Remote Patient Health and Medicine Monitoring by Data Logging Using IoT

Abhishek Yadgire, Nagaraju Bogiri.

Abstract*: Considering the day by day rapid increase in the population of the world, providing appropriate healthcare to elderly or unwell people becomes a crucial issue and needs high attention from mainly medical, also industrial and academic fields of the society. Nowadays on the Internet of Things (IoT), there is extensive research on finding the solution for improving the quality of life of the people. In this Project we are presenting a prototype of a health monitoring system which is based on IoT and makes use of wearable sensors, thereby providing remote and continuous monitoring of a patient's health. The system continuously monitors the patient's heartbeat, temperature and medicines consumed, by using a web application. Various sensors will be used such as heartbeat sensor and temperature sensor for patients as well as load sensor to get data about how many medicines patient have and when to refill the medicine box. Based on the values acquired from temperature and heartbeat sensor predictions are given about the patient's condition. All sensors will be communicating with an application through a remote web server where all data will be hosted using IoT protocols.

Keywords— Internet of Things, Health monitoring system, IoT-MD, heart rate sensor, temperature sensor, MQTT, medicine box.

I. INTRODUCTION

Recently e-health or sensor-based healthcare system is increasingly getting attention by many researchers. IoT is one of the pioneer fields in recent years by which the society is being revolutionized by means of integrating the advances in the wireless networking with miniaturized microsensors, Nanosensors, devices and microprocessors that can be embedded on actuators or controllers which will fulfill a wide range of healthcare applications. The web of things (WoT) e-health application which requires an embedded web server in the device has been studied by Duquennoy et al. [1]. This embedding is nowadays possible due to existing and specially created technologies. In IoT and WoT the web protocol is used to connect physical devices like microcontrollers or sensors to the internet [2]. There are many protocols used to build a remote healthcare system, the most commonly used protocols are communication protocol, application protocol, and captured data type and data format [3]. A detailed survey of IoT has been done by Riazul et al. [4]. In his survey, he studied all the aspects of IoT and also discussed different methods. The different methods of connecting sensor nodes to the internet have been discussed and the role of an IoT gateway is studied by Kulkarni and Sathe [5].

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Traditionally the healthcare monitoring system in the hospitals was characterized by huge and complex circuits which require high power consumption and cannot be remotely accessed in case of emergency [6]. Many authors are continuously working to get better healthcare monitoring system. Now a day's remote healthcare monitoring system is extensively used in the modern hospitals which give exact information about the patient's vital body state remotely. This system minimizes the risk of getting the worse condition of the patient. The continuous advances in the semiconductor technology, sensors, and microcontrollers reduce the cost of the system whereas increases its efficiency [7],[8].

Hospitals are continuously in need of up gradation and better management. The database of all patients where the vital parameters are stored should be kept handy so that it is easily accessible to doctors and patient's relatives. The security of patient's data is also one of the most important aspects of the healthcare management system.

Objectives:

The main objective of the system is to provide a home-based application for monitoring health with less hardware and also for online medication. This technology is used for monitoring patients outside the conventional clinical settings- for example, in the home settings, which may lead to increasing care of patient and decrease in the healthcare delivery cost. This technology can be used to reduce the number of emergency department visits, situations where hospitalization is necessary and also the duration of hospital stays. The Patient monitoring system is the new technology used for monitoring heartbeats and temperature of the patients for knowing the appropriate rate. To overcome the problem which requires human presence each time to measure the patient's heartbeat and temperature by using the wireless technology to monitor patients remotely. Another objective is to keep real-time track of the availability of medicines for a patient by using the internet and alerting respective pharmacist for the refilling of medicines. Patients will also be notified by means of alerting or alarming to get a reminder of taking medicines.

The remaining paper is organized as follows. In section II, we have reviewed the literature on IoT and remote healthcare systems. In Section III, we have proposed the methodology for the remote patient health monitoring system. In section IV, we have put forward the mathematical model for remote patient health monitoring. In section V, we have given our own idea in order to improve the existing healthcare system. In section VI, we discussed and analyzed the predictive results. Finally, in section VII we have summarized the conclusions of the work.

