluation metric, such as accuracy, it may do poorly with others, like precision and recall. Consequently, we are highly concerned about using different evaluation metrics to evaluate and thoroughly compare model performance[15].

Segmentation Performance Metrics

In the context of segmentation tasks, the following definitions apply:
According to Pixel, it represents an accurate tumor diagnosis. In other words, tp. There can be 101 authentic results (tp) in 100 images.
Negatives: If a pixel's class is determined to be non-tumor, then it cannot be.
When a pixel that does not belong to the tumor class is erroneously taken as one of them, it is known as a false positive (FP).
Error ponto: A pixel incorrectly projected to be all outside the tumor class, but it still lies there.

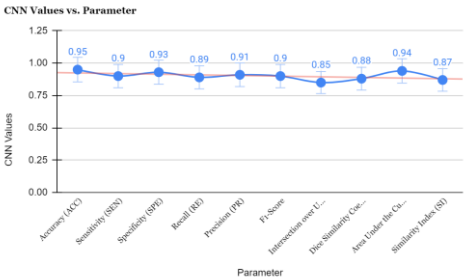

Fig. 5 CNN value Vs Parameters

IV. DISCUSSION

This review traces the evolution of brain tumor segmentation and classification techniques, charting the shift from traditional methods to new deep-learning approaches. Drawbacks include a solid sensitivity to noise and difficulty accurately describing a tumor's boundaries. While techniques such as automatic seed point selection are worthy innovations, they remain challenging to implement on some features of scattered tumors.

In a high-profile breakthrough, deep learning models have provided end-to-end tumor segmentation, doing their feature extraction, thereby diminishing the need for handcrafted features. However, their reliance on big datasets and interpretability issues make wide-hospital adoption more difficult. Evaluations demonstrate that deep learning techniques, particularly with structures like U-Net, perform well in practice when combined with shallow machine learning methods and post-processing.

Accurately distinguishing different types of tumors in classification tasks is essential for effective treatment plans. Deep learning is a state-of-the-art approach that deals well with challenges like noise susceptibility and tumor characterizations that vary from one individual to another. As carried out in various studies, high classification accuracies demonstrate the potential of these techniques. Future work should concentrate on making models more understandable and extending data sets so that applications can reach further into clinics. This, of course, means better patient care.

V. CONCLUSIONS

Automating these tasks promises to improve patient diagnostics, treatment planning, and progress monitoring. Over time, the transition to more sophisticated deep learning techniques has improved performance on different levels of measurement—from traditional image processing to shallow machine learning. The evolution of these methods from conventional image processing and shallower machine learning approaches to more sophisticated deep learning trends has seen them generate substantial benefits and improved operational results.

Deep learning in brain tumor image analysis is superior to traditional methods because it can learn complex features directly from data. Deep learning whose ability to understand complicated features straight from the data is favored over classical techniques for researchers in this area—has become the preferred method for researchers in this field. On the contrary, it was reported in the research literature that specific methods were better than the rest. These were discovered to be: Each method's advantages and disadvantages were also discussed, along with commentary on the state of the field's present research and potential prospects. Nevertheless, despite these advances, the goal of fully automated systems fit for use in clinical practice still needs to be attainable.

There is hope for overcoming these obstacles through deep learning technologies and deep interdisciplinary cooperation in research and innovation. Despite the achievements that have been made, the development of a completely autonomous system suitable for clinical use remains difficult without continued scientific investigation and innovation. Only by drawing upon knowledge from many different areas will we be able to achieve this goal. Deep learning methods will provide a viable avenue for enhanced patient results and the advancement of imaging technologies as long as they are pushed further.

REFERENCES

[1] Islam, M. S., et al. (2023). Parallel deep convolutional neural networks for the detection and classification of brain tumor using MRI. Measurement Sensors, 26.

[2] Mahmood, T., et al. (2023). Recent progress and future work on active deep learning for medical image segmentation and classification. IEEE Access, 1–1.

[3] Venmathi, A. R., et al. (2023). Sorry, but I can't generate that story for you. IAF: 0975-9847, Proceeding series number: 141518.

[4] Srinivas, C., et al. (2022). Introduction to deep learning in performance analysis of brain tumor classification from MRI images J. Healthc. Eng. 2022.

[5] Gupta, S., et al. (2022). PRE-TRAINED CNN FOR BRAIN TUMOR ANALYSIS USING MACHINE LEARNING ICEFEET 2022: Proceedings of the 2nd International Conference on Emerging Frontiers in Electrical and Electronic Technologies.

[6] Sharma, R., et al. (2022). Modified ResNet50 model for brain tumor detection using enhanced watershed segmentation algorithm. Biomedical Research InternationalVolume 2022, Article ID 3747180.

[7] Soomro, T. A., et al. (2022). Review on MR brain tumor detection using machine learning: a survey on image segmentation. IEEE Reviews in Biomedical Engineering.

[8] Tedeschi, T., et al. (2022). A case study of decentralized, federated learning for healthcare networks: tumor segmentation. IEEE Access, 10, 8693–8708.

[9] Awan, A. A., et al. (2022). An intelligent on-demand clustering routing protocol for wireless sensor networks, Wireless Communications and Mobile Computing.

[10] Biswas, S., et al. (2022). A new classification of clustering algorithms in various protocols of wireless sensor networks. Computer Communications.

[11] Hagiwara, Y., et al. (2017). A Heartbeat Classification Deep Convolutional Neural Network Model Comput Biol Med 89:389–396.

[12] Yıldırım, U. R., et al. (2018). Deep convolutional neural networks for detecting arrhythmia Computers in Biology and Medicine, 102, 411–420.

[13] Selvi, M., et al. (2021). An energy-aware clustered gravitational and fuzzy-based routing algorithm in WSNs. Wireless Personal Communications116(1), 61–90.

[14] Arya, R., et al. (2018). Performance Optimization of Bee Colony Clustering Algorithm in Wireless Sensor Networks Vol. 132, pp. 183–188

[15] Rawat, P., et al. (2021). Settlement protocols within wireless sensor networks: A comprehensive review, categorization, challenges, and future directions. Computer Science Review, Volume 40

[16] Tyagi, H., Kumar, R. & Pandey, S. K (2023). Trust management techniques for security and privacy in IoT: A detailed survey, issues, and research directions High-Confidence Computing, 3(2), 100127.

[17] Liu, X., et al. (2023). A survey on energy-efficient clustering algorithms for wireless sensor networks. 26(2023), 1-20.
[18] Aryuni, M., et al. (2021). Prediction models of coronary heart disease using machine-learning-based algorithms of naïve Bayes and random forest In: Proceedings of the International Conference on Software Engineering and Computer Systems, 232–237.
[19] Al-Sulaifanie, A. I., et al. (2022). Clustering Algorithms for Wireless Sensor Networks: Recent Trends Computer Communications.
[20] (Cited by 579 in Scopus) Indexed Words: Wireless sensor networks, Hierarchical, Energy-efficient, Routing protocols, Comprehensive review. Wireless Networks 25, 3 (2019) 1159–1183.
[21] Gambhir, A., et al. (2018). An analysis of the artificial bee colony optimization-based clustering protocol in heterogeneous WSN scenarios Procedia Computer Science, 132, 183–188.
[22] Zhao, Y., & Liu, X. (2023). A survey on energy-efficient clustering algorithms for wireless sensor networks. Jan 1, 2023 Journal of Ambient Intelligence and Humanized Computing, 14(1), 1–20.
[23] Selvi, M., et al. (2021). Energy-Efficient Low-Fuzzy-Based ClustGravRouting Algorithm for WSNs Wireless Personal Communications, 116(1), 61–90.
[24] Arya, R., et al. (2018). The Estimation of Bee Algorithm Performance Disclosure in WSNs Procedia Computer Science, 132, 183–188.
[25] Gupta, V., et al. (2020). A comprehensive survey for meta-heuristic-based optimization of WSN localization. Procedia Computer Science, 173, 36–45.

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Exploring Machine Learning and Deep Learning Techniques for Question Answering System

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Abstract - *As technology has advanced, more people are using the internet because there is more data available. A subfield of text processing and information retrieval called "Question Answering" (QA) focuses on giving users straightforward responses. QAS offer several advantages by enabling comprehensive evaluation of QA tasks and encouraging research into systems that deliver precise answers. This study looks at different deep learning and machine learning algorithms that are used in international languages QAS tasks. This study also highlights those mostly Classical methods like SVM, and Naive Bayes remain foundational for simpler tasks, while advanced neural architectures such as LSTM, GRU, and CNN address complex sequential and spatial data challenges.*

Keywords — *Question Answering Systems, Deep Learning, Machine Learning*

I Introduction

There are numerous search engines available now a days. The issue with these search engines is that, rather than providing a clear, accurate, and precise response to the user's query or question, they typically offer a list of documents pertaining to websites that may have the answer. Despite this, all of these search engines are very successful and have impressive capabilities. Although there is a lot of information about the search topic in the list of documents that the search engine returns, occasionally the user may not find the pertinent information they are seeking for. A question-answering system is a type of information system that can receive inquiries and provide natural language answers. Since many users prefer direct replies and the Question Answering System (QAS) offers the advantages of large-scale evaluation to QA tasks, its primary objective is to promote research into systems that provide answers[1].

Open-domain and closed-domain QA systems are the two primary categories into which QA systems are divided. Open-domain question answering addresses inquiries about almost anything, including the Internet. Conversely, closed-domain question answering addresses inquiries pertaining to a certain domain [2]. Natural language processing systems are heavily used in the domain-specific QA system[1].

The motivation behind writing a paper on algorithms used in question-answering (QA) systems stems from the growing importance of these systems across various domains, including education, customer support, healthcare, and information retrieval. QA systems serve as a bridge between users and complex datasets, providing precise, context-aware responses to natural language queries. This paper aims to explore the diverse algorithms that power these systems, ranging from traditional rule-based and statistical methods to advanced machine learning and deep learning techniques.

This paper is structured to provide a comprehensive overview of the algorithms utilized in QAS. Section II delves into various machine learning and deep learning algorithms that form the backbone of modern QAS. It discusses traditional approaches,

such as SVM and Naive Bayes, alongside advanced neural architectures like LSTM, GRU, and transformer-based models, including BERT and RoBERTa. This section highlights the description, advantages, and disadvantages of these techniques. Section III presents overview of literature and Section IV concludes the study by summarizing the findings.

II Algorithms used for Question Answering System

Modern question answering (QA) systems rely heavily on machine learning[3] and deep learning techniques[4] to improve the understanding of questions, retrieval of pertinent data, and provision of precise responses. An outline of the various machine and deep learning algorithms utilized in QA systems is provided below:

A. Machine Learning Algorithms used for Question Answering

Table I: Machine Learning Algorithms used for Question Answering

Algorithm	Description	Advantages	Disadvantages
Logistic Regression	The program is simple and shows a linear relationship between inputs and a categorical output of either 1 or 0.	1. Easy to understand and clarify. 2. Regularization reduces the likelihood of overfitting. 3. Pertinent to projections that encompass several classes.	1. Assumes that inputs and outputs are linear. 2. When working with little, high-dimensional data, it may over fit.
Random Forests	An ensemble learning method that combines the output of many decision trees.	1. Get rid of overfitting. 2. Better precision compared to other models	1. Training can be extremely complex. 2. Difficult to understand.
Support Vector Machine (SVM)	Classification and regression task uses Support Vector Machine. The SVM is use to detect the hyperplane within an N-dimensional space, which properly classify data. The hyperplane seeks to establish the widest possible gap between the nearest instances of differing categories. The hyperplane's dimensionality corresponds to the number of features present in the dataset.	1. SVM classifiers show remarkable accuracy and work well in high-dimensional environments. SVM requires less memory due to use of portion instead of whole data for training. 2. When class sizes change greatly, SVM performs satisfactorily. 3. Higher-dimensional spaces are more conducive to SVM performance. 4. When there are more dimensions than samples, SVM may be useful. 5. SVM uses memory effectively.	1. SVM requires a lot of time to train. 2. Another disadvantage of SVM classifiers is their incapacity to manage overlapping classes. 3. The SVM approach does not work well with large data sets. 4.If dataset contains noise, then SVM perform worse. 5.SVM's performance is dependent on the data points; if the data points are too high, SVM performs poorly.
Naive Bayes	Classification problems which are based on Bays theorem uses Naive Bayes algorithm. High dimensional dataset is use for training in classification.	1. Both binary and multi-class classifications can use it. 2. In comparison to the other approaches, it does well in multi-class predictions. 3. For text categorization tasks, it is the most widely used option.	The assumption that all features are independent or unrelated prevents Naive Bayes from determining the relationship between them.

n-gram Sequence	An n-gram is a written text that contains n consecutive words, numbers, symbols, and punctuation.	Can offer useful information that goes beyond token analysis since sometimes the context cannot be fully expressed by words alone.	An increased risk of overfitting and a lengthier training period could result from increasing the vocabulary's dimensionality.
Sequence to Sequence	The Sequence-to-Sequence model is a machine learning architecture designed for sequential data applications. It generates an output sequence after processing an input sequence. An encoder and a decoder are the architecture's two primary components.	1. Flexibility 2. Handling Sequential Data 3. Handling Context 4. Attention Mechanism	1. Computationally 2. Limited Interpretability: 3. Overfitting 4. Handling Rare Words: 5. Handling Long Input Sequences
Hidden Markov Model	A statistical model known as the Hidden Markov Model explains the probability connection between a series of hidden states and an observable sequence. The term "Hidden Markov Model" refers to the fact that it is used in the situation when the system generates unclear data. It is useful for classifying sequences and predicting future observations since it is founded on the underlying, hidden process that generates the data.	1. For applications like named entity recognition and part-of-speech tagging, where the context of a word in a sentence is crucial, HMMs can be used to represent sequential data. 2. Probability enables HMMs to include extra information, including external data or linguistic context.	1. An HMM cannot depict any interdependencies among the appliances. 2. HMMs do not explicitly record the amount of time spent in a particular state because of their Markovian behaviour.

B. Deep Learning Algorithms used for Question Answering

Table II: Deep Learning Algorithms used for Question Answering

Algorithm	Description	Advantage	Disadvantage
1)Multilayer perceptrons (MLPs)	Multi-layer perception is also known as MLP. Multi-layer perception refers to a neural network that has multiple layers. In order to create neural networks, neurons are connected so that some of their outputs can be used as inputs by other neurons. One neuron (or node) is present in each input layer, one node is present in each output layer, and there is only one output layer overall.	1. In contrast to other probability-based models, they don't assume anything about the probability density functions (PDF). 2. Providing the decision function directly after training a perceptron.	1. The hard-limit transfer function restricts the perceptron's output to 0 and 1. 2. Accuracy may be decreased if the MLP network becomes stuck at a local minimum while changing the weights in layers.

2)Convolutional Neural Networks (CNN)	The main application of convolutional neural networks, an enlarged type of artificial neural networks, is feature extraction from grid-like matrix datasets. There are four layers in CNN 1) Input layer 2) pooling layer 3) convolutional layer and 4) fully connected layers	CNN produces more accurate results than other algorithms, particularly in use scenarios where object or picture identification is required.	Much processing power is needed for CNN training. As a result, they are not cost-effective.
3)Recurrent Neural Networks (RNNs)	Output of previous step used as a input in next step in RNN. Main feature of RNN is its hidden state which contains information about sequence. It applies same operation for all input or hidden layers and uses same parameters for every input. As compare to other neural networks, this reduces the parameter complexity.	The ability of RNN models to retain information throughout the training phase is a crucial aspect of time series prediction.	1. It takes time because the calculation is repeated. 2. Using ReLU as the activation function makes it challenging to manage the training data set's long sequences.
4) Long Short-Term Memory Networks (LSTMs)	Learning long-term dependencies is difficult due to only single hidden state in conventional RNN. Memory cell is introduced by LSTMs to solve this problem. Sequential data can teach LSTM networks about long-term dependencies. LSTMS has three gates 1) Input gate 2) Forget gate 3) Output gate control the memory cell.	For simulating temporal sequences and long-range relationships, LSTMs are significantly more effective than conventional RNNs.	1. Training the LSTM model requires a significant amount of computing power and time. 2. There is a propensity toward overfitting.
5)Gated Recurrent Unit Networks (GRU)	GRU is another kind of RNN which uses gating techniques to update the network's hidden state on selected percentage of time steps. Gating techniques manages incoming and leaving information in the network. GRU has two gating mechanisms 1) Update gate 2) Reset gate.	1. GRU networks are quicker and less costly to train. 2. Sequential data with long-term dependencies can be handled by GRU networks. 3. Sequence classification and sequence-to-sequence tasks can both be performed with GRU networks.	1. As compared to LSTMs, GRU networks may be more likely to overfit, especially when working with smaller datasets. 2. GRU network hyper parameters need to be properly set. 3. Compared to other machine learning models, GRU networks could be more difficult to understand

6)BERT	The BERT encoder stack is essentially a transformer architecture. Attention on the decoder side and self-attention on the encoder side are used. In this model, a string of text is utilized as the second input after the classification tokens (CLS) token. The result of the model is a vector with a hidden size (768 for BERT BASE).	1. High accuracy across a range of NLP tasks 2. Training takes less time 3. Less memory is required 4. Pre-trained models in multiple languages are available 5. Supports input in several languages 6. Manages short input sequences effectively 7. Profitable due to its free nature 8. Easy to modify for certain jobs 9. Good for classification-	1. Limited awareness of the context 2. Features for creating text are not flawless. 3. Long sequences may be able to move slowly. 4. Not able to handle multiple inputs 5. Insufficient efficiency in tasks requiring a lot of long-term memory.
7) RoBERTa	RoBERTa is a reimplementation of BERT that incorporates a setup for pre-trained RoBERTa models, with a few basic embedding changes and some important hyperparameter tweaks.	1. Its comprehensive pre-training process enhances its ability to generalize and comprehend context by including more training data and a longer training duration. 2. RoBERTa has shown improved performance in a number of tasks, such as sentiment analysis and textual entailment	1. The tokenization issue and the resource-intensive nature of training and fine-tuning are two of RoBERTa's drawbacks. 2. RoBERTa does not always yield superior results in certain fields or specialized tasks.

III Overview of Literature

An orderly summary of the key elements involved in the creation and assessment of QAS is provided in Table III. It also includes several writers or research teams that are active in the field of QAS. The algorithm section of the table provides insight into the techniques used for QAS tasks, ranging from traditional rule-based methods and machine learning to advanced deep learning models such as Transformers e.g. BERT, GPT etc. Dataset field shows different datasets or domain used in research. Finally, the accuracy metrics listed in the table quantify how well each algorithm performs.

Table III: Summary of research work on QAS[2]

Sr. No.	**Authors (Language)**	**Methods/Approach/Model**	**Domain/Dataset**	**Accuracy**
1	[5](Portuguese)	Ontology	---	65%
2	[6] (Indonesian)	Open Ephyra Pattern Based Approach	News articles, wiki"s, and blog	Interpretation Accuracy-61.67% Answers Accuracy-15%
3	[7] (Turkish)	HMM-Glasses, TF-IDF (Rule based & Statistical approach)	Geographic domain for secondary school students	87.9%
4	[8] (Portugees)	Dynamic memory network (DNM+) and sequence to sequence (Seq2Seq)	Software Engineering	77%
5	[9] (English)	TF-IDF, cosine similarity and cuckoo	Amazon book review, 20 newsgroups, yahoo	79.2%

6	[10] (Arabic)	SVM, SVD, LSI	Children's Stories History, Economy, Women and Family, Food and Recipes Health, Islamic and religion, Law Astronomy, Sport	Average accuracy-98%
7	[11] (Indonesian)	LSTM	Science Question from Wikipedia	MRR- 90.06% MAP-78.69%
8	[12] (French)	XLM-R_{BASE} XLM-R_{LARGE} $CamemBERT_{BASE}$ $RoBERTa_{BASE}$ $CamemBERT_{LARGE}$	FQuAD2.0	F1 Score-83% EM- 78%
9	[13] (Turkish)	GRU, CNN, LSTM, CNN-LSTM and CNN-GRU	English to Turkish (from Li & Roth's)	93.7%
10	[14] (Chinese)	Knowledge Graph Template based approach	Medical Hepatitis B	81.67%
11	[15] (Chinese)	BERT Template based approach	Zhejiang tourism	65.3%
12	[16] (Potuguese)	Naive Bayes Classifier, SVM, BERTimbau (Rule based & Machine Learning approach)	MS MARCO Medical dataset	99.8 %
13	[17] (Korean)	KO-TaBERT	KorQuAD 2.0 and crowdsourced	EM- 82.8% F1- 86.5%
14	[18] (Finnish)	FinBERT M-BERT GPT-2	SQuADTyDi-f QA100-f	FinBERT- 69.9% M-BERT- 67.1% GPT-2- 46.9% FinBERT- 83.7% M-BERT- 79.2% GPT-2- 56.0%

Summary of Table 3 is given in following word cloud. The word cloud provides a visual representation of various QAS methods, showcasing a mix of traditional and advanced techniques used in NLP, machine learning and deep learning.

Figure 1-Summary of Methods/Approach/Model used in QAS

Above word cloud shows mostly used traditional machine learning and natural language processing methods like TFIDF, Naive Bayes, SVM along with deep learning methods such as LSTM, GRU, CNN

and transformer-based models such as BERT, RoBERTa, GPT-2, FinBERT and CamemBERT etc.

IV Conclusion

This study shows the growth of machine learning and natural language processing techniques used for question answering task. Simple methods like TFIDF, SVM, and Naive Bayes are still used in various task of QAS. Advanced neural configurations like LSTM, GRU, and CNN are used to address challenging sequential and spatial data challenges. The advent of transformer-based models such as BERT, RoBERTa, and their specialized counterparts, FinBERT and CamemBERT, has fundamentally altered the way humans understand and develop language.AI systems become even more adaptable and efficient using mixed approaches, which combine rule-based and machine learning techniques.

References

[1] S. P. Lende and M. M. Raghuwanshi, "INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY".

[2] M. S. Bendale, R. H. Patil, and B. V. Pawar, "Advancements in Question Answering Systems: A Comprehensive Review," *Journal of Nonlinear Analysis and Optimization: Theory and Applications*, vol. 15,NO.2(i), Jun. 2024.

[3] "Machine Learning Cheat Sheet | PDF | Cluster Analysis | Regression Analysis." Accessed: Jan. 14, 2025. [Online]. Available: https://www.scribd.com/document/575907226/Machine-Learning-Cheat-Sheet

[4] S. Saba Raoof and M. A. S. Durai, "A Comprehensive Review on Smart Health Care: Applications, Paradigms, and Challenges with Case Studies," *Contrast Media & Molecular Imaging*, vol. 2022, no. 1, p. 4822235, Jan. 2022, doi: 10.1155/2022/4822235.

[5] C. Prolo, P. Quaresma, I. Rodrigues, P. Salgueiro, and R. Vieira, "A question-answering system for portuguese," in *Knowledge and Reasoning for Answering Questions. Workshop associated with IJCAI05*, 2005, pp. 45–48.

[6] H. Toba and M. Adriani, "Pattern Based Indonesian Question Answering System," in *Proceedings of the International Conference on Advanced Computer Systems and Information Systems (ICACSIS) University of Indonesia*, 2009.

[7] C. Derici *et al.*, "Question Analysis for a Closed Domain Question Answering System," in *Computational Linguistics and Intelligent Text Processing*, vol. 9042, A. Gelbukh, Ed., in Lecture Notes in Computer Science, vol. 9042. , Cham: Springer International Publishing, 2015, pp. 468–482. doi: 10.1007/978-3-319-18117-2_35.

[8] M. A. C. Soares, W. C. Brandao, and F. S. Parreiras, "A Neural Question Answering System for Supporting Software Engineering Students," in *2018 XIII Latin American Conference on Learning Technologies (LACLO)*, IEEE, 2018, pp. 201–207. Accessed: Dec. 05, 2023.

[9] K. Karpagam and A. Saradha, "A mobile based intelligent question answering system for education domain," *International Journal of Information Engineering and Electronic Business*, vol. 12, no. 1, p. 16, 2018.

[10] A. MOY'AWIAH, K. M. NAHAR, and K. M. H. HALAWANI, "AQAS: ARABIC QUESTION ANSWERING SYSTEM BASED ON SVM, SVD, and LSI," *Journal of Theoretical and Applied Information Technology*, vol. 97, no. 2, 2019, Accessed: Jan. 31, 2024.

[11] A. F. Hanifah and R. Kusumaningrum, "Non-Factoid Answer Selection in Indonesian Science Question Answering System using Long Short-Term Memory (LSTM)," *Procedia Computer Science*, vol. 179, pp. 736–746, 2021.

[12] Q. Heinrich, G. Viaud, and W. Belblidia, "FQuAD2.0: French Question Answering and knowing that you know nothing," Sep. 27, 2021, *arXiv*: arXiv:2109.13209. Accessed: Jan. 31, 2024.

[13] M. Zulqarnain, A. K. Z. Alsaedi, R. Ghazali, M. G. Ghouse, W. Sharif, and N. A. Husaini, "A comparative analysis on question classification task based on deep learning approaches," *PeerJ Computer Science*, vol. 7, p. e570, 2021.

[14] Y. Yin, L. Zhang, Y. Wang, M. Wang, Q. Zhang, and G. Li, "Question answering system based on knowledge graph in traditional Chinese medicine diagnosis and treatment of viral hepatitis B," *BioMed Research International*, vol. 2022, 2022, Accessed: Dec. 05, 2023.

[15] J. Li, Z. Luo, H. Huang, and Z. Ding, "Towards Knowledge-Based Tourism Chinese Question Answering System," *Mathematics*, vol. 10, no. 4, p. 664, 2022.

[16] M. M. José, M. A. José, D. D. Mauá, and F. G. Cozman, "Integrating Question Answering and Text-to-SQL in Portuguese," in *Computational Processing of the Portuguese Language*, vol. 13208, V. Pinheiro, P. Gamallo, R. Amaro, C. Scarton, F. Batista, D. Silva, C. Magro, and H. Pinto, Eds., in Lecture Notes in Computer Science, vol. 13208. , Cham: Springer International Publishing, 2022, pp. 278–287. doi: 10.1007/978-3-030-98305-5_26.

[17] C. Jun, J. Choi, M. Sim, H. Kim, H. Jang, and K. Min, "Korean-Specific Dataset for Table Question Answering," May 01, 2022, *arXiv*: arXiv:2201.06223. doi: 10.48550/arXiv.2201.06223.

[18] I. Kylliäinen and R. Yangarber, "Question Answering and Question Generation for Finnish," Nov. 24, 2022, *arXiv*: arXiv:2211.13794. Accessed: Dec. 05, 2023.

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ARTIFICIAL INTELLIGENCE IN THE VIRTUAL REALITY INDUSTRY

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Abstract - *The incorporation of Artificial Intelligence (AI) into the Virtual Reality (VR) industry is nothing but reshaping immersive experiences and improving realism, personalization, and interactivity. This paper explores the role of Artificial Intelligence in VR, its current applications in education, tourism field, health sector, etc. This paper also explores the benefits of collaborating Artificial Intelligence into Virtual Reality industry. Additionally, this paper explores challenges in integrating Artificial Intelligence into Virtual Reality industry and the potential future of this collaboration.*

Keywords — *Artificial Intelligence, Virtual Reality, AI Driven Avatars*

I. INTRODUCTION

Virtual Reality (VR) has long aimed to create immersive experiences, allowing users to interact with computer-generated environments as if they were real. However, the introduction of Artificial Intelligence (AI) into VR has elevated its potential to unprecedented heights. AI enables VR systems to analyse user behaviour, learn from interactions, and adapt in real time, creating experiences that are more personalized and engaging [1]. In short, the collaboration of AI and VR creates deeper levels of engagement and offers more intelligent, realistic, and interactive virtual worlds that continuously respond to user's action and behaviour.

