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***Research paper***

# Real-Time Health Care Monitoring System using IoT

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**Abstract**

Incorporation of Information and Communication Technology (ICT) in healthcare industry explored the possibilities to optimize the supply of all the available medical resources and provide reliable, efficient healthcare services to the aged people and patients with physical disabilities and chronic illness. In consumer electronics and growing costs of healthcare a vision of connected e-health has evolved which constitute Personal Health Devices (PHD). Present day mobile devices are capable enough to gather data from various sensors and often play a role in physical fitness gateway and then data are collected in PHDs. The network overhead and suitability of the proposed solution for the different environment is presented which includes the integration of different wireless interfaces with cloud services. The work focuses on adapting the MQTT (Message Queue Telemetry Transport) communication model. This protocol is preferred over CoAP which is one-one protocol because it is one of the lightweight protocols used in TCP/IP and it has the feature of many to many communication models. The evaluation of the work is on a PHD prototype device and feasibility of the solution is discussed. The proposed work is to design and develop a Real-time healthcare monitoring system using IoT which is featured with Random Forest algorithm for heart disease prediction by gathering patient's data from various PHD sensors and timely alert the caretaker as well as a doctor by sending messages through MQTT. It monitors the patient's physiological parameters remotely and diagnoses the heart diseases as early as possible.The main motto is to reduce the cost of healthcare and give people the awareness about health and fitness.

***Keywords:*** *IOT, ICT, Personal health care, CoAP, MQTT, Random Forest Algorithm.*

## 1. Introduction

In today's era, the rapidly growing population and insufficient healthcare facilities to all urge people to move towards the emerging idea of "Self Healthcare". The increasing cost of healthcare and the sedentary lifestyle of people with unhealthy food habits lead to increase in chronic diseases such as Cardio Vascular disease (CVD), hypertension, diabetes, stroke, etc. According to World Health Organization (WHO), cardiovascular diseases cause nearly 31 percent of all global deaths every year (estimated 17.7 million deaths in 2015) and it keeps on increasing at an alarming rate. Similarly, numbers of diabetic people have been quadrupled to 422 million (2014) from 108 million (1980). Continuous surveillance of patients and early detection of chronic diseases is the need of the hour to avoid the risk of its fatal effects. In recent years, hospitals and rehabilitation centers face many challenges such as complex installation and wiring of the monitoring devices, effective patient monitoring, proper devices maintenance, etc in providing adequate health facilities to all [1].

Internet of Things (IoT) is an emerging technology which is used to interconnect humans and other objects anywhere and anytime through the internet domain. Experts forecast that 50 billion devices or things will be linked to the Internet by theyear2020.IOT in the medical field is used for remote monitoring of patients through Personal Health Devices and send timely notification messages to doctors and caretakers during an emergency situation. Personal Health Devices (PHD) is the devices which are used to collect the patients' health data.

The collected personal health data include Temperature, pressure, breathing activity, Heartbeat, glucose, blood PH level, fall detection. This technology enables to deliver healthcare services over a long distance and also minimizes the cost of healthcare services through less hospital stays, less travel time and shared clinicians and professionals.

Compared to other existing protocols, Message Queuing Telemetry Transport (MQTT) protocol plays a vital role in M2M communications. MQTT is an application layer protocol which is used to transmit messages by connecting devices through constrained approach. It is lightweight protocol when compared to all other protocols. It is based on publish and subscribes messaging pattern through MQTT broker. The main advantage of MQTT is that it will buffer the unsent messages during broker disconnection and will send to the subscriber when it is connected again.

Machine learning is an algorithmic application of computer science that enables the systems to learn, act and improve them automatically without being programmed explicitly. Machine Learning algorithms are used for comparing the health data with an existing data set of a person and enable it to analyze further. Random Forest algorithm is used to find the accurate predictions about diseases using the collected health data [14]. The real-time monitoring process is not only for the patients but it also suites the normal persons for maintaining the fitness of their life.[2]

In order to address the key issues present in the existing healthcare systems, the proposed project aims to design and develop Real-time Healthcare Monitoring System using which is featured with a combination of MQTT protocol for transmitting the data between clients and Random Forest Algorithm for predicting the possibility of heart disease. The proposed system will be used by the doctors and medical professionals to diagnose the diseases as soon as possible and provide appropriate treatments.

