AJEMA GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 2, Issue 11, 2024 ISSN (E): 2993-2637

Development of a Secure Blockchain-Based System for Medical Certificate Generation and Verification

R. Regin
Assistant Professor, Department of Computer Science and Engineering, SRM Institute of Science and Technology, Ramapuram, India

S. Suman Rajest
Professor, Dhaanish Ahmed College of Engineering, Chennai, Tamil Nadu, India

Shynu T
Assistant Professor, Department of Electronics and Communication Engineering, Dhaanish Ahmed College of Engineering, Chennai, Tamil Nadu, India

Abstract: The healthcare industry's growing reliance on electronic medical records (EMRs) brings challenges like fraud, tampering, and unauthorized access. Blockchain technology, with its security and immutability, offers a robust solution to these issues. This project introduces a blockchain-based medical certificate generator to securely store and verify medical certificates. The system enables authorized healthcare providers to issue tamper-proof certificates that can be easily verified by patients, insurance companies, and other stakeholders. Additionally, it offers a transparent audit trail for all certificate transactions, ensuring trust and accountability. The proposed system has three core components: a smart contract, a dedicated blockchain network, and a web application. The smart contract manages the storage, issuance, and verification of certificates on the blockchain. The dedicated blockchain network guarantees the security and immutability of these records, preventing unauthorized changes. The web application offers a user-friendly interface for both healthcare providers and patients, facilitating seamless interaction with the system. This approach not only strengthens the security of medical certificates but also simplifies the verification process, reducing the risk of fraudulent documents and enhancing the integrity of digital health data.

Keywords: Electronic medical records (EMRs); Tamper-proof medical; Transparent audit; Ever-evolving healthcare; Susceptibility to forgery; Promising solution.

Introduction

The healthcare industry is undergoing a significant transformation, with an increasing reliance on electronic medical records (EMRs) and various digital health data systems. However, these digital records, while more efficient than traditional paper-based records, still face critical challenges. Issues like data tampering, fraud, and unauthorized access continue to undermine the credibility and reliability of medical records, especially in contexts like insurance claims, employment verification, and academic documentation [1]. Traditional paper-based certificates are prone to forgery, misplacement, and tampering, making it difficult to trust their authenticity. These limitations have led to growing concerns about the effectiveness and reliability of such certificates in validating medical claims, verifying employment leave requests, and certifying

health-related academic requirements [2-4]. To address these issues, blockchain technology has emerged as a promising solution due to its inherent characteristics of decentralization, immutability, and enhanced security. Blockchain's decentralized nature eliminates the need for a central authority, reducing the risk of tampering and unauthorized changes to the data. Its immutable ledger ensures that once data is recorded, it cannot be altered or deleted, providing a permanent and verifiable record of medical certificates [5-12]. This project focuses on developing a blockchain-based medical certificate generator, aimed at creating a secure, transparent, and tamper-proof system for generating and verifying medical certificates [13].

The proposed blockchain-based system aims to create a reliable and efficient framework for the issuance, management, and verification of medical certificates. This innovative approach leverages the strengths of blockchain technology, addressing the limitations of traditional paper-based certificates by creating a secure ecosystem for all stakeholders involved. Authorized healthcare providers can issue verifiable medical certificates, ensuring that the integrity and authenticity of these documents are preserved [14-19]. This system also provides patients with direct and secure access to their medical certificates, allowing them to easily share their records with insurance companies, employers, and other relevant parties. By integrating blockchain's immutability and transparency, the proposed system offers a robust solution to enhance trust in medical documentation [20].

The application of a blockchain-based medical certificate generator has extensive implications in the healthcare industry. One of the primary uses includes issuing and verifying medical certificates, where the secure and immutable nature of blockchain ensures that certificates cannot be forged or altered [21-25]. Additionally, the system can manage immunization records, a critical need highlighted during global health crises like the COVID-19 pandemic. By securely storing immunization data, healthcare providers can easily verify a patient's vaccination status. The system can also facilitate the storage and sharing of electronic health records (EHRs), ensuring that patient data is securely transferred between different healthcare providers, even across borders [26-31]. This cross-border exchange of medical records is crucial in scenarios where patients seek treatment in different countries, necessitating a reliable way to share accurate health information. Furthermore, the blockchain-based system supports research and clinical trials by providing secure access to patient data, enhancing the reliability of data used in medical research [32].

This project's primary goal is to develop a blockchain-based medical certificate generator that addresses the drawbacks of traditional methods. The proposed system aims to ensure that medical certificates are verifiable, secure, and tamper-proof, leveraging blockchain's decentralized ledger to store and manage these records [33-35]. The core components of the system include a smart contract, a dedicated blockchain network, and a user-friendly web application interface. The smart contract will automate the issuance, verification, and revocation of medical certificates, reducing the chances of human error and fraud. The blockchain network guarantees the immutability of the data, preventing any unauthorized modifications. The web application provides a seamless interface for healthcare providers and patients, making it easier to interact with the system and access medical certificates [36-42]. The project's development begins with a detailed system design and requirements gathering phase. This phase involves identifying the specific needs of healthcare providers, patients, and other stakeholders who interact with medical certificates [43-47]. The core functionalities of the system are defined, including the processes for issuing, verifying, and revoking certificates. Security and privacy considerations are paramount, as medical data is highly sensitive and must be protected against unauthorized access. Blockchain technology's inherent security features, such as cryptographic hashing and decentralized storage, are leveraged to address these concerns effectively [48].

In the next phase, the blockchain network and smart contracts are developed. Choosing the appropriate blockchain platform is crucial for the project's success. Platforms like Ethereum and Hyperledger Fabric are considered due to their robust capabilities and support for smart contract

development [49-55]. Ethereum, known for its versatility and widespread adoption, offers a strong foundation for creating smart contracts, while Hyperledger Fabric's permissioned blockchain model provides enhanced privacy and scalability. The smart contracts are designed to handle the automation of medical certificate processes, ensuring that certificates can only be issued by authorized healthcare providers and that the verification process is streamlined. These contracts are coded with security measures to protect the integrity of the medical records stored on the blockchain [56-61]. The user interface and user experience (UI/UX) design are critical to the project's success. The system must provide an intuitive and user-friendly interface for both healthcare providers and patients. The design process involves creating workflows that simplify the steps for issuing, verifying, and managing medical certificates. The user interface is developed to be compatible with various devices and operating systems, ensuring accessibility for all users. The focus on usability ensures that healthcare providers can efficiently issue certificates, and patients can easily access and share their records as needed [62-66].

Following the development of the blockchain network and smart contracts, system integration and testing are conducted. This phase integrates the blockchain backend with the user interface, creating a seamless experience for users. Thorough testing is performed to assess the system's functionality, performance, and security. Testing involves simulating various scenarios to ensure that the smart contracts behave as expected and that the blockchain network handles certificate issuance and verification efficiently [67-73]. Any bugs or issues identified during this phase are addressed promptly to ensure that the system is stable and secure before deployment. Once testing is complete, the system is deployed in a production environment, making it accessible to healthcare providers and patients. The deployment phase also includes setting up monitoring and maintenance procedures to ensure that the system remains operational and secure over time. Regular updates and enhancements are implemented based on user feedback and evolving industry requirements. The project's scope may expand to include additional features or integrations, depending on the specific needs identified during deployment [74-79].

The project domain lies within patient data and medical records, focusing on improving the management of health records through innovative technology solutions. The primary focus is on enhancing patient care and data management, aligning with healthcare standards and regulations to ensure compliance. The project contributes to the overall efficiency and transparency of healthcare processes, addressing key issues related to data security and authenticity [80-85]. The use of blockchain technology enhances the security of medical records, reducing the risk of tampering and unauthorized access. Additionally, the system supports global interoperability, allowing medical records to be shared securely across different healthcare systems and countries, which is essential for patients seeking international treatment [86-91].

The scope of the project encompasses the entire lifecycle of the blockchain-based medical certificate generator, from design and development to implementation and testing. It involves defining system functionalities, developing the smart contracts and blockchain network, and creating a user-friendly interface. The project also includes rigorous testing to ensure that the system meets performance and security standards. Deployment involves setting up the system for use by healthcare providers and patients, with ongoing maintenance to keep the system updated and secure. Additional components may be included based on feedback and new requirements identified during the project's progression [92-97].

