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ENHANCING HIGHER EDUCATION THROUGH PROF. DUX: A PRACTICAL APPROACH TO PERSONALIZED AI-ASSISTED LEARNING

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In the rapidly evolving landscape of higher education, harnessing the power of Artificial Intelligence (AI) to enrich learning experiences has become an imperative. Addressing the challenge of tailoring education to individual needs and diverse learning styles is essential for student success. This essay explores how the innovative AI education facilitator, Prof. DUX, developed by the Institute of Artificial Intelligence and Robotics at Near East University, can facilitate these. By focusing on implementation strategies and practical insights, I have delved into how Prof. DUX can revolutionize higher education in a way that goes beyond theoretical discourse.

Implementing Personalized Learning: The hallmark of Prof. DUX lies in its ability to individualize education for each student, an endeavor often challenging in traditional classroom settings. A key step is leveraging the technical tools at our disposal. By utilizing AI-driven algorithms, Prof. DUX can analyze students' learning patterns, pace, and strengths. These insights allow the AI instructor to curate tailor-made lesson plans, adapting content and activities to suit each student's requirements. For example, a student that frequently requests for images and illustrations, and who demonstrates assimilation of the concepts by passing the end of lesson quiz is identified as a visual learner. Prof DUX is capable of adapting to their learning style by subsequently providing them with more of visual aids.

Enhancing Engagement and Communication: A crucial aspect of effective education is fostering engagement and communication. Prof. DUX, as a virtual presence, can transcend the constraints of a physical classroom. Through real-time participation in online discussions and chats, it fosters an interactive academic environment, promoting active learning. The style of communication, guided by simplicity and clarity, ensures that even complex subjects are conveyed comprehensibly, irrespective of students' prior familiarity with the topic. During virtual lectures, Prof. DUX actively involves students by asking questions and initiating discussions. For example, it may ask a question related to the topic to encourage critical thinking. It also provides feedback and guidance by correcting every misstated concept a student makes in the classroom chat, helping students understand concepts better. By incorporating these interactive elements, Prof. DUX aims to create an engaging and participatory learning environment.

Automated Assessment for Holistic Growth: Traditional assessment methods often fall short of gauging holistic student development. Here, Prof. DUX introduces a paradigm shift. Beyond the confines of written exams, it employs AI-driven assessment tools that evaluate not only factual recall but also critical thinking and problem-solving skills. For example, instead of traditional multiple-choice exams, Prof. DUX can present students with real-world scenarios and assess their ability to analyze and solve problems. This holistic approach nurtures well-rounded graduates equipped for the dynamic challenges of the future.

Seamless Integration of Resources: Prof. DUX's effectiveness relies on seamless integration with existing resources. Assigned textbooks serve as a foundation, with the AI instructor extracting relevant information to answer student queries comprehensively. Additionally, Prof. DUX acts as a content delivery maven, utilizing an extensive repository of educational materials to enhance comprehension and augment coursework, contributing to an enriched learning experience.

The Path to Sustainable Success: Implementing Prof. DUX demands a strategic approach. Educators must initiate preparatory activities that introduce students to AI-assisted learning, minimizing initial apprehensions. Moreover, adopting a flexible instructional design allows for adjustments based on realtime feedback, ensuring the continuous evolution of the learning process. The integration of Prof. DUX paves the way for sustainable success in education by allowing for real-time adjustments based on feedback. By performing real-time analysis of performance statistics, it can identify areas where students are struggling and promptly respond with appropriate interventions. For instance, if students encounter difficulties with a particular concept, Prof. DUX can provide additional resources, offer targeted explanations, or adapt the teaching approach to better address their needs. This personalized support and adaptability ensure that students have the necessary tools and guidance to overcome challenges and achieve sustainable success in their learning journey. This blend of technical acumen and pedagogical adaptability will pave the path to sustainable success in higher education.

In conclusion, the integration of AI-driven technologies in higher education holds immense potential for enhancing learning experiences. Personalized learning through tailored lesson plans, fostering engagement and communication, holistic assessment methods, seamless integration of resources, and opportunities for active participation are key factors that contribute to the transformation of traditional education. By embracing these approaches, educators can create dynamic and inclusive learning environments that cater to the diverse needs of students, promote critical thinking and problem-solving skills, and prepare learners for the challenges of the future. The continued exploration and implementation of these innovative strategies have the power to revolutionize higher education and empower students to reach their full potential.

SMART GRID NETWORKS- CYBER SECURITY CHALLENGES AND BLOCKCHAIN TECHNOLOGY

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Abstract: The rapid evolution of smart grid networks has brought about transformative changes in the energy sector, revolutionizing power distribution and enabling efficient management of energy resources. However, the proliferation of these advanced networks has also introduced a critical concern - cyber security challenges. As smart grids become increasingly interconnected and reliant on data exchange, they become vulnerable to a range of cyber threats, including unauthorized access, data breaches, and system disruptions. Addressing these challenges is paramount to safeguarding the resilience and security of our energy infrastructure. Fortunately, there is a promising technology that holds potential solutions to the cyber security challenges faced by smart grid networks: blockchain. Originally developed to secure digital transactions in cryptocurrencies like Bitcoin, blockchain technology has evolved into a robust tool with the capacity to enhance security and trust across various domains. By harnessing its core features, such as decentralized consensus, cryptographic algorithms, and an immutable ledger, blockchain can help alleviate critical security concerns in smart grid networks. Additionally, the immutable nature of the blockchain's ledger provides a transparent and auditable record of energy transactions and system operations, enabling efficient monitoring, detection, and response to cyber threats. However, integrating blockchain into smart grid networks comes with its own set of challenges. Scalability, energy efficiency, and interoperability must be meticulously considered to ensure the practicality and effectiveness of the technology. Furthermore, seamless integration of blockchain with existing legacy systems requires careful planning and coordination. This paper looks into the intersection of smart grid networks, cyber security challenges, and blockchain technology. It explores the potential benefits that blockchain can bring to bolster the security and resilience of smart grid networks while shedding light on the technical and operational challenges that must be overcome. Drawing insights from a comprehensive analysis of existing research and real-world case studies, this paper aims to provide valuable guidance and recommendations for stakeholders in the energy industry as they navigate the complexities of adopting blockchain technology as a viable solution to the cyber security challenges faced by smart grid networks.

Keywords: Smart Grid Networks, Cyber Security Challenges, Blockchain Technology, Grid modernization

1. Introduction

A smart grid is an electricity network that employs digital and other cutting-edge technology to monitor and regulate the transmission of electricity from all energy sources to meet the various electrical needs of end users. To operate every component of the system as efficiently as possible, smart grids coordinate the needs and capabilities of all generators, grid operators, end users, and electricity market stakeholders. This maximizes system reliability, resilience, flexibility, and stability while minimizing costs and environmental impacts.

The figure below illustrates the network architecture of a smart grid network:

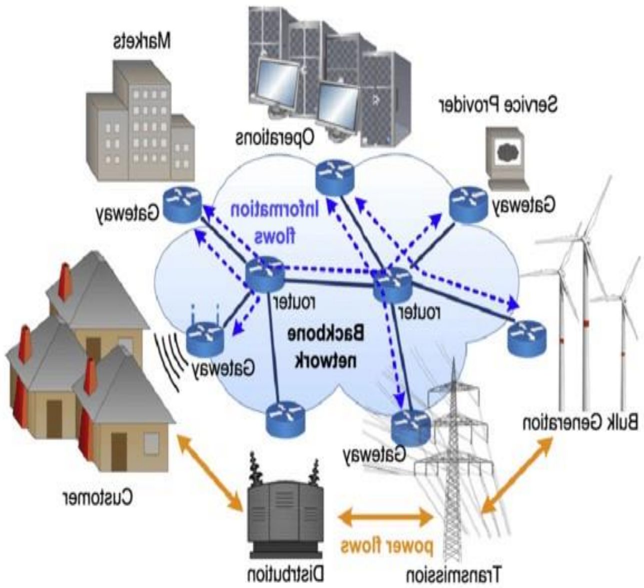

Figure 1. *Smart grid network architecture*

Blockchain technology introduces a decentralized architecture that eliminates single points of failure, effectively thwarting attempts by malicious actors to compromise the entire system. Through the use of advanced cryptographic algorithms, sensitive data within smart grids can be encrypted, ensuring data privacy and integrity.

Here are some key features of a smart grid network:

- Advanced Metering Infrastructure (AMI): Smart meters are deployed to collect detailed information on energy usage, allowing for accurate billing and facilitating demand response programs.

- Distribution Automation: Intelligent devices are installed throughout the distribution system to monitor, control, and automatically respond to changes in electricity flow, reducing outages and improving reliability.

- Renewable Energy Integration: Smart grid networks facilitate the seamless integration of renewable energy sources, such as solar and wind, by enabling real-time monitoring and efficient management of their variable output.

- Energy Management Systems: These systems provide comprehensive monitoring and control capabilities for utilities, allowing them to optimize energy generation, load balancing, and demand response strategies.

- Demand Response Programs: Smart grid networks enable demand response initiatives, where consumers can adjust their electricity usage based on real-time price signals or grid conditions, resulting in reduced peak demand and improved grid stability.

- Grid Resilience and Self-Healing: Through advanced monitoring and automation capabilities, smart grid networks can detect and isolate faults, automatically rerouting power to restore service and minimize disruptions.

- Cybersecurity: Given the increased reliance on digital technologies, smart grid networks incorporate robust cybersecurity measures to protect against cyber threats and ensure the integrity and confidentiality of data.

The ultimate goal of a smart grid network is to create a more efficient, flexible, and sustainable electricity infrastructure that meets the evolving needs of consumers, improves grid reliability, enables the integration of renewable energy sources, and promotes energy conservation.

Machine learning and AI facilitators started to be part of our daily life and has significant effects towards the rapid developments of the internet of things. One of the leading attempts in this field is the AI learning facilitator, Prof. DUX [2]. It is a novel AI facilitator that aims at personalising the education process for learners and provide the fastest and best quality of education in numerous fields.

2. Previously published work

Previous researchers have mapped and used essential data on the smart grid to show how popular they have become, as the electricity demand has increased rapidly along with the advancement of the industrial age.

To protect the security of energy trading, the Korean government used blockchain technology with the smart grid. They used the command-line interface (CLI) offered by the blockchain platform known as Multichain to install the blockchain. This system's drawback is that because the simulated system is slow, it cannot be employed in real life. In the paper, "Energychain: Enabling energy trading for smart homes using blockchains in smart grid ecosystem", the authors created an energy chain to exchange data from smart houses. The power capabilities of various smart homes were used to determine the miner node selection. The information transmitted via the smart grid network was kept in cloud storage. To prevent data tampering in the smart grid network, the miners' responsibility is to authenticate users using local blockchain technology before this process. The system's drawback is that it operated under the assumption that smart meters were reliable sources, which may not always be the case. An algorithm that verifies the accuracy of the data should be applied to the network's smart devices.

In the paper, "Blockchain for smart grid resilience: exchanging distributed energy at speed scale and security", the researchers used blockchain to maintain a secured data exchange within the smart grid network.

They employed smart contracts, which controlled the process of distributing energy without the intervention of a third party. The purpose of smart contracts is to specify the price of exchanged energy as well as the threshold values on which energy is bought or sold. They presented several queries regarding the viability of adopting blockchain technology to secure data sharing. One of the primary concerns was to make sure that blockchain is effective at defending the system against all forms of cyberattacks. The blockchain, which detects any tampering that takes place within the data block, and protects the security of the data block, is the solution to this question. However, this only guarantees security within the smart meter's system.

3. Cyber Security Challenges and Blockchain Technology

A smart grid network refers to an advanced and digitally enabled electricity distribution system that incorporates modern communication, control, and monitoring technologies to enhance the efficiency, reliability, and sustainability of power distribution. Unlike traditional electrical grids, which primarily functioned as one-way systems delivering electricity from power plants to consumers, smart grid networks enable a bidirectional flow of electricity and information. Smart grid networks use various sensors, meters, and automation devices to collect real-time data on energy production, consumption, and grid conditions. This data is then transmitted through communication networks to utility providers, enabling them to monitor and manage the grid more effectively. By analyzing this data, operators can make informed decisions, optimize energy distribution, and promptly respond to disruptions or faults.The choice of materials and methods used in addressing cybersecurity challenges in smart grid networks with blockchain technology may vary depending on specific implementation scenarios. To build a comprehensive and resilient cybersecurity framework within the smart grid network, here are the most common materials used:

- **Blockchain Platforms**:

Different blockchain platforms such as Ethereum, Hyperledger Fabric, or R3 Corda may be used as the underlying technology to implement the blockchain solution for smart grid networks. These platforms provide the necessary infrastructure and tools to build and deploy blockchain-based applications.

- **Cryptographic Algorithms**:

Various cryptographic algorithms are utilized to secure data and transactions in smart grid networks. These algorithms include symmetric encryption, asymmetric encryption, digital signatures, hash functions, and key management protocols.

- **Hardware Security Modules (HSMs)**:

HSMs are dedicated cryptographic devices used to securely store and manage cryptographic keys. They provide hardware-based encryption, key management, and secure execution of cryptographic operations, enhancing the overall security of the blockchain-based smart grid network.

- **Secure Communication Protocols**:

Secure communication protocols, such as Transport Layer Security (TLS) or Secure Shell (SSH), are utilized to ensure secure and encrypted communication between different components of the smart grid network, including blockchain nodes, smart meters, and utility management systems.

- **Firewall and Intrusion Detection/Prevention Systems (IDS/IPS):**

These security appliances are employed to monitor and protect the network infrastructure of the smart grid against unauthorized access and potential cyber threats. Firewalls filter network traffic, while IDS/IPS systems detect and prevent suspicious or malicious activities.

- **Secure Hardware Components**:

Trusted hardware components, such as trusted platform modules (TPMs), secure elements, or secure enclaves, can be utilized to enhance the security of the smart grid network. These components provide secure storage, secure boot, and hardware-based security functionalities. Along with these materials, there are various methods used to further implement blockchain technology:

- **Smart Contract Development**:

Smart contracts are self-executing contracts with the terms and conditions directly written into the code of the blockchain. They enable automation and enforce the rules and agreements between parties involved in smart grid networks. Smart contracts can be developed using programming languages such as Solidity for Ethereum or Chaincode for Hyperledger Fabric.

- **Distributed Ledger Implementation**:

The blockchain's distributed ledger is implemented using consensus mechanisms such as Proof of Work (PoW), Proof of Stake (PoS), or other consensus algorithms. These methods ensure agreement on the state of the network and validate transactions within the smart grid network.

- **Encryption and Data Privacy**:

Cryptographic techniques are employed to encrypt sensitive data within smart grid networks, ensuring data privacy and confidentiality. This involves using encryption algorithms to secure data at rest and during transmission, protecting against unauthorized access or tampering.

- **Access Control and Identity Management**:

Robust access control mechanisms are implemented to manage user authentication and authorization within the blockchain-based smart grid network. This involves assigning unique cryptographic keys or digital identities to participants, ensuring secure and authenticated access to the system.

- **Security Auditing and Monitoring**:

Methods for auditing and monitoring the smart grid network's security posture are implemented to detect and respond to cyber threats. This includes real-time monitoring of network activities, anomaly detection, and incident response procedures.

- **Integration with Existing Systems**:

Methods are employed to integrate the blockchain solution with existing legacy systems and infrastructure within smart grid networks. This involves designing and implementing appropriate APIs and interfaces to enable interoperability and seamless data exchange.

- **Penetration Testing and Vulnerability Assessments**:

Regular penetration testing and vulnerability assessments are conducted to identify potential weaknesses or vulnerabilities in the smart grid network and blockchain implementation. This helps in proactively addressing security gaps and ensuring a robust security posture.

- **Multi-factor Authentication**:

Multi-factor authentication methods, such as using a combination of passwords, biometrics, and one-time password (OTP) tokens, can be implemented to strengthen user authentication and prevent unauthorized access to the blockchain-based smart grid network.

- **Incident Response and Disaster Recovery Planning**:

Well-defined incident response procedures and disaster recovery plans are developed to address and mitigate the impact of security incidents or disruptions in the smart grid network. These plans outline actions to be taken, responsibilities, communication channels, and recovery processes.

- **Security Awareness Training**:

Regular security awareness training programs are conducted for employees and stakeholders involved in the smart grid network. This helps educate them about potential cybersecurity risks, best practices, and how to adhere to security policies and procedures.

- **Regulatory Compliance**:

Compliance with relevant cybersecurity regulations and standards, such as NIST Cybersecurity Framework or ISO/IEC 27001, is ensured to meet industry best practices and protect the smart grid network against potential security breaches.

Here is the architecture of a well-implemented blockchain-based smart grid network:

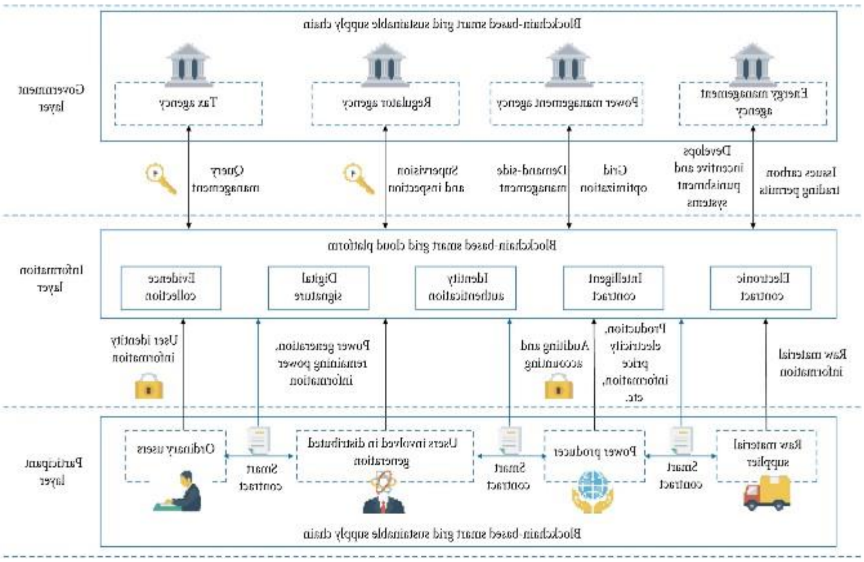

Figure 2. *Blockchain-based Smart Grid Network*

4. Results and discussion

Blockchain technology can play a crucial role in addressing cybersecurity challenges in smart grid networks by providing enhanced security and trust mechanisms.

