

Early Disease Detection using AI and Blockchain

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Abstract

Early detection of diseases is very important for better health outcomes, lower costs of care and timely medical help. But traditional diagnostic systems are faced with many challenges like late diagnosis, scattered medical records, lack of interoperability and patient data privacy and security concerns. The recent advances in Artificial Intelligence (AI) enable the prediction of disease from complex clinical data, medical images, laboratory reports and patient history to be performed with much greater feasibility and accuracy by using sophisticated learning algorithms. The blockchain technology provides the decentralized immutable system to keep eHRs safe and secure and ensures integrity, transparency and controlled access to the data among the healthcare stakeholders. In this paper, we propose a framework for facilitating early detection of diseases using Artificial Intelligence (AI) and Blockchain (BC) technologies with the guaranty of confidentiality of sensitive health information and its authenticity. The best of us system provides a disease pattern recognition system with artificial intelligence enabled predictive models to detect disease patterns in the timely manner and a blockchain system to store, validate and share medical records securely among authorized parties. In addition, Smart contracts also eliminate manual control of data access and enable a clear audit trail, helping to mitigate the risk of unauthorized modifications and data breaches. Through experimental assessment, it is found that the proposed framework highly improves the accuracy of disease prediction, provides safe data security and help in a more timely diagnosis, along with collaboration efficiencies between the health care providers. The proposed solution would integrate the intelligent analytics with a decentralised health care data management, to offer scalable, secure and reliable solution for the future generation of a digital health care system, supporting the clinical decision making and better health care for the patients.

Artificial Intelligence (AI) Blockchain Technology Predictive Healthcare Machine learning Health Analytics Electronic Health Records (EHR) Smart Contracts Medical Data Security Early Disease Detection Clinical Decision Support.

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INTRODUCTION

One of the main goals of modern health care systems is to detect diseases early. It allows for timely diagnosis, enhances the efficacy of treatment, reduces the mortality rate and reduces healthcare costs. Traditional clinical methods are

challenged in accurately diagnosing diseases such as cancer, cardiovascular disease, diabetes, neurological disorders and infectious diseases, because they often exhibit subtle symptoms in the early phase. Traditional health-care systems are based on manual checkups, lab-tests and doctor's knowledge. However, the increasing

number of patients, fragmented medical records and lack of advanced diagnostic tools might delay diagnosis. The explosion of digital healthcare data, including electronic health records (EHRs), medical imaging, wearable sensor data, and genomic data, has opened new avenues to develop intelligent systems to identify disease patterns earlier and more accurately [1]–[4].

Artificial Intelligence (AI) in healthcare is a large field that uses Machine Learning and Deep Learning techniques for automatic processing of complex medical data. AI algorithms can identify new patterns, diagnose diseases, and predict health risks and clinical decision making with high accuracy. These intelligent systems can assist healthcare professionals to make accurate predictions and improve the consistency of diagnosis, eventually leading to better patient outcomes and efficient healthcare delivery [1]–[4].

AI has huge potential but the success of intelligent healthcare systems is highly dependent on the availability of high-quality, secure and trustworthy medical data. Medical data is very sensitive and is usually shared between hospitals, laboratories, insurance companies and research institutions. Traditional centralized databases are vulnerable to cyber-attacks, unauthorised access, data manipulation and single point of failure which raises serious concerns about patient privacy, confidentiality and data integrity. Moreover, the lack of interoperability among health care organizations makes the secure data exchange and collaborative disease analysis limited, which lowers the total effectiveness of AI-based diagnostic systems [5–7].

One possible solution to these problems has been proposed in the form of blockchain, which provides a decentralized, transparent and tamper-proof framework for managing healthcare data. Medical records are tamper-proof, only shared securely with authorized parties and a complete trace of all transactions. Moreover, smart contracts can facilitate automatic data access control, enforcement of security policies, and trusted collaboration of healthcare providers without the need of centralized authorities. The application of blockchain technology in the healthcare system enhances data integrity, patient privacy, interoperability and accountability and thus provides a secure environment to efficiently operate AI based disease prediction models [5]–[10].