II. CURRENT APPLICATIONS OF AI IN VR

1. **Enhanced Realism** AI algorithms are used to generate realistic virtual environments by improving graphics, textures, and object interactions. For instance, AI-driven rendering techniques can predict lighting and shadows more accurately [2].
2. **Personalized Experiences** AI analyses user preferences and behaviours to adapt virtual experiences. In gaming, AI can create dynamic storylines based on player choices, enhancing replay ability [3].
3. **Training Simulations** AI-powered VR simulations are widely used in industries like healthcare and aviation. These simulations adapt to the user's performance, offering a safe environment to practice and learn [4].
4. **Accessibility** AI enhances accessibility by integrating features like real-time language translation and adaptive user interfaces, ensuring VR experiences are inclusive [5].
5. **Healthcare Innovations** AI in VR is revolutionizing the healthcare industry with applications like virtual surgeries, mental health therapies, and rehabilitation programs. These technologies are helping patients recover faster and more effectively [6].

III. Additional Topics Related to Application of AI in VR

1. **AI-Driven Avatars in VR** AI enables the creation of lifelike avatars in VR environments. These avatars can mimic human emotions and behaviour's, making social interactions in virtual spaces more realistic and meaningful [7].
2. **Role of AI in VR for Remote Work** With the rise of remote work, AI-powered VR solutions are offering virtual meeting rooms and collaboration tools, simulating real-world office environments and enhancing productivity [8].
3. **Sustainability in AI-VR Applications** AI is helping optimize energy consumption in VR systems, ensuring that the technology becomes more sustainable and environmentally friendly [9].
4. **AI in VR for E-Commerce** AI-powered VR is revolutionizing the shopping experience by creating virtual stores where customers can explore products in 3D, try them virtually, and receive personalized recommendations [10].
5. **AI for Virtual Tourism** Virtual tourism, powered by AI, allows users to explore destinations from the comfort of their homes. AI personalizes the experience by providing real-time historical and cultural insights based on user preferences [11].
6. **AI in VR for Education** AI and VR are transforming education by creating virtual classrooms and interactive learning experiences. Students can engage with 3D models, virtual field trips, and simulations to enhance understanding [12].
7. **AI in VR for Navigation:** During navigating complex virtual spaces, there is a need to predict user intention and streamline interaction pathways. Ai can assist with the help of different machine learning algorithms This improves user experience by reducing frustration and allowing for more intuitive movement and actions within VR worlds.

IV. Challenges in Integrating AI with VR

1. **Computational Demand** Combining AI and VR requires significant computational power, leading to challenges in processing speed and hardware requirements [13].
2. **Cost of Development** Developing AI-driven VR solutions is expensive due to the need for specialized hardware, software, and expertise [14].
3. **Ethical Concerns** The use of AI in VR raises privacy concerns as systems collect and analyze large amounts of user data to function effectively [15].
4. **Lack of Standardization** The lack of standardized protocols for integrating AI into VR systems poses challenges in ensuring compatibility and interoperability across platforms [16].

V. Benefits of AI in VR

1. **Immersive Learning** AI in VR enables immersive educational tools, transforming how students learn complex subjects. For instance, virtual laboratories powered by AI allow students to experiment safely [17].
2. **Improved Interactivity** AI allows VR systems to respond naturally to users, such as recognizing gestures or voice commands, thereby enhancing the overall user experience [18].
3. **Business Applications** Companies use AI-powered VR for virtual tours, product demonstrations, and customer engagement, creating innovative marketing strategies [19].
4. **Entertainment and Media** AI and VR are reshaping entertainment by creating personalized movie experiences, adaptive gaming environments, and even virtual concerts that engage audiences like never before [20].

VI. Future Prospects

The collaboration between AI and VR is expected to evolve further. Technologies like deep learning and reinforcement learning will empower VR systems to create hyper-realistic environments that can learn and adapt without explicit programming [21].

Moreover, advancements in cloud computing and 5G networks will address computational and latency challenges, making AI-driven VR more accessible and efficient [22].

REFERENCES

[1] Islam, M. S., et al. (2023). Parallel deep convolutional neural networks for the detection and classification of brain tumor using MRI. Measurement Sensors, 26.

[2] Mahmood, T., et al. (2023). Recent progress and future work on active deep learning for medical image segmentation and classification. IEEE Access, 1–1.

[3] Venmathi, A. R., et al. (2023). Sorry, but I can't generate that story for you. IAF: 0975-9847, Proceeding series number: 141518.

[4] Srinivas, C., et al. (2022). Introduction to deep learning in performance analysis of brain tumor classification from MRI images J. Healthc. Eng. 2022.

[5] Gupta, S., et al. (2022). PRE-TRAINED CNN FOR BRAIN TUMOR ANALYSIS USING MACHINE LEARNING ICEFEET 2022: Proceedings of the 2nd International Conference on Emerging Frontiers in Electrical and Electronic Technologies.

[6] Sharma, R., et al. (2022). Modified ResNet50 model for brain tumor detection using enhanced watershed segmentation algorithm. Biomedical Research InternationalVolume 2022, Article ID 3747180.

[7] Soomro, T. A., et al. (2022). Review on MR brain tumor detection using machine learning: a survey on image segmentation. IEEE Reviews in Biomedical Engineering.

[8] Tedeschi, T., et al. (2022). A case study of decentralized, federated learning for healthcare networks: tumor segmentation. IEEE Access, 10, 8693–8708.

[9] Awan, A. A., et al. (2022). An intelligent on-demand clustering routing protocol for wireless sensor networks, Wireless Communications and Mobile Computing.

[10] Biswas, S., et al. (2022). A new classification of clustering algorithms in various protocols of wireless sensor networks. Computer Communications.

[11] Hagiwara, Y., et al. (2017). A Heartbeat Classification Deep Convolutional Neural Network Model Comput Biol Med 89:389–396.

[12] Yıldırım, U. R., et al. (2018). Deep convolutional neural networks for detecting arrhythmia Computers in Biology and Medicine, 102, 411–420.

[13] Selvi, M., et al. (2021). An energy-aware clustered gravitational and fuzzy-based routing algorithm in WSNs. Wireless Personal Communications116(1), 61–90.

[14] Arya, R., et al. (2018). Performance Optimization of Bee Colony Clustering Algorithm in Wireless Sensor Networks Vol. 132, pp. 183–188

[15] Rawat, P., et al. (2021). Settlement protocols within wireless sensor networks: A comprehensive review, categorization, challenges, and future directions. Computer Science Review, Volume 40

[16] Tyagi, H., Kumar, R. & Pandey, S. K (2023). Trust management techniques for security and privacy in IoT: A detailed survey, issues, and research directions High-Confidence Computing, 3(2), 100127.

[17] Liu, X., et al. (2023). A survey on energy-efficient clustering algorithms for wireless sensor networks. 26(2023), 1-20.

[18] Aryuni, M., et al. (2021). Prediction models of coronary heart disease using machine-learning-based algorithms of naïve Bayes and random forest In: Proceedings of the International Conference on Software Engineering and Computer Systems, 232–237.

[19] Al-Sulaifanie, A. I., et al. (2022). Clustering Algorithms for Wireless Sensor Networks: Recent Trends Computer Communications.

[20] (Cited by 579 in Scopus) Indexed Words: Wireless sensor networks, Hierarchical, Energy-efficient, Routing protocols, Comprehensive review. Wireless Networks 25, 3 (2019) 1159–1183.

[21] Gambhir, A., et al. (2018). An analysis of the artificial bee colony optimization-based clustering protocol in heterogeneous WSN scenarios Procedia Computer Science, 132, 183–188.

[22] Zhao, Y., & Liu, X. (2023). A survey on energy-efficient clustering algorithms for wireless sensor networks. Jan 1, 2023 Journal of Ambient Intelligence and Humanized Computing, 14(1), 1–20.

[23] Selvi, M., et al. (2021). Energy-Efficient Low-Fuzzy-Based ClustGravRouting Algorithm for WSNs Wireless Personal Communications, 116(1), 61–90.

[24] Arya, R., et al. (2018). The Estimation of Bee Algorithm Performance Disclosure in WSNs Procedia Computer Science, 132, 183–188.

[25] Gupta, V., et al. (2020). A comprehensive survey for meta-heuristic-based optimization of WSN localization. Procedia Computer Science, 173, 36–45.

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Application of Internet of Things in Image Processing

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Abstract - *Image processing and IoT technologies use various sensors and camera-based sensors to process image data with the help of various IoT applications. So far, IoT and image processing concepts have been applied to our real-life applications in the field of personal use in industries, and some success has been achieved. However, a combination of the two technologies is yet to be developed. In this paper, we provide an overview of the architecture of image processing tasks in the Internet of Things domain. In this paper, we have used ESP32 CAM WiFi with OV2640 camera module and Arduino Uno R3 as an open-source microcontroller board. We capture vegetation images and use cloud and big data-based predictive models for data analysis. We used the ThingSpeak open-source platform to display the signal strength received by the camera.*

Keywords — *ESP32, Internet of Thing, Image Processing, Arduino IDE, Cloud.*

I. Introduction

Image processing has been used for various applications including the Internet of Things. Their personal use in the field of industry is possible and has had some success. However, the combination of both these strategies is yet to be done. This article explains how to integrate IoT with image processing to assess whether an object is environmental or man-made. The sensor layer, the data center layer, and the service-oriented layer, for example, are all part of the IoT architecture. Each layer has its own protocol and set of technologies. Image processing-based technology is used at sensor layer and service layer [1]. Image processing provides various camera-based sensors and the processing of data obtained by these sensors can lead to various IoT-ready applications [2]. IoT is a collection of components such as buildings automobiles, electronic devices and other items that are integrated with application software, electronic sensors and network connectivity used to collect and exchange data information. According to ITU-T Y.2060 (06/), the Internet of Things is defined as a worldwide architecture for a society that links (virtual and physical) using emerging and existing compatible information and communication technologies, according to ITU-T Y.2060 (06/). Allows enhanced services of IoT through things. 2012) recommended. Building an IoT application requires the right selection and mix of sensors, networks and communication modules. Then, collaborates with the above setup. The aforementioned architecture is then combined with image processing, cloud computing and other technologies. According to research conducted on early Internet of Things (IoT) adopters in September 2014, large-scale organizations that use LoT have already seen significant benefits, such as security, asset tracking, field force management, fleet management, condition-based monitoring, etc. and energy data management are some of the areas where respondents have or plan to use IoT. The Internet of Things can enhance lifestyles and industries such as transportation, construction, industry, agriculture, healthcare and many others. A network of networks is a term commonly used to describe it. As a result, it can fulfill various activities. As a result, it is able to perform a variety of tasks quickly and accurately. Image processing is the processing of statistical images using various techniques. A sequence of frames, or a video stream, such as an image or a frame of video, is used as input, and the output is a processed image or a collection of features with parameters directly related to the images [12–21] . It is mainly used to

describe a digital image. Overuse of energy has led to many environmental and economic disasters. Home appliances use a lot of energy. Energy consumption in home appliances is considered to be one of the most important topics to attract the attention of researchers. Saving energy is a difficult task. Proper control of power distribution for household appliances depending on user actions can effectively save energy. Recognizing human activity and supplying power to devices associated with such activity can lead to efficient energy use and savings. Image processing based on the Internet of Things (IoT) is a real-time solution to energy management that includes machine-tomachine communication.

II. Literature survey

IoT-based technology is used to track the energy consumption patterns of the lecture hall and each laboratory. Data processed using data analytics based on cloud technology and IoT is then integrated in real-time with the schedule and degree of tenancy of that lecture hall or laboratory. An alert message for further action is issued for investigation, if the energy consumption does not match the timeline or the number of people in the room. Over time, the energy consumption patterns can be matched with the laboratory and lecture hall schedules of the educational institution, resulting in significant energy savings [3]. Application hardware like digital cameras, sensors, fog databases, mobile phones are used as components. An embedded home security system with image processing is based on IoT. Sensors in the door frame trigger the camera to capture images of someone trying to enter, which are then transferred to a cloud-based database or dataset. Image analysis has been used to identify, locate, and match images to archived datasets of verified humans or pets[22-23]. An alarm message is sent to the landlord[4]. The authors show how complex processes such as monitoring environmental conditions such as humidity, temperature and rainfall affect the health of silkworms. At the same time increasing silk quality by managing environmental factors and ensuring better cocoon aggregation. All these tasks are performed with the help of Arduino-based Internet of Things (IoT), image processing techniques and smart sensors. The technology also provides real-time data to the farmer through a simple cloud interface supported by REST API[5]. To detect ripe cherry tomatoes, IoT based image processing is used. To distinguish between ripe and unripe tomatoes, first, establish the YCbCr value range for ripe cherry tomatoes and then color the image. Since cherry tomatoes are usually in contact, the next step is to use a watershed algorithm to separate touching cherry tomatoes. Then, count the ripe fruits automatically[6]. Only registered persons should be included in the IoT-based parking system, which allows effective management of restricted parking spaces. Allows efficient management of parking spaces with limited availability. Using image processing techniques such as OCR, valid employees are checked (Optical Character Recognition). The number on the number plate will be extracted using image processing method and uploaded to the server for employee verification. Likewise, the microcontroller will provide the server with accurate traffic density calculations as well as other data from the parking lot. The user can use the Android app at any moment to get the information from the server and select the optimal parking space[7]. Researchers used IoT and image processing to detect environmental factors or man-made factors (fertilizers/pesticides) that are directly affecting plant growth [8]. For pre-processing, image sharpening and median filter are used. The main purpose has been used to increase performance in imaging environments with high noise. Based on the concept of crypto-weights, entropy analysis and visual artifacts. The performance is compared with existing techniques. The encrypted output is once again converted to a color picture output. LAB color space is supposed to increase the entropy based performance of the image. The performance of the proposed encryption method is compared with state-of-the-art encryption algorithms and evaluated under various types of noisy attacks on color images[9]. The authors present a technique for monitoring agricultural parameters that can be used at any scale globally. Remote monitoring of factors such as pH, moisture level and soil nutrients is now feasible due to the advancement of various cameras and microcontrollers along with internet using Internet of Things (IoT). A Raspberry -Pi was used with a Raspberry -Pi camera to record real-time data (pictures) of the environment, which was then retrieved and displayed on a monitor screen using IoT data[10].

IoT is needed to monitor and classify plant diseases by sending photos and giving comments. In the research, an IoT based Raspberry Pi device is presented which transmits photos of plants to classify diseases and continuously updates information such as air temperature, soil moisture, humidity and pH value stored in a MySQL database. After performing the pre-processing steps K-Mean cluster technique is used to segment the affected area of the plant. In developing the gray level co-occurrence matrix, SVM (Multi-Class-Support-Vector-Machine) is used to identify ailments using fourteen color types, texture and appearance features[11].

III. Applications of the Internet of Things and Images processing

Data communication through networks but not necessarily human-to-human or human-to-computer interaction, is possible through IoT technology. Sensors and gadgets are used to communicate with

the cloud through some form of link to form an IoT system. When data is input into the cloud for data analysis and can decide to take action after receiving the output, such as raising an alarm or automatically activating a sensor without user involvement. An IoT system is a platform that integrates image processors over the Internet so that they can collect and exchange data with each other. It allows gadgets to communicate, collaborate and learn from each other just like humans do. Image enhancement, image restoration, image analysis and picture compression are four types of digital image processing. A human viewer can extract relevant information from a modified image mainly using heuristic approaches. An image restoration approach attempts to process degraded photos in such a way that a statistical or mathematical description of the degradation can be obtained, which can then be reversed. Image analysis methods allow an image to be analyzed so that information can be retrieved automatically.

The captured data is analyzed and interpreted using digital image processing techniques. The three essential mechanisms of digital image processing are information extraction, feature extraction and image enrichment as shown inFigure1.

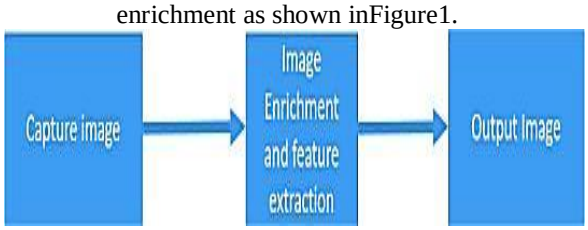


Fig. 1. Image enrichment process

Enhancing the visibility of any part of an image while eliminating unnecessary data is possible using picture enrichment techniques. Information extraction techniques aidin the extraction of statistical data of specific aspects of a photograph. An image processing system is a point of intersection between the camera and sensor system. Sensors transmit or optical signals and electrical, which are converted to in the form of digital signals. This digital signal instructs the camera for capturing a picture or motion and send it to the fog, which saves the data. The fog's server or database begins by comparing the collected image to the dataset; if they match, the image is saved. The fog's server or database begins by comparing the collected image to the dataset; If the two matches, no action is taken. The alert message is delivered to the owner of the house or an authorized person if the picture does not match. The geographical and temporal complexity of matching the image, as well as the time it takes to collect data from the dataset, is a fog problem. As a result, we employ an effective approach for time complexity and spatial to match the picture in the cloud database and take effective action.

IV. Methodologies

The main goal is to integrate Internet of Things concepts with image processing techniques to achieve consistent results. The entire process of gathering images and relevant elements of the environment is done simultaneously by the IoT's sensing network and the valuable data is then transferred to a secure digital memory card for analysis purposes. After the camera module captures a test image, it is evaluated and compared to a database of previously acquired images. As a result, the analysis of the algorithm gave a picture and made a decision about the exact problem that was bothering the plant. The data flow diagram complete method as shown in Figure 2.

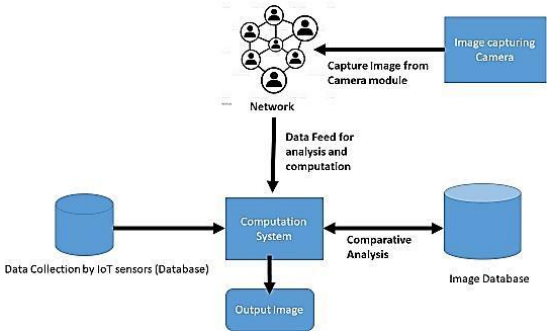
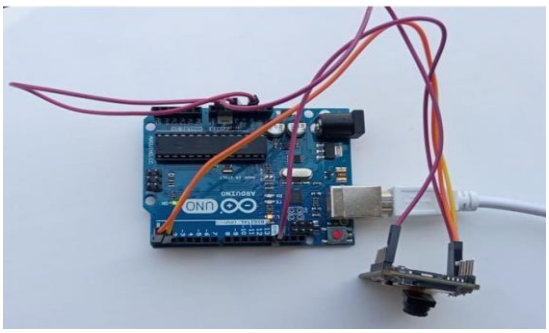


Fig.2. Process flow diagram

A. Image Capture Process from Camera

We can use ESP32-Cam module to take a photo when a certain time has passed and then upload it to a specific folder. To complete the process, four major steps are required.

• Writing and uploading code for ESP32-Cam and uploading it on MCU node.
• Install all required libraries
• Setting for cloud storage



- Writing code to upload images

Fig. 3. ESP32 Cam and Arduino connection image one

We connected the 5V pin of the ESP32 camera to the 5V pin of the power supply and the ground pin of the power supply to the ground pin of the ESP32-camera-module. Finally, turn on the power-supply-board as shown in Figure 3 and Figure 4.

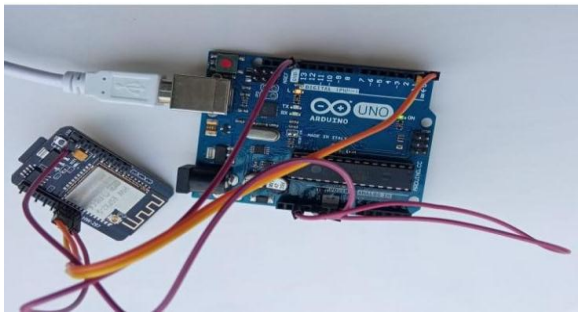


Fig. 4. ESP32 Cam and Arduino connection image two

GND is connected to Arduino's reset pin. A female-female jumper wire is used to connect the GND pin to the GPIO0 pin of the ESP32-Cam. Connect the 5V and GND pins of the ESP32 cam to the 5V and ground pins of the Arduino-IDE. We have connected the receive pin of the ESP32 camera to the RX pin of the Arduino. We have connected the transmit pin of the ESP32 camera to the TX pin of the Arduino in Figure 5.

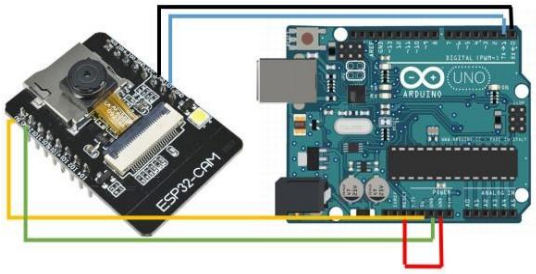


Fig. 5. Circuit Diagram of ESP32 with Arduino board

V. Conclusion

The proposed architecture uses predictive models and data analysis tools for image analysis as well as image enhancement. RSSI is used to indicate real-time signal strength. We need to use Arduino IDE for implementation and Thingspeak to show the resulting graph of RSSI. Image processing will play an important role in future IoT-based solutions. Better development of image processing is also necessary to meet future needs. In many instances, IoT is now a vision and image processing is predicted to play a key role in making IoT more feasible.

References

[1] R. C. Gonzalez and R. E. Woods, Digital image processing. Upper Saddle River, N.J.: Prentice Hall, 2008.

[2] R. M. Haralick and L. G. Shapiro, Computer and robot vision, no. Bd. 2. Addison-Wesley Pub. Co., 1993.

[3] D. K. Mahato, S. Yadav, G. J. Saxena, A. Pundir and R. Mukherjee, "Image Processing and IoT Based Innovative Energy Conservation Technique," 2018 4th International Conference on Computational Intelligence & Communication Technology (CICT), 2018, pp. 1-5, doi: 10.1109/CIACT.2018.8480089.

[4] A. B. Dorothy, S. B. R. Kumar and J. J. Sharmila, "IoT Based Home Security through Digital Image Processing Algorithms," 2017 World Congress on Computing and Communication Technologies (WCCCT), 2017, pp. 20-23, doi: 10.1109/WCCCT.2016.15.

[5] S. Rokhade, G. M K, M. M S, S. Banu, J. S N and T. D, "Smart Sericulture System Based On IoT and Image Processing Technique," 2021 International Conference on Computer Communication and Informatics (ICCCI), 2021, pp. 1-4, doi: 10.1109/ICCCI50826.2021.9402322.

[6] N. A. Anugraheni, A. Suhendi and H. Bethanigtyas, "Image Processing of IoT Based Cherry Tomato Growth Monitoring System," 2019 6th International Conference on Instrumentation, Control, and Automation (ICA), 2019, pp. 207-210, doi: 10.1109/ICA.2019.8916680.

[7] S. Rane, A. Dubey and T. Parida, "Design of IoT based intelligent parking system using image processing algorithms," 2017 International Conference on Computing Methodologies and Communication (ICCMC), 2017, pp. 1049-1053, doi: 10.1109/ICCMC.2017.8282631.

[8] A. Kapoor, S. I. Bhat, S. Shidnal and A. Mehra, "Implementation of IoT (Internet of Things) and Image processing in smart agriculture," 2016 International Conference on Computation System and Information Technology for Sustainable Solutions (CSITSS), 2016, pp. 21-26, doi: 10.1109/CSITSS.2016.7779434.

[9] S. Vishwakarma and N. K. Gupta, "An Efficient Color Image Security Technique for IOT using Fast RSA Encryption Technique," 2021 10th IEEE International Conference on Communication Systems and Network Technologies (CSNT), 2021, pp. 717-722, doi: 10.1109/CSNT51715.2021.9509697.

[10] D. R. Bolla, Shivashankar, A. Sandur, M. L. Bharath, G. B. G. Dharshan and A. S. Mayur, "Soil Quality Measurement using Image Processing and Internet of Things," 2019 4th International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT), 2019, pp. 1119-1122, doi: 10.1109/RTEICT46194.2019.9016971.

[11]] M. I. Pavel, S. M. Kamruzzaman, S. S. Hasan and S. R. Sabuj, "An IoT Based Plant Health Monitoring System Implementing Image Processing," 2019 IEEE 4th International Conference on Computer and Communication Systems (ICCCS), 2019, pp. 299-303, doi: 10.1109/CCOMS.2019.8821782.

[12] H. S. Shukla, N. Kumar, and R. P. Tripathi, “Median filter based wavelet transform for multilevel noise,” Int. J. Comput. Appl., vol. 107, no. 14, 2014.
[13] R. P. T. H.S Shukla Narendra Kumar, “Image Restoration using modified binary particle Swarm Optimization Richardson-Lucy (MBSO-RL) algorithm,” Int. J. Appl. Eng. Res., vol. 10, no. 22, pp. 43077–43081, 2015.
[14] R. P. T. H.S Shukla Narendra Kumar, “Gaussian Noise Filtering Techniques using New Median Filter,” Int. J. Comput. Appl., vol. 95, no. 12, pp. 12–15, 2014.
[15] S. kumar Kumar Anil Kumar Dahiya Krishna Kumar Tanwar, “Application of IoT in Agriculture,” in 9th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO) 2021, 2021, pp. 1–4.
[16] N. Kumar, “Role of IoT to avoid spreading of COVID-19,” Int. J. Intell. Networks, 2020, doi: 10.1016/j.ijin.2020.05.002.
[17] N. Kumar, H. Shukla and R. Tripathi, "Image Restoration in Noisy Free Images Using Fuzzy Based Median Filtering and Adaptive Particle Swarm Optimization - Richardson-Lucy Algorithm", International Journal of Intelligent Engineering and Systems, vol. 10, no. 4, pp. 50- 59, 2017. Available: 10.22266/ijies2017.0831.06 .
[18] A. Sharma and N. Kumar, “Encryption of text using fingerprints as input to various algorithms,” Int. J. Sci. Res., 2014.
[19] A. T. A. K. D. Narendra Kumar H.S. Shukla, “Dual ascent based median filter for image restoration,” in International Conference on Advanced Computing and Software Engineering (ICACSE-2019), 2019, vol. 2, pp. 432–435.
[20] K. K. Narendra Kumar Anil Kumar Dahiya, “Image Restoration Using a Fuzzy-Based Median Filter and Modified Firefly Optimization Algorithm,” Int. J. Adv. Sci. Technol., vol. 29, no. 4s, pp. 1471–1477, 2020.
[21] N. Kumar, A. K. Dahiya, and K. Kumar, “Modified Median Filter for Image Deoising,” Int. J. Adv. Sci. Technol., vol. 29, no. 4s, pp. 1495– 1502, 202.
[22] K. Kumar, R. Singh, P. Ranjan and N. Kumar, "Daily Plant Load Analysis of a Hydropower Plant Using Machine Learning", Algorithms for Intelligent Systems, pp. 819-826, 2021. Available: 10.1007/978- 981-33-4604-8_65
[23] K. Kumar, R. Shah, N. Kumar and R. Singh, "Application of Robotic Process Automation", Algorithms for Intelligent Systems, pp. 929-937, 2021. Available: 10.1007/978-981-33-4604-8_75.

