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Securing healthcare data management using machine learning and blockchain technology: A comparative performance evaluation of support vector machine and conventional classifiers

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Abstract

As access to healthcare has become more central to people's daily lives, the amount of medical big data has grown exponentially. Wearable Internet of Things (IoT)-reliant technology is gaining popularity in the medical field as a means to improve patient care and reduce wait times. In recent years, billions of sensors, devices, and machines have been hooked up to the web. One such technology, remote patient monitoring, is increasingly used in modern patient care and treatment. In addition, these developments pose substantial security issues about the recording of transaction data and the transmission of information itself, and pose considerable dangers to users' privacy. Concerns about the privacy of a patient's medical records have the ability to discontinue treatment, putting the patient's life in threat. Thus, a system is proposed using machine learning in combination with blockchain technology to allow secure management as well as analysis of large amounts of healthcare data. With the help of machine learning, it is feasible to sort through all of the data and extract out only the most pertinent information. This is accomplished with the help of trained methodologies. After this data has been saved, the next issue will be the exchange of data and ensuring its trustworthiness. The concept of blockchain is introduced at this point. The Blockchain technology relies on consensus to ensure that all data is accurate and that all transactions are conducted in a safe manner. The management of healthcare is one area where blockchain technology offers the ability to have a huge impact by placing patients at the center of the system and improving the privacy and portability of health records. This study is primarily concerned with finding solutions to issues relating to the administration of healthcare data by utilizing Blockchain technology and incorporating some crucial characteristics developed

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with Machine Learning. The performance evaluation of proposed Support Vector Machine is compared with the other conventional machine learning classifiers. It is observed from the experimental finding that performance accuracy of Support vector machine is 98% which is better as compared to other traditional machine learning classifiers.

Subject Classification: *Primary 93A30, Secondary 49K15.*

Keywords: *Electronic medical records, Decentralized interplanetary file system, Internet of Things, Blockchain technology.*

1. Introduction

In Rapid development and widespread use have led to the Internet of Healthcare Things (IOHT) [1]. Connecting diverse devices through the Internet of Things facilitates the collection of information about people that may be used to enhance their well-being, efficiency, and performance [2, 3]. The notions of smart buildings, smart grids, and intelligent dwellings are becoming increasingly common and are having a significant impact on our day-to-day lives [4, 5]. Utilizing an internet-of-things-based surveillance system of patient health is one of the most promising new technical techniques that have emerged in recent years for bridging the international health equality gap [6].

A patient who lives in a rural area may have difficulty reaching a doctor in an urban area without the assistance of a sophisticated health monitoring system. This innovation serves as a conduit for communication between professionals and patients. It monitors vital signs such as a person's heartbeat, electrocardiogram (ECG), hypertension, temperature, and the extent to which they have been ill. This information is gathered by the system and then transmitted to the app for additional examination through a wireless network. It is vitally necessary to develop efficient data mining methods in examine medical data so as to contribute to the discovery of diseases, provide medical therapy, and improve patient care. Machine learning is a complex computational method that has found applications in a wide number of fields, including image processing, speech processing, and medical services [7]. However, for machine learning algorithms to gain a high level of accuracy, a substantial quantity of training data is required. This is particularly important in the medical field, where a lack of precision often can make the difference among a patient's life and death.

It is possible for the patient's reputation to be ruined, as well as the patient's psychological health, if confidential information about the

patient is disclosed to the public at large. This kind of information breach might also cause financial losses for the individual who was affected by it. The aim of the system that has been proposed is to give a remedy for all EMR-related issues. The goal of the work that has been presented is to build and develop a blockchain for the health care industry that can be used in wearable Internet of Things devices and that focuses on the safe transmission and storage of data in a distributed environment. The system establishes reliable communication between numerous participants without the involvement of any external interface provided by a third party.

The organization of the paper can be divided into the following categories: In the part 2, the research that was carried out by a variety of different researchers are discussed in detail. In part 3, a system model is proposed for the electronic medical record sharing scheme. This system model takes use of blockchain technology, smart contracts, and the technique of machine learning. In addition, the goals of the design are outlined in this part. In part 4, the results of the tests are analyzed, and an evaluation of the system as well as a security analysis is presented. This section also includes some discussion on the outcomes of the findings. In the part 5, the conclusion as well as the future scope is discussed.