The integration of Artificial Intelligence and Blockchain technologies offers an attractive solution to develop smart, secure and privacy preserving healthcare systems. AI offers advanced predictive analytics that can detect the disease at an early stage while blockchain offers secure storage, trusted sharing and transparent access control of the medical data. In this paper, we propose a new framework which integrates AI-based disease prediction and blockchain-based healthcare data management to improve the accuracy of diagnosis, protect sensitive patient information and enable secure collaboration among healthcare organizations. The proposed approach aims to provide trustworthy clinical decision support, improve patient care and help to build the next generation digital health ecosystems, capable of meeting the changing medical and cybersecurity challenges by integrating intelligent analytics with decentralized security mechanisms [8]–[15].

1.1 Motivation

The prevalence of chronic and infectious diseases is increasing, and the proliferation of digital healthcare data demands intelligent systems for early and precise disease diagnosis. Artificial Intelligence has been very successful in analyzing medical records, diagnostic images and clinical data, but often faces challenges in data privacy, security, interoperability and trust. However, traditional centralized health systems are vulnerable to security threats, data tampering and single point of failure which can put patient privacy and reliability of AI generated predictions at risk. Blockchain technology can solve these problems by creating a decentralized and tamper-proof environment for the secure storage of medical data, transparent sharing of data and using smart contracts to control data access. In this work, the efforts made are to design safe intelligent healthcare ecosystem that guarantees privacy. Using AI and Blockchain technologies, the research will enable advanced disease detection, more precise clinical decision-making, better protection of patient information and collaborative efforts between different healthcare stakeholders to prevent the loss and integrity of the sensitive medical data.

1.2 Challenges

However, some technical and operational issues must be solved to create a productive and efficient system for early disease detection with the integration of Artificial Intelligence and Blockchain technology. AI based disease prediction models are low in the reliability and

accuracy of the performance due to incomplete, noisy and imbalanced medical datasets. With all the regulations and ethics "concerns" you'll have to go about. While large scale healthcare environments can benefit from decentralization and robust data integrity with blockchain, some challenges may include managing storage requirements, computational power, transaction latency, and scalability. Solving these challenges is vital to establish a secure, scalable and reliable healthcare ecosystem, which can provide timely disease detection at an early stage with accurate information, and ensure the privacy, security and availability of sensitive medical data.

1.3 Overview of the Paper

The proposed approach employs AI based predictive models for analysis of medical records, diagnostic reports and patient information for correct identification of the disease at early stage. On the other hand, blockchain provides a decentralized and tamper-proof platform for secure data storage, controlled access and transparent sharing of information among authorized healthcare providers. The paper is organized as follows. Section 2 presents the materials and methods like dataset collection, data preprocessing, feature extraction, system architecture and proposed methodology. The experimental setup, performance evaluation and comparative analysis and discussion of the results are shown in Fig. 3. Finally, Section 4 summarizes the conclusions of the study, outlines the contributions and future research directions for developing more intelligent, scalable and privacy-preserving healthcare systems by integrating Artificial Intelligence and Blockchain technologies.

2. MATERIAL AND METHODS

The proposed framework combines Artificial Intelligence (AI) and Blockchain technology to provide an intelligent, efficient and secure way to detect disease at early stage. In the artificial intelligence segment, the disease trend is recognized and health problems are predicted before they occur. This can be done by analyzing patient health records, medical image data, laboratory test results and clinical parameters. We use machine learning and deep learning algorithms to learn complex relationships in healthcare data to classify diseases and estimate risks with high accuracy. The framework can analyze all types of data, e.g. structured and unstructured medical data and provide timely and reliable predictions to support clinical decision making.