II. LITERATURE SURVEY

Krishnan and Gupta [6] have presented their work for especially monitoring the old age patients and informing the doctors and their loved ones about the patient's health. So, to dodge such sudden death rates they have proposed an innovative project by using Patient Health Monitoring that makes use of sensor technology along with the internet to communicate the loved ones during emergencies. The designed system operates on readings of Temperature and heartbeat sensor. The Arduino-Uno board connects to both the sensors and takes the input. The patient health is tracked by interfacing the microcontroller with the LCD display and wi-fi is connected to send the data to the web-server. An alert is sent if any abrupt changes occur in the patient's heart-rate or body temperature using IoT. Patient's temperature and heartbeat data which is tracked live with timestamps are shown over the Internetwork. The patients' health data and other related information will be accessed easily by the doctor. Thus, by effectively using the internet along with monitoring system patient health is monitored.

Jayeeta Saha and Arnab Kumar Saha [7] proposed a unique solution that offers alarm notification to provide the patient with the prescribed medicine in time. Heart rate, blood pressure, respiration rate, body temperature, body movements and saline levels have been monitored by authors to solve the said purpose. Human error could be successfully reduced to an extent by the use of remotely monitoring patient's health and taking necessary action in case of chronic diseases. If any of the health parameters of patient crosses the threshold value then an alert message will be sent through email and SMS. Using the notification scheme the respective authorities are kept conscious about the situation of the patient. As per the requirement of the patient's health condition the optimum surrounding is created describing a significant area of the proposed solution. Proper bandwidth internet connection is essential for the working of E-mail alert notification and visits to the website.

To remotely monitor the patient's health authors have divided their proposed solution into four basic modules as follows:

A. Health monitoring and data collection.
B. Medication and precaution according to the degree to which the patient needs attention and appliance control.
C. Database preparation from the acquired data.
D. Sending alerts and medical reports to the patient's family members and concerned doctors.

An innovative web-based remote healthcare diagnostic system is demonstrated by Divakaran and Manukonda [8] that provides vital medical data and live video images of a patient who is situated in rural areas. This data is accessible to a health professional located anywhere in urban cities which results in better diagnosis and treatment of that patient. The author's work can be an enhanced version of various existing monitoring systems as it utilizes the IoT technology for faster and more secure data transmission. Patients, doctors, devices and software are all integrated into one system, by means of IoT technology making it convenient to use. Both the patient's and doctor's time is saved as this technology is more useful to the people that are located in rural areas and thereby cannot make frequent hospital visits because of lack of resources.

A faster diagnosis for a patient can be provided which is very efficient and saves the doctor's time.

An STM32F429 microcontroller is used in addition to IoT technology whereas the most existing systems utilize the PIC microcontroller. This STM32F429 is equipped for applications in Embedded Systems and has considerably low power consumption.

Krishna and Sampath [9] represents an IoT usage in the healthcare system which is mainly designed for the real-time monitoring of patient's vital parameters. The smartphones and laptops of an authorized person such as a doctor or patient's relatives can be used to access the patient's vital parameters with the help of a cloud server. The proposed IoT technology in the healthcare system is cost effective and makes a highly scalable solution as an easy expansion of nodes for a vital collection of data as well as its processing is supported. IoT based system being highly distributed, still makes the system function in the occurrence of failure of a single node. The third-party applications and devices can be easily integrated with the help and use of IoT protocols. The information coming from the temperature sensor and pulse oximeter that is attached to the patient's body can be viewed in smartphones and laptops of the doctors or relatives of a patient. Here for displaying this information, measurements are taken using a software named MQTT Lens and MQTT Dashboard. An application for displaying the measurements in laptops the MQTT Lens is used.

Alamelu and Mythili [10] have proposed an architecture for wireless sensor network which is based on the cloud computing platform. For implementing any real-time application like microclimate and Tsunami warning system, this work could be beneficial.