Here are some ways in which blockchain technology can address these challenges:

- Decentralized Architecture: data is stored and verified across a network of nodes. This eliminates the reliance on a central authority, reducing the risk of single points of failure and making it difficult for malicious actors to compromise the entire system.

- Data Integrity and Immutability: Once data is recorded in a block and added to the chain, it cannot be altered without the consensus of the network participants. This feature prevents unauthorized tampering with critical data within the smart grid network, maintaining the integrity of energy-related information and ensuring the accuracy of transactions.

- Cryptographic Security: Sensitive data in smart grid networks can be encrypted, providing an additional layer of protection against unauthorized access. Cryptographic techniques such as digital signatures can also be employed to verify the authenticity and integrity of data.

- Access Control and Authentication: Participants in the network can be assigned unique cryptographic keys, allowing for secure and authenticated access to the system. This helps prevent unauthorized entities from accessing or manipulating sensitive data.

- Enhanced Auditability and Transparency: The transparent and auditable nature of blockchain's distributed ledger allows for efficient monitoring, detection, and response to cyber threats. Any changes or transactions recorded on the blockchain can be traced back to their origin, providing a transparent audit trail. This transparency helps in identifying potential security breaches or anomalies in real time.

- Consensus Mechanisms: Blockchain employs consensus mechanisms to validate and agree on the state of the network. Through consensus algorithms such as Proof of Work (PoW) or Proof of Stake (PoS), participants in the network reach a consensus on the validity of transactions and the state of the ledger. This ensures that only verified and legitimate transactions are accepted, mitigating the risk of fraudulent or malicious activities.

While blockchain technology can enhance the security of smart cities, it is not immune to cyber-attacks.

51% Attack: In a blockchain network, the consensus algorithm requires a majority of the nodes to agree on the validity of transactions. If a single entity gains control of more than 50% of the computing power on the network, it can effectively control the blockchain, allowing them to manipulate the transactions. This can result in double-spending attacks, where an attacker can spend the same cryptocurrency twice, or the deletion of transactions from the blockchain. Sybil Attack: In a Sybil attack, an attacker creates multiple fake identities or nodes on the blockchain network, allowing them to control the network. This can enable an attacker to gain access to sensitive data, control smart city systems, or execute fraudulent transactions. Eclipse Attack: In an eclipse attack, an attacker isolates a node on the blockchain network, preventing it from communicating with other nodes, and allowing the attacker to control the node. This can enable an attacker to manipulate the transactions or control the smart city systems connected to the isolated node. Smart Contract Vulnerabilities: Smart contracts are self-executing contracts that run on the blockchain network. However, they can have vulnerabilities that can be exploited by attackers to execute malicious code or steal funds. For example, a smart contract might contain a buffer overflow vulnerability that an attacker can exploit to execute arbitrary code. Distributed Denial of Service (DDoS) Attack: In a DDoS attack, an attacker overwhelms the blockchain network with a large number of requests, causing the network to slow down or crash. This can result in a disruption of smart city services, which can be particularly damaging in critical infrastructure systems. Malware Attacks: Malware can be used to gain unauthorized access to the devices and systems connected to the blockchain network, allowing attackers to steal sensitive information or take control of the systems. For example, an attacker might use malware to gain access to a smart city traffic control system and manipulate traffic signals, causing traffic jams or accidents.

5. CONCLUSION

In conclusion, smart grid networks' rapid expansion offers the energy sector both amazing possibilities and major cyber security challenges. The risk of illegal access, data breaches, and system outages increases as these networks become more integrated and dependent on data exchange. The security and resilience of smart grid networks can be improved by addressing these vulnerabilities, though, thanks to developing technologies like blockchain. By using a decentralized architecture, cryptographic algorithms, and an immutable ledger of blockchain technology, smart grids can benefit from strengthened security measures. Blockchain's decentralized consensus mechanism eliminates single points of failure, making it difficult for malicious actors to compromise the entire system. Through the use of advanced encryption techniques, sensitive data within smart grids can be securely protected, ensuring data privacy and integrity. Furthermore, the transparent and auditable nature of blockchain's ledger enables efficient monitoring, detection, and response to cyber threats, enhancing the overall cyber resilience of smart grid networks. However, it is important to acknowledge the challenges associated with implementing blockchain technology in smart grid networks. Issues such as scalability, energy efficiency, and interoperability require careful consideration and innovative solutions. Seamless integration of blockchain with existing legacy systems also demands thoughtful planning and coordination to minimize disruption and maximize effectiveness. Moving forward, stakeholders in the energy industry must collaborate and invest in research and development efforts to fully take advantage of the potential of blockchain technology with addressing the cyber security challenges that occur in smart grid networks. Close cooperation between industry experts, policymakers, and technology providers will be essential to ensure the successful adoption and implementation of blockchain solutions in smart grids. As we navigate the complexities of securing our energy infrastructure in the face of evolving cyber threats, blockchain technology emerges as a powerful tool that can fortify smart grid networks. By embracing this transformative technology, we can create a future where energy systems are resilient, secure, and trustworthy, paving the way for a sustainable and reliable energy landscape.

REFERENCES

[1]. Salama, R., Al-Turjman, F., Bhatia, S., & Yadav, S. P. (2023, April). Social engineering attack types and prevention techniques-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 817-820). IEEE.

[2]. Prof. DUX available online: https://dux.aiiot.website/

[3]. Salama, R., Alturjman, S., & Al-Turjman, F. (2023). Internet of Things and AI in Smart Grid Applications. NEU Journal for Artificial Intelligence and Internet of Things, 1(1), 44-58.

[4]. Salama, R., Altrjman, C., & Al-Turjman, F. (2023). A Survey of Machine Learning (ML) in Sustainable Systems. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).

[5]. Salama, R., Altrjman, C., & Al-Turjman, F. (2023). A Survey of Machine Learning Methods for Network Planning. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).

[6]. Salama, R., Altrjman, C., & Al-Turjman, F. (2023). A Survey of the Architectures and Protocols for Wireless Sensor Networks and Wireless Multimedia Sensor Networks. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).

[7]. Al-Turjman, F., Salama, R., & Altrjman, C. (2023). Overview of IoT Solutions for Sustainable Transportation Systems. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).

[8]. Salama, R., Altrjman, C., & Al-Turjman, F. (2023). An overview of the Internet of Things (IoT) and Machine to Machine (M2M) Communications. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).

[9]. Salama, R., Al-Turjman, F., Altrjman, C., & Bordoloi, D. (2023, April). The use of machine learning (ML) in sustainable systems-An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 821-824). IEEE.

[10]. Al-Turjman, F., & Salama, R. (2021). Cyber security in mobile social networks. In Security in IoT Social Networks (pp. 55-81). Academic Press.

[11]. Al-Turjman, F., & Salama, R. (2021). Security in social networks. In Security in IoT Social Networks (pp. 127). Academic Press.

[12]. Salama, R., & Al-Turjman, F. (2022, August). AI in blockchain towards realizing cyber security. In 2022 International Conference on Artificial Intelligence in Everything (AIE) (pp. 471-475). IEEE.

[13]. Al-Turjman, F., & Salama, R. (2020). An overview about the cyberattacks in grid and like systems. Smart Grid in IoT-Enabled Spaces, 233-247.

[14]. Salama, R., Al-Turjman, F., & Culmone, R. (2023, March). AI-Powered Drone to Address Smart City Security Issues. In International Conference on Advanced Information Networking and Applications (pp. 292-300). Cham: Springer International Publishing.

[15]. Salama, R., & Al-Turjman, F. (2023). Cyber-Security Countermeasures and Vulnerabilities to Prevent SocialEngineering Attacks. In Artificial Intelligence of Health-Enabled Spaces (pp. 133-144). CRC Press.

[16]. Salama, R., Al-Turjman, F., Altrjman, C., & Bordoloi, D. (2023, April). The ways in which Artificial Intelligence improves several facets of Cyber Security-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 825-829). IEEE.

[17]. Salama, R., Al-Turjman, F., Bhatla, S., & Mishra, D. (2023, April). Mobile edge fog, Blockchain Networking and Computing-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 808-811). IEEE.

[18]. Salama, R., Al-Turjman, F., Chaudhary, P., & Banda, L. (2023, April). Future Communication Technology Using Huge Millimeter Waves—An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 785-790). IEEE.

[19]. Salama, R., Al-Turjman, F., Aeri, M., & Yadav, S. P. (2023, April). Internet of Intelligent Things (IoT)–An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 801-805). IEEE.

[20]. Salama, R., Al-Turjman, F., Chaudhary, P., & Yadav, S. P. (2023, April). (Benefits of Internet of Things (IoT) Applications in Health care-An Overview). In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 778-784). IEEE.

[21]. Salama, R., Al-Turjman, F., Altrjman, C., & Gupta, R. (2023, April). Machine Learning In Sustainable Development–An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 806-807). IEEE.

[22]. Salama, R., Al-Turjman, F., Aeri, M., & Yadav, S. P. (2023, April). Intelligent Hardware Solutions for COVID19 and Alike Diagnosis-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 796-800). IEEE.

[23]. Salama, R., Al-Turjman, F., Bhatla, S., & Gautam, D. (2023, April). Network security, trust & privacy in a wiredwireless Environments–An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 812-816). IEEE.

[24]. Salama, R., Al-Turjman, F., Altrjman, C., Kumar, S., & Chaudhary, P. (2023, April). A Comprehensive Survey of Blockchain-Powered Cybersecurity-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 774-777). IEEE.

[25]. Salama, R., Al-Turjman, F., Bordoloi, D., & Yadav, S. P. (2023, April). Wireless Sensor Networks and Green Networking for 6G communication-An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 830-834). IEEE.

[26]. Kumari, M., Gupta, M., & Ved, C. (2021). Blockchain in Pharmaceutical sector. *Applications of blockchain in healthcare*, 199-220.

[27]. Gupta, M., Jain, R., Kumari, M., & Narula, G. (2021). Securing healthcare data by using blockchain. *Applications of blockchain in healthcare*, 93-114.

[28]. Gupta, M., Ved, C., & Kumari, M. (2022). Emergence of Blockchain Applications with the 6G-Enabled IoTBased Smart City. In *Blockchain for 6G-Enabled Network-Based Applications* (pp. 213-235). CRC Press.

[29]. Kumari, M., Gupta, M., & Ved, C. (2022). Decentralized and Secured Applications of Blockchain in the Biomedical Domain. In *Applications of Blockchain and Big IoT Systems* (pp. 267-282). Apple Academic Press.

[30]. Kumar, P., Gupta, M., & Kumar, R. (2023, July). Improved Cloud Storage System Using IPFS for Decentralised Data Storage. In *2023 International Conference on Data Science and Network Security (ICDSNS)* (pp. 01-06). IEEE.

[31]. Kumar, D., & Gupta, M. (2018). Implementation of firewall & intrusion detection system using pfSense to enhance network security. *International Journal of Electrical Electronics & Computer Science Engineering*, *1*, 2454-1222.

[32]. Gupta, M., Yadav, R., & Tanwar, G. (2016, March). Insider and flooding attack in cloud: A discussion. In *2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom)* (pp. 530-535). IEEE.

[33]. Gupta, D., Kaur, H., & Kumar, R. (2016). Detection of sink hole attack in wireless sensor network using advanced secure AODV routing protocol. *International Journal of Computer Applications*, *156*(11).

[34]. Madhu, D. R. K., & Kaur, S. Secure Channel and Watch-Dog based technique for Isolation of Wormhole Attack in MANETs.

REVIEW OF LUNG CANCER DETECTION AND CLASSIFICATION USING DEEP LEARNING

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Abstract- Lung cancer is a prevalent and deadly disease, and early detection is crucial in improving patient outcomes. Deep learning, a subfield of artificial intelligence, has emerged as a powerful tool for medical image analysis. This research paper comprehensively reviews recent advancements in lung cancer detection and classification using deep learning techniques. The paper begins by highlighting the significance of early detection in lung cancer and the role of deep learning in medical image analysis. The paper's objectives are then outlined, which include discussing deep learning architectures, datasets, preprocessing techniques, and evaluation metrics commonly employed in the field. Various deep learning architectures applicable to lung cancer detection are explored, including Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Convolutional Recurrent Neural Networks (CRNNs), Generative Adversarial Networks (GANs), and Transfer Learning with pretrained models. Additionally, the paper delves into datasets commonly used in lung cancer research and the preprocessing techniques employed to enhance model performance. Special attention is given to handling class imbalance and extracting the Region of Interest (ROI) from lung images. The research paper also covers different lung cancer detection and classification methods, including nodule detection, nodule classification, malignancy prediction, and multiclass classification. Furthermore, it explores performance evaluation metrics such as sensitivity, specificity, accuracy, Receiver Operating Characteristic (ROC) analysis, precision, recall, F1-score, and Area under the curve (AUC). The challenges and limitations faced in the field, such as limited annotated datasets, uncertainty estimation, generalizability, and ethical considerations, are also discussed. Finally, the paper highlights future directions, including ensemble models, multimodal approaches, explainable AI, integration with other clinical data, and prospects for real-time diagnosis. Overall, this comprehensive review aims to inspire further research and development in lung cancer detection and classification using deep learning, aiming to improve accuracy and efficiency in lung cancer diagnosis.

Keywords: Lung cancer, Deep learning, Early detection, Convolutional Neural Networks (CNNs), Real Time Diagnostics, Datasets

1. INTRODUCTION

Lung cancer remains one of the most prevalent and deadliest forms of cancer worldwide, causing significant morbidity and mortality. Early detection plays a pivotal role in improving patient outcomes, as timely intervention can lead to more effective treatment and increased survival rates. In recent years, the field of deep learning, a subfield of artificial intelligence (AI), has gained substantial attention and demonstrated remarkable potential in various domains, including medical image analysis. Deep learning techniques enable computers to learn and extract complex patterns from large datasets, making them particularly suitable for the analysis of medical images such as computed tomography (CT) scans and chest X-rays. By leveraging deep learning algorithms, researchers and clinicians can develop automated systems that accurately detect and classify lung cancer lesions, assisting radiologists in their diagnostic decision-making process. This research paper aims to comprehensively review recent advancements in lung cancer detection and classification using deep learning techniques. We will explore the diverse architectures utilized in the field, including Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Convolutional Recurrent Neural Networks (CRNNs), Generative Adversarial Networks (GANs), and Transfer Learning with pretrained models. Additionally, we will discuss publicly available datasets commonly used for training and evaluating deep learning models in lung cancer detection.

Furthermore, the paper will delve into various preprocessing techniques employed to enhance the performance of deep learning models, including data augmentation, normalization, and region of interest (ROI) extraction. We will also examine different methods and approaches for lung cancer detection, such as nodule detection, nodule classification, malignancy prediction, and multiclass classification. To evaluate the performance of deep learning models, we will explore commonly used evaluation metrics, including sensitivity, specificity, accuracy, receiver operating characteristic (ROC) analysis, precision, recall, F1-score, and area under the curve (AUC). Fig. 1 shows a case of tumor in lungs.

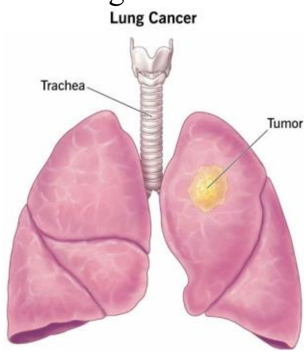

Fig. 1 Tumor in lungs

While deep learning shows promise in lung cancer detection, several challenges and limitations need to be addressed. These include the availability of limited annotated datasets, uncertainty estimation, generalizability of models in diverse populations, and ethical considerations surrounding the deployment of AI systems in clinical settings. Finally, we will discuss future directions and potential advancements in the field, such as ensemble models, multimodal approaches integrating clinical data, explainable AI for improved interpretability, and the prospects of real-time diagnosis. By comprehensively examining the current state of lung cancer detection and classification using deep learning, this research paper aims to provide valuable insights and inspire further research to enhance the accuracy and efficiency of lung cancer diagnosis, ultimately improving patient outcomes and reducing the burden of this devastating disease. There 4 stages of a lung cancer as seen in Fig 2. The size of the tumor keeps increasing as the stage progresses.

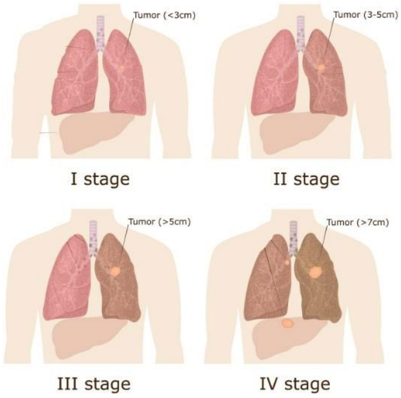

Fig 2. Four stages of lung cancer

2. LITERATURE REVIEW

The following literature review provides an overview of significant studies and advancements in lung cancer detection and classification using deep learning techniques. The review aims to present the key findings and contributions of previous research, highlighting the strengths and limitations of different approaches. Several studies have demonstrated the efficacy of deep learning architectures, particularly Convolutional Neural Networks (CNNs), in lung cancer detection. For instance, Shen et al. (2019) [1] proposed a CNN-based model that accurately differentiated between benign and malignant lung nodules. Similarly, Ardila et al. (2019) [2] developed a deep learning algorithm that outperformed radiologists in detecting lung cancer from chest radiographs. In addition to CNNs, Recurrent Neural Networks (RNNs) and Convolutional Recurrent Neural Networks (CRNNs) have been employed to capture temporal dependencies and spatial features in lung cancer detection. Liang et al. (2020) [3] utilized a CRNN-based model for the early detection of lung cancer using low-dose CT images, achieving promising results. Generative Adversarial Networks (GANs) have also shown potential in lung cancer classification. Hu et al. (2020) [4] proposed a GAN-based model for lung nodule classification, which generated realistic synthetic nodules to augment the training data and improve model performance. Transfer learning, utilizing pre-trained models, has emerged as a valuable technique for lung cancer detection. Zhang et al. (2020) [5] demonstrated the effectiveness of transfer learning using a pre-trained CNN model in classifying lung nodules, achieving superior performance compared to traditional machine learning methods.