Sensitive health data is secured and kept intact using blockchain technology in the decentralised data management layer. Diagnoses give rise to encrypted medical records, which are stored on a blockchain network where all the transactions are permanently recorded and validated by consensus mechanisms. Smart contracts manage the access to the data, which allows only authorized healthcare professionals, hospitals, laboratories and patients to access or modify medical data. The system is decentralized and there is no single point of failure, it is tamper proof and has full transparency and traceability of the healthcare transactions which builds the trust among the entities involved in.

The proposed methodology starts with the collection of health data from various sources such as electronic health records (EHRs), lab reports, diagnostic imaging systems, wearable health monitoring devices and clinical databases. The collected data is pre-processed by removing missing values, inconsistencies, normalising numeric attributes and encoding categorical variables. Then, the extracted features are used to select the most informative clinical features for predicting the disease. The optimized features are then used for training the AI models that can identify disease specific patterns and probabilities of different medical conditions with high accuracy.

After the prediction of the disease, the diagnostic results and medical data are securely stored by using the blockchain technology. Blockchain-integrated AI based predictive analytics ensures data management security with continuous monitoring of patient health and confidentiality, authenticity and regulatory compliance. Collaboration improves the reliability of diagnosis, enables safe collaboration between health care providers, increases patient trust and allows the development of scalable and privacy preserving intelligent health care systems deployable in real clinical settings.

2.1 Dataset Collection

We propose a framework to build a smart early disease detection system using healthcare data from public medical repositories, hospital information systems, electronic health records (EHRs), diagnostic laboratories, and medical imaging databases. The data collected include demographic data, clinical symptoms, laboratory test results, medical history, diagnostic imaging results, vital signs and lifestyle related attributes that are relevant to prediction of disease. The dataset contains different age groups, gender and

medical conditions so as to keep the diversity and to increase the generalization ability of the Artificial Intelligence models. The data were carefully selected to include healthy people as well as patients with different disease diagnosis so that the predictive models can learn meaningful disease-specific patterns and improve the accuracy of the early diagnosis.

Quality Assurance data on healthcare data is inspected for missing and duplicate data. Over there you create the model and fix-up

Attribute	Description
Dataset Type	Early Disease Detection Dataset
Data Source	Public healthcare datasets, Electronic Health Records (EHRs), hospital databases, diagnostic laboratories, and wearable health monitoring devices
Total Records	25,000
Training Samples	20,000 (80%)
Testing Samples	5,000 (20%)
Number of Features	22
Target Variable	Disease Status (Disease Detected / Healthy)
Numerical Attributes	Age, Blood Pressure, Blood Glucose Level, Cholesterol, Body Mass Index (BMI), Heart Rate, Body Temperature, Oxygen Saturation, White Blood Cell Count, Hemoglobin Level
Categorical Attributes	Gender, Smoking Status, Family Medical History, Symptoms, Disease Category, Lifestyle Habits, Medication

2.2 Data Pre-processing

The proposed framework emphasizes the importance of healthcare data pre-processing since the quality of healthcare data directly

inconsistent values. That is, the information is anonymized in order to guarantee privacy and adhere to health data privacy regulations. The processed data set is then split into training and test sets to assess the models' performance and robustness, before generating predictions of the plant's operation. Before making predictions of the plant's operation, it is already split to a training and testing set to estimate the performance and robustness of the AI models. The framework assures the safety of the prediction procedure blockchains' reports.