2. Review of Literature

In recent years, the word "blockchain" has become increasingly commonplace among advocates of smart healthcare, and a number of research articles have investigated the ways in which blockchain technology might be implemented in the sector. S. Aggarwal et. al. [12] investigated numerous areas of the healthcare industry, including the merging of transactions, personal care, and capital distribution, amongst others. There are many different ways in which the blockchain could be utilized within the smart home market. M. Andoni et. al. [13] provided a comprehensive review of the many uses of a P2P resource sharing system that involve blockchain technology. The research covers in-depth expertise on the deployment and capabilities of numerous different intelligent home networks, incorporating smart grid security challenges, Big Data analysis, artificial intelligence, and payment systems. Researchers came to the conclusion that the survey did not adequately take into account the difficulties that are associated with smart houses. Some examples of these difficulties include inadequate financial management for smart cities and inadequate smart home surveillance.

G. Li et. al. [14] proposed the implementation of a blockchain framework that would be user-centric in order to guarantee the confidentiality of information transmissions made over the IoT. Z. Zhou et. al. [15] carried out study into a variety of blockchain technologies, as well as predefined research and decentralized computation, with the goal of relocating control over certain autos and enhancing the efficiency of these systems. The authors Du et. al. [16] suggested a research project with the objectives of examining the execution of blockchain architecture in health care; designing a centralized concept for smart healthcare; summarizing the influence of blockchain - based technique on sophisticated health-care system; and, ultimately, establishing a stakeholder-based progression application design of smart healthcare.

Ihnaini et. al. [17] proposed a smart strategy for predicting the onset of diabetes disease that is based on machine learning techniques and data mining approaches. The proposed method, which involves combining information, has the potential to lessen the unneeded strain placed on the system's computational power while simultaneously enhancing the suggested system's capacity for accurately predicting and advising on how to deal with this potentially fatal condition. The development of a model for diabetes prediction is completed with the use of an ensemble machine learning technique.

According to [18] Naregal K. and Kalmani V. proposed attribute-based encryption and its need to IoT. The study reveals potential issues with implementing ABE for cloud-based IoT applications and suggests approaches to resolving them. The cloud is a multipurpose platform that may be used for a wide range of tasks like data storage, application development, and server management. Due to ABE's ability to grant or deny access to very tiny data sets, it has become a popular encryption method for use in cloud-based services. The usage of Internet of Things (IoT) devices and cloud-based apps have both grown rapidly in the recent decade, as their respective user bases have shown. Due to the cloud's abundance of storage space and computing power, it is expected that many IoT devices would utilize the cloud to store their data. The security implications of Internet of Things devices using the cloud for storage and other purposes must be kept in mind. Many applications now rely on ABE for access control in the cloud; however, when using this same method to IoT applications, there are problems that must be investigated.

According to Prakash K Sonwalkar and Vijay Kalmani [19] efficient energy efficient protocol in WSN. This approach improved network coupling between nodes makes this protocol the best choice for clustering

and routing in WSNs. The variables of network stability, network longevity, and the selection of a cluster monitor method are all studied and improved by our proposed updated technique. If you want to save the most power possible, you should probably merge your sensors' outputs. The simulation results showed that the suggested protocol greatly improved network characteristics, making it a potentially useful alternative for WSNs. The similar approach proposed by Vijay H. Kalmani et. al. in [20] called effective key management techniques for detection mitigate the attacks in WSN. Security in WMNs is complicated by the fact that Mesh Clients are constantly moving around and opening themselves up to new threats. In this paper, a security technique is introduced to provide an effective key management system with key agreement, ensuring that the induced network is both linked and secure from any eavesdropping assaults. Based on simulation findings, it's clear that the technique described in this study provides a network secure against malicious eavesdropping attacks.