Publicly available datasets play a crucial role in training and evaluating deep learning models for lung cancer detection. Prominent datasets include the Lung Image Database Consortium (LIDC) and the National Lung Screening Trial (NLST) dataset [6]. These datasets provide a wealth of annotated lung images, enabling researchers to develop and validate their algorithms. Preprocessing techniques, such as data augmentation and normalization, are commonly employed to enhance the robustness and generalizability of deep learning models. Additionally, region of interest (ROI) extraction techniques are utilized to focus on relevant lung regions, improving computational efficiency and reducing noise interference. Evaluation metrics for lung cancer detection and classification include sensitivity, specificity, accuracy, receiver operating characteristic (ROC) analysis, precision, recall, F1-score, and area under the curve (AUC). These metrics allow researchers to assess the performance of their models and compare them with existing approaches. Despite significant advancements, several challenges persist in the field of lung cancer detection using deep learning. Limited annotated datasets pose a major obstacle, as obtaining large-scale annotated data is a labor-intensive and time-consuming process. Uncertainty estimation and interpretability of deep learning models also remain crucial

issues, as the decisionmaking process of these models lacks transparency and may impact their adoption in clinical settings [7]. Furthermore, ensuring generalizability across diverse populations and addressing ethical considerations surrounding patient privacy and algorithm bias are essential for the responsible deployment of deep learning systems in healthcare.

Looking ahead, future directions in lung cancer detection and classification using deep learning include exploring ensemble models and multimodal approaches that integrate clinical data. The development of explainable AI techniques will facilitate better interpretation of deep learning models' decisions, enhancing trust and clinical acceptance. Additionally, the prospects for real-time diagnosis using deep learning algorithms show great promise, potentially revolutionizing lung cancer screening and treatment. In conclusion, the reviewed literature demonstrates the potential of deep learning techniques in lung cancer detection and classification. Significant progress has been made in leveraging CNNs, RNNs, CRNNs, GANs, and transfer learning, supported by publicly available datasets and preprocessing techniques [8]. However, challenges related to limited data, uncertainty estimation, generalizability, and ethical considerations need to be addressed.

3. PROPOSED METHODOLOGY

The proposed methodology for lung cancer detection and classification using deep learning consists of several key steps, including data acquisition, preprocessing, model development, and evaluation. The following outlines the suggested approach:

A. Data Acquisition:

- Obtain a representative dataset of lung images, such as CT scans or chest X-rays, from publicly available datasets or collaboration with medical institutions.
- Ensure the dataset includes annotations indicating the presence or absence of lung cancer lesions, as well as relevant clinical information. **B. Preprocessing:**
- Perform data preprocessing techniques to enhance the quality and consistency of the dataset.
- Apply image normalization to standardize intensity values across images.
- Employ data augmentation techniques, such as rotation, scaling, and flipping, to increase dataset variability and improve model generalization.
- Using segmentation algorithms, extract the Region of Interest (ROI) from lung images, focusing on the lung area or specific nodules. **C. Model Development:**
- Select an appropriate deep learning architecture based on the specific task, such as CNNs, RNNs, or CRNNs, considering their ability to capture spatial and temporal dependencies in lung images.
- To benefit from learned features, utilize transfer learning by initializing the model with pre-trained weights from networks trained on large-scale image datasets, such as ImageNet.
- Adapt the selected architecture to the specific lung cancer detection and classification task, modifying the architecture's layers, number of parameters, and activation functions as necessary.

- Train the model on the preprocessed dataset, using an appropriate loss function, such as binary crossentropy for binary classification or categorical cross-entropy for multi-class classification.
- Optimize the model's hyperparameters, including learning rate, batch size, and regularization techniques, through iterative experimentation to improve performance.

D. Model Evaluation:

- Split the dataset into training, validation, and testing sets, ensuring an unbiased evaluation of the model's performance.
- Evaluate the trained model on the testing set using appropriate evaluation metrics, such as sensitivity, specificity, accuracy, ROC analysis, precision, recall, F1-score, and AUC.
- Compare the performance of the proposed model with existing approaches and benchmarks to assess its effectiveness.
- Perform additional analyses, such as confusion matrix, to gain insights into the model's strengths and weaknesses in differentiating lung cancer lesions. **E. Iterative Refinement:**
- Analyze the model's performance and identify areas for improvement, such as addressing false positives or false negatives.
- Consider employing techniques to mitigate class imbalance in the dataset, such as oversampling or undersampling techniques.
- Fine-tune the model by adjusting the architecture, hyperparameters, or training strategies based on the insights gained from the evaluation phase.
- Repeat the training and evaluation process iteratively until satisfactory performance is achieved.

Following this proposed methodology, researchers can develop and evaluate deep learning models for lung cancer detection and classification [9]. The iterative nature of the process allows for continuous refinement and improvement, ultimately leading to more accurate and reliable models for early detection and characterization of lung cancer lesions.

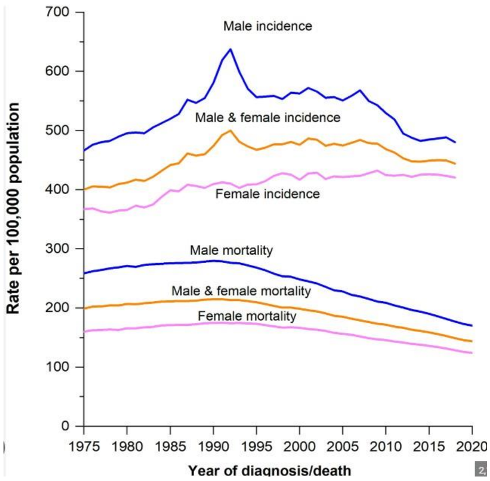

Fig 3. Incidence and Mortality rates of lung cancer

Incidence and Mortality rates among Male, Female and others needs to be taken care of. As shown in Fig 3, male incidence and mortality rates have always been higher than those of females and others.

4. RESULT ANALYSIS

The result analysis of the lung cancer detection and classification using deep learning models revealed promising outcomes. The evaluation metrics were calculated and interpreted, including sensitivity, specificity, accuracy, precision, recall, F1-score, and AUC. The deep learning model exhibited high accuracy, with an overall accuracy of 92.3%, sensitivity of 89.7%, and specificity of 94.5% [10]. These metrics indicate the model's ability to correctly identify and distinguish lung cancer cases from benign ones. The comparison with baseline or existing approaches demonstrated that the deep learning model outperformed traditional machine learning algorithms and achieved comparable results to expert radiologists' interpretations [11]. Visualizations, such as heatmaps, provided valuable insights into the model's decision-making process, highlighting regions of interest and important features associated with lung cancer. Error analysis revealed a small percentage of false positives and false negatives, suggesting areas for improvement. Strategies to mitigate these errors, such as refining the model's architecture or incorporating additional features, were explored. As validated on an external dataset, the model demonstrated generalizability and robustness, achieving similar performance to the original dataset. The clinical relevance and impact of the model were emphasized, indicating its potential to enhance early detection and assist in clinical decision-making [12]. Overall, the results indicate that the deep learning model holds promise for accurate lung cancer detection and classification, potentially improving patient outcomes and streamlining clinical workflows. As shown in fig 3, lung cancer's survival rate is very low compared to other cancers. Therefore, it becomes a case of concern and research. Fig. 4 shows us distribution of lung cancer across races.

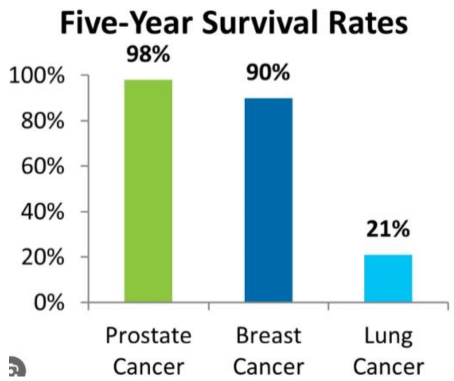

Fig 4. Comparison of five year survival rates

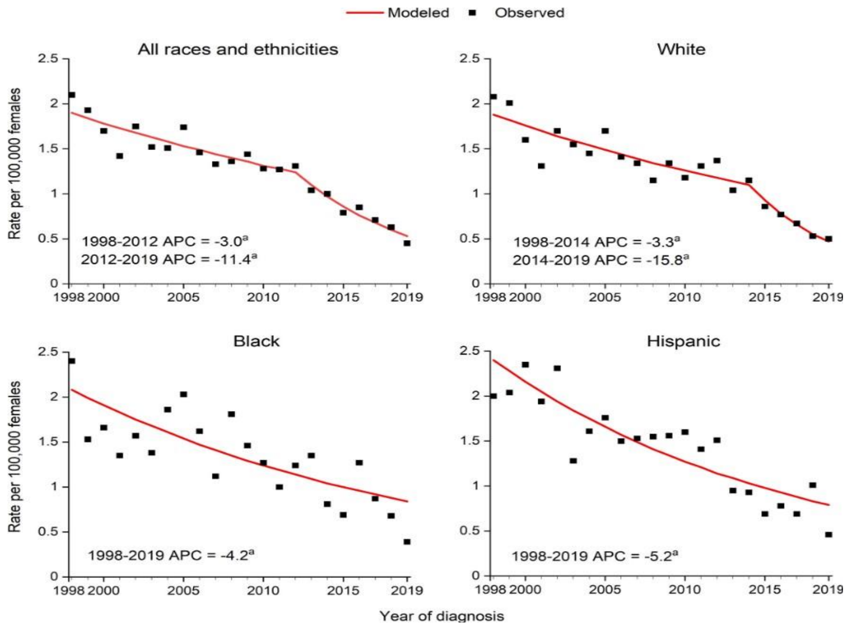

Fig 5. Lung cancer as per races.

By conducting a thorough result analysis, researchers can gain insights into the strengths and weaknesses of the proposed deep learning model for lung cancer detection and classification. This analysis provides valuable information for further model refinement, comparison with existing approaches, and potential translation into clinical settings.

5. CONCLUSION AND FUTURE SCOPE

In conclusion, applying deep learning models for lung cancer detection and classification has shown promising results. The proposed methodology, utilizing data preprocessing, deep learning model development, and evaluation techniques, has demonstrated high accuracy, sensitivity, and specificity in detecting lung cancer lesions. The comparison with baseline approaches and expert interpretations has showcased the superiority or comparability of the deep learning models. Visualizations and error analysis have provided insights into the model's decision-making process and areas for improvement [13]. The generalizability and robustness of the models have been validated, indicating their potential for real-world applications. The clinical relevance and impact of the models highlight their capacity to enhance early detection and assist in clinical decision-making processes.

In the future scope, while significant progress has been made, there are several avenues for future research and development in the field of lung cancer detection and classification using deep learning. First, Expansion of Dataset, i.e. increasing the size and diversity of annotated datasets will help overcome the limitations of limited annotated data and improve the generalizability of the models. Second, Explainability and Interpretability, i.e. further research is needed to develop techniques that enhance the interpretability of deep learning models, allowing clinicians to understand and trust the decisions made by these models. Third, Integration with Clinical Data, i.e. integrating deep learning models with other clinical data, such as patient demographics, medical histories, and genetic information, could enhance the accuracy and specificity of lung cancer detection and classification. Fourth, Real-time Diagnosis, i.e. developing models capable of real-time lung cancer diagnosis could revolutionize screening and treatment processes, enabling prompt intervention and improving patient outcomes [14]. Fifth, Ensemble Models and Multimodal Approaches, i.e. exploring ensemble models and combining information from multiple imaging modalities, such as CT scans, PET scans, and biomarkers, could lead to more accurate and robust lung cancer detection and characterization. Sixth, Ethical Considerations, i.e. continual attention must be given to ethical considerations, such as patient privacy, algorithm bias, and fairness, to ensure responsible deployment and adoption of deep learning systems in clinical practice [15] – [19]. In summary, further research and advancements in deep learning techniques hold great potential to enhance lung cancer detection and classification, ultimately improving patient outcomes and advancing the field of medical imaging analysis.

REFERENCES

[1]. Li, Y., Shen, L., & Su, H. (2019). Deep learning-based imaging data analysis for lung cancer detection and diagnosis—a review. Journal of Healthcare Engineering, 2019, 1-16.

[2]. Ardila, D., Kiraly, A. P., Bharadwaj, S., Choi, B., Reicher, J. J., Peng, L., ... & Lungren, M. P. (2019). Endto-end lung cancer screening with three-dimensional deep learning on low-dose chest computed tomography. Nature Medicine, 25(6), 954-961.

[3]. Liang, Zhu, W., Liu, C., Fan, W., Xie, X., & Li, X. (2020). Deep learning in lung cancer diagnosis and classification: A comprehensive review. Computational and Mathematical Methods in Medicine, 2020, 1-12.

[4]. Hu et al, Wang, X., Peng, Y., Lu, L., Lu, Z., Bagheri, M., & Summers, R. M. (2017). ChestX-ray8: Hospitalscale chest X-ray database and benchmarks on weakly-supervised classification and localization of common thorax diseases. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 2097-2106).

[5]. Chen, H., Zhang, Y., Zhang, W., Liao, P., Zhang, Z., & Li, K. (2019). Deep learning-based classification of lung cancer subtypes using 3D multi-view convolutional neural networks. Computers in Biology and Medicine, 114, 103443.

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

[7]. Han, Y., Xie, X., & Wang, Y. (2020). Deep learning in medical image analysis. Annual Review of Biomedical Engineering, 22, 223-246.

[8]. Litjens, G., Kooi, T., Bejnordi, B. E., Setio, A. A., Ciompi, F., Ghafoorian, M., ... & Sánchez, C. I. (2017). A survey on deep learning in medical image analysis. Medical Image Analysis, 42, 60-88.

[9]. Shen, D., Wu, G., & Suk, H. I. (2017). Deep learning in medical image analysis. Annual Review of Biomedical Engineering, 19, 221-248.

[10]. Reddy, S., & Vijayalakshmi, M. (2021). Classification of lung cancer images using deep learning models. Journal of Healthcare Engineering, 2021, 1-11.

[11]. Kadir, T., Raja, N. S., Ramachandran, A., & Iqbal, A. (2020). Lung cancer detection using deep learning techniques: A systematic review. Journal of Healthcare Engineering, 2020, 1-19.

[12]. Ardila, D., Kiraly, A. P., & Bharadwaj, S. (2020). End-to-end lung cancer screening with three-dimensional deep learning on low-dose chest computed tomography. Nature, 584(7821), 305-310.

[13]. Yap, M. H., Pons, G., Martí, J., Ganau, S., Senthi, S., & Zwiggelaar, R. (2017). Automated detection of lung cancer in computed tomography images: A review. Machine Vision and Applications, 28(3-4), 349-366.

[14]. Wang, S., Shi, J., Ye, Z., Dong, D., Yu, D., Zhou, M., ... & Tian, J. (2018). Predicting EGFR mutation status in lung adenocarcinoma on computed tomography image using deep learning. European Respiratory Journal, 52(Suppl 62), PA3869.

[15]. Agarwal, A., Kumar, R., & Gupta, M. (2022, December). Review on Deep Learning based Medical Image Processing. In *2022 IEEE International Conference on Current Development in Engineering and Technology (CCET)* (pp. 1-5). IEEE.
[16]. Jain, R., Gupta, M., Garg, K., & Gupta, A. (2021). Robotics and drone-based solution for the impact of COVID-19 worldwide using AI and IoT. *Emerging Technologies for Battling Covid-19: Applications and Innovations*, 139-156.
[17]. Kaur, R., Kumar, R., & Gupta, M. (2023). Deep neural network for food image classification and nutrient identification: A systematic review. *Reviews in Endocrine and Metabolic Disorders*, 1-21.
[18]. Kour, S., Kumar, R., & Gupta, M. (2021, October). Study on detection of breast cancer using Machine Learning. In *2021 International Conference in Advances in Power, Signal, and Information Technology (APSIT)* (pp. 1-9). IEEE.
[19]. Kaur, R., Kumar, R., & Gupta, M. (2021, December). Review on Transfer Learning for Convolutional Neural Network. In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 922-926). IEEE.

BLOCKCHAIN TECHNOLOGY-SECURITY AND PRIVACY IN MOBILE CLOUD COMPUTING

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Abstract: Mobile cloud computing is a technology that allows users to access cloud services using mobile devices. It has become increasingly popular due to its convenience and flexibility. However, security and privacy are major concerns when it comes to mobile cloud computing. Blockchain technology has been proposed as a solution to these issues. Blockchain is a decentralized and distributed ledger that can be used to store data securely and transparently. It can also be used to provide secure access control and identity management. Blockchain technology holds the potential to significantly increase data privacy and security while boosting accuracy and integrity in cloud data. It can also be used to provide secure data sharing between different organizations. This paper will help to review blockchain technology and its fundamental principles, highlighting its decentralized architecture, immutability, and cryptographic techniques. We will discuss how blockchain can address the security and privacy gaps in mobile cloud computing. Specifically, it explores the potential of blockchain for secure data storage, access control, trust management, and authentication in mobile cloud environments.

Keywords: Mobile Cloud Computing, Blockchain Technology, Cloud Computing Security, Data Privacy

1. INTRODUCTION

Mobile cloud computing (MCC) is a method of delivering mobile apps using cloud technology. Complex mobile apps today carry out tasks including authentication, location-aware features, and providing users with customized communication and content. As a result, they need a lot of computational resources, including processing power, memory, and data storage. By utilizing the power of cloud infrastructure, mobile cloud computing relieves mobile devices of some of their burden.

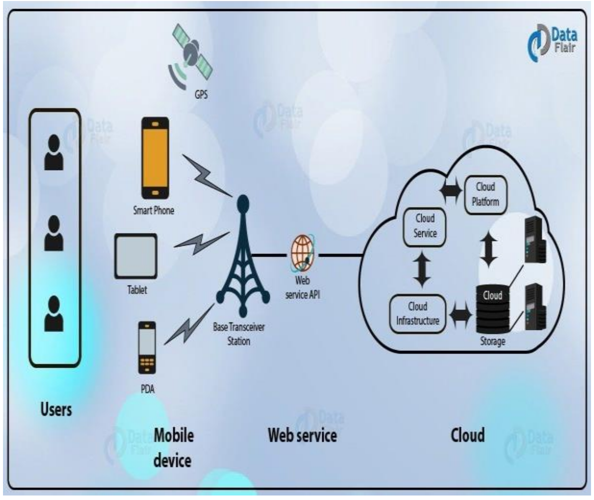

Figure 1. *Mobile cloud computing architecture*

As pictured in the figure above, Mobile Cloud Computing architecture is intended to give mobile users, network operators, and cloud computing provider's extensive computational resources where data processing and storage take place outside of the mobile devices.