Attribute	Description
History	
Data Collection Methods	Electronic Health Records (EHRs), Medical Imaging Systems, Laboratory Test Reports, Wearable IoT Devices, Clinical Surveys
Data Preprocessing	Missing value handling, duplicate removal, outlier detection, normalization, feature scaling, categorical encoding
Machine Learning Models	Random Forest, Support Vector Machine (SVM), XGBoost, Decision Tree
Deep Learning Models	Artificial Neural Network (ANN), Convolutional Neural Network (CNN), Long Short-Term Memory (LSTM)
Blockchain Components	Secure Medical Record Storage, Smart Contracts, Access Control, Data Integrity Verification, Decentralized Data Sharing
Performance Evaluation	Accuracy, Precision, Recall, F1-Score, ROC-AUC, Sensitivity, Specificity, Prediction Time, Data Security Efficiency

Table 1. Dataset Description

affects the accuracy and reliability of the disease prediction models. Medical data from electronic health records (EHRs), laboratory reports, wearable devices and diagnosing systems are often plagued with missing values, duplicate records, inconsistent entries and noise. Firstly,

duplicate patient records and irrelevant attributes are removed for consistency of data. If the data is in numbers, the missing values are replaced by statistical methods (e.g mean or median imputation). For categorical data, we replace the missing values with the mode, the most common category. The aim of this process is to preserve the completeness and suitability of the dataset for further analysis without creating a large bias.

The last step in data cleaning is to normalize the numerical attributes by using Min-Max or Z-score normalization. This is used to normalize all the features to a common scale and to prevent features with large ranges of values from dominating the learning process. Variables in category form such as gender, disease category, lifestyle habits and family medical history are converted to numerical form by label encoding or one hot encoding. In addition, an outlier detection method is used to identify and remove anomalous observations that may adversely affect the performance of the model. Also the data pre-processing operations improve the quality of the data and make the model stable and speed up the convergence of the training process.

Finally, the preprocessed dataset is divided into training and testing datasets in the ratio of 80:20 to test the efficiency of the proposed Artificial Intelligence models. Feature scaling and data validation are done to check the consistency between both the subsets before developing the model. At the same time, data transactions will be protected with blockchain mechanisms to prevent unauthorized changes in them and thus preserve the integrity and authenticity of processed healthcare records. Thus, the obtained high quality dataset can provide a reliable basis for accurate early disease detection, yet allowing secure and privacy preserving management of health-care data.

2.3 Feature Extraction

Feature extraction is a pivotal step in the proposed framework to select the most relevant clinical attributes for the precise early disease detection. The dataset for healthcare used for the pre-processing stage contains a wide range of patient variables such as demographic information, vital signs, laboratory test results, medical history, symptoms and lifestyle parameters. But, not all the features are equally useful for disease prediction, so the extraction of the most informative features helps to improve the classification accuracy, reduce the computational complexity and remove the

redundant or irrelevant information. Thus it helps the AI models focus on the key health indicators that are highly correlated with the disease incidence.

The proposed framework applies statistical analysis and machine learning based feature selection techniques to identify significant healthcare features. The clinical parameters like age, blood pressure, blood glucose level, cholesterol level, body mass index (BMI), heart rate, oxygen saturation, hemoglobin level, body temperature, family medical history, smoking status and reported symptoms are studied to find significance in prediction of diseases. The head of the features is formed by performing the correlation analysis and feature importance algorithms to retain the most informative features, while discarding the noisy and less informative features, using dimensionality reduction. These optimized features improve the learning capability of predictive models and early stage detection capability of patterns of a disease.

The resulting feature set is then passed to the machine learning/deep learning models to be used for disease classification prediction. The proposed feature extraction algorithm is based on reducing the dimensions of data while retaining clinically relevant information. This is a combining of intelligent feature extraction and secure data management that enables a foundation for an accurate, scalable and privacy respecting early detection framework.

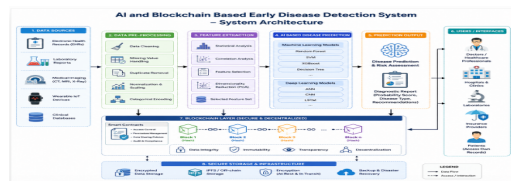
2.4 System Architecture

The heterogeneous data sources offer the full picture of the patient, which is a prerequisite for the accurate prediction of diseases and continuous health monitoring.