Here the sensors are used to acquire and transmit the patient's information through a network using a gateway node/sink node. This sensor information containing the patient health information/data will be stored in the cloud so that further data analysis and decision making can be done. The present work acquires the health care information such as blood sugar, Blood Pressure (BP), weight scales of the patient by means of autonomous processor-based devices in IoT and transmits the data to the internet

A system that will be useful for monitoring the vital body parameters such as pulse rate and body temperature of the patient is presented by Kaur and Jasuja [11] with the help of dedicated sensors along with Raspberry Pi and IoT. The proposed system is a set of wearable sensors and it supports remote health monitoring. Bluemix cloud is used to store the collected data and this data can be retrieved by the doctor or any relative of a patient for the further analysis and if any aberrancy occurs will be timely detected thereby attaining the remote health monitoring. Bluemix being a cloud platform uses the MQTT (Message Queuing Telemetry Transport) protocol.

The accuracy and cost of a system remain important and unignored parameters along with remote health monitoring and wearability of a system. By the selection of appropriate sensors which are DS18B20 for temperature sensing and KG011 for heart rate sensing a perfect tradeoff between accuracy and cost of the system is accomplished. The use of wearable sensors in the system facilitates the self-monitoring of the system. A single board minicomputer Raspberry pi and IBM Bluemix cloud are used in the system which further makes use of MQTT protocol for reliable services. The system consists of cheap-yet-serviceable, small

in size microcontroller Arduino UNO board and also a single but powerful-enough minicomputer Raspberry PROPOSED Pi board.

III. PROPOSED METHODOLOGY

In the IoT patient monitoring system, we have taken three sensors namely temperature sensor, heartbeat sensor and load cell sensor. Here load sensor is additionally taken in order to show the present status of medicine in the medicine box. This Project will provide easy access to all the information regarding the health of the patient to the doctor or family members by just visiting a website or URL or Apps. The ESP8266 microchip is a Wi-Fi module which also works as a microcontroller, takes input from the sensors from time to time. This gathered data is stored in the cloud by sending it to a particular URL or IP address. This process is repeated after regular intervals. Here in the project, we have set this interval to five seconds.

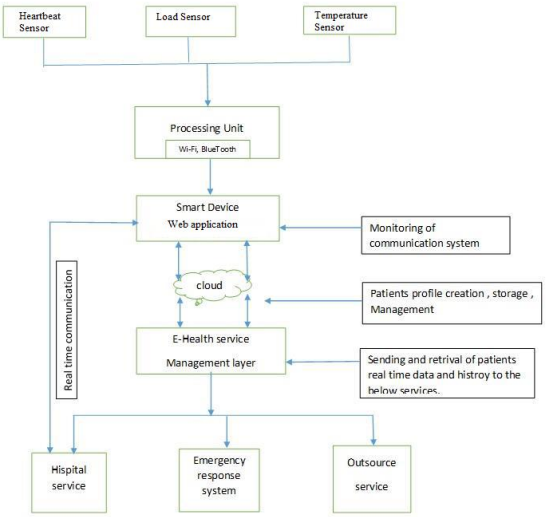

Fig.1: System Architecture

A. *Algorithms*

1) Naive Bayes algorithm for analysis:

The Bayesian Classification is used especially to represent a supervised learning method and also a statistical method for classification. It allows us to capture uncertainty about the model in a principle way by determining probabilities of the outcomes in addition to assuming an underlying probabilistic model. It can solve diagnostic and predictive problems. Bayesian classification provides practical learning algorithms and prior knowledge besides the observed data can be combined too. A useful perspective for understanding and evaluating many of the learning algorithms is provided by the Bayesian Classification. It also calculates the explicit probabilities for hypothesis which are robust to noise in input data.

Step 1: Sensor data is continuously uploaded to a web server.
Step 2: As constant uploading is there, data is overwritten on previous data and no need to re-upload.
Step3: Microcontroller checks the value from the sensor with the predefined thresholds.
Step 4: It is determined by the probability that the patient is unwell or medicine box is going to be empty according to sensor values is checked and re-evaluated.
Step 5: Continuous re-evaluation until the result is the same.
Step 6: Classification of sensor data according to thresholds.
Step 7: Final output of alert or user notification.

