Cardiac Disease Detection Using IoT-Enabled ECG Sensors and Deep Learning Approach

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Abstract. These days, heart disease is a fatal disease. People from different age ranges are suffering from this disease. They sometimes are unaware of the spread of this disease and its overall impact on their health. To handle this concern, it is important to be known about the details of heart disease and the regular follow-up of the same in this era. Though the transience rate can be radically regulated when the disease is detected in the initial phases and some precautionary actions are adopted as soon as possible. We have proposed the detection of heart disease for protecting the patient's life by combining Deep Learning methods along with the Internet of Things. In order to perform proper sorting of available information, the ANOVA-F test is used as a novel feature selection algorithm. Through the proposed system, the severity level of the disease will be identified. For that purpose, it is essential to provide accurate input data using ECG sensors and IoT devices. For that purpose, it is required to categorize patient data as per kind of heart disease and its severity. Convolutional Neural Network Model will be used for the classification process. We will notify the concerned doctors about patients' health on a timely basis by referring to available data.

Keywords: Heart disease detection · ANOVA-F test · Feature selection · Convolutional Neural Network · ECG sensors · Internet of Things

1 Introduction

Nowadays, heart disease is a disease impacting several lives. Individuals are unaware of the severity and the type of heart disease they are suffering from. It is essential to be conscious of the type of heart disease and to take intensive care of disease in this fast-moving life. The diagnosis of heart disease is a difficult job as it needs expertise along with advanced information. In view of gathering the sensor values for heart disease detection, the Internet of Things (IoT) is applied in the clinical field. For performing the prediction of cardiac disease, several investigators are working in this area. In hospitals, there is an important development in intensive care units in healthcare sectors. Nowadays

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movable healthcare nursing systems with rising skills need time. The use of Internet of Things techniques can help in the growth of the medical field and transfer control from direct consulting to the online consultation. Deep learning helps produce smart computerized applications that will assist specialists to identify the disease by making use of the Internet of Things.

2 Literature Review

The exhaustive literature survey has been carried out through various sources. A comprehensive review of the literature is presented below.

D. Komalavalli, R. Sangeethapriya, R. Indhu, N. Kanimozhi and G. Kasthuri [1] have considered a system in which ML techniques are applied to create a simple TensorFlow model. It detects major features helpful in increasing accuracy for cardiovascular disease prediction. Various sets of features and classification algorithms are used in the prediction.

Sandhiya S, Palani U [2] have implemented a Heart disease monitoring system using the Deep Learning techniques and the Internet of Things by keeping the patient information as records. In this system, the algorithm for choosing the appropriate features is applied for sorting using a deep learning algorithm. Then the system screens the illness level as per inputs composed via IoT devices. Also, it categorizes the patient's particulars as per kinds of heart disease and the severity.

Bing Zhang et al. [3] proposed a BP prediction system using the CART model using biological attributes. Using the method of cross-validation, the optimum model parameters were calculated. Here, the comparison of the CART model with other standard methods is done. For choosing the most correlated variables, the Pearson correlation coefficient was also used.

Mohammad Ayoub Khan [4] has proposed a heart disease prediction system that uses wearable IoT devices along with an MDCNN classifier. Wearable technologies are used efficiently in the healthcare industry, mainly in chronic heart disease. Many patient's life who are located in remote places where medical facilities are unavailable can be saved by using these monitoring and prediction systems. Here, heart disease is predicted using pre-processing, feature selection, and classification.

Md. Milon Islam et al. [5] have applied smart healthcare to display the vital features of patients. Hospital staff can collect the patient's test report for the 4 cases where they have done tests outside the hospital. This system can help doctors and nurses in emergencies where rough information is available to them.

Shawni Dutta et al. [6] has proposed and implemented a system using deep learning methods and a stacked GRU layer-based model. Relevant features influencing heart disease are considered while designing the model with essential constraint tuning.

Irfan Javid et al. [7] have considered a grouping of Deep Learning and Machine Learning models for implementing their proposed system. It is considered for detection of the cardiac disease. This method may be highly beneficial to support the clinicians to examine the patient cases concerning their treatment.

Yuanyuan Pan et al. [8] here, the usage of a Convolutional Neural Network model is proposed and implemented for the prediction of cardiac disease. Prediction as well as.

classification done in the system, have focussed on reducing the wrong diagnosis.

Asma Baccouche et al. [9] have done categorization of four sorts of heart disease in their proposed system. The proposed system illustrated a method of taking mean and arbitrary under matching of the records, to similarly create a relational dataset for preparing classification models.

Qingyun He et al. [10] In their system, IoT technology is joined with the hospital data to provide online interaction of remote placed patients with doctors and to detect and monitor heart disease patients remotely. So, here it is tried to find the finest way to detect and control heart disease using sensor data.

P. Ramprakash et al. [11] have proposed a self-acting analysis model for heart disease detection by making use of a deep neural network. Analysis of patients' data will be done for detecting the disease.

Jian Ping Li et al. [12] have implemented heart disease diagnosis based on machine learning. Classification is done by machine learning classifiers. Feature selection is done by feature selection algorithms.