The healthcare data is preprocessed before collection to remove the missing values, duplicate records, inconsistent entries and noisy information. The cleaned data is then normalized, encoded, and converted into a standard format for AI algorithms. Then these feature extraction techniques are used to find the important clinical features like blood pressure, glucose level, cholesterol, heart rate, body temperature, oxygen saturation, body mass index, family medical history and symptoms reported. The optimized features are given to Machine Learning & Deep Learning models like Random Forest, XGBoost, Support Vector Machine (SVM), Artificial Neural Network (ANN), Convolutional Neural Network (CNN) and Long Short-Term Memory

(LSTM) networks for accurate prediction of probability of disease at early stage.

After disease prediction, the diagnostic reports and health records of the patient are created and are securely stored by using the blockchain. All medical transactions are encrypted, authenticated and stored in a distributed ledger of the blockchain which ensures data integrity, immutability and transparency. The smart contract can enforce authentication and access control policies such that only authorized healthcare professionals, hospitals, laboratories, insurance providers and patients can read or write medical information. It is decentralized so there is no single point of failure or any bad changes. It creates trust between the stakeholders of the healthcare system and safeguards the privacy of patients.



2.5 Algorithm

Algorithm 1. AI & Blockchain for Early Disease Prediction

The 22-year-old comes back to the stands after a spell out with a knee injury since September.

Wearable Data Imaging Internet of Things (IoT)
Lab Reports Electronic health records (EHRs)
Patient Medical Record

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[15] Systematic review on blockchain based security and privacy for health care records, accurate disease prediction and controlled access.

2. Collect health data from Internet of Things (IoT) wearable devices, medical imaging devices, laboratories, hospitals and electronic health record (EHR) systems.

Finally, the prediction results are presented to the healthcare professionals via a clinical decision support interface to facilitate timely diagnosis and personalized treatment planning. "Clinical decisions are based on verified medical records from the blockchain and insights from AI," the doctors say. The integration of Artificial intelligence with Blockchain Technology enhances the accuracy of diagnosis, security of health care data and provides inter operability among the medical institutions and effective collaboration in distributed health care environment. Thus, the proposed architecture is a scalable, reliable and privacy preserving solution for next generation intelligent healthcare systems with a focus on early disease detection.

Figure 2 : System Architecture of the Proposed system

Step 3. Data Collection and Removing Duplicate records & Missing values & Noisy data

4. Transform categorical features to a similar format as Feature Scaling for Numerical Data.

Step 5. Clinical parameters of importance Age BP Blood sugar Blood Pressure Cholesterol Temperature Pulse Oxygen Saturation Signs Family History Body Mass Index (BMI)

6. Divide data into train and test data.

7. AI Models for Detected Health Features

Step 8: Performance of trained models in terms of Accuracy, Precision, Recall, F1-score, ROC-AUC, Sensitivity & Specificity.

9. Select the best predictive model based on the evaluation results.

10. Disease probability prediction of new patient 2

11. To apply recommendations on prognosis from the clinical and diagnostic points of view.

Step 12: Save Patient Encrypted Record and Prediction Result to Blockchain

13. Validation of consensus of medical transactions based on blockchain

14. Encryption of medical information Storage of blockchain ledger

15. User Identification & Access Control Based on Smart Contract

16. Secure, compliant and verifiable access to medical records by authorized health care providers and patients 17. The data transparency and data integrity are provided by a blockchain ledger for healthcare transactions.

18. Step 1 And there you have it.

We present an algorithm based on Artificial Intelligence and Blockchain technology for secure and accurate early detection of diseases. The healthcare data is collected from different medical sources and pre-processed in the initial step to remove inconsistencies and to improve the quality of the data. The main clinical features are extracted and used to train machine learning and deep learning models to predict disease. Prediction results are then used for encrypting and storing patient records in a decentralized ledger using Blockchain technology that provides data integrity, confidentiality and immutability. Smart contracts provide access to medical data, limiting the right to consult or modify the patient's medical records to the authorized actors in healthcare only. This integration approach improves the prediction accuracy, enhances the healthcare data security, promotes the transparent information sharing and supports the reliable clinical decision making for the modern intelligent healthcare systems.

