IoT based heart disease prediction and diagnosis model for healthcare using machine learning models

M.Ganesan
Research Scholar, Dept. of CSE,
Pondicherry University,
Puducherry,India
ganesan@smvec.ac.in

Dr.N.Sivakumar
Assistant Professor, Dept. of CSE,
Pondicherry Engineering College,
Puducherry, India,
sivakumar11@pec.edu

***Abstract*—Latest advancements in field of IoT and sensing technologies can be employed for online healthcare services. The gigantic quantity of information is being formed through the IoT devices in the medical field and cloud computing techniques have been used to manage the massive amount of data. To avail good service to the user using the online healthcare services, a fresh Cloud as well as IoT based Healthcare application to monitor in addition to diagnose serious diseases is developed. In this study, an efficient framework is utilized for heart disease is created utilizing the UCI Repository dataset as well as the healthcare sensors to predict the public who suffer from heart disease. Moreover, classification algorithms are used to classify the patient data for the identification of heart disease. In the training phase, the classifier will be trained using the data from benchmark dataset. During the testing phase, the actual patient data to identify disease is used to identify the presence of disease. For experimentation, a benchmark dataset is tested using a set of classifiers namely J48, logistic regression (LR), multilayer perception (MLP) and support vector machine (SVM). The simulation results ensured that the J48 classifiers shows superior performance in terms of different measures such as accuracy, precision, recall, F-score and kappa value.**

Keywords*—IoT, Classification; Machine learning; Cloud computing

I. INTRODUCTION

Due to the advanced technologies in the domain of internet, IoT as well as sensing gadgets, the healthcare monitoring is significantly increased in the past few years. Several hospitals make use of mobile applications for making an appointment, enquire patient record and examine reports. However, healthcare wearable gadgets (like 3G BPmeasuring device, Bluetooth blood glucose measuring device, smart ECG machine) can be utilized to monitor blood pressure, blood sugar, ECG as well asother physiologic symptoms. The monitored data can be transmitted to the information platform to diagnose the patient in real time or stored in a dataset [1]. The development of intelligent devices in healthcare has more benefits like reduced cost, improve the medical understanding of patients as well as decrease the workload of the hospital staff [2]. In addition, the intelligent devices are connected to one other to attains theseintention is still a big issue. The major challenge lies in the communication protocol [3]. Since the traditional wired transmission is not applicable for mobile, large number of research works has been developed to connect smart things through short range as well as long range wireless transmissions. Boudra et al. in [4] developed a healthcare model by the use of ZigBee as well as a long range wireless protocol. Catarinucci et al. in [5] presented a three-tier network framework to monitor as well as track patient data in hospitals, comprises of three components: hybrid sensing network (HSN), the IoT smart gateway, as well as user interfaces for data visualization in addition to management. Alharbe et al. in [6] presented a method by the incorporation of ZigBee and RFID to develop an information management system of hospitals. Here, ZigBee is employed for data transmission to the cloud was used to transmit the gathered data to the cloud center, and RFID is used for automatic object identification.

The integration of cloud as well as IoT based online applications outperforms the standard cloud based applications with respect to effectiveness. The rising applications, for example, medicinal, military and managing account applications can utilize it. Uniquely, the Cloud depended IoT system would be helpful for giving the effective administrations to the medicinal applications for observing and getting to the reportsout offseveral remote area. IoT driven Healthcare applications are employed to gather the essential information like adequate alteration in wellbeing constraint on instance and it refreshes the seriousness of the therapeutic parameters in a predefined time period.

Likewise, IoT gadgets as well as the medicinal parameters associated sensor values would be used proficiently for disease diagnosis over correct time previous to reaching the critical circumstance. Machine learning (ML) algorithms plays a vital part in the decision making process even dealing with massive amount of data. The procedure of adapting the data investigation approaches to particular fields. The traditional data investigation modeling includes neural network, classification model and clustering are also employed. The generation of data can be done in various ways with specific data type and it is additionally essential for creating strategies which can deal with the information qualities. In IoT, the expansive volume of assets which make the vital information progressive with no issue, for example, adaptability, speed and

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for judgment the finest data structure. These are altogether assumed as each of the imperative problems in IoT. To conduct this study, we have gathered an extensive volume of enormous information which has distinctive kinds of information for example, picture, content and all out information through IoT gadgets as input. This information will be put away in the cloud platform safely and gain access through the recently evolved healthcare applications. Here, we have employed another machine learning process that performs mapping the information into two modules, for example, 'Ordinary' as well as the 'Sickness'.