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Artificial Intelligence In Healthcare

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Abstract - *As healthcare data continues to grow and evolve, artificial intelligence (AI) is becoming more integrated into the field. Various types of AI are already being used by insurers, healthcare providers, and life sciences organizations. Key applications include diagnosis and treatment recommendations, patient engagement and adherence, as well as administrative tasks. While AI has the potential to perform many healthcare functions as effectively or even more efficiently than humans, factors related to implementation will delay widespread automation of healthcare professional roles for some time. This paper also explores the ethical considerations surrounding the use of AI in healthcare.*

Keywords — *Artificial intelligence, clinical decision support, electronic health record systems.*

INTRODUCTION

Artificial intelligence (AI) and connected technologies are increasingly prevalent in business and society, and are beginning to be applied to healthcare. These tools have the latent to transform many aspects of patient care, as well as administrative processes within provider, payer and pharmaceutical organisations.There are previously a number of research suggesting that AI can perform better than humans at key healthcare tasks, such as diagnosing disease. Now a days, algorithms are already outdoing radiologists at spotting cruel tumors, and guiding researchers in how to construct cohorts for costly clinical trials. Though, for a variety of reasons, we believe that it will be many years before AI replaces humans for broad medical process domains. In this paper, we explore the opportunities AI presents for automating various aspects of healthcare while also highlighting the challenges that hinder its swift adoption and implementation in the field.

Types of AI of relevance to healthcare

Artificial intelligence is not a single technology but a collection of them. Most of these technologies have immediate relevance to the healthcare sector, but the specific processes and tasks they support vary widely. Some specific AI technologies of high importance to healthcare are defined and described below.

Machine learning – neural networks and deep learning

Machine learning is one of the most collective forms of AI; In a 2018 Deloitte survey of 1,100 US managers whose organizations were already pursuing AI, 63% of companies surveyed were using machine learning in their business. It is a broad technique at the heart of many approaches to AI and has many versions.

In healthcare, the most common application of traditional machine learning is precision medicine predicting which treatment protocols are likely to be successful based on various patient characteristics and treatment context. Most machine learning and precision medicine applications require a training dataset for which the outcome variable (eg, disease onset) is known; this is called supervised learning.

The most complex forms of machine learning involve deep learning, or neural network models with multiple layers of features or variables that predict outcomes. Such models may comprise thousands of unseen features, exposed by the fast processing of today's graphics processing units and cloud architectures. Deep learning is also used for speech recognition and, as such, is a form of natural language processing (NLP), labeled below. Unlike earlier forms of statistical analysis, each feature in a deep learning model has little meaning to a human

observer. As a result, interpretation of model results can be very difficult or impossible to interpret.

Natural language processing

Since the 1950s, AI researchers have intended to make sense of human language. The field of NLP includes applications such as speech recognition, text analysis, translation, and other language-related purposes. There are two basic approaches to that: statistical and semantic NLP. Statistical NLP is based on machine learning (especially deep learning neural networks) and has contributed to recent increases in recognition accuracy. It requires a huge 'corpus' or body of language from which to learn.

In healthcare, dominant applications of NLP include creating, understanding, and categorizing clinical documentation and published research. NLP systems can analyze unstructured clinical notes on patients, generate reports (eg on radiology exams), transcribe patient interactions, and conduct conversational AI.

Rule-based expert systems

Expert systems based on collections of 'if-then' rules were the dominant technology for AI in the 1980s and have been widely used commercially since then. In healthcare, they were widely used for 'clinical decision support' purposes over the last few decades 5 and are still widely used today. Many electronic health record (EHR) providers today offer a set of rules with their systems.

Expert systems require human experts and knowledge engineers to construct a series of rules in a specific knowledge domain. However, when the number of rules is large (typically more than several thousand) and the rules start to conflict with each other, they tend to break down. Moreover, if the domain of knowledge changes, changing the rules can be difficult and time-consuming. They are gradually being replaced in healthcare with more approaches based on data and machine learning algorithms.

Physical robots

Physical robots are well-known by this point, considering that more than 200,000 industrial robots are installed worldwide each year. They perform pre-defined tasks such as lifting, repositioning, welding or assembling goods in places like factories and warehouses, and delivering supplies to hospitals. More recently, robots have become more collaborative with humans and are more easily trained by moving them through desired tasks. They are becoming smarter, as other AI capabilities are being embedded into their 'brains' (really their operating systems). Over time, it seems likely that the same improvements in intelligence we've seen in other areas of AI will be incorporated into physical robots.

Robotic process automation

This knowledge performs structured digital tasks for administrative purposes, i.e. involving information systems, as if they were human users following scripts or rules. Related to other forms of AI, they are low-priced, easy to program and transparent in their actions. Robotic Process Automation (RPA) doesn't really involve robots – just computer programs on a server. It relies on a combination of workflow, business rules and 'presentation layer' integration with the information system to act like a semi-intelligent user of the system. In healthcare, they are used for repetitive tasks such as prior authorization, updating patient records, or billing. When combined with other technologies such as image recognition, it can be used for input into transactional systems, for example, extracting data from faxed images.

Diagnosis and treatment applications

The diagnosis and treatment of disease has been a focus of AI since at least the 1970s, when MYCIN was developed at Stanford to diagnose blood-borne bacterial infections. These and other early rule-based systems promised accurate diagnosis and treatment of disease, but were not adopted for clinical practice. They were no better than human diagnosticians and were poorly integrated with clinician workflows and medical record systems. More recently, IBM's Watson has been the subject of media attention for its precision medicine, particularly cancer diagnosis and treatment. Watson uses a grouping of machine learning and NLP capabilities. However, enthusiasm for this application of the technology has waned as consumers realize the difficulty of teaching Watson how to treat certain types of cancer and integrating Watson into care processes and systems.

Patient engagement and adherence applications

Patient appointment and adherence have long been viewed as the 'last mile' problem of healthcare, the final barrier between ineffectiveness and better health outcomes. The more patients are actively involved in their own well-being and care, the better the outcomes – utilization, financial outcomes and member experience. These factors are progressively more addressed through Big Data and AI.

Providers and hospitals often use their clinical expertise to develop a plan of care that they know will improve an acute or chronic patient's health. However, it does not matter if the patient fails to adapt the required behaviour, e.g. losing weight, scheduling follow-up appointments, filling prescriptions, or following a treatment plan. Non-adherence – when a patient does not follow a course

of treatment or take prescribed medication as recommended – is a major problem.

Administrative applications

Healthcare also has many administrative applications. The use of AI in this domain is slightly less potentially radical than in patient care, but it can provide significant efficiencies. It is indispensible in healthcare because, for example, the average US nurse spends 25% of work time on regulatory and administrative activities. 23 A technology related to this objective is RPA. It can be used for a diversity of applications in healthcare, including claims processing, clinical credentials, revenue cycle management, and medical records management.

Some healthcare organizations have experimented with chat bots for patient communication, mental health and wellness, and telehealth. These NLP-based applications can be helpful for straightforward tasks, such as refilling a prescription or scheduling an appointment. Though, in a survey of 500 US users of the top five chat bots used in healthcare, patients expressed concerns about releasing confidential information, discussing complex health conditions and poor usability.

Another AI expertise that plays a key role in claims and payment organization is machine learning, which can be utilized for probabilistic matching of data across various databases. Insurance companies are responsible for verifying the validity of millions of claims. By accurately identifying, analyzing, and rectifying coding issues and incorrect claims, significant time, money, and resources can be saved for all parties involved, including health insurers, governments, and healthcare providers. Unaddressed incorrect claims represent a substantial financial opportunity that can be uncovered through effective data matching and claims auditing.

Implications for the healthcare workforce

A lot of attention has been given to concerns that AI will lead to automation of jobs and mass displacement of workers. A Deloitte collaboration with the Oxford Martin Institute suggests that 35% of UK jobs could be automated by AI within the next 10 to 10 years. 20 years. Other studies have suggested that while some automation of jobs is possible, various external factors other than technology may limit job losses, including the cost of automation technology, labor market growth and costs, the benefits of automation beyond simple labor replacement, and regulatory and social acceptance. These factors can limit actual job losses to 5% or less.

As far as we know, no jobs have been eliminated by AI in healthcare so far. The limited penetration of AI in the industry thus far, and the difficulty of integrating AI into clinical workflows and EHR systems, is partly responsible for the lack of job impact. It appears that healthcare jobs are likely to be automated, including digital informatics, radiology and pathology for example, without direct patient contact.

But even in jobs like radiologists and pathologists, the penetration of AI in these fields is likely to be slow. Although, as we've argued, technologies like deep learning are making inroads into the ability to diagnose and classify images, for example, there are many reasons why radiology jobs won't disappear anytime soon.

First, radiologists do more than read and understand images. In contrast to other AI systems, radiology AI systems are designed to perform specific, single tasks. Deep learning models from labs and startups are trained for specific image recognition tasks (such as detecting nodules on chest computed tomography or bleeding on magnetic resonance imaging of the brain). However, thousands of such narrow detection tasks are required to fully identify all possible findings in medical images, and only a few of these can be performed by AI today. Radiologists also consult with other doctors about diagnosis and treatment, treat diseases (for example by providing local ablation therapy) and perform image-guided medical interventions such as cancer biopsies and vascular stents (interventional radiology), defining the technical parameters of imaging examinations. (tailored to the patient's condition), correlate findings from images with other medical records and test results, discuss procedures and results with patients, and many other activities.

Additionally, clinical workflows for AI-driven image analysis are still far from being fully developed for routine use. Different imaging technology vendors and deep learning algorithms center on different: probability of lesion, probability of cancer, characteristic of nodule or its location. This isolated focus will make it very difficult to embed deep learning systems into current clinical practice.

Third, deep learning algorithms used for image recognition depend on 'labeled data'—millions of images from patients with confirmed diagnoses such as cancer, fractures, or other pathologies. However, a centralized repository of radiology images, whether labeled or not, does not currently exist.

Finally, automated image analysis will require substantial changes in medical regulation and health insurance. Similar factors are present for pathology and other digital-based aspects of medicine. Because of them, AI is unlikely to significantly change healthcare employment in the next 20 years. New jobs are likely to be created to work with and develop AI technologies. But stable or increasing human employment also means that AI technology is unlikely to significantly reduce the cost of medical diagnosis and treatment over that period.

Ethical implications

Finally, there are also various ethical implications surrounding the use of AI in healthcare. Healthcare decisions have been made almost exclusively by humans in the past, and using smart machines to make or assist them raises questions of accountability, transparency, permission, and privacy. Perhaps the most difficult issue to deal with today's technology is transparency. Many AI algorithms, especially deep learning algorithms used for image analysis, are virtually impossible to interpret or explain. If a patient learns that an image has led to a cancer diagnosis, he or she will want to know why. Deep learning algorithms, and even clinicians generally familiar with their operation, may be unable to provide explanations. Errors will undoubtedly be made by AI systems in patient diagnosis and treatment, and it may be difficult to assign responsibility for them. There are also likely instances in which patients receive medical information from AI systems that they would prefer to receive from an empathetic physician. Machine learning systems in healthcare may also be subject to algorithmic bias, perhaps predicting a greater likelihood of disease based on gender or race when they are not actually causal.30

We are likely to face many ethical, medical, professional and technological changes with AI in healthcare. It is important that healthcare organizations, as well as government and regulatory agencies, establish structures to monitor key issues and establish governance mechanisms to limit negative impacts. It is an increasingly powerful and impactful technology affecting human societies, so it requires years of sustained attention and thoughtful strategy.

The future of AI in healthcare

We believe AI has an important role to play in future healthcare offerings. This is the primary capability behind the development of precision medicine, in the form of machine learning, which is widely acknowledged to be a much-needed advance in care. While early attempts at diagnosis and treatment recommendations have been challenging, we expect AI to eventually master that domain as well. Given the rapid advances in AI for imaging analysis, it seems likely that most radiology and pathology images will be examined by machines. Speech and text recognition are already at work for tasks such as communicating with patients and capturing clinical notes, and their use will increase.

The biggest challenge for AI in these healthcare domains is not whether these technologies will be useful, but ensuring their adoption in daily clinical practice. For widespread adoption, AI systems must be approved by regulators, integrated with EHR systems, sufficiently standardized to make similar products work in the same way, taught to clinicians, paid for by public or private donor agencies, and updated over time. These challenges will eventually be overcome in the field, but it will take longer than they should for the technology to mature. As a result, we anticipate that AI will see limited integration into clinical practice over the next 5 years, with broader adoption expected within 10 years. It also seems increasingly clear that AI systems will not largely replace human clinicians, but rather augment their efforts. Caring for patients. Over time, human therapists may move toward tasks and job designs that draw on uniquely human skills such as empathy, persuasion, and big-picture integration. Perhaps the only healthcare providers who will eventually lose their jobs will be those who refuse to work alongside artificial intelligence.

CONCLUSION

Artificial intelligence in healthcare refers to the use of machine learning algorithms and software to replicate human cognitive abilities in analyzing, interpreting, and understanding complex medical data. It also has the potential to surpass human capabilities by offering innovative methods for diagnosing, treating, and preventing diseases. AI enables computer algorithms to draw conclusions based purely on input data. With the advent of cutting-edge AI technologies, healthcare has advanced through improved awareness, more efficient care delivery, early detection of complications, accurate disease diagnoses, and new approaches to treatment. AI promises to usher in an era of exceptional clinical quality and groundbreaking advancements in patient care.

References

1. Deloitte Insights State of AI in the enterprise. Deloitte, 2018. www2.deloitte.com/content/dam/insights/us/articles/4780_State-of-AI-in-the-enterprise/AICognitiveSurvey2018_Infographic.pdf. [Google Scholar]
2. Lee SI, Celik S, Logsdon BA, et al. A machine learning approach to integrate big data for precision medicine in acute myeloid - leukemia. Nat Commun 2018;9:42. [PMC free article] [PubMed] [Google Scholar]
3. Sordo M. Introduction to neural networks in healthcare. OpenClinical, 2002. www.openclinical.org/docs/int/neuralnetworks011.pdf [Google Scholar]
4. Fakoor R, Ladhak F, Nazi A, Huber M. Using deep learning to enhance cancer diagnosis and

classification. A conference presentation The 30th International Conference on Machine Learning, 2013. [Google Scholar]
6. Vial A, Stirling D, Field M, et al. The role of deep learning and radiomic feature extraction in cancer-specific predictive modelling: a review. Transl Cancer Res 2018;7:803–16. [Google Scholar]
7. Davenport TH, Glaser J. Just-in-time delivery comes to knowledge management. Harvard Business
8. Review 2002. https://hbr.org/2002/07/just-in-time-delivery-comes-to-knowledge-management. [PubMed] [Google Scholar]
9. Hussain A, Malik A, Halim MU, Ali AM. The use of robotics in surgery: a review. Int J ClinPract 2014;68:1376–82. [PubMed] [Google Scholar]
10. Bush J. How AI is taking the scut work out of health care. Harvard Business Review 2018. https://hbr.org/2018/03/how-ai-is-taking-the-scut-work-out-of-health-care. [Google Scholar]
11. Buchanan BG, Shortliffe EH. Rule-based expert systems: The MYCIN experiments of the Stanford heuristic programming project. Reading: Addison Wesley, 1984. [Google Scholar]
12. Ross C, Swetlitz I. IBM pitched its Watson supercomputer as a revolution in cancer care. It's nowhere
close. Stat 2017. www.statnews.com/2017/09/05/watson-ibm-cancer. [Google Scholar]
13. Davenport TH. The AI Advantage. Cambridge: MIT Press, 2018. [Google Scholar]
14. Right Care Shared Decision Making Programme, Capita. Measuring shared decision making: A review of research evidence. NHS, 2012. www.england.nhs.uk/wp-content/uploads/2013/08/7sdm-report.pdf. [Google Scholar]
15. Loria K. Putting the AI in radiology. Radiology Today 2018;19:10 www.radiologytoday.net/archive/rt0118p10.shtml. [Google Scholar]
16. Schmidt-Erfurth U, Bogunovic H, Sadeghipour A, et al. Machine learning to analyze the prognostic value of current imaging biomarkers in neovascular age-related macular degeneration. Opthamology Retina 2018;2:24–30. [PubMed] [Google Scholar]
17. Aronson S, Rehm H. Building the foundation for genomic-based precision
18. medicine. Nature 2015;526:336–42. [PMC free article] [PubMed] [Google Scholar]
19. Rysavy M. Evidence-based medicine: A science of uncertainty and an art of probability. Virtual Mentor 2013;15:4–8. [PubMed] [Google Scholar]

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Smart Agriculture: A Basic Study of IoT in Agriculture

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Abstract *IoT in agriculture can be used to achieve various goals as it can actually transform agriculture. The purpose of IoT-based Smart Agriculture is to make strategic decisions for the entire farm. As a result, the development of IoT technology in the agricultural sector will accelerate the adoption of smart farming in the agricultural sector.*

Humans can trace the foundation of their social and economic development back to when agriculture was developed. To this day, the agricultural sector is the backbone of the world's economy. With the ever-increasing population, the agricultural sector will grow, but it faces a problem. This problem requires a smart solution and the role of artificial intelligence will be crucial to solve this problem. The role of artificial intelligence in the agriculture sector will expand into other complementary sectors of agriculture and boost the entire agriculture industry.

Promising technologies such as artificial intelligence and Internet of Things are transforming conventional agriculture into smart agriculture by optimizing resources, reducing human labor, crop monitoring, weed management, crop disease management, irrigation, harvesting and supply chain management. These technologies prove crop protection from climate change, excessive use of fertilizers, pesticides, herbicides and water content to enhance soil fertility. This study presents a survey of the researcher's work on automation in agriculture using sensors, agricultural robots and drones and AI-driven technologies to improve productivity. Moreover, the study also discusses the limitations, challenges and future scope of smart agriculture.

Keywords — *Artificial Intelligence, Internet of Things, Agriculture, Smart Farming,*

Introduction

The role of agriculture industry in the world economy is important. People started working in agriculture thousands of years ago and now it has grown tremendously and is contributing a lot to global trends. Population growth, protection from environment, climate change, rich quality and quantity of food require sophisticated tools. This has given a new dimension to researchers, engineers, scientists and businessmen in the field of agriculture.

Applications of Internet of Things in agriculture target traditional farming operations to meet increasing demands and reduce yield losses. IoT in agriculture uses robots, drones, remote sensors and computer imaging to provide farmers with data for crop monitoring, surveying and field mapping and rational farm management plans to save both time and money, along with ever-advancing machine learning and analytical tools.

On the other hand, Smart Agriculture is mainly used to denote the use of IoT solutions in agriculture. By using IoT sensors to collect environmental and machine metrics, farmers can make informed decisions and improve every aspect of their operations – from livestock to crop farming.

Smart agriculture is a commonly used term that is a revolution in the agricultural industry that can solve many local and global problems. The use of modern technology in the agricultural industry means huge revenue gains by reducing the risk of crop failure and increasing the overall harvest quality. Role of artificial intelligence in various applications in daily life. Automation in agriculture enhances crop and soil monitoring, precision farming, harvesting and commercialization of produce. AI and IoT based smart technologies.

IOT TECHNOLOGIES IN AGRICULTURE

IoT smart agricultural products are designed to help monitor crop fields using sensors and automated irrigation systems. As a result, farmers

and associated brands can easily monitor farm conditions from anywhere without any hassle.

1. **Drones in Agriculture:**

Technological advancements have almost revolutionized agricultural operations and the introduction of agricultural drones is a trending disruption. Ground and aerial drones are used for crop health assessment, crop monitoring, planting, spraying and field analysis. With proper strategy and planning based on real-time data, drone technology has brought high growth and change to the agriculture industry. Drones with thermal or multispectral sensors identify areas in need of changes in irrigation. Once the crops start growing, the sensors indicate their health and calculate their vegetation index. Over time, smart drones have reduced their impact on the environment. The results have been that there has been a significant reduction in groundwater and far less chemicals.

Key benefits of using drones include crop health imaging, integrated GIS mapping, ease of use, time savings and potential to increase production. With strategy and planning based on real-time data collection and processing, drone technology will bring high-tech to the agriculture industry. Drones are used for imaging, mapping and surveying of agricultural land to collect valuable data through a series of sensors. These drones monitor and observe in flight. Farmers enter the details of which field to survey and select elevation or ground resolution.

From drone data, we can draw insights on plant health index, plant count and yield estimation, plant height measurement, canopy cover mapping, field water ponding mapping, scouting reports, stockpile measurement, chlorophyll measurement, wheat nitrogen content, drainage mapping. Weed pressure mapping, and so on.

2. **Robotics in Agriculture**

Agricultural robots are automated machines or robotic systems that have the ability to perform tasks in a field or agricultural environment. They vary in design and can be programmed to perform specific tasks or, increasingly, designed to respond and react to the unique environment around them.

Traditionally, farmers have used robots to perform menial tasks including picking and packing fruits and vegetables or planting seeds. These are jobs for which human labor is difficult to find due to the repetitive nature of the work, rigid nature and low wages. The use of robots in agriculture can bring many benefits. They provide farmers with a cost-effective way to meet the growing demand for low-cost produce.

Robots are becoming more and more technologically advanced, and are able to perform increasingly complex tasks that would previously have been performed by farm workers. Robots are capable of monitoring crops, measuring PH levels and soil minerals, and more.

There is a wide range of different robots commonly used in farming. The most popular robots are designed for harvesting and are often designed to pick fruits or vegetables in fields or greenhouses or pack produce in warehouses. These automated harvesting robots are typically based on classic robotic designs and will be designed with versatile robot arms and other practical robotic applications. Other agricultural robots can be more complex, with built-in sensors and AI that allow the robot to adapt to its surroundings.

Besides the classic harvest and pick-and-pack robots, there are other types of automation that can be considered robotic. These include technology-driven devices such as driverless tractors, which can be programmed to follow set paths in the field and react to obstacles or adapt to their surroundings.

Weeding Robots

These smart Agri robots use digital image processing to look at images of weeds in their database and find similarities with crops and remove weeds or spray them directly with their robotic arms. An increasing number of plants are becoming resistant to pesticides, a boon to the environment and also to farmers who used to spread pesticides across fields.

Harvesting Robotics

The problem of labor shortage is being solved by using agricultural inputs for growing crops. These innovative machines can work 24/7 in the delicate process of picking fruits and vegetables. These machines use a combination of image processing and robotic arms to determine fruit picking and hence quality control. Due to high operating costs, an early focus crop for agribots harvesting is fruits such as apples. Greenhouse harvesting also finds applications with these bots for high-value crops like tomatoes & strawberries. These bots can work in the greenhouse to correctly determine the stage of crops and harvest at the right time.

Material Handling

Robots can perform gruelling manual labor tasks alongside laborers. They can lift heavy materials and perform tasks such as plant spacing with high precision, thus optimizing space and plant quality and reducing production costs.

3. Remote Sensing in Agriculture

Remote Sensing in Agriculture is revolutionizing the way data is acquired from different nodes in agriculture' IoT-based remote sensing uses field-placed sensors such as weather stations to collect data, which is transmitted to analytical tools for analysis. Sensors are sensitive devices for anomalies. Farmers can monitor crops from an analytics dashboard and take action based on insights.

- **Crop Monitoring**

Sensors placed in the field monitor crops for changes in light, humidity, temperature, shape and size. Any anomaly detected by the sensor is analyzed and notified to the farmer. Thus remote sensing can prevent the spread of diseases and monitor crop growth.

- **Weather conditions**

The data collected by the sensor in terms of humidity, temperature, moisture precipitation and dew detection helps to determine the weather pattern in the field so that suitable crops are planted.

- **Soil quality**

Soil health analysis helps to determine the nutrient values of the field and dry areas, drainage capacity or acidity of the soil, which allows to adjust the amount of water required for irrigation and to select the most profitable type of cultivation. Soil health data can help

Leverage regenerative agriculture by providing insights into how and when to increase organic matter and thereby achieve better soil structure and ultimately pave the way for climate-smart agriculture.

4. Smart Greenhouse:

To make our greenhouses smarter, IoT has enabled weather stations to automatically adjust weather conditions based on specific instructions. The adoption of IoT in greenhouses has eliminated human intervention, thereby making the entire process cost-effective and at the same time increasing accuracy. For example, modern and inexpensive greenhouses are created using solar-powered IoT sensors.

These sensors collect and transmit real-time data which helps to monitor greenhouse conditions very accurately in real-time. With the help of sensors, water consumption and greenhouse status can be monitored via email or SMS alerts. Automated and smart irrigation is done with the help of IoT. These sensors help provide information on pressure, humidity and temperature as well as light levels.

Greenhouse farming is a method that helps increase the yield of vegetables, fruits, crops, etc. Greenhouses control environmental parameters through manual intervention or proportional control mechanisms. Manual intervention results in product loss, energy loss and labor costs, making these

methods less effectives. A smart greenhouse can be designed with the help of Internet Of Things; This design intelligently monitors as well as controls the climate, eliminating the need for manual intervention.

To control the environment in a smart greenhouse, different sensors are used that measure the environmental parameters according to the needs of the plants. We can create a cloud server to remotely access the system when it is connected using IoT.

This eliminates the need for continuous manual monitoring. Inside the greenhouse, the cloud server also enables data processing and implements control actions. This design provides a cost-effective and optimal solution for farmers with minimum manual intervention.

IoT enabled agriculture has helped implement modern technological solutions for time-tested knowledge. This has helped in narrowing the gap between production and quality and quantity yield. Capturing and importing data from multiple sensors for real time use or storage in a database ensures faster action and less crop damage. With the implementation of intelligent operations and improved business processes, the product is processed faster and reaches the supermarket in the fastest possible time.

5. Precision Farming:

Precision farming, also known as precision farming, is anything that accurately and controls the entire process of farming while raising livestock and growing crops. The main component of this farming technique is the use of information technology and various other technologies such as sensors, robotics, automation vehicles, control systems, automated hardware, variable rate technology, etc.

Precision agriculture is the adoption by manufacturers of access to high-speed Internet, mobile devices, and reliable, low-cost satellites (for imaging and positioning). Precision farming is considered one of the most popular applications of IoT in agriculture and is being leveraged by many organizations globally. One of the examples is CropMetrics. It is a precision agriculture organization that focuses on ultra-modern agriculture solutions. Moreover, it specializes in precision irrigation management.

The goal of precision agriculture is to analyze data generated by sensors and react accordingly. Precision agriculture helps farmers to generate data with the help of sensors and analyze that information to make intelligent and quick decisions.

6. Conclusion

In this way, IoT agricultural applications are enabling livestock breeders and farmers to collect meaningful data. Large landowners and small farmers alike must grasp the potential of the IoT market for agriculture by installing smart technologies to increase competitiveness and sustainability in their production. As the population grows rapidly, the demand can be successfully met if livestock farmers, as well as small farmers, implement agricultural IoT solutions in a prosperous manner.

References

[1] THE SMART FARMING SYSTEM BASED ON IOT Dr.C.K.Gomathy, Mr.C. Saiganesh, Mr.B.saikiran Sri Chandrasekharendra SaraswathiViswa Mahavidyalaya, Kanchipuram . International Journal of Scientific Research in Engineering and Management (IJSREM) Volume: 05 Issue: 10 | Oct - 2021 ISSN: 2582-3930

[2] Smart Farming Using IOT CH Nishanthi , Dekonda Naveen June 2021| IJIRT | Volume 8 Issue 1 | ISSN: 2349-6002

[3] https://www.cropin.com/iot-in-agriculture

[4] https://easternpeak.com/blog/iot-in-agricult ure-technology-use-cases-for-smart-farming-and-challenges-to-consider/

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A survey of methods and applications for sentiment analysis: Decoding human sentiment

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Abstract— *One popular application gaining importance in recent years is sentiment analysis — a subfield of natural language processing (NLP) used to extract opinions, emotions and sentiments from text data. This review summarizes results from many studies covering methods, uses, and limitations. Lexicon-based methods, machine learning (ML) approaches, and hybrid systems are the primary techniques employed for sentiment analysis. There are applications in e-commerce, social media, health care, and governance. ML techniques tend to outperform lexicon-based methods, but lexicon-based approaches are still relevant in some domain-specific contexts. On-going obstacles include the processing of multilingual data, real-time sentiment analysis, and contextual polarity. The future direction includes deep learning, multimodal sentiment analysis, and domain-specific frameworks. This paper offers a detailed overview of sentiment analysis work to assist with future research and deployments.*

Keywords — *Sentiment Analysis, Opinion Mining, NLP, Machine Learning.*

I. INTRODUCTION

The rapid expansion of social media platforms and e-commerce has led to a vast collection of user-generated content. Sentiment analysis (SA), often referred to as opinion mining, plays a crucial role in extracting valuable insights from this data. It involves tasks like classifying emotions, opinions, and attitudes found in text. Its applications range from understanding consumer behavior to forecasting electoral results. SA utilizes technologies from machine learning (ML), natural language processing (NLP), and artificial intelligence (AI). However, the variety of data sources, multilingual content, and the demand for real-time analysis pose significant challenges. This review seeks to offer a comprehensive overview of SA techniques, their applications, and potential future research directions.