### 1.1 Overview of MQTT

In IOT protocol, both COaP and MQTT (Message Queuing Telemetry Transport) are widely used for transmitting the data between IoT devices and the host server. Compared to CoAP protocol, MQTT protocol has high reliability and low power and thus made a good choice to IoT networks. Being lightweight, MQTT is a messaging protocol that enhances transmission and distribution of telemetry information between clients in a simple way [10]. The protocol is based on publish and subscribe messaging pattern in contrast to HTTP request/response model and transmit data between machine-to-machine (M2M) as well. The main advantage of it [16] is to reduce the network bandwidth issue, achieving high reliability on unreliable connections and assuring message delivery during disconnect.

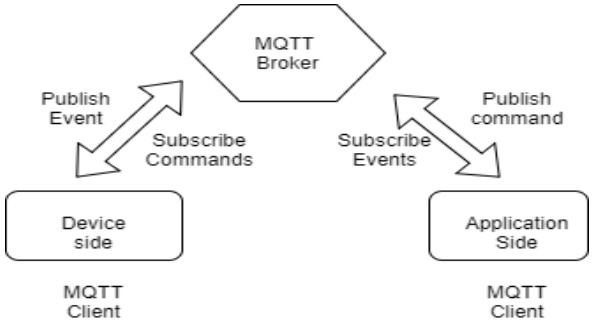


**Fig. 1:** MQTT System

## 2. Related Work

Tele-monitoring healthcare system monitors the patient's health parameters through a collection of body sensors' data using Raspberry Pi board [2]. The patient's health report is developed and displayed on a webpage where doctors and patients can communicate each other without physical presence [4]. The patients' health parameters are collected through Raspberry Pi microcontroller and transmitted to the physicians and caretaker wireless using Body wireless sensor Network (BWSN) [5].
Through Ciphertext-Policy - Attribute-Based Encryption (CP-ABE) method, the web server rings an alarm to the ambulance [6] if the patients' health is at stake. The main challenge is to make elders equipped with growing new technologies and to become familiarity towards Smartphone, computer, etc. [7].IoT based Smart healthcare along with smart devices reduce complexity and complications through intelligent integration of data collected, maintaining the integrated data smartly through cloud service [8].

The main objective of M-health and E-health applications is to make people aware of healthy eating habits and effective workout routines for improving their quality of healthy life [9]. In remote mobile health monitoring system, the patient health parameters are recorded by a smartphone by eliminating an additional hardware and transmit data through a web interface [16]. The challenge in wearable tracking devices is based mainly on small size, rough use and low energy consumption [2]. The two fundamental aspects of monitoring people at risk are1) Prevention 2) Effective and early intervention during a medical emergency [12].

## 3. Proposed Methodology

The proposed system is mainly designed to have real-time health monitoring system that provides healthy life and timely care through emerging technologies. The system comprises of major parts.

1. **Medical Sensors:** Vital signals such as temperature, pressure, and heartbeat sensor are periodically measured from the patient by using corresponding sensors.
2. **Processing and Analysis:** The vital parameters are analyzed and checked against the health standards to detect the abnormal condition of the patient being monitored.
3. **Alert assurance:** In case of any abnormality, an alert message to the doctor and caretaker will be viewed through Dashboard, Web interface, mail notification and mobile app is ensured.

### 3.1 Proposed Framework

Fig:2 In the proposed framework, the real-time data from the sensors can be collected through sensor technologies and transmitted via MQTT protocol and published to the MQTT client. Eclipse Paho is used for message communication between the clients. Then, the collected data are stored in the back-end client database for further analysis in the clinical process to predict the diseases early and provide timely medication.
The end user Dashboard can be prepared by subscribing the collected data from the MQTT client and displayed in an interactive mode where everyone can understand the health status easily. The mail notification regarding the patient current health status can be sent through the SMTP protocol to the doctor and caretaker for further treatment. The Dashboard can be viewed on a web server and Mobile API. Patient's location is monitored to assure that the patient can be reached in case of any emergency situations.The patient's health status can be tracked through the Dashboard on regular basis to improve the health condition of the patients. The daily health tip can be provided based on the health condition of the patients.