Ruchi Nanda et.al. [21] proposed a system a system for NOSQL datastore caching architecture designed to accelerate the handling of many requests. This system caches commonly executed searches on top of a column-based datastore since they are costly to reevaluate. Some queries are cached to speed up query processing. In this research, the effectiveness of the architecture is assessed using query processing times independent of the relational database or system cache.

Shailee Bhatiya et. al. [22] describes an air pollution forecasting in India using machine learning on data from sensors, historical and current pollutant concentrations, and satellite imagery. We stress the importance of not just quantifiable contaminants, but also meteorological variables such as wind, temperature, and fire in determining pollution. Long Short-Term Memory, the cutting-edge method for time series prediction, is employed in the model.

Ajit Kumar Rout et. al. [23] proposed a system novel form of deep neural networks, MLELMAE approach, to make five-day stock market forecasts. By applying the model to the YES, SBI, and BOI datasets, we can evaluate its efficacy and compare it to that of other Deep Learning (DL) approaches.

Yashpal Soni et. al. [24] proposed a system A secure e-health framework for rural Rajasthan. In this article suggest a robust and secure framework for providing high-quality healthcare to residents of rural Rajasthan, with the goal of making all available resources easily accessible to them.

Sinem Şahnagil et. al. [25] The structures include the creation of a digital transformation office, the establishment of a digital transformation council, the development of a digital transformation strategy, the implementation of digital transformation initiatives, the adoption of digital transformation technologies, and the establishment of a digital transformation governance framework. Additionally, the government has also taken steps to ensure that the digital transformation process is successful by providing resources and support to the public sector, encouraging collaboration between the public and private sectors, and creating a culture of innovation and experimentation.

Rita Roy et. al. [26] usability of the data and the transparency of the data will be improved by using blockchain technology. The data will be stored in a distributed ledger which will be immutable and secure. The data will be shared among the stakeholders in the food supply chain. This will help to reduce the cost of the food supply chain and will also reduce the time taken for the food products to reach the consumers. The blockchain technology will also help to reduce the food wastage and will improve the food safety. The blockchain technology will also help to reduce the food frauds and will help to improve the food quality. The blockchain technology will also help to reduce the food spoilage and will help to improve the food traceability. The blockchain technology will also help to reduce the food waste and will help to improve the food sustainability. The blockchain technology will also help to reduce the food adulteration and will help to improve the food authenticity. The blockchain technology will also help to reduce the food contamination and will help to improve the food safety.

3. Research Methodology

In the proposedmodel, Blockchain technology as well as Machine Learning Techniques are utilized in order to create a solution that is more secure in terms of security. Further capabilities are provided through the use of machine learning, and these features can serve as the foundation for ideas regarding subsequent implementations relating to this topic. Machine learning is predicated on the idea of collecting and storing data in a centralized location, but the Blockchain technology relies on dispersing data over multiple locations to ensure data integrity and confidentiality.

Both the patient and the doctor who has access to their records respect the patient's right to privacy. When a doctor who is authorized to access the patient's records adds new information that is relevant to the patient's

medical history, the machine will update the record automatically. Clinicians who have been authorized access to the system are the only ones who can see the modifications. No doctor has ever been granted unrevocable access, and no patient has ever been prevented from revoking a doctor's consent. As a result, the doctor will lose access to the patient's medical records.This is crucial in scenarios when a change in the attending physician is required, and thanks to Blockchain, such transitions will be easy and secure. There will be no more opportunities for data leakage during this exchange, and healthcare institution employees won't have any more trouble transferring data. Furthermore, data transfers across international borders may be cheaper than using more conventional methods. In the case of a potentially fatal situation in which the patient has been rendered insensible and is incapable to deliver any involvement on his health, immediate access to the patient's medical records is an imperative need. In order to perform potentially lifesaving procedures, it is crucial to have this information on hand before beginning any major procedure. This contains medical and therapy background information.