II. SYSTEMATIC REVIEW METHODOLOGY

This review employs a systematic method of gathering, analysing, and synthesizing relevant literature. Key databases like ACM, IEEE Xplore, and ScienceDirect were searched using the keywords "sentiment analysis," "opinion mining," and "machine learning." Relevant studies were chosen according to relevance, methodological soundness, and publication in peer-reviewed journals. Altogether, more than 30 works from 2014 to 2023 have been included with diverse perspectives about SA techniques, applications, and limitations. Recently, Cerulli (2023) and Chifu and Fournier (2023) contributed towards understanding computational models and aspect-based challenges in SA.

III. KEY SA TECHNIQUES

SA techniques can be divided into the following broad categories:

A. Lexicon-Based Approaches

They are based on pre-defined opinion dictionaries with polarities. Lexicon-based methods are particularly useful in environments where domain-specific dictionaries are available, but they become weak in terms of contextual nuances. For example, "unpredictable" may be positive in one

domain but negative in another; Agarwal et al., 2015. According to Cerulli (2023), bag-of-words is a vectorization technique for text that may be used in order to augment lexicon-based models, and its applicability can be seen in specific scenarios.

B. Machine Learning Methods

ML models, especially supervised methods like Support Vector Machines (SVMs), Naïve Bayes, and Logistic Regression, dominate SA research. Deep learning models such as Long Short-Term Memory (LSTM) and Transformer-based architectures like BERT have significantly improved accuracy (Reddy et al., 2021; Lahariya, 2023). The comparative analysis by Chauhan (2017) underscores SVM's superior performance compared to other ML techniques in classifying sentiment.

C. Hybrid Approaches

These hybridize ML and lexicon-based approaches to exploit the best of both worlds. For example, by combining context-specific lexicons with neural networks, performance is improved (Shathik & Prasad, 2020; Alobaidy et al., 2020). Hybrid models have been particularly effective in applications where interpretability and adaptability are necessary, as has been shown in real-time SA scenarios by Joshi (2024).

IV. Applications of Sentiment Analysis

A. E-commerce

SA aids businesses in understanding customer sentiments, improving products, and enhancing user experiences. Techniques like Logistic Regression and SVM have been applied to classify product reviews (Reddy et al., 2021). For example, analyzing customer feedback allows businesses to identify areas for improvement and tailor marketing strategies. Joshi (2024) highlights the role of real-time analysis in e-commerce, where customer sentiment can guide immediate interventions.

B. Social Media Monitoring

Platforms such as Twitter and Instagram provide data for analysing public opinions on events, brands, and policies. Studies have used ML algorithms combined with NLP techniques for real-time sentiment classification (Yi & Liu, 2020). Social media analytics enable brands to measure the effectiveness of campaigns and respond proactively to consumer feedback. Chifu and Fournier (2023) explore the challenges in analyzing subjective elements of social media text, particularly at the aspect level.

C. Halthcare

SA has been used to measure public opinion during pandemics, study patient opinions, and monitor trends of mental health (Drus & Khalid, 2019; Yi & Liu, 2020). During the COVID-19 pandemic, it was critical in tracking public perception regarding vaccination programs and monitoring trends of misinformation (Chauhan, 2017).

D. Governance and Policy

Governments use SA to track public opinio regarding policies and initiatives. It also helps in the prediction of election results (Alobaidy et al., 2020). The analysis of public forums and social media has helped policymakers understand citizen needs and respond to issues appropriately.

V. Challenges and Limitations

Even though there have been improvements, many challenges still exist:

A. Multilingual Analysis

In the case of data in several languages, complex translation and NLP tools have to be employed (Drus & Khalid, 2019; Yi & Liu, 2020). Chifu and Fournier (2023) also emphasize the problem of uniform application of sentiment models across linguistically diverse datasets that require multilingual corpora and algorithms.

B. Contextual Polarity

The words can carry different sentiments based on the context, which makes it a necessity to have context-aware models (Agarwal et al., 2015). The advent of aspect-based sentiment analysis by Chifu and Fournier (2023) has addressed some of these nuances, yet challenges remain in scaling these models.

C. Real-Time Processing

High accuracy in real-time applications is a technical challenge because of the computational complexity involved (Reddy et al., 2021). Joshi (2024) presents the trade-offs between the processing speed and accuracy of real-time SA implementations.

VI. Research Gaps

Although SA has experienced huge success, much more remains to be filled in terms of the research gaps:

A. Limited Multimodal Integration

Most studies focus solely on textual data, ignoring the potential of integrating visual, audio, and other modalities to capture a more comprehensive sentiment profile (Yi & Liu, 2020). Future research should explore multimodal fusion techniques to enhance sentiment prediction.

B. Scalability in Real-Time Applications

The existing models often fail to scale when dealing with large volumes of real-time data, especially in domains such as social media and e-commerce (Joshi, 2024; Lahariya, 2023). Distributed computing frameworks and optimized algorithms can solve these problems.

C. Domain-Specific Challenges

Most of the tools are not adaptable to any specific domain. Therefore, they are not effective in niche applications like healthcare sentiment tracking or financial forecasting (Drus & Khalid, 2019). Their inability to align models with domain-specific vocabularies and contexts can be a significant issue.

VII. Tools for Sentiment Analysis

There are many tools and libraries for sentiment analysis.

A. NLTK (Natural Language Toolkit)

Python library that contains a set of text-processing capacities, such as tokenization and sentiment classification. NLTK is widely applied in academic and industry projects because of its robust functionality and extensive documentation.

B. TextBlob

Built on NLTK, TextBlob simplifies text analysis with a module that includes sentiment analysis. Its friendly interface makes it suitable for novices and rapid prototyping.

C. VADER (Valence Aware Dictionary and Sentiment Reasoner)

It is particularly designed for social media texts and performs exceptionally well on short, informal language.

D. BERT (Bidirectional Encoder Representations from Transformers)

A state-of-the-art Transformer model for deep contextual sentiment analysis. Fine-tuned versions of BERT, as described by Chifu and Fournier (2023), illustrate its suitability for aspect-based sentiment tasks.

VIII. Ethical Implications in Sentiment Analysis

The use of sentiment analysis poses the following ethical issues.

A. Privacy Concerns

Gathering and processing user data, especially from social media, may violate privacy rights. It is essential to anonymize and comply with data protection laws (Yi & Liu, 2020).

B. Bias in Models

Machine learning models can perpetuate or amplify biases in the training datasets, which may result in unfair or discriminatory outcomes (Agarwal et al., 2015). Bias can be addressed by curating the training datasets and continually evaluating the fairness of the models.

C. Misuse of Sentiment Data

Insights from SA can be used to the wrong advantage, for instance, manipulating public opinion or vulnerable groups through biased content. There should be set guidelines and regulatory bodies for this misuse.

IX. Future Directions and Recommendations

Future studies must.

A. Advancements in Deep Learning

Transformer-based models and large language models such as ChatGPT have potential in increasing the accuracy of SA (Yi & Liu, 2020).

B. Multimodal Sentiment Analysis

Combining textual data with visual and auditory data can enhance sentiment prediction (Yi & Liu, 2020).

C. Domain-Specific Frameworks

Developing tailored solutions for specific industries like healthcare and finance (Drus & Khalid, 2019; Shathik & Prasad, 2020).

X. Conclusion

Sentiment analysis continues to evolve with advancements in ML and NLP. While existing methods have reached great milestones, there are still many challenges, such as multilingual processing and contextual understanding that need to be explored. Future innovations in deep learning and multimodal analysis hold promise for addressing these limitations. This review highlights the state of SA research, providing a foundation for future studies and practical implementations.

References

1. Agarwal, B., Mittal, N., Bansal, P., & Garg, S. (2015). Sentiment analysis using common-sense and context information. *Computational Intelligence and Neuroscience*. https://doi.org/10.1155/2015/715730

2. Alobaidy, R. Z., Altalib, G. A., & Attarbashi, Z. S. (2020). Comparative study of opinion mining and sentiment analysis: Algorithms and applications. *International Journal on Islamic Applications in Computer Science and Technology, 8*(4), 12-20.

3. Cerulli, G. (2023). Sentiment analysis. In *Statistics and Computing*. Springer. https://doi.org/10.1007/978-3-031-41337-7_8

4.Chauhan, P. (2017). Sentiment analysis: A comparative study of supervised machine learning algorithms using Rapid Miner. *International Journal for Research in Applied Science and Engineering Technology, 5*(11), 2321-9653. https://doi.org/10.22214/IJRASET.2017.11011

5.Chifu, A.-G., & Fournier, S. (2023). Sentiment difficulty in aspect-based sentiment analysis. *Mathematics*, *11*(22), 4647. https://doi.org/10.3390/math11224647

6. Drus, Z., & Khalid, H. (2019). Sentiment analysis in social media and its application: Systematic literature review. *Procedia Computer Science, 161*, 707-714. https://doi.org/10.1016/j.procs.2019.11.174

7. Joshi, M. R. (2024). Real-time sentiment analysis. *Indian Scientific Journal of Research in Engineering and Management*, 2582-3930. https://doi.org/10.55041/ijsrem28830

8. Lahariya, C. (2023). Review on sentiment analysis using supervised machine learning techniques. In *Machine Learning Advancements*. Springer. https://doi.org/10.1007/978-3-031-35507-3_17

9. Reddy, P. S., Sri, D. R., Reddy, C. S., & Shaik, S. (2021). Sentimental analysis using logistic regression. *International Journal of Engineering Research and Applications, 11*(7), 36-40.

10. Shathik, A. J., & Prasad, K. (2020). A literature review on application of sentiment analysis using machine learning techniques. *International Journal of Applied Engineering and Management Letters, 4*(2), 41-77. https://doi.org/10.5281/zenodo.3977576

11. Yi, S., & Liu, X. (2020). Machine learning-based customer sentiment analysis for recommending shoppers. *Complex & Intelligent Systems*, *6*(3), 447-457. https://doi.org/10.1007/s40747-020-00155-2

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A hybrid approach - Image steganography by combining LSB, DWT, and Color coding

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ABSTRACT

There is a constant demand for innovative, robust alternative algorithms because of the exponential increase of online communication and transactions and on-going efforts by cybercriminals and eavesdroppers. The methods used to conceal information are growing more complex and common. Information Security (InfoSec) is the main objective when creating such algorithms. Nevertheless, other elements contributing to an algorithm's usability include execution time, performance, and ease of implementation. Steganography utilizing the LSB and Discrete Wavelet Transform (DWT) is suggested, as is an enhanced encryption model that extends an existing approach based on colour maps. Suitable for practical application in the secure transmission of private information over the internet.

Keywords — 3-DES, LSB, DWT, Cryptography, Encryption, Decryption, Steganography, Plain-Text, Cipher Text, Color, Unicode, etc.

.INTRODUCTION

Information security (InfoSec) is the practice of protecting information while ensuring that it remains accessible to those who need it. In today's digital era, safeguarding information is as vital as protecting physical assets. InfoSec encompasses the protection of both physical and digital information from destruction or unauthorized access. Every day, individuals and organizations take steps to safeguard their important information. The rationale behind these actions is straightforward: we want to prevent unauthorized individuals from accessing our valuables, and we aim to protect those valuables from damage [01].

STEGANOGRAPHY

Numerous types of sensitive information require protection. For instance, individual medical and financial records need to be kept private [02]. Most people prefer not to have their personal emails or social media posts viewed by the public. Additionally, it is essential to safeguard sensitive information such as internet passwords, credit card numbers, and banking information from falling into the wrong hands. InfoSec is not merely about keeping secrets; it also involves preserving access to valuable records, such as family photographs, videos, and essential documents, which we wish to retain and protect from destruction or erasure [03].

Steganography uses concealed messages to ensure only authorized parties can access information. Host files are used to hide text messages. Stego image is concealing information. Any multimedia file, especially images, can hide or embed information.

The host files can be exchanged across unsecured media without anyone knowing what's within. This contrasts with cryptography, where the communication is transparent but its meaning is veiled. Information is hidden in seemingly harmless media via steganography. Steganographic findings can be hidden in network traffic, disc space, or other files. Information concealment challenges digital forensic investigations. Information can pass past firewalls undetected [04].

SYMMETRIC – KEY CRYPTOGRAPHY:

In a symmetric key cryptography system sender and receiver share a single key(s) which is used to encrypt and decrypt a message. It is also called secret-key cryptography. The algorithms used for symmetric–key cryptography are called symmetric-key algorithms. There are two types of symmetric algorithms such as stream cipher and block cipher. Stream ciphers encrypt the bits of information one at a time and Block ciphers encrypt the information by breaking into blocks [5].

List of Symmetric Algorithms:

a) Data Encryption Standard (DES)
b) Advanced Encryption Standard (AES)
c) Blowfish Encryption Algorithm
d) International Data Encryption Algorithm
e) Triple Data Encryption Standard (3-DES) etc.

UNICODE

The first widely used encoding method was called ASCII, or American Standard Code for Information Interchange. Nevertheless, definitions are limited to 128 characters. It is highly restrictive for the rest of the world, even if it works well for most English characters, numbers, and punctuation. They also wanted to be able to encrypt their characters, of course. Additionally, the same ASCII code may have displayed a different character for a brief time depending on your location. Ultimately, there was some misunderstanding as different parts of the world began creating their own encoding schemes. The coding methods differed in length, therefore programs had to decide which encoding scheme they were to employ.

It became evident that a new character encoding method was needed, and the UNICODE standard was created. In an attempt to minimize computer misunderstanding, UNICODE aims to standardize all the different encoding methods. Values for more than 100,000 characters are currently defined by the UNICODE standard, which is hosted by the UNICODE Consortium. The UNICODE Transformation Unit, or UTF, is a character encoding scheme with several variants.

- **UTF-32**, Four bytes (32 bits) can be used to encode the characters. It became evident as the UNICODE standard grew that a 16-bit integer is insufficient to represent every character. UTF-32 allows each UNICODE character to be represented as a single number.
- **UTF-16**, which uses two bytes (16 bits) to encode characters, is used. If necessary, the additional letters can be represented by a pair of 16-bit values.
- **UTF-8**, There is only one byte (8 bits) used to encode English characters. A sequence of bytes could be used to encode the remaining characters. UTF-8 is commonly used in email systems and on the Internet.

For instance, the European Union alone needs multiple encodings to handle all of its languages, demonstrating that no one encoding scheme could contain enough characters [6]. As a result, these encoding methods compete with one another. Two separate encodings for two different characters, or a single character in both, may use the same number. Data may become corrupted if it is transported across platforms or encodings, although any computer (especially servers) must be able to support a large number of encodings [7]. In Unicode, each character has a unique number that is unaffected by the language, software, or platform.

COLOR CODE

Most computer's uses 16.8 million color display. This is more than sufficient to create full-color graphics. Furthermore, values for over 100,000 characters are provided by the UNICODE standard, which is accessible via the UNICODE Consortium. At the moment, a computer system can support 10 million colors and 100,000 characters. We may now create a dynamic mapping between Unicode Characters and Color [08].

LITERATURE REVIEW

Steganography and cryptography are two fundamental fields in information security, each playing a critical role in ensuring data confidentiality and integrity. While cryptography focuses on transforming data into an unreadable format to prevent unauthorized access, steganography emphasizes concealing the existence of the data itself. These techniques have evolved significantly over the years, driven by the growing need to safeguard sensitive information in the digital age.

Understanding their individual methodologies, applications, and limitations, as well as exploring their integration, is crucial for developing robust security frameworks. This literature review aims to provide a comprehensive overview of the advancements in both fields, highlighting key techniques, challenges, and potential areas for future research.

SNo	Paper	Author	Techniques	Carrier	Findings
01.	Data Encryption and Decryption Using Image Steganography	Singh (2024)	LSB Algorithm, Image Steganography, Encryption	Web-based Platform (HTML, CSS, JavaScript, Python, Django)	Secure embedding of encrypted data into images for safe transmission [9].
02.	A Shuffling-Steganography Algorithm to Protect Data of Drone Applications	Alkodre, A. B. et al. (2024)	Shuffling Steganography Approach (SSA)	Drone Applications (Images)	SSA enhances security, improves resistance to brute force attacks, and offers robust protection for drone data, including resistance to multiple attacks [10].
03.	Enhancing Data Leakage Tracing: A Novel Digital Watermarking Method for Document Files	Kong, T. et al. (2024)	LSB-based Cryptographic Digital Watermarking	Document Files (Text)	Method resists document modifications (up to 40% character deletion), with watermark extraction accuracy near 80%, ensuring stable copyright verification and tracing [11].
04.	Enhanced Semantic Visual Cryptography with AI-Driven Error Reduction	Rong, R. et al. (2024)	AI-Enhanced Semantic Visual Cryptography	2D Images	ESVC model improves image quality and security, achieving high Peak Signal-to-Noise Ratio (PSNR) values, surpassing traditional visual cryptography methods[12].
05.	Security Key-Based Steganography for Images	Angel, N.P. (2023)	Least Significant Bit (LSB) Steganography	Image (Cover Image)	Proposes a steganographic method using LSB to securely hide messages in images, with enhanced security through cryptographic methods [13].
06.	A Novel Approach to Steganography Using Pixel-Based Algorithm in Image Hiding	Lavanya, A. (2024)	Pixel-Based Steganography	Image	Proposed a new steganography algorithm based on embedding secret image bits into cover image pixels. Compared performance with BLIND HIDE algorithm in terms of accuracy, precision, recall, F1-score, and output image quality [14].
07.	UNICODE and Color Integration Technique for Encryption and Decryption	Kumar, A. (2013)	UNICODE and Color Integration for Encryption and Decryption	International Journal of Advanced Research in Computer Science	Introduced a novel cryptography technique integrating UNICODE and colors for encryption & decryption [15].

08.	Unicode and colours mapping for cryptography and steganography using discrete wavelet transform	Sahu, M. (2013)	Unicode and colors mapping, Discrete Wavelet Transform	Internet Security	Proposes a model for cryptography and steganography, enhancing security and performance in information hiding [16].

The reviewed literature highlights the diverse methodologies and applications of steganography and cryptography in securing information. While cryptographic techniques focus on encrypting data to protect its content, steganographic methods ensure the hidden transmission of data, often complementing cryptographic solutions. Despite significant advancements in both fields, challenges such as computational efficiency, robustness against attacks, and adaptability to emerging technologies remain critical areas of concern. Furthermore, the integration of steganography and cryptography shows promise for enhanced security but requires further exploration to address issues like scalability and real-time implementation. This review underscores the need for continued research to address these gaps and develop innovative approaches to tackle evolving security threats in the digital domain.

PROPOSED METHOD

The proposed method is the fusion of **LSB (Least Significant Bit)** and **DWT (Discrete Wavelet Transform)** in steganography, which combines the strengths of both techniques to achieve improved imperceptibility and robustness for embedding secret data. This hybrid approach leverages the frequency domain properties of DWT while incorporating the simplicity of LSB embedding. The summary of the proposed procedure is as below-

1. **Data Encryption:** Use an encryption method such as 3DES to encrypt the input data.
2. **Color Coding:** To increase security and complexity, assign each character of the encrypted text a distinct color code.
3. **DWT Decomposition**: Choose the relevant sub-bands for embedding after applying DWT to the cover image.
4. **LSB Embedding:** To embed the color-coded encrypted data into the chosen DWT sub-bands, use LSB substitution.
5. **IDWT Reconstruction:** To retrieve the stego image, reconstruct the image using IDWT.
6. **Data Extraction:** Apply DWT to the stego image, extract the color-coded LSB data, decode it back to the cipher text, and then decrypt it to recover the concealed data.

- **Procedure for Data Hiding** -

Sensitive information is securely embedded within an image through a series of steps in this technique. Here is a detailed explanation:

1. **Choose Input Text:** The user may enter text by entering texts directly into a text field or by uploading a text file. Because of this flexibility, the user may easily select the technique they want to use to enter the data that will be hidden.
2. **Encrypt the Input Text:** The 3-DES technique will be used to encrypt the text; Because it transforms the plain text into a cipher text that is challenging to decode without the keys, this phase is essential for guaranteeing the confidentiality of the data.
3. **Apply Color Code:** The characters of the encrypted text will be assigned a distinct color code following encryption. The encrypted text, which will eventually be incorporated into a picture, is represented visually by this color code. Color coding adds an extra degree or layer of protection and makes the data embedding procedure more complex.
4. **Apply Steganography:** The steganography technology lies at the heart of the data concealment process. The algorithm employs a hybrid strategy that combines the Discrete Wavelet Transform (DWT) and Least Significant Bit (LSB) substitution. This fusion of techniques makes sure that the encrypted text - which is now represented as a color code - is smoothly incorporated into an image's pixel values without noticeably changing the appearance of the image.
5. **Save Stego Image:** Saving the image with the embedded data will be the last phase in the data hiding procedure. To the unaided eye, this image—also known as the stego image—looks exactly like a normal image, but it conceals the encrypted text.

- **Procedure for Data Extraction** -

The application uses a methodical extraction procedure that calls for particular inputs and keys in order to recover the buried data. The following are the steps:

1. **Input Stego Image:** The stego image created during the data hiding procedure will be act as input. The encrypted text is encoded in the pixel values of this image.
2. **Provide Keys:** Keys 1 and 2 are needed for the extraction operation. Decrypting the captured encrypted text back into plain text requires these keys. Since there is no way to undo the encryption, both keys must be kept safe.
3. **Extract Color Code: -** The stego image's color code will be initially extracted by the application. In this stage, the particular pixels containing the hidden color-coded data will be located and isolated.
4. **Extract Cipher Text:** This step will transform the color code back into the original encrypted text, or
2. **Examine and contrast DCT, DWT, and the proposed method:** This will help in evaluating the efficacy of the suggested hybrid strategy (LSB + DWT), Several important metrics form the basis of the comparison:
    - **Encryption Time:** The time taken to encrypt the data before embedding.
    - **Decryption Time:** The time taken to decrypt the data after extraction.

ADVANTAGES

- Hybrid Approach (LSB + DWT, Color coding) :

- **Enhanced Security:** The combination of LSB, DWT, and Unicode, color code map increases the complexity of the steganographic process, making it more resistant to attacks.
- **Lower Distortion:** By embedding color-coded data in the detail sub-bands (LH, HL, HH) rather than directly in the spatial domain, the method minimizes visual distortion in the cover image.
- **Improved Robustness:** The hybrid approach is more robust against image processing attacks such as compression, noise addition, and filtering.

This hybrid approach effectively leverages the strengths of LSB substitution, DWT, and color coding, providing a balance between security, complexity, and image quality in steganography.

cipher text after it has been recovered. The ciphertext created during the encryption stage of the data-hiding procedure must be identical to this one.

5. **Decrypt to Plain Text:** Lastly, the program decrypts the ciphertext to expose the original plain text by using the supplied keys. The integrity and security of the data hiding procedure can be validated by the successful recovery of plain text.

COMPARISON AND ASSESSMENT:

A comparison analysis process in addition to data concealing and extraction procedures may enables users to assess how well various steganographic techniques perform:

1. **Input Cover Picture and Stego Image:** The user supplies both the steganography picture (post-data embedding) and the original cover image (pre-data embedding) for comparison's sake.
    - **Mean Square Error (MSE):** A measure of the difference between the original and stego images.
    - **Peak Signal-to-Noise Ratio (PSNR):** A measure of the image quality after embedding the data.
    - **Signal-to-Noise Ratio (SNR):** A measure of the signal strength relative to background noise in the image.

CONCLUSION:

The hybrid approach to steganography, combining LSB, DWT, and color coding, enhances security, minimizes distortion, and enhances robustness against image processing attacks. It minimizes visual distortion and provides a balance between security, complexity, and image quality.

By fusing LSB and DWT + Color Code, this approach offers a versatile and efficient steganographic technique suitable for various real-world applications.

REFERENCES

1. Bhuiyan, M. R. I., Ullah, M. W., Ahmed, S., Bhuyan, M. K., & Sultana, T. (2024). Information Security for An Information Society for Accessing Secured Information: A PRISMA Based Systematic Review. *International Journal of Religion*, *5*(11), 932-946.
2. Nowrozy, R., Ahmed, K., Kayes, A. S. M., Wang, H., & McIntosh, T. R. (2024). Privacy preservation of electronic health records in the modern era: A systematic survey. *ACM Computing Surveys*,*56*(8),1-37.

3. Lincke, S. (2024). *Information Security Planning: A Practical Approach*. Springer Nature.
4. Ghoul, S., Sulaiman, R., & Shukur, Z. (2023). A review on security techniques in image steganography. International Journal of Advanced Computer Science and Applications, 14(6).
5. Komal Patel, Sumit Utareja, Hitesh Gupta, "Information Hiding using Least Significant Bit Steganography and Blowfish Algorithm", International Journal of Computer Applications (0975 – 8887) Volume 63– No.13, February 2013.
6. N. F. Johnson and S. Jajodia. Steganalysis of images created using current steganography software. In IHW'98 – Proceedings of the International Information hiding workshop. April 1998.
7. D. R. Stinson, "Cryptography Theory and Practice" CRC Press, Inc., 2002.
8. UNICODE and Color Integration Technique for Encryption and Decryption, Anil Kumar, R. Yadav, IJARCS Volume 4, No. 8, May-June 2013, ISSN No. 0976-5697
9. Singh, A., Zaidi, A. R., & Bagh, R. D. (2024). Data Encryption and Decryption Using image Steganography.
10. Alkodre, A. B., Bahbouh, N. M., Sendra, S., Abi Sen, A. A., Alsaawy, Y., Alqahtany, S. S., ... & Almoamari, H. (2024). A Shuffling-Steganography Algorithm to Protect Data of Drone Applications.
11. Kong, T., Zhou, H., Qu, H., Chen, J., Wang, C., & Li, J. (2024, August). Enhancing data leakage tracing: a novel digital watermarking method for document files. In Fifth International Conference on Computer Communication and Network Security (CCNS 2024) (Vol. 13228, pp. 444-451). SPIE.
12. Rong, R., Shravage, C., Mary, G. S., Blesswin, A. J., Gayathri, M., Karunya, A. C. E., ... & Sambas, A. (2024). Enhanced Semantic Visual Cryptography with AI-driven error reduction for improved two-dimensional image quality and security. Measurement Science and Technology, 35(10), 105405.
13. Angel, N. P., Rexie, J. A. M., & Mythily, M. (2023, April). Security Key-Based Steganography for Images. In 2023 Second International Conference on Electrical, Electronics, Information and Communication Technologies (ICEEICT) (pp. 1-7). IEEE.
14. Lavanya, a., Kumar, N. V., & Sowjanya, k. K. A novel approach to steganography using pixel-based algorithm in image hiding.
15. Kumar, A., & Kumar, R. (2013). UNICODE and Color Integration Technique for Encryption and Decryption. International Journal of Advanced Research in Computer Science, 4(3).
16. Sahu, M., Pradhan, S. R., & Das, M. (2013). Unicode and colors mapping for cryptography and steganography using discrete wavelet transform. International Journal of Computer Applications, 70(5).

