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Internet of Things Integrated with Blockchain and Artificial Intelligence in Healthcare System

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Abstract

Blockchain technology has attained importance in the field of health as it overcomes the challenges in securing Electronic Health Records (EHR) as well as Electronic Medical Records (EMR) in eHealth systems. Distributed nature of the technology produces a single ecosystem of patient information which can be monitored more efficiently and quickly by doctors, pharmacists and hospitals or anyone who diagnosis or gives treatment. Blockchain technology is used to securely store digital health records and maintain the source record in order to protect and preserve the identity of patients. This work aims to integrate secure data from IoT devices so as to clearly understand the effects of Blockchain in the real environment field. A novel blockchain approach is designed for eHealth and is employed to discover different ways of sharing decentralized view of health information and improve medical accuracy, health and prevent health disorders.
Keywords: Blockchain, eHealth, Security, Electronic Health records, Electronic Medical Records..

1. Introduction

Blockchain technology is a peer-to-peer system that promotes global consensus and ensures that transactions that have already been verified cannot be changed or altered. It offers a distributed, transparent, secure, auditable, and immutable ledger [1]. Every transaction ever made is contained in a specific, verifiable record on the blockchain [2]. Due to the numerous advantages, it offered over existing alternatives, researchers and corporations have recently become interested in blockchain technology [3]. Smart healthcare systems are extremely susceptible to a number of security lapses and different malicious assaults, including privacy leakage, tampering, forgery, etc. Recently, the blockchain technology has become a viable defense against these breaches and difficulties [4].

2. Related Works

A permissioned blockchain with off-chain information storage was developed as part of work [5] to construct a blockchain-based eHealth integrity model that ensures information integrity in eHealth systems. Work [6] focuses mostly on the architecture of classic blockchain technology (bitcoin characteristics). Some application cases for implementing blockchain technology in healthcare are described by author [7]. The use of blockchain technology in healthcare was examined in work [8], which also covered medical education, health insurance, electronic health records, drug delivery, and biological research. By creating secure cloud storage for patients' private medical records, author [9] created a blockchain architecture for sharing secure medical data. This framework uses a digital archive with access control rights to its owners' information to handle medical data [10].

3. System Model

The proposed methodisto integrate secure data from IoT device so as to clearly understand the effects of Blockchain in the real environment field. The issue is that patient health status information is extremely private and should only be checked by the patient, the patient's family, and the medical officer. Blockchain technology and remote health monitoring systems working together has a lot of application possibilities right now.

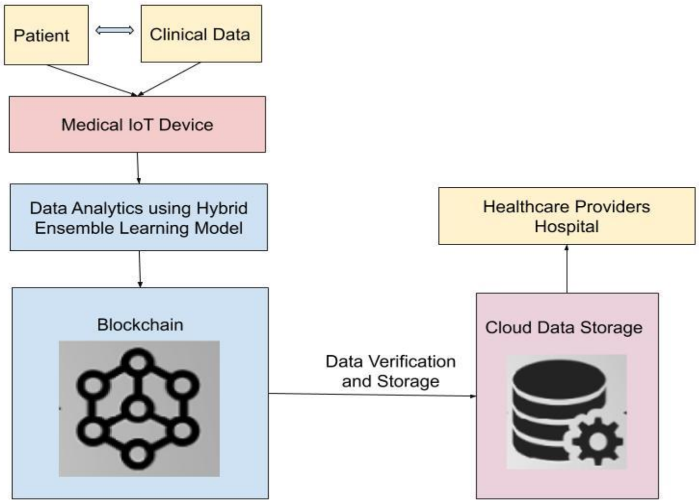

Figure 1: Proposed Methodology

3.1 Data Analytics using Hybrid Ensemble Learning Model (DA-HELM)

The practise of mixing different algorithms and approaches so that it can take use of each one's advantages and make up for the flaws of the others is known as a hybrid ensemble approach. It involves several layers.Figure 2 illustrates the Self Organising Map (SOM), k-means, and Multi-Layer Perceptron (MLP) approaches that make up the multilayered process in the suggested approach. In the first layer, soft clusters are created using the intelligent clustering technique called SOM, in the second layer, soft clusters are created using the statistical clustering technique known as k-means, and in the third layer, strong clusters are fused using the MLP technique.