2) Decision tree:

The Decision Tree algorithm is from the family of a supervised learning algorithm. Unlike other supervised learning algorithms, decision tree algorithm can be used for solving classification problems too. To create a training model which can be used to predict the class or value of target variables by learning decision rules is the general motivation of using Decision Tree. As compared with other classification algorithms, the understanding level of Decision Tree algorithm is very easy.
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Step 5: Continuous reevaluation until the result is the same.
Step 6: Classification of sensor data according to thresholds.
Step 7: Checking if the need to alert or to display medicine box empty message.
Step 8: If the medicine box is not empty yet the probability of it to be empty in very less time than the decision is to send alert for making it refill.
Step 9: If the medicine box is completely empty then an alert must have been generated earlier else regenerate alert and send it to the respective persons for immediate actions.
By the above-mentioned algorithms working, it is clear that the output of the Bayesian classifier is used in a decision tree algorithm to take appropriate decision accordingly.

B. *Mathematical model*

System Description:
Input:
Function Health Calculation ()
P: Patient.
M: Microcontroller.
S: Sensors
D: Doctor.
V: Value of Patient health.
Output:
When Patient connects to the device, then patient health is automatically calculated.
Input
Function SMS (id, request, data)
ID: unique id for each patient.
Request: Doctor send request to patient.
Data: Doctor input text data.
Output: SMS is sent by the doctor in case of a patient emergency.
Success Conditions: Success system when Correct health values are sent to the doctor.
Failure Conditions: Our system fails when no result is found to the given input.

C. *Own contribution*

Our project aims towards a real-time monitoring system using a load sensor in the medicine box. In this, the load sensor measures the weight of the medicines in the medicine box. As the patient consumes the medicines, the weight of the medicine box reduces gradually. If the weight of the medicine box decreases below the threshold value, the immediate notification will be sent to the pharmacist or doctor and relatives of the patient. Here the personal report of a patient gets uploaded to the system and is continuously monitored. All the information of the patient can be accessed by logging in to the patient's account using his login details. Thereby, no need to carry a bunch of reports with the patient. This will help us to provide immediate assistance to the patient.

IV. PREDICTED RESULT AND DISCUSSION

The proposed architecture will collect the sensor data through the microcontroller and stores it to the cloud where it is processed and analyzed for remote viewing. Feedback actions based on the analyzed data can be sent back to the doctor or guardian through Email and/or SMS alerts in case of any emergencies.

Email and SMS alert: Here email and SMS alerts have been sent to the registered email address and mobile phone with the information about patient vitals and link to patient monitoring page. Comparative results of the existing and proposed system are as follow,

Table I: Comparative Results

Parameter	Existing System	Proposed System
Health data monitoring	Yes	Yes
Wearable Sensors	Yes	Yes
M-Box	No	Yes
SMS Alert	No	Yes
Email Alerts	No	Yes
Graphical Monitoring	Yes	Yes

For the experimenting purpose, we tested the system on different people by placing sensors on their body and also tested it with medicine boxes, as filling and removing pills in it. We observe the following results as shown in Fig.2 and Fig.3

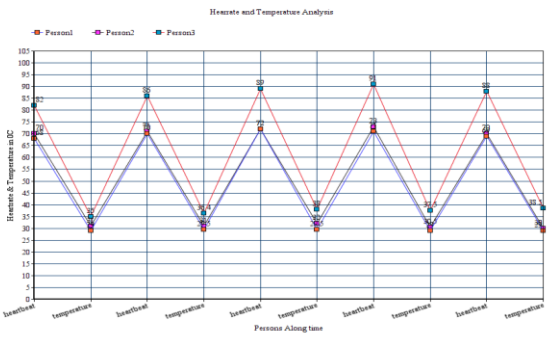

Fig.2: Heart rate and temperature of three persons over time

By observing Fig.2 it is clear that person 1 and person 2 are having constant values for heart rate and temperature but person 3 is having constant differing values and values are higher than that of expected thresholds. So, the third person's need for medical assistance can be predicted.