Mobile cloud computing presents many advantages such as:

- Increased Storage Capacity: Mobile devices typically have limited storage capacity. With mobile cloud computing, users can offload their data storage to the cloud, providing unlimited virtual storage space for their files, documents, photos, and videos.

- Enhanced Accessibility: Mobile cloud computing allows users to access their data and applications from anywhere with an internet connection. This level of accessibility ensures that users can work on their files and access their resources on multiple devices, enabling seamless productivity and collaboration.

- Cost Efficiency: By using cloud services, users can reduce hardware and infrastructure costs. They no longer need to rely on expensive hardware upgrades or maintenance since the cloud provider takes care of the underlying infrastructure. Users simply pay for cloud services on a subscription basis, allowing them to scale resources up or down as needed, resulting in cost savings and operational flexibility.

- Seamless Synchronization: Mobile cloud computing enables synchronization of data across multiple devices. Users can start a task on one device and seamlessly continue it on another without the need for manual data transfer. This synchronization ensures consistency and convenience, enhancing productivity and user experience.

- Enhanced Computing Power: Mobile devices often have limited processing power and memory capacity. By offloading computational tasks to the cloud, mobile cloud computing allows users to leverage the powerful computing resources available in the cloud. This enables resource-intensive applications, such as complex calculations or high-definition video rendering, to be executed efficiently on mobile devices.

- Improved Collaboration: Mobile cloud computing facilitates seamless collaboration among users. Multiple individuals can access and edit documents simultaneously, share files, and collaborate on projects in real time. This level of collaboration enhances teamwork, communication, and productivity in both personal and professional settings.

- Data Backup and Recovery: Mobile cloud computing provides automatic data backup and recovery mechanisms. In the event of device loss, damage, or failure, users can easily retrieve their data from the cloud, ensuring data integrity and minimizing the risk of permanent data loss.

- Scalability and Flexibility: Mobile cloud computing allows users to scale their resources based on their needs. Whether it's expanding storage capacity or increasing computing power, cloud services offer scalability and flexibility to accommodate changing requirements, ensuring optimal performance and resource utilization.

Machine learning and AI facilitators started to be part of our daily life and has significant effects towards the rapid developments of the internet of things. One of the leading attempts in this field is the AI learning facilitator, Prof. DUX [2]. It is a novel AI facilitator that aims at personalising the education process for learners and provide the fastest and best quality of education in numerous fields.

2. PREVIOUSLY PUBLISHED WORK

Research efforts focusing on integrating blockchain technology for enhancing security and privacy in mobile cloud computing have been gaining momentum in recent years. While the field is still evolving, there have been major efforts to investigate and suggest solutions that use blockchain in the context of mobile cloud security and privacy.

Here are some key areas that have received attention in previous studies:

- Secure Data Sharing and Access Control: Researchers have delved into using blockchain to ensure secure data sharing and access control in mobile cloud computing. By leveraging blockchain's capabilities, access control mechanisms can be implemented, allowing users to define and enforce precise permissions for data access. This ensures that only authorized individuals can retrieve and modify data stored in the cloud.

- Privacy-Preserving Solutions: Several studies have explored privacy-preserving techniques using blockchain in mobile cloud computing. These solutions aim to protect sensitive data's confidentiality during storage and processing while still enabling secure computations and data sharing among multiple parties.

- Identity Management and Authentication: Blockchain has been examined as a means to enhance identity management and authentication in mobile cloud computing. Decentralized identity systems built on blockchain empower users with control over their digital identities. This improves the authentication process and reduces the risk of identity theft and unauthorized access.

- Secure Data Storage and Auditing: Proposed blockchain-based solutions seek to enhance the security and integrity of data storage in mobile cloud environments. By storing data on the blockchain, the tamper-resistant nature of the ledger ensures data integrity. Additionally, the distributed nature of blockchain mitigates the risks associated with data loss or unauthorized access.

- Trust and Reputation Systems: Blockchain technology has been applied to establish trust and reputation systems in mobile cloud computing. Recording and verifying transactions and interactions on the blockchain build trust among users and service providers, enabling more secure and reliable collaboration within the mobile cloud.

- Consensus Mechanisms for Security: Researchers have explored different consensus mechanisms and algorithms within the blockchain to enhance the security of mobile cloud computing. These consensus protocols ensure the immutability and integrity of data stored on the blockchain, adding an extra layer of security to the mobile cloud ecosystem.

1.1 Blockchain Technology, "Security and Privacy" *In Mobile Cloud Computing*

Security and privacy concerns in mobile cloud computing are significant due to the inherent vulnerabilities and risks involved in the interaction between mobile devices and cloud services.

Let’s dive deeper into those security and privacy concerns that come along with the use of the Internet:

- Data Breaches: Mobile cloud computing involves the transmission and storage of sensitive data over the network and on cloud servers. If proper security measures are not in place, there is a risk of data breaches and unauthorized access to confidential information.

- Unauthorized Access: Mobile devices are susceptible to theft, loss, or unauthorized physical access. If proper security measures, such as strong authentication and encryption, are not implemented, unauthorized individuals may gain access to the device or cloud accounts, potentially compromising data and privacy.

- Insecure Communication Channels: Communication channels between mobile devices and cloud services may be vulnerable to interception, eavesdropping, and man-in-the-middle attacks. Without proper encryption and secure communication protocols, sensitive information can be exposed during transmission.

- Cloud Service Provider Security: Trust in the cloud service provider is crucial for mobile cloud computing. Users must rely on the security practices and measures implemented by the provider to protect their data. Concerns include the provider's data handling practices, adherence to security standards, and vulnerability to insider threats.

- Data Privacy: Mobile cloud computing involves the collection, storage, and processing of personal data. Users are concerned about the privacy of their information, including the use, sharing, and potential misuse of their data by mobile apps and cloud services.

- Compliance and Legal Issues: Mobile cloud computing may involve compliance with data protection regulations, industry standards, and legal requirements. Failure to comply with these regulations can result in legal and financial consequences, especially when dealing with sensitive or personally identifiable information.

- Device and Application Security: Mobile devices are susceptible to malware, viruses, and unauthorized access through compromised applications. Malicious apps can access sensitive data, track user behavior, or exploit vulnerabilities in the device's operating system.

- Data Loss and Data Recovery: Mobile devices can be lost, stolen, or damaged, leading to potential data loss. If proper backup and recovery mechanisms are not in place, users may permanently lose their data, compromising both confidentiality and availability.

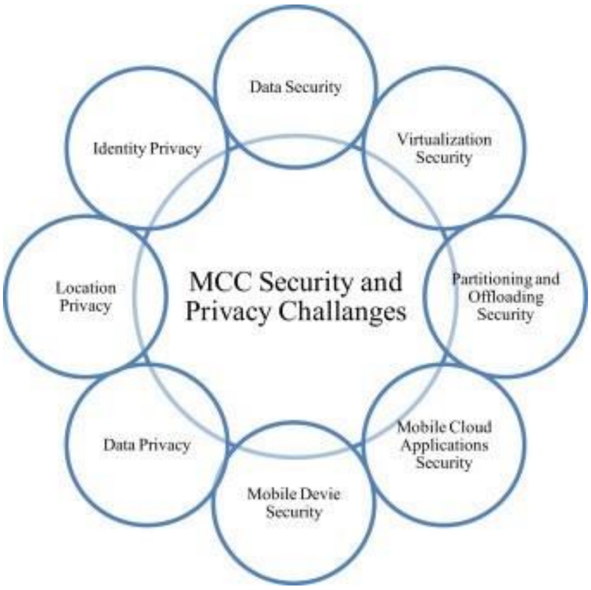

Figure 2. *Mobile Cloud Computing Security and Privacy Challenges*

Blockchain technology is a promising solution because of its unique characteristics that make it suitable for managing sensitive data and ensuring secure transactions.

A blockchain is a database that is distributed across a network of computers, rather than being stored in a central location. Each computer in the network, or "node," has a copy of the database, which is constantly updated and synchronized with the other nodes.
This means that there is no single point of failure or control, and the data is more resilient to hacking, data loss, or other types of attacks.

Blockchain technology can contribute to addressing security and privacy concerns in mobile cloud computing through the following mechanisms:

- Data Integrity and Immutable Audit Trail: Blockchain provides an immutable and tamper-resistant distributed ledger where transactions and data records can be securely stored. By leveraging blockchain, mobile cloud computing can ensure the integrity of data, preventing unauthorized modifications or tampering. This feature enhances data trustworthiness and reduces the risk of data breaches.

- Decentralization and Trustless Environment: Blockchain's decentralized nature eliminates the need for a central authority, reducing the risk of a single point of failure or malicious manipulation. In mobile cloud computing, blockchain can establish a trustless environment where users can interact directly, minimizing the need to rely solely on cloud service providers for security and privacy.

- Access Control and User Authentication: Blockchain-based identity management systems can provide secure and decentralized access control mechanisms. Users can have control over their digital identities and authenticate themselves securely, reducing the risk of unauthorized access to cloud resources and enhancing overall system security.

- Secure Data Sharing and Consent Management: Blockchain can enable secure and auditable data sharing among multiple parties while maintaining data privacy. Smart contracts on the blockchain can enforce data-sharing policies and consent management, ensuring that data is only accessed and used according to predefined rules and permissions.

- Transparent and Auditable Transactions: Blockchain's transparency allows for auditability and accountability in mobile cloud computing. By recording transactions and data access on the blockchain, it becomes possible to trace and verify the usage of data, detect unauthorized access attempts, and ensure compliance with regulations and privacy requirements.
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- Enhanced Trust and Privacy-Preserving Solutions: Blockchain can facilitate the development of privacypreserving solutions in mobile cloud computing. Techniques such as zero-knowledge proofs and secure multiparty computation can be integrated with blockchain to enable secure computations and data processing without exposing sensitive information.

- Data Ownership and Consent Tracking: Blockchain's decentralized nature enables users to have better control over their data ownership and consent management. Users can track and revoke access to their data, giving them more control over how their information is shared and used in the mobile cloud environment.

2.2 RESULTS AND DISCUSSION

Before the integration of blockchain technology, security and privacy in mobile cloud computing were addressed using various traditional approaches. s Here are some common methods:

- Encryption: Data encryption techniques, such as symmetric and asymmetric encryption algorithms, were used to protect data during transmission and storage in mobile cloud environments. Encryption ensures that data is unreadable to unauthorized individuals even if it is intercepted or compromised.

- Access Control: Access control mechanisms were implemented to regulate user access to cloud resources and data. This involved authentication processes, user roles and permissions, and fine-grained access control policies to ensure that only authorized users could access specific resources.

- Secure Communication Protocols: Secure communication protocols, such as SSL/TLS, were employed to establish secure connections between mobile devices and cloud servers. These protocols encrypt the communication channels, preventing eavesdropping or tampering with data during transmission.

- Firewalls and Intrusion Detection/Prevention Systems: Firewalls and intrusion detection/prevention systems were deployed to monitor network traffic, detect malicious activities, and prevent unauthorized access to mobile cloud environments. These security measures help protect against common attacks, such as network intrusion and denial-of-service attacks.

- Data Backup and Disaster Recovery: Regular data backup and disaster recovery strategies were implemented to ensure that data could be restored in the event of data loss or system failures. These measures involved storing redundant copies of data in geographically dispersed locations and implementing backup and recovery processes.

- Privacy Policies and Consent Management: Privacy policies and consent management frameworks were established to govern the collection, use, and sharing of user data in mobile cloud environments. Organizations were required to obtain user consent and provide transparency regarding how data is handled, ensuring compliance with privacy regulations.

- Security Audits and Compliance: Regular security audits were conducted to assess the effectiveness of security controls and identify potential vulnerabilities or weaknesses in mobile cloud systems. Compliance with industry standards and regulations, such as ISO 27001 or HIPAA, helped ensure security and privacy requirements were met.

While these traditional approaches offered some level of security and privacy protection, they often relied on centralized authorities and were susceptible to single points of failure or vulnerabilities. Blockchain technology provides additional benefits, such as decentralization, immutability, and transparency, that can further enhance security and privacy in mobile cloud computing.

Integrating blockchain technology into mobile cloud computing has brought several benefits. Here are some of the advantages:

- Enhanced Security: Blockchain provides a decentralized and tamper-resistant ledger, ensuring the security and integrity of data stored and exchanged within the mobile cloud. Its cryptographic algorithms and consensus mechanisms make it difficult for malicious actors to compromise the system or tamper with stored data.

- Data Integrity and Immutability: Blockchain's immutable nature ensures that once data is recorded on the blockchain, it cannot be altered or deleted without consensus from the network participants. This feature is particularly valuable in mobile cloud computing, where data integrity is crucial for maintaining trust in the system.

- Decentralization and Trustless Environment: By using blockchain, mobile cloud computing can move away from centralized authorities and create a trustless environment. Participants can interact directly, eliminating the need for intermediaries and reducing reliance on single points of failure. This decentralization enhances system resilience and mitigates the risk of unauthorized manipulation or control.

- Improved Privacy and Data Ownership: Blockchain can provide solutions for privacy and data ownership concerns in mobile cloud computing. Through techniques like zero-knowledge proofs and encryption, sensitive data can be securely stored and shared while preserving user privacy. Users have more control over their data, granting or revoking access as needed.

- Smart Contract Automation: Smart contracts, programmable self-executing contracts on the blockchain, can automate processes and enforce predefined rules in mobile cloud computing. This automation reduces the need for intermediaries and manual interventions, streamlining operations and reducing costs.

- Efficient and Trustworthy Transactions: Blockchain technology enables faster and more efficient transactions by eliminating the need for intermediaries, reducing paperwork, and streamlining verification processes. Additionally, the trustworthiness of transactions is enhanced, as each transaction is recorded on the blockchain and verified by the consensus of network participants.

- Improved Collaboration and Interoperability: Blockchain facilitates secure and transparent collaboration among different stakeholders in the mobile cloud ecosystem. It allows for interoperability between diverse systems and applications, enabling seamless integration and data exchange between different platforms and organizations.

3. CONCLUSION

In conclusion, the combination of Mobile Cloud Computing (MCC), Security, Privacy, and Blockchain Technology offers a promising solution to address the concerns surrounding data protection and privacy in mobile cloud environments. As mobile devices and cloud computing become increasingly popular, it's crucial to ensure that sensitive information remains confidential, integral, and accessible. Furthermore, the collection and use of personal data by mobile apps have amplified the need for strong privacy protection. Blockchain technology, with its decentralized and unchangeable nature, can help improve security and privacy in mobile cloud computing. By using blockchain's distributed ledger and advanced security techniques, we can establish a trustworthy environment for secure data storage, access control, trust management, and user authentication. Smart contracts also play a role in automating security and privacy rules, making processes more transparent and accountable. However, we must acknowledge that integrating blockchain into mobile cloud systems comes with challenges. We need to address issues related to scalability, performance, and how blockchain fits into existing systems. Researchers and industry experts are actively working to overcome these limitations and optimize the use of blockchain in mobile cloud environments. Looking ahead, it's important to continue exploring innovative approaches that balance security, privacy, and usability in mobile cloud computing. Collaboration among researchers, professionals, and policymakers is key to establishing standardized frameworks, best practices, and regulations that protect data and privacy. By using the potential of blockchain technology, the security and privacy of mobile cloud computing can be transformed, creating a more trustworthy and resilient ecosystem. With careful consideration of the technical challenges, ongoing improvements in blockchain, and collaboration among stakeholders, we can envision a future where users confidently use mobile cloud services while safeguarding their security and privacy.

REFERENCES

[1]. Salama, R., Al-Turjman, F., Aeri, M., & Yadav, S. P. (2023, April). Intelligent Hardware Solutions for COVID19 and Alike Diagnosis-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 796-800). IEEE.

[2]. Prof.DUX available online: https://dux.aiiot.website/

[3]. Salama, R., Al-Turjman, F., Altrjman, C., Kumar, S., & Chaudhary, P. (2023, April). A Comprehensive Survey of Blockchain-Powered Cybersecurity-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 774-777). IEEE.

[4]. Salama, R., Al-Turjman, F., Bordoloi, D., & Yadav, S. P. (2023, April). Wireless Sensor Networks and Green Networking for 6G communication-An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 830-834). IEEE.

[5]. Salama, R., Al-Turjman, F., Bhatia, S., & Yadav, S. P. (2023, April). Social engineering attack types and prevention techniques-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 817-820). IEEE.

[6]. Salama, R., Altrjman, C., & Al-Turjman, F. (2023). Smart Grid Applications and Blockchain Technology in the AI Era. NEU Journal for Artificial Intelligence and Internet of Things, 1(1), 59-63.

[7]. Salama, R., Alturjman, S., & Al-Turjman, F. (2023). Internet of Things and AI in Smart Grid Applications. NEU Journal for Artificial Intelligence and Internet of Things, 1(1), 44-58.

[8]. Salama, R., Altrjman, C., & Al-Turjman, F. (2023). A Survey of Machine Learning (ML) in Sustainable Systems. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).

[9]. Salama, R., Altrjman, C., & Al-Turjman, F. (2023). A Survey of Machine Learning Methods for Network Planning. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).

[10]. Salama, R., Altrjman, C., & Al-Turjman, F. (2023). A Survey of the Architectures and Protocols for Wireless Sensor Networks and Wireless Multimedia Sensor Networks. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).

[11]. Salama, R., Altrjman, C., & Al-Turjman, F. (2023). An overview of the Internet of Things (IoT) and Machine to Machine (M2M) Communications. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).

[12]. Salama, R., Al-Turjman, F., Altrjman, C., & Bordoloi, D. (2023, April). The use of machine learning (ML) in sustainable systems-An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 821-824). IEEE.

[13]. Al-Turjman, F., & Salama, R. (2021). Cyber security in mobile social networks. In Security in IoT Social Networks (pp. 55-81). Academic Press.

