International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 15 (2018) pp. 11984-11989

Smart Healthcare Monitoring using IoT

Shubham Banka[1], Isha Madan[2] and S.S. Saranya[3]

[1]*Bachelor of Technology, Computer Science and Engineering, SRM University, Tamil Nadu, India.*

[2]*Bachelor of Technology, Computer Science and Engineering, SRM University, Tamil Nadu, India.*

[3]*Assistant Professor, Computer Science and Engineering, SRM University, Tamil Nadu, India.*

[2]*Orcid Id: 0000-0001-8715-4640*

Abstract

IoT in healthcare is the key player in providing better medical facilities to the patients and facilitates the doctors and hospitals as well. The proposed system here consists of various medical devices such as sensors and web based or mobile based applications which communicate via network connected devices and helps to monitor and record patients' health data and medical information. The proposed outcome of the paper is to build a system to provide world-class medical aid to the patients even in the remotest areas with no hospitals in their areas by connecting over the internet and grasping information through about their health status via the wearable devices provided in the kit using a raspberry pi microcontroller which would be able to record the patient's heart rate, blood pressure. The system would be smart to intimate the patient's family members and their doctor about the patient's current health status and full medical information in case any medical emergency arises. The collected information can be used to analyze and predict chronic disorders or other diseases such as heart attacks in preliminary stage itself using the data mining techniques that will also provide the approach advantageous for decision making.

Keywords: Internet of Things, IoT in Healthcare, Patient Monitoring, Raspberry Pi, Smart Health Monitoring.

INTRODUCTION

The Internet of things is the inter-connection of devices, apps, sensors and network connectivity that enhances these entities to gather and exchange data. The distinguishing characteristic of Internet of Things in the healthcare system is the constant monitoring a patient through checking various parameters and also infers a good result from the history of such constant monitoring. Many such devices equipped with medical sensors are present in the ICUs now-a-days. There could be instances where the doctor couldn't be alerted in time when there is an emergency, despite of 24 hours of monitoring. Also there might be hurdles in sharing the data and information with the specialist doctors and the concerned family members and relatives. The technology that enhances these features is already available but is not accessible and affordable by most of the people in developing countries such as India. Hence these solutions to these problems can be just a simple extension to the current devices which don't have these facilities.

This paper demonstrates a Remote Health Monitoring System controlled by Raspberry pi. Raspberry Pi is a small payment card-sized single-board microcontroller made to enhance the basic computer science education in colleges and developing nations. In this paper, a system is designed to continuously monitor the vital parameters such as heart rate, blood pressure and body temperature. The information is stored on a cloud server database and can be displayed through an online website or mobile application by authorized personnel only. The idea might not be very new, but we propose an absolute and cheap method for the system using Raspberry pi. The main objective of this system is to update the data online and send an alert to the doctors for any abnormality and also predict if the patient is having any disease. The former is accomplished by using MySQL db module to link Raspberry pi to the database whereas the latter is achieved by the combination of Raspberry Pi and GSM module and the web interface. This system has much future scope as the data collected by monitoring is so valuable and can be used for any kind of research by the medical community.

The major aim of the paper can be summarized as following:

- To obtain the real-time medical information about a patient via IoT.
- Processing and classification of information gathered about the patient.
- To interpret and predict any disease or disorder in preliminary stage itself using the data mining techniques that will also provide the approach advantageous for decision making.
- To provide Internet of Things based healthcare solutions at anytime and anywhere.

RELATED WORK

A number of researchers have proposed various models for IoT in Healthcare and the prediction of various types of diseases using various techniques. This part focuses on the work done in the same area.

Ahn et al. [1] implemented a system for measuring the physiological signals in sitting position such as ECG and BCG by using a smart chair that senses the non-constrained bio-signals and can be monitored using a monitoring system such as the one they had developed providing a classic example of the application of iot in healthcare.

Almotiri et al. [2] proposed a system of m-health that uses mobile devices to collect real-time data from patients in and store it on network servers connected to internet enabling access only to a certain specific clients. This data can be used for the medical diagnosis of patients and is achieved by using a number of wearable devices and body sensor network.

Barger et al. [3] made a smart house facility using a sensor network to monitor and track the movements of the patient in hoke and a prototype of the same is also being tested. The primary objective of their work is to check if their system is capable to outsmart the behavioral patterns and have discussed about the same in their work.

Chiuchisan et al. [4] proposed a framework to prevent the threats to patient in smart ICUs. The proposed system intimates the patient's relatives and doctors about any inconsistency in their health status or their body movements and also about the atmosphere of the room so that the necessary precautionary measures can be taken.