In this paper, another Cloud as well as IoT based disease diagnosis model has been developed to monitor, predict and diagnose the heart disease. In this study, an efficient framework is utilized for heart disease is created utilizing the UCI Repository dataset in addition to the healthcare sensors to predict the people who suffer from heart disease. Moreover, classification algorithms are used to classify the patient data for the identification of heart disease. In the training phase, the classifier will be trained using the data from benchmark dataset. During the testing phase, the actual patient data to identify disease is used to identify the presence of disease. For experimentation, a benchmark dataset is tested using a set of classifiers namely J48, logistic regression (LR), multilayer perceptron (MLP) and support vector machine (SVM). The simulation results ensured that the J48 classifiers shows superior performance interms of different measures such as accuracy, precision, recall, F-score and kappa value.

II. Related Works

There are numerous works have been done toward this path by the different researches and are found in the literature [7-11]. From the literature, [12] developed a model to monitor the disease level and diagnose it through utilizing cloud in addition to IoT. This system is basically employed to foresee the seriousness of the disease. Key terms are extended that to create the client based health estimations that investigates the computational science idea. They have built up the system to take care of the student's health. In this study, a In their work, a methodical health data that is student viewpoint has been produced utilizing the typical UCI Repository as well as the sensors that are utilized in therapeutic departmentas well asemployed to foresee the different diseases which are influenced by understudy with seriousness. Different classification techniques to predict different diseases are validated interms of F-measure, specificity as well as sensitivity. At last, they demonstrated that their system performed well as far as predicted accuracy than the current models.

[13] clarified the fundamentals of IoT with its reasonable applications which are accessible toward u-healthcare service. They have presented another structure that is helpful for the IoT based u-healthcare service. [14] explained a new technique, which depends on IoT therapeutic gadgets in body sensor systems. In their innovation, the patient is able to be checked utilizing the different powered as well as the light-weight sensor systems. Furthermore, they additionally assumed the precautions necessities for planning the healthcare module. They proposed a web based monitoring framework known asHealthcare Industrial IoT for observing the health. Their framework has the capability to analyze patients' medical records for invalidating the demise conditions. Also, it gathers the pertinent patient information which is fundamental for examination utilizing sensors as well as the medical devices. In any case, they consolidated in their framework to eliminate clinical mistakes and different personal thefts throughsubsequent the security techniques, for example, watermarking as well as the signal improvements.

[10] clarified an insight about the different procedures accessible for building up the applications that are accessible toward m-healthcare. The applications, for example, web designer and the applications developer which are utilized to screen the patient's health constraintsdistantly by utilizing the IoT depended framework. They have created different online applications for giving the wellbeing data of the separate patients to the doctor'sexterior a therapeutic setting.

[16] projected a public centric sensing model for elder as well as physically challenged individuals. The primary goal of their framework is to give a service on emergency response or in the event of the unusual state of the patients. [8] presented an efficient security replica to reduce the risks in IoT based medicinal services condition. Likewise, they investigated the advancementswhich are accessible in IoT based healthcare environment. [7] projected an intellectual diagnosing framework known as neuro-fluzzy transient knowledge demonstration system to predict the foreseeing and diagnosing the different deadly diseases. Other work projected toward this path, an intellectualas well as advanced fluzzy rule based classification model was projected by [17]. [18] proposed another online healthcare services diagnosis framework for observing the remote heart patients utilizing cell phone and the wearable sensors. [19] presented another observing framework for giving the crisis circumstance in checking service by utilizing the circumstance of the motion tracking disease patients.

III. Proposed Model

The proposed system framework is depicted in figure 1. It comprises of five mainpartslike Medical IoT sensors, heart disease dataset, patient data, Cloud Database, ML based heart disease prediction system. The general block diagram of the proposed work is depicted in Figure 1.

The wearable as well as implanted IoT gadgets are assumed as IoT gadgets. They are employed to gather the patient data out off distant regions. These straight measurements are gathered as patient data which are collected using IoT devices linked with the human body.