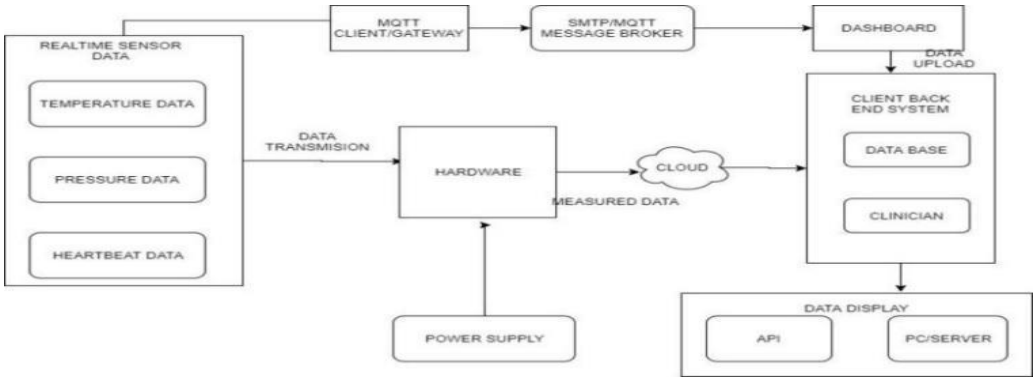


**Fig. 2:** Framework of Real-Time Health Monitoring System

### 3.2 Algorithm

There are numerous algorithms available for predicting the heart diseases but the real challenge is to choose the best fit algorithm to get an accurate projection in predicting the possibility of the heart diseases. The main purpose of accurate prediction is to timely alert the caretaker and doctor for immediate treatment in case of emergency. Random Forest algorithm is considered to be one of the

most powerful and popular supervised machine learning algorithms in predicting the possibility of heart diseases. It is an ensemble type machine learning algorithm that consists of many decision trees that fits into many subsets of dataset samples and to enhance the predictive accuracy using averaging method. Each decision tree is constructed by using a Random subset of the training data. The important features of Random forest are faster runtimes, handling unbalanced and missing data and provide nearly accurate prediction when compared with other machine-learning algorithms. Random forest performs efficient by handling binary, categorical and numerical features without need of scaling.