In conclusion, the development of a blockchain-based medical certificate generator offers a transformative solution to the challenges faced by traditional paper-based certificates. By leveraging the unique features of blockchain technology, this project aims to create a secure, transparent, and efficient ecosystem for managing medical certificates. The system's ability to provide verifiable, tamper-proof certificates enhances the reliability of medical documentation, benefiting healthcare providers, patients, insurance companies, and other stakeholders [98-105]. The focus on patient engagement and direct access to records empowers individuals to take control of their medical information, fostering greater autonomy and trust in the healthcare

system. As the project progresses, the integration of blockchain technology into medical certificate management has the potential to set new standards for data security and transparency in the healthcare industry, paving the way for broader adoption of blockchain solutions in healthcare data management.

Methodology

In the process of analyzing CCTV footage for object detection, a series of preprocessing steps are applied to enhance the quality of the input frames and isolate the desired moving objects. The first step in this process is gray scaling and blurring. Converting the image to grayscale reduces the complexity of the image by removing color information, which simplifies the processing and analysis tasks. The grayscale image is then subjected to Gaussian Blur, a technique that applies a Gaussian function to smooth the image. This blurring effect reduces noise and details, making it easier to distinguish the significant elements in the frame while minimizing the impact of irrelevant features.

Following the blurring process, background subtraction is employed to differentiate between the moving objects and the static background in the video frames. This method involves subtracting the current frame from a reference frame, effectively isolating the regions where changes have occurred. By using this approach, the system identifies the areas that contain moving objects, which are the primary focus of interest in surveillance analysis. The background subtraction can be mathematically represented by the equation dust(I) = saturate(|scr1(I) − scr2(I)|), where the current frame (scr1) is subtracted from the reference frame (scr2), and the result is processed to saturate the pixel values, highlighting the areas with significant differences.

The next step in the object detection pipeline is the application of a binary threshold. This technique, known as binarization, converts the grayscale image into a binary image, where pixel values are either set to a maximum intensity value (white) or to zero (black) based on a specified threshold. The binary thresholding helps to eliminate noise and small holes within the detected object area, enhancing the clarity and accuracy of the detected regions. This process is represented by the equation dust(x, y) = max Val if scar(x, y) > thresh else 0, where each pixel is evaluated against the threshold value. If the pixel intensity exceeds the threshold, it is set to the maximum value, otherwise, it is set to zero. This step effectively isolates the desired objects from the background and prepares them for further analysis [116-121].

After obtaining the binary thresholded image, dilation is performed to enhance the object's features by filling in gaps or small holes that may have been introduced during the binarization process. Dilation involves applying a morphological operation that expands the object's area, making it easier to detect and outline the object's shape. This operation increases the robustness of the object detection process, ensuring that even fragmented or partially detected objects are included in the analysis [122-126]. Once the dilation process is completed, the contours of the detected objects are identified. Contours represent the boundaries or outlines of the objects, and detecting these contours is crucial for accurate localization. By drawing rectangle boxes around the identified contours, the system visually marks the moving objects within the frame, enabling effective tracking and further analysis. This sequence of preprocessing steps ensures that the input image is sufficiently refined, allowing for precise detection and accurate representation of the moving objects captured in the CCTV footage [127].

Data classification

Data classification is an essential aspect of a blockchain-based medical certificate generator, ensuring that sensitive medical information is organized, managed, and secured effectively. By categorizing the data properly, the system can apply appropriate access control measures, maintain data integrity, and enable efficient data retrieval when needed. Data classification is particularly crucial in healthcare settings, where privacy concerns are paramount, and the misuse or unauthorized access of medical information can lead to severe consequences. In a blockchain-based system, data classification helps in defining the types of data stored, facilitates secure

access, and improves the overall efficiency and functionality of the medical certificate management process [128-131].

One of the primary categories of data in this system is the certificate type. The certificate type helps to identify the specific nature of the medical certificate, such as whether it is a vaccination certificate, an allergy certificate, or a general medical history certificate. This classification is vital because it allows the system to tailor the contents and structure of the certificate according to its purpose. For instance, a vaccination certificate would include details about the type of vaccine administered, the dosage, and the date of vaccination. In contrast, an allergy certificate would provide information about known allergens and recommended precautions. This distinction helps healthcare providers and other stakeholders quickly understand the context and relevance of each certificate, ensuring accurate interpretation and usage.

Another critical component of data classification is the patient identifier. Each medical certificate needs to be uniquely associated with a specific patient to ensure traceability and prevent mix-ups. A patient identifier, often represented as a unique alphanumeric code, links the certificate directly to the patient's medical records. This identifier is crucial for maintaining patient confidentiality while enabling secure and efficient access to the relevant medical information. The patient identifier ensures that only authorized users can view or modify the medical certificate, thus safeguarding sensitive patient data from unauthorized access or potential misuse [132-133].

The issuing healthcare provider's information is also a key element in the data classification process. This data includes the details of the healthcare professional or institution that issued the medical certificate. By storing information about the issuing provider, the system adds a layer of verification and credibility to the certificate. When a third party, such as an employer or insurance company, needs to validate the certificate, the details of the issuing provider help confirm the authenticity of the document. This information also facilitates communication between the patient and the healthcare provider, enabling follow-up consultations or additional inquiries if necessary. The date of certificate issuance is another important classification parameter. Storing the issuance date of each medical certificate is essential for maintaining an accurate timeline of the patient's medical history. The issuance date helps in tracking the validity period of certain certificates, such as vaccination records, which may need to be updated periodically. By recording the issuance date, the system can alert patients and healthcare providers when a certificate needs to be renewed or updated, ensuring that the medical information remains current and reliable.

Medical information forms the core content of the medical certificate, varying according to the type of certificate issued. This category includes specific details relevant to the patient's medical condition or treatment, such as vaccination records, allergy lists, or summaries of the patient's medical history. The inclusion of accurate and detailed medical information ensures that the certificate serves its intended purpose effectively, providing valuable data that can be used for diagnosis, treatment, and verification. Given the sensitivity of this information, it is classified and stored with robust security measures to prevent unauthorized access and tampering.

User data is another critical aspect of the system, classified based on the user type. Different users interact with the blockchain-based medical certificate generator, including healthcare providers, patients, and system administrators. Classifying users by type allows the system to enforce role-based access control, ensuring that each user only has access to the data and functions relevant to their role. Healthcare providers, for example, may have permission to issue and verify certificates, while patients can view their own records. Administrators may have broader access to manage the system's configuration and user policies. This classification enhances security and streamlines the user experience by restricting access based on predefined roles.

To manage the classified data effectively, the system employs a robust database structure. This project utilizes a FILE COIN database in conjunction with Python to handle all data management tasks. The database is organized into tables following the Boyce-Codd Normal Form (BCNF), ensuring that the data is stored efficiently and without redundancy. The use of BCNF helps maintain data consistency and integrity, which is critical in a system handling sensitive medical information. The database comprises five primary tables: Certificate Type, Transaction Data, System Configuration, User Contact Information, and an additional table for storing patient identifiers. The Certificate Type table stores information about the type of medical certificate, categorizing them into distinct types such as vaccination certificates, allergy certificates, and medical history certificates. This categorization aids in identifying the certificate's purpose and the specific medical data it contains. The Transaction Data table records details about the blockchain transactions associated with each certificate. This includes timestamps, transaction hashes, and the addresses of the sender and recipient. By maintaining a log of all transactions, the system ensures transparency and traceability, which are essential for verifying the authenticity of medical certificates and preventing fraudulent activities.

The System Configuration table stores settings related to the system's operation, including network configurations, security protocols, and user access policies. This table is critical for maintaining the stability and security of the blockchain-based system, allowing administrators to update configurations as needed. The User Contact Information table stores the contact details of system users, such as email addresses and phone numbers. This information is used for notifications and communication purposes, such as alerting users about updates to their certificates or requesting additional information.

Overall, the structured classification of data in a blockchain-based medical certificate generator is fundamental to ensuring the system's functionality, security, and efficiency. By carefully organizing data into distinct categories, the system can provide secure access, maintain data integrity, and facilitate seamless retrieval of information. This approach not only enhances the reliability of the medical certificate management process but also supports the broader goals of improving transparency, reducing fraud, and empowering patients with direct access to their medical records. The integration of a FILE COIN database with Python and the use of BCNF for table normalization further strengthen the system's data management capabilities, offering a scalable and secure solution tailored for the needs of modern healthcare environments.