M. Ganesan et al. [13] have developed a combination of the Internet of Things and a Cloud-based heart disease detection model. Here, sensors are used to forecast people having heart disease. The patient information is classified.

Bo Jin et al. [14] have implemented an analytical model outline for heart failure verdict via LSTM methods. In the trial data examination and pre-processing, patient diagnostic actions were displayed.

Vineet Sharma et al. [15] have done classification using machine learning classification methods. The neural networks perform the classification to detect heart disease. Here, the use of SVM classifier is done for the classification. It will reduce the odds of misdiagnosis.

Abdullah Alharbi et al. [16] have proposed a heart rate prediction system to notice the initial danger of less heart rate. In the proposed system, various neural networks are used for training and testing purposes.

Armin Yazdani et al. [17] have used important features in WARM for heart disease prediction to get the maximum confidence score.

Karim Bayoumy et al. [18] have emphasized the elementary engineering values of regular wearable sensors, and wherever they can be likely to the errors. Nowadays, trials such as device correctness, scientific legitimacy, the absence of consistent supervisory rules, and worries for ill person's secrecy are still clogging the extensive acceptance of modern wearable techniques in scientific exercise.

K. Butchi Raju et al. [19] have proposed a computerized health care model using the method of cloud, fog, and edge computing. It has collected data from various hardware devices.

Edward Choi et al. [20] have anticipated an analytical model outline for HF judgment using Gated Recurrent Unit Networks.

REMARKS OF LITERATURE REVIEW

- The strategy of using a combination of IoT and Deep Learning techniques has the potential to predict heart disease.

- No researcher has addressed the issue of reducing the energy consumption and extended time monitoring of sensor devices.
- From the social point of view by increasing the accuracy of heart disease prediction lives of many patients can be saved effectively.
- Using Neural Networks, the HR prediction system works well to notify the initial danger of low HR.

3 Motivation and Contribution to Society

3.1 Key Parameters to Consider

- To discover an efficient mechanism to continually observe the ECG signal of patients using IoT sensor devices to achieve suitable prediction accuracy.
- To have an improved vision for differentiating between the behavior of various heart disease detection methods.
- To improve the capability of the system to handle a large amount of information obtained from the Internet of Things sensor devices for the whole day continuously.
- The Execution time of the system and the use of a large amount of energy are the factors that need to be reduced.

3.2 Role of the Proposed System

- The proposed system has the potential to increase the feature selection and classification techniques precision needed for Heart Disease Prediction.
- The proposed system will reduce medical errors and will contribute to saving many lives by early detection and controlling the disease effectively.
- Use of IoT and Deep Learning Techniques will be done in the proposed Heart Disease Prediction System by considering Medical Field.
- This proposed system has the potential of enhancement to the existing system because the combination of medical decision support with patients' Electronic Health Records will decrease mistakes, enhance the privacy of the patient and reduce undesirable changes in the treatment.
- Automation of systems predicting diseases will help doctors as well as patients in terms of treatment and wellness of health.
- Heart Disease is a fatal disease and it has affected many peoples throughout the world.
- We can control the mortality rate of individuals suffering from this disease using an accurate and efficient prediction system.
- The proposed system will help doctors a better way to deal with it promptly and will heal patients more precisely.
- Also, it will be profitable in accordance with the equipment, analysis and detection.

4 Proposed System Architecture

See Fig. 1.

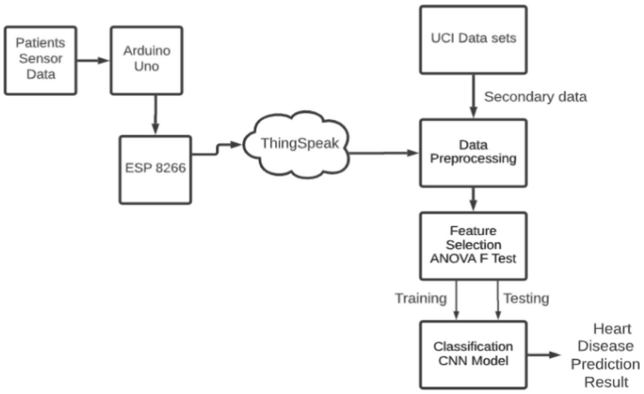

Fig. 1. Block diagram of proposed system

5 Proposed System Methodology

5.1 Requirement Analysis

- The First step of the proposed system will be to gather the patient's information using the digital standard 12-lead electrocardiograms [21] and IoT Sensor devices like ECG Sensors [22].
- Also, it is required to collect information from UCI Data Sets and consider them as secondary input.

5.2 Data Preprocessing

- Missing and noisy information will be removed from the data set through data pre-processing.
- Different pre-processing techniques used can be: Mean normalization, standardization and whitening.