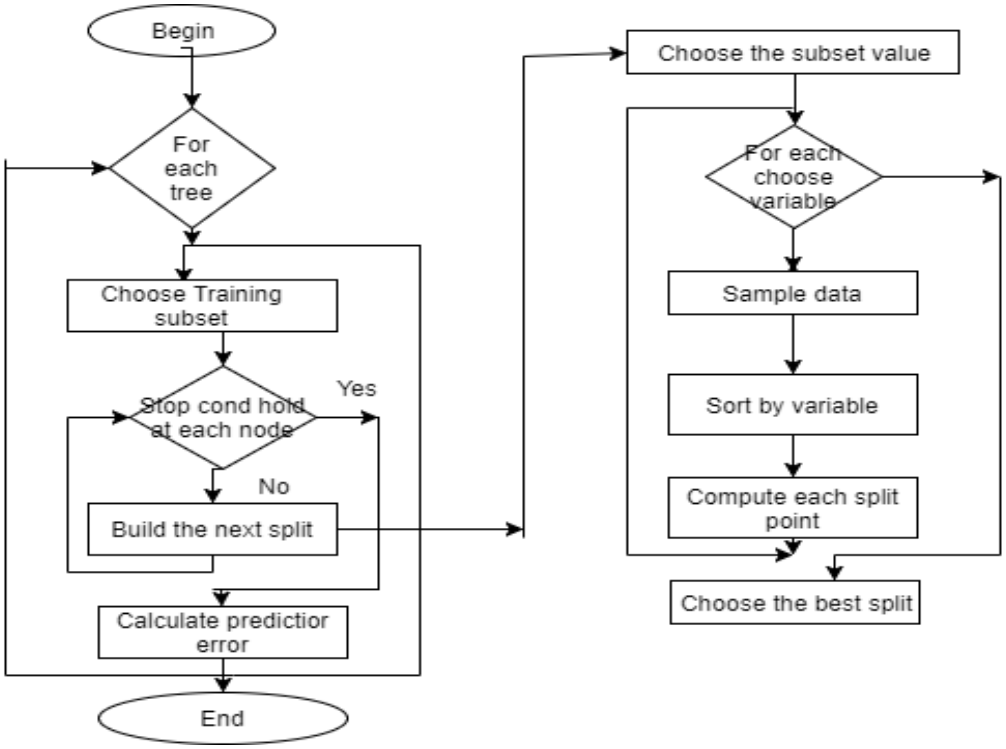


**Fig. 3:** Random Forest Algorithm

## 4. Implementation

The proposed architecture can be divided into three phases such as data acquisition phase, data transmission and data display & data storage phases.

### 4.1 Data acquisition Phases

The temperature sensor, pressure sensor, spo2 sensor are using for detecting the Heart related problem. The pulse oximetry is used for measurement of oxygen content in haemoglobin. If the brain does not receive sufficient amount of oxygen, it will lead to the cerebral hypoxia. The developed real-time pulse oximetry monitoring system consists of pair of light-emitting diodes (LEDs), One LED has a red wavelength and other one has a infrared wavelength. The photodiode can be used to detect the light emitted [17]. The Velcro strip can be used to pack the LEDs and photodiode that faces the patient's fingertip.

**The principle of measuring Pulse Oximetry**

The transmitted light through the tissue of the finger can be calculated using Beer-Lambert Law in the Equation.1 as follows.

$$I_{0utput} = I_{in\,e^{A}} \quad (1)$$

$SpO_2$ can be calculated by using this Eq.2

$$SpO_2 = \log\left({}^{R\,rms}/_{IR\,dc}\right)/\log\left({}^{IR\,rms}/_{IR\,dc}\right) \quad (2)$$

Heart rate can be calculated by measuring the peak value of IR signal in Eq.3

$$Heart\ Rate = {}^{60}/_{periods_{(seconds)}} \quad (3)$$

## 5. Experimental Setup

The proposed method is implemented in Raspberry Pi board. IoT server is attached to the devices which helps in controlling the devices and remotely access the network. The temperature sensor, pressure sensor, and Heartbeat sensor are interfaced with the board as shown in Fig 4. The sensor signals can be read and displayed in the raspberry pi terminal. The information can be transmitted to IOT server for further analysis.

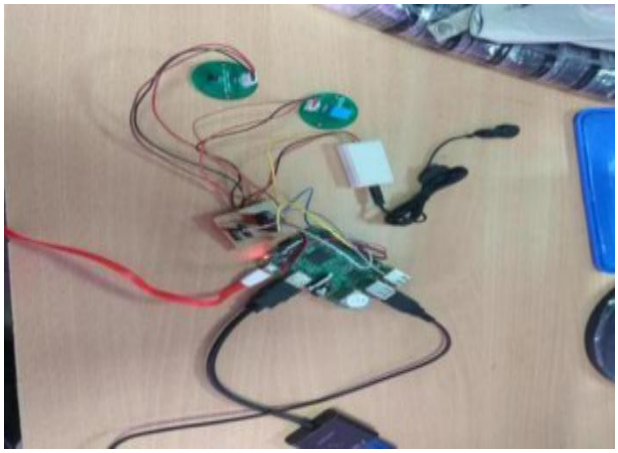

**Fig. 4:** Setup of Hardware with Sensor

## 6. Performance Evaluation

There are various machine learning algorithms available for the prediction of the possibility of heart disease using health data [15]. But it is very important to select the best algorithm which provides an accurate prediction of heart disease. We have chosen the four machine learning algorithms namely Random forest, Knn algorithm, logistic algorithm and Naive bayes for the analysis. Using python matplotlib script, we will compare the performance of these algorithms and select the best algorithms based on accurate results. We will use our test data along with sample dataset of 303 records from the University of California Irvine (UCI) machine learning repository for comparing and analyzing these algorithms results.
139 out of 303 records belong to class A (possible heart disease) and 164 records are with class B (No possibility of heart disease). Using python Matplotlib script, performance and comparison analysis of an algorithm are based on the confusion matrix which is a table that shows the number of correct occurrences and incorrect occurrences predicted by the algorithm. The following measures are used to analyze the performances of machine learning algorithms. Confusion matrix is described in Table:1