Dwivedi et al. [5] developed a framework in order to secure the clinical information that has to be transmitted over the internet for Electronic Patient Record (EPR) systems in which they propose a multi-layered healthcare information system framework which is a combination of Public Key Infrastructure, Smartcard and Biometrics technologies.

Gupta et al. [6] proposed a model which measures and records ECG and other vital health parameters of the patient using Raspberry Pi and can be of a great use for the hospitals and patients as well as their family members.

Gupta et al. [7] present an approach using Intel Galeleo development board that collects the various data and uploads it to the database from where it can be used by the doctors and also reduce the pain born by the patients to visit hospital each and every time to check their health arameters.

Lopes et al. [8] proposed a framework based on IoT for the disabled people so as to study and find the IoT technologies in healthcare segment that can benefit them and their community. They took two use cases to study the latest IoT technologies and its application that can be used mainly for the disabled people.

Nagavelli and Rao [9] proposed a novel method to predict the severity of the sickness from the patient's medical record using mining based statistical approach which they said as degree of disease probability threshold. And in order to meet their goal they have revamped an0 algorithm that is mostly needed to derive the hyperlink weight of the websites.

Sahoo et al. [10] studied the healthcare management system and about the large amount of patient data that is generated from various reports. They further analyzed the health parameters to predict the future health conditions of the patient or the said subject. They use a cloud based big data analytic platform to achieve the same using the means of probability.

Tyagi et al. [11] explored the role of IoT in healthcare and studied its technical aspects to make it reality and identify the opportunities for which they propose a cloud based conceptual framework in which the patients' medical data and information can be securely transferred, with the permission of patient and their family by building a network among patient, hospital, doctors, Labs etc. The primary reason behind this is to relieve patient from the expensive clinical aid, overcome the shortage of doctors and therefore providing enhanced care and service to patients.

Xu et al. [12] presented a data model to record and use the IoT data. They designed and developed a resource-based Ubiquitous Data accessing method to collect and publish IoT data globally to so that it can be accessed anywhere, anytime. They also present an emergency medical service based on IoT and how to collect and use the IoT data on different platforms.

SYSTEM ARCHITECTURE

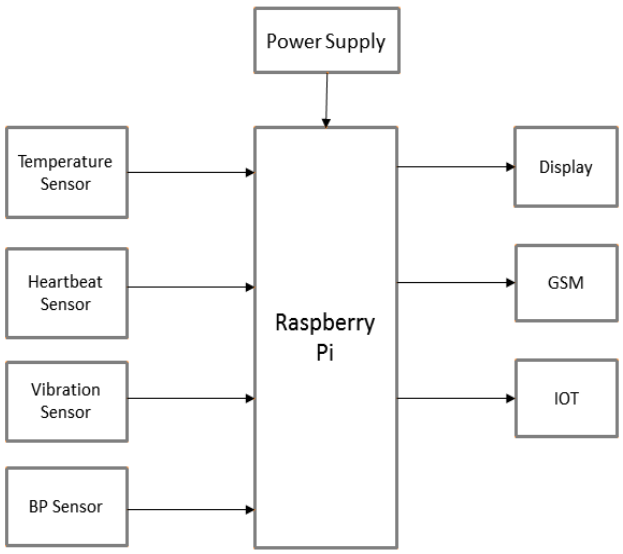

Figure 1. System Architecture

PROPOSED METHODOLOGY

In this paper, we propose an automatic system to monitor patient's body temperature, heart rate, body movements and blood pressure. Further we extend the existing system to predict if the patient is suffering from any chronic disorder or disease using the various health parameter and various other symptoms that are obtained by the system.

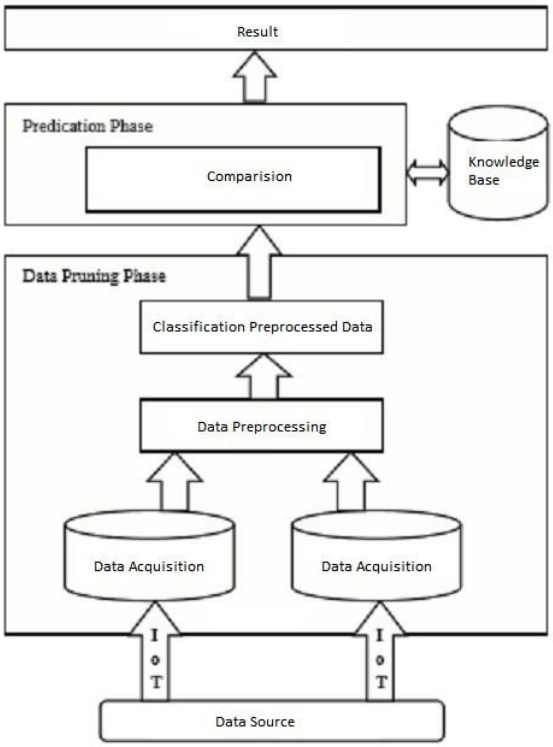

Figure 2. Proposed Methodology

The above figure depicts how to how to retrieve the information about patient health status by monitoring various parameters and use the same information to predict if the patient is suffering from any kind of chronic disorder or other such disease.

