iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** VIII **Month of publication:** August 2019

DOI:

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VIII, Aug 2019- Available at www.ijraset.com

Remote Healthcare Monitoring System with Home Automation.

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Abstract: ***In this paper, Internet of Things (IoT) based healthcare monitoring system is studied. Several number of sensors are used to extract data of various health parameters of a patient, which is then reserved into the cloud. The data stored in cloud can be further displayed through website. The performance of a healthcare monitoring system is investigated where a short message service (SMS) notification helps a patient to remember the timing of medication and create an optimum surrounding as per the patient's condition. Under any emergency condition, the system also generates list of nearby doctors using their geographical coordinates, which is given by GPS module. The closest doctor is then located by comparing the distance of each doctor from the patient using a distance algorithm.***

Keywords: ***Arduino Uno, GPS module, Glucose sensor, Heart rate sensor, Oxygen sensor, Temperature sensor.***

I. INTRODUCTION

Wireless communication devices are gaining vast importance as it is making automation the need of our daily life, and the increasing demand for internet related things encourages people to work on innovations. Over the past decade, IoT and Automation has brought about many changes in the world. IoT has proved to reduce human efforts and has made our life easier and comfortable. Due to unsteady lifestyle and a busy schedule, people have become ignorant of their health. In this situation, IoT proves to provide an effective solution by keeping a check and monitoring the health of the patients in hospitals, which can also be accessed from home. The IoT is the compilation of software, physical devices, embedded systems, actuators and sensors, which allows them to create a network and share data. Information and data can be easily accessed using IoT and as the price of these components has dropped rapidly, it has become economically efficient for the people. In this fast pace world, the number of health problems has increased as people have become ignorant about it. This has raised a concern regarding the surge of chronic diseases. This has made it mandatory to have a regular health test to diagnose problems before they occur. IoT plays a key role in the healthcare remote monitoring system. When a patient is in the hospital, the doctor has to regularly visit the patient to keep a check on his heath record and it is difficult to manage it all the time. Also, the close relatives of the patients are worried about his/her health condition throughout the entire time. Therefore, we can solve this problem by implementing the combination of Arduino kit and IoT. Arduino Uno is a platform, which is a complete operating environment on a tiny scale, which is also cost effective, and it allows interfacing software, actuators, sensors, through the I/O pins. In our proposed system, Arduino collects the patient's body temperature, heart rate, oxygen level, acceleration rate, blood pressure, glucose content and stores them in the cloud, which can be accessed through the website. Also, the relay helps in maintaining the optimum surrounding for the patient. Moreover, the distance formula is used to determine the nearest doctor available for the patient during an emergency.

II. LITERATURE SURVEY

Jayeeta Saha et al. [1] has demonstrated a healthcare monitoring system to allow doctors and close relatives to examine the patients' health condition using Raspberry Pi. However, in our solution, Arduino Uno is used which is cost effective and the data is displayed through website.

Danilo F. S. Santos et al. [2] has explained how proper data can be collected from the electronic physical health sensors. But it does not provide solution to maintain the optimum surrounding for the patient.

Ananda Mohan Ghosh et al. [3] has proposed a health monitoring system to know the patients' health condition using Arduino Uno to provide data for hospital management and relatives. But it does not include SMS feature to alert the patient about the medication time.

Boyi Xu et al. [4] has discussed the problem of gathering, reading and storing data via the internet into the cloud and has also provided the method to understand and solve it. Under this context due to multiple input of data at regular interval, it becomes difficult to read and store this data in the correct format. Hence, this system gives a solution to do that.

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S. Sival et al. [5] has explained the effective healthcare monitoring system, which records the patients' heart rate and temperature using the spark kit. But it does not record the body movement, glucose content and respiration. Also, it does not create adequate surrounding as per patients' requirement.

R. Kumar et al. [6] has demonstrated a healthcare monitoring system using raspberry pi where it records the patients' temperature, heart rate, body movement. But it does not provide a reminder to the patient about the prescribed medicines.

Sarfraz Fayaz Khan [7] tells us about healthcare monitoring system using microcontroller and RFID tags. This combination is used to increase the strength of IoT. However, it does not control the appliances according to the patients' health requirements.

The additional feature, which is proposed in this paper, is the generation of SMS to remind the prescribed medicine to be taken in time. Another unique advantage of this system is that the SMS alert will also be sent to the doctor and close relatives. This will help the relatives and the doctor to take proper care of the patient efficiently. The newly added solution is to maintain the surroundings of the patient by controlling the appliances using a relay.

The rest of the paper is organized as follows. In Section III methodology of healthcare monitoring system is discussed followed by the working of various sensors. Graphical simulation is discussed in Section IV. Finally, the study is concluded in Section V.

III. METHODOLOGY

Fig. 1 shows the block layout of the proposed system using Arduino Uno.