Implementation of Machine Learning

When developing a brand-new machine learning technique, there are two stages involved. The first thing that needs to be done is to import the dataset and make any necessary changes to the weights of the model so

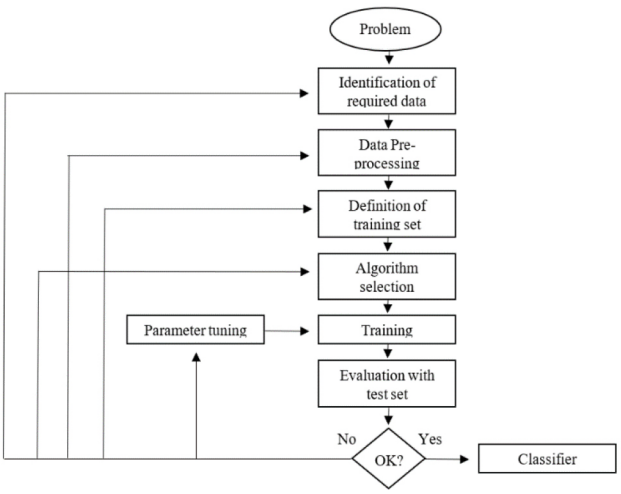

Figure 1

Proposed Supervised Learning Flowchart

that it can predict more accurately. The second phase involves validating the machine learning algorithm by testing it on novel or independent datasets to determine how accurate it is. This helps to avoid overfitting the algorithm by ensuring that it isn't too perfect for the data. An overfit model performs exceptionally well on a particular dataset yet performs poorly when hypothesizing solutions to a particular problem. Figure 1 provides a visual representation of the Machine Learning process that the suggested model incorporates.

After been trained via supervised learning, a machine learning techniques can then be used to perform a variety of tasks, like classification and prediction on datasets that have not been previously trained using that model. The "Bag of Words" technique is utilized in the suggested model. This algorithm will retrieve only the necessary dataset and disregard the many other items, such as the patient's name, age, location, and other personally identifiable information, in order to protect the confidentiality.A mathematical formalism of the supplied dataset is constructed using Supervised Learning. This model includes both the data input and the data output. Classification and regression are both possible applications for supervised learning.

The outcomes of the test dataset may be used as a barometer for the method's accuracy. To alleviate some of these problems, the Bag of Words (BOW) method is used. This is a method for extracting characteristics needed from text to utilize them in modeling. The suitable features are selected from among the terms utilized by this approach, which are included in the training data. Once the features have been defined, values are given to them, and a representation of the features is mapped to both the training and testing datasets. Two major values are most often reflected in the BOW:

1. Value of the binary feature: The feature's presence or absence from the dataset is indicated by the value of this representation property, which may be either 0 or 1.
2. Value of Frequency Feature: In this approach, a feature's value is determined by the frequency with which it appears in the dataset, with a value of 0 for features that do not appear. If it does show up, we add 1 to the value.

In this particular research study, a frequency-feature-value representation is utilized. When a feature is mentioned multiple times within a single sentence, the author of this representation considers that

feature to be noteworthy. The efficiency of the data collection can be significantly improved by locating and removing terms that do not contain information about sickness or therapy. Only disease-related information that also contains health data is extracted by the suggested algorithm; other unnecessary materials, like forms, users, remarks, navigation, choices, comments, and promotion, are ignored. The application of this method has the advantage of improving precision with an accuracy ranging from 79.05% to 82.5% due to the utilization of a weighted unigram extraction algorithm.

This model will obtain the dataset from reputable sources in order to supply the machine learning algorithm with the necessary information, which then classifies the data according to predetermined criteria. Utilizing the health data of individuals suffering from ailments that are extremely uncommon is also of utmost relevance to the researchers and medical professionals in the medical field. Take, for instance, the scenario in which there is an emergence of a new illness in a certain region or country, as to which there is not a great deal of information available. The data that is generated by the medical reports of the patient is loaded into the cloud in the format of data without letting the patient's personal and private data, which in turn will provide the investigators and the experts with certain accurate and dependable data.

When a sufficient number of patients' medical records are input into the computer, it generates sufficient statistical data for a certain illness or condition. In addition, the classification of disorders will make it easier for patients to have access to and comprehend the information included in their individual health records, and it will also make it simpler for researchers to locate the information they require.