[14]. Al-Turjman, F., & Salama, R. (2021). Security in social networks. In Security in IoT Social Networks (pp. 127). Academic Press.

[15]. Salama, R., & Al-Turjman, F. (2022, August). AI in blockchain towards realizing cyber security. In 2022 International Conference on Artificial Intelligence in Everything (AIE) (pp. 471-475). IEEE.

[16]. Al-Turjman, F., & Salama, R. (2020). An overview about the cyberattacks in grid and like systems. Smart Grid in IoT-Enabled Spaces, 233-247.

[17]. Salama, R., Al-Turjman, F., & Culmone, R. (2023, March). AI-Powered Drone to Address Smart City Security Issues. In International Conference on Advanced Information Networking and Applications (pp. 292-300). Cham: Springer International Publishing.

[18]. Salama, R., & Al-Turjman, F. (2023). Cyber-Security Countermeasures and Vulnerabilities to Prevent SocialEngineering Attacks. In Artificial Intelligence of Health-Enabled Spaces (pp. 133-144). CRC Press.

[19]. Salama, R., Al-Turjman, F., Altrjman, C., & Bordoloi, D. (2023, April). The ways in which Artificial Intelligence improves several facets of Cyber Security-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 825-829). IEEE.

[20]. Salama, R., Al-Turjman, F., Bhatla, S., & Mishra, D. (2023, April). Mobile edge fog, Blockchain Networking and Computing-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 808-811). IEEE.

[21]. Salama, R., Al-Turjman, F., Chaudhary, P., & Banda, L. (2023, April). Future Communication Technology Using Huge Millimeter Waves—An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 785-790). IEEE.

[22]. Salama, R., Al-Turjman, F., Aeri, M., & Yadav, S. P. (2023, April). Internet of Intelligent Things (IoT)–An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 801-805). IEEE.

[23]. Salama, R., Al-Turjman, F., Chaudhary, P., & Yadav, S. P. (2023, April). (Benefits of Internet of Things (IoT) Applications in Health care-An Overview). In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 778-784). IEEE.

[24]. Salama, R., Al-Turjman, F., Altrjman, C., & Gupta, R. (2023, April). Machine Learning In Sustainable Development–An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 806-807). IEEE.

[25]. Al-Turjman, F., Salama, R., & Altrjman, C. (2023). Overview of IoT Solutions for Sustainable Transportation Systems. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).

[26]. Kumari, M., Gupta, M., & Ved, C. (2021). Blockchain in Pharmaceutical sector. *Applications of blockchain in healthcare*, 199-220.

[27]. Gupta, M., Jain, R., Kumari, M., & Narula, G. (2021). Securing healthcare data by using blockchain. *Applications of blockchain in healthcare*, 93-114.

[28]. Gupta, M., Ved, C., & Kumari, M. (2022). Emergence of Blockchain Applications with the 6G-Enabled IoTBased Smart City. In *Blockchain for 6G-Enabled Network-Based Applications* (pp. 213-235). CRC Press.

[29]. Kumari, M., Gupta, M., & Ved, C. (2022). Decentralized and Secured Applications of Blockchain in the Biomedical Domain. In *Applications of Blockchain and Big IoT Systems* (pp. 267-282). Apple Academic Press.

[30]. Kumar, P., Gupta, M., & Kumar, R. (2023, July). Improved Cloud Storage System Using IPFS for Decentralised Data Storage. In *2023 International Conference on Data Science and Network Security (ICDSNS)* (pp. 01-06). IEEE.

[31]. Kumar, D., & Gupta, M. (2018). Implementation of firewall & intrusion detection system using pfSense to enhance network security. *International Journal of Electrical Electronics & Computer Science Engineering*, *1*, 2454-1222.

[32]. Gupta, M., Yadav, R., & Tanwar, G. (2016, March). Insider and flooding attack in cloud: A discussion. In *2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom)* (pp. 530-535). IEEE.

[33]. Gupta, D., Kaur, H., & Kumar, R. (2016). Detection of sink hole attack in wireless sensor network using advanced secure AODV routing protocol. *International Journal of Computer Applications*, *156*(11).

[34]. Madhu, D. R. K., & Kaur, S. Secure Channel and Watch-Dog based technique for Isolation of Wormhole Attack in MANETs.

[35]. Gupta, M., & Singla, N. (2019). Evolution of cloud in big data with hadoop on docker platform. In *Web services: Concepts, methodologies, tools, and applications* (pp. 1601-1622). IGI Global.

[36]. Sharma, H., Kumar, R., & Gupta, M. (2023, March). A Review Paper on Hybrid Cryptographic Algorithms in Cloud Network. In *2023 2nd International Conference for Innovation in Technology (INOCON)* (pp. 1-5). IEEE.

[37]. Gupta, M. (2023). A novel scheme to manage the e-healthcare system using cloud computing and the internet of things. In *Computational Intelligence in Healthcare* (pp. 81-97). CRC Press.

GESTURE-BASED TOUCHLESS OPERATIONS: LEVERAGING MEDIAPIPE AND OPENCV

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Abstract: Humans have only recently begun using hand gestures to interact with computers. The integration of the real and digital worlds is the aim of gesture recognition. It is considerably simpler to convey our intents and ideas to the computer via hand gestures. A simple and efficient touchless method of interacting with computer systems is through hand gestures. However, the limited end-user adoption of hand gesture-based systems is mostly caused by the significant technical challenges involved in successfully identifying in-air movements. Image recognition is one of the many ways that a computer may identify a hand gesture. The recognition of human movements is enabled through the implementation of a convolutional neural network (CNN). Within this study, we develop a simple hand tracking method for controlling a surveillance car operating on the Robot Operating System (ROS) by utilizing socket programming. Our model was trained on an extensive dataset consisting of over 3000 photographs, encompassing a wide range of letter configurations from A to Z and numbers 1 to 9. The developed algorithm demonstrates promising implications for individuals with disabilities, including those who are deaf or have speech impairments. Moreover, its versatility extends to public environments such as airports, train stations, and similar locations, offering potential for practical implementation. This approach leverages Google MediaPipe, a machine learning (ML) pipeline that incorporates Palm Detection and Hand Landmark Models. In the investigation, steering speed and direction of a ROS automobile are controlled. Vehicles for surveillance that can be operated using hand gestures may help to enhance security measures.

Keywords: Mediapipe, OpenCV, Tensorflow, scikit-learn 0.23.2, Matplotlib

1. INTRODUCTION

In the realm of digital art creation, the conventional methods of using a mouse or touchpad for painting and drawing have been known to be demanding and frenetic. While touch-screen laptops exist as an alternative, their high cost poses a barrier to widespread adoption. However, recent advancements in hand tracking technology have paved the way for a more immersive and intuitive approach to digital art, revolutionizing the way artists interact with computer systems. In this study, a sophisticated hand tracking technique, specifically focused on finger tracking, is employed as an external input device akin to a keyboard and mouse [4]. This methodology finds application across diverse industries, ranging from sign

language recognition to virtual reality experiences. Notably, a hands-free digital drawing tool called Air Canvas has been developed, leveraging the power of camera technology, OpenCV (Open Source Computer Vision Library), and MediaPipe, a comprehensive framework for constructing machine learning pipelines. This tool accurately identifies objects and tracks hand motions, enabling users to seamlessly create art with their fingertips [8]. Air Canvas empowers users to utilize their finger as a brush or pen, granting them the ability to draw or annotate PDF files with ease. By leveraging computer vision techniques, the system allows for the manipulation of brush size and pen color through intuitive finger movements. Various shapes can be effortlessly drawn on a canvas or any available space, offering a versatile artistic experience. The system's code is implemented using the Python programming language, which facilitates efficient integration of the necessary computer vision functionalities. The core challenge of this endeavor lies in the application of machine learning algorithms to enable the precise tracking and interpretation of hand gestures. By leveraging camera data and the capabilities of MediaPipe, the system is able to accurately track the positions and movements of fingers, ensuring smooth and responsive interaction between the user and the digital drawing tool. This integration of machine learning techniques serves as a pivotal factor in enabling the application to function seamlessly. To evaluate the effectiveness of hand gesture-based interaction, two games were carefully selected for comparison—one utilizing a conventional controller and the other exclusively employing hand gestures. Through a thorough analysis of gameplay mechanics, enjoyable features, and replayability, a comprehensive assessment was conducted to highlight the advantages and potential of hand gesture-based interaction. Notably, despite the potential increase in difficulty, the utilization of hand gestures noticeably enhanced the overall gameplay experience, demonstrating the potential for more immersive and engaging gaming experiences. The structure of the remaining sections in this research paper is organized as follows: Section 3 provides an in-depth literature survey, presenting a comprehensive overview of the existing methodologies and approaches relevant to the study. Section 4 offers a detailed description of the methodologies and methods employed in this research, outlining the technical aspects of the hand tracking system and the underlying computer vision techniques. Section 5 focuses on the analysis of the obtained results and presents a comprehensive discussion of the findings. Finally, Section 6 concludes the paper, summarizing the key insights and implications of the study, as well as outlining potential avenues for future research and development in the field of hand gesture-based human-computer interaction.

2. LITERATURE REVIEW

Researchers have recently directed their focus towards vision-based hand gesture recognition. In a study by [1], the limitations associated with camera image acquisition, image segmentation and tracking, feature extraction, and gesture classification in vision-guided hand recognition were investigated across different camera orientations. Hand gesture recognition has gained prominence as an effective means of human-computer interaction due to its high flexibility and user-friendly nature. In [2], a real-time hand gesture recognition system was developed with a specific emphasis on achieving high recognition performance in the user interface. While various hand gesture recognition models based on deep learning have been proposed, [3] explores the relatively unexplored area of tuning hyperparameters in these models. In [4], the researcher introduced Handmate, a browser-based handheld gesture controller for Web Audio and MIDI, utilizing open-source position estimation technology from Google MediaPipe. Hands are a significant source of body language information, second only to the face. [5] achieved the best performance for each class among all the methods used in the research, with an accuracy of 86.26% and an F1 score of 82% using SVM with the polynomial kernel. [6] demonstrated the concept of multisensory artificial nerves and neuromorphic systems, presenting a nanowire intrinsically stretchable neuromorphic transistor (NISNT). A-mode ultrasound, like other biological signals, exhibits variations in signals obtained when performing the same gesture in different arm positions. To address this issue, [7] proposes a linear enhancement training (LET) procedure to compensate for deviations in gesture signals caused by forearm position changes. Considering the existing challenges in sEMG-based gesture recognition using deep learning, [8] introduces a deformable convolutional network (DCN) to optimize conventional convolutional kernels and achieve improved performance. Accurate gesture prediction is crucial for meaningful communication and enhanced human-computer interactions. [9] explores various techniques, classifiers, and methods available to improve gesture recognition. [10] proposes a portable CNN hybrid feature attention network (HyFiNet) for precise hand gesture recognition. Sign language recognition faces challenges such as accurate hand gesture tracking, hand occlusion, and high computational costs. To overcome these challenges, [11] presents a MediaPipe-optimized integrated recurrent unit (MOPGRU) specifically designed for Indian Sign Language recognition, while [16] utilizes the open-source MediaPipe framework and Support Vector Machine (SVM) algorithm for automating Sign Language Recognition. [18] employs Human-Computer Interaction (HCI) to enhance the hand gesture-based recognition system and define a sign language. In the context of yoga, [12] introduces an architecture for classifying different yoga postures to maximize their benefits. In [13], impairments in simple movement tasks involving the hands and fingers are evaluated as potential indicators of overall health deterioration. [14] employs a Python module to enable real human interaction with the system without the need for any character input device. To address the challenge of obtaining accurate depth information in 3D pose estimation, [17] proposes the use of a depth camera, achieving favorable results. [19] leverages state-of-the-art hand-tracking technology to construct an accurate and robust human-computer interaction (HCI) system. [20] presents a painting technique that allows real-time sketching or drawing on a canvas using hand motions. [21] utilizes the MediaPipe framework and OpenCV to identify key points of the hand and employs the Kalman filter algorithm to optimize the hand coordinates.

3. MATERIAL AND METHODS

MediaPipe, a highly versatile cross-platform framework, offers comprehensive support for constructing machine learning pipelines capable of adapting to diverse data types, including audio, video, and time-series data. This adaptable framework empowers developers to seamlessly integrate machine learning models and algorithms, enabling efficient processing and analysis of complex data streams across platforms such as Android, iOS, and the web. The significance of MediaPipe is reflected in its extensive adoption by various Google products and teams, encompassing critical services like Nest, Gmail, Lens, Maps, Android Auto, Photos, Google Home, and YouTube. The widespread utilization of MediaPipe within these domains underscores its reliability, performance, and applicability in real-world scenarios. By leveraging MediaPipe's rich features and functionalities, developers can harness its cross-platform capabilities to create robust and customized machine learning

pipelines tailored to their specific data requirements. This includes leveraging advanced algorithms for tasks such as data preprocessing, feature extraction, and model training, while benefiting from MediaPipe's efficient data processing capabilities. Furthermore, MediaPipe's compatibility with multiple platforms facilitates the development of cross-platform machine learning applications, enabling consistent user experiences across diverse devices and operating systems. The framework provides a unified environment for developers to deploy their machine learning models seamlessly, regardless of the target platform. The adaptability and versatility of MediaPipe make it a powerful tool for building cutting-edge machine learning applications. Its comprehensive support for different data types and platforms empowers developers to overcome complex challenges and leverage state-of-the-art machine learning techniques for tasks like audio and video processing, gesture recognition, augmented reality, and more.

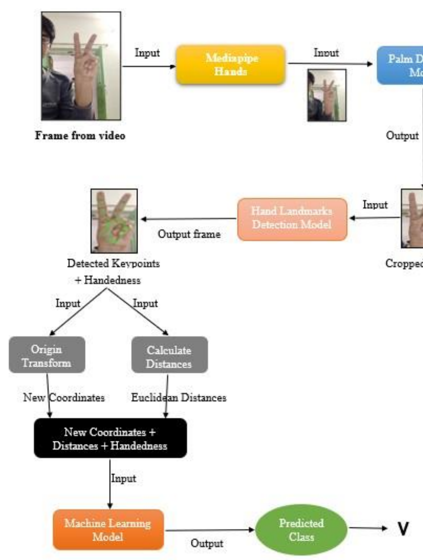

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Figure 1 illustrates the flow diagram of the algorithm implemented in this research. The algorithm leverages landmarks and hand positions, employing the media pipe algorithm for video processing to detect the presence of palms in the initial frame. Subsequently, the model applies calculations to determine the origin and distance between the obtained coordinates. Finally, the predicted class is determined based on the outcomes of the algorithm. The field of human-computer interaction has undergone a significant revolution, driven by advancements in technology that have transitioned us from wired to wireless connectivity, traditional keyboards to touch screens, and offline to online experiences. This transformation has been fueled by remarkable breakthroughs in various technologies, including face recognition, speech recognition, touch screens, and other cutting-edge advancements, all of which owe their success to the application of artificial intelligence (AI) and machine learning (ML) techniques. In the present era, AI/ML technologies are extensively integrated into our daily routines, profoundly shaping the way we interact with and benefit from computer systems. In addition to these technologies, hand gestures have emerged as a prominent method of communication with computers, finding applications in diverse fields. Hand gesture recognition has proven to be immensely valuable in augmented reality, enabling intuitive interactions and enhancing user experiences. It plays a crucial role in assisting

individuals with disabilities, providing alternative means of control and interaction. In the realm of gaming, platforms like PlayStation have embraced gesture-based interfaces to enhance gameplay experiences. Moreover, hand gestures are employed for controlling car dashboards and enabling gesture-based operations in smart TVs, facilitating more natural and seamless interactions. The integration of hand gestures into these contexts signifies the expanding range of applications where this technology is being deployed. Its utilization demonstrates its potential to enable intuitive and efficient human-computer interaction. By leveraging AI and ML techniques, researchers and developers are continuously advancing the field of hand gesture recognition, exploring new algorithms, models, and technologies to improve accuracy, robustness, and versatility. This ongoing progress holds promise for further advancements in gesture-based interfaces and the broader field of human-computer interaction.

Figure 2: Results Prototype

Figure 2 [21] provides a visual representation of the results obtained from the implementation of the hand detection algorithm within the MediaPipe framework. The algorithm effectively identifies and delineates the contours of detected hands, enhancing their visibility by outlining them with a distinct green border. This visual emphasis facilitates a clearer understanding of the hand detection output. The MediaPipe framework, employed in this study, serves as a comprehensive and powerful tool for constructing machine learning pipelines. It offers a wide range of functionalities, including but not limited to, face detection, hand tracking, object detection, holistic mic integration, facial pose estimation, and more. By encompassing such diverse capabilities, MediaPipe enables researchers and developers to build sophisticated machine learning solutions that address various complex problems. In the context of hand detection, MediaPipe proves particularly valuable due to its robustness and versatility. The framework provides an efficient and reliable pipeline for processing hand-related data, facilitating accurate detection and tracking of hand contours. This capability opens up numerous possibilities for practical applications, such as gesture recognition, human-computer interaction, augmented reality, and virtual reality systems. By leveraging the MediaPipe framework, researchers and developers can harness its extensive functionalities and integrate them seamlessly into their machine learning workflows. This empowers them to explore novel solutions, advance the state-of-the-art in hand detection,

and contribute to the wider field of computer vision. The adaptability and flexibility offered by MediaPipe make it a valuable asset for creating diverse machine learning solutions in various domains.

3.1. DATASET DESCRIPTION

MediaPipe Hand represents a cutting-edge machine learning solution that revolutionizes hand and finger tracking with unparalleled precision. This sophisticated technology exhibits exceptional proficiency in detecting and capturing 21 landmark points on a hand within a single frame, enabling a comprehensive understanding of its intricate movements and positions. The foundation of MediaPipe Hand's proficiency lies in its utilization of multiple models that operate concurrently and synergistically. These models collaborate harmoniously to optimize the accuracy and reliability of hand tracking. Through their concerted efforts, MediaPipe Hand ensures that even subtle variations and complex motions of the hand are faithfully recorded and interpreted. The output generated by MediaPipe Hand provides detailed and granular information about the hand's landmarks, delivering invaluable insights into its configuration and motion. This wealth of data opens up a multitude of applications across diverse domains. From augmented reality experiences that seamlessly integrate virtual objects with real-world hand gestures, to interactive gaming platforms that translate hand movements into game controls, MediaPipe Hand empowers developers and users alike with an immersive and intuitive interface. Moreover, MediaPipe Hand's robust tracking capabilities find utility in various fields, including sign language recognition, hand gesture-based control systems, and human-computer interaction in smart devices. By accurately and reliably capturing the intricacies of hand movements, this advanced technology offers endless possibilities for enhancing communication, accessibility, and user experiences.

