Advanced IOT Based Combined Remote Health Monitoring, Home Automation and Alarm System

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***Abstract*— Nowadays, automation and Internet of Things are changing the world. The day-by-day development of the Internet of Things causes a revolution in modern technology, which makes our life easier and automated. Due to a busy schedule and irregular lifestyle, health hazard is not an age-dependent factor in the recent era. Under these circumstances, Internet of Things has provided a much easier solution for remote real-time health monitoring of patients from the hospital as well as home. Sensors acquire the data of various parameters regarding patients' health, and the Internet of Things stores that data and displays through the website, which provides access for remote monitoring. Use of Sensor reduces the human error, and the size of the system reduces the occupied space of the room. The unique part of this proposed solution is the alarm generation to provide the prescribed medicine to the patient in time. The other beneficial area of the system is the scheme of sending the notification through email and SMS alert if any of the health parameters crosses the threshold value. Notification scheme will keep the respective authority conscious of the situation. Another significant area of the proposed solution is to create the optimum surroundings as per the requirement of patient's health condition. In this paper, we have discussed the monitoring of heart rate, blood pressure, respiration rate, body temperature, body movement and saline levels.**

Keywords*— Raspberry Pi; Alarm; Heart rate Sensor; Blood pressure Sensor; Respiration Sensor; Body temperature Sensor ; Accelerometer Sensor; Appliance Control.

I. INTRODUCTION

Internet-connected devices are acquiring vast potential as it pushes our daily life forward towards automation, and the rapid drop in price for typical IoT components allows people to innovate new products. IoT is the combination of embedded systems, sensors, software and this can be also referred to as internet of everything [1][6]. As health is one of the most important issues nowadays, IoT could be utilized in the health industry as a continuous health monitoring system. At the same time, the internet is now easily available for mobile technologies, which makes remote observance in everything more popular. When a patient gets admitted to a hospital or in other location under observation of medical assistant, the relatives of the patients are anxious about his/her health situation throughout all the time. The combination of Raspberry Pi and IoT has solved this situation by a new innovative technology in healthcare system through which it is also possible to monitor the health condition of the patient remotely. Raspberry Pi is a platform which offers a complete Linux environment on a tiny platform at a very low cost, and it also permits interfacing services and actuators through the general purpose I/O pins. In this proposed system, patient's heart rate, blood pressure, respiration rate, body temperature, body movement and saline levels are measured. Instant conveyance of the health information of the patient to the relatives will make the hospital management more responsible and liable for their works. Hospital management typically uses huge machines to measure the health data of the patients. On the other hand, we can be able to measure the health data using e-Health Sensor Platform in Raspberry Pi. This might be employed in the hospitals yet as home. Moreover, it will additionally decrease the cost of health observance and the space of the room. We have tried to develop a health monitoring system to acquire the data and share the information with the health units and relatives by remotely monitoring through the internet. In order to do this, Raspberry Pi collects the health data of the patients from the sensors and stores in the cloud and it is displayed on the website. For the security and safety issues, a role-based user authentication system is also available in the system to access the information. Also, the Raspberry Pi automatically controls the appliances according to the health condition of the patient.

II. LITERATURE SURVEY

Ananda Mohan Ghosh et al. [1] has demonstrated a health care system for hospital management to allow relatives and doctors to remotely monitor the health condition of a patient via internet using Arduino Uno connected with E-health sensor shield kit and Phidgets interface kit. But unlike our solution, it does not provide email and SMS alert to an emergency contact list.

P Kumar et al. [2] has proposed a raspberry pi controlled patient monitoring system where heartbeat, respiration, temperature and body movement of the patient is being measured using sensors and displayed on the screen using the putty software. However, it does not contain the alarm

notification for providing prescribed drugs to the patient which has been added in our proposed solution.

Sarfraz Fayaz Khan [3] has proposed a complete and effective healthcare monitoring system using IoT and RFID tags. In this system, for supervising and weighing the health condition of the patient and for increasing the power of IoT, a combination of microcontroller and sensors have been used. But, it does not include medication and precaution according to the patient health condition by controlling the appliances and providing the prescribed medicine which is present in our paper.

Freddy Jimenez et al. [4] have focused on monitoring the health of a patient and sending relevant updates and alerts to doctors, family members and other important people. However, it does not include the appliance control part, which has been added in our project, it only deals with the Monitoring part and informing the relevant people about it.

S. Siva [5] et al. have proposed a solution to monitor patients' health care condition using the smart hospital system. The patients' health condition can be monitored by means of a spark kit. It records the temperature and heart rate of the patient and triggers an alert system if the parameters go out of a certain prescribed range.