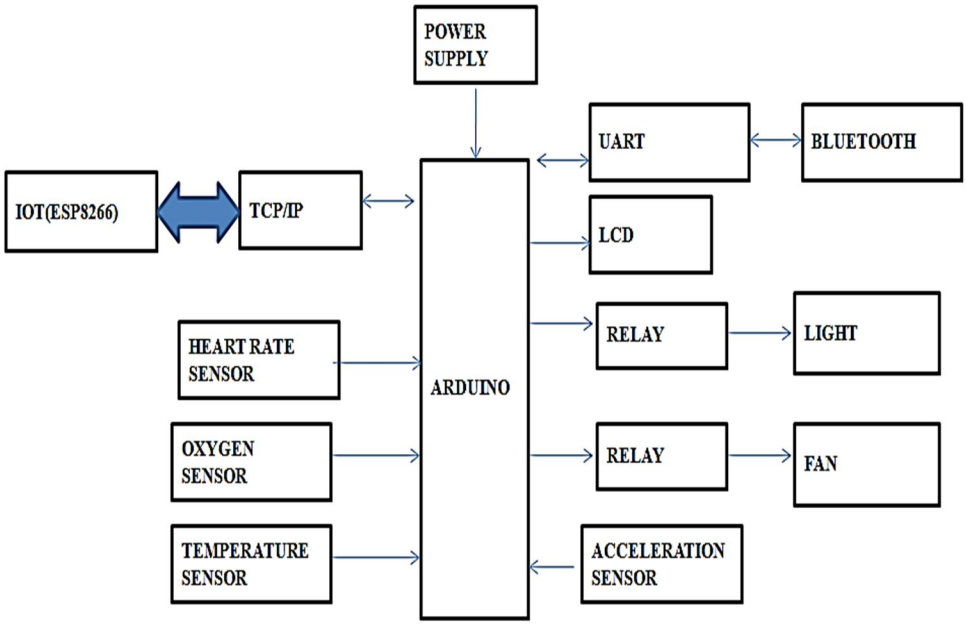

Fig.1. Block diagram of health monitoring system using Arduino Uno.

The step down transformer is used as a power supply, which is connected to the Arduino. The various sensors, GSM and IOT modules are connected to the Arduino. The Arduino is further connected to the LCD and relay. The LCD screen displays the health parameters of the patient. The relay controls the appliances to maintain the surroundings of the patient. The proposed solution is divided into the following four modules:

A. Data Compilation

The module discusses about the different sensors which will collect data about various health parameters of the patient. After collecting data from the sensors, it is then sent to the Arduino kit.

The Arduino Uno which is an open source microcontroller that can be easily programmed, erased and reprogrammed at any instant of time. [8]. Moreover, it is capable of sharing information over the internet which can be accessed from any part of the world. This data is then stored into the cloud and can be further viewed through website.

A step down transformer is used because the requirement of power for each sensor is different. It converts 230 V to less than 9 V. The data is then sent to the bridge rectifier which converts the AC power into DC power. The filter circuit then allows the DC voltage to pass through it. The regulator then regulates the voltage level as per the need of the sensors.

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A heartbeat Sensor is made of a control circuit and a sensor. The sensor part has a photodiode and an IR LED inserted in a clip. The Control Circuit has an Op-Amp IC and some more components to connect the signal to the Arduino. The heartbeat sensor used in this system is a finger type sensor and the output is given in digital format. The LED on the sensor starts flashing with every heartbeat and this is recorded by the Arduino. It will function according to the principle of light modulation by blood flow through the nerves of the finger at every single pulse [9][10].

Another major parameter is the body movement of the patient which is observed using ADXL345 which is a 3-axis, low power, thin and small MEMS acceleration sensor which has a high resolution measurement (13 bit) upto +/- 16g. This will be fitted to the bed of the patient. The supply voltage of this sensor is between 2.0 - 3.6 VDC. The output data is accessed through SPI or I2C interface. This sensor has some special abilities. It can detect a single or double tap when either a single or two acceleration movement occur simultaneously. It also performs the inactivity and activity sensing which depends upon the presence of movement. Further, the feature of free fall sensing measures the acceleration on all the coordinate axes and compares it with the threshold value to know if the device is falling. Furthermore, its high resolution allows the measurement of inclination change less than 1°.

In this system, LM35 is used as the temperature sensor to record the temperature more efficiently with an accuracy of +/- 0.4 ºC which is more accurate than a thermistor. This sensor has a working principle of the thermocouple. Being an analog type device, it needs an ADC converter to convert the signal in digital form. The sensor also carries a significant characteristic to draw 60 micro amps from the voltage supply and gain a self-heating capacity with a low value. The voltage at the output of this sensor is related to the measured temperature.

For measuring the respiration rate of the patient, oxygen sensor is used. It works on the principle of fluorescence quenching by oxygen. It requires less power and has a longer lifetime. It has a response time and warm-up time of less than 60 seconds. The output is accessible through UART or analog interface.

B. Maintaining Database from the Collected Data

The records of the patient's medical information can be useful for future references and hence, it needs to be stored. These records will help the patients to determine what precautions they need to take in their life like which medicines they should continue consuming or what diet chart they should follow and many other necessary information. This database will also be advantageous in a situation where