- **SN (Success normal value):** depicts the total number of normal occurrences predicted correctly by the machine learning algorithm
- **FN (Failure normal value):** depicts the total number of normal occurrences predicted wrongly as abnormal by the machine learning algorithm
- **FA (Failure abnormal value):** depicts the total number of abnormal occurrences predicted wrongly as normal occurrences.
- **SA (Success abnormal):** depicts the total number of abnormal occurrences predicted correctly by the machine learning algorithm.
- **Success Prediction:** It depicts the total number of success normal and success abnormal predictions for the specified dataset.

Success Prediction = SN+SA

- **Failed Prediction:** It depicts the total number of failure normal and failure abnormal predictions for the specified dataset.

Failed Prediction = FN+FA

**Table 1:** Confusion Matrix

| Confusion Matrix | | Prediction | |
|---|---|---|---|
| | | Normal | Abnormal |
| Health Status | Normal | SN | FN |
| | Abnormal | FA | SA |

Fig 5-8 The performance of above four algorithms can be evaluated with the basic parameters such as success normal, failure normal, success abnormal and failure abnormal of class B(Normal Condition) and class A(Possibility of heart disease ie Abnormal condition).

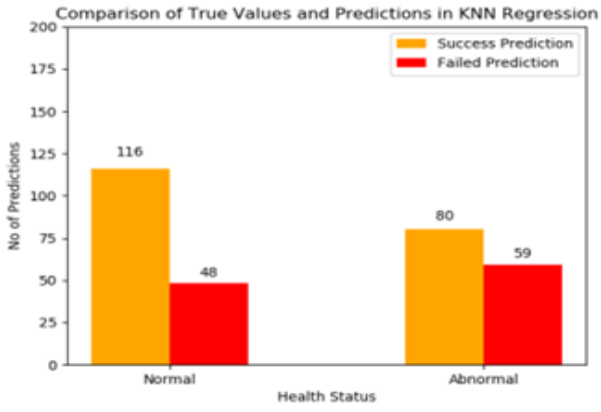


**Fig. 5:** KNN Prediction

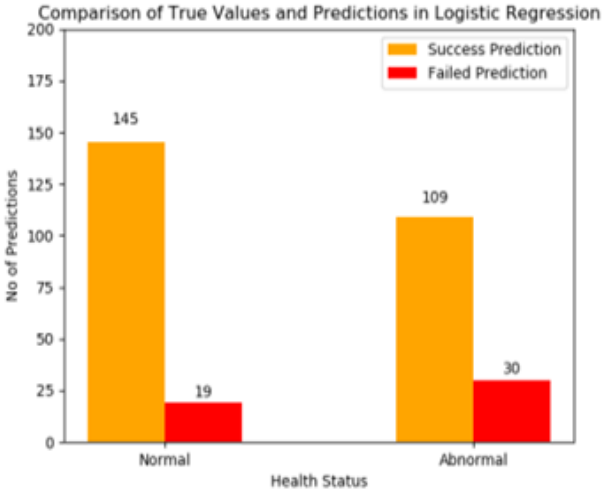


**Fig. 6:** Logistic Regression Prediction

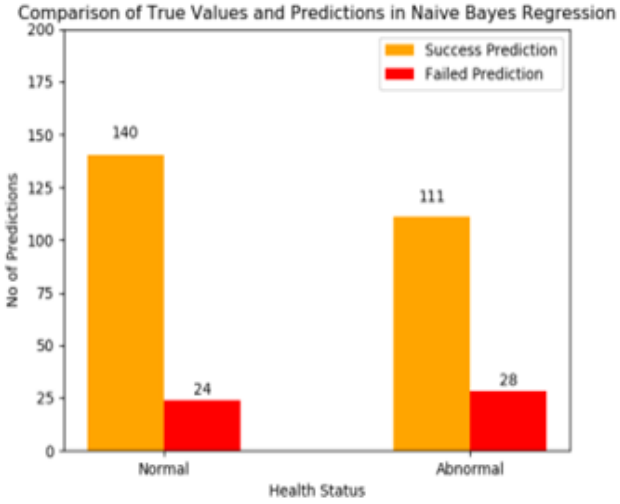


**Fig. 7:** Navie Bayes Prediction

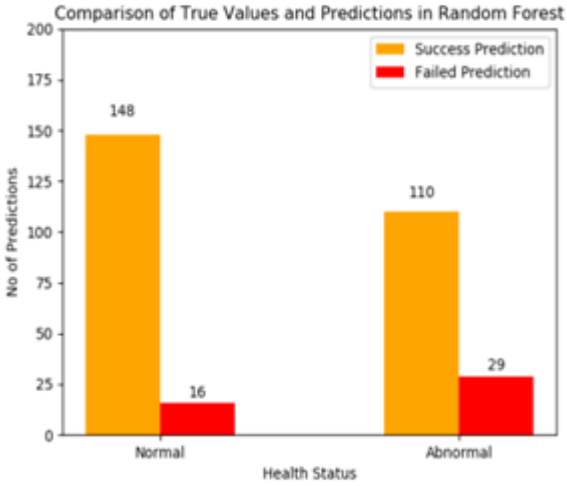


**Fig. 8:** Random Forest Prediction

## 7. Result and analysis

Experimental setup uses the various datasets to analyze the accuracy of the specified algorithms and improves the prediction of the possibility of the heart diseases. The performance of these

algorithms can be analyzed based on the measurement of the accuracy of predictions.

**Accuracy** It depicts the total number of success normal and success abnormal predictions for the specified dataset.Accuracy of each algorithm is specified in Table2.

Accuracy = (SN+SA)/N, where N be the total number of records (ie 303).