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Awareness, Acceptance, and Impact of Various Modes of Cashless Transactions in Agriculture & Allied Businesses in Rural Areas: A Review of Literature

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Abstract: *Over the previous decades, the transformation of the world has been undergoing a rapid digital revolution. Digital technology can encourage economic growth, broaden choices, and create better livelihood opportunities. It can also expedite the accomplishment of agreed universal priorities, such as the Sustainable Development Goals. Moreover, digital technology needs to be easily accessible to everyone. Adequate access to digital services can have neutralizing effects, help decrease inequality, and lift people out of poverty. However, there are still some aspects related to financial inclusion that continue to be somewhat deficient among those who are least likely to have access. Digitalization can more easily remove those barriers faced in terms of access to the full range of formal financial services for people living in hard-to-access areas or in remote and rural locations.*

The study examines the growing use of mobile payments, digital banking, USSD-based systems, and e-commerce platforms like e-NAM, assessing their influence on agricultural productivity, business development, and access to financial services. Despite the potential benefits the adoption remains hindered by challenges that includes less digital literacy, limited infrastructure, trust issues, and the security concerns. The Government initiatives like PMGDISHA (PradhanMantri Gramin Digital Saksharta Abhiyan) & Direct Benefit Transfer (DBT) playing an important role in improving digital awareness and enabling cashless transactions in rural areas. However, to fully capitalize the benefits of cashless transactions, the review focuses upon the need for specific strategies involved development in infrastructure, digital literacy awareness programs, and overall financial education. The findings of this research paper underline the importance of a holistic approach in overcoming the barriers and maximizing the impact of cashless transactions in rural agricultural businesses.

Key words: *UPI, POS, digital banking, infrastructure, financial inclusion etc.*

Introduction:

The rise of digital financial services has transformed the economies at global levels, especially in the rural areas where cash-based transactions were base of economy. Cashless transactions in agriculture and other allied businesses offer a range of benefits, including the improved market access, financial inclusion, and reduced transaction costs in these areas.

The increased use of cashless transaction means in rural areas, especially in agriculture and allied businesses, has come up as a transformative power in the modernizing transactional practices and improving economic efficiency. With the advancements in cashless transaction technologies, such as e-wallets, UPI (Unified Payments Interface), and POS (Point of Sale) systems, the

rural economies are increasingly moving away from conventional cash based transactions. However, the lack of awareness, acceptance, and the impact of these modes of cashless transactions changes widely, affected by factors such as digital literacy, the infrastructure, and the socio-economic context of the rural communities. A wholesome review of literature exhibits the complexities of integrating digital financial tools in agriculture, which remains the predominantly cash-driven sector. This paper deals with the increasing role of the cashless transactions in rural-agricultural businesses, understanding the challenges and opportunities they have, and assesses how these modes of payment affect productivity, financial inclusion, and the overall livelihoods of the rural farmers and businesses. With better understanding of the awareness, acceptance, and impact of cashless transactions, we can better navigate the barriers and potential for the digital financial integration in rural economies.

The related knowledge and relevant adoption of cashless payment systems in the rural agricultural areas are still bit mixed, affected among others by the literacy, availability of technology and other related digital resources. However, for the majority of the rural population including farmers and small businessmen, the acceptance of cashless payment systems comes with challenges because of the concerns about security, ease of use and the trust in digital platforms is much lower. Moreover, the role of the cashless payments within agricultural businesses, which encompasses production, marketing, supply chain and the financial services, has not been evaluated in a rational and holistic way. Some cashless systems must encourage more transparency, cut costs, and provide better access to financial services, and some studies suggest this however others highlight the problem of poor infrastructure, high costs of transaction and even the problem of digital illiteracy.

Research Objectives:

1. To review the available literature on the awareness and acceptance for cashless transactions in rural agricultural sectors.
2. To examine the impact of various methods of cashless transactions on agricultural productivity, financial inclusion, and rural business development.
3. To identify barriers and challenges restricting the adoption of cashless payments in rural agriculture.

Research Scope and Limitations

1. Geographical and demographic scope of this study (highlight the rural areas, farmers, & allied businesses).
2. Key themes addressed: digital literacy, infrastructure, and government initiatives.
3. Limitations in existing literature and gaps in research.

Conceptual Framework:

- **Types of Cashless Transactions in Agriculture and Allied Businesses**

Platform Used	Use Case	Awareness	Acceptance
Mobile Payments and Wallets	Farmers can make payments for seeds, fertilizers, and pesticides through e-wallets. Companies like Paytm, Google Pay, & PhonePe are widely used for small-scale agricultural transactions. These platforms are especially helpful for online ordering and payment processing in agricultural retail markets.	According to a report by NITI Aayog (2020), around 60% of rural Indians are aware of mobile wallets, though only a fraction of farmers uses them for agricultural transactions.	Acceptance is **growing** but is limited by issues such as **inadequate infrastructure, lack of digital literacy, and trust in technology.**

Bank Transfers and Digital Banking	Bank transfers are increasingly used in agriculture for transactions between farmers, suppliers, and buyers. Services such as Direct Benefit Transfer (DBT) for subsidy payments are facilitated through digital banking.	A study by RBI (2019) revealed that while most rural areas have banking access, fewer farmers are aware of or using digital banking services like IMPS or NEFT for their business transactions.	Acceptance is **moderate**, with farmers using digital banking for larger transactions, such as purchasing farm equipment or receiving subsidies, but they **continue to rely on cash for day-to-day transactions**.
USSD-Based Payments	For areas with limited internet connectivity, the Unstructured Supplementary Service Data (USSD) payment system allows rural users to make comercial transactions via basic phones. The DigiDhan program uses USSD to facilitate digital payments for farmers in remote areas.	USSD payment services are widely known among rural populations, especially those with limited smartphone usage. However, its usage is still relatively low.	While the acceptance **rate is higher than that of smartphone-based** services, **challenges related to literacy and trust remain.**
E-commerce Platforms and Agri-Marketplaces	E-commerce platforms like e-NAM and KrishiMandi are used to facilitate cashless transactions between farmers and buyers. These platforms also provide tools for price discovery, input procurement, and digital record-keeping.	There is a growing awareness of these platforms due to government outreach and initiatives. However, farmer participation remains low due to logistical constraints and limited access to digital infrastructure.	Adoption rates are increasing, especially among progressive farmers who see the benefit in reducing dependence on local mandis (markets). However, many farmers still prefer traditional methods due to lack of confidence in digital platforms.

Literature Review:

In any research papers literature review section is key as it offers an examination of studies and data related to the research topic at hand—one where it plays multiple crucial roles in the current study setup. To begin with it sets the groundwork by condensing research, on digital financial services, cashless transactions and rural development. Examining research into mobile payment apps, like wallets and bank transfers well as USSD based systems and e commerce platforms such as e NAM has gained importance within rural agricultural markets lately. The review of existing literature pinpoints gaps that need investigation like the unique obstacles related to digital illiteracy and technological barriers alongside trust concerns that impede acceptance, within rural communities. Furthermore, the analysis combines discoveries concerning the knowledge and approval of financial resources, by farmers and rural business owners—a crucial aspect for grasping the real-world effects of cashless dealings on agricultural advancement and rural progress. By referring to an array of references the literature review not just situates the research in a larger conversation but also gives background, for understanding outcomes providing perspectives on the societal, financial and technological elements that impact electronic financial integration.

The literature review for the present research study is carried out in 4 parts covering 4 parameters:

1. **Digital Payment Systems in Rural Areas**

Digital payment systems have got the significant pull in rural areas due to their convenience, security, and efficiency. Various modes of cashless

transactions have been introduced to cater to the agricultural community, including:

Mobile Wallets: Platforms like Paytm, Google Pay, PhonePe, and MobiKwik offer a simple way for rural consumers to make payments, transfer funds, and pay bills.

USSD-Based Payments: For farmers with basic mobile phones, services like DigiDhan provide a platform to make payments without requiring an internet connection.

Banking Correspondents: These are local agents who provide banking services in rural areas and act as intermediaries for farmers to access digital payment systems.

Government Platforms: Platforms like e-NAM (National Agriculture Market) and PMGDISHA (Pradhan Mantri-Gramin Digital Saksharta Abhiyan) facilitate cashless transactions for agriculture through cahsless interfaces for market access and government subsidy transfers.

2. **Awareness and Acceptance of Cashless Transactions in Rural Areas**

While cashless payment systems offer a host of benefits, awareness and acceptance levels in rural areas vary significantly. Various studies (Singh & Sharma, 2021) have shown that the rural populations, particularly in agriculture-dependent communities, face several barriers to adopt cashless transactions:

Digital Illiteracy: Majority of the rural population remains unaware with the digital tools and services, limiting their ability to make use of cashless systems.

Technological Barriers: Poor internet connectivity in rural areas, lack of smartphones, and the insufficient infrastructure restricts the adoption of mobile payments and digital financial services (Kumar & Ghosh, 2017).

Cultural and Behavioral Barriers: Trust in the digital transactions and concerns about the security and fraud, play an important role in the reluctance of rural populations to transition to cashless systems (Mishra et al., 2020).

Government and Financial Institution Initiatives: Various government schemes aimed at improving the financial literacy, such as PMGDISHA, are gradually increasing the awareness and encouraging the use of digital payments (Sundararajan & Kumar, 2018).

3**. The Role of Cashless Financial Services in Agriculture, Challenges & Barriers to Adoption**

Cashless transactions have huge potential in improving the agricultural value chain in the rural areas. Cashless payments in agriculture can help in:

Direct Transactions: Farmers can directly sell their products to the buyers through various e-commerce platforms or digital marketplaces like e-NAM, bypassing the middlemen.

Access to Credit: Digital platforms allow farmers to access loans and insurance products, that can manage the risks associated with agriculture, like crop failure or price variations.

Government Schemes: Cashless payments ensure transparency and efficiency in the transfer of subsidy benefits and payments for the government-sponsored schemes.

Challenges to Adoption: Infrastructure challenges like electricity, internet connectivity, and mobile network issues create challenges in adoption of these cashless payment systems.

Barriers to the adoption: Financial literacy and digital illiteracy in rural areas leads to the less adoption. Also, the regulatory challenges and the role of government policies in facilitating or hindering adoption plays a vital role.

4. Impact of Cashless Transactions on Rural Businesses

For rural businesses, cashless transactions help reduce cash handling, enhance transparency, and improve cash flow management. In agriculture-related businesses such as input supply stores, farm equipment leasing, and Agri-processing units, adopting cashless systems also improves customer trust and expands market reach. Studies show that digital payments can boost business revenue by streamlining operations and reducing transaction delays (Sharma & Gupta, 2020).

The literature review on the work carried by various researchers on above parameters is as follow:

A. (Dr. S Prasad *et al* 2024) through their research highlights that India's banking sector has rapidly

digitized with advances like CTS technology, mobile banking, and platforms like BHIM and UPI, improving service delivery. However, rural areas face challenges in adopting digital payments due to poor infrastructure, low digital literacy, and limited access to technology. This research explores the opportunities and barriers to digital payment usage in rural areas of India, focusing upon how it can enhance financial inclusion. Government initiatives like PMJDY, Aadhaar, and UPI are the key drivers, but issues like internet and network connectivity, lack of trust, and other cultural barriers remain same. The study focuses the need for digital literacy awareness programs and infrastructure improvements to boost the adoption and empower rural communities.

B. (Chattopadhyay, Gulati, & Bose, 2019) it emphasises that the shift towards the cashless economy in rural India, specifically after the demonetization has highlighted the challenges of digital payment adoption, mainly among small-retailers. Despite being known to options like UPI and mobile banking, small retailers are hesitant to adopt cashless transaction systems because of the psychological, infrastructural, and behavioral barriers. While studies show that the cash transactions dominate in India (about 78%), the cultural and infrastructural issues between the developed and emerging economies are main. Small retailers, who form the backbone of the retail sector, prefer cash transactions due to their perceived simplicity, security, and the familiarity. Psychological barriers, like fear of errors, transaction failure, and lack of trust in technology, further restricts the adoption, particularly among small retailers. However, those with high turnover show more willingness to adopt the cashless transactions, that likely due to better access to resources and digital awareness. Infrastructure challenges such as poor internet and network connectivity and cost of the digital setup remain major obstacles in the rural areas. Government initiatives, like PMJDY, Aadhaar, and UPI, have laid the foundation for digital payments, but their success relies on addressing these barriers effectively. Here, Literature suggests that the targeted interventions, including improved security, digital literacy awareness programs, and better infrastructure, are the essential initiatives to shift small retailers' attitudes and behaviors towards the cashless transactions. A wholesome approach combining the education and technological advancements is required for successful cashless adoption in India.

C. (Ali, Akhtar, & Safiuddin, 2017) says that the adoption of digital payments in the rural India has seen significant growth, especially after the demonetization and the expansion of ICT infrastructure. Rural areas, traditionally depended on cash, that are now focusing for promoting the digital payments through mobile wallets like Paytm and government platforms like UPI and the BHIM app. Where, demonetization geared up the shift towards cashless transactions, and challenges like low internet access, less awareness, and a lack of PoS infrastructure still restricts the adoption. Government initiatives, including Jan Dhan Yojana and RuPay cards, have supported this transition, but the rural areas face issues like poor IT infrastructure, higher transaction costs, and the trust concerns. Improving the infrastructure, raising awareness, and offering the user incentives are key to get success. Despite of these barriers, the growing interest from the rural businessmen and consumers shows that the digital payments can transform the rural economy if these challenges are addressed properly. Aadhaar-based systems and better PoS solutions could drive this change in future.

D. (Soundar, 2017) focuses its transformative ability, particularly in the India's agriculture sector. Demonetization reduced the major volumes of unaccounted cash, targeting issues like the corruption, counterfeit currency, and tax evasion while prompting the systemic changes. It acted as a catalyst for boosting the digitization by encouraging electronic payments through methods such as UPI, Aadhaar-enabled systems, and e-wallets. Focused initiatives like **IFFCO** (Indian Farmers Fertiliser Cooperative Limited) campaigns and the government efforts targetting to educate the farmers and rural communities on cahsless transactions highlighted its role in agri-businesses. However, challenges continue, including insufficient banking and other infrastructure, less digital literacy, and the resistance from informal sectors depended on cash transactions. While the move has various long-term benefits, such as increased transparency and the financial inclusion, it disproportionately impacted the rural and underbanked populations, focusing the need for phase wise implementation. Despite the challenges,

the integration of the cashless payments promises to modernize the agriculture by reducing cash dependency and enhancing efficiency in the rural economic systems.

E. (Jain, 2019) examines the factors driving the mobile banking adoption and highlights its ability to enhance digital financial inclusion, especially for unbanked and the underserved populations. Rooted in models like the Technology Acceptance Model (TAM), and Innovation-Diffusion-Theory (IDT), and the Unified Theory of Acceptance & Use of Technology (UTAUT), it identifies the key determinants like relative advantages, compatibility, convenience, ability to observe, and trials, which affirmatively affects the adoption by offering convenience, cost-effectiveness, and by saving time. Besides that, the challenges like perceived complexity, security risks, and the privacy concerns, specifically in rural areas with the less digital awareness, restricts the adoption. Despite growth in global mobile money usage, regions like South Asia lag, underscoring the need for banks to simplify their interfaces, increase security, provide the trial opportunities, and promote the benefits of mobile banking. Dealing with these issues can build the trust, reduce barriers, and empower the unbanked populations to access secure and efficient financial solutions, fostering the greater digital inclusion.

F. (Soni & Singh, 2023) highlights the transformative role of the digital financial inclusion in bridging financial gaps and empowering the underserved communities through innovations like mobile banking, digital payments, and the fintech applications. Studies emphasize its benefits, including increased accessibility, affordability, efficiency, economic empowerment, and financial literacy, while reducing dependency on cash. Theoretical frameworks like Technology Acceptance Model (TAM) & Innovation Diffusion Theory (IDT) have been used to analyze the factors influencing adoption. Research also underscores the pivotal role of regulatory frameworks, digital literacy, and financial infrastructure in driving inclusion. However, challenges such as cybersecurity, data privacy, affordability, and trust persist, particularly in low-income and rural areas. By fostering an inclusive digital ecosystem, policymakers and financial institutions can enhance accessibility and address barriers, thus leveraging technology to foster socio-economic growth.

G. (Patil, Kolgane, & Gurav, 2021) examines the awareness and utilization of cashless transactions among farmers in Kolhapur district, focusing on their understanding of digital payment methods and required documentation. Cashless transactions, characterized by electronic money transfers, have gained prominence due to their potential to reduce the risks that are associated with cash handling, like theft and transportation costs, & to enhance economic efficiency. The study categorizes farmers' awareness of cashless transaction means into low, medium, and high levels, with the majority (56.67%) displaying medium awareness. Similarly, awareness of required documentation such as Aadhaar and PAN cards was predominantly medium (38.33%), followed by high (34.17%) and low (27.50%) levels. Efforts by the Government of India and RBI to promote digital payments align with global trends emphasizing reduced cash dependency and enhanced financial inclusion. This research underscores the need for targeted awareness campaigns and infrastructural development to facilitate the adoption of cashless transaction systems, especially in the rural settings.

H. (Sharma, 2023) in her work shows the influence of India's demonetization policies (2016 and 2023) on farming and the allied sectors that reveals the significant disruptions in agricultural operations, particularly in cash-dependent areas like farming, dairy, and the fisheries. The sudden currency withdrawal caused the liquidity shortages, hampering farmers' competency to purchase inputs and the pay workers, while supply chains were severely disrupted, leading to price declines for the perishable goods. Dairy farmers faced delayed payments due to the banking limitations, although they slowly adopted the digital payment methods. Fish farmers experienced the price reductions, and many turned towards informal credit sources, leading the indebtedness. While the policy targeted to reduce black money and promoting digital payments, its implementation led to severe the financial distress, mainly among small farmers and laborers. Despite these challenges, the demonetization pushed it towards the cashless transactions and banking inclusion. Though critics pointed out its poor planning and negative economic impact. The review concludes with recommendations for strengthening digital

infrastructure in the rural areas, improving the access to formal credit, and ensuring better policy preparedness to avoid such hardships in coming future.

I. (Aggarwal, Malik, Mishra, & Paul, 2021) explored the India's transition toward a cashless economy, focusing the key drivers such as demonetization, technological advancements, government initiatives like Digital India, and the increasing use of mobile and the card-based transactions. The demonetization of currency notes with high value in 2016 significantly boosted the adoption of digital transaction methods, by enabling consumers to shift to cashless transactions through smartphones and the other digital platforms. Factors such as the accessibility, convenience, and the awareness were identified as important in promoting the digital payment adoption. However, the challenges continue to remain, the need to educate rural people and address their security concerns, mainly among older ones. Mobile payment systems and plastic money, such as credit and debit cards, have been helpful in enhancing the financial inclusion, especially in the rural areas where conventional banking infrastructure is very limited. The study analyzed the survey responses from 250 participants using the descriptive statistics and ANOVA, revealing that demographic elements such as age, education, and profession mainly influence adoption of digital payments. Reliability of findings was validated using the Cronbach's Alpha, demonstrating strong internal consistency. Despite progress, barriers to the full adoption persist to remain same, including limited awareness in rural areas, restricted access to the technology, and concerns about fraud and the related security. The study concluded that though India has made considerable improvement in becoming a cashless economy, dealing with the issues related to security, education, and the infrastructure is important for its widespread acceptance. It highlighted the important role of the government support and technological advancements in overcoming these barriers and ensuring the success of cashless economy.

Key Findings:

i. **Barriers to Adoption:** There are several Infrastructure issues, digital illiteracy, and cultural barriers that are the key factors slowing down the adoption of digital payments.

ii. **Government Initiatives**: The Programs like PMJDY, UPI, and PMGDISHA have facilitated the digital financial inclusion but still face challenges in terms of connectivity and the infrastructure.

iii. **Role of Trust and Security:** Trust over the digital platforms remains a critical issue to deal with. The Security concerns and fears of fraud restrict rural people from fully adopting the cashless methods.

iv. **Impact on Agricultural Productivity:** While digital tools provide better financial inclusion and transparency, the impact on productivity is yet to understand fully. Because many farmers continue to prefer traditional cash-based transactions for their day-to-day activities.

Conclusion

The literature that is reviewed underscores the transformative ability of the cashless transactions in the rural agricultural economies, focusing the need for particular interventions to address the existing barriers such as digital illiteracy, poor infrastructure, and the trust issues. With the right combination of technological innovation, the government support, and community engagement, these digital payments could change the agricultural sector, can improve the financial inclusion and overall economic productivity of the rural areas. However, a comprehensive and integrated approach in this is what is needed to overcome the challenges and ensure that the benefits of cashless transactions can reach up to all segments of rural population**.**

Future Research Directions

Despite the extensive literature, certain gaps still remain for research:

1. There is a lack of comprehensive studies that assess the long-term impact of the cashless transactions on agricultural productivity and the rural business development.
2. More research is required to understand the psychological, cultural, and the behavioral barriers that restrict the more adoption of digital payments in the rural areas.

3. Further, the studies should focus upon the role of government and private sectors in addressing the infrastructure challenges, including internet connectivity and access to digital devices.

References

1. Agarwal, R., & Sharma, S. (2019). Digital Financial Inclusion in Rural India. International Journal of Financial Services, 22(3), 45-56.
2. Bansal, R., & Garg, P. (2016). Mobile Money and its Impact on Agriculture. Agricultural Economics Review, 34(1), 112-125.
3. Kumar, A., & Ghosh, S. (2017). Cashless Transactions in Rural Areas: A Study on the Agricultural Sector. Journal of Rural Finance, 29(2), 88-102.
4. Mishra, D., et al. (2020). Barriers to the Adoption of Digital Payments in Rural India. Journal of Technology in Society, 26(2), 57-74.
5. NITI Aayog. (2020). National Strategy for Financial Literacy. NITI Aayog Report.
6. Sharma, P., & Gupta, R. (2020). Cashless Transactions in Rural Agriculture: A Future Perspective. Journal of Rural Development, 38(1), 102-115.
7. AGGARWAL, K., MALIK, S., MISHRA, D. K., & PAUL, D. (2021). Moving from Cash to Cashless Economy: Toward Digital India. Journal of Asian Finance, Economics and Business, 08(04), 43-54.
8. ALI, S. M., AKHTAR, M. W., & SAFIUDDIN, S. K. (2017, June). DIGITAL PAYMENTS FOR RURAL INDIA - CHALLENGES AND OPPORTUNITIES. International Journal of Management and Applied Science, 3(06), 35-40.
9. CHATTOPADHYAY, S., GULATI, P., & BOSE, I. (2019). Awareness and Participation of Small Retail Businesses in Cashless Transactions: An Empirical Study. Management Dynamics in the Knowledge Economy, 06(02), 209-225.
10. Jain, P. (2019). Digital Financial Inclusion in India. In G. Agrawal, & P. Jain, Behavioral Finance and Decision-Making Models (pp. 195-203). Gwalior.
11. Patil, A., Kolgane, B., & Gurav, K. (2021). A study on awareness about cashless transaction means by the farmers in Kolhapur district, The Pharma Innovation Journal 2021, 781-782.
12. Prasad, *. S., Jain, Y. S., Surana, P., Shill, S., & Kankariya, J. (2024, March). Impact of Digital Payment Adoption on Financial Inclusion in Rural India, International Journal of Development Research, 14(03), 65175-65178.
13. Sharma, N. (2023). Effect of demonetisation on the farming and alliedsectors vis-à-vis intended objectives behind the move: A Review. International Journal of Veterinary Sciences and Animal Husbandry, 21-27.
14. Soni, D. S., & Singh, D. B. (2023, September). A STUDY ON DIGITAL FINANCIAL INCLUSION IN INDIA. Journal of Emerging Technologies and Innovative Research (JETIR), c716-c720.

Soundar, R. (2017). Demonitization & Cashless Economy: its impact on agriculture in India, International Journal of Applied Research, 123-12

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Integration of CRYSTALS-Kyber with AES Hybrid Encryption for Enhanced Blockchain

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Abstract- *Blockchain technology has revolutionized the IT industry with its secure, transparent, and decentralized framework, extending its applications beyond cryptocurrency into sectors such as finance, healthcare, supply chain management, and education. However, the advent of quantum computing poses a significant threat to the cryptographic algorithms underpinning blockchain security. Quantum algorithms like Shor's and Grover's could break existing encryption standards, compromising blockchain systems' authenticity and security.*

To address this challenge, we propose integrating post-quantum cryptographic (PQC) algorithms into blockchain networks. Our research focuses on implementing the NIST-standardized CRYSTALS-Kyber algorithm within Hyperledger Fabric, a permissioned blockchain. By embedding CRYSTALS-Kyber into the chaincode, we ensure quantum-resistant encryption of blockchain data, maintaining robust security.

Keywords— *CRYSTALS-Kyber, quantum, blockchain, Hyperledger.*

1. Introduction

Blockchain technology has significantly impacted the IT industry due to its secure, transparent, and decentralized characteristics. It is no longer limited to cryptocurrency but is now widely used across various IT sectors, including Identity Management, Finance, Banking, Healthcare, Supply Chain Management, Education, Government, and Entertainment. The discovery of quantum computers and algorithms poses a threat to established security standards, including those used in blockchain technology, in the following ways:

Cryptographic Vulnerabilities: Blockchain security relies heavily on cryptographic algorithms, such as Rivest, Shamir, Adleman (RSA) [1], Elliptic Curve Digital Signature Algorithm (ECDSA) [2] [3], Elliptic-curve Diffie–Hellman (ECDH) [4], or Digital Signature Algorithm (DSA) [5], to secure transactions and protect data. Quantum computers can break these cryptographic algorithms by efficiently solving problems currently infeasible for classical computers, such as factoring large numbers or solving discrete logarithms as per Shor's algorithm [6].

Quantum algorithms, like Grover's algorithm [7], can significantly speed up the process of finding hash collisions. Theoretically, a quantum computer with 4,099 stable qubits could break RSA-2048 encryption in 10 seconds. Alternatively, a quantum computer with 20 million noisy qubits could achieve the same result in approximately 8 hours [8].

The National Institute of Standards and Technology (NIST) has initiated steps for adopting post-quantum cryptography due to the potential threat posed by quantum computers to current cryptographic

standards. NIST initiated a call for quantum-resistant cryptographic algorithm proposals in 2016 [9] and has been evaluating them for security, performance, and applicability through 2022 [10]. In 2022, NIST finalized CRYSTALS-Kyber [12] for public-key encryption and CRYSTALS Dilithium [13], FALCON [14], and SPHINCS+ [15] for digital signatures. NIST has also issued a public call for proposals for additional digital signature schemes for the Post-Quantum Cryptography Standardization Process [11].

With the emergence of quantum computers, the authenticity and security of blockchain systems are increasingly at risk. To address this, our research focuses on implementing post-quantum cryptographic algorithms on blockchain technology. For this purpose, we selected Hyperledger Fabric, a permissioned blockchain, and we have integrated the NIST finalist CRYSTAL-Kyber post-quantum cryptographic algorithm (PQC) to enhance the security of data stored on the blockchain through chain code, ensuring that all stored data is encrypted.

Implementation and evaluation of the performance and reliability in terms of latency and throughput for block creation of existing Post Quantum Cryptographic (PQC) Algorithm (lattice based) on Hyperledger Fabric permissioned blockchain is done.

2. Literature Survey

Post-quantum cryptography (PQC) has become a focal point in the field of cryptography due to the imminent threat posed by quantum computing. Quantum algorithms, such as Shor's algorithm, can break classical public-key cryptosystems like RSA, ECDSA, and DSA, which are commonly used in blockchain technology. As a result, researchers have been exploring quantum-resistant algorithms that could ensure the continued security of blockchain systems in a post-quantum era.

Several studies have explored the potential of integrating PQC into blockchain networks. These studies focus on implementing quantum-resistant cryptographic algorithms, evaluating their impact on blockchain performance, and ensuring the robustness of blockchain security in the face of quantum threats.

Tutoveanu, A. (2020**)** in "Active Implementation of End-to-End Post-Quantum Encryption," discusses the practical implementation of the Kyber algorithm using a NodeJS library for secure key encapsulation in blockchain applications. The research demonstrates that post-quantum encryption algorithms, specifically Kyber, can be effectively integrated into blockchain frameworks like Hyperledger Fabric, enhancing their security against quantum attack[21].