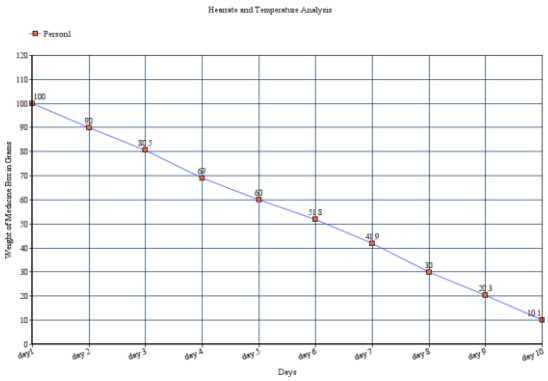

Fig.3: Weight of Medicine Box over 10 Days

As clear in Fig.3 we can observe that weight of medicines box is constantly decreasing which means that patient is taking the medicines regularly and as on the 10th day, it is clear that weight is so low that there is need to refill the medicines in it.

V. CONCLUSION

In the present healthcare monitoring system, we will continuously monitor the patient's heartbeat, temperature, and medicines consumed by using a web application. We have additionally used the load cell sensor to keep track of medicine intake by the patient. The system is able to carry out long-term monitoring on patient's condition and is equipped with an emergency rescue mechanism using SMS and E-mail alert. The range of communication is increased by using a mesh type Wi-Fi network in the system. Future scope would be to add more sensors to the system in order to enhance the healthcare parameters. We expect that our system will overcome various existing problems and will work efficiently. Our system will add one step towards the evolution of a better healthcare system.

REFERENCES

1. S. Duquennoy, G. Grimaud, J.-J. Vandewalle, "The Web of Things: interconnecting devices with high usability and performance", IEEE International Conference on Embedded Software and Systems (ICESS), 2009, pp. 323-330.
2. P. Maia, T. Batista, E. Cavalcante, A. Baffa, F. C. Delicato, P. F. Pires, A. Zomaya, "A Web platform for interconnecting body sensors and improving health care", Procedia Computer Science 40, 2014, pp. 135-142.
3. I. de Morais Barroca Filho, G. S. de Aquino Junior, "IoT-Based Healthcare Applications: A Review", International Conference on Computational Science and Its Applications, Springer, Cham, 2017, pp. 47-62.
4. S. M. Riazul Islam, D, Kwak, MD. Humaun Kabir, M. Hossain, K. S. Kwak, "The internet of things for health care: a comprehensive survey", Access, IEEE 3: 678-708, 2015.
5. A. Kulkarni, S. Sathe, "Healthcare applications of the Internet of Things: A Review", International Journal of Computer Science and Information Technologies (IJCSIT), Vol. 5, 2014.

6. D. Shiva Rama Krishnan, and Subhash Chand Gupta "An IoT based Patient Health Monitoring System" 978-1-5386-4485-0/18/$31.00 ©2018 IEEE.
7. Jayeeta Saha and Arnab Kumar Saha "Advanced IOT Based Combined Remote Health Monitoring, Home Automation and Alarm System" 978-1-5386-4649-6/18/$31.00 ©2018 IEEE.
8. Sindu Divakaran and Lavanya Manukonda" IOT Clinic-Internet based Patient Monitoring and Diagnosis System" 978-1-5386-0814-2/17/$31.00 ©2017 IEEE.
9. Krishna C S and Nalini Sampath "Healthcare monitoring system based on IoT" 978-1-5386-2044-1/17/$31.00 ©2017 IEEE.
10. J.V. Alamelu and A. Mythili "Design of IoT based Generic Health Care System" 978-1-5386-1716-8/17/$31.00 ©2017 IEEE.
11. Amandeep Kaur and Ashish Jasuja "Health Monitoring Based on IoT using RASPBERRY PI" ISBN:978-1-5090-6471-7/17/$31.00 ©2017 IEEE.

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