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Research paper

Application of Data Analytics for Iot based Healthcare System

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Abstract

An Information and Communication Technology (ICT) is an emerging field in the healthcare system applications for efficient health monitoring, disease detection and treatment process. Current venture of Internet of Things (IoT) in ICT has paved the way for continuous heath monitoring remotely and wirelessly. By regular health monitoring, diseases can be diagnosed and treated very early. In this research work, a remote healthcare monitoring system is proposed with cloud service and data analytics as the aiding features. The readings are captured by mobile phone and this acts as the graphical user interface to get the status of patient's health. Also, the necessary information is shared to the doctors and authorized personnel through a web interface. Henceforth, the patient's health condition could be observed from the remote diagnosis center. The experimental results illustrate that the proposed model can continuously observe the physiologic parameters and suitably report the health status of user.

Keywords: *Healthcare; Data analytics; Classification algorithm; Internet of Things (IoT)*

1. Introduction

Recently with the growth of ICT technology and its impact in science, engineering and healthcare, the traditional diagnosis services in health care domain have turned out to be insufficient to meet the current user's need. With the rapid increasing of the elderly population coupled with a longer life span, e-health is targeted to provide low cost and everyday household usage. In fact, the Remote Mobile Health Monitoring (RMHM) system has become a research hotspot in recent years. It is possible to monitor the user's health condition in real-time. Furthermore, long-term and continuous detection is also achievable. Since it can help doctors to process regular monitoring and to achieve on-time remote diagnosis, RMHM will not only guarantee the patient's quality of life, but also lessen the overhead of the traditional medical system and the cost of public health.

For RMHM systems, a traditional approach is to adopt wearable textile, wireless monitoring, and patient tracking as given in Figure 1. In recent years, physiologic sensors and wireless communication have gained great progress. Various RMHM systems have been proposed, but there are still limitations and challenges in improving their application. The principle disadvantage of healthcare monitoring systems is that patients are inhibited within smart rooms and beds incorporated with monitoring equipment. Patient comfort is another issue, as some may find wearing vests with several sensors physically uncomfortable, restrictive, and even irritating. Healthcare applications require lightweight devices with sensing, computation, and communication capability so that they can be comfortably.

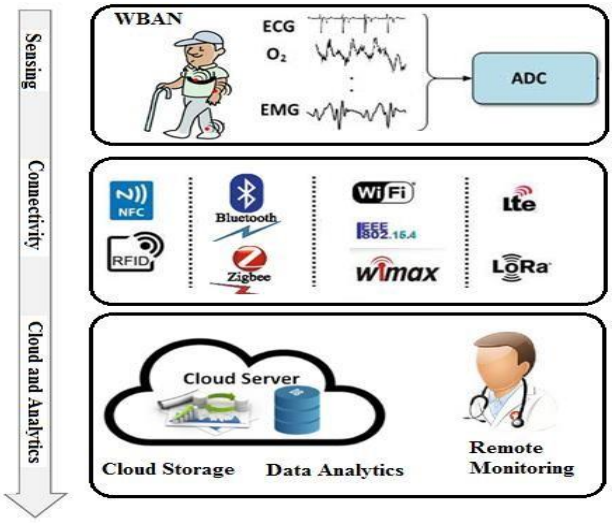


Fig. 1: IoT healthcare system architecture

In this paper, an RMHM system based on smart phone and web service is proposed and implemented for patients with chronic diseases, especially the elderly. The portable terminal integrates vital sign sensors to monitor physiologic data. Smart phones are used as both an intuitive human-machine interface and an information transmission platform so that a user can easily master his/her own health status.

The rest of the paper is organized with different sections. Section II gives a detailed description of related work in health care monitoring systems with IoT and data analytics. Section III elaborates the proposed IoT based health care monitoring system with big data analytics. Section IV describes the design development process. Section V describes the experimental results and discussion. Section VI comprises the conclusion.

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2. Literature Review

This section discusses the exploration carried out for the design of a remote healthcare monitor system by different researchers. Survey was carried out on present communication protocols and security problems related to health monitoring, their limitations and possible solutions were described. After which a basic protocol stack design was proposed for handling interoperability in heterogeneous low-power wireless body area networks.