In level-1, unprocessed data from various IoT devices is obtained and stored on the server. These devices include various sensors such as temperature sensor, vibration sensor, BP sensor and pulse sensor. Since some of the sensors give analog output which cannot be used by raspberry pi, we first convert the analog values into digital form and using convertor IC. Then using the raspberry pi on which Linux OS is installed, we write the code in python that reads the values from the sensors and update them into the database at regular intervals.

In level-2, the relevant information is obtained as a result from the data stored by filtering, classifying and categorizing it. This information is nothing but the patient's real-time health data and symptoms that the patient has. This information will be further used in the next level to predict if the patient is suffering from any kind of disease. This helps to make the system smart and efficient.

In level-3 the analysis/predication phase, we use data mining techniques to predict the type and nature of the disease or the disorders for which the system was designed. Using artificial intelligence can further improvise the system by making it smarter. Hence we can infer the disease or disorder by using the existing knowledge base and categorize the result in various categories such as Ideal, Normal, and With Symptoms etc.

SYSTEM MODULES

1) Health Monitoring Section
2) Emergency Alert Section
3) Health Status Prediction System

A. Health Monitoring Section

This module comprises of the hardware components of the system that makes it IoT enabled and is used to record the health parameters of the patient using various sensors. Here, Raspberry pi acts as a central server to which all the sensors are connected through the GPIO pins or using MCP3008 analog-to-digital convertor if their output is in the analog form as raspberry pi works only on digital signals. The pi reads the real-time values and updates them to mySQL db which is then used to display them on the web interface.

B. Emergency Alert Section

This module in particularly deals with the steps to be taken after an abnormality is detected in the health of patient such as notifying his/her family member as well as the hospital. We have set up certain threshold values in our program which if crossed will trigger an alert in the form of email/SMS to the patients family/doctor. The various values used here are:

Table 1: Threshold Values

Component	Normal Range
Blood Pressure Body Temperature Heart Rate	80-120 mm Hg 36.5-37.5C 60-100 beats/min

C. Health Status Prediction System

This is one of the most promising modules of our system. In this module, we use the patients' health data as recorded by our system along with any symptoms they may be feeling by asking a few simple questions and compare it with the existing knowledge base to predict if any disease/disorder the patient may have thus making it an efficient Expert System with proper data mining techniques.

IMPLEMENTATION

In this paper, we have proposed a system in which patient's body temperature, heart rate, body movements and blood pressure reading results that are being monitored by the system. The various sensors are placed on the patient's body and they take the readings and send the corresponding signal to the raspberry pi. The Raspberry Pi is a credit card-sized single-board computer that operates on Linux OS. Here, various sensors are used to measure the patient's body temperature, heart rate, Blood Pressure and their respective results are sent to the database via Raspberry Pi and can be monitored from anywhere worldwide through the internet facilitated via GSM module.

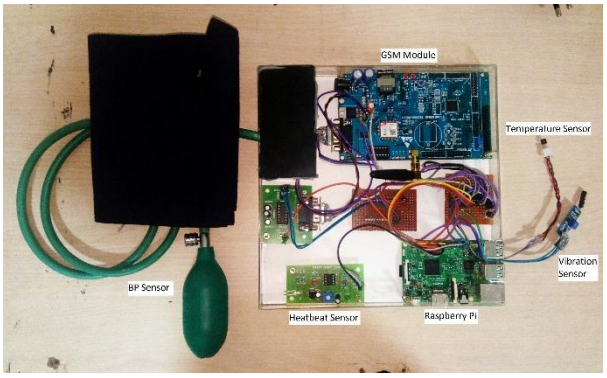

Figure 3. Experimental Setup

The programming in Raspberry Pi is done in python language and it sends the data related to the patients' health to the server connected via Internet. The details can be easily accessed online by proper authentication and health status of the patient can be monitored.