Felipe Fernandez et al. [6] tell us about the probable problem which we will be encountering if we actually go ahead to create an IoT based health care system. It also tells us about the reliability of IoT based systems, which is an important concern in health emergencies.

Boyi Xu et al. [7] put forward the challenge of reading and storing data in the IoT platform and ways to solve it. As we know most of the IoT based systems include reading real-time data in regular intervals and health care is one of such cases. Under this scenario due to the different kinds of data and regular input of data it becomes more difficult to interpret and sequentially store the data in proper format. Hence this paper gives us a method to do that.

Danilo F. S. Santos et al. [8] have discussed the use of connected Personal Health Devices (PHD) using which proper data can be retrieved from the actual sensors. This paper actually provides a standard architecture that actually helps in sharing of data between the systems like out mobile phones and cloud databases.

The newly proposed area, in this paper, is the activation of alarm to provide the prescribed medicine in time, which will be displayed in the LCD display. This alarm notification will reduce the human error and help the medical assistant or responsible person to take care of the patient more efficiently. The additional and another beneficial part of the system is the process of sending an email alert and SMS alert using a python script to doctor, medical assistant and relatives of the patient if any of the measured physiological parameters cross the threshold value. Another unique part of the proposed solution is to create the optimum surroundings as per the requirement of patient's health condition which can be achieved by sending the measured data to the control unit of the system which in turn, commensurate to a coding script will communicate to the appliances of the patient's room to create optimal room conditions.

III. METHODOLOGY

Figure 1 shows the Block diagram of the proposed system using Raspberry Pi.

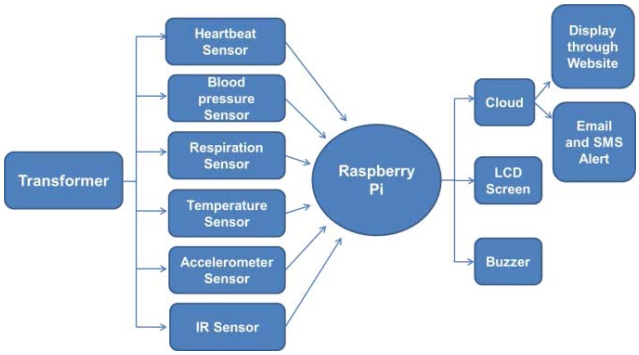

Fig. 1. Block diagram of the appliance controlled remote Health monitoring system using Raspberry Pi

In the present work, our proposed solution is divided into four basic modules as follows:

A. Health Monitoring and Data Collection

The Health Monitoring and data collection module consists of all the below-mentioned sensors that would collect the data i.e. the health parameters from the patient.

Critical health parameters like heart rate, blood pressure, respiration, temperature, blood sugar level, movement of the patient's and saline level could be monitored by various sensors available within the proposed system. After receiving the signals from these sensors, it will be sent to the Raspberry Pi. Raspberry Pi runs on a Linux based operating system named as Raspbian and it can work like a small PC.

Figure 2 shows the Raspberry Pi 3 Model B which will be used as the heart of the system. It can be programmed as per the project requirement, and also patient's health parameters can be displayed on a screen connected with pi. Moreover, one can access the system from any part of the world using the internet. The health data will be sent and stored in the cloud, and it will also be displayed on the website. [9]

Fig. 2. Raspberry Pi 3 Model B

In the proposed system, a step-down transformer will be required to operate the sensors, as the power requirement is different for different sensors. The supply voltage of 230V will be converted into 0-9 V and 15-0-15 V. It will then send to a switched mode power supply (SMPS). Diodes will be required to convert AC voltage to DC voltage. The converted DC voltage will be rippled. So, a 1000 µf capacitor will also be used for power supply which will be connected to the sensors [2][5].

The heartbeat of the patient will be measured by an ECG sensor in our proposed system. Heartbeats are triggered by bioelectrical signals of low amplitude generated by a special set of cells in the SA node of the heart. Electrocardiography (ECG) allows the transformation of these electrical signals into numerical values by which the signals could be used in a wide array of applications. A normal heart rate chart of a patient is mentioned in Figure 3. The sensor used in this proposed system will be designed to provide a digital output of heartbeat when a finger will be placed on it. When the heart detector will start working, the uppermost LED will start flashing with every individual heartbeat. The output of this sensor will be connected to the microcontroller to measure the heart beats per minute (BPM) rate. It will function according to the principle of light modulation by blood flow through the nerves of the finger at every single pulse.[9][11]