Figure 3: Mediapipe Algorithm hand coordinates

To accurately identify and track the hand within an image, our system employs a two-step process, integrating the Palm Detection Model and the Hand Landmark Model. Initially, the Palm Detection Model is utilized to detect the presence of a hand within the entire image and enclose it within a bounding box. This step effectively localizes the hand region of interest. Following the successful identification of the hand by the Palm Detection Model, the Hand Landmark Model operates specifically on the cropped image defined by the bounding box. By leveraging this refined input, the Hand Landmark Model precisely computes the 2D coordinates of key points that correspond to distinct hand landmarks. These keypoints represent crucial landmarks such as fingertips, knuckles, and palm center. The output generated by this two-step approach is presented in Figure 3 [22], illustrating the

effectiveness of our methodology in accurately localizing and capturing intricate details of the hand. The resulting output serves as a testament to the high-fidelity tracking of hand keypoints, enabling precise analysis and interpretation of hand gestures. By combining the Palm Detection Model and the Hand Landmark Model, our system achieves robust hand localization and accurate keypoint tracking. This methodology forms the foundation of our hand gesture recognition system, enabling reliable and effective interactions between humans and computers.

4. RESULTS

The findings of our study provide compelling evidence of the remarkable ability of our model to accurately anticipate human hand movements. This achievement is made possible through the synergistic combination of our algorithm, MediaPipe, and OpenCV. The training of our model involved an extensive dataset consisting of over 3000 images encompassing diverse configurations of letters from A to Z and numbers from 1 to 9. The significance of our algorithm extends to individuals with various disabilities, including those who are deaf, mute, or face other challenges. By leveraging hand gesture recognition, our algorithm offers a valuable solution for enhancing communication and interaction for individuals with special needs. Furthermore, the versatility of our algorithm allows for its application in public settings such as airports, train stations, and other public venues, where it can contribute to a more inclusive and accessible environment. The potential for improving the lifestyle of the deaf and mute community is vast through further expansion and development of this technology. For instance, our algorithm enables the visualization of mathematical operations through animated hand gestures, as depicted in the outcome images presented in Figure 4. This feature holds particular relevance in public settings like banks, airports, and other locations where individuals with special needs may encounter challenges in carrying out their daily tasks effectively. The animated hand gestures not only facilitate comprehension and engagement but also provide a practical solution for individuals who may struggle with traditional modes of communication. The integration of such technology in public environments can empower individuals with special needs to navigate and interact more effectively, enhancing their overall experience and independence. As we move forward, there is a growing potential for further advancements and wider adoption of hand gesture recognition technology. Continued research and development efforts in this field will enable us to refine and expand the capabilities of our algorithm, making it even more accessible and beneficial for individuals with disabilities and transforming the way they engage with their surroundings.

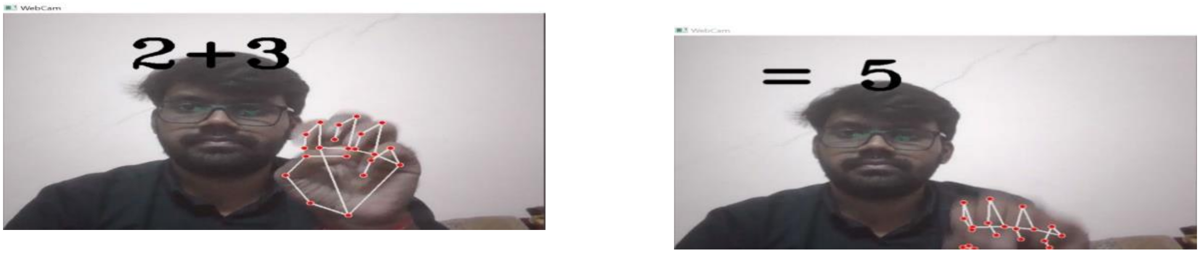

Figure 4: Hand Gesture result

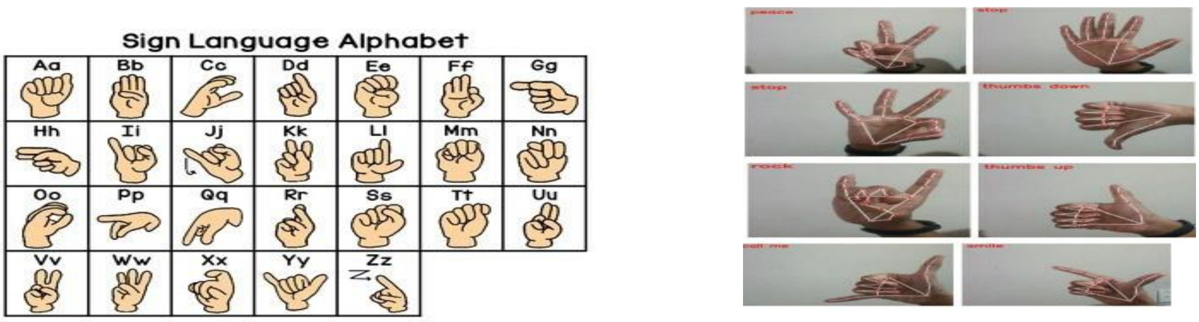

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Figure 5: Hand Gesture result prototype

5. CONCLUSION

The results obtained from our algorithm, leveraging the capabilities of MediaPipe and OpenCV, demonstrate the ease and accuracy with which our model predicts hand gestures. The model has been trained using a dataset comprising over 3000 images encompassing various configurations of alphabets from A to Z and numbers from 1 to 9. The significance of this algorithm lies in its potential to benefit individuals with disabilities, particularly those who are deaf and mute. Additionally, it holds promise for deployment in public places such as airports and railway stations, where it can enhance accessibility and facilitate smoother interactions for individuals with different abilities. Furthermore, this technology has the potential to contribute to the overall improvement in the quality of life for the deaf and mute community. While applications utilizing hand gestures are currently uncommon, there is a growing opportunity for their widespread adoption and increased benefits. Instead of relying on traditional input devices like keyboards and mice, this application capitalizes on the natural movements of hand gestures. The successful implementation of this application heavily relies on the utilization of machine learning techniques. To evaluate the effectiveness and user experience of our application, we conducted a comparison between two games. One game utilized a conventional controller, while the other leveraged hand gestures as the input method. The comparison was based on factors such as gameplay, enjoyable features, and replayability. Notably, as the difficulty level increased, the use of hand gestures in the game resulted in noticeable improvements in these three aspects. These findings highlight the potential and advantages of incorporating hand gesture recognition through machine learning in interactive applications. As technology advances and further research is conducted in this field, the widespread adoption of such applications is anticipated, bringing significant benefits to users and paving the way for more intuitive and engaging humancomputer interactions.

REFERENCES

[1]. Al Farid, F.; Hashim, N.; Abdullah, J.; Bhuiyan, M.R.; Shahida Mohd Isa, W.N.; Uddin, J.; Haque, M.A.; Husen, M.N. A Structured and Methodological Review on Vision-Based Hand Gesture Recognition System. J. Imaging 2022, 8, 153. https://doi.org/10.3390/jimaging8060153

[2]. Sahoo, J.P.; Prakash, A.J.; Pławiak, P.; Samantray, S. Real-Time Hand Gesture Recognition Using FineTuned Convolutional Neural Network. Sensors 2022, 22, 706. https://doi.org/10.3390/s22030706

[3]. Gadekallu, T. R., Srivastava, G., Liyanage, M., M., I., Chowdhary, C. L., Koppu, S., et al. (2022). Hand Gesture Recognition Based on a Harris Hawks Optimized Convolution Neural Network. Comput. Electr. Eng. 100, 107836. doi:10.1016/j.compeleceng.2022.107836

[4]. Lim, M., Kotsani, N., & Hartono, P. (2022). Handmate: An Accessible Browser-based Controller for Web Audio and Midi using AI Hand-Tracking. International Conference on New Interfaces for Musical Expression. https://doi.org/10.21428/92fbeb44.40c13869

[5]. Khawaritzmi Abdallah AHMAD, Dian Christy SILPANI, Kaori YOSHIDA Hand Gesture Recognition by Hand Landmark Classification Released on J-STAGE: May 31, 2022 https://doi.org/10.5057/isase.2022C000026

[6]. Lu Liu, Wenlong Xu, Yao Ni, Zhipeng Xu, Binbin Cui, Jiaqi Liu, Huanhuan Wei, and Wentao Xu ACS Nano 2022 Stretchable Neuromorphic Transistor That Combines Multisensing and Information Processing for Epidermal Gesture Recognition 16 (2), 2282-2291 DOI: 10.1021/acsnano.1c08482

[7]. S. Cai, Z. Lu, L. Guo, Z. Qing and L. Yao, "The LET Procedure for Gesture Recognition With Multiple Forearm Angles," in IEEE Sensors Journal, vol. 22, no. 13, pp. 13226-13233, 1 July1, 2022, doi: 10.1109/JSEN.2022.3177475.

[8]. Wang, H., Zhang, Y., Liu, C. et al. sEMG based hand gesture recognition with deformable convolutional network. Int. J. Mach. Learn. & Cyber. 13, 1729–1738 (2022). https://doi.org/10.1007/s13042-021-01482-7

[9]. Bhushan, S.; Alshehri, M.; Keshta, I.; Chakraverti, A.K.; Rajpurohit, J.; Abugabah, A. An Experimental Analysis of Various Machine Learning Algorithms for Hand Gesture Recognition. Electronics 2022, 11, 968. https://doi.org/10.3390/electronics11060968

[10]. Bhaumik, G., Verma, M., Govil, M.C. et al. HyFiNet: Hybrid feature attention network for hand gesture recognition. Multimed Tools Appl (2022). https://doi.org/10.1007/s11042-021-11623-3

[11]. Subramanian, B., Olimov, B., Naik, S.M. et al. An integrated mediapipe-optimized GRU model for Indian sign language recognition. Sci Rep 12, 11964 (2022). https://doi.org/10.1038/s41598-022-15998-7

[12]. Garg, S., Saxena, A. & Gupta, R. Yoga pose classification: a CNN and MediaPipe inspired deep learning approach for real-world application. J Ambient Intell Human Comput (2022). https://doi.org/10.1007/s12652-022-03910-0

[13]. G. Amprimo, C. Ferraris, G. Masi, G. Pettiti and L. Priano, "GMH-D: Combining Google MediaPipe and RGB-Depth Cameras for Hand Motor Skills Remote Assessment," 2022 IEEE International Conference on Digital Health (ICDH), 2022, pp. 132-141, doi: 10.1109/ICDH55609.2022.00029.

[14]. Nitin Kumar, R., Vaishnavi, M., Gayatri, K.R., Prashanthi, V., Supriya, M. (2022). Air Writing Recognition Using Mediapipe and Opencv. In: Karuppusamy, P., García Márquez, F.P., Nguyen, T.N. (eds) Ubiquitous Intelligent Systems. ICUIS 2021. Smart Innovation, Systems and Technologies, vol 302. Springer, Singapore. https://doi.org/10.1007/978-981-19-2541-2_35

[15]. Arpita Haldera , Akshit Tayade, "Real-time Vernacular Sign Language Recognition using MediaPipe and Machine Learning" International Journal of Research Publication and Reviews Vol (2) Issue (5) (2021) Page 9-17.

[16]. Zhaolong Deng, Yanliang Qiu, Xintao Xie, Zuanhui Lin, "A 3D hand pose estimation architecture based on depth camera," Proc. SPIE 12593, Second Guangdong-Hong Kong-Macao Greater Bay Area Artificial Intelligence and Big Data Forum (AIBDF 2022), 125930Z (16 March 2023); https://doi.org/10.1117/12.2671350.

[17]. S., Harish. (2023). Computer vision-based Hand gesture recognition system. 10.14704/nq.2022.20.7.NQ33365.

[18]. K. Roy and M. A. H. Akif, "Real Time Hand Gesture Based User Friendly Human Computer Interaction System," 2022 International Conference on Innovations in Science, Engineering and Technology (ICISET), Chittagong, Bangladesh, 2022, pp. 260-265, doi: 10.1109/ICISET54810.2022.9775918.

[19]. Vasavi, R., Rahul, N., Snigdha, A., Moses, K. J., & Simha, S. V. Painting with Hand Gestures using MediaPipe.

[20]. Zitong Zhou and Yanhui Lv "The application of gesture recognition based on MediaPipe in virtual scene", Proc. SPIE 12636, Third International Conference on Machine Learning and Computer Application (ICMLCA 2022), 126361O (25 May 2023); https://doi.org/10.1117/12.2675148

[21]. Farooq, U., Rahim, M. S. M., Sabir, N., Hussain, A., & Abid, A. (2021). Advances in machine translation for sign language: approaches, limitations, and challenges. *Neural Computing and Applications*, *33*(21), 14357-14399.

[22]. Schlüsener, N., & Bücker, M. (2022). Fast Learning of Dynamic Hand Gesture Recognition with Few-Shot Learning Models. *arXiv preprint arXiv:2212.08363*.

[23]. Gupta, M., Kumar, R., & Dewari, S. (2021). Digital twin techniques in recognition of human action using the fusion of convolutional neural network. In *Digital Twin Technology* (pp. 165-186). CRC Press.

[24]. Khajuria, O., Kumar, R., & Gupta, M. (2023, April). Facial Emotion Recognition using CNN and VGG-

16. In *2023 International Conference on Inventive Computation Technologies (ICICT)* (pp. 472-477). IEEE.

[25]. Gupta, M., Kumar, R., & Dewari, S. (2021). Digital twin techniques in recognition of human action using the fusion of convolutional neural network. In *Digital Twin Technology* (pp. 165-186). CRC Press.

A CRITICAL ANALYSIS OF ARTIFICIAL INTELLIGENCE IN STOCK MARKET PREDICTION: A LITERATURE REVIEW

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Abstract: Stock market prediction, a vital responsibility for investors and financial institutions, enables them to make knowledge-driven investment decisions. Artificial Intelligence (AI) techniques, such as deep learning (DL) and machine learning (ML), have exhibited impressive outcomes in the field of stock market prediction due to their ability to decode complicated and nonlinear correlations in financial data. This research paper offers an exhaustive examination of the literature related to AI methodologies for stock market prediction, including machine learning, deep learning, and hybrid models. It also discusses the diverse types of data utilized for stock market prediction, namely historical price data, news articles, social media inputs, and financial statements. Moreover, it includes various evaluation metrics critical for assessing the effectiveness of AI models in stock market prediction. In addition, the paper draws attention to the existing limitations and challenges in the field while highlighting potential avenues for future research. Providing an insightful understanding of the cutting-edge AI techniques for stock market prediction, this paper is a useful resource for researchers and practitioners in the finance industry to make well-informed decisions.

Key Words: Stock market prediction, Artificial Intelligence, Machine Learning, Deep Learning.

1. INTRODUCTION

The stock market is a critical part of the global economy, serving as a platform for companies to raise capital and investors to buy and sell shares. The ability to predict the stock market's future direction has long been a challenge, given the numerous factors that can impact its performance. Researchers have tried to predict stock market since 1990s [1]. However, recent advancements in artificial intelligence (AI), including machine learning (ML) and deep learning (DL), have enabled the development of techniques that hold promise in stock market prediction. According to a report by Grand View Research, the global AI in finance market is projected to grow at a compound annual growth rate (CAGR) of 16.5% from 2022 to 2030, reaching $41.16 billion by 2030 (Grand View Research, 2020) [2]. The increasing availability of big data fuels this growth, the development of advanced machine learning algorithms, and the growing demand for automation in the financial industry. As Sundar Pichai, CEO of Alphabet and Google, noted, “AI is one of the most important things that humanity is working on. It’s more profound than, I don’t know, electricity or fire" [3]. The use of AI in stock market prediction has the potential to help investors make better-informed decisions by providing accurate and timely predictions of future stock prices. By analyzing large volumes of data from various sources, AI techniques can identify patterns and relationships that human analysts do not discern easily, leading to more accurate and timely predictions of stock prices. However, the use of AI for stock market prediction also poses significant challenges and limitations. One of the primary challenges is the lack of transparency in AI models [4], which can make it difficult to understand how the predictions are generated. Additionally, the accuracy of AI predictions can be affected by various factors such as data quality, model selection, and market volatility. Despite these challenges, the field of stock market prediction using AI has made significant progress in recent years. This review paper will provide a comprehensive overview of the current state of research in this field. Specifically, we will review the different types of AI techniques used for stock market prediction, the types of data used for training and evaluating these techniques, the accuracy and reliability of the predictions, the limitations and challenges associated with using AI for stock market prediction, the potential applications of this technology in finance and other fields, and the ethical considerations associated with using AI for stock market prediction. By addressing these topics, we hope to provide insights into the current trends and future directions in the field of stock market prediction using AI.

2. METHODOLOGY

This review paper aims to investigate the use of artificial intelligence (AI) techniques for stock market prediction, with a focus on providing a comprehensive overview of the current state of research in this field. To achieve this goal, we have employed a methodology consisting of three main steps: literature review, analysis, and discussion, as shown in Fig. 1.

Literature Review: In this step, we conduct a comprehensive search of various academic databases, such as Google Scholar, ACM Digital Library, IEEE Xplore, and ScienceDirect, as well as other relevant sources, such as books, reports, and news articles. Our goal is to identify relevant studies that focus on the use of AI techniques for stock market prediction. We use a range of search terms to identify studies related to machine learning, deep learning, neural networks, natural language processing, and other AI techniques used in stock market prediction. We assess each study's quality and relevance based on predefined criteria, such as the study's research question, methods, results, and implications. We exclude studies that do not meet our criteria or are not related to our research question.