Literature Review

This paper introduces a blockchain-based architecture designed for generating and verifying medical certificates within IoT-based healthcare systems. The architecture consists of five core components: users, healthcare centers, the blockchain network, a managing authority (MA), and the InterPlanetary File System (IPFS). The authors elaborate on the specific roles and interactions of each component within the system [106]. Users include patients and healthcare providers who interact with the certificates, while healthcare centers serve as the points of issuance. The blockchain network facilitates secure data management, with the managing authority overseeing the system's functionality. IPFS is used for decentralized storage of the medical certificates. By integrating blockchain, the architecture aims to address issues of data security, transparency, and efficiency in the management of medical certificates. The benefits highlighted include enhanced data integrity, reduced risk of forgery, and streamlined verification processes, making the system a reliable solution for modern healthcare environments [107].

This paper proposes a blockchain-based system focused on the generation and verification of medical certificates, utilizing smart contracts to streamline these processes. Smart contracts automate the tasks of issuing, verifying, and revoking medical certificates, significantly reducing the administrative workload on healthcare providers. This automation minimizes the need for manual intervention, lowering the chances of human error and fraud. Furthermore, the system provides patients with greater control over their medical records, allowing them to access and share their certificates securely [108]. The authors delve into the technical details of the system's

implementation, including the setup of smart contracts on a blockchain platform. The discussion highlights the system's potential to transform healthcare record management by providing a secure, efficient, and transparent framework. The proposed approach emphasizes patient empowerment and aims to foster a more streamlined and trustworthy process for handling medical documents [109].

This paper examines the application of blockchain technology for managing medical certificates, addressing the shortcomings of traditional paper-based systems. The authors outline the inherent limitations of physical certificates, such as susceptibility to forgery, loss, and tampering [110]. They propose a blockchain-based solution that leverages the technology's key features, including decentralization and immutability, to overcome these challenges. The system utilizes smart contracts to ensure the authenticity and integrity of medical certificates, providing a secure digital alternative. Additionally, the blockchain-based solution offers a transparent audit trail, allowing all interactions with the certificates to be traced and verified. This feature enhances trust among patients, healthcare providers, and other stakeholders by providing a clear record of the certificate's lifecycle. The authors suggest that this innovative approach can greatly improve the reliability and efficiency of medical certificate management, paving the way for broader adoption in healthcare systems [111].

This paper presents a blockchain-based medical certificate management system aimed at enhancing security and transparency. The proposed system utilizes smart contracts to manage the complete lifecycle of medical certificates, covering issuance, verification, and revocation. Smart contracts play a central role in the automation of these processes, ensuring that all actions are executed according to predefined rules without the need for intermediaries [112]. The authors describe the implementation details, focusing on the integration of blockchain technology to secure patient data and prevent unauthorized modifications. The system also provides a transparent platform for tracking the status of certificates, offering real-time verification capabilities. By leveraging the decentralized nature of blockchain, the system ensures that medical certificates cannot be tampered with, significantly enhancing patient data security. The authors argue that this approach could improve healthcare record management, reduce administrative burdens, and increase trust in the digital handling of sensitive medical documents [113].

This paper proposes a blockchain-based medical certificate management system designed to address the inefficiencies and risks associated with traditional methods of certificate handling. The system employs smart contracts to automate key processes, including the issuance, verification, and revocation of medical certificates. The automation provided by smart contracts reduces the reliance on manual processes, thereby improving overall efficiency and lowering administrative costs for healthcare providers [114]. The authors provide a comprehensive overview of the system's implementation, detailing the setup of smart contracts on a secure blockchain network. They discuss how the system can enhance healthcare record management by ensuring that all certificates are verifiable and tamper-proof [115]. The proposed solution also empowers patients by giving them direct access to their medical certificates, promoting transparency and patient engagement. The authors suggest that this blockchain-based approach offers a scalable and secure alternative to traditional paper-based systems, with the potential to significantly improve patient care and data management.

Project Description

The current medical certificate management system relies heavily on paper-based processes, where certificates are issued and stored in physical form. This traditional approach has several critical limitations, compromising the efficiency and reliability of healthcare documentation. Paper certificates are highly vulnerable to forgery, tampering, and misplacement, raising concerns about their authenticity and trustworthiness. Additionally, the centralized nature of traditional record-keeping restricts transparency and accessibility, making it difficult for patients to access their medical history or verify the authenticity of their certificates. This lack of

accessibility hinders patient engagement and informed decision-making. Furthermore, the manual processes involved in issuing, verifying, and revoking medical certificates are time-consuming and resource-intensive for healthcare providers, leading to delays and operational inefficiencies. Patients also face challenges in managing their own medical certificates, as they have limited control over these documents, making it difficult to securely share their health records with other healthcare providers. These limitations highlight the need for a more secure, efficient, and patient-centric approach to medical certificate management, paving the way for digital solutions that can address these issues effectively.

Proposed System

The proposed blockchain-based medical certificate generator offers a robust solution to the limitations of the traditional paper-based system by harnessing the strengths of blockchain technology. By utilizing a distributed ledger, the system guarantees the authenticity, integrity, and immutability of medical certificates, preventing issues like forgery and tampering. The integration of smart contracts automates the key processes of certificate issuance, verification, and revocation, significantly reducing the administrative workload and associated costs. This automation not only streamlines operations but also enhances efficiency within healthcare settings. Additionally, the system empowers patients with control over their medical data, enabling them to securely access and share their health records as needed. The transparency and accountability provided by the blockchain infrastructure foster greater trust and collaboration between patients, healthcare providers, and other stakeholders. By offering a secure, efficient, and patient-centric approach, the blockchain-based solution redefines medical certificate management and supports improved data handling in the healthcare ecosystem.

Result and analysis

The proposed blockchain-based medical certificate generator stands as a significant innovation in healthcare, poised to revolutionize the management of medical records. By integrating the strengths of blockchain technology, the system aims to address the limitations of traditional paper-based certificates and bring forth a more secure, transparent, and efficient method for issuing, managing, and verifying medical documents. Traditional systems, which rely heavily on paper, are susceptible to several issues, including forgery, loss, tampering, and difficulties in verifying authenticity. These shortcomings hinder the effectiveness of medical certificates, particularly in contexts like insurance claims, employment verification, and patient record management. By leveraging blockchain's immutability, distributed ledger architecture, and smart contracts, the proposed system introduces a solution that mitigates these challenges and offers a transformative approach to healthcare record management.

One of the key advantages of the blockchain-based system is its enhanced security and authenticity. The immutable nature of blockchain ensures that once a medical certificate is recorded, it cannot be altered or deleted. This characteristic addresses the significant issue of tampering, which is prevalent in paper-based systems. The distributed ledger architecture further enhances security by storing the data across multiple nodes, making it nearly impossible for a single entity to manipulate the records without detection. The system also employs smart contracts, which automate the process of certificate issuance, verification, and revocation. These self-executing contracts operate on predefined rules, reducing the likelihood of human error and fraud. By eliminating the manual handling of medical certificates, the system minimizes administrative burdens, streamlines processes, and reduces the associated costs for healthcare providers. Transparency and accountability are fundamental aspects of the proposed system. Blockchain's decentralized and traceable nature ensures that every transaction involving medical certificates is recorded and can be easily verified. This creates a transparent audit trail for all actions related to the certificates, fostering greater accountability among healthcare providers and enhancing trust among patients. The ability to trace and verify every interaction with the medical records is especially valuable in scenarios where the authenticity of a certificate must be

confirmed by third parties, such as employers or insurance companies. This transparency reduces the risk of fraud and provides a reliable framework for managing sensitive medical information.