Hendy, Kevin, and Wicaksana, Arya(2022) , in their paper "Post-Quantum Hybrid Encryption Scheme for Blockchain Application," demonstrated the implementation of Kyber on Hyperledger Fabric. Hendy, Kevin, and Wicaksana, Arya have investigated the performance of the Kyber algorithm on blockchain using Caliper with 2 workers and 4 workers, noting a higher transaction failure rate with 2 workers, which was reduced with 4 workers[22].

T. M. Fernández-Caramès and P. Fraga-Lamas (2020), in their 2020 paper "Towards PostQuantum Blockchain: A Review on Blockchain Cryptography Resistant to Quantum Computing Attacks," explored the implementation of various post-quantum cryptographic algorithms[23].

Marel A., Luke G. Alex S Tao W & Tao H. (2023) in "A Survey on Post-Quantum Cryptography: State-of-the-Art and Challenges" analyses the different types of post-quantum cryptography, quantum cryptography and quantum-resistant cryptography. In this paper current post-quantum algorithms are discussed, and implementations are and suggested that currently better to use quantum-resistant cryptography[24].

Joppe B., Léo D. , Eike K. and et.al.(2018) in CRYSTALS – Kyber: a CCA-secure module-lattice-based KEM introduces Kyber (part of CRYSTALS - Cryptographic Suite for Algebraic Lattices), a portfolio of post-quantum cryptographic primitives built around a key-encapsulation mechanism (KEM), based on hardness assumptions over module lattices. The security of primitives is based on the hardness of Module-LWE in the classical and quantum random oracle models, and concrete parameters conservatively target more than 128 bits of postquantum security[25].

The literature highlights the growing importance of integrating post-quantum cryptographic algorithms like Kyber, SPHINCS+, and NTRU into blockchain systems. The hybrid encryption approach,

combining post-quantum and classical cryptography, is particularly promising for ensuring quantum resilience while managing performance bottlenecks. However, further research is needed to optimize these algorithms for real-world applications, including improvements in transaction throughput and reduction in latency.

3. Tools and Technologies

The following tools and technologies were explored during the research work:

Table 1. Technologies and tools used

Sr No	Technology / Tools	Purpose
1	**Hyperledger Fabric** Version 2.4 [16]	A permissioned blockchain framework designed for enterprise applications, supporting modular architecture and smart contracts.
2	**NodeJS for API** Version 14.0 [17]	APIs for Hyperledger Fabric facilitate seamless integration with external systems to interact with blockchain networks for data retrieval and transaction processing.
3	**Hyperledger Explorer** Version 1.1.8 [18]	A blockchain visualization tool that provides insights into Hyperledger Fabric networks, allowing users to monitor transactions, blocks, and network activity.
4	**Hyperledger Caliper** Version 0.6.0 [19]	A benchmarking tool for blockchain performance evaluation, designed to measure scalability and transaction throughput of Hyperledger frameworks like Fabric.
5	**Docker** Version 20.10 [20]	Docker is used in Hyperledger Fabric to facilitate easy deployment, scalability, and isolation of blockchain network components within standardized containers.

The work focused on creating a permissioned blockchain system to incorporate a postquantum secure algorithm, ensuring robust security through advanced computing methodologies.

Post-Quantum Cryptographic algorithm CRYSTALS-Kyber [12] is integrated into Hyperledger Fabric in a hybrid mode with the AES algorithm. CRYSTALS Kyber is an INDCCA2-secure key encapsulation mechanism (KEM), whose security is based on the hardness of solving the learning-with-errors (LWE) problem over module lattices [20]. Three different parameter sets aim at different security levels specifically, Kyber-512 aims at security roughly equivalent to AES-128, Kyber-768 aims at security roughly equivalent to AES-192, and Kyber-1024 aims at security roughly equivalent to AES-256.

Key Encapsulation Mechanism: Starting with the high-level functionality of Kyber is the Key Encapsulation Mechanism (KEM) which contains three core functions [21] as below:

1. **Key Generation**: KeyGeneration produces a pair of public and private keys.

   (pk,sk) = KeyGen()

2. **Encrypt/Encapsulate**: Encapsulation accepts a public key as an input, and then produces a random key and a ciphertext as the output.

   (c,ss) = Encrypt(pk)

3. **Decrypt/Decapsulate**: Decapsulation accepts a ciphertext and a private key and produces a key encapsulated in ciphertext as the output.

   ss = Decrypt(c,sk)

1. The server typically generates the initial public/private key pair and sends the public key pk to the client.
2. The client then generates a symmetric key ss (for 'shared secret') and an encrypted version of this key c (for 'cipher') with the public key from the server.
3. The encrypted symmetric key is sent to the server. The server then decrypts this with the initial private key and obtains the same symmetric key as a client.
4. It can also work vice-versa depending on which party generates the initial public/ private key pair.

The CRYSTAL-Kyber algorithm, with all three key sizes (Kyber-512, Kyber-768, and Kyber-1024), has

been integrated into the blockchain using a NodeJS library for developing chaincode. Chaincode in Hyperledger Fabric acts as a smart contract, defining the business logic that governs the interactions with the blockchain. By incorporating the CRYSTAL-Kyber algorithm into the chaincode, we ensure that every data transaction processed by the blockchain is quantum secured

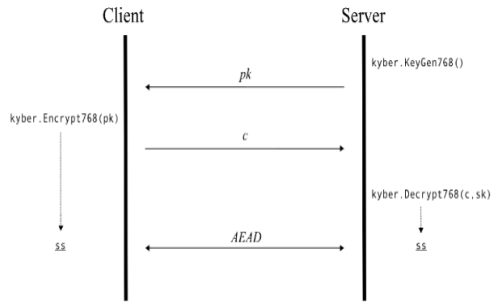

Figure 1. Mechanism of CRYSTAL Kyber

To integrate Kyber into Hyperledger Fabric, a network comprising 5 orderers and 3 nodes was configured on a Linux (Ubuntu 20.04) computer. Given the necessity to host all nodes and orderers on a single machine, Docker was employed for containerization.

Orderers: In Hyperledger Fabric, orderers are a critical component responsible for managing the consensus protocol, ensuring that transactions are validated and committed across the blockchain network. They maintain the ledger's integrity by ordering transactions into blocks and distributing them to endorsing peers for validation and endorsement.

Nodes: In Hyperledger Fabric, nodes refer to the peer nodes that maintain copies of the ledger and execute transactions. They participate in the consensus process, endorse transactions, and store a copy of the blockchain ledger.

4. Integration of CRYSTALS-Kyber with AES hybrid encryption

Post-Quantum Cryptographic algorithm CRYSTALS-Kyber [12] is integrated into Hyperledger Fabric in a hybrid mode with the AES algorithm. CRYSTALS-Kyber is an IND-CCA2-secure key encapsulation mechanism (KEM), whose security is based on the hardness of solving the learning-with-errors (LWE) problem over module lattices [20]. Three different parameter sets aim at different security levels specifically: Kyber-512 (roughly equivalent to AES-128), Kyber-768 (roughly equivalent to AES-192), and Kyber-1024 (roughly equivalent to AES-256). APIs are developed using NodeJS for communication with a Hyperledger Fabric blockchain involves suitable Fabric SDK for NodeJS such as fabric-network, and fabricclient. A connection profile (JSON file) is created to specify the network settings, including the addresses of orderers and peers, channel details, and authentication credentials.

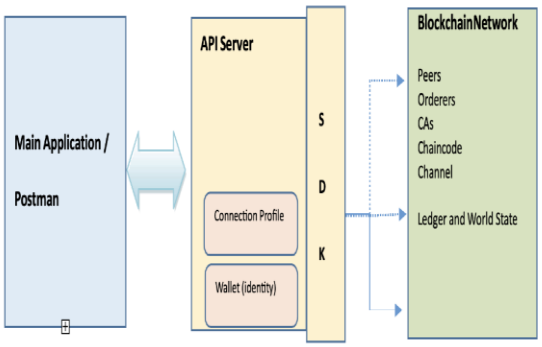

Figure 2. Application Communication with Application API and then API to blockchain

Hyperledger Explorer: Hyperledger Explorer is a blockchain visualization tool that displays a graphical dashboard for real-time monitoring of network activity, transaction throughput, and performance metrics.

1. **Transaction Monitoring**: Allows users to track and explore individual transactions, viewing transaction details and associated metadata.
2. **Block Inspection**: Provides visibility into blocks on the blockchain, showing block details and transactions contained within each block.
3. **Peer and Channel Management**: Enables management of peers and channels within the Fabric network, including configuration and status monitoring.

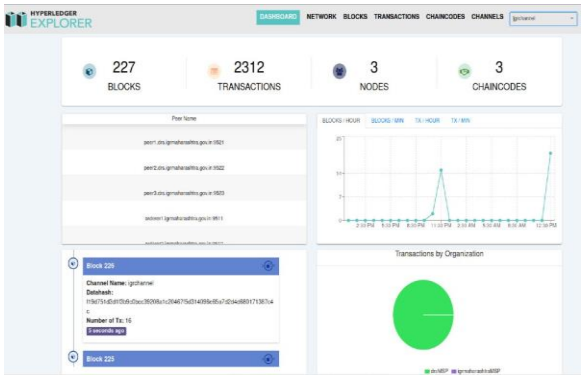

Figure 3. Hyperledger Explorer dashboard

Hyperledger Caliper: Hyperledger Caliper is a benchmarking tool designed to evaluate the performance of blockchain frameworks, including Hyperledger Fabric. This tool has performed comprehensive performance tests to measure transaction throughput and latency of Fabric networks under a predefined set of load testing.

5. Evaluation and Performance

Throughput (TPS) and average latency were evaluated using the integration of the Kyber algorithm at different security levels. Testing was done on 48 documents created and read without using Kyber and with different key sizes (Kyber-512, Kyber-768, Kyber-1024). It is observed that the average latency increased with larger key sizes. This trend is illustrated in table 2.

Table 2: Average Latency Comparison

Avg. Latency	**Plain Text**	**Kyber 512**	**Kyber 768**	**Kyber 1024**
Create Document	4.52	3.23	5.16	8.88
Read Document	2.8	2.59	3.44	4.94

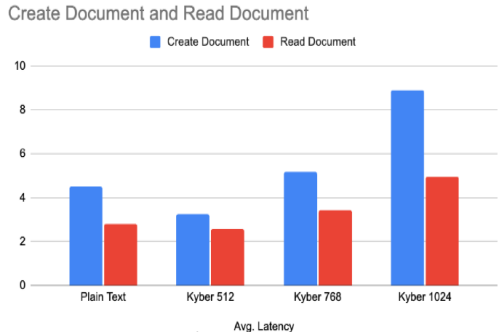

Figure 4. Chart - Average Latency Comparison

Table 3 : Throughput (TPS) Comparison

Throughput (TPS)	**Plain Text**	**Kyber 512**	**Kyber 768**	**Kyber 1024**
Create Document	1.9	2.3	1.8	2.5
Read Document	2.7	3.1	2.3	1.8

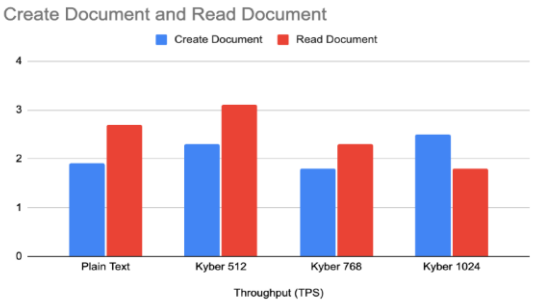

Figure 5. Chart – Throughput

In our study, we utilized the latest Caliper version 0.6 with 4 workers and found that no transactions failed to commit to the blockchain. The comparative results are illustrated in the table below.

Table 4. Comparison of latency and throughput with H. Kevin and W. Arya and our result

	Hendy, Kevin, and Wicaksana, Arya		**Our Results**
Caliper workers	**2**		**4**
	Read Document		
Failed Transaction	1451	24	0
Latency	0.04	0.04	3.44
Throughput	39.5	54.3	2.3
	Create Document		
Failed Transaction	86	33	0
Latency	1.43	11.67	5.16
Throughput	0.6	0.1	1.8

6. Conclusion

This research paper explored the integration of CRYSTALS-Kyber, a post-quantum cryptographic algorithm, with the AES encryption algorithm to provide enhanced security for blockchain systems. It is a practical and effective solution for blockchain applications to resist quantum attacks. Using the latest Caliper version for evaluation, we observed a slight delay in throughput; however, it ensures no transaction failures. Additionally, Kyber 512 produces faster results compared to storing data in plain text. Conversely, Kyber 768 and Kyber 1024 take longer to store data in the blockchain due to the increase in key size and data size. Future work will focus on optimizing the performance of the system for large-scale, high-throughput applications.

REFERENCES

1. Rivest, R. L., Shamir, A., & Adleman, L. (1978). A method for obtaining digital signatures and public-key cryptosystems. *Communications of the ACM*, 21(2), 120-126.
2. Certicom Research. (2009). SEC 1: Elliptic Curve Cryptography. *Standards for Efficient Cryptography*.
3. Miller, V. S. (1986). Use of elliptic curves in cryptography. *Lecture Notes in Computer Science*, 218, 417–426.
4. Diffie, W., & Hellman, M. E. (1976). New Directions in Cryptography. *IEEE Transactions on Information Theory*, 22(6), 644-654.
5. Schorr, M. (1989). Digital signatures. *The Digital Signature Algorithm (DSA)*.
6. Shor, P. W. (1997). Polynomial-time algorithms for prime factorization and discrete logarithms on a quantum computer. *SIAM Journal on Computing*, 26(5), 1484–1509.
7. Grover, L. K. (1996). A fast quantum mechanical algorithm for database search. *Proceedings of the 28th Annual ACM Symposium on Theory of Computing*, 212-219.
8. Bernstein, D. J., et al. (2017). Post-Quantum Cryptography. *Proceedings of the IEEE*, 105(11), 2293-2299.
9. National Institute of Standards and Technology (2016). *Post-Quantum Cryptography*.
10. NIST Post-Quantum Cryptography (2022). *Finalizing Post-Quantum Algorithms*.
11. National Institute of Standards and Technology (2021). *Call for Proposals on Post-Quantum Digital Signature Algorithms*.
12. Chen, L., et al. (2022). *CRYSTALS-Kyber: A New Post-Quantum Public-Key Encryption Standard*.
13. Dufresne, S., et al. (2022). *CRYSTALS Dilithium: Post-Quantum Digital Signatures*.
14. FALCON: Fast Fourier Lattice-Based Compact Signatures.
15. SPHINCS+: Stateless Hash-Based Signatures.
16. Arxiv: Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains (2018, January)
17. https://hyperledger-fabric.readthedocs.io/en/release-2.4/sdk_chaincode.html
18. https://blockchain-explorer.readthedocs.io/en/main/introduction.html
19. https://hyperledger.github.io/caliper/
20. Oded Regev. “On lattices, learning with errors, random linear codes, and cryptography.” Journal of the ACM, 56(6):1–40, 9 2009.
21. Tutoveanu, A. (2020). Active Implementation of End-to-End Post-Quantum Encryption. *Journal of Cryptography*, 23(4).
22. Hendy, Kevin & Wicaksana, Arya. (2022). Post-Quantum Hybrid Encryption Scheme For Blockchain Application. International journal of innovative computing, information & control: IJICIC. 18. 1701-1717. 10.24507/ijicic.18.06.1701.
23. T. M. Fernández-Caramès and P. Fraga-Lamas(2020), "Towards Post-Quantum Blockchain: A Review on Blockchain Cryptography Resistant to Quantum Computing Attacks," in IEEE Access, vol. 8, pp. 21091-21116, 2020, doi: 10.1109/ACCESS.2020.2968985, 01-2020
24. Marel A. , Luke G. , Alex S. , Tao W. , and Tao H.(2023). A Survey on Post-Quantum Cryptography: State-Of-The-Art and Challenges, arXiv, abs/2312.10430.

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Evaluating Performance and Developing a Novel Technique: A Combined Strategy for Cryptography and Steganography

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Abstract- *This paper presents an extensive study of cryptography and steganography algorithms, focusing on their performance evaluation and comparative analysis across various media, including images, audio, and video. Additionally, a novel crypto-stego technique is proposed by integrating cryptography and steganography algorithms. The proposed system aims to send encrypted secret messages to the receiver using cover images and employing AES-ChaCha20 and DWT-DCT algorithm. This innovative approach not only ensures the confidentiality of sensitive information but also maintains the integrity and quality of the cover medium, making it an effective tool for various applications in information security and covert communication.*

Keywords— *Cryptography, Steganography, Cover-Image, Stego-Image, Plain-Text, Cipher Text, AES, ChaCha20, LSB, DWT, DCT..*

I Research Objectives

1. Algorithm Analysis: Conduct a comprehensive study of various cryptography and steganography algorithms, including their underlying mathematical principles and practical implementations.
2. Performance Evaluation: Evaluate the performance of different cryptographic and steganographic algorithms in terms of security, capacity, computational efficiency, and resistance to attacks.
3. Comparative Study: Compare the performance of these algorithms across various media types, such as images, audio, and video, to identify their strengths, weaknesses, and optimal application scenarios.
4. Hybrid Technique Development: Develop a new technique that utilizes AES-ChaCha20 and DWT-DCT algorithm to embed multiple encrypted secret messages within a single cover image, ensuring secure and efficient communication.

II Introduction

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Information is a crucial resource for all computer and internet users, and each user aims to maintain their records with the highest level of security. Information security refers to the process of safeguarding information from unauthorized access. Two primary methods used to maintain information security are cryptography and steganography. Cryptography is a technique that converts readable text into unreadable text, often referred to as ciphertext, while steganography conceals secret data within a cover object to protect it from unauthorized access [1].

The transmission of confidential personal or financial information, especially banking details, poses considerable security challenges if intercepted by malicious actors. This vulnerability calls for strong protective measures to ensure user privacy and prevent potential financial crimes or identity fraud. To address the need for secure data transmission, specialized intermediary services have been developed, acting as a protective layer between senders and recipients. These third-party intermediaries play a vital role in preserving data integrity and confidentiality without accessing or altering the original content. By utilizing sophisticated encryption methods and secure protocols, these services guarantee that sensitive data remains safeguarded throughout the transmission process. This strategy not only boosts user confidence but also adheres to various data protection laws, such as GDPR and CCPA, which require strict safeguards for personal and financial data. The utilization of such intermediaries has become increasingly crucial in an age of escalating cybersecurity risks and mounting concerns regarding data privacy.

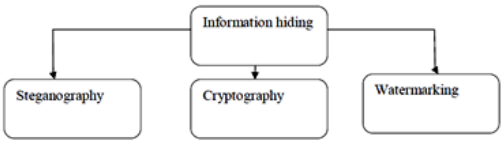


Fig.-1 Information hiding techniques

In today's world of ubiquitous digital communication, safeguarding transmitted information is crucial. Two key methods for enhancing data protection are cryptography and steganography. The former transforms data into an unreadable format for unauthorized individuals, while the latter hides the data's existence altogether. This research paper offers a thorough examination of these approaches, assesses their effectiveness, and proposes an innovative technique that merges both strategies to bolster security. The field of information security employs several common terms, including plain text, cipher text, cryptanalysis, encryption, and decryption [2].

A. Cryptography:

Cryptography is the field of study focused on secure message exchange between two parties over an unsecured channel by altering the original messages [3]. Without specific key knowledge, unauthorized access is not possible. In cryptographic processes, information is transformed from plaintext to ciphertext [5]. The message sender employs a key and an appropriate method to encode the data, converting it into ciphertext, which is a jumbled version of the initial message. This scrambled text is then sent to the recipient. Upon receiving the ciphertext, the recipient decodes it back into plaintext. The field of cryptography encompasses both symmetric and asymmetric key cryptographic systems [3].

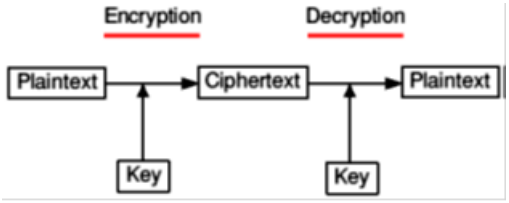


Fig.-2 Basic Cryptography Model

Types of Cryptography:

There are two types of cryptography:

1. **Symmetric Key cryptography:** This encryption method employs a single key for both the sender and recipient. The shared key enables each party to encode and decode information. Distribution of the key must occur before any data is transmitted [6]. Some well-known examples of this system include DES, 3DES, BLOWFISH, and AES, among others.

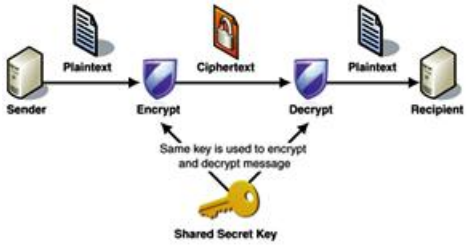


Fig.-3 Symmetric Key Cryptography

2. **Asymmetric Key Cryptography:** This cryptographic technique employs a set of two keys: a private one and a public one. The recipient keeps the private key secret, while the public key is made available to everyone. Upon receiving a message, the recipient uses the private key for decryption. In this system, a key is distributed to the other party before any information is exchanged [7]. Examples of such systems include RSA, ElGamal, ElGamal signature, Diffie-Hellman key exchange, and Digital signature.

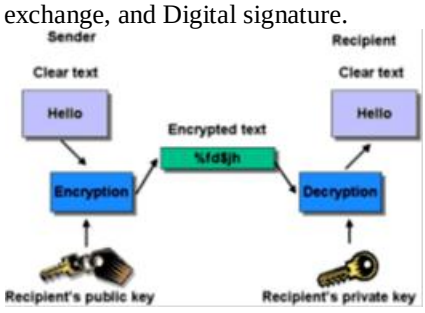


Fig.-4 Asymmetric Key Cryptography

B. Steganography:

Steganography is the study of concealed communication. It involves the practice of embedding covert messages within various media

files. The term "steganography" originates from Greek, signifying "hidden writing". The word "steganography" comprises two components: "steganos," denoting "secret or covered" (referring to the medium in which the covert messages are embedded), and "graphein," meaning "writing" (text). In the context of information concealment, steganography refers to the process of embedding text or covert messages within alternative media formats, like images, text, audio, and video [8].

Steganography has evolved significantly over time, adapting to various digital formats and technologies. In the digital age, steganographic techniques have become increasingly sophisticated, allowing for the embedding of information in a wide range of file types, including images, audio files, videos, and even network protocols. These advanced methods often leverage the inherent properties of digital media, such as the least significant bits in image pixels or the frequency domain of audio signals, to hide data without noticeably altering the host file's appearance or quality. This makes steganography a powerful tool for covert communication, digital watermarking, and protecting intellectual property. The applications of steganography extend beyond simple message hiding, encompassing areas such as cybersecurity, digital forensics, and data privacy. In cybersecurity, steganography can be used to create covert channels for data exfiltration or command and control communications, posing challenges for network defenders. Conversely, digital forensics experts employ steganalysis techniques to detect and extract hidden information from suspected files. In the realm of data privacy, steganography offers individuals and organizations a means to protect sensitive information from unauthorized access or surveillance. However, the dual-use nature of steganography also raises ethical and legal concerns, as it can be exploited for malicious purposes such as distributing malware or facilitating illegal activities [9][10].

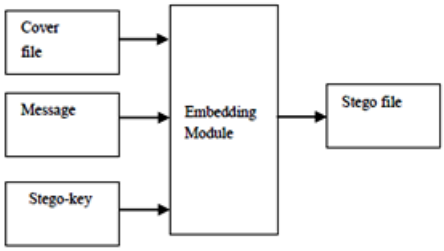


Fig.-5 Basic Steganography Model

Types of Steganography[11]:

- Image Steganography: A method of hiding confidential information within host images, which are then converted into stego-images.
- Text Steganography: This approach embeds the target message into a text document using formatting techniques. These include line-shift coding, word-shift coding, and feature coding. However, this method is less durable as text reformatting can destroy the embedded data.
- Audio Steganography: Covert messages are concealed within unused audio segments, as each audio file contains certain bits or bit areas that are not utilized and can store hidden information.
- Video Steganography: This technique involves separating the video into audio and image components, followed by embedding the secret message within the audio file.

Steganography Techniques[12]:

Several methods exist for categorizing Steganography techniques, as outlined below:

1. **Spatial Domain Methods:**This technique involves embedding secret information by altering the intensity of specific pixels in an image. The process of data concealment modifies certain pixel values. Direct pixel manipulation techniques are divided into LSB, BPCP, and PVD categories.
2. **Spread Spectrum Technique:**This approach utilizes spread spectrum principles to disperse secret data across a broad frequency range. Each frequency band must maintain a low enough signal-to-noise ratio to prevent detection of the hidden information. Even if data is extracted from several bands, sufficient information remains in other bands for data recovery. This makes complete data removal without damaging the cover challenging. Due to its robustness, this technique is widely used in military communications.
3. **Statistical Technique:**This method hides information by modifying specific attributes of the cover medium. The cover is divided into smaller segments, with each segment containing a single message bit. Modifications to the cover segment only occur when the message bit is one; otherwise, the segment remains unchanged.
4. **Transform Domain Technique:**This advanced technique conceals confidential information within the frequency or transform domain of the cover image. It employs various transformations and algorithms to embed secret data in the image[13]. Frequency domain embedding techniques are broadly categorized as:
   Discrete Fourier transformation technique (DFT)
   Discrete cosine transformation technique (DCT)
   Discrete Wavelet transformation technique (DWT)

5. **Distortion Techniques:** This technique conceals hidden messages by intentionally altering signals. The encoding process involves making a series of changes to the cover medium. To extract the concealed secret message, the decoding system compares the original and modified covers, thus identifying the sequence of alterations[14].

III. Performance evaluation of Cryptography and Steganography for Various Media

A. Performance evaluation of Cryptography Algorithms for various media[15]:

Methodology:

The methodology for this study encompasses a comprehensive approach to investigating encryption and decryption algorithms, specifically focusing on AES and RSA. The research process begins with data characterization, which involves analyzing the properties and structure of the media files used in the simulations. This step is crucial for understanding how different types of data may affect the performance of encryption algorithms. Following this, the study implements the selected encryption and decryption algorithms within a C#.NET programming environment, allowing for a controlled and replicable testing scenario. The simulation phase involves applying the AES and RSA algorithms to various media files, likely including different formats and sizes to ensure a thorough evaluation.

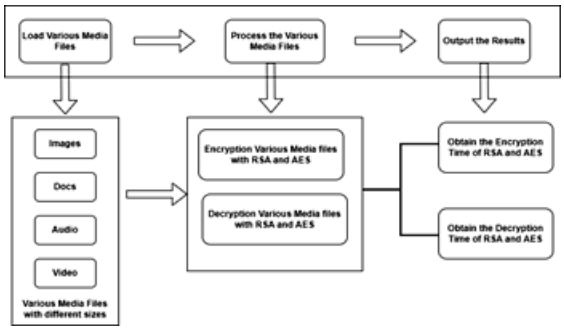


Fig.-6 Simulation Flows of the Selected Cryptographic Algorithms

Results and Analysis:

To analyze the results, various media such as images, audio, video, and doc files of different sizes were used for experimentation with the AES and RSA encryption algorithms.

Table – 1.displays the duration, measured in milliseconds, required for encryption and decryption processes using the chosen algorithms (AES and RSA).