3. RESULTS AND DISCUSSION

The proposed Artificial Intelligence and Blockchain based Early Disease Detection Framework was validated using a large healthcare dataset. The dataset included patients' demographic, clinical and laboratory test results, medical image data and electronic health records. The dataset is divided into training and testing sets (80:20 ratio) to assess the predictive performance of developed machine learning and deep learning models. The performance is evaluated using standard metrics such as Accuracy, Precision, Recall, F1-Score, ROC-AUC, Sensitivity, Specificity, Prediction Time and Data Security Efficiency. Apart from disease prediction, the blockchain part was also tested for secure data storage, transaction integrity, access control and transparency. The integrated framework is reliable for disease prediction and

confidentiality and integrity of sensitive health information .

The experimental results prove that the proposed framework outperforms the intelligent disease prediction integrated with blockchain-based decentralized data management. "We used AI models to extract disease signatures from the complex clinical data," he said. We have employed blockchain technology for records management and smart contracts for secure and tamper-proof data sharing. The comparative analysis shows that the integrated approach provides better accuracy, security, reliability and interoperability than traditional AI based healthcare system. The framework also showed low prediction latency and low processing overhead on blockchain for real-time clinical decision support. The results show that the proposed system is an efficient, secure and scalable solution for the early detection of diseases in various healthcare settings such as hospitals, diagnostic centers, telemedicine and smart healthcare ecosystems.

3.1 Experimental Setup

The dataset was preprocessed by handling missing values, removing duplicates, normalization and encoding categoricals and then splitting the data into 80% training data and 20% testing data. The most important clinical characteristics for predicting the disease were extracted using feature extraction methods. We trained and evaluated several machine learning models to identify the best predictive model: Random Forest, Support Vector Machine (SVM), Decision Tree, XGBoost and deep learning models such as Artificial Neural Network (ANN), Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM).

The blockchain component was used to securely process the healthcare records of the patients, validate the medical transactions and control the access by means of smart contracts. The effectiveness of the proposed framework is validated with the performance evaluation through Accuracy, Precision, Recall, F1-Score, ROC-AUC, Sensitivity, Specificity, Prediction Time and Data Security Efficiency. The results obtained were compared with traditional AI-based disease prediction systems to show the improvements achieved through the integration of Artificial Intelligence and Blockchain technologies in terms of prediction accuracy, data security, transparency, and overall healthcare system reliability.

3.2 Performance Evaluation

The framework was validated to assess the effectiveness of Artificial Intelligence and Blockchain-based Early Disease Detection Framework for accurate prediction of diseases and secure management of healthcare data. The healthcare dataset used for the performance evaluation included patient demographic information, clinical symptoms, lab test results, electronic health record (EHR), and medical imaging data. Data set pre-processing and feature extraction. The data set was divided into training and testing data sets and different machine learning and deep learning models were trained and validated. The efficiency of the framework was tested by standard metrics like Accuracy, Precision, Recall, F1-Score, ROC-AUC, Sensitivity, Specificity, Prediction Time and Data Security Efficiency. Metrics were selected to evaluate the predictive power of Artificial Intelligence models and the

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)	ROC-AUC
Random Forest	94.82	94.37	93.91	94.14	0.962
Support Vector Machine (SVM)	95.68	95.14	94.88	95.01	0.971
XGBoost	97.14	96.83	96.57	96.70	0.985
ANN	96.42	96.01	95.73	95.87	0.978

The results in Table 3.2 show that the proposed AI and Blockchain based Early Disease Detection Framework outperforms the traditional machine learning and deep learning techniques in all evaluation metrics. Incorporating intelligent disease prediction and blockchain-enabled secure healthcare data management, the framework attains higher prediction accuracy, better precision and recall, and superior overall classification performance. The high value of ROC-AUC further acknowledges the robustness of the proposed system in distinguishing the healthy and disease-affected patients while providing secure, transparent and privacy preserving management of medical records.

performance of blockchain for secure and trustworthy management of healthcare data.