The various Components to be used in system are :

A. Raspberry Pi

The Raspberry Pi is a bank card size microcontroller with the features of a small pc and is extremely popular for development purposes because it offers the entire Linux server and peripheral device connectivity on a single chip and is very cost-effective.

Figure 4. Raspberry Pi

The GPIO pins available on the board are used for the input/output purpose and can be programmed as per the need. For, the proposed system we'll be using Raspberry Pi board version 3. The Raspberry Pi and IoT together prove to be a pioneer innovation technology in healthcare system.

B. Temperature Sensor

For measuring the temperature LM35 sensor has been used which is an IC sensor used to measure the temperature with the help of the analog output proportional to the temperature.

Figure 5. Temperature Sensor

The LM35 is an IC temperature sensor with an output voltage which is proportional to the Celsius temperature. The LM35 is better than linear temperature sensors which have calibration in Kelvin, because one doesn't need to remove a large constant voltage from the output value to obtain the Celsius reading. These salient features of the LM35 sensor make interfacing to any type of circuit extremely easy.

C. Heartbeat Sensor

The heart rate is measured using a pair of LED and LDR and a microcontroller and it works on the fundamentals of optoelectronics. The infrared radiation is emitted by IR led and the infrared light is reflected by the surface. The intensity of radiation generated electron-hole pair which in turn produces leakage current. This current thus generated is sent through a resistor to obtain the proportional voltage. Thus, the greater is the intensity of the incident ray, the larger value of voltage flowing across resistor will be obtained.

Figure 6. Heartbeat Sensor

The heart rate is measured by placing the tip of forefinger upon the sensor. Once the circuit senses the pulse, an LED will start blinking along with your pulse. The output is sent to a circuit or a micro-controller to measure the heart beat rate in BPM.

D. Vibration Sensor

The vibration sensor used in here senses the shaking of the surrounding and hence we use it here to monitor whether the patient is shivering so that proper aid can be given.

Figure 7. Vibration Sensor

Ideally, the two contacts of sensor don't touch each other. When by any external force these two contacts touch each other and when the force is removed the sensor terminals seperate. The on-board blue LED visually indicates communication online and activation.

E. BP Sensor

For measuring the blood pressure, we have used here a manual blood pressure monitor instead of a digital one as it is cheaper. It is commonly known as a sphygmomanometer and the kit consists of an arm cuff, a squeeze bulb to inflate the cuff, stethoscope and a sensor to read the pressure. Blood pressure is measure using an air pressure sensor. The readings are in the form of electrical signals. These readings are also converted to digital form to be read by the Raspberry Pi.

Figure 8. BP Sensor

F. ADC

The MCP3008 is a low cost 8-channel 10-bit analog to digital converter. This chip is a great option if one needs to read simple analog signals, like from a temperature or light sensor.

Figure 9. MCP3008

G. GSM Module

The GSM module used here in this paper is GPRS/GSM Quadband Module (SIM900) which offers GPRS connection to our system, and includes the SIM900 communication module from SIMCom. This module can accept any type of sim card having its own unique number. The same can be used to send messages, make calls or create sockets to provide internet connectivity.

The data from the above sensors is constantly updated in MySQL database which is linked to the web UI using the python code. The patient can log in and monitor their health status at any time. The system is made smart to trigger a SMS/Email alert via the proper gateways which assure an efficient delivery of the message. Also, the values from these sensor in combination with various other symptoms which are asked from user based on initial diagnosis is used to predict the disease patient is suffering from, if any, using the data mining technique through our programming logic and is displayed as a result of analysis along with the details of a doctor for the disease in their area.

RESULT

As the title says, the result of Smart Health Monitoring system is of extreme use to patients and doctors as well. The patient can check their health status anytime from the comfort of their homes and visit hospitals only when they really need to. This can be done by using our system whose result are brought online and can be seen from anywhere around the world. Since it is a prototype model, our system shows the almost real time values of various health parameters and emulates how the same can be implemented in the real world. The doctors can also use the log of the patient body condition to study and determine the effect of medicine or other such things.