It is essential for patients to have authority over their own medical records and to reap benefits from the information that they contribute to the healthcare system. Because of this, it is feasible to locate people who are open to the possibility of their healthcare data being utilized for study. These participants will be provided with clear data regarding the specific purpose for which the data will be used as well as the type of data that will be necessary in order to fulfill the study's objectives. Because the data has been anonymized, there won't be any problems with people's right to privacy. In exchange, participants are given the chance to get compensation.

Blockchain using Machine Learning

When combined, blockchain technology and machine learning bring up a wealth of new possibilities for protecting patients' private health information. Combining the two of them is a task that requires a fair amount of effort. In this particular field, there hasn't been a substantial amount of research conducted.

In the proposed work, the machine learning technique is trained using supervised learning on datasets gathered from a variety of sources. In order to minimize the size of the data, the "bag of words" method is applied. This algorithm will start taking only the essential components of the dataset in addition to training the supervised ML based algorithm.

The Blockchain network provides protection for the patient's medical records, and it is through this network that transactions between patients and their approved doctors can take place. This is the end of Blockchain's functional capabilities.

After then, a fresh batch of patient health records is introduced to the trained model. The model first processes the data by removing any traces of personally identifiable information and details, and then it classifies the remaining data according to the various diseases. The function of the algorithm for machine learning is accomplished at this point.

E-mails can be used to send the dataset from one hospital to another hospital, or the dataset can be uploaded to a cloud-based storage solution that can be accessible by facilities as well as investigators. Either way,

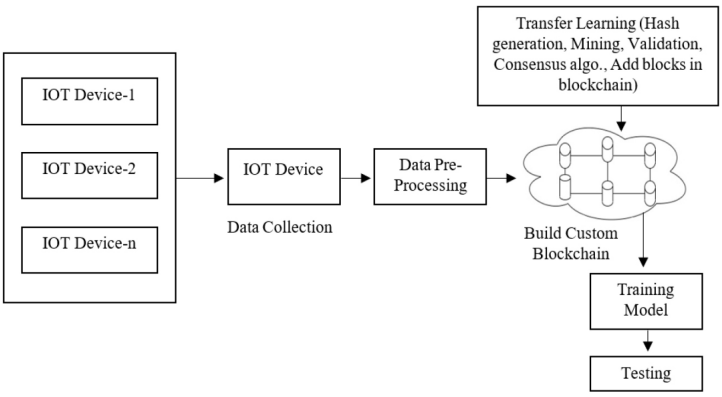

Figure 2

Proposed System IOT based Management of Medical Data using Blockchain and Machine Learning

the dataset can be shared with other facilities.The data collected at each facility would be entirely different from one another, making it extremely necessary to share this information. The most significant benefit of utilizing algorithms for machine learning is that it enables researchers and medical professionals to have access to the information they need for the purpose of conducting studies.This model has the potential to offer two distinct advantages: first, Blockchain can protect medical records by facilitating secure transactions between the doctor and the patient; second, processed data can be used by investigators and doctors without the need for additional security measures because it has been stripped of any personally identifiable information. Figure 2 Proposed System IOT based Management of Medical Data using Blockchain and Machine Learning.

5. Algorithm Design

Data Pre-Processing: Data preprocessing is an essential step in the data analysis pipeline. It involves transforming raw data into a clean, organized, and suitable format for further analysis. Data preprocessing tasks aim to enhance the quality and usefulness of the data, improve data mining algorithms' performance, and eliminate potential biases or inconsistencies. The below techniques we used for data preprocessing;

1. **Data Cleaning:** This step we handled missing values, outliers, and noise in the data. Missing values can be either removed, imputed (replaced with estimated values), or filled using various techniques. Outliers and noisy data points can be detected using statistical methods and either removed or adjusted.
2. **Data Integration:** When working with multiple datasets, data integration combines them into a unified dataset. It involves resolving inconsistencies in attribute names, merging datasets based on common variables, and handling data redundancy.
3. **Data Transformation:** in this phase we converting variables into appropriate formats for analysis. This may involve scaling numerical values to a common range (e.g., normalization or standardization), logarithmic or power transformations for skewed data, or encoding categorical variables into numerical representations.