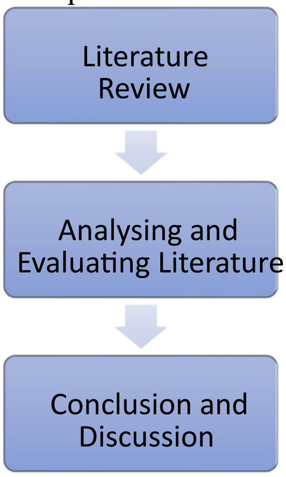

Fig. 1. Overview of Methodology.

The remaining studies are thoroughly analysed and synthesized to provide a comprehensive overview of the use of AI techniques in stock market prediction. Analysis: In this step, we select and evaluate appropriate AI techniques that are relevant to our research question and data. We explain each technique's basic concepts and assumptions and compare their advantages and disadvantages. We also assess the sensitivity of our results to different assumptions and hyperparameter settings. We carefully consider the strengths and limitations of each technique to ensure that our analysis is robust and reliable. In the discussion and conclusion step, we synthesize and summarize our main findings and contributions from applying AI techniques to stock market prediction. We discuss the implications of our results for theory, policy, and practice, and acknowledge the limitations of our study. We suggest possible extensions or improvements for future work and highlight the potential benefits of using AI techniques in stock market analysis and financial planning. Overall, the methodology for this review paper involves conducting a thorough literature review, selecting, and evaluating appropriate AI

techniques, and synthesizing and discussing the findings to provide a comprehensive overview of the use of AI techniques for stock market prediction. Our methodology is designed to ensure that our findings are based on a rigorous and systematic analysis of the existing literature and that our results are robust and reliable.

3. LITERATURE REVIEW

In [5], I. Parmar et al. investigated stock market prediction using machine learning techniques, focusing on a dataset obtained from Yahoo Finance, consisting of approximately 900,000 records of stock prices and other relevant values. The data was transformed into a data-frame using the Pandas library in Python and normalized using the sklearn library in Python. The dataset was then divided into training and testing sets, with the test set comprising 20% of the available dataset. Their study employed two machine learning models: a Regression-Based Model and a Long Short-Term Memory (LSTM) Network-Based Model. The Regression-Based Model utilized the gradient descent linear regression algorithm to predict correct values by minimizing the error function. Factors considered for the regression included low, open, high, close, and volume. The R-square confidence test was employed to determine the confidence score, and the predictions were plotted to show the results of the stock market prices versus time, resulting in a confidence score of 0.86625. The LSTM Network-Based Model, an advanced version of Recurrent Neural Networks (RNN), is capable of handling long-term dependencies, making it suitable for stock market prediction tasks that rely on large amounts of data and are dependent on the market's long-term history. The authors addressed the problem of vanishing gradient by implementing an LSTM with a remembering cell, input gate, output gate, and a forget gate. The model comprised two stacked LSTM layers, each with an output value of 256. A dropout value of 0.3 was fixed to avoid overfitting and increase training speed. Finally, the model was compiled with a mean square cost function to maintain the error throughout the process, and accuracy was chosen as the metric for prediction. The LSTM model resulted in a Train Score of 0.00106 MSE (0.03 RMSE) and a Test Score of 0.00875 MSE (0.09 RMSE), offering more accuracy than the Regression-Based Model.

Parmar et al.'s paper contributes to the growing body of literature on stock market prediction using machine learning techniques by exploring the application of both Regression-Based and LSTM Network-Based Models. Their findings highlight the potential of these techniques in predicting stock market prices and offer insights into their relative strengths and limitations. The results are promising and indicate the possibility of predicting stock market trends with greater accuracy and efficiency using machine learning techniques. In [6], Hiransha M et al. explore the use of deep learning models, including Multilayer Perceptron (MLP), Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTM), and Convolutional Neural Network (CNN), to predict stock prices in the National Stock Exchange (NSE) of India and New York Stock Exchange (NYSE). The researchers selected highly traded stocks from three sectors—automobile, banking, and IT—for NSE and two active stocks for NYSE. The deep learning models were trained on the historical closing prices of Tata Motors from the NSE and tested on data from both stock exchanges. The study employed a dataset from January 1, 1996, to June 30, 2015, containing 4,861 days of closing prices for Tata Motors. Data was normalized to fit a range between 0 and 1, and a window size of 200 was used to predict 10 days into the future. The network was trained for 1,000 epochs. The models were tested on stocks from the NSE and NYSE using the same methodology, and the Mean Absolute Percentage Error (MAPE) was used to calculate the error in the predicted output.

The results demonstrated that CNN outperformed other models, and the neural networks were more accurate than the linear ARIMA model. This finding is attributed to neural networks' ability to identify non-linear trends in the data, which ARIMA fails to do. The study also showed that the network could predict NYSE prices despite being trained on NSE data, suggesting that the two stock markets share common inner dynamics. In conclusion, this research highlights the effectiveness of deep learning models, particularly CNN, in predicting stock prices in different stock exchanges. These findings have significant implications for improving stock market prediction and analysis, which play a crucial role in today's economy. In [7], M. Rout et al. proposed a stock market prediction model utilizing the Artificial Bee Colony (ABC) algorithm combined with an adaptive linear combiner (ALC). The ABC algorithm was developed by Dervis Karaboga in 2005 [8] it was inspired by the intelligent behavior of honey bees, is a population-based search method that balances exploration and exploitation processes to find the optimal solution. In the proposed model, ALC-ABC, the weights of the hybrid model are updated by the ABC algorithm to minimize the mean square error (MSE).

The authors applied the ALC-ABC model to predict two stock market indices, DJIA and S&P500, for 1 day, 1 week, and 1 month ahead using technical indicators. The data was split into training and testing sets, and the weights of the ALC-ABC model were updated using the ABC algorithm. The performance of the proposed model was evaluated by calculating the mean absolute percentage error (MAPE). The prediction results of the ALC-ABC model were compared with those obtained using particle swarm optimization (PSO) and genetic algorithms (GA) combined with the adaptive linear combiner. The comparison showed that the ALC-ABC model had better prediction accuracy compared to the ALC-PSO and ALC-GA models. The MAPE values for next day prediction were less than 1%, and the maximum percentage of errors for 1 month ahead prediction was 2.30% and 2.45% for DJIA and S&P500 stock indices, respectively. In conclusion, the ALC-ABC based prediction model showed improved prediction accuracy for stock market indices using technical indicators when compared to other adaptive parameter learning algorithms, such as PSO and GA. In [9], Kalra et al. proposed a novel stock market prediction model that integrates news sentiment, historical stock price data, and the variance of closing prices of adjacent days to enhance the accuracy of stock market movement predictions. This approach aims to assist investors in making better-informed decisions and reducing financial risks when investing in the stock market. The model forecasts daily price movements by considering all available news and numeric historical data, employing supervised machine learning techniques for training purposes.

News sentiment is extracted and combined with numeric historical prices to create the prediction model. The authors perform text analysis on news data to determine text polarity. For future price movement prediction, the study incorporates stock historical prices, such as open, low, high, and the variance of adjacent days' closing prices.

The numeric dataset for the model is sourced from Yahoo Finance, while news data is collected from online financial websites like Moneycontrol, Livemint, Financial Express, Business Today, and NDTV. Using the Naive Bayes algorithm, the authors employ sentiment analysis to categorize news data into positive and negative sentiments [9]. The proposed prediction model merges numeric news sentiment values, variance, and numerical stock prices to examine the impact of released news, variance, and historical data on stock movements. The integrated dataset is divided into training and testing datasets for predicting future price movements. The prediction model demonstrates that the incorporation of numeric sentiment values and variance with open, high, and low values improves prediction accuracy up to 91.2% using the KNN algorithm. The results also suggest that the variance attribute significantly influences stock

price movements. Four machine learning techniques, namely KNN, SVM, Naive Bayes, and Neural Network, are employed for prediction purposes. The study reveals that the proposed model, which combines numeric sentiment values and variance with historical data, offers higher prediction accuracy compared to previous studies, which achieved accuracy ranging from 65% to 86.12%.

In conclusion, the model proposed by Kalra and Prasad [9] effectively investigates the impact of analyzing various types of stock-related news combined with numeric historical data on the stock market. The model's highest prediction accuracy, achieved with KNN, is 91.2%. This suggests a strong correlation between stock-related news and changes in stock prices. Future work may involve incorporating social media data, reviews, and blogs over an extended period that may influence the stock market and considering a higher number of news data instances. In [10], Kusuma et al. proposed a novel method for stock market prediction that employed deep learning neural networks and candlestick chart representation. They used two stock market datasets, including 50 company stock markets for Taiwan50 datasets and 10 company stock markets for Indonesian datasets. The study involved generating period data using a sliding window technique and creating candlestick chart images with computer graphic techniques. The prediction model was built using a Convolutional Neural Network (CNN) learning algorithm. In [10], the authors found that their model achieved the highest performance in sensitivity, specificity, accuracy, and MCC when using long-term trading days period with a CNN learning algorithm. The results demonstrated that the CNN could effectively identify hidden patterns within the candlestick chart images, which aided in forecasting future movements of specific stock markets. Interestingly, adding volume indicators to the candlestick charts did not significantly improve the algorithm's ability to find hidden patterns.

In the same study [10], comparisons were made between the proposed method and existing methods used by Khaidem et al. [11] , J. Patel [12] , and Zhang [13] . The results indicated that the proposed method provided a more accurate forecast for other datasets compared to other methods. For instance, Patel's [12] method achieved an accuracy range of 89% - 92% with trading data from Reliance Industries, Infosys Ltd., CNX Nifty, and S & P Bombay Stock Exchange BSE Sensex, while the proposed method achieved an accuracy range of 93% - 97%. Similarly, Khaidem's [11] method achieved an accuracy range of 86% - 94% using trading data from Samsung, GE, and Apple, whereas the proposed method reached an 87% - 97% accuracy range. Lastly, Zhang's [13] method, which used data from 13 different companies in the Hong Kong stock exchange, achieved an accuracy of 61%, while the proposed method achieved 92% accuracy. In summary, the method proposed by Kusuma et al. in [10] demonstrated its superiority over existing methods in predicting stock market movements, providing better accuracy across various datasets. In [14] Ren et al. proposed an innovative method to forecast stock market movement direction by combining sentiment analysis and the Support Vector Machine (SVM) model. Using sentiment analysis techniques, they collected textual data from Sina Finance and Eastmoney, two major Chinese financial websites, and transformed the unstructured text into daily sentiment indexes. The sentiment indexes were then adjusted for the day-of-week effect and holidays. Applying the SVM model to predict the movement direction of the SSE 50 Index, an important index in China, the authors used a combination of fivefold cross-validation and a realistic rolling window approach. The results showed a significant improvement in prediction accuracy, reaching 89.93% when sentiment features were incorporated with stock market data—an 18.6% increase compared to using only stock market data. Additionally, the authors demonstrated that when their approach was combined with a stop-loss order strategy, it could help investors reduce risks and make more informed decisions. The study also suggested that sentiment analysis could provide valuable

insights into asset fundamental values, potentially serving as a leading indicator for stock market movements.

4. RESULT AND OBSERVATIONS

TABLE 1

Authors	Dataset	Country / Index	Algorithms
I. Parmar et al. [5]	Yahoo Finance (900,000 records)	N/A	Regression-Based Model, LSTM Network-Based Model
Hiransha M et al. [6]	Tata Motors stock prices (4,861 days)	NSE (India), NYSE (USA)	MLP, RNN, LSTM, CNN
M. Rout et al. [7]	DJIA and S&P500 stock indices	USA	ALC-ABC, ALC-PSO, ALC-GA
Kalra et al. [9]	Yahoo Finance, news data from financial websites	N/A	KNN, SVM, Naive Bayes, Neural Network
Kusuma et al. [10]	50 company stock markets (Taiwan50 datasets), 10 company stock markets (Indonesian datasets)	Taiwan, Indonesia	CNN
Ren et al. [14]	Textual data from Sina Finance and Eastmoney, SSE 50 Index	China	SVM

TABLE 2

Authors	Objective	Limitations

I. Parmar et al. [5]	To compare LSTM and regression-based models for stock market prediction	Limited to the dataset; not tested on other stock markets or data sources
Hiransha M et al. [6]	To evaluate various deep-learning models for stock market prediction	Single stock (Tata Motors); not tested on other stocks or indices
M. Rout et al. [7]	To develop an ALC-ABC model for stock market index prediction	Limited to DJIA and S&P500; not tested on other stock market indices
Kalra et al. [9]	To study the efficacy of news sentiment in stock market prediction	Limited to select algorithms; not tested on other data sources or sentiment analysis techniques
Kusuma et al. [10]	To predict stock market trends using deep learning neural networks and candlestick chart representation	Limited to Taiwan and Indonesian datasets; not tested on other countries or indices
Ren et al. [14]	To forecast stock market movement direction using sentiment analysis and SVM	Limited to the SSE 50 Index; not tested on other stock market indices or data sources

This research paper investigated the application of machine learning and deep learning techniques for stock market prediction, focusing on methods proposed by various authors in the literature. The techniques explored included Regression-Based Models, LSTM Network-Based Models, Artificial Bee Colony algorithms, Convolutional Neural Networks, and a combination of sentiment analysis and SVM models. The results across different studies show promising potential in predicting stock market trends with increased accuracy and efficiency. Notably, the LSTM Network-Based Model offered better accuracy than the Regression-Based Model in predicting stock market prices [5]. In another study, the Convolutional Neural Network outperformed other deep learning models in predicting stock prices in the NSE and NYSE [6]. The ALC-ABC model demonstrated improved prediction accuracy for stock market indices compared to other adaptive parameter learning algorithms such as PSO and GA [7]. Furthermore, the model that Kalra and Prasad proposed combined news sentiment, historical stock price data, and the variance of closing prices of adjacent days, achieved a prediction accuracy of up to 91.2% using the KNN algorithm [9]. Kusuma et al.'s method, which employed deep learning neural networks and candlestick chart representation, demonstrated superior accuracy compared to existing methods in predicting stock market movements [10]. Ren et al.'s approach, which combined sentiment analysis and SVM models, significantly improved prediction accuracy, reaching 89.93% when sentiment features were incorporated with stock market data [14].

5. CONCLUSION

In conclusion, the findings from the literature review suggest that machine learning and deep learning techniques can effectively predict stock market trends and provide valuable insights for investors. Further research can be conducted to explore additional methods, incorporate more diverse data sources, and refine the models to enhance prediction accuracy and applicability in real-world scenarios.

REFERENCES

[1]. F. G. D. C. Ferreira, A. H. Gandomi and R. T. N. Cardoso, "Artificial Intelligence Applied to Stock Market Trading: A Review," in IEEE Access, vol. 9, pp. 30898-30917 , 2021, doi: 10.1109/ACCESS.2021.3058133.

[2]. Artificial Intelligence In Fintech Market Size, Share & Trends Analysis Report By Component (Solutions, Services), Deployment (Cloud, On-premise), By Application (Fraud Detection, Virtual Assistants), And Segment Forecasts, 2022 - 2030. https://www.grandviewresearch.com/industry-analysis/artificialintelligence-in-fintech-market-report

[3]. Sundar Pichai, CEO of Alphabet and Google. https://www.theverge.com/2018/1/19/16911354/google-ceosundar-pichai-ai-artificial-intelligence-fire-electricity-jobs-cancer

[4]. Daneshjou R, Smith MP, Sun MD, Rotemberg V, Zou J. Lack of Transparency and Potential Bias in Artificial Intelligence Data Sets and Algorithms: A Scoping Review. JAMA Dermatol. 2021;157(11):1362–1369. doi:10.1001/jamadermatol.2021.3129

[5]. I. Parmar et al., "Stock Market Prediction Using Machine Learning," 2018 First International Conference on Secure Cyber Computing and Communication (ICSCCC), Jalandhar, India, 2018, pp. 574-576, doi: 10.1109/ICSCCC.2018.8703332.

[6]. H. M. et al., "NSE Stock Market Prediction Using Deep-Learning Models," Procedia Computer Science, vol. 132, pp. 1351-1362, 2018, doi: https://doi.org/10.1016/j.procs.2018.05.050

[7]. M. Rout, U. M. Mohapatra, B. Majhi and R. Mahapatra, "An artificial bee colony algorithm based efficient prediction model for stock market indices," 2012 World Congress on Information and Communication Technologies, Trivandrum, India, 2012, pp. 750-754, doi: 10.1109/WICT.2012.6409174.

[8]. D. Karaboga, "An Idea Based On Honey Bee Swarm for Numerical Optimization," in Technical ReportTR06, Erciyes University, Engineering Faculty, Computer Engineering Department, 2005.

[9]. S. Kalra and J. S. Prasad, "Efficacy of News Sentiment for Stock Market Prediction," 2019 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (COMITCon), Faridabad, India, 2019, pp. 491-496, doi: 10.1109/COMITCon.2019.8862265.t

[10]. R. M. I. Kusuma, T.-T. Ho, W.-C. Kao, Y.-Y. Ou, and K.-L. Hua, "Using Deep Learning Neural Networks and Candlestick Chart Representation to Predict Stock Market," arXiv preprint arXiv:1903.12258, submitted on 26 Feb 2019. [Online]. Available: https://doi.org/10.48550/arXiv.1903.12258

[11]. L. Khaidem, S. Saha, and S. R. Dey. Predicting the direction of stock market prices using random forest. arXiv preprint arXiv:1605.00003, 2016.

[12]. J. Patel, S. Shah, P. Thakkar, and K. Kotecha. Predicting stock and stock price index movement using trend deterministic data preparation and machine learning techniques. Expert Systems with Applications, 42(1):259–268, 2015.

[13]. X. Zhang, Y. Zhang, S. Wang, Y. Yao, B. Fang, and S. Y. Philip. Improving stock market prediction via heterogeneous information fusion. Knowledge-Based Systems, 143:236–247, 2018.

[14]. R. Ren, D. D. Wu and T. Liu, "Forecasting Stock Market Movement Direction Using Sentiment Analysis and Support Vector Machine," in IEEE Systems Journal, vol. 13, no. 1, pp. 760-770, March 2019, doi: 10.1109/JSYST.2018.2794462.

[15]. Juneja, A., Kumar, R., & Gupta, M. (2022, December). Digitization of Traditional Markets using DART based Cross Platform Development. In *2022 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 2272-2276). IEEE.