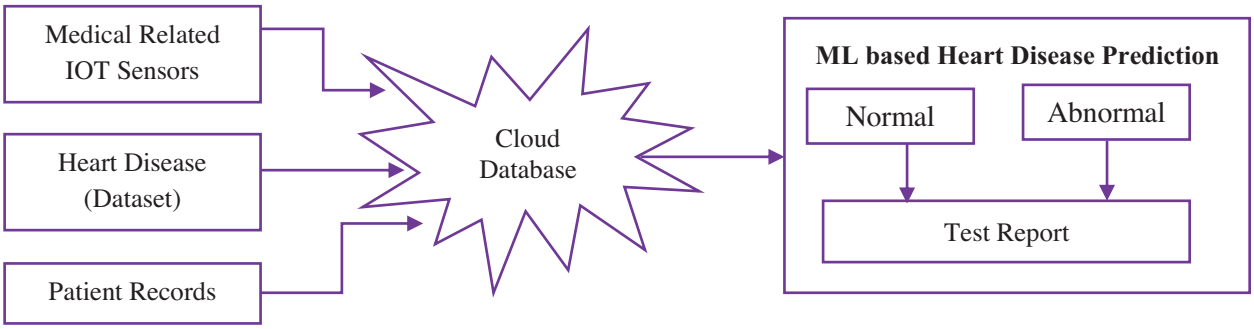

Fig. 1 Block diagram of the proposed model

The benchmark heart disease dataset from UCI repository is used. The heart disease dataset includes the past logs of the medical data which are gathered from medical institutions. The patient records consist of medical old records of the patients which are collected from hospitals. All these datasets are saved in the cloud. The required data will be saved in the cloud for access at any time.The heart disease prediction system is responsible to predict heart diseases by the use of machine learning based classification algorithms. The presented IoT based healthcare model operates in three stages. In the first stage, the data will be gathered by the use of IoT devices from human body, data from benchmark dataset and patient records. In the next stage, all the gathered data will be saved in the cloud database. In the last stage, the prediction of heart disease takes place by classifying the data. Initially, the classification algorithm executes the training process which utilizes the heart disease dataset to train the classifier to identify the presence of heart disease or not. Then, the trained classifier is ready to test the incoming patient details to properly identify whether the patient suffers from heart disease. Finally, the test report will be generated and available to the user.

IV. Performance Evaluation

The projected work has been implemented in JAVA programming as well as Amazon Cloud. Classification of data is crucial process in this study those classifiers the data into presence and absence of heart disease. Since the simulations are carried out utilizing medical dataset, different classification measures such as accuracy, precision, recall, F-score and kappa value. For experimentation, a benchmark dataset is tested using a set of classifiers namely J48, logistic regression (LR), multilayer perceptron (MLP) and support vector machine (SVM). In this study, we have focused mainly on heart diseases and it can also be employed to predict other major disease also by changing the data in the training and testing phase. The simulation outcomes are also evaluated by means of ten-fold cross validation to finalize the results of the projected model.

A. Dataset

To validate the classifier results, a benchmark heart disease dataset from UCI repository is employed [20]. The description of the dataset is tabulated in Table 1. The CKD dataset contains a total of 270 instances, 13 attributes and 2 classes. Among 270 instances, 150 instances are labeled with the presence of heart disease and the remaining 120 instances are labeled with the absence of heart disease.

TABLE I
Dataset Description

Dataset	Source	# of instances	# of attributes	# of class	Present/ Absent
Heart Disease	**UCI**	**270**	**13**	**2**	**150/120**

B. Metrics

The metrics used for the comparison purposes are accuracy, precision and recall. In prior to the explanation of performance measures, the concept of confusion matrix is given in Table 2.

TABLE II
Confusion Matrix

CONFUSION MATRIX		
	Actual positive	**Actual negative**
Predicted positive	True Positive(TP)	False Positive(FP)
Predicted negative	False Negative(FN)	True Negative(TN)

Accuracy is the percent of correctly classified instances. It is one of the most extensivelyemployed classification performance metrics and the value should be closer to 100 for better classification performance.