In [1], researchers proposed that Internet of Things (IoT) innovation has pulled in significant consideration as of late for its capability to reduce the issues in healthcare area mainly because of ageing population and a rise in chronic illness. As indicated by them, this identifies with every region of the model, assessing their qualities, shortcomings, and general reasonableness for a wearable IoT human services framework. They have also explained the real time problems that the healthcare IoT faces comprising wearability comfort, security and privacy and low-power operation. The research work in [2], has shown few future research directions in e-healthcare.

In [3], researchers proposed streamlined machine learning algorithms to predict efficiently the cardiovascular disease outbreak among disease-frequent communities. To handle the problem of incomplete data, they have used a latent factor model to recreate the data which is missed. Also, very few of the current work focused on data types in the field of medical big data analytics. Contrasted and a few normal forecast calculations, the expectation exactness of their proposed calculation is speedier than that of the Convolutional Neural Network (CNN) based unimodal illness hazard forecast calculation.

In [4], researchers proposed a framework for Structural Health Monitoring (SHM) using IoT technologies on intelligent and reliable monitoring. As the data generated by sensors and other input devices are rapid and voluminous than ever, big data solutions are initiated. This helps to deal with the complex and huge volume of data gathered from sensors deployed on structures. In [5], researchers proposed a Wearable 2.0 healthcare system to enhance Quality of Service (QoS) and Quality of Experience (QoE) of next-generation healthcare systems. They have proposed a framework which comprises of sensors, actuators, electrodes, and connecting wires as the basic elements to gather patients' physiological information. Further the users' health status will be analyzed with the advanced cloud-based machine learning algorithms. Such analysis results are provided to the user for the betterment of their healthy life.

In [6], researchers proposed a scheme to detect diabetic retinopathy in its initial stage which has become a vital initiative as it decreases blindness prevalence. They have proposed a Classification and Regression Trees (CART) classifier which discriminates Micro Aneurysm (MA) and non-MA pixels effectively. The proposed method attains a remarkable classification accuracy of 98.6% and their results reveal that the proposed system performance is comparable to clinical experts. In [7], researchers have studied and implemented a remote healthcare monitoring model using mobile phone and web service facilities. This guarantees an end-to-end solution by measuring physiologic parameters such as heart rate and respiration rate, with the help of IoT health care related wearable sensors. The data is further stored in a mobile phone which acts as the graphical user interface to get the status of patients' health. Their experimental results have shown that the proposed method can constantly monitor the physiologic parameters and eventually notifies the current position to the user.

In [8], researchers proposed a multi-parameter health monitoring system that uses Arduino as the controller to detect the disease. Primarily human health is related to his own level of functional and metabolic efficiency. The researchers have prototyped the system in Arduino environment using an array of sensors and focused on monitoring the general abnormal state of the patient and early detection of disease.

In [9], researchers proposed a remote patient monitoring through patient authentication as it is a challenge in IoT. They have proposed a novel authentication framework based on biometric modalities and wireless device radio fingerprinting. Their framework is able to check that the monitored data belongs to the appropriate patient during the entire session, and ensuring the integrity and trust of the received information.

In [10], researchers proposed that there are several systems available for IoT based healthcare and ambient-assisted living named as the Internet of Health Things (IoHT). They have also identified the technological advances made so far and their results gives an overall picture to serve as a source of information for healthcare providers, technology specialists, researchers and the general population to progress in Internet of Health Things

In [11], researchers proposed an idea to design and develop heart rate measurement equipment that captures real-time data. This data will the physician via the internet. In the proposed system, body temperature and heart rate wireless sensors were used. This paper gives a glimpse of heart rate monitoring system as a prototype. The major hardware elements utilized in this research work are pulse sensor to check the heart condition, a microcontroller, and wireless connectivity device. The compact heart rate estimation module was tested and the outcomes demonstrate that the real-time heart rate measurement could be effectively monitored both in local and remote locations. In [12], researchers proposed that there is no need for monitoring of patient health by care takers. Hence a constant monitoring of patient's wellbeing using wireless network is developed.