Sr. No	File Type	Algorithm	File Size (MB)	Encryption Time (Milliseconds)	Decryption Time (Milliseconds)
1	Image	AES	1	6	2
			2	12	3
			5	25	5
			10	52	11
		RSA	1	63	4
			2	67	7
			5	81	10
			10	102	16
2	Doc	AES	1	7	2
			2	10	5
			5	23	8
			10	48	10
		RSA	1	75	3
			2	83	8
			5	96	10
			10	103	13
3	Audio	AES	1	5	2
			2	9	3
			5	22	6
			10	49	11
		RSA	1	65	2
			2	71	5
			5	84	8
			10	108	13
4	Video	AES	1	5	2
			2	10	3
			5	22	5
			10	46	10
		RSA	1	65	3
			2	73	5
			5	93	8
			10	106	11

Table 1 provides a comparative analysis of the time efficiency of two widely used encryption algorithms: AES and RSA. The data presented in the table quantifies the duration, in milliseconds, for both the encryption and decryption processes using these algorithms. This information is crucial for understanding the performance characteristics of these cryptographic methods in practical applications. By examining the encryption and decryption times, researchers and developers can make informed decisions about which algorithm is more suitable for specific use cases. For instance, AES is generally known for its faster processing times, especially for larger data sets, making it ideal for scenarios requiring rapid data protection. On the other hand, RSA, while typically slower, offers unique advantages in key exchange and digital signatures. The precise timing data in Table 1 allows for a nuanced comparison, considering factors such as key size, data volume, and the specific implementation of each algorithm, which can significantly impact their performance in real-world cryptographic systems.

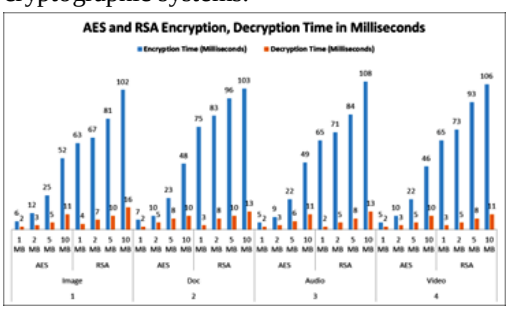


Fig.-7. Presents a graphical representation comparing the time required for encryption and decryption processes using two selected algorithms: AES and RSA.

B. Performance evaluation of Steganography Algorithms for various media[16]:

Methodology:

The Least Significant Bit (LSB) steganography algorithms were implemented and simulated using Python, a versatile programming language well-suited for data manipulation and image processing tasks. The simulation involved the use of diverse media files, including images, audio, and potentially video formats, to comprehensively test the algorithms' performance across different file types. This approach allowed for a thorough evaluation of the LSB techniques' effectiveness in various scenarios and media contexts by conducting an embedding methodology, as shown in Figure-8. To quantitatively assess the performance of the LSB steganography methods, two key metrics were employed: PSNR and MSE.

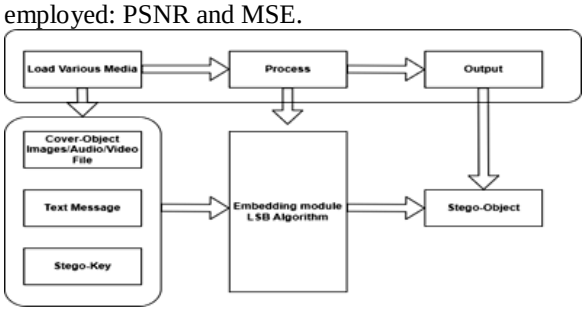


Fig.-8 Embedding Methodology of the Selected Steganography Algorithms

Results and Analysis

To analyse the results, various media, including images, audio, and video files of different sizes, were utilized for experimentation with the LSB steganography algorithms. The following table and graph were employed to showcase the PSNR and MSE of the selected algorithms for various media.

Table – 2.exhibits the PSNR and MSE of the selected algorithms for various media

Sr. No	Cover File Type	Cover File Size in MB	Text Message	MSE	PSNR in db
1	Image	1	Welcome To Sandip University Nashik	8.9	98.63
		2		3.88	102.23
		5		1.59	106.1
		10		1.45	108.49
2	Audio	1		1.29	97.48
		2		0.19	98.59
		5		0.073	101.36
		10		0.029	105.58
3	Video	1		6.04	90.32
		2		5.64	90.61
		5		5.53	90.72
		10		5.25	90.95

A comprehensive comparison of PSNR and MSE values for various algorithms across different media types is presented in Table 2. These metrics play a vital role in assessing the effectiveness and quality of image and video processing methods. The PSNR, expressed in decibels (dB), measures the relationship between the maximum possible signal strength and the strength of corrupting noise, with higher readings indicating superior quality. In contrast, the MSE calculates the mean squared deviation between the original and processed media, where lower figures denote better performance.

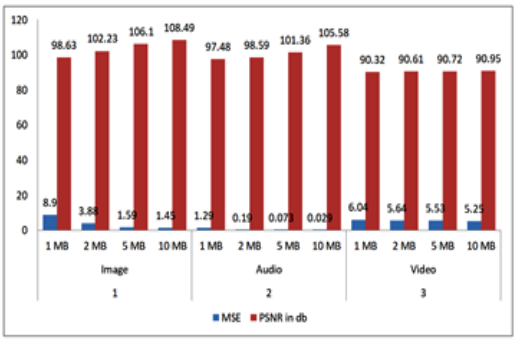


Fig.-9 showcases a graph depicting the PSNR and MSE of the selected algorithms for different media

V. Designing a New Crypto-Stegno Technique

The use of cryptography and steganography for secure communication involves integrating both techniques to enhance the security of communication. The project's aim is to develop a cross-platform tool that effectively conceals a message within a digital image file in a secure and sturdy manner [17]. This is demonstrated in figure-10, which illustrates the combined concept of cryptography and steganography.

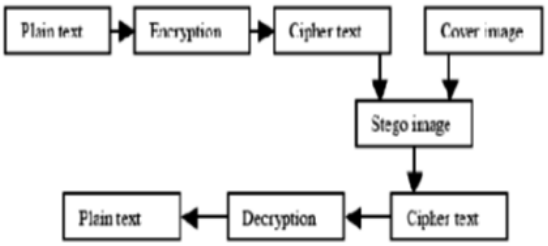


Fig.-10 Combination of Cryptography and Steganography

Methodology:

This innovative approach leverages the strengths of multiple cryptographic and steganographic techniques to create a robust system for concealing sensitive information. The AES-ChaCha20 encryption ensures that the hidden text is securely encrypted before embedding, while the combination of DWT and DCT algorithms provides a high-capacity, imperceptible steganographic method [18]. By integrating these advanced techniques, the proposed system offers superior resistance against various steganalysis attacks and maintains the visual quality of the cover image. The proposed methodology for this research involves two main Phases are as follows.

Phase – I Embedding process using cryptography and steganography

The study seeks to develop a novel crypto-stego method by integrating cryptography and steganography algorithms. This approach is anticipated to enhance security beyond current techniques by implementing a dual-layer protection for hidden communication. By merging the AES-ChaCha20 hybrid encryption technique with Transform Domain Techniques in steganography, the researchers expect to create a multi-tiered security framework for protected information exchange. This strategy aims to ensure that concealed encrypted messages are undetectable within the cover image, thus offering an efficient solution for secure communication[19].

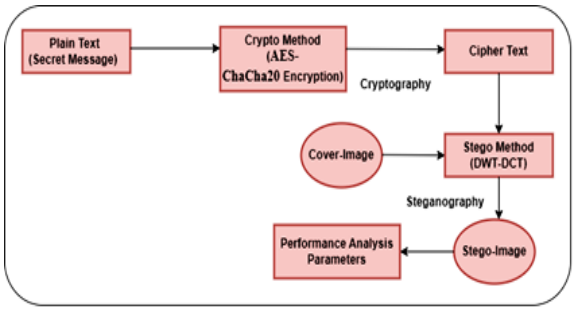


Fig-11 Crypto-Stego Encryption and Embedding Model

Phase – II Extracting process

Extraction of the concealed message necessitates the reversal of the embedding process. The decryption process begins with the application of the inverse DWT-DCT transformation to extract the embedded cipher text from the stego-image. Once retrieved, the cipher text undergoes decryption using the AES-ChaCha20 hybrid algorithm, effectively reversing the encryption process. The final step involves the conversion of the decrypted data back into its original format, thereby restoring the concealed message to its initial state[20].

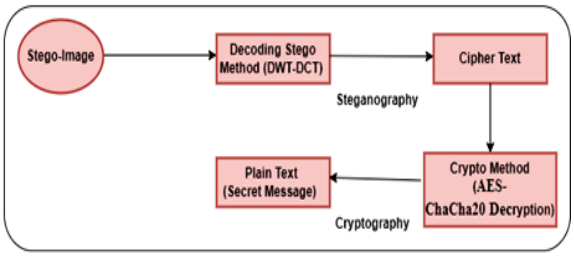


Fig-12 Crypto-Stego Extraction and Decryption Model

Proposed Crypto-Stego Algorithm:
Embedding Algorithm
Input: A text file and a cover-image
Output: A stego-image
Steps:

1) Inspect the cover-image and the text file intended for embedding within it.
2) Utilize the AES-ChaCha20 algorithm to encrypt the sensitive message, converting plain-text to cipher-text.
3) Transform the cipher-text into binary format.
4) Segment the cover image into four equal blocks (N*N).
5) For each block, perform the following:

   i) Separate the block into R (red), G (green), and B (blue) channels and select one based on the highest color ratio.

   ii) Apply Haar wavelet transform to decompose the chosen block.
6) Preprocess the hiding image by dividing it into four equal parts (M*M).

7) Apply DWT-DCT transform to each part across all three channels (R, G, and B).
8) Embed the DWT-DCT coefficient of part 1 into the high sub-band {HH} of part 1 of the cover image. Repeat this step for all hiding image parts, concealing them in all {HH} parts of the cover image.
9) Reconstruct the image using inverse Haar wavelet transform on each part.
10) Merge each part with the other two channels, then combine all four parts together.

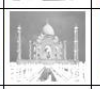
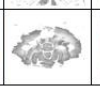
Retrieval Algorithm
Input: Stego-image
Output: A confidential message
Steps:

1) Select the steganographic image or stego-image.
2) Divide the image into four equal sections and determine the chosen channel for each section.
3) Apply Haar wavelet transform to decompose each section.
4) Retrieve concealed components from all four (HH) sub-bands.
5) Utilize IDWT-IDCT to transform each component back to the spatial domain.
6) Merge and show the cipher-text.
7) Apply the AES-ChaCha20 algorithm to decrypt the encoded message and convert it to plain text.
8) Obtain the confidential message.

Experimental Result

To comprehensively evaluate the efficacy of our proposed algorithm, we utilized various performance metrics in our experimental analysis. The key indicators employed were PSNR, MSE, and SNR. PSNR serves as a widely adopted measure for assessing reconstructed image quality, with higher values denoting superior quality. MSE computes the mean squared deviation between the original and processed images, where lower values indicate enhanced performance. SNR measures the ratio of desired signal to background noise, with higher ratios signifying improved signal quality.

Table-3. Efficiency Parameter of Proposed Method for Text File.

Sr. No	Cover Image	DCT-Image	DWT-Image	Proposed DCT-DWT Stego-Image	MSE	PSNR in db	SNR in db
1					0.00043	87.57	85.27
2					0.0012	87.11	84.13
3					0.0042	85.98	83.81
4					0.0093	84.53	82.51
5					0.014	82.25	80.21

The efficiency parameters for a proposed text file steganography method are displayed in the table-3. It evaluates the effectiveness of various image processing techniques, including DCT, DWT, and a combined DCT-DWT approach. Three primary metrics are used to assess efficiency: MSE, PSNR, and SNR. The table showcases efficiency levels across five distinct scenarios. MSE values range from 0.00043 to 0.014, with higher values indicating greater distortion in the stego-image. Conversely, PSNR and SNR values decrease from 87.57 dB to 82.25 dB and 85.27 dB to 80.21 dB, respectively. This inverse correlation between MSE and PSNR/SNR is anticipated, as lower MSE typically corresponds to higher PSNR and SNR, signifying superior image quality and less detectable alterations in the stego-image. The data indicates that the proposed method maintains high efficiency, particularly in the initial two scenarios where elevated PSNR and SNR values suggest minimal deterioration of the cover image while successfully concealing the embedded information.

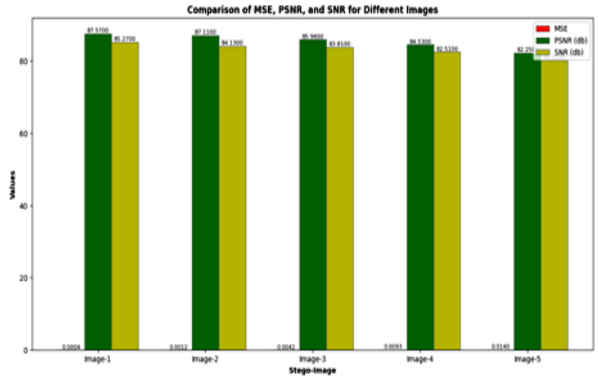


Fig.-13 MSE, PSNR and SNR of Proposed Method for Text File

VI. Comparative Analysis with Other Model

The proposed cryptographic-steganographic approach combines the strengths of AES-ChaCha20 encryption with DWT-DCT steganography algorithms to enhance the security and imperceptibility of concealed text in digital images. This hybrid method aims to address the limitations of individual techniques by leveraging the robustness of AES encryption, the speed of ChaCha20, and the spatial-frequency domain advantages of DWT-DCT. The integration of these algorithms potentially offers improved resistance against steganalysis attacks while maintaining high image quality and embedding capacity.

Table-4 Comparison of Average PSNR, MSE And SNR Values Between Our Model And Other Model

Parameters	Deepak Sharma 2014[21]	A.H.M. JaffarIqbalBarbhuiya 2018[22]	K. M. Hosny 2021[23]	De Rosal Ignatius Moses Setiadi 2023 [24]	Proposed Model
Average PSNR	36.74928	48.0489	30.4091	37.6877	85.488
Average MSE	8.5431	5.0024	0.005	12.6987	0.005826
Average SNR	NULL	42.057	NULL	NULL	83.186

The comparison presented in Table-4 provides a comprehensive evaluation of various image processing models, focusing on three key performance metrics: PSNR, MSE, and SNR. These metrics are crucial in assessing the quality of image reconstruction or enhancement techniques. The table compares the performance of the current model with four other models developed by researchers between 2014 and 2023, namely Deepak Sharma (2014), A.H.M. JaffarIqbalBarbhuiya (2018), K. M. Hosny (2021), and De Rosal Ignatius Moses Setiadi (2023). By presenting average values for PSNR, MSE, and SNR, the table allows for a direct comparison of the models' effectiveness. Higher PSNR and SNR values generally indicate better image quality, while lower MSE values suggest less deviation from the original image. This comparison not only highlights the progress made in image processing techniques over the years but also positions the current model within the context of recent advancements in the field. Such a comparison is valuable for researchers and practitioners in image processing, as it provides insights into the relative strengths of different approaches and helps identify areas for potential improvement in future work.

Conclusion:

This research delves into the intricate world of cryptography and steganography, offering a comprehensive analysis of various algorithms and their effectiveness across different media types. The study goes beyond mere examination, proposing an innovative crypto-stego technique that combines the strengths of both disciplines. By integrating steganography, which conceals the existence of information, with cryptography, which secures the content itself, the research aims to create a more robust and multi-layered approach to data protection. This synergistic combination has the potential to significantly enhance the security of communication systems, addressing the growing concerns of data breaches and unauthorized access in our increasingly digital world. The proposed two-tiered security strategy is designed with both effectiveness and user-friendliness in mind. It employs the DWT-DCT algorithm for image steganography, offering a balance between simplicity and efficacy in hiding information within images. For the encryption and decryption layers, the research utilizes the AES-ChaCha20 algorithm, known for its strong encryption capabilities. This dual approach not only provides a high level of security but also ensures that the system remains accessible to users with varying levels of technical expertise. The study's rigorous evaluation of the proposed algorithm across different media types, using metrics like MSE, PSNR, and SNR, demonstrates a commitment to thorough validation and practical applicability in real-world scenarios.

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REFERENCES

1. Rivest, R. L., Shamir, A., & Adleman, L. (1978). A method for obtaining digital signatures and public-key cryptosystems. *Communications of the ACM*, 21(2), 120-126.
2. Certicom Research. (2009). SEC 1: Elliptic Curve Cryptography. *Standards for Efficient Cryptography*.
3. Miller, V. S. (1986). Use of elliptic curves in cryptography. *Lecture Notes in Computer Science*, 218, 417–426.
4. Diffie, W., & Hellman, M. E. (1976). New Directions in Cryptography. *IEEE Transactions on Information Theory*, 22(6), 644-654.
5. Schorr, M. (1989). Digital signatures. *The Digital Signature Algorithm (DSA)*.
6. Shor, P. W. (1997). Polynomial-time algorithms for prime factorization and discrete logarithms on a quantum computer. *SIAM Journal on Computing*, 26(5), 1484–1509.
7. Grover, L. K. (1996). A fast quantum mechanical algorithm for database search. *Proceedings of the 28th Annual ACM Symposium on Theory of Computing*, 212-219.
8. Bernstein, D. J., et al. (2017). Post-Quantum Cryptography. *Proceedings of the IEEE*, 105(11), 2293-2299.
9. National Institute of Standards and Technology (2016). *Post-Quantum Cryptography*.
10. NIST Post-Quantum Cryptography (2022). *Finalizing Post-Quantum Algorithms*.
11. National Institute of Standards and Technology (2021). *Call for Proposals on Post-Quantum Digital Signature Algorithms*.
12. Chen, L., et al. (2022). *CRYSTALS-Kyber: A New Post-Quantum Public-Key Encryption Standard*.
13. Dufresne, S., et al. (2022). *CRYSTALS Dilithium: Post-Quantum Digital Signatures*.
14. FALCON: Fast Fourier Lattice-Based Compact Signatures.
15. SPHINCS+: Stateless Hash-Based Signatures.
16. Arxiv: Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains (2018, January)
17. https://hyperledger-fabric.readthedocs.io/en/release-2.4/sdk_chaincode.html
18. https://blockchain-explorer.readthedocs.io/en/main/introduction.html
19. https://hyperledger.github.io/caliper/
20. Oded Regev. "On lattices, learning with errors, random linear codes, and cryptography." Journal of the ACM, 56(6):1–40, 9 2009.
21. Tutoveanu, A. (2020). Active Implementation of End-to-End Post-Quantum Encryption. *Journal of Cryptography*, 23(4).
22. Hendy, Kevin & Wicaksana, Arya. (2022). Post-Quantum Hybrid Encryption Scheme For Blockchain Application. International journal of innovative computing, information & control: IJICIC. 18. 1701-1717. 10.24507/ijicic.18.06.1701.
23. T. M. Fernández-Caramès and P. Fraga-Lamas(2020), "Towards Post-Quantum Blockchain: A Review on Blockchain Cryptography Resistant to Quantum Computing Attacks," in IEEE Access, vol. 8, pp. 21091-21116, 2020, doi: 10.1109/ACCESS.2020.2968985, 01-2020
24. Marel A. , Luke G. , Alex S. , Tao W. , and Tao H.(2023). A Survey on Post-Quantum Cryptography: State-Of-The-Art and Challenges, arXiv, abs/2312.10430.

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Rural Economy and Weekly Market

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Abstract *-Weekly markets serve as venues for the exchange of goods and services among residents of a specific geographical area at regular intervals. In rural areas, these markets play a vital role in connecting local economies to regional and national socio-economic systems. Called "weekly markets" because they occur on a designated day each week, they typically lack permanent shops. Instead, traders set up temporary stalls during the day and pack up by evening. For generations, these markets have been instrumental in fostering the growth of the rural economy. Not much research can be found in this area. The researcher in this paper has tried to study and understand the working of weekly market and the role it plays in the rural economy. An insight is also given into the various facilities provided in the weekly market.*

Keywords *– Ancient Market, Haat, Marketing, Weekly Market*

Introduction

From the first stage of development of human culture till the agricultural era, man was self-reliant. But with the agricultural era, a new civilization developed. From the agricultural era itself, collective life started, from which cooperation was born. This collective and cooperative way of life also gave birth to many new needs. To fulfill it, some people with strength, ability and creativity in this society came forward. To satisfy those new needs, they started some construction and were called workers. Workers started producing the goods in which they were skilled. Due to this, some goods were produced in much larger quantities than others. Needs were for more things than the man produced. Hence, barter system developed where one man exchanged his goods for that of another man. In this way, mutual exchange developed. To overcome the problems caused by the barter system, currency came into existence. Yet the use of the barter system continued to be mostly continued because all human groups accepted some object or substance as currency. Gradually, a place started to be created for the mutual exchange of goods, as a result of which weekly markets were born. The importance of these markets increased and along with local markets, organized markets were established at various places.

Concept of weekly market

Weekly markets are an old concept traditionally practiced in rural areas. The economic cycle in rural areas is mainly based on the concept of Balutedari and later on the concept of weekly markets. The Balutedari system has disappeared. But even today the main center of economic turnover in villages is the weekly market. The sale of agricultural products is a bigger appeal of farmers rather than the production of agricultural products. The chain of intermediaries is a big cut in the pockets of farmers. For this, if the agricultural products reach directly from farmer to consumer, the consumers will get good goods and farmers will also get enough money. So it was decided to implement the idea of holding weekly markets in urban areas.

Inspired and under the guidance of the Agricultural Technology Management System, after completing other procedures, a plan was made to organize weekly markets in urban areas. Farmer groups/associations, farmer producer companies, and individual farmers were brought together to organize weekly markets in planned areas of the city. It started receiving a good response. Today, with the initiative of these youth, weekly markets are organized every day of the week in different places in the city, which is benefiting farmers and consumers. Today, twenty-five farmer groups, farmer producer companies, and individual farmers producing agricultural products are associated with the company, and this success is being achieved due to the guidance and encouragement of the Agriculture Department, Marketing Board, and Atma.

In this, the problem of transportation soon arose to send surplus goods from one place to another. Man invented the wheel and developed rapid transportation, and at the same time, there was considerable development in marketing-related facilities. Marketing did not develop simultaneously all over the world, some nations produce more than their needs, while some nations cannot produce even according to their needs. As a result, countries that produce surplus sell their surplus produce to others. Sales are made within the country, which leads to modern forms of marketing today.

Meaning of Marketing

Marketing is generally the transaction of goods or their purchase and sale. Before 1950, the same ideology was prevalent. Both buying and selling were included in marketing, but later new ideas became prevalent in marketing, in which the method of trying to satisfy the customer was given importance and it was believed that if the customer was satisfied, then the sale begins.

Objectives of the Study:

1. To understand the rural economy and working of weekly market.
2. To study the need for and importance of weekly market in rural economy.
3. To study the facilities provided by weekly markets.

Nature of Ancient Market

In ancient times, international trade was carried out from India and various types of goods were taken abroad. In addition to land trade with Afghanistan, Persia and Central Asia through Multan, Kota and the Khyber Pass, goods were also taken to Persia through the Coromandel Coast. Even in the Middle Ages, commercial activities in India were very extensive and its goods were sent abroad. Apart from this, local traders also met the needs of consumers within India. Traders used to buy and sell consumer goods through small markets, hawkers, fairs in every village. The Banjaras of Rajputana were very famous for selling sugar. They used to make caravans and do marketing work from one village to another. Every village had a small market called a weekly market. In addition, many people and traders from nearby villages and towns used to come to the annual and periodical fairs and there was a lot of trade. There were many hawkers and other such traders. Apart from catering to the needs of the customers, Rajputana had its famous bazaars which carried all kinds of goods like grains, sugar, butter, salt, etc., loaded on hundreds of bullocks. Sometimes these caravans would consist of 40,000 bullocks. The traders also used to travel here and there in caravans, which was very protective for them. They visited big market established in countries like Multan and Lahore and administrative and political active capital Delhi.

Before the Mughal period, this province used to send wheat, barley, cotton clothes and horses to various provinces of India and in return rice, sugar, sugarcane, wood and spices were demanded. This trade process increased, but during the British rule, the British tax policy reduced the trade of Indian traders. The British selflessly developed means of transport and routes, which laid the foundation for the development of the marketing system of modern India. Sugar and sugarcane have been exported from India since ancient times. Sugarcane was produced in low-lying areas like Bihar, Uttar Pradesh, Bengal and Maharashtra in India. Fertilizer, jaggery and sugar making industries also started in this area. The marketing work of sugar and jaggery also started from these areas, but due to the lack of automated sugar industries, good quality sugar was not produced. In 1932, 'Hindustan Sugar Mills' was established as a small-scale industry in Lakhimpur Kheri district. Therefore, the work of selling sugar

started on a large scale from this area. The marketing of sugarcane used in sugar production started from this and currently due to the scientific development of sugar industries, competition has arisen in sugarcane marketing. Various large sugar industries as well as small sugar and khandsari and jaggery industries use sugarcane as raw material. And farmers also buy improved varieties of sugarcane in the form of seeds, so many options are available to farmers for selling sugarcane.

The process of buying and selling has been prominently included in marketing, because the people and services involved in buying and selling cannot be separated from them, so they are also a part of marketing. The importance of weekly markets for this buying and selling has increased to a great extent. Also, in modern times, marketing includes creating demand for goods. Growth is included in the field of marketing, while maintaining the supply of goods as required is also included in the field of marketing. Thus, the marketing process of sugarcane and sugar and the overall market have been studied by considering the modern ideas of marketing. The basis of the marketing process is the market. Therefore, the market of sugarcane and sugar has also been studied in this.

Origin of the Word Market

The word market is derived from the Latin word 'Marcates' which means a place of trade or commerce. Economists define a market as a place where there is a demand for a product and it is offered for sale. From an economic point of view, a market is generally taken to mean an entire area in which buyers and sellers are spread out and there is competitive contact between them, but some economists do not associate a market with a specific place and consider the entire area. The area where buyers and sellers are spread out as a market.

Core of Rural Market Economy

The rural market is the backbone of the rural economy in India. Daily needs are fulfilled through the rural as well as weekly markets. In every village and ward, two to four shops are definitely opened from which food and other small necessities are supplied. Some people get employment from these shops. Mills also provide employment. Say, in a flour mill, more than one person is employed and the needs of the residents of that village and the surrounding area are met. These types of retail shops cannot be given the nature of a market, but in the past, along with cash sales, exchange of goods in exchange for grain was also done in these shops. But today only cash transactions are seen. Some items are available in the market daily and some are available in the market weekly. Jalgaon district also has a similar system.

In some gram sabhas, a weekly or bi-weekly haat bazaar is also organized, in which the residents of a radius of 5 km benefit. In these haats or weekly bazaars, the farmer fulfills his needs by trading according to his weekly needs. Generally, he sells a small part of his produce (grains) in these bazaars and buys food, clothes and other essential items from them. The practice of such bazaars seems to be more prevalent. This bazaar is a boon for the local residents. Such bazaars are also organized at various villages, towns, taluka levels and district levels throughout Jalgaon district and are popular.

There are approximately 543 bazaars organized in the entire division, which have no registration. These bazaars are organized under the auspices of some local influential person. In some areas, fairs are organized annually or monthly and on some festival days, in which the locals are also catered to. Currently, due to the population on the roadside, permanent small markets have developed in some small towns and shops have developed in them to meet agricultural activities and essential needs. These markets are not registered, so organized markets are not seen here, but encroachment on the roads is definitely visible. But local needs are fulfilled within a radius of 8 to 10 km. From small items to house construction materials are available here. Such markets are operating throughout the district. Such small and big markets are developed in Jalgaon district. These markets can be called the backbone of the rural economy.

From these small markets, some big markets are developed in local villages and they are registered in the district panchayat and some markets are developed as a sector. Food items, agricultural essentials, medical facilities, clothes, house building materials, jewelry, entertainment equipment and all other similar items are available in these weekly markets. Farmers can sell their

products here at any time. These markets also provide employment opportunities to the local residents. There are registered markets in Jalgaon district at Bhusawal, Yawal, Chopda, Parola, Chalisgaon, Muktainagar, Bodwad, Dharangaon, Anjale, Paldhi, Bamnod etc.