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \quad (1)$$

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Precision is defined as below:

$$\text{Precision} = \frac{\text{TP}}{\text{TP}+\text{FP}} \qquad (2)$$

Mathematically, recall is defined as follows:

$$\text{Recall} = \frac{\text{TP}}{\text{TP}+\text{FN}} \qquad (3)$$

F-score measures the accuracy of the testing process. It is an average measure which makes use of both precision and recalls set and is expressed in Eq. (4).

$$\text{F} - \text{Score} = \frac{2\text{TP}}{2\text{TP} + \text{FP} + \text{TN}} \qquad (4)$$

Kappa value (K) can be computed as

$$\text{K} = \frac{\text{Overall accuracy} - \text{Expected Agreement}}{100 - \text{Expected Agreement}} \qquad (5)$$

C. Results and discussion

The comparative analysis of the different classifier performance against heart disease dataset is tabulated in Table 3 and the results are illustrated in Fig. 2. From the table values, it is clear that the MLP showed worst performance with a lowest accuracy of 78.14. The SVM and LR showed competitive performance with the accuracy of 84.07 and 83.70 which is higher than the accuracy attained by MLP. Even though SVM and LR outperform MLP, it fails to show better performance than J48 classifier. Next, interms of F-score, the MLP obtained the lowest accuracy of 78.20, which implies poor classification performance. At the same time, the SVM and LR achieve better classification performance than MLP. In addition, the J48 obtained 91.50 F-score, which showed better classification performance.

With respect to precision, the maximum value indicates the better classification performance. The MLP classifier showed poor results with a minimum precision value of 78.40 whereas SVM and LR classifier attained a precision value of 84.10 and 83.70 respectively. Interestingly, the J48 classifier attained better classification performance with a maximum precision value of 91.50. It is also observed that the lowest recall value is obtained by MLP and highest recall value is attained by J48 classifier. At the same time, the SVM and LR classifiers shows almost equal performance with a recall value of 84.10 and 83.70 respectively. Finally, it is reported that the worse classification performance of the MLP classifier is proved with a lowest kappa value of 56. Next, the SVM and LR classifiers showed better performance than MLP with a kappa value of 67.67 and 66.83. It is interesting that the J48 classifier obtained that the maximum kappa value of 82.68. It is perhaps surprisingly that the J48 classifier is found to be efficient interms of all performance measures on the applied heart disease dataset. In overall, from the table and Fig, it is clear that J48 classifier is found to be the appropriate algorithm for the IoT based healthcare prediction model for heart disease.

TABLE III
CLASSIFIER RESULTS ON HEART DISEASE DATASET

Algorithm	Accuracy	F-score	Precision	Recall	Kappa
J48	91.48	91.50	91.50	91.50	82.68
SVM	84.07	84.10	84.10	84.10	67.67
LR	83.70	83.70	83.70	83.70	66.83
MLP	78.14	78.20	78.40	78.10	56.00

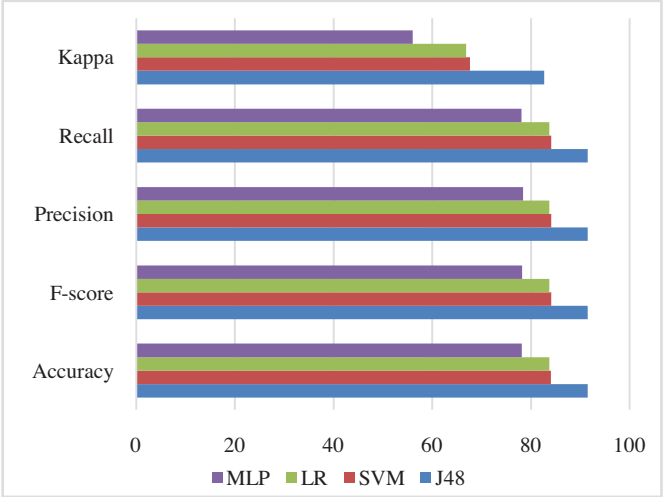

Fig. 2 Comparison of different classifier results on heart disease dataset

V. CONCLUSION

In this work, an effective Cloud and IoT based disease diagnosis model has been developed to monitor, predict and diagnose the heart disease. In this study, an efficient framework is utilized for heart disease is created utilizing the UCI Repository dataset and the healthcare sensors to predict the people who suffer from heart disease. Moreover, classification algorithms are used to classify the patient data for the identification of heart disease. Initially, the classification algorithm executes the training process which utilizes the heart disease dataset to train the classifier to identify the presence of heart disease or not. Then, the trained classifier is ready to test the incoming patient details to properly identify whether the patient suffers from heart disease. From the extensive experimental results, it is clear that J48 classifier is found to be the appropriate algorithm for the IoT based healthcare prediction model for heart disease compared to MLP, SVM and LR classifiers.

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