IoT and Machine Learning Based Health Monitoring and Heart Attack Prediction System

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Abstract. The increased use of mobile technologies and smart devices in the area of health has caused great impact on the world. Health experts are increasingly taking advantage of the benefits of these technologies and hence generating a significant improvement in health care in clinical settings. Internet of things (IoT) and machine learning techniques can be used efficiently for this purpose. The objective of this work is to design and develop a real-time IoT based health monitoring and heart attack prediction system that integrates vital signs sensors, location sensors, ad-hoc networking and web portal technology to allow remote monitoring of patient’s health status and to predict the heart disease through various machine learning techniques. In this work it has ensured the correct and efficient transmission of the vital signs data to the ThingSpeak server through the internet via a given access point (AP) and notified the user of the same through the GSM module. A heart attack prediction system is also developed to predict the probability of heart attack from the available parameters. The novelty of the proposed work is that it takes the advantage of both the IoT and machine learning technology to monitor and predict the diseases. The proposed system is inexpensive too.

Keywords: Health monitoring, vital signs, IoT, heart attack prediction system, machine learning.

1. Introduction

Recent advances in wireless networking, microelectronics and wireless sensors help to cope with the imminent problems and social challenges of a growing aging population. The population of India is increasing continuously and simultaneously the number of elderly people is constantly increasing. Health maintenance costs are also increasing due to novel technological solutions in hospitals. One effective way to address the above problems could be to shift health monitoring from hospital systems to those places where elderly people live. This solution allows the elderly to stay longer at home, hence increasing the accessibility of proper healthcare. This can also provide more independence to them while monitoring their overall health at lower cost.

The proposed idea is to develop a health monitoring system that takes the advantage of IoT and artificial intelligence to allow remote monitoring of patient status. This system can be deployed in both indoor and outdoor environments and enables transmission of both routine and emergency vital signs. The patient’s probability of heart attack is also predicted by continuous monitoring of the ECG signal.

The health monitoring systems with and without IoT can be found in many literatures. R. Ali Khan et al. explains a system architecture of a wireless body area sensor network for health monitoring [1]. Similarly, R. Buls et al. explains a body area networks for ambulant patient monitoring over next generation public wireless networks [2]. The wearable health monitoring system can be found in many past works [3,4]. Proper sensor network is required for proper monitoring in health care system [5,6]. M. Zaharia et al. shows resilient distributed datasets for in-memory cluster computing. The use of IoT
in health monitoring system is very useful and gives many advantages [8-10]. The use of artificial intelligence and machine learning techniques makes the health care system more applicable and reliable [11,12]. In this work, the architecture of a real-time wearable IoT based patient monitoring system is designed and developed.

2. Experimental work

![Flow diagram of the proposed work](image)

**Figure 1. Flow diagram of the proposed work**

The work flow diagram of the proposed work is shown in Figure 1. The sensors used for the measurement of body temperature, position/gesture of the person and the blood oxygen saturation level measurement are LM35, MPU 6050 and MAX30100 respectively. The AD8232 is an integrated signal conditioning block for Electro cardio gram (ECG) and is used for the acquisition of the ECG signals for heart attack prediction. All the sensors are selected based on their performance reviews in sensing the respective health parameters. All the sensors are connected to NodeMCU. The NodeMCU is connected to a specific access point. The processor used in this work has two units, that is a micro controller unit NodeMCU and a wifi unit ESP8266. The sensor data collected by the microcontroller is sent to the ESP8266 for transmitting to cloud via WiFi. The cloud solution used for storing and analysis of data is called ThingSpeak. ThingSpeak is integrated with MATLAB by Mathworks which is used for graphical representation and analysis. The end-user can connect to the ThingSpeak using an internet connection. The data stored in cloud can be used for the analysis of the parameter and continuous monitoring purpose. The data is transmitted via internet through the access point. The data transmission is done in the form of packets. The transmitted data is acquired by the ThinkSpeak server. The data is received in the form of string data type and is decoded by the ThingSpeak server for further analysis. The ECG data acquired from the ThingSpeak server is applied to the machine learning algorithms to predict the heart attack. The flow chart for the heart attack prediction is shown in figure 2. In the proposed system, the
software implementation has played a major role while retrieving the sensor data and updating it to the server. Here, the software mainly used is ARDUINO IDE. The ARDUINO IDE is an embedded programming platform which supports various microcontrollers and provides a complete programming environment for the microcontrollers.

Figure 2. Flow chart of the heart attack prediction system
3. Results and Discussion
The ThingSpeak channel used for this experimental work is shown in Figure 3. The temperature data acquired from the ThingSpeak server is plotted and is shown in Figure 4. The patient movement data acquired from the ThingSpeak server is plotted and is shown in Figure 5. The blood oxygen saturation level data acquired from the ThingSpeak server is plotted in Figure 6. All the plots are plotted with respect to time. These plots provide the information of the required data throughout the day. These plots are helpful for the physicians and care takers for the proper diagnosis and caring of the individuals.

![The ThingSpeak channel](image)

**Figure 3:** The ThingSpeak channel

![Temperature plot](image)

**Figure 4:** Temperature plot (received signal from ThingSpeak)
To test the model for the heart attack prediction, different machine learning techniques are implemented using the ECG output signal acquired from the AD8232 sensor. The serial monitor for ECG output from AD8232 is shown in Figure 7. Number of entries in the dataset is 304. The graph for comparison of the test set dependent variable (Y_test) and the predicted values (Y_predict) obtained after applying different
machine learning techniques are shown in Figure 8. The different classifiers and their maximum accuracies obtained in the classification of heart disease is shown in Table 1. This table shows that the highest accuracy is obtained by the RBF SVM machine learning algorithm. The reason for this highest accuracy is that the RBF SVM is compatible with the ECG data used in this work. The reason may be this algorithm is proven to be optimal for linearly separable cases.

Figure 7. Serial monitor for ECG output from AD8232

Figure 8: comparison of the test set dependent variable (Y test) and the predicted values(Y_predict) obtained after applying different machine learning techniques.
Table 1. Different classifiers and their maximum accuracies obtained in the classification of heart disease

| Classifier                  | Maximum Accuracy |
|-----------------------------|------------------|
| 1. Simple Linear Regression | 49.8%            |
| 2. RBF SVM                  | 80%              |
| 3. K Nearest Neighbor       | 50%              |
| 4. Gaussian Naive Bayes     | 50%              |

4. Conclusion
The sensors are successfully interfaced to acquire the vital signs data and then the data is accurately transmitted to the ThingSpeak server. The transmitted and received signals were compared and found to be accurate. However, a time delay of 2-5 minutes has been observed between transmission of message from the client and reception by the server. Also, for the notification of anomalies in vital signs a GSM module is used to send a message to the user. The heart attack prediction model with the help of machine learning models is also implemented using appropriate dataset. The experimental results showed that the RBF SVM classifier has given the highest classification accuracy of 80%. The novelty of the proposed work is that it takes the advantage of both the IoT and machine learning technology to monitor and predict the diseases. The proposed approach is a low-cost system too. The proposed work can be extended with a real-time heart attack prediction system by continuous monitoring of ECG signal.

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