5.3 Feature Selection

- By choosing appropriate features, the accuracy of heart disease prediction can be improved. The process of Feature selection begins by picking a small subset of the utmost applicable features from huge group of unique features, that affect the result most. The benefits of feature selection involve upgrading of data quality, a reduced amount of evaluation time by the prediction model, analytical performance development and an effective data gathering procedure.
- A feature selection method called the ANOVA-F test [23] will be used to choose the utmost significant features from the datasets.
- A group of parametric numerical models and their approximation measures that regulate the average of many trials of data sourced from a similar supply is termed Analysis of Variance (ANOVA). A group of numerical examinations that utilizes a few arithmetic techniques to find the proportion of the variance values such as the modification

of 2 distinct trials etc. is termed an F-test. In this test, the association of every feature is performed with the goal feature for checking if there is any mathematically important association among them.

5.4 Classification

- Convolutional Neural Network Model will be used for the classification process [4].

5.5 Testing

- The classification model will be tested on the considered datasets using the chosen set of features to predict the results. The prediction model will be trained on whole data with 80% training and 20% testing subsets.
- It will provide accurate results after passing through multiple phases of evaluation.

6 Datasets

6.1 Heart Disease Dataset

It includes four databases as Cleveland, Hungary, Switzerland, Long Beach V [26].
Few attributes from the data set are as follows:

1. Age
2. Sex
3. Chest pain type (4 values)
4. Resting blood sugar
5. Resting blood pressure
6. Serum cholesterol in mg/dl
7. Fasting blood sugar $>$ 120 mg/dl
8. Resting electrocardiographic results (values 0, 1, 2)

6.2 Heart Failure Prediction Dataset [27]

Few attributes from the data set are as follows:

1. Resting BP
2. Cholesterol
3. Fasting BS
4. Resting ECG
5. Max HR
6. Exercise Angina

6.3 Cardiovascular Disease Dataset [28]

Few attributes from the data set are as follows:

1. Systolic blood pressure
2. Diastolic blood pressure
3. Weight
4. Gender
5. Age
6. Height
7. Cholesterol

6.4 PTB-XL Dataset [29]

Few attributes from the data set are as follows:

1. ecg_id
2. patient_id
3. device
4. recording_date
5. report
6. scp_codes

7 Evaluation Parameters

Performance of the proposed system will be obtained based on the standard metrics [2] as follows:

The result of the person infected with the disease and recognized properly is measured as the True Positive (TP). The result of the person not infected with the disease and recognized as infected is measured as the False Positive (FP). The result of the person not infected with the disease and recognized as not infected is measured as the True Negative (TN). The result of the person infected with the disease and recognized as not infected is measured as the False Negative (FN). All of the above-mentioned measures are applied to find specificity, sensitivity and prediction accuracy. The potential to find out individuals affected by a particular disease accurately is termed Sensitivity.

The potential to find out individuals not affected by a particular disease accurately is termed Sensitivity. To calculate accuracy of the classification, we have to use sensitivity and specificity.

They are represented mathematically as follows:

$$\mathrm{ST} = [TP/(TP + FN)] \times 100$$
$$\mathrm{SP} = [TN/(TN + FP)] \times 100$$
$$\mathrm{AY} = [(TP + TN)/(TP + TN + FP + FN)] \times 100$$

where ST stands for sensitivity, SP stands for specificity and AY stands for accuracy. All these estimation parameters are applied for checking the performance of the proposed disease monitoring system.

8 The Choice of Method for ECG Signal Reading

Various options are available for the ECG Signal reading based on sampling techniques. Table 1 illustrates the variation based on its performance [24].

Table 1. Sampling Techniques for ECG Reading

Unique ECG signal			
Name of segment	Duration (seconds)	Count of samples	Sampling rate
SQ	0.850	200	175.23
PQRST	0.480	85	210.15
QRS	0.05	20	190.05
RR	0.7	150	180.21
Uniform sampling technique			
Name of segment	Duration (seconds)	Count of samples	Sampling rate
SQ	0.890	153	185.23
PQRST	0.390	75	180.15
QRS	0.06	15	255.05
RR	0.90	160	195.21
Adaptive sampling technique			
Name of segment	Duration (seconds)	Count of samples	Sampling rate
SQ	0.775	115	130.26
PQRST	0.400	55	155.25
QRS	0.150	25	118.09
RR	0.85	125	125.21

Our proposed system has utilized the adaptive sampling for the purpose of ECG readings. The decision for the same is dependent on the research study done by Yuan et al. [25] which specifies that for the reduction in the energy consumption it is efficient to make the selection of adaptive sampling.

9 Conclusion

Nowadays heart disease is considered as one of the deadliest diseases having a high impact on mortality and turning into one of the reasons for demise everywhere in the world. The harm produced by this illness can be minimized highly if suitable measures of clinical care are taken at the initial steps.

As we are making the combination of ECG Sensor data using IoT and considering the UCI data set like CVD, Framingham and ECG Data sets as Secondary data, it will help in getting more variation in the data used in the analysis as compared to existing

systems. Also, the proposed system will select the significant features using ANOVA F TEST which provides a good impact on the performance of the model. The use of the Convolutional Neural Network model for the classification technique will give us accurate heart disease prediction results for the large data set.

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