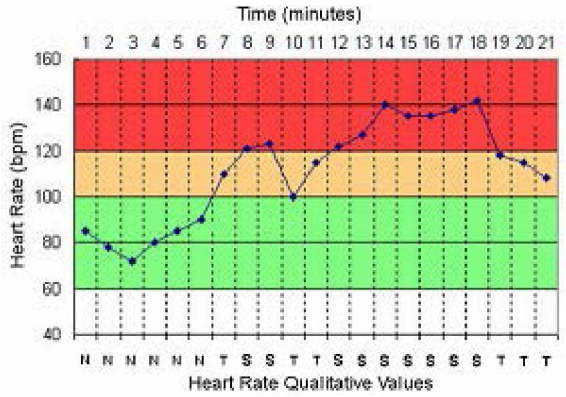

Fig. 3. Heart rate chart of a patient

Another important health parameter is Blood pressure. It is the pressure of blood in the arteries as it is circulated by pumping of heart around the body. Blood pressure is usually expressed in two terms - one is systolic pressure which means maximum during one heartbeat and another one is diastolic pressure which means minimum in between two heartbeats and it is measured in millimetres of mercury, above the surrounding atmospheric pressure. For a healthy full grown human being, the systolic pressure is 120 millimetres of mercury and the diastolic pressure is 80 millimetres of mercury, which is abbreviated as 120/80 mmHg. Figure 4 shows the Systolic vs. Diastolic blood pressure chart of a human being which also mentions the health condition and necessary steps to follow. The blood pressure sensor will measure 80 measurement results with time and date automatically and store it.

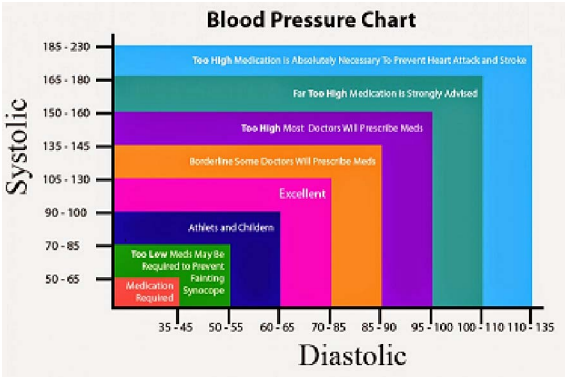

Fig. 4. Systolic vs. Diastolic Blood pressure chart

In this system, two thermistors will be connected to the resistor bridge network for respiration measurement. One thermistor will measure the respiration while the other one will be used for room temperature measurement. The bridge terminals shall be connected to the inverting and non-inverting input terminal of the operational amplifier LM741 (Figure 5 shows). Transistor-Transistor Logic (TTL) pulse will go through the transistor BC547 and the final TTL pulse will be sent to Raspberry Pi for respiration monitoring [2].

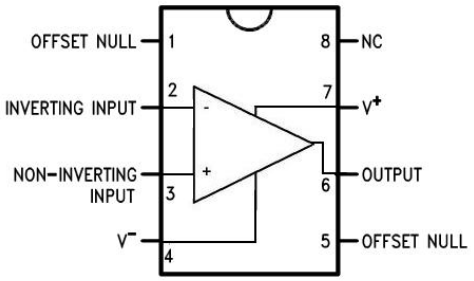

Fig. 5. LM741 Pin Configuration

The temperature sensor LM35(Figure 6 shows) will be used in this system to sense the temperature more accurately with an accuracy level of +/-0.4 °C and it will work according to the principle of the thermocouple. It is an analog type of device and an ADC converter will be used to convert it in digital form. This sensor has better accuracy than that of the thermistor and it does not undergo any oxidation as it is completely sealed. Amplification of the output voltage is not required in this case. It could provide the output voltage, which would be proportional to the sensed temperature.

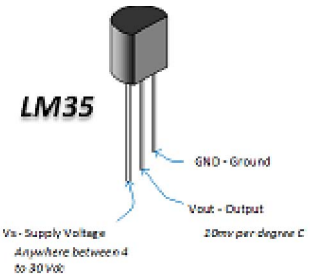

Fig. 6. Pin Configuration of LM35

The body movement of a patient will be monitored by using MMA7260QT (Figure 7 shows) which will be fit to the bed of the patient, and the sensor will detect every small movement using X, Y, Z axis. MMA7260QT is a micromachined integrated-circuit accelerometer. This module contains two surfaces. These are micromachined capacitive sensing cells (g-cell) and a signal conditioning ASIC contained in a single board. The g-cell is a mechanical arrangement made of semiconductor materials using semiconductor process which beams from two back to back capacitors. ASIC uses switched capacitor to measure the g-cell capacitance, and it will also measure the difference in the acceleration data between two capacitors [2].