**Table 2:** Accuracy

| SML | Correctly classified instances | Wrongly classified instances |
|---|---|---|
| KNN | 246 | 57 |
| Logistic | 254 | 49 |
| Naïve Bayes | 251 | 52 |
| Random Forest | 258 | 45 |

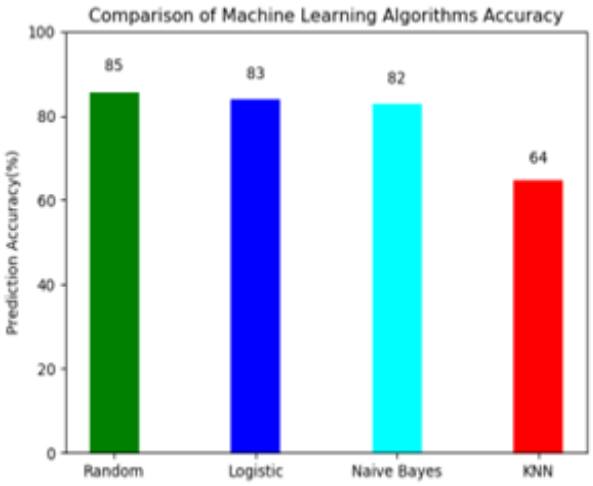


**Fig. 9:** Comparison of ML Result

The comparative result can be calculated based upon the prediction of successive and failure rate of normal and abnormal values. From the above figure 9 of health status prediction results, Random forest algorithm performs well with an accuracy of 85% compared with other machine learning algorithms of Logistic regression algorithms with 83%, Naïve Bayes algorithms with 82% and Knn algorithms with 64%. Hence, random forest algorithms have an edge over other algorithms in predicting the possibility of heart diseases.

## 8. Conclusion

Many researchers are focusing towards the application of emerging IoT technology in several industries including healthcare. IoT technology provides possible openings for the development of smart systems for healthcare. This paper proposes an intelligent real-time patient monitoring system which can be used in hospitals and homes for predicting the possibility of heart diseases. The proposed patient monitoring system monitors the subject's vital parameters such as temperature, pressure, and Heartbeat as well as detects any abnormality in the behavior of heart functions accurately. Appropriate medications are suggested based on the diagnosis of the provided set of symptoms. The system sends an alert message to the caretakers and doctors in case of any abnormality. The proposed method enables the clinicians to optimize the usage of available medical resources and minimize the costs of monitoring the patients especially heart patients. The adaptive learning ability of the developed system improves the forecasting accuracy and results in enhanced decisions. The system remains more reliable and robust.

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