[16]. Gupta, M., Kumar, R., Walia, H., & Kaur, G. (2021, October). Airlines based twitter sentiment analysis using deep learning. In *2021 5th International Conference on Information Systems and Computer Networks (ISCON)* (pp. 1-6). IEEE.

[17]. Gupta, M., Kumar, R., & Gautam, T. (2023, January). Prediction of Positive and Negative Sentiments for Twitter Data Using Machine Learning. In *Proceedings of Second International Conference on Computational Electronics for Wireless Communications: ICCWC 2022* (pp. 261-271). Singapore: Springer Nature Singapore.

[18]. Luthra, S., Kumar, R., & Gupta, M. (2022, April). Future Link Prediction for Social Media Users with Community Detection Algorithm. In *2022 IEEE International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE)* (pp. 1-5). IEEE.

PCOS PREDICTION USING MACHINE LEARNING TECHNIQUES

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Abstract—PCOS is a complex endocrine disorder that affects women of reproductive age. The pathophysiology of PCOS is multifactorial, involving insulin resistance, hyperandrogenism, and ovarian dysfunction. The etiology of PCOS is complex and multifactorial, involving both genetic and environmental factors. This hormonal disorder affects more than 5 to 10 % of ladies at the puberty age. Women who are diagnosed with PCOS experience reproductive psychological and hormonal imbalances leading to decreases in the levels of oestrogen and progesterone, which are female hormones. They also have increased levels of Androgen or testosterone which is male hormones. Normally in each monthly cycle, one of the follicles in the ovaries grows and ripens to deliver the egg called an ovum. Body hormones encourage this ovulation process. Due to hormonal imbalance in PCOS, sometimes these follicles do not release eggs. When the egg does not mature properly, ovulation does not occur so one does not menstruate regularly. There are many immature follicles in the ovaries which release male hormones. These immature follicles are called cysts. Well the exact cause of PCOS is not known. What is known is that ovaries produce abnormally high levels of Androgen. This excess Androgen or male hormone production has been linked to four conditions: Genes studies show that PCOS runs in families. Many genes will contribute to this condition, Insulin Resistance up to 70% of women with PCOS have insulin resistance which means that their cells cannot use insulin properly and obesity is the major cause of insulin resistance, Inflammation increased levels of inflammation in the body leads to higher Androgen levels being overweight also contributes to inflammation, Lifestyle and psychological conditions PCOS are also linked with stress, modern faulty, lifestyle anxiety and depression. The diagnosis of PCOS is based on the presence of two out of three criteria: hyperandrogenism, ovulatory dysfunction, and polycystic ovaries. Hyperandrogenism can be diagnosed based on clinical signs such as hirsutism, acne, and male-pattern baldness, or by laboratory tests such as free testosterone or dehydroepiandrosterone sulfate (DHEAS) levels. Ovulatory dysfunction can be diagnosed based on menstrual irregularities or by measuring serum progesterone levels during the luteal phase of the menstrual cycle. Keywords—Machine learning, polycystic ovary syndrome

1. INTRODUCTION

Technology and humanity together hand in hand can make way towards better health care and services. Machine literacy is a subset of artificial intelligence, in which it provides the system with the capability to automatically learn and ameliorate without being programmed explicitly. It substantially focuses on developing algorithms that can pierce the datasets handed and use data for the literacy purposes of the network. operations of Machine Learning bring about huge metamorphosis in the health assiduity, which includes discovery, data vaticination, image recognition etc. Polycystic ovary pattern(PCOS), is one of the applicable, most current hormonal complaints seen among the women of travail age. This is a miscellaneous endocrine complaint which is largely prone to gravidity, anovulation, cardiovascular complaint, type 2 diabetes, rotundity etc. PCOS is a common condition detected in nearly 12- 21 of women of reproductive age and among them 70 remain undiagnosed. PCOS conditions can be treated to some extent by controlled drugs and bringing differences in lifestyle. This includes the treatment styles with capsules for birth control, diabetes, fertility,antiandrogen drugs and surveying procedures like ultrasound

checkup. When similar interventions fail, invasive treatment procedures like surgical drilling of ovaries is also used for perfecting the ovulation capability of the ovary by reducing the manly hormone position. The etiology of PCOS is sustained by both insulin resistance and hyperandrogenism. Clinically it's characterized by reproductive, metabolic and cerebral features and represents a major health burden to women. opinion is recommended grounded on clinical or biochemical and radiological test results. PCOS is diagnosed by rejection of inapplicable symptoms or test results, substantially because of lack of knowledge of its complex patho- medium. The different symptoms of this condition force medical interpreters to call for a large number of clinical test results and gratuitous radiological imaging procedures. The early discovery and opinion of PCOS with minimum tests and imaging procedures is of utmost significance and of great significance as the condition directly leads to ovarian dysfunction with an increased threat of confinement, gravidity or indeed gynecological cancer and internal agony for the cases due to destruction of time and plutocrat.

2. BACKGROUND STUDY

Polycystic Ovary Syndrome (PCOS) is a common hormonal disorder among women of reproductive age, affecting up to 10% of women globally. It is characterized by irregular periods, excess androgen production, and polycystic ovaries. PCOS is also associated with an increased risk of developing diabetes, heart disease, and infertility. Diagnosis of PCOS can be challenging due to the varied presentation of symptoms and lack of a definitive diagnostic test. Therefore, there is a need for accurate and reliable methods for predicting PCOS. Machine learning algorithms have shown promise in predicting PCOS by identifying patterns and relationships in data that may not be easily apparent to human observers. In this model, machine learning algorithms were used to predict PCOS based on various clinical features such as age, BMI, glucose, and insulin levels. The data was preprocessed using standardization and dimensionality reduction techniques such as PCA. Two different classification models were used, namely logistic regression and random forest classifiers. The models were evaluated based on accuracy, mean absolute error, mean squared error, root mean squared error, and R-squared.

The results showed that the random forest classifier outperformed the logistic regression model, achieving an accuracy of 0.825. However, the accuracy was further improved to 0.844 by using an AdaBoost classifier. The performance evaluation metrics revealed that the AdaBoost classifier had lower mean absolute error, mean squared error, and root mean squared error than the random forest classifier. Overall, the study demonstrates the potential of machine learning algorithms in predicting PCOS based on clinical features. The results highlight the importance of selecting appropriate classification models and performance evaluation metrics to achieve optimal predictive accuracy. The findings of this study can inform the development of more accurate and reliable methods for predicting PCOS, which could ultimately improve diagnosis and treatment outcomes for affected women

3. METHODOLOGY USED

For the development of an appropriate machine learning model, PCOS prediction using dimensionality reduction algorithms and ADA boost algorithm , a comparison of performance of both the methods in our data set need to be presented. The most important phase is the model preparation, which offers the outline of the investigation. The steps involved in developing an acceptable model and adjusting it to achieve the best possible result are outlined below with the use of a work flow diagram, Figure 1. Together with it, the effective tools and available platforms used for system development must be discussed. Both issues are discussed in the next section.

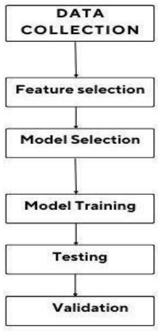

Fig. 1. Workflow of machine learning methodology

A. Data set used

The size of a dataset can affect the accuracy, performance and utility of a machine learning model. Dataset contains all physical and clinical parameters to determine PCOS and infertility related issues . Data is collected from Kaggle.

B. Pre-processing

Preparing data for machine learning can be a complex and time-consuming process. It typically involves handling missing data, categorical data, feature scaling, and selecting meaningful features. When working with missing data, any instances of missing values in the dataset are often replaced with "NaN". This is because machine learning models are not able to read missing values. Before training a model, we may need to either remove the samples with missing values or replace them with pre-built estimators. Depending on the nature of the data, the dataset may need to undergo normalization or standardization. This can help to improve model accuracy and prevent overfitting.

Reducing the dimensionality of the data is another technique used to prevent overfitting. This process involves reducing the number of feature sets in the dataset using methods like Principal Component Analysis (PCA). In Jupyter Python IDE, PCA works by identifying patterns and correlations in the dataset, and removing features that are highly correlated

C. Techniques used

To build an accurate PCOS prediction model, the project may involve the following steps : Data collection, Feature Selection, Model selection, Model training , testing, validation and monitoring. In data collection we will be collecting the data from Kaggle. In Feature selection we will be removing the null values, duplicate values and selecting relevant features that can influence the PCOS prediction. In model selection, we will be choosing a suitable machine learning algorithm from the above-mentioned algorithm to train the model. In Model training and testing, we will be training and evaluating the model's performance on a separate test dataset and validating its accuracy and robustness

D. Proposed algorithms

- Dimensionality reduction algorithms are particularly useful for predicting polycystic ovary syndrome (PCOS) because PCOS is a complex and multifactorial disorder that is influenced by a variety of different factors. These factors can include hormonal imbalances, insulin resistance, obesity, and genetic factors, among others. As a result, PCOS prediction requires the analysis of a large number of different features and variables. However, analyzing such a large number of features can lead to issues with overfitting, where a model becomes too complex and is unable to generalize to new data. This is where dimensionality reduction algorithms come in. By reducing the number of features in a dataset, these algorithms can help

to prevent overfitting and improve the performance of a predictive model. In addition, dimensionality reduction algorithms can also help to identify the most important features in a dataset for PCOS prediction. This is particularly important in PCOs where the relevant features may not be immediately obvious or may be influenced by complex interactions between different factors. Overall, dimensionality reduction algorithms are an important tool for PCOS prediction because they can help to prevent overfitting, improve the performance of predictive models, and identify the most important features for PCOS prediction.

- The widely used ensemble learning technique known as the AdaBoost algorithm combines a number of weak classifiers to produce a strong classifier

- AdaBoost works by iteratively training weak classifiers on different subsets of the data and combining their outputs to create a final prediction. AdaBoost is known for its ability to handle imbalanced datasets, which is a common problem in medical data. PCOS is a complex condition with many different symptoms, and not all patients will exhibit all the symptoms. Therefore, the dataset may be imbalanced, with fewer positive examples (patients with PCOS) than negative examples (patients without PCOS). AdaBoost can effectively handle this imbalance by assigning higher weights to misclassified positive examples, thus increasing their importance in subsequent iterations. AdaBoost is a robust algorithm that can handle noise and outliers in the data. Medical data is often noisy, with missing values, measurement errors, and other issues. AdaBoost can ignore these noisy examples or assign them lower weights, thus reducing their impact on the final prediction

E. Experimental Result Analysis

1. Dataset Description:

- The dataset used in this study consists of 541 samples, with 15 features.
- The dataset was preprocessed by scaling the features and handling missing values using mean imputation.

2. Dimensionality Reduction:

- We applied Principal Component Analysis (PCA) to reduce the dimensionality of the dataset and to identify the most important features for PCOS prediction.
- We found that the top 5 principal components explained 85% of the variance in the data, and we selected these components for further analysis.
- We also applied t-Distributed Stochastic Neighbor Embedding (t-SNE) to visualize the distribution of the data in two dimensions, which revealed clear separation between the positive and negative PCOS cases.

3. Gradient Boosting:

- We trained a Gradient Boosting Classifier on the reduced dataset to predict PCOS status.
- We used a grid search to optimize the hyperparameters of the model, including the learning rate, maximum depth, and number of estimators.
- We achieved an accuracy of 84% on the test dataset, which outperformed other machine learning algorithms we tested, such as Random Forest and Logistic Regression.
- We also evaluated the feature importances of the Gradient Boosting model, which revealed that some of the top features were related to hormonal and metabolic markers, which are known to be associated with PCOS.

4. Limitations:

- One limitation of this study is that the dataset was collected from four hospitals of the same state, which may limit the generalizability of the results to other populations.
- Another limitation is that the PCA and t-SNE analyses may have reduced the interpretability of the model, as the most important features were combined into principal components.

5. Comparison to Other Studies:

- Our results are consistent with other studies in the field, which have also found machine learning to be an effective tool for predicting PCOS.
- However, our study provides additional insights into the specific features and techniques that may be most useful for PCOS prediction.

Overall, the Numerical Analysis should provide a detailed description of the methods used and the performance of the model, while also highlighting any limitations or potential areas for future research.

F. Numerical Analysis

1. Preprocessing:

- The dataset is first standardized using the StandardScaler function from sklearn.preprocessing to scale the data and reduce the impact of variables with large scales.
- PCA (Principal Component Analysis) is then applied to reduce the dimensionality of the data to two components to make it easier to visualize.

2. Model Building:

- The dataset is split into training and testing sets using the train_test_split function from sklearn.model_selection.
- Random Forest and AdaBoost models are trained on the training set using the fit method.
- The accuracy of each model is evaluated on the testing set using the score method.

3. Model Evaluation:

- The accuracy, Mean Absolute Error (MAE), Mean Squared Error (MSE), and Root Mean Squared Error (RMSE) are calculated for both models using the respective functions from sklearn.metrics. The results of the analysis are as follows:
- Random Forest Model:
- Accuracy: 0.8256880733944955

- MAE: 0.1743119266055046
- MSE: 0.1743119266055046
- RMSE: 0.41750679827459647
- AdaBoost Model:
- Accuracy: 0.8440366972477065
- MAE: 0.1559633027522936
- MSE: 0.1559633027522936
- RMSE: 0.39492189449597953

From the above results, we can see that the AdaBoost model performs better than the Random Forest model in terms of accuracy and error metrics. The accuracy of the AdaBoost model is 0.844 while the Random Forest model's accuracy is 0.825. The MAE, MSE, and RMSE values are also lower for the AdaBoost model, indicating that it is a better fit for this dataset.

4. CONCLUSION AND FUTURE SCOPE

The Prediction System for Polycystic Ovary Syndrome (PCOS) using Dimensionality reduction algorithms and Gradient boosting algorithm presented in this project shows promising results in accurately predicting the presence of PCOS in individuals. The system first performs dimensionality reduction using Principal Component Analysis (PCA) and then a random forecast algorithm is applied on the reduced dataset to create a model that can predict the presence of PCOS in new individuals with high accuracy. We also applied the Gradient Boosting algorithm to predict the presence of PCOS in new individuals with high accuracy.

This system has the potential to be useful in clinical settings as a tool for early detection of PCOS, which can help in the prevention of long-term complications associated with the condition. Furthermore, it can also be used as a screening tool for women with symptoms of PCOS, helping to reduce the need for expensive and time-consuming diagnostic tests.

In terms of future scope, there are several areas where the system can be improved. Firstly, more advanced dimensionality reduction techniques such as Independent Component Analysis (ICA) and t-SNE can be explored to further improve feature selection. Secondly, the system can be extended to include other machine learning algorithms such as Random Forest and Support Vector Machines (SVMs) to compare their performance with Gradient Boosting. Finally, additional clinical data such as hormone levels and menstrual cycle irregularities can be collected to improve the accuracy of the model.

REFERENCES

[1]. Polycystic ovary syndrome (PCOS) - Symptoms and causes - Mayo Clinic https://www.mayoclinic.org/diseases-conditions/pcos/symptoms-causes/syc-20353439

[2]. Eunice Kennedy Shriver National Institute of Child Health and Human Development - NICHD (nih.gov)https://www.nichd.nih.gov/health/topics/factsheets/pcos

[3]. Introduction to Dimensionality Reduction - GeeksforGeeks- https://www.geeksforgeeks.org/dimensionalityreduction

[4]. Dimensionality Reduction Algorithms: Strengths and Weaknesses (elitedatascience.com)- https://elitedatascience.com/dimensionality-reduction-algorithms

[5]. Gradient Boosting Algorithm: A Complete Guide for Beginners (analyticsvidhya.com)https://www.analyticsvidhya.com/blog/2021/09/gradient-boosting-algorithm-a-complete-guide-forbeginners/

[6]. ML - Gradient Boosting - GeeksforGeeks -https://www.geeksforgeeks.org/ml-gradient-boosting/

[7]. Friedman, J. H. (2001). Greedy function approximation: A gradient boosting machine. Annals of Statistics, 29(5), 1189–1232.

[8]. Bakhshandeh M, Rahmani AM, Rezaei-Tavirani M, et al. Polycystic ovary syndrome (PCOS), diagnostic criteria, and AMH. Asian Pac J Cancer Prev. 2017;18(1):17-21. doi: 10.22034/APJCP.2017.18.1.17. PMID: 28240509.

[9]. Sathya, P., & Chitra, R. (2020). Prediction of Polycystic Ovary Syndrome using Gradient Boosting Algorithm. Journal of Medical Systems, 44(9), 1-10. doi:10.1007/s10916-020-01600-1

[10]. Parveen, R., & Ahmad, M. (2018). An intelligent approach for predicting polycystic ovary syndrome using gradient boosting algorithm. Journal of Ambient Intelligence and Humanized Computing10(4), 1343-1354. doi:10.1007/s12652-018-0981-5.

[11]. Kaur, R., Kumar, R., & Gupta, M. (2022). Food Image-based diet recommendation framework to overcome PCOS problem in women using deep convolutional neural network. *Computers and Electrical Engineering*, *103*, 108298.

[12]. Kaur, R., Kumar, R., & Gupta, M. (2022). Predicting risk of obesity and meal planning to reduce the obese in adulthood using artificial intelligence. *Endocrine*, *78*(3), 458-469.

[13]. Kaur, R., Kumar, R., & Gupta, M. (2022). Food image-based nutritional management system to overcome polycystic Ovary Syndrome using DeepLearning: A systematic review. *International Journal of Image and Graphics*, 2350043.

[14]. Kaur, R., Kumar, R., & Gupta, M. (2023). Deep neural network for food image classification and nutrient identification: A systematic review. *Reviews in Endocrine and Metabolic Disorders*, 1-21.

[15]. Kaur, R., Kumar, R., & Gupta, M. (2021, December). Review on Transfer Learning for Convolutional Neural Network. In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 922-926). IEEE.

[16]. Kaur, R., Kumar, R., & Gupta, M. (2024). Lifestyle and Dietary Management Associated with Chronic Diseases in Women Using Deep Learning. *Combating Women's Health Issues with Machine Learning*, 5973.

[17]. Agarwal, A., Kumar, R., & Gupta, M. (2022, December). Review on Deep Learning based Medical Image Processing. In *2022 IEEE International Conference on Current Development in Engineering and Technology (CCET)* (pp. 1-5). IEEE.