Feature Extraction and Selection:

Feature extraction and feature selection are techniques used in machine learning to identify and extract the most relevant and informative

features from the original dataset. The TF-IDF, co-relational co-occurrence, dependency feature etc. we extract from data that help in reducing the dimensionality of the data, improving model performance, and addressing issues like the curse of dimensionality. Feature extraction involves transforming the original dataset into a reduced set of representative features while preserving the essential information. It aims to capture the most important characteristics of the data.

Different selection methods we used for extract the optimized feature set that aims to identify the most relevant features from the original dataset while discarding irrelevant or redundant features. It helps reduce model complexity, improves interpretability, and avoids overfitting. The choice of feature extraction or selection technique depends on the dataset, the problem at hand, and the specific requirements of the machine learning task. It is often beneficial to experiment with different methods to find the most effective approach for a given problem.

Classification:

Hybrid Machine Learning (HML) based classification algorithm are used for prediction results from test data. The proposed HML refers to the combination of multiple machine learning algorithms or techniques to build a more robust and accurate classification model. It leverages the strengths of different algorithms and combines them in a synergistic manner to improve overall performance. Here are some common approaches to hybrid machine learning classification

Input: Train_Data_Set [] as training dataset, TestingDBLits[] test dataset after cross validation

Output: Predict the result as final class label

Step 1: using below formula we extract each record information from testing dataset that contain various attributes.

$$\text{Test List}(k) = \sum_{m=1}^{n} (\text{feat Set}[A[i]\ldots\ldots..A[n]\ \text{Testing}\ DBL\text{its}\ [\,]\ )$$

Step 2: Generate the optimized feature vector for entire test data TestList (k) using below function

$$\text{Optimized\_Test\_Features}\ [t\ldots\ldots n]\ = \sum_{x=1}^{n} (\text{t}) \leftarrow \text{TestList}\,(\text{k})$$

Optimized_Test_Features[t] output of every feedback layer in recurrent neural network that optimized the feature set which is extracted from convolutional layer.

Step 3: The training data should be pre-trained model as well as runtime rule generation approach. By using below equation we extract all features from training data according to class existence.

$$\text{Train\_Features}[] = \sum_{m=1}^{n}(\text{featSet}[\text{A[i]}\ldots\ldots\ldots\text{A[n]}\ \text{Train\_Data\_Set}[])$$

Step 4: Generate the new feature vector for current train da Train_Features[] by using following function.

$$\text{Train\_Features\_opt}[t\ldots\ldots n] = \sum_{x=1}^{n}(t) \leftarrow \text{Train\_Features} \qquad (1)$$

Train_Features_opt[t] output of every feedback layer in recurrent neural network that optimized the feature set which is extracted from convolutional layer.

Step 5: During the classification of each instance below similarity calculation function has used to evaluate each instance

$$W = \text{Generate\_weight}(\text{Optimized\_Test\_Features} \,||\, \sum_{i=1}^{n}\text{Train\_Features\_opt}[\text{i}])$$

Step 6: detect the class in training vector which is associated with higher *W<class>* in feedback layer

Step 7: Return *W<class>*

Both the *Train_Feature[]* and the *Test_Feature[]* are needed as input for the test classification in order to calculate a similarity score between the two objects that are provided as input. These are two distinct characteristics, one of which represents the teaching instance, while the other represents the testing instance. The Th is the denominator that is utilized for the purpose of selecting the results of each period stratum. The *T[j]* represents the jth characteristics of the testing instance, and the *T[k]* illustrates the kth information about the train's attributes. We take some characteristics from both of the instances by using a technique called feature selection, and

then we send those features on to the similarity measurement function, which is explained in step 5. The dense optimal results for the classifier are determined by the number of instances that have been validated by the threshold.