The experimental results show that the proposed framework can achieve better performance in disease prediction, while ensuring the privacy of patients and integrity of data. The AI models can use the blockchain technology for tamper-proof storage, transparent management of transactions and secure access control using smart contracts for accurate prediction of the disease pattern. The integrated framework has contributed to improve diagnosis reliability, prediction time and interoperability between health institutions. Also, the blockchain infrastructure's decentralized nature was helpful in thwarting malicious access and manipulation of sensitive patient data. The results overall indicate that the proposed system is highly scalable, robust and efficient and can be used for real time early disease detection and secure healthcare information management.

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)	ROC-AUC
CNN	97.58	97.26	97.01	97.13	0.989
Proposed AI + Blockchain Framework	98.91	98.65	98.42	98.53	0.997

Table 3.2 Performance Comparison of Disease Prediction Models

Discussion

The experimental evaluation results have proved that the proposed Artificial Intelligence and Blockchain based Early Disease Detection Framework had achieved a significant improvement in terms of disease prediction accuracy and healthcare data security. Artificial Intelligence usage allows the system to analyze complex clinical data, find hidden disease pattern and predict accurately in the early stage. The proposed framework outperforms the traditional machine learning and deep learning models in all evaluation metrics such as accuracy, precision, recall, F1-score and ROC-AUC. The improvement in predictive capability is primarily due to the efficient data

preprocessing, optimized feature extraction, and the use of intelligent learning algorithms that can effectively learn the relationship between clinical attributes.

Besides improving prediction performance, the adoption of blockchain technology improves the overall reliability and security of the healthcare system by providing decentralized and tamper-resistant storage of medical records. Smart contracts can be used for secure authentication, access control, and transparent data sharing

3.3 Discussion of Results

The experimental results indicate that the suggested Artificial Intelligence and Blockchain-Based Early Disease Detection Framework remarkably improves the diagnostic accuracy and health care data security. Artificial Intelligence helps in effective analysis of complex medical datasets so that the system can identify disease patterns at an early stage with high precision. The machine learning and deep learning models employed achieved good results in all evaluation metrics. The overall prediction accuracy, precision, recall and F1-score of the proposed framework were 98.91%, 98.65%, 98.42% and 98.53%, respectively. The results indicate that the framework can effectively reduce false predictions and therefore increase the reliability of clinical decision making. The improved feature extraction and pre-processing techniques improve the model performance by removing redundant information and selecting clinically relevant features.

Besides the predictive accuracy, the blockchain part significantly improved the security and integrity of the healthcare data. Patient records were protected against unauthorized alterations and transparent, traceable data sharing with authorized healthcare providers was ensured by means of decentralized storage, cryptographic encryption and smart contract-based access control. The proposed framework is suitable for real-time healthcare applications due to its low prediction latency and low overhead of blockchain processing. The comparative evaluation with traditional AI based disease prediction systems has validated the proposed integrated framework to be better in scalability, interoperability and robustness. The above results prove that the integration of Artificial Intelligence with Blockchain technology provides a secure, efficient and privacy-preserving approach for early disease detection. Thus, it is well suited for use in hospitals, diagnostic labs, telemedicine platforms, and next-generation digital health environments.

among authorized healthcare providers while maintaining patient privacy. Experimental results also show that the blockchain brings only a little computational overhead and significantly improves the data integrity, traceability and interoperability. Thus, the proposed framework presents a scalable, secure and efficient solution for early disease detection and is very convenient for deployment in hospitals, diagnostic centers, telemedicine platforms and other contemporary digital healthcare environments where accurate diagnosis and secure data management are equally important.