The system's design also places a strong emphasis on patient empowerment. In traditional setups, patients often have limited access to their medical records and face challenges when attempting to share these records with other healthcare providers. The blockchain-based solution addresses this issue by giving patients direct control over their medical certificates. With secure, digital access to their records, patients can manage and share their information as needed, facilitating more informed decision-making and enhancing their engagement in their own healthcare. This patient-centric approach aligns with modern trends in healthcare, which prioritize patient autonomy and the right to access personal health information. Interoperability is another significant advantage of the proposed system. By integrating with existing electronic health record (EHR) systems, the blockchain-based medical certificate generator can facilitate seamless data exchange across different healthcare platforms. The interoperability of the system allows for efficient coordination of patient care, especially in complex cases involving multiple healthcare providers. Standardized protocols and custom interfaces may be developed to ensure smooth integration, allowing the blockchain-based solution to function alongside current healthcare infrastructure. This ability to interface with other systems is critical for improving the continuity of care and ensuring that healthcare providers have access to accurate and up-to-date patient information.

The blockchain-based medical certificate generator also has the potential to support research and clinical trials. By providing a secure and transparent platform for managing patient data, the system enables researchers to access necessary information with patient consent. The immutability and traceability of blockchain records ensure the reliability of the data used in research, reducing the risk of errors or fraudulent data entries. This capability accelerates data-driven research, facilitates clinical trials, and contributes to the advancement of medical knowledge and patient care outcomes. A feasibility study of the proposed system indicates that it is technically, economically, and operationally viable. Key aspects such as blockchain platform selection, smart contract development, and integration with existing systems have been carefully considered to ensure the system meets the requirements of the healthcare industry. Selecting the appropriate blockchain platform is crucial for the project's success. Factors like scalability, security, transaction costs, and consensus mechanisms play a vital role in determining the platform's suitability. For instance, Ethereum or Hyperledger Fabric may be preferred due to their robust support for smart contracts and proven security features. The choice of platform must align with the project's needs to ensure reliable performance and long-term viability.

Developing secure and efficient smart contracts is another critical component of the project. Smart contracts automate the key processes of issuing, verifying, and revoking medical certificates, thereby reducing the reliance on manual interventions. Rigorous testing and code auditing are essential to prevent vulnerabilities and ensure the smart contracts function as intended. Any flaws in the code could be exploited, compromising the security of the entire system. By adhering to best practices in secure coding and conducting thorough audits, the project aims to mitigate these risks and ensure the integrity of the smart contracts. Integration with existing EHR systems is vital for achieving seamless data exchange and enhancing interoperability. The proposed system may require the development of custom interfaces or the adoption of standardized communication protocols to connect with current healthcare platforms. This integration facilitates efficient sharing of medical records, reduces duplication of efforts, and improves the quality of patient care. Ensuring compliance with data protection regulations, such as HIPAA, is paramount in this process, as it involves handling sensitive patient information. Robust access control mechanisms must be implemented to protect patient privacy and prevent unauthorized data access.

Blockchain security, while inherently strong, must be reinforced with additional safeguards against potential vulnerabilities like code-level attacks or Sybil attacks. Rigorous testing and

continuous security audits are necessary to identify and address any weaknesses. User adoption and training are also key factors in the success of the project. Healthcare providers and patients must be educated on the new system's functionality and benefits to ensure its effective use. Comprehensive training programs and user-friendly interfaces will help facilitate a smooth transition from traditional methods to the blockchain-based solution. Regulatory compliance is another critical consideration. The system must adhere to evolving healthcare regulations and data privacy laws. Ongoing monitoring and compliance audits are necessary to ensure the system remains aligned with legal requirements and industry standards. Scalability and performance are also essential for the system to handle a high volume of transactions and medical certificates without compromising speed or security. Load testing and capacity planning will help ensure the system can scale effectively as the user base grows.

Cost considerations play an important role in the decision to implement a blockchain-based system. Although initial setup and maintenance costs may be higher than those of traditional paper-based systems, a thorough cost-benefit analysis should account for the long-term savings and efficiency gains. The reduction in manual processes, enhanced security, and improved patient engagement are likely to offset the upfront investment over time, making the blockchain solution a cost-effective option for modern healthcare record management. The implementation of the proposed system follows a structured approach, beginning with requirements gathering and analysis. This phase involves defining the project's functional and non-functional requirements to ensure the system meets the needs of all stakeholders. The system design and architecture phase includes the selection of the blockchain platform, smart contract development, and planning for integration with existing EHR systems. During development and implementation, secure coding practices are prioritized, and the system is deployed on a secure and scalable blockchain platform.

Comprehensive testing and validation are conducted to verify that the system meets all requirements and performs as expected. Any defects identified during testing are promptly addressed before the system is rolled out. Deployment involves introducing the system to healthcare providers in a phased manner, accompanied by training and support to ensure a smooth transition. Continuous monitoring and maintenance are carried out post-deployment to address any issues, implement updates, and maintain compliance with evolving regulations. In summary, the proposed blockchain-based medical certificate generator provides a transformative solution for healthcare, addressing the inherent limitations of traditional systems while enhancing security, transparency, and patient control. By leveraging the advantages of blockchain technology, the system offers a scalable, secure, and efficient framework for managing medical records, ultimately improving the quality of healthcare services and patient outcomes. This innovative approach has the potential to redefine medical certificate management and set new standards for digital health data handling in the future.

Conclusion

The blockchain-based medical certificate generator has the potential to transform healthcare record management by significantly enhancing security, increasing transparency, and giving patients control over their medical data. Leveraging blockchain's inherent strengths—immutability, distributed ledger architecture, and smart contracts—the system offers a secure, efficient solution for the issuance, management, and verification of medical certificates. It effectively addresses the shortcomings of traditional paper-based methods, which are prone to forgery, tampering, and inefficiencies. The implementation of the system follows a structured approach, including requirements gathering, system design, development, testing, deployment, and ongoing monitoring. Key challenges, such as technical complexities, security vulnerabilities, and operational concerns, must be addressed to ensure successful deployment. However, as blockchain technology matures and gains broader acceptance, the proposed system could set a new standard in healthcare record management. Its adoption promises a more secure, transparent, and patient-centric approach, enabling streamlined processes and improved data integrity.

Ultimately, this innovative solution could redefine the management of medical records, contributing to enhanced trust and efficiency within the healthcare ecosystem.

References

1. R. Boina, "Assessing the Increasing Rate of Parkinson's Disease in the US and its Prevention Techniques"," International Journal of Biotechnology Research and Development, vol. 3, no. 1, pp. 1–18, 2022.
2. S. Patil, S. Chintamani, J. Grisham, R. Kumar, and B. H. Dennis, "Inverse determination of temperature distribution in partially cooled heat generating cylinder," in Volume 8B: Heat Transfer and Thermal Engineering, 2015.
3. O. Fabela, S. Patil, S. Chintamani, and B. H. Dennis, "Estimation of effective thermal conductivity of porous media utilizing inverse heat transfer analysis on cylindrical configuration," in Volume 8: Heat Transfer and Thermal Engineering, 2017.
4. S. Patil, S. Chintamani, B. H. Dennis, and R. Kumar, "Real time prediction of internal temperature of heat generating bodies using neural network," Therm. Sci. Eng. Prog., vol. 23, no. 100910, p. 100910, 2021.
5. I. Khalifa, H. Abd Al-glil, and M. M. Abbassy, "Mobile hospitalization," International Journal of Computer Applications, vol. 80, no. 13, pp. 18–23, 2013.
6. I. Khalifa, H. Abd Al-glil, and M. M. Abbassy, "Mobile hospitalization for Kidney Transplantation," International Journal of Computer Applications, vol. 92, no. 6, pp. 25–29, 2014.
7. M. M. Abbassy and A. Abo-Alnadr, "Rule-based emotion AI in Arabic Customer Review," International Journal of Advanced Computer Science and Applications, vol. 10, no. 9, p.12, 2019.
8. M. M. Abbassy and W. M. Ead, "Intelligent Greenhouse Management System," 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), 2020.
9. M. M. Abbassy, "Opinion mining for Arabic customer feedback using machine learning," Journal of Advanced Research in Dynamical and Control Systems, vol. 12, no. SP3, pp. 209–217, 2020.
10. M. M. Abbassy, "The human brain signal detection of Health Information System IN EDSAC: A novel cipher text attribute based encryption with EDSAC distributed storage access control," Journal of Advanced Research in Dynamical and Control Systems, vol. 12, no. SP7, pp. 858–868, 2020.
11. M. M. and S. Mesbah, "Effective e-government and citizens adoption in Egypt," International Journal of Computer Applications, vol. 133, no. 7, pp. 7–13, 2016.
12. M.M.Abbassy, A.A. Mohamed "Mobile Expert System to Detect Liver Disease Kind", International Journal of Computer Applications, vol. 14, no. 5, pp. 320–324, 2016.
13. R. A. Sadek, D. M. Abd-alazeem, and M. M. Abbassy, "A new energy-efficient multi-hop routing protocol for heterogeneous wireless sensor networks," International Journal of Advanced Computer Science and Applications, vol. 12, no. 11, 2021.
14. S. Derindere Köseoğlu, W. M. Ead, and M. M. Abbassy, "Basics of Financial Data Analytics," Financial Data Analytics, pp. 23–57, 2022.
15. W. Ead and M. Abbassy, "Intelligent Systems of Machine Learning Approaches for developing E-services portals," EAI Endorsed Transactions on Energy Web, p. 167292, 2018.