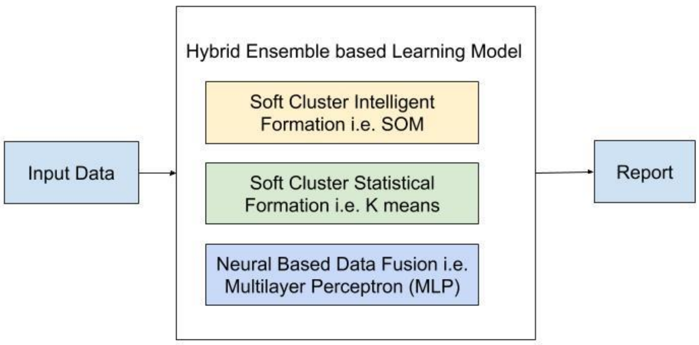

Figure 2: Multilayer Process

Consider the following set of input patterns: IP = "IP1, IP2,..., IPn," where n is the number of input patterns and cn is the number of clustering algorithms Ai I = 1,..., cn), and each algorithm Ai returns output clusters OCi of IP that maximise the confidence function associated with each individual cluster contained in cluster decisions. Formally, OCi is equal to X1,..., Xk,X1,..., Xk eq. (1).

$$f_c\,(OC_i\;(IP)) = \max\{OC_i\;(IP)\} \qquad (1)$$

whereOCi stands for soft clusters created by Ai clustering methods or collective output clusters. The kth cluster's value is represented by Xk. Algorithm-1-generated soft clusters by eq. (2)

$$OC_1 = \{X_1^1, \ldots, X_k^1\} \qquad (2)$$

nth algorithm-generated soft clusters by eq. (3)

$$OC_n = \{X_1^n, \ldots, X_k^n\}$$

$$f_c\,(OC_i\;(IP)) = \max(||\mathrm{IP} = \mathrm{W}||) \qquad (3)$$

W stands for the weights that were given to the output units. The above equation can be made even more precise aseq. (4),

$$f_c\,(OC_i\;(IP)) = \max((\mathrm{IP}_1 - \mathrm{W}_1)^1 + (\mathrm{IP}_2 - \mathrm{W}_2)^2 + \cdots + (\mathrm{IP}_\mathrm{n} - \mathrm{W}_\mathrm{n})^\mathrm{n}) \qquad (4)$$

For the input pattern, the output unit with the smallest Euclidean distance is referred to as the "image" unit. Similarly, the confidence function for the k-Mean criteria is defined as eq. (5)

$$f_c\,(OC_i\;(IP)) = \max(\textstyle\sum_{\mathrm{i}=1}^{\mathrm{k}} \mathrm{IP} - \mu_\mathrm{i}) \qquad (5)$$

The confidence function can be different if T = Ti,..., Tk is the target class (desired output) along with the input patterns by eq. (6).

$$f_c\,(OC_i(IP), T_{i-k}) \qquad (6)$$

The output units are functionally intended to have almost double the dimensions of the input feature spaces in order to make decisions from a variety of soft clusters utilising the SOM criterion.

3.2 Cloud Data Storage

A medical database is called the Master Patient Index (MPI) [30]. It stores digital data of every patient enrolled with a healthcare institution. These records contain details like the patient's name, date of birth, race, gender, security number, and residence. It also contains additional information related to the patient's medical history. Additionally, it might contain information on doctors and/or other medical supplies. Every patient is only ever depicted once, thanks to MPI. This also means that all hospital data systems must consistently identify demographic information. The institution that has the data can guarantee more precise patient care if the MPI is well-organized.

4. Results and Discussion

In this section discuss about performance of proposed and existing techniques. The existing method is PBFTA [11].

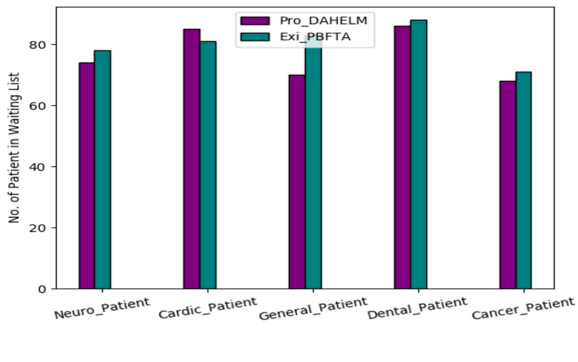

Figure 3: Inpatients and Day cases across different departments/specialty for Smart contract deployment

The above figure 3 shows number of transactions for each of these cases as well as their association patient waiting list as evaluated by our method are plotted. The X axis and Y axis indicates that the Specialty/ Department and Number of patients in Waiting List respectively. Purple and teal color indicates Proposed Data analytics using Hybrid Ensemble based Learning Model (DAHELM) and Existing Practical Byzantine Fault Tolerant algorithm (PBFTA) methods.