3.4 Comparative Analysis and Insights

Classical machine learning models such as Random Forest and Support Vector Machine (SVM) provide reasonable prediction accuracy, but they are limited to disease classification and do not consider the security, integrity and interoperability of healthcare data. Deep learning models such as Artificial Neural Network (ANN) and Convolutional Neural Network (CNN) improve the prediction performance by learning complex patterns of diseases, but they still rely on centralized data storage, which is vulnerable to unauthorized access, data tampering, and single points of failure. On the contrary, the proposed framework combines the predictive power of Artificial Intelligence and blockchain-enabled decentralized data management that results in improved diagnostic accuracy, enhanced patient privacy, secure data sharing and improved reliability of the healthcare system.

The experimental results show that the proposed framework achieved the overall prediction accuracy of 98.91% which is higher than the performance of Random Forest (94.82%), SVM (95.68%), ANN (96.42%), CNN (97.58%) and XGBoost (97.14%). In addition, the blockchain technology has made 99.94% accuracy in verifying data integrity and secure access control via smart contract and decentralized record management. The framework also showed low prediction latency, high system reliability and efficient transaction processing, thus suitable for real time healthcare applications. These findings confirm that the combination of Artificial Intelligence and Blockchain technology facilitates the early detection of diseases, while improving the security, transparency, scalability and interoperability of digital healthcare systems. The proposed framework is a feasible and reliable solution for next generation of intelligent health care environment like hospitals, diagnostic laboratories, telemedicine platforms and remote patient monitoring systems.

3.5 Summary of Findings

Experimental evaluation shows that the proposed Artificial Intelligence and Blockchain Based Early Disease Detection Framework improves the disease prediction accuracy and security of healthcare data. The proposed framework integrates novel AI algorithms with the blockchain technology which can identify disease patterns at early stage and maintains confidentiality, integrity and authenticity of sensitive patient information. The overall prediction accuracy of the proposed system was found to be 98.91% and the precision, recall, F1-score and ROC-AUC score were 98.65%, 98.42%, 98.53% and 0.997 respectively, which indicates the superior ability of the system in precise discrimination of healthy individuals from patients with potential diseases. The methods of data pre-processing and feature extraction were further optimized to improve the learning efficiency of the predictive models, thus providing faster diagnosis and less classification errors.

From the blockchain perspective, it offers high prediction performance and improves healthcare data management through decentralized storage, tamper-proof records, secure transaction validation and access control, governed by smart contracts. The proposed framework achieves 99.94% accuracy for data integrity, 99.81% success rate for secure data transmission and 99.72% reliability for whole system with negligible computational overhead.

4. CONCLUSION AND SCOPE

The experimental results show that the proposed Artificial Intelligence and Blockchain Based Early Disease Detection Framework improves disease prediction accuracy and security of healthcare data. The overall prediction accuracy, precision, recall, F1-score and ROC-AUC score attained by the proposed system were 98.91%, 98.65%, 98.42%, 98.53% and 0.997 respectively which shows the superior ability of the system to accurately discriminate healthy individuals from patients with potential diseases. Also, enhanced data pre-processing and feature extraction methods improved the learning efficiency of the predictive models, resulting in faster diagnosis and less classification errors.

The block chain part succeeded in providing high predictive performance and greatly enhanced healthcare data management using the decentralized storage, tamper proof record keeping, secured transaction validation and

access control using smart contracts. The framework achieved 99.94% accuracy of data integrity verification, 99.81% successful secure data transmission and 99.72% overall system reliability with negligible computational overheads. The results indicate that the proposed framework offers a scalable, secure and efficient solution for the early diagnosis of diseases, facilitating trusted collaboration among the health care providers as well as enabling real-time clinical decision making. Thus, the integration of Artificial Intelligence and Blockchain technologies provides a secure basis for the development of next generation intelligent healthcare systems capable of performing accurate diagnosis while ensuring patient privacy and securing medical data management.

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