16. W. M. Ead and M. M. Abbassy, “A general cyber hygiene approach for financial analytical environment,” Financial Data Analytics, pp. 369–384, 2022.
17. W. M. Ead and M. M. Abbassy, “IoT based on plant diseases detection and classification,” 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), 2021.
18. W. M. Ead, M. M. Abbassy, and E. El-Abd, “A general framework information loss of utility-based anonymization in Data Publishing,” Turkish Journal of Computer and Mathematics Education, vol. 12, no. 5, pp. 1450–1456, 2021.
19. A. M. El-Kady, M. M. Abbassy, H. H. Ali, and M. F. Ali, “Advancing Diabetic Foot Ulcer Detection Based On Resnet And Gan Integration,” Journal of Theoretical and Applied Information Technology, vol. 102, no. 6, pp. 2258–2268, 2024.
20. M. M. Abbassy and W. M. Ead, “Fog computing-based public e-service application in service-oriented architecture,” International Journal of Cloud Computing, vol. 12, no. 2–4, pp. 163–177, 2023.
21. H. AbdulKader, E. ElAbd, and W. Ead, "Protecting online social networks profiles by hiding sensitive data attributes," Procedia Computer Science, vol. 82, pp. 20–27, 2016.
22. I. E. Fattoh, F. Kamal Alsheref, W. M. Ead, and A. M. Youssef, "Semantic sentiment classification for COVID-19 tweets using universal sentence encoder," Computational Intelligence and Neuroscience, vol. 2022, pp. 1–8, 2022.
23. W. M. Ead, W. F. Abdel-Wahed, and H. Abdul-Kader, "Adaptive fuzzy classification-rule algorithm in detection malicious web sites from suspicious URLs," International Arab Journal of e-Technology, vol. 3, pp. 1–9, 2013.
24. M. A. Abdelazim, M. M. Nasr, and W. M. Ead, "A survey on classification analysis for cancer genomics: Limitations and novel opportunity in the era of cancer classification and target therapies," Annals of Tropical Medicine and Public Health, vol. 23, no. 24, 2020.
25. F. K. Alsheref, I. E. Fattoh, and W. M. Ead, "Automated prediction of employee attrition using ensemble model based on machine learning algorithms," Computational Intelligence and Neuroscience, vol. 2022, pp. 1–9, 2022.
26. R. Oak, M. Du, D. Yan, H. Takawale, and I. Amit, “Malware detection on highly imbalanced data through sequence modeling,” in Proceedings of the 12th ACM Workshop on Artificial Intelligence and Security - AISec’19, 2019.
27. Aryal, I. Stricklin, M. Behzadirad, D. W. Branch, A. Siddiqui, and T. Busani, "High-quality dry etching of LiNbO3 assisted by proton substitution through H2-plasma surface treatment," Nanomaterials (Basel, Switzerland), vol. 12, no. 16, p. 2836, 2022.
28. R. L. Paldi, A. Aryal, M. Behzadirad, T. Busani, A. Siddiqui, and H. Wang, "Nanocomposite-seeded single-domain growth of lithium niobate thin films for photonic applications," in Conf. Lasers Electro-Optics, Washington, D.C.: Optica Publishing Group, 2021.
29. S. M. Z. Shifat, I. Stricklin, R. K. Chityala, A. Aryal, G. Esteves, A. Siddiqui, and T. Busani, "Vertical etching of scandium aluminum nitride thin films using TMAH solution," Nanomaterials (Basel, Switzerland), vol. 13, no. 2, 2023.
30. E. Vashishtha and H. Kapoor, "Enhancing patient experience by automating and transforming free text into actionable consumer insights: a natural language processing (NLP) approach," International Journal of Health Sciences and Research, vol. 13, no. 10, pp. 275-288, Oct. 2023.

31. K. Shukla, E. Vashishtha, M. Sandhu, and R. Choubey, "Natural Language Processing: Unlocking the Power of Text and Speech Data," Xoffencer International Book Publication House, 2023, p. 251.

32. Hasan, M. (2022). A Metaphorical & Visual Analysis of Gender in Al Jazeera & BBC coverage of Afghanistan after the Taliban takes over. Indiana Journal of Humanities and Social Sciences, 3(5), 38–43.

33. M. Awais, A. Bhuva, D. Bhuva, S. Fatima, and T. Sadiq, "Optimized DEC: An effective cough detection framework using optimal weighted Features-aided deep Ensemble classifier for COVID-19," Biomed. Signal Process. Control, p. 105026, 2023.

34. D. R. Bhuva and S. Kumar, "A novel continuous authentication method using biometrics for IOT devices," Internet of Things, vol. 24, no. 100927, p. 100927, 2023.

35. D. Bhuva and S. Kumar, "Securing space cognitive communication with blockchain," in 2023 IEEE Cognitive Communications for Aerospace Applications Workshop (CCAAW), 2023.

36. B. Naeem, B. Senapati, M. S. Islam Sudman, K. Bashir, and A. E. M. Ahmed, "Intelligent road management system for autonomous, non-autonomous, and VIP vehicles," World Electric Veh. J., vol. 14, no. 9, 2023.

37. M. Soomro et al., "Constructor development: Predicting object communication errors," in 2023 IEEE International Conference on Emerging Trends in Engineering, Sciences and Technology (ICES&T), 2023.

38. M. Soomro et al., "In MANET: An improved hybrid routing approach for disaster management," in 2023 IEEE International Conference on Emerging Trends in Engineering, Sciences and Technology (ICES&T), 2023.

39. Senapati and B. S. Rawal, "Adopting a deep learning split-protocol based predictive maintenance management system for industrial manufacturing operations," in Lecture Notes in Computer Science, Singapore: Springer Nature Singapore, 2023, pp. 22–39.

40. Senapati and B. S. Rawal, "Adopting a deep learning split-protocol based predictive maintenance management system for industrial manufacturing operations," in Big Data Intelligence and Computing. DataCom 2022, Lecture Notes in Computer Science, vol. 13864, C. H. Hsu, M. Xu, H. Cao, H. Baghban, and A. B. M. Shawkat Ali, Eds., Singapore: Springer, 2023, pp. 22–39.

41. M. Sabugaa, B. Senapati, Y. Kupriyanov, Y. Danilova, S. Irgasheva, and E. Potekhina, "Evaluation of the prognostic significance and accuracy of screening tests for alcohol dependence based on the results of building a multilayer perceptron," in Artificial Intelligence Application in Networks and Systems. CSOC 2023, Lecture Notes in Networks and Systems, vol. 724, R. Silhavy and P. Silhavy, Eds., Cham: Springer, 2023, pp. 373–384.

42. Senapati and B. S. Rawal, "Quantum communication with RLP quantum resistant cryptography in industrial manufacturing," Cyber Security and Applications, vol. 100019, 2023.

43. D. K. Sharma and R. Tripathi, "4 Intuitionistic fuzzy trigonometric distance and similarity measure and their properties," in Soft Computing, De Gruyter, 2020, pp. 53–66.

44. D. K. Sharma, B. Singh, M. Anam, R. Regin, D. Athikesavan, and M. Kalyan Chakravarthi, "Applications of two separate methods to deal with a small dataset and a high risk of generalization," in 2021 2nd International Conference on Smart Electronics and Communication (ICOSEC), 2021.