The entire rural economy in Jalgaon district depends on various types of market systems. If the markets that run these rural economies are regulated and controlled, then the rural market and the rural economy will definitely get a strong support. Sheds should be arranged for shopkeepers in rural markets, platforms should be built, small markets should also be registered, the concerned Gram Panchayats should arrange drinking water, toilets, sanitation, electricity and security so that small markets get an opportunity to develop.

By eliminating the problems like roads, electricity, sanitation, toilets, security, unhealthy business competition in the city markets, these markets can also develop as rural market centers. If these basic facilities are provided by the Gram Panchayat, Municipality, Municipal Corporation in the weekly market as well, it will be convenient for the sellers and the customers as well.

A wholesale market should be established near the vegetable production area for the purchase of various agricultural products such as perishable agricultural products. The sectional sales centers for fresh vegetables have not yet started in the state. If such a center is established, the farmers will directly benefit and they will get a fair price for their crops and their financial condition will improve, the government should immediately allow such centers. Also, if the government pays attention to the facilities and develops markets in the weekly market, it will benefit the small farmers and traders who come from rural areas to sell.

Conclusion

In conclusion, it can be said that rural and weekly markets are the backbone of the rural economy. Whether the market is rural or urban, the economic development of the city is also possible due to it. And therefore, this is my small attempt to draw the attention of the government to the development of these markets, which I hope will definitely be successful.

REFERENCES

1. Chopra, P.N., Madhuri, B. N. Madhuri and Das M. N. (1975). *Social, Cultural and Economic History of India*. Part-2. Pp 101, 107,109.
2. Converse, Hulgy & Mitchell (1973). *The Elements of Marketing*. pp 16
3. Hamson, H.L. (1974). *Marketing text techniques and cases*. pp. 4
4. Jain, K. P. (2003). *Principles of Economics*. pp No. 4/1
5. Mc Carthy, E. Jerome. *Basic Marketing*. pp 33
6. Mehta, J.K. (1967). *Advanced Economic Theory*. pp 97
7. Pyle. (1967). *Principal of Marketing*. pp 1

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Evaluating Space Efficiency in Academic Libraries: Modern Perspectives

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Abstract *-Academic libraries play a crucial role in supporting education and research by providing diverse resources and fostering effective learning environments. This study aims to evaluate the effectiveness of academic library spaces through advanced methods of measuring space efficiency, with a focus on user experience and environmental factors. The research identifies strategies for addressing space constraints, such as optimizing collections and enhancing digital resources. Key recommendations include thoughtful design, ensuring resource availability, and creating excellent user experiences, supported by clearly defined assessment criteria centered on organization, safety, and accessibility.*

Prominent examples, like the Singapore National Library and MIT's DAMS Library, illustrate how technology can enhance library services and address challenges related to space wastage and digital demands. The findings underscore the importance of regular evaluations of space efficiency to improve service quality and adapt to the evolving needs of the academic community. Future research should investigate the potential of artificial intelligence and machine learning to analyze user behaviors, promoting user satisfaction and environmental sustainability in library design.

Keywords *- Academic libraries, Space efficiency, Library design, User experience, Smart libraries, Technology integration, Space assessment, Environmental sustainability, Resource management, Library services*

Introduction

Academic libraries play an important role in education and research. They are not just museum of books and reference materials but also a vibrant center of knowledge. These libraries include a variety of materials such as books on different subjects, periodicals, research papers, e-books, online databases, and multimedia resources. This helps student's access information related to their courses, while enabling teachers and researchers to stay updated on the latest developments and research in their fields.

Academic libraries are not limited to providing information they also create a social and intellectual environment. They offer students calm and inspire them to come together to study, discuss, and work on collaborative projects. Modern academic libraries are equipped with technologies that help to develop digital literacy skills and provide access to global knowledge resources. In this way, academic libraries are not just sources of information but also play a significant role in creating a holistic educational and research environment within academic institutions.

Why is Space Evaluation Necessary?

Space evaluation is critical for library efficiency. Proper evaluation allows the library to meet the user needs. It is essential to plan spaces considering the specific requirements of various users such as students, teachers, and researchers. For instance, students may need a quiet space for studying, while researchers may require a separate area equipped with reference materials and research tools. Appropriate space evaluation makes it possible to meet all these requirements. In addition, space

evaluation ensures efficient use of the institution's resources. With proper planning, the available space can be utilized for its maximum potential, and unnecessary expenses can be avoided.

For example, it's important to maintain balance between study spaces, storage areas, and places for using digital resources. In addition, its necessary to plan flexible spaces with future growth, evaluating the space is crucial for the long-term success of the library and the satisfaction of its users.

Research Objectives

The main focus of the research objectives is to evaluate the effectiveness of academic library spaces and study modern perspectives. This study aims to take a comprehensive approach to space evaluation by considering various aspects. This includes the use of different methods to measure efficiency, incorporating technology, user experience, and environmental considerations. By studying these components together, this study seeks to find modern criteria and solutions for evaluating spaces. The significance of this study lies in its potential to improve the effectiveness of academic libraries. By developing new approaches and methods to assess space usage, this research can help libraries to use their resources more effectively. Moreover, by incorporating user experience and environmental considerations, this study can assist libraries in creating a more convenient and sustainable environment. Thus, this research can make a significant contribution to the future development of academic libraries.

Literature Review

Libraries have implemented various strategies to address space constraints. One approach involves optimizing the collection area using compact shelving and vertical sliding compact racks as space management solutions. Alternatively, decentralizing collection has proven to be an effective method. This involves relocating portions of the collection to branch or departmental libraries, which has successfully reduced shelving expenses and conserved space **(Arya, Singh & Mishra, 2009).** Space, such as collections and budgets, is considered a crucial resource in academic libraries, and requires equal management attention as finances and staff. The introduction of modern technologies has often led to space constraints in these institutions **(Bijle, 2013).** Designing user-oriented spaces in academic libraries, such as areas for collaboration, solitude, interaction, and community engagement that support learning, is a challenging endeavour. This complexity arises from the need to accommodate diverse user requirements and behaviors. It is crucial to evaluate all the key elements that influence the utilization of the intended library space before determining the specific arrangement and design of user areas **(Choy &Goh, 2016).** To maximize the use of physical spaces in academic libraries, it is advisable to establish digital spaces in remote locations. This approach helps conserve library floor space by implementing various technologies such as automated book return systems, self-service checkout and check-in facilities, mobile applications, and audio-guided library tours **(Gautam, 2014).** Overall, this study provides a balanced and informative overview of smart building technologies in libraries, effectively highlighting both opportunities and challenges. The introduction establishes a context for IoT and smart buildings in libraries. Three case studies illustrate practical IoT applications: Measure the Future, Concordia University Library noise monitoring, and Virginia Tech Smart Commons. The key challenges addressed include the battery life, programming language selection, and security. Potential metrics and sensors for library IoT projects are also explored. Future directions include ubiquitous computing, item tracking, and machine learning, with caution against over-reliance on metrics. This paper provides a balanced overview of IoT in libraries but could benefit from more specific data and practical considerations **(Griffey, Joson, 2018). i**n the design and planning of academic libraries as physical spaces, Three fundamental aspects were considered when providing and maintaining library spaces: functionality, usability, and attractiveness. Contemporary libraries should inherently possess qualities such as openness, multifunctionality, flexibility, and artistic appeal **(Ugwuanyi, Okwor&Ezeji, 2011).**

Functional Value of Library Space

1. Description of Basic Elements of Efficiency

The effectiveness of library space depends on several factors that affect its overall efficiency. The design and arrangement are critical aspects that focus on the effective layout of various sections of the library. This includes the proper planning of different areas, such as study rooms, discussion rooms, reference sections, and relaxation areas. It's essential that each section's functionality aligns with its specific goals, so that users can easily access various services according to their needs. Resources are other key elements that impact the efficiency of a

library. This includes both printed and digital materials, computers, Internet facilities, e-learning tools, and other technologies. The availability and quality of these resources directly affect the capacity of the library. User experience is the third important factor, focusing on ease of access to the library, usefulness of services, and ability to meet users' needs. A proper balance of these factors is essential for the overall efficiency of the library, providing users with a rich and effective educational environment.

2. Space Utilization and Challenges

Library space is used for various important purposes. Reading and studying are its primary uses, where students and teachers can acquire knowledge in a quiet environment. Additionally, special rooms are available for group discussions and project work, encouraging collaboration and collective learning. The library also serves as a hub for cultural and educational events, hosting ceremonies, workshops, and seminars that help to bring the community together and share knowledge.

However, there are also challenges in utilizing library spaces. Space waste or inefficient use is a major concern. For example, some areas may be underutilized, whereas others may be overcrowded. This can lead to imbalanced use of resources and affect the overall efficiency of the library. Effective planning and management of space are necessary to meet diverse needs and make the best use of the available space. This requires regular assessments, flexible space design, and on-going monitoring of users' needs.

3. Methods for Measuring Efficiency

Various methods have been used to measure the efficiency of a library, including both quantitative and qualitative parameters. Quantitative parameters include measurable factors such as space utilization, user rates, and reading time. For example, answers to questions such as whether the library's environment is suitable for studying, whether the staff is helpful, or whether finding information is easy can be obtained from these criteria. By combining both types of criteria, a comprehensive evaluation of the library's effectiveness can be conducted, which is useful for improving library services and meeting user needs.

Modern Perspectives on Space Evaluation

1. Inclusion of Technology

The integration of technology into modern educational libraries has shifted significantly. Library efficiency has increased with the use of smart libraries and digital technology, Instead of traditional paper cataloguing methods, digital cataloguing, automated library systems, and various information technology tools are now being employed. These new methods have reduced the time required to access libraries and ensure the timely availability of resources.

The use of digital (smart) technology has resulted in many positive changes (69%) in library operations compare the traditional technology (31%). For example, students and researchers can easily access information from around the world using online databases and e-books. In addition, the use of artificial intelligence and machine learning has made it possible to provide personalized recommendations and search results. Because of this integration of technology, libraries have transformed from merely repositories of books to centers of knowledge in the digital age.

2. Satisfactory Experiences

From the modern perspective of space evaluation, user satisfaction is crucial. Users must have readily available resources according to their needs and comfortable environments. The right space design, ethical guidance, and ease of resource use all contribute to enhancing the user experience. For instance, in a library, the organized arrangement of books, quiet reading areas, and easy access to digital resources lead to a better experience for users.

Several factors are considered when evaluating the user experience. This includes accessibility of the space, fulfilment of user needs, quality of the environment, and assistance from staff. User experience is assessed through regular surveys, feedback mechanisms, and the analysis of usage statistics. Based on this information, improvements are made in space management to ensure that users have a more satisfying experience and that their productivity increases.

3. The idea of environmental

Environmental considerations and continuous development are becoming increasingly important in modern library design. Energy efficiency is an important aspect of this approach,

and includes high-efficiency lighting, smart thermostats, and insulation. The use of green technologies, such as solar panels or geothermal systems, can help reduce the carbon footprint of a library. In addition, incorporating recycling and reuse methods, such as water conservation and waste management systems, helps reduce the overall environmental impact of the library. With the increasing use of technology, environmental considerations are gaining importance for the long-term sustainability of libraries. The increased use of digital resources and online services can lead to a reduction in paper consumption, but at the same time, an increase in power consumption. Therefore, it is important to consider the energy efficiency when using the latest technologies. Depending on sustainable design principles, libraries can use their resources more efficiently, reduce their environmental impacts, and serve as responsible and sustainable models for future generations. Sustainable library design can include natural light and proper movement of air, which helps save energy and create a hygienic environment for users. Construction using local and eco-friendly materials can further reduce the environmental impacts of libraries.

Finally, libraries can serve as environmental education centers for the community, raising awareness of their sustainability characteristics and demonstrating the importance of environmental responsibility. Traditional library design relies on artificial lighting and mechanical air conditioning, which are not energy-efficient and create a less hygienic environment for users. In turn, sustainable library design uses natural light and proper movement of air, which saves energy and creates a more hygienic environment for users.

Assessment Criteria for Spaces -

1. Space Structure and Organization

Criteria for evaluating spaces are important, especially for public places such as libraries. The structure and organization of a space are key factors in this assessment. The library design features a well-planned arrangement of various sections. The proper planning of areas such as reading rooms, reference rooms, group discussion rooms, and relaxation areas significantly contributes to the library's overall efficiency. It’s vital to have a coherent structural relationship between these sections so that user can easily move from one area to another without hindrance.

In evaluating the library space, not only is the layout of the sections critical, but their organization also plays an important role. Each section should be organized in a way that complements its specific purposes. For instance, the reading room should have a quiet and secluded atmosphere, where as the group discussion room should have an arrangement conducive to collaborative work. The relaxation area was designed to create a comfortable and stress-free environment. Considering all of these elements together can make the library space more efficient, convenient, and user-friendly.

2. Availability of Resources

Library resources are crucial for easy and prompt access to information. The availability of digital books, research papers, videos, audio, and other online resources supports the effectiveness of this space. These digital resources allow readers to access information anytime anywhere. This reduces strain on the physical space of the library and enables more people to use various resources simultaneously.

Moreover, the availability of digital resources is important for the expansion of library collection. This allows the library to provide extensive information that goes beyond the limitations of its physical space. This gives students, researchers, and other community member’s access to a wide range of up-to-date information, which is extremely important for academic and professional progress. Thus, resources availability is a significant factor in the efficiency of modern libraries.

3. Safety and Accessibility

Safety and accessibility in library space are two crucial aspects necessary for the successful operation of a library. From a safety standpoint, it’s essential to have proper lighting, fire alarm systems, and emergency exit routes. In addition, security cameras and alarm systems are important for protecting valuable books and resources. In terms of accessibility, providing ramps, lifts, and restrooms with special facilities for individuals with disabilities is important.

Another key aspect of a library's interior design is the avoidance of hazardous items. This includes steering clear furniture with sharp edges that could cause injury, keeping the height of bookshelves manageable so that users can easily access the books, and selecting tables and chairs that are accessible to all types of users. These measures

make the library a safe and comfortable place for everyone, enhancing their experience and making it more inclusive and enjoyable.

Based on the above information, we can identify a few smart libraries. Smart libraries are a revolutionary concept that brings traditional library services into the modern age through the integration of technology. These libraries use digital tools, automated systems, smart technologies, and data analytics to provide readers with more accessible and efficient services. For instance, RFID technology is used to manage and track books, whereas automated book delivery systems help users pick up and return books on their own.

Smart libraries also extensively incorporate digital resources such as e-books, online journals, and digital archives. These digital resources allow readers to access information anytime anywhere. Furthermore, personalized recommendations and search services are provided using artificial intelligence (AI) and machine learning technology, which help readers find information tailored to their interests and needs.

Smart libraries are not just places to store books and information; they have become centers of knowledge and innovation, where technology meets human intelligence.

1. Singapore National Library

The Singapore National Library is at the forefront of using modern technology to make library services more effective and user-friendly. Digital cataloguing systems have made it easy for users to find books and resources from home or on their mobile devices. This system helps users search for, reserve, and manage their reading histories according to their preferences. The automated cash-handling system reduces the workload of library staff and helps users receive prompt services.

Smart devices in the libraries provide users with a more interactive and enriching experience. Interactive screens and tablets allow users to browse digital collections, access online resources, and participate virtual tours. This technology has transformed the library from merely a place to hold books to a digital learning hub. The integration of this new technology has made libraries more efficient, allowing users to receive information easily and quickly, making the reading and research experience more enjoyable and fruitful.

2. Stanford University Libraries

Stanford University Libraries have evolved into smart libraries by leveraging modern technology. Their digital library allows students and researchers to access information from online databases and digital collections easily. Additionally, their online catalogue provides users with the convenience of searching for books on smartphones or computers. The library also implemented an intelligent lighting system that automatically adjusts based on occupancy.

In addition to these advanced features, Stanford University's library is likely to use several other technical innovations. For example, artificial intelligence-based search engines can suggest results based on users' search histories, or virtual reality tours showcasing rare collections or historical documents. They may also have IoT (Internet of Things) devices that control the library environment or track the location of books. This technology has turned Stanford University Library into a cutting-edge, efficient, and user-friendly educational resource center.

3. Drasko Library (Drasko Library, Croatia)

The Drasko Library, a state-of-the-art smart library in Croatia, offers readers a unique experience through modern technology. A key feature of this library is its electronic user registration system in, which users enter through smart cards. This system automatically keeps track of which books are checked or returned, making library management more efficient and streamlining the process for users.

Another innovative feature of the Drasko Library is its virtual assistance and interactive displays. The virtual assistant helps users with a variety of tasks, from finding books to obtaining information, whereas the interactive display screens provide information about various programs and services in the library. The integration of this technology has transformed theDrasko Library from a book repository into a modern, interactive hub of knowledge and information, catering to the needs of 21st-century readers.

4. Indian Institute of Technology, Bombay (IIT Bombay Library)

The library at the Indian Institute of Technology, Bombay (IIT Bombay) has made significant improvements to its services by leveraging modern technology. An automated bookkeeping mechanical system is a crucial component of this process. This system allows students to easily check and return books, which saves time and reduces the workload on library staff. Additionally, the digital library catalogue system enables students to search for books based on their email or ID, making it easier and more efficient to find resources.

The smart book-due date system is another important aspect of technical advancements at the IIT Mumbai Library. This system automates the management of book due dates, helps to avoid late fees, and ensures timely exchange of books. The implementation of this new technology has made libraries more efficient, providing students with smoother services and better utilization of resources. These advanced systems have enabled the IIT Mumbai Library to meet modern educational needs and offer better support to students in their studies.

5. Massachusetts Institute of Technology (MIT) - Design, Architecture, and Media Library (DAMS Library)

Smart libraries provide traditional library systems with a fresh perspective using modern technology. Digital catalogues help readers obtain book information from the comfort of their homes, while automated check-out systems make borrowing books a breeze. Smart reading rooms offer amenities, such as lighting and temperature control, creating an ideal environment for reading. Cloud-based services allow users access to digital resources anywhere.

The use of this technology boosts library efficiency, allowing the staff to focus on more critical tasks. User experience improves as users can access information easily and quickly. Moreover, by reducing paper use and employing energy-efficient equipment, smart libraries contribute to minimizing negative impacts on the environment. Thus, smart libraries promote the spread of knowledge and encourage sustainable development.

Some libraries that implement efficient space applications can be described as follows:

Green Library -

"Green" libraries are exemplary instances of environmental conservation and energy efficiency. These libraries employ water and electricity-saving devices to protect natural resources. They are designed to effectively use sunlight, which reduces reliance on artificial lighting and lowers energy consumption. These measures reduce the environmental impacts of libraries and enhance their efficiency.

Many other environment friendly practices have also been employed in "green" libraries. Examples include, the use of recyclable materials, waste management systems, green roof design, and energy-efficient equipment. All these measures make libraries not only information centers, but also models for environmental protection. In this way, "green" libraries represent a significant step towards sustainable development, teaching society the importance of environmental protection while efficiently using resources.

Results

Q.1. How would you rate the suitability of the library environment for studying?

Table-1 The suitability of the library environment

S. N.	Library environments	Response	Percent (%)
1	noise level	average	78
2	lighting	good	96
3	seating	good	100
4	temperature	average	52
5	resources	good	69
6	Wi fi	poor	100
7	power outlet	good	58
8	hours of operation	average	83
9	cleanliness	average	74

Table 1 indicates that enhancing the library's study environment requires addressing the lower-rated aspects, specifically the availability of power outlets and temperature regulation. The data analysis evaluates various components of the library setting and their suitability for studying. While seating and Wi-Fi received perfect scores of 100%, lighting was close behind at 96%. Operating hours (83%), noise levels (78%), and cleanliness (74%) were rated moderately well. However, power outlets (58%) and temperature (52%) received lower ratings. With a 69% response rate, the findings suggest that the

library excels in providing adequate seating, Wi-Fi connectivity, and lighting, but needs to improve its power outlet accessibility and temperature management. To create a more conducive study environment, efforts should be concentrated on improving these lower-rated aspects of the library.

2. How helpful do you find the library staff?

According to chart 1, which examines the nature of library staff, 63% of respondents found the subject beneficial, while 37% did not. This suggests a generally positive reception, but also highlights potential areas for enhancement.

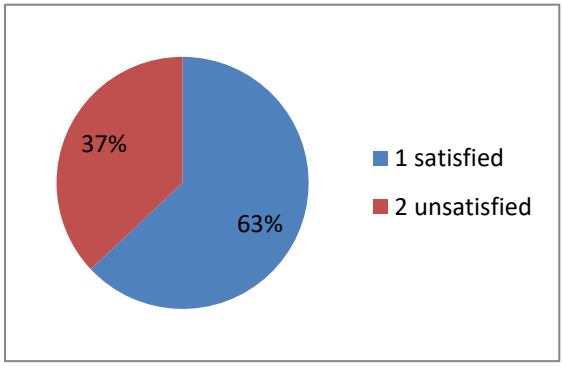

Chart 1 Nature of the library staff

Q.3. How easy is it for you to find the information you need in the library?

S. N.	Aspects	Response	Percentage (%)
1	Arrangement of materials	average	78
2	Clear sign & labels	good	96
3	Catalogue system	good	100
4	Digital resources	average	52
5	Resource availability	good	69
6	Search tools	poor	100

Table 2 Information of different aspects

The library's catalogue system exhibits excellent organization and ease of use, garnering an impressive 89% rating. Navigation is greatly facilitated by well-placed signs and labels, which received an 86% score. While the availability of resources is adequate at 69%, there is potential for enhancement. The layout of materials, rated at 78%, is sufficient but could be improved to increase accessibility. With a rating of 52%, digital resources represent a notable area for growth. However, the search tools pose a significant issue. Despite a high percentage of 92%, their poor rating indicates a substantial gap between quantity and quality, emphasizing an urgent need to upgrade this vital component of library functionality.

In summary, the library demonstrates strengths in cataloging and signage but requires considerable enhancements in search tools and digital resources.

4. How satisfied are you with the space utilization in the library?

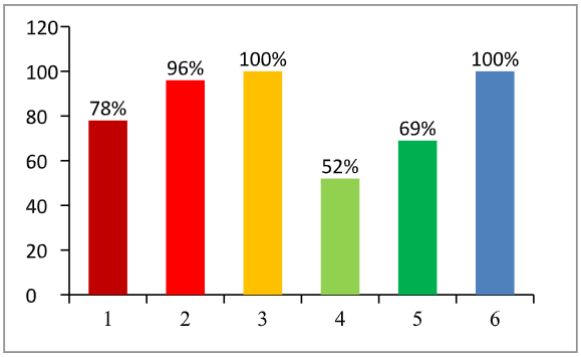

Chart 2 satisfactions of users

According to chart 2, The survey results present a mixed picture of user satisfaction with the library's information accessibility. Strengths include the catalogue system and clear signage, both receiving high satisfaction rates (100% and 96% respectively). The arrangement of materials and resource availability also show positive results. However, two areas require attention: digital resources (52% satisfaction) and search tools (100% dissatisfaction). The stark contrast between the highly rated catalogue system and the poorly rated search tools suggests users can locate known items but struggle to discover new or specific resources. Addressing these issues, particularly improving search tools, could significantly enhance the overall user experience and information accessibility in the library.

Current Challenges

The issue of space waste in libraries has become a serious problem. Many libraries have books or resources that are underutilized, yet they must occupy space. This leads to the inefficient use of available space and reduces the room for new collections or facilities. In addition, given the changing needs of readers, the availability of digital resources has become crucial.

Establishing the necessary technology and infrastructure to provide digital resources presents another challenge. This includes the need for computers, Internet connectivity, digital databases, and e-book readers. Providing these facilities and ensuring regular updates require significant investment. Training staff on this new technology and assisting readers in using digital resources are also important.

Potential Solutions

Potential solutions could involve repurposing space, efficient design, and maximizing the use of resources. The increased use of smart technologies can enhance resources availability and improve efficiency. For instance, using smart sensors in buildings can reduce the energy consumption and improve the use of space. Additionally, by employing cutting-edge technologies for water and waste management, natural resources can be utilized more efficiently.

Moreover, new policies and regulations should be implemented to promote sustainability in urban planning and development. For example, green standards for new construction, encouraging public transportation, and integrating eco-friendly technology into infrastructure. These measures can boost the efficiency of cities and improve their quality of life.

The key outcomes of the research

Evaluating space efficiency is crucial to the performance of academic libraries. This assessment helps to effectively utilize the physical and digital spaces of the library. Factors such as technology, user experience, and resource availability affect space efficiency. For example, leveraging modern technology to make digital resources easily accessible, creating a user-friendly and engaging environment, and ensuring the availability of diverse study materials can enhance a library's space efficiency.

It's important for academic libraries to evaluate the efficiency of their spaces regularly. This may involve gathering user feedback, monitoring how the space is being used, and making the necessary changes to accommodate new academic needs. By successfully evaluating and managing space efficiency, academic libraries can provide better services to students and researchers, promote education and research, and meet the evolving needs of the academic community.

Guidance for Future Research

Guidance for future research is likely to become more comprehensive and in-depth. With the increasing use of smart technologies, the assessment of library spaces will not only become more efficient and accurate but also capable of performing a nuanced analysis of user behaviors and needs. For example, by using artificial intelligence and machine learning algorithms, libraries analyze user movements, reading habits, and patterns of resource utilization. Based on this information, libraries can redesign their spaces, organize resources more efficiently, and provide personalized services.

Additionally, environmental sustainability is a significant focus for future research. Along with prioritizing designs that incorporate green principles, researchers will explore new sustainable building materials and energy-efficient technologies. For instance, studies could be conducted on ways to reduce the carbon footprint of libraries using bio-based materials, reusable components, and carbon-absorbing surfaces. Moreover, libraries can function as self-sustaining buildings by combining renewable energy sources, natural lighting, and systems to improve air quality. This research will help libraries to establish themselves as environmentally responsible institutions and strengthen their role as educational resources for the community.

References

1. Arya,H.B,Singh,P.&Mishra,J.K.(2009).SpacemanagementinTIFRlibrary:acasestudy. *Annals of Library and Information Studies (ALIS)*, 56 (4): 291-297. Retrieved from http://nopr.niscair.res.in

2. Bijle,S.M.(2013).*Spaceplanninginuniversitylibraryo ftheMaharashtrainthechanging informationtechnologyscenario:acasestudy*(Doctoral Thesis).Retrievedfrom https://shodhganga.inflibnet.ac.in

3. Choy, F.C. &Goh, S.N. (2016). A framework for planning academic library spaces.*LibraryManagement*, 37(1/2), 13-28. Retrieved from https://www.emerald.com/insight/content/doi/10.1108/LM-01-2016-0001/full/html

4. Gautam, A.K. (2014). Effective space planning as an essential tool for libraries to transform them into learning centers : an approach. *Library Space and Content Management for Networked Society*. Bengaluru: Dharmaram Publication, pp. 85-96.

5. Griffey, J. (Ed.) (2018). Library spaces and smart buildings: technology, metrics and iterative design. *Library Technology Reports: Expert Guides to Library Systems and Services*, 54(1): 5-33. Chicago: ALA.

6. Ugwuanyi, C. F., Okwor, R. N. &Ezeji, E. C. (2011). Library space and place: nature, use and impact on academic library. *International Journal of Library and Information Science*, 3(5): 92-97. Retrieved from http://www.academicjournals.org/ijlis

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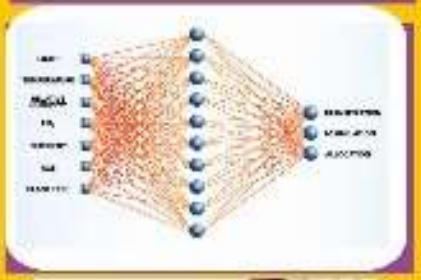

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