4.1 Accuracy

The Hybrid Ensemble Learning Model's performance is evaluated most frequently using accuracy. The accuracy of the suggested method was determined using eq. (7).

$$Accuracy(\%) = \frac{Correctly\ identified\ the\ availability\ data}{Total\ number\ of\ data} \quad (7)$$

Table 1: Accuracy of Existing and Proposed Methods

Number of Patients	Existing PBFTA	Proposed DAHELM
50	39	42
100	48	56
150	55.7	68.2
200	69.1	74.3
250	74.8	80.8

The above table 1 and below figure 4 shows that accuracy calculation of existing and proposed method. The X axis and Y axis indicates that the Number of patients and accuracy values in percentage respectively. Brown and Orange color indicates Proposed Data analytics using Hybrid Ensemble based Learning Model (DAHELM) and Existing Practical Byzantine Fault Tolerant algorithm (PBFTA) methods. When compared to existing method, proposed method shows the better results.

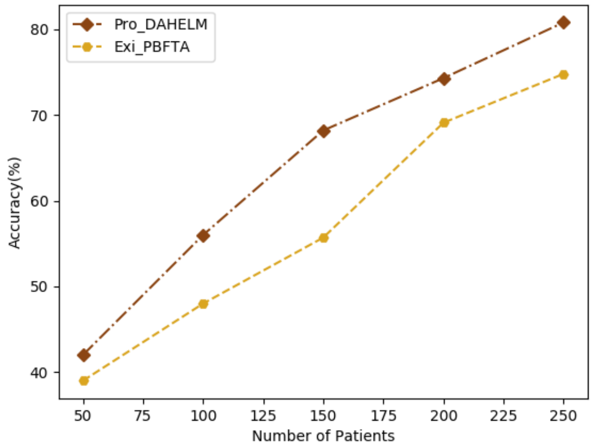

Figure 4: Accuracy of Existing and Proposed Methods

4.2 Root Mean Squared Error (RMSE)

RMSE shows the error rate by variance and mean between the predicted and the real one by eq. (8).

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(PR-RR)^2}{N-1}} \quad (8)$$

Where, PR is predicted rate, RR is real rate, N is the total number of Patients.Below table 2 shows RMSE values calculation for existing and Proposed method.

Table 2: RMSE of Existing and Proposed Methods

Number of Patients	Existing PBFTA	Proposed DAHELM
50	21	18
100	34	22
150	56	43
200	69	58
250	81	66

The below figure 5 shows that RMSE calculation of existing and proposed method. The X axis and Y axis indicates that the Number of patients and RMSE values respectively. Brown and Orange color indicates Proposed Data analytics using Hybrid Ensemble based Learning Model (DAHELM) and Existing Practical Byzantine Fault Tolerant algorithm (PBFTA) methods. When compared to existing method, proposed method shows the better results.

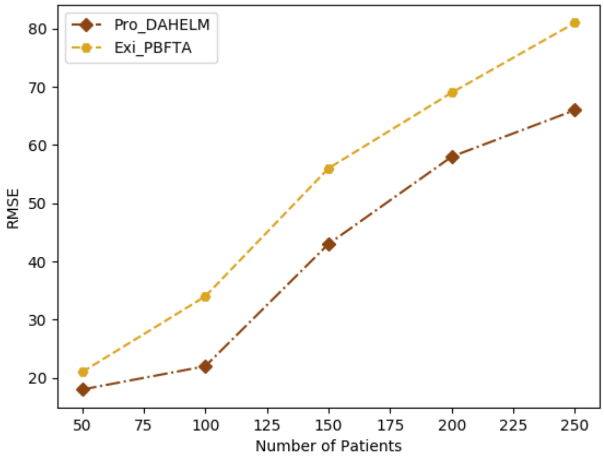

Figure 5: RMSE of Existing and Proposed Methods

5. Conclusion

The flaws of the current system and proposed blockchain and AI-based IoT in eHealth were reviewed in this work's proposed work, which also analysed the current needs of the healthcare industry.The proposed methodisto integrate secure data from IoT device so as to clearly understand the effects of Blockchain in the real environment field. A blockchain approach is designed for eHealth and is employed to discover different ways of sharing decentralized view of health information and improve medical accuracy, health and prevent health disorders using Hybrid ensemble based learning model.The proposed solution employs blockchain technology to provide a decentralised, iterative, scalable, and accessible healthcare ecosystem. This would provide patients complete control over the privacy of their medical data while enabling them to freely and securely exchange their medical records with physicians, hospitals, research institutions, and other stakeholders.

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