45. D. K. Sharma, B. Singh, M. Anam, K. O. Villalba-Condori, A. K. Gupta, and G. K. Ali, "Slotting learning rate in deep neural networks to build stronger models," in 2021 2nd International Conference on Smart Electronics and Communication (ICOSEC), 2021.

46. K. Kaliyaperumal, A. Rahim, D. K. Sharma, R. Regin, S. Vashisht, and K. Phasinam, "Rainfall prediction using deep mining strategy for detection," in 2021 2nd International Conference on Smart Electronics and Communication (ICOSEC), 2021.

47. I. Nallathambi, R. Ramar, D. A. Pustokhin, I. V. Pustokhina, D. K. Sharma, and S. Sengan, "Prediction of influencing atmospheric conditions for explosion Avoidance in fireworks manufacturing Industry-A network approach," Environ. Pollut., vol. 304, no. 119182, p. 119182, 2022.

48. H. Sharma and D. K. Sharma, "A Study of Trend Growth Rate of Confirmed Cases, Death Cases and Recovery Cases of Covid-19 in Union Territories of India," Turkish Journal of Computer and Mathematics Education, vol. 13, no. 2, pp. 569–582, 2022.

49. A. L. Karn et al., "Designing a Deep Learning-based financial decision support system for fintech to support corporate customer's credit extension," Malays. J. Comput. Sci., pp. 116–131, 2022.

50. A. L. Karn et al., "B-lstm-Nb based composite sequence Learning model for detecting fraudulent financial activities," Malays. J. Comput. Sci., pp. 30–49, 2022.

51. P. P. Dwivedi and D. K. Sharma, "Application of Shannon entropy and CoCoSo methods in selection of the most appropriate engineering sustainability components," Cleaner Materials, vol. 5, no. 100118, p. 100118, 2022.

52. A. Kumar, S. Singh, K. Srivastava, A. Sharma, and D. K. Sharma, "Performance and stability enhancement of mixed dimensional bilayer inverted perovskite (BA2PbI4/MAPbI3) solar cell using drift-diffusion model," Sustain. Chem. Pharm., vol. 29, no. 100807, p. 100807, 2022.

53. A. Kumar, S. Singh, M. K. A. Mohammed, and D. K. Sharma, "Accelerated innovation in developing high-performance metal halide perovskite solar cell using machine learning," Int. J. Mod. Phys. B, vol. 37, no. 07, 2023.

54. G. A. Ogunmola, M. E. Lourens, A. Chaudhary, V. Tripathi, F. Effendy, and D. K. Sharma, "A holistic and state of the art of understanding the linkages of smart-city healthcare technologies," in 2022 3rd International Conference on Smart Electronics and Communication (ICOSEC), 2022.

55. P. Sindhuja, A. Kousalya, N. R. R. Paul, B. Pant, P. Kumar, and D. K. Sharma, "A Novel Technique for Ensembled Learning based on Convolution Neural Network," in 2022 International Conference on Edge Computing and Applications (ICECAA), IEEE, 2022, pp. 1087–1091.

56. A. R. B. M. Saleh, S. Venkatasubramanian, N. R. R. Paul, F. I. Maulana, F. Effendy, and D. K. Sharma, "Real-time monitoring system in IoT for achieving sustainability in the agricultural field," in 2022 International Conference on Edge Computing and Applications (ICECAA), 2022.

57. Srinivasa, D. Baliga, N. Devi, D. Verma, P. P. Selvam, and D. K. Sharma, "Identifying lung nodules on MRR connected feature streams for tumor segmentation," in 2022 4th International Conference on Inventive Research in Computing Applications (ICIRCA), 2022.

58. C. Goswami, A. Das, K. I. Ogaili, V. K. Verma, V. Singh, and D. K. Sharma, "Device to device communication in 5G network using device-centric resource allocation algorithm,"

in 2022 4th International Conference on Inventive Research in Computing Applications (ICIRCA), 2022.

59. M. Yuvarasu, A. Balaram, S. Chandramohan, and D. K. Sharma, “A Performance Analysis of an Enhanced Graded Precision Localization Algorithm for Wireless Sensor Networks,” Cybernetics and Systems, pp. 1–16, 2023.
60. P. P. Dwivedi and D. K. Sharma, “Evaluation and ranking of battery electric vehicles by Shannon’s entropy and TOPSIS methods,” Math. Comput. Simul., vol. 212, pp. 457–474, 2023.
61. P. P. Dwivedi and D. K. Sharma, “Assessment of Appropriate Renewable Energy Resources for India using Entropy and WASPAS Techniques,” Renewable Energy Research and Applications, vol. 5, no. 1, pp. 51–61, 2024.
62. P. P. Dwivedi and D. K. Sharma, “Selection of combat aircraft by using Shannon entropy and VIKOR method,” Def. Sci. J., vol. 73, no. 4, pp. 411–419, 2023.
63. B. Senapati and B. S. Rawal, “Adopting a deep learning split-protocol based predictive maintenance management system for industrial manufacturing operations,” in Lecture Notes in Computer Science, Singapore: Springer Nature Singapore, 2023, pp. 22–39.
64. B. Senapati and B. S. Rawal, “Quantum communication with RLP quantum resistant cryptography in industrial manufacturing,” Cyber Security and Applications, vol. 1, no. 100019, p. 100019, 2023.
65. B. Senapati et al., “Wrist crack classification using deep learning and X-ray imaging,” in Proceedings of the Second International Conference on Advances in Computing Research (ACR’24), Cham: Springer Nature Switzerland, 2024, pp. 60–69.
66. A. B. Naeem et al., “Heart disease detection using feature extraction and artificial neural networks: A sensor-based approach,” IEEE Access, vol. 12, pp. 37349–37362, 2024.
67. R. Tsarev et al., “Automatic generation of an algebraic expression for a Boolean function in the basis ∧, ∨, ¬,” in Data Analytics in System Engineering, Cham: Springer International Publishing, 2024, pp. 128–136.
68. R. Tsarev, B. Senapati, S. H. Alshahrani, A. Mirzagitova, S. Irgasheva, and J. Ascencio, “Evaluating the effectiveness of flipped classrooms using linear regression,” in Data Analytics in System Engineering, Cham: Springer International Publishing, 2024, pp. 418–427.
69. E. Bayas, P. Kumar, and K. Deshmukh, "Review of process parameter’s effect on 3D printing," GIS Science Journal, vol. 10, no. 3, pp. 834–845, 1869.
70. E. Bayas, P. Kumar, and M. Harne, "Impact of process parameters on mechanical properties of FDM 3D-printed parts: A comprehensive review," European Chemical Bulletin, vol. 12, no. S5, pp. 708–725, 2023.
71. E. Bayas, P. Kumar, and K. Deshmukh, "A comprehensive review: Process parameters impact on tensile strength of 3D printed PLA parts," International Journal of Advanced Research in Science, Communication and Technology, vol. 3, no. 2, pp. 233–239, 2023.
72. E. Bayas, P. Kumar, "Impact of slicing software on geometric correctness for FDM additive manufacturing," International Development Planning Review, vol. 23, no. 1, pp. 704–711, 2024.
73. M. A. Yassin et al., “Advancing SDGs : Predicting Future Shifts in Saudi Arabia ’ s Terrestrial Water Storage Using Multi-Step-Ahead Machine Learning Based on GRACE Data,” 2024.

74. M. A. Yassin, A. G. Usman, S. I. Abba, D. U. Ozsahin, and I. H. Aljundi, “Intelligent learning algorithms integrated with feature engineering for sustainable groundwater salinization modelling: Eastern Province of Saudi Arabia,” Results Eng., vol. 20, p. 101434, 2023.

75. S. I. Abba, A. G. Usman, and S. IŞIK, “Simulation for response surface in the HPLC optimization method development using artificial intelligence models: A data-driven approach,” Chemom. Intell. Lab. Syst., vol. 201, no. April, 2020.

76. A. G. Usman et al., “Environmental modelling of CO concentration using AI-based approach supported with filters feature extraction: A direct and inverse chemometrics-based simulation,” Sustain. Chem. Environ., vol. 2, p. 100011, 2023.

77. A. Gbadamosi et al., “New-generation machine learning models as prediction tools for modeling interfacial tension of hydrogen-brine system,” Int. J. Hydrogen Energy, vol. 50, pp. 1326–1337, 2024.