3. Proposed System Architecture

The sensor modules incorporate in the embedded device yield analogue value which can be interpreted by calibrating the sensors. These readings are transmitted to the cloud which can be used by both smart phone and analytics module.

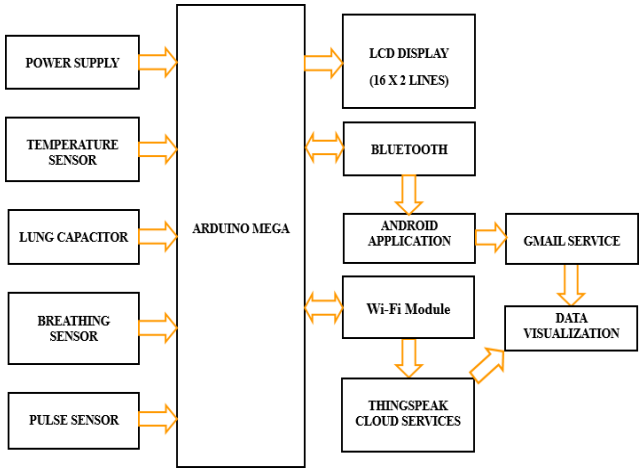


Fig. 2: System architecture of the proposed work

The overall architecture of the proposed model is represented in Figure 2. The model can be sub-divided into 4 modules. The first module is the embedded hardware system consisting of Arduino Mega and the sensors, a 16x2 LCD screen has been attached with the module to display the current reading of the sensors. Bluetooth and Wi-Fi module are also attached with the Arduino for further transposal.

The second module is an Android Application developed to assist a person in keeping track of his health history, the Application uses Bluetooth communication to receive data directly from the first module. The data is then saved in a database associated with the application. The user is also provided with the facility of mailing his history through the application which helps the user in keeping another copy of his history over the mail.

The third module consists of ThingSpeak Cloud Services which helps in collecting the data so that it can access from anywhere with internet access. This helps in transferring the patient details without any delays to concerned doctor or hospital. ThingSpeak provides easy to use visualization of the information which helps in further monitoring the trends of the parameter over a period of time.
The fourth and the last module is the analysis module in which implementation of two classification algorithms namely, CART classification algorithm and Random Forest, are done in order to suggest further test to the patient depending upon their current health scenario. The system gets the data using ThingSpeak API, the response is scrapped to get the last set of reading which is then used to make the prediction. Furthermore, we have compared the above mentioned algorithms in terms of their performance.

4. Development of System

The basic design of the implementation of the system is represented in Figure 3.

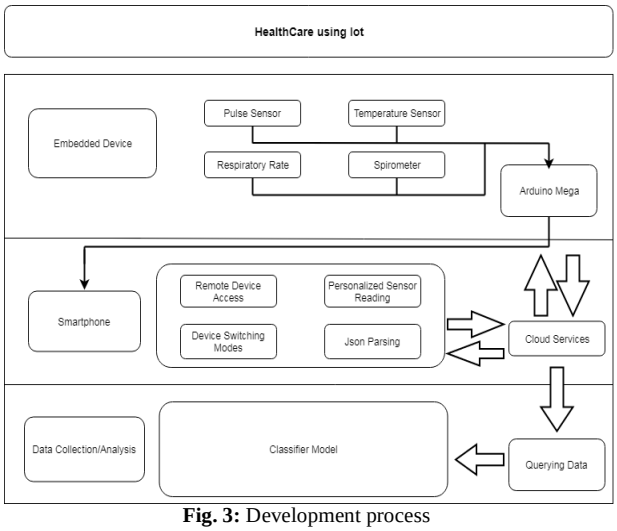


Fig. 3: Development process

4.1. Hardware Module

The embedded system which consists of Arduino Microcontroller, Sensors, Bluetooth Module, Wi-Fi Module and a 16x2 LCD screen is the first module of the system. The sensors are attached to the Arduino mega that helps in accumulating the required for data analysis. The sensors are as per the following:

- Pulse Rate – Place your finger inside the sensor and it will detect the pulse by estimating the adjustment in light from the expansion of capillary blood vessels. It contains a LED
  (Light Emitting Diode) light and a LDR (Light Dependent Resistor) for pulse sensing.
- Breath Count – This device counts the breath per minute of the patient. It contains a small ball and an infrared light and a p-diode which helps in counting whenever a patient inhales and exhales.
- Lung Capacity – It is typically used in a clinical setting to diagnose pulmonary disease. These apparatuses measure the amount of air expired, and at times, can demonstrate the adjustment in stream rate after some time. This simple sensor allows for a rough calculation of the volume of air expired from the lungs.
- Temperature Sensor – Thermistors are simple analog signal device and are inexpensive and accurate components that make it easier to get temperature data.

The information gathered can be seen on dings which can be viewed on the LCD screen, and is also send to Android Application and Cloud for storing the information in database for future referral or to send it to the doctor/hospital for further analysis. This data is also used to further suggest specialized tests that the patient should take if there is any anomaly in the any of the parameter.

4.2. Android Module

The patients can monitor and keep track of their health status. The application receives real time data from the sensors. The user first need to provide the registered username and password allotted to his account which is then checked in the database for previous records, if no history exist then a new user is created.
The Bluetooth communication is being used for transmitting the data gathered from the sensors to the application. The Application contains a user named Admin that provides access to the history of all the patients. This helps in accessing the information even if user forgets about his username or password. The application also create a text file containing all the records of the patient that can be mailed by using Gmail services to any mail account, further a python script that can then be used along with this file that helps the user in visualizing the data.

4.3. Cloud Services Module

To help the user in transmitting the information without any delay, we are using ThingSpeak. ThingSpeak is a cloud based platform that is designed to work with modern day IoT devices. ThingSpeak provides easy to use API that can be integrated in any IoT device to post and get information on remote servers. ThingSpeak further aids the user by providing the information visually to see the trends of their health records.

4.4. Data Analysis Module

The user's health data is used for further data analysis. The model is trained with two supervised classification algorithms namely, Classification and Regression Trees (CART), and Random Forest. The classical non-parametric decision tree learning techniques are classification and regression trees. The user's health data are transformed to either regression or classification trees, based on numeric or categorical aspect of the dependent variable respectively. Decision trees are shaped by a gathering of standards in view of factors in the model informational index. Rules based on variables' values are chosen to obtain the precise split to distinguish observations based on the dependent variable.
After choosing a rule the node and the precise split of a node into two, the same steps are carried out in every child node. Once CART finds no further gain in the result, splitting of node stops.

5. Result and Discussion

After analyzing all the performance metrics, the best classification model based on the requirement is chosen. This on the basis of these three criterions:

- Stability – The model ought to have comparative execution measurements crosswise over both training and validation da- ta. This is very essential because anything can live with a lower accuracy but not with a lower stability. We will give the highest weight to stability. For this case let's take it as 5.
- Performance and Training Data – This is one of the important metric but nothing conclusive can be said just based on this metric. This is because an overfit model is unacceptable but will get a very high score at this parameter. Hence, we will give a low weight to this parameter. Let's take it as 2.

Table 1: Score table.

Weights	**5**	**2**	**3**	
Out of 10	***Stability***	***Training Per-formance***	***Validation Performance***	***Total***
CART	9	8	8	85
Random Forest	7	9	9	80

As should be obvious from the Table 1 that however Random forest gives a better performance, despite everything we will simply go ahead and use CART model because of the stability factor. Other factor in favor of CART model is the easy justification. The choice of model selection is entirely dependent on the requirement.

6. Conclusion

Recently telemedicine has achieved technology breakthrough with the emergence of IoT. In this paper, a low power data analytics driven IoT system is proposed for health care monitoring application. The major components of the proposed system are explained with the implementation details. It is guaranteed that the system notifies the patients about their condition by analyzing their data which will further recommend some medical tests. Through which the patient can know about their health status in prior and this eliminates the need to physically go to a medical facility. It also reduces the distance barriers and will extensively diminish insurance premiums and conceivably lessen the time a patient must be far from work.

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