Fig. 7. Accelerometer sensor MMA7260QT

For saline level detection, IR sensor will be placed at the threshold level of the saline bottle. When the solution in the bottle will drop below the threshold level, it will be sensed by the sensor and the logic 1 will be sent to the Raspberry Pi. As a result, an email, as well as an SMS alert, will be received by a doctor and medical assistant. So this would help to avoid the risk of backflow of the blood to the saline bottle when it is finished.

B. *Medication and Precaution according to the degree to which the patient needs attention and Appliance control:*

There are two basic cases that can arise regarding a patient's health.

i)Major Ailment - In the case of a major health issue, the alarm will be activated in order to attend the patient quickly and moved him/her to a hospital immediately where a better human monitored health monitoring system will be available. In major ailment of patient's health, the appliance control part will not be required. However, in the second case, the appliance control part will play a very important role as during that time the patient needs optimum surroundings to cater to his/her condition. This can be achieved by sending the monitoring data to the Raspberry Pi module which in turn, commensurate to a coding script that will communicate to the appliances of the patient's room to create optimal room conditions. For example, if the heartbeat of the patient is high, he/she will be feeling hot and perspiring. In this situation, the fans will be switched on at high speed or an air conditioner will be switched on at an optimal temperature. Opposing, if the patient is down with fever and he/she will be feeling cold. Then the room heater will be switched on and the other cooling appliances would be switched off. So, in a similar fashion, the appliances could be controlled to create a favourable environment for the patient. In case of an emergency or a major ailment, the monitoring system will automatically activate the alarm and ask for an input whether controlling of appliances is required or not. It would effectively save the energy and the unnecessary use of the appliance module.[10]

i*i) Semi-Major Ailment:* For a semi-major health issue, the required reaction or response would not be as severe as the major health ailment. In this case, the rooms conditions will be altered according to the need of the patient, and the required medicine with the precautions will be displayed by the Raspberry Pi Module. Hence, the IoT based Room control part of the entire project is essential for both the cases.

For major and semi-major ailment, the alarm will be activated to provide the prescribed medicine to the patient in time. The medicine name and required dose will be displayed in the LCD display by Raspberry Pi module which will help the medical assistant or responsible person to take care of the patient more efficiently.

C. *Database preparation from the acquired data*

It is important to keep the records of the medical data of a patient as it can be immensely useful in future. The storage of data will enable the patient to take several decisions like whether they need to lose weight or not, which drugs are the specifically allergic for the patient, which disease are they more prone to and much other necessary information. This database could also help the doctor to interpret the physical problem of the patient and its origin, which will lead to better diagnosis and faster recovery in case of a major health issue. This could be achieved by storing the data in a script in the cloud through Raspberry Pi module [7][8].

D. *Sending alerts and Medical reports to the patient's Family Members and Concerned Doctors*

The additional feature and the most beneficial part of the proposed system is the process of sending email and SMS alert to the doctor, medical assistant, and relatives of the patient[3][4] using python script if any of the measured physiological parameters cross the threshold value. They can also monitor the patient's health condition through website login. These would enable better diagnosis from the doctor's side as well as the family members could also take good care of their patient. The patient himself/herself would be able to monitor their health and take the right decisions regarding their health. This is very important because people tend to neglect their health very often and such notifications would keep them on track for a better health.

IV. Conclusion and Future Work

In this paper, we have successfully proposed an advanced IOT based automated remote health monitoring system by offering alarm notification along with prescribed medicine name and dose display. It could reduce the human error. The most important feature in this system is that the health condition of the patient could be monitored from the home as well and necessary action could be taken during semi-major ailment. The probability of human error while acquiring the data could be effectively reduced as sensors are used for health data measurement. The proposed system would also provide

automatic appliance control which makes the environment comfortable for the patient. Another beneficial part is the alert notification to the respective authority of the patient, and health data monitoring through the website which allows performing their regular task.

This system needs an appropriate bandwidth since email alert notification and website visit for remote data monitoring through internet depends on the proper bandwidth of internet connection.

In future, a fully formed mobile app can be made to manage the data of all the external sensors and other hooked up devices. This will help to send the notification in a faster and efficient way to the patient regarding their current status, and also help to make a compact data storage in the cloud. The reliability of the system can be further improved by the addition of strict security protocols like fingerprint scans and password protection so that no confusion and hassle occurs. Further, a phone call or a video call service can be included to inform doctor, medical assistant and family members about the condition of the patient and the patient could be also able to communicate with them.

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