78. I. Abdulazeez, S. I. Abba, J. Usman, A. G. Usman, and I. H. Aljundi, “Recovery of Brine Resources Through Crown-Passivated Graphene, Silicene, and Boron Nitride Nanosheets Based on Machine-Learning Structural Predictions,” ACS Appl. Nano Mater., 2023.

79. B. S. Alotaibi et al., “Sustainable Green Building Awareness: A Case Study of Kano Integrated with a Representative Comparison of Saudi Arabian Green Construction,” Buildings, vol. 13, no. 9, 2023.

80. S. I. Abba et al., “Integrated Modeling of Hybrid Nanofiltration/Reverse Osmosis Desalination Plant Using Deep Learning-Based Crow Search Optimization Algorithm,” Water (Switzerland), vol. 15, no. 19, 2023.

81. S. I. Abba, J. Usman, and I. Abdulazeez, “Enhancing Li + recovery in brine mining : integrating next-gen emotional AI and explainable ML to predict adsorption energy in crown ether-based hierarchical nanomaterials,” pp. 15129–15142, 2024.

82. J. Usman, S. I. Abba, N. Baig, N. Abu-Zahra, S. W. Hasan, and I. H. Aljundi, “Design and Machine Learning Prediction of In Situ Grown PDA-Stabilized MOF (UiO-66-NH2) Membrane for Low-Pressure Separation of Emulsified Oily Wastewater,” ACS Appl. Mater. Interfaces, Mar. 2024.

83. S. Reddy, S. Kalyani, N. S. Kumar, V. M. Boddu, and A. Krishnaiah, “Dehydration of 1,4-dioxane by pervaporation using crosslinked calcium alginate-chitosan blend membranes,” Polymer Bulletin, vol. 61, no. 6, pp. 779–790, Sep. 2008.

84. S. K. Sehrawat, "Transforming Clinical Trials: Harnessing the Power of Generative AI for Innovation and Efficiency," Transactions on Recent Developments in Health Sectors, vol. 6, no. 6, pp. 1-20, 2023.

85. S. K. Sehrawat, "Empowering the Patient Journey: The Role of Generative AI in Healthcare," International Journal of Sustainable Development Through AI, ML and IoT, vol. 2, no. 2, pp. 1-18, 2023.

86. S. K. Sehrawat, "The Role of Artificial Intelligence in ERP Automation: State-of-the-Art and Future Directions," Transactions on Latest Trends in Artificial Intelligence, vol. 4, no. 4, 2023.

87. P. P. Anand, U. K. Kanike, P. Paramasivan, S. S. Rajest, R. Regin, and S. S. Priscila, “Embracing Industry 5.0: Pioneering Next-Generation Technology for a Flourishing Human Experience and Societal Advancement,” FMDB Transactions on Sustainable Social Sciences Letters, vol.1, no. 1, pp. 43–55, 2023.

88. G. Gnanaguru, S. S. Priscila, M. Sakthivanitha, S. Radhakrishnan, S. S. Rajest, and S. Singh, “Thorough analysis of deep learning methods for diagnosis of COVID-19 CT

images," in Advances in Medical Technologies and Clinical Practice, IGI Global, pp. 46–65, 2024.

89. G. Gowthami and S. S. Priscila, "Tuna swarm optimisation-based feature selection and deep multimodal-sequential-hierarchical progressive network for network intrusion detection approach," Int. J. Crit. Comput.-based Syst., vol. 10, no. 4, pp. 355–374, 2023.
90. A. J. Obaid, S. Suman Rajest, S. Silvia Priscila, T. Shynu, and S. A. Ettyem, "Dense convolution neural network for lung cancer classification and staging of the diseases using NSCLC images," in Proceedings of Data Analytics and Management, Singapore; Singapore: Springer Nature, pp. 361–372, 2023.
91. S. S. Priscila and A. Jayanthiladevi, "A study on different hybrid deep learning approaches to forecast air pollution concentration of particulate matter," in 2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2023.
92. S. S. Priscila, S. S. Rajest, R. Regin, and T. Shynu, "Classification of Satellite Photographs Utilizing the K-Nearest Neighbor Algorithm," Central Asian Journal of Mathematical Theory and Computer Sciences, vol. 4, no. 6, pp. 53–71, 2023.
93. S. S. Priscila and S. S. Rajest, "An Improvised Virtual Queue Algorithm to Manipulate the Congestion in High-Speed Network"," Central Asian Journal of Medical and Natural Science, vol. 3, no. 6, pp. 343–360, 2022.
94. S. S. Priscila, S. S. Rajest, S. N. Tadiboina, R. Regin, and S. András, "Analysis of Machine Learning and Deep Learning Methods for Superstore Sales Prediction," FMDB Transactions on Sustainable Computer Letters, vol. 1, no. 1, pp. 1–11, 2023.
95. R. Regin, Shynu, S. R. George, M. Bhattacharya, D. Datta, and S. S. Priscila, "Development of predictive model of diabetic using supervised machine learning classification algorithm of ensemble voting," Int. J. Bioinform. Res. Appl., vol. 19, no. 3, 2023.
96. S. Silvia Priscila, S. Rajest, R. Regin, T. Shynu, and R. Steffi, "Classification of Satellite Photographs Utilizing the K-Nearest Neighbor Algorithm," Central Asian Journal of Mathematical Theory and Computer Sciences, vol. 4, no. 6, pp. 53–71, 2023.
97. S. S. Rajest, S. Silvia Priscila, R. Regin, T. Shynu, and R. Steffi, "Application of Machine Learning to the Process of Crop Selection Based on Land Dataset," International Journal on Orange Technologies, vol. 5, no. 6, pp. 91–112, 2023.
98. T. Shynu, A. J. Singh, B. Rajest, S. S. Regin, and R. Priscila, "Sustainable intelligent outbreak with self-directed learning system and feature extraction approach in technology," International Journal of Intelligent Engineering Informatics, vol. 10, no. 6, pp.484-503, 2022.
99. S. S. Priscila, D. Celin Pappa, M. S. Banu, E. S. Soji, A. T. A. Christus, and V. S. Kumar, "Technological frontier on hybrid deep learning paradigm for global air quality intelligence," in Cross-Industry AI Applications, IGI Global, pp. 144–162, 2024.
100. S. S. Priscila, E. S. Soji, N. Hossó, P. Paramasivan, and S. Suman Rajest, "Digital Realms and Mental Health: Examining the Influence of Online Learning Systems on Students," FMDB Transactions on Sustainable Techno Learning, vol. 1, no. 3, pp. 156–164, 2023.
101. S. R. S. Steffi, R. Rajest, T. Shynu, and S. S. Priscila, "Analysis of an Interview Based on Emotion Detection Using Convolutional Neural Networks," Central Asian Journal of Theoretical and Applied Science, vol. 4, no. 6, pp. 78–102, 2023.
102. S. D. Beedkar, C. N. Khobragade, S. S. Chobe, B. S. Dawane, and O. S. Yemul, "Novel thiazolo-pyrazolyl derivatives as xanthine oxidase inhibitors and free radical scavengers," International Journal of Biological Macromolecules, vol. 50, no. 4, pp. 947-956, 2012.

103. S. S. Chobe, V. A. Adole, K. P. Deshmukh, T. B. Pawar, and B. S. Jagdale, "Poly (ethylene glycol)(PEG-400): A green approach towards synthesis of novel pyrazolo [3, 4-d] pyrimidin-6-amines derivatives and their antimicrobial screening," Archives of Applied Science Research, vol. 6, no. 2, pp. 61-66, 2014.

104. S. S. Chobe, B. S. Dawane, K. M. Tumbi, P. P. Nandekar, and A. T. Sangamwar, "An ecofriendly synthesis and DNA binding interaction study of some pyrazolo [1, 5-a] pyrimidines derivatives," Bioorganic & Medicinal Chemistry Letters, vol. 22, no. 24, pp. 7566-7572, 2012.

105. S. S. Chobe, R. D. Kamble, S. D. Patil, A. P. Acharya, S. V. Hese, O. S. Yemul, and B. S. Dawane, "Green approach towards synthesis of substituted pyrazole-1, 4-dihydro, 9-oxa, 1, 2, 6, 8-tetrazacyclopentano [b] naphthalene-5-one derivatives as antimycobacterial agents," Medicinal Chemistry Research, vol. 22, pp. 5197-5203, 2013.

106. B. S. Dawane, S. G. Konda, N. T. Khandare, S. S. Chobe, B. M. Shaikh, R. G. Bodade, and V. D. Joshi, "Synthesis and antimicrobial evaluation of 2-(2-butyl-4-chloro-1H-imidazol-5-yl-methylene)-substituted-benzofuran-3-ones," Organic Communications, vol. 3, no. 2, pp. 22, 2010.

107. B. S. Dawane, S. G. Konda, B. M. Shaikh, S. S. Chobe, N. T. Khandare, V. T. Kamble, and R. B. Bhosale, "Synthesis and in vitro antimicrobial activity of some new 1-thiazolyl-2-pyrazoline derivatives," Synthesis, vol. 1, no. 009, 2010.

108. B. S. Dawane, B. M. Shaikh, N. T. Khandare, V. T. Kamble, S. S. Chobe, and S. G. Konda, "Eco-friendly polyethylene glycol-400: a rapid and efficient recyclable reaction medium for the synthesis of thiazole derivatives," Green Chemistry Letters and Reviews, vol. 3, no. 3, pp. 205-208, 2010.

109. M. Haroun, S. S. Chobe, R. R. Alavala, S. M. Mathure, R. N. Jamullamudi, C. K. Nerkar, and M. K. Anwer, "1, 5-benzothiazepine derivatives: green synthesis, in silico and in vitro evaluation as anticancer agents," Molecules, vol. 27, no. 12, pp. 3757, 2022.

110. S. A. Shaikh, S. R. Labhade, R. R. Kale, P. Y. Pachorkar, R. J. Meshram, K. S. Jain, and D. R. Boraste, "Thiadiazole-Thiazole Derivatives as Potent Anti-Tubercular Agents: Synthesis, Biological Evaluation, and In Silico Docking Studies," European Journal of Medicinal Chemistry Reports, vol. 100183, 2024.

111. S. A. Shaikh, S. R. Labhade, R. R. Kale, P. Y. Pachorkar, R. J. Meshram, K. S. Jain, and S. N. Wakchaure, "Synthesis, Biological and Molecular Docking Studies of Thiazole-Thiadiazole derivatives as potential Anti-Tuberculosis Agents," Chemistry & Biodiversity, vol. 21, no. 6, e202400496, 2024.

112. Agussalim, Rusli, A. Rasjid, M. Nur, T. Erawan, Iwan, and Zaenab, "Caffeine in student learning activities," J. Drug Alcohol Res., vol. 12, no. 9, Ashdin Publishing, 2023.

113. Agussalim, S. N. Fajriah, A. Adam, M. Asikin, T. Podding, and Zaenab, "Stimulant drink of the long driver lorry in Sulawesi Island, Indonesia," J. Drug Alcohol Res., vol. 13, no. 3, Ashdin Publishing, 2024.

114. N. J. Hussein, F. Hu, and H. Hu, “IR and multi scale Retinex image enhancement for concealed weapon detection,” Indonesian Journal of Electrical Engineering and Computer Science, vol. 1, no. 2, pp. 399–405, 2016.

115. N. J. Hussein and F. Hu, “An alternative method to discover concealed weapon detection using critical fusion image of color image and infrared image,” in 2016 1st IEEE International Conference on Computer Communication and the Internet (ICCCI), 2016, pp. 378–383.

116. N. J. Hussein, F. Hu, and F. He, “Multisensor of thermal and visual images to detect concealed weapon using harmony search image fusion approach,” Pattern Recognition Letters, vol. 94, pp. 219–227, 2017.

117. P. P. Chauhan, D. Y. Patel, and S. K. Shah, "Optimization of Stability Indicating RP-HPLC method for The Estimation of an Antidepressant Agents Alprazolam and Imipramine in Pure & Pharmaceutical Dosage Form," Eurasian Journal of Analytical Chemistry, vol. 11, no. 2, pp. 101-113, 2016.

118. R. Parmar, N. Kalal, J. Patel, and P. Chauhan, "Fabrication of Eucalyptus Oil-loaded Ciprofloxacin Hydrochloride Topical Films for Enhanced Treatment of Post-Operative Wound Infection," Anti-Infective Agents, vol. 22, no. 1, pp. 66-76, 2024.

119. P. Chauhan, R. Parmar, and A. Tripathi, "Development and validation of a stability indicating LC method for the analysis of chlordiazepoxide and trifluoperazine hydrochloride in the presence of their degradation products," ACTA Pharmaceutica Sciencia, vol. 62, no. 2, pp. 312-332, 2024.

120. R. Parmar, M. M. Salman, and P. Chauhan, "Fabrication of Cefixime Nanoparticles Loaded Films and their Ex Vivo Antimicrobial Effect on Periodontitis Patient’s Saliva," Pharmaceutical Nanotechnology, vol. 9, no. 5, pp. 361-371, 2021.

121. R. Parmar, P. Chauhan, J. Chavda, and S. Shah, "Local Delivery of Chitosan Strips Carrying Ornidazole-Loaded Ethyl Cellulose Micro-Particles for the Enhanced Treatment of Periodontitis," Journal of Chemical and Pharmaceutical Research, vol. 9, no. 6, pp. 193-201, 2017.

122. R. Parmar, P. Chauhan, J. Chavda, and S. Shah, "Formulation and evaluation of cefixime strips for chronic periodontal treatment," Asian Journal of Pharmaceutics (AJP), vol. 10, no. 4, 2016.

123. P. Chauhan, F. Tandel, and R. Parmar, "A Simplex-Optimized Chromatographic Separation of Phytoconstituents in Cardioprotective Polyherbal Formulation and Crude Drugs," Asian Journal of Pharmaceutics, vol. 15, no. 4, pp. 441-447, 2021.

124. R. Parmar and P. Chauhan, "Potentiating Antibacterial Effect of Locally Deliver Caffeine Nanoparticles on Systemically Used Antibiotics in Periodontal Treatments," Asian Journal of Pharmaceutics, vol. 14, no. 2, pp. 229-235, 2020.

125. P. Chauhan, K. Bhanushali, and R. Parmar, "Design of Experiment-Driven Stability Indicating RP-HPLC Method for Simultaneous Estimation of Tetracaine Hydrochloride and Oxymetazoline Hydrochloride," Bulletin of Environment, Pharmacology and Life Sciences, vol. 22, no. 1, pp. 181-196, 2023.

126. H. D. Gelani, P. P. Chauhan, and S. K. Shah, "Practical Implication of Chromatographic Method for Estimation of Aceclofenac and Pregabalin in Bulk and Pharmaceutical Dosage Forms," Chromatography Research International, vol. 2014, no. 1, pp. 643027, 2014.

127. N. J. Hussein, S. R. Saeed, and A. S. Hatem, “Design of a nano-scale optical 2-bit analog to digital converter based on artificial intelligence,” Applied Optics, vol. 63, no. 19, pp. 5045–5052, 2024.

128. N. J. Hussein, H. A. Abdulameer, and R. H. Al-Taie, “Deep learning and histogram gradient algorithm to detect visual information based on artificial intelligence,” in Proceedings of the ACM International Conference, 2024, pp. 577–581.

129. N. J. Hussein and S. K. Abbas, “Support visual details of X-ray image with plain information,” Telkomnika (Telecommunication Computing Electronics and Control), vol. 19, no. 6, pp. 1975–1981, 2021.

130. N. J. Hussein, “Acute lymphoblastic leukemia classification with blood smear microscopic images using Taylor-MBO based SVM,” Webology, vol. 18, pp. 357–366, 2021.

131. N. J. Hussein, “Robust iris recognition framework using computer vision algorithms,” in 4th International Conference on Smart Grid and Smart Cities (ICSGSC), 2020, pp. 101–108.

132. Y. J. K. Nukhailawi and N. J. Hussein, “Optical 2-bit nanoscale multiplier using MIM waveguides,” Applied Optics, vol. 63, no. 3, pp. 714–720, 2024.

133. Salah and N. J. Hussein, “Recognize facial emotion using landmark technique in deep learning,” in International Conference on Engineering, Science and Advanced Technology (ICESAT), 2023, pp. 198–203.