5. Results and Discussion

The quantity of overhead that is connected with accessing EMRs that are kept on blockchain cloud storage is another factor that is taken into consideration when determining whether or not the technique that has been presented for sharing EMRs is effective (Figure 3). The duration of time that is evaluated is the total amount of time that is needed for the technique of accessing EMRs, beginning with the request for data access and finishing with the data being obtained on the mobile phone. The total amount of time needed for the technique is what is measured. The time overhead that is involved with obtaining EMRs from the suggested blockchain-based storage is analyzed in comparison to the time overhead that is connected with obtaining EMRs from centralized storage. The findings of the experiments indicate that the proposed method of decentralized storage using blockchain outperforms the conventional method of using centralized storage in terms of the amount of time that is needed for overhead. This finding lends credence to the hypothesis that the EMRs arrangement on the cloud blockchain that was proposed makes effective use of the available resources.

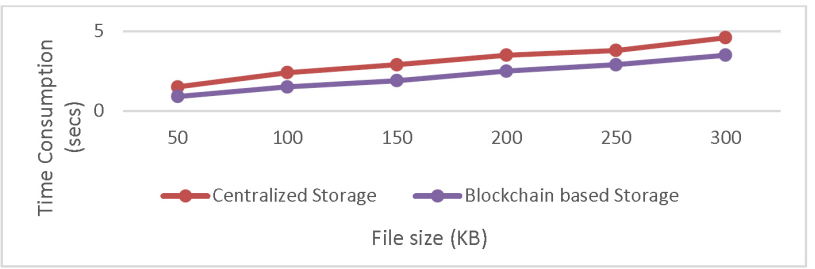

Figure 3

Time overheads in terms of time consumption for EMRs access on cloud storage

In comparison to more traditional machine learning classifiers, the performance of the proposed support vector machine that was presented is shown in Figure 4.

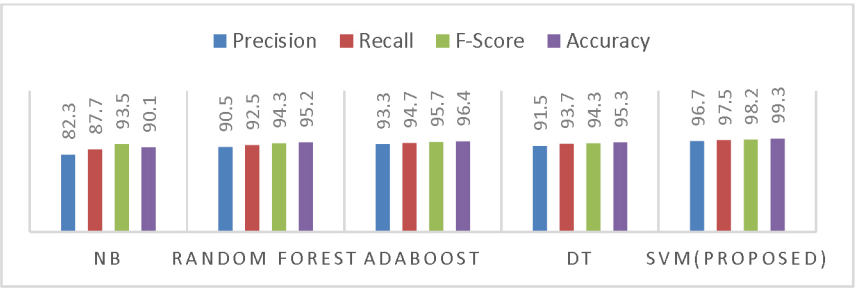

Figure 4

Performance Comparison of Proposed HML with Conventional ML

The above Figure 4 describes an proposed SVM obtains highest accuracy 98.00% accuracy which is higher than other machine learning algorithms such as NB, RF and DT etc.

6. Conclusion and Future Work

The blockchain framework has used in nowadays as advancement in distributed framework over the world. The IoT and banking areas are previously utilizing Blockchain because of the incomparable benefits it provides. However, in light of the significant rise in the amount of health data breaches caused by hacking, the usage of Blockchain for protection has become essential element. It would not be an overstatement to suggest that the Blockchain constructed medical care framework is the way of the future in the healthcare industry. This model also has the possibility of changing the way in which medical archives are stored and protected. The introduction of 5G networks and data transfer capabilities that are far quicker than in the past will boost the development of data-based technologies such as machine learning, blockchain, and others across a variety of industries, including healthcare sector. The use of Blockchain, which is part of this emerging new ecosystem for technology, offers significant improvements in the management of health records for patients. Continuous attempts are actuality made to improve the exactness of smart IoT based and health care sensing systems. The proposed presents a novel Internet of Things -based healthcare model that makes use of machine learning and blockchain technology to address a variety of concerns pertaining to the management of electronic health care records. The suggested Support Vector Machine's performance evaluation is compared with those of various traditional machine learning classifiers. According

to the results of the experiments, the performance accuracy of the SVM is 98%, which is better than traditional machine learning classifiers. In the future, there is room for this concept to be improved by integration of ANN, the IoT and a great deal more of the technology that is currently accessible such data over the world via distributed network.

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