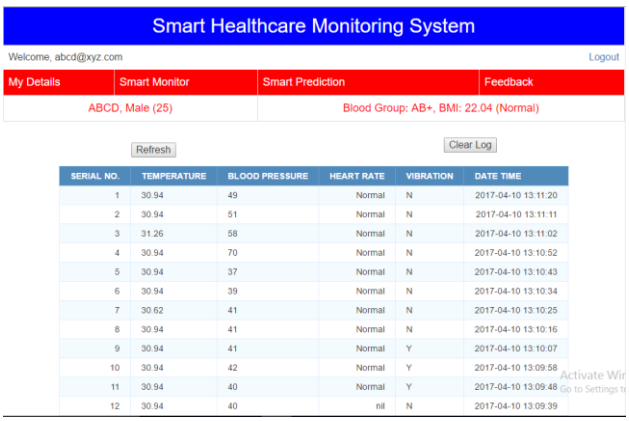

Figure 10. Screenshot: WebUI

The smart prediction module predicts the disease that the patient is suffering from by asking them for various symptoms they may have and the options are based on the previous symptom. The final conclusion is made after at least 3-4 symptoms are identified. The result is most accurate if more

and more symptoms are identified. A sample screen shot of the web interface can be seen in Fig. 10.

CONCLUSION AND FUTURE WORK

In this paper, we have presented and proved the prototype for an automatic system that guarantees a constant monitoring of various health parameters and prediction of any kind of disease or disorder that prevents the patient from the pain of paying frequent visits to the hospitals. The proposed system can be set-up in the hospitals and massive amount of data can be obtained and stored in the online database. Even the results can be made to be accessed from mobile through an application.

The system can be further improved further by adding artificial intelligence system components to facilitate the doctors and the patients. The data, consisting medical history of many patients' parameters and corresponding results, can be explored using data mining, in search of consistent patterns and systematic relationships in the disease. For instance, if a patient's health parameters are changing in the same pattern as those of a previous patient in the database, the consequences can also be estimated. If the similar patterns are found repeatedly, it would be easier for the doctors and medical researchers to find a remedy for the problem.

REFERENCES

[1] B. G. Ahn, Y. H. Noh, and D. U. Jeong. Smart chair based on multi heart rate detection system. In *2015 IEEE SENSORS*, pages 1–4, Nov 2015.

[2] S. H. Almotiri, M. A. Khan, and M. A. Alghamdi. Mobile health (m-health) system in the context of iot. In *2016 IEEE 4th International Conference on Future Internet of Things and Cloud Workshops (FiCloudW)*, pages 39–42, Aug 2016.

[3] T. S. Barger, D. E. Brown, and M. Alwan. Health-status monitoring through analysis of behavioral patterns. *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans*, 5(1):22–27, Jan 2005. ISSN 1083-4427.

[4] I. Chiuchisan, H. N. Costin, and O. Geman. Adopting the internet of things technologies in health care systems. In *2014 International Conference and Exposition on Electrical and Power Engineering (EPE)*, pages 532– 535, Oct 2014.

[5] A. Dwivedi, R. K. Bali, M. A. Belsis, R. N. G. Naguib,P. Every, and N. S. Nassar. Towards a practical healthcare information security model for healthcare institutions. In *4th International IEEE EMBS Special Topic Conference on Information Technology Applications in Biomedicine, 2003.*, pages 114–117, April 2003.

[6] M. S. D. Gupta, V. Patchava, and V. Menezes. Healthcare based on iot using raspberry pi. In *2015 International Conference on Green Computing and Internet of Things (ICGCIoT)*, pages 796–799, Oct 2015.

[7] P. Gupta, D. Agrawal, J. Chhabra, and P. K. Dhir. Iot based smart healthcare kit. In *2016 International Con- ference on Computational Techniques in Information and Communication Technologies (ICCTICT)*, pages 237– 242, March 2016.

[8] N. V. Lopes, F. Pinto, P. Furtado, and J. Silva. Iot architecture proposal for disabled people. In *2014 IEEE 10th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob)*, pages 152–158, Oct 2014.

[9] R. Nagavelli and C. V. Guru Rao. Degree of disease possibility (ddp): A mining based statistical measuring approach for disease prediction in health care data min- ing. In *International Conference on Recent Advances and Innovations in Engineering (ICRAIE-2014)*, pages 1–6, May 2014.

[10] P. K. Sahoo, S. K. Mohapatra, and S. L. Wu. Analyzing healthcare big data with prediction for future health condition. *IEEE Access*, 4:9786–9799, 2016. ISSN 2169-3536.

[11] S. Tyagi, A. Agarwal, and P. Maheshwari. A conceptual framework for iot-based healthcare system using cloud computing. In *2016 6th International Conference - Cloud System and Big Data Engineering (Confluence)*, pages 503–507, Jan 2016.

[12] B. Xu, L. D. Xu, H. Cai, C. Xie, J. Hu, and F. Bu. Ubiq- uitous data accessing method in iot-based information system for emergency medical services. *IEEE Transac- tions on Industrial Informatics*, 10(2):1578–1586, May 2014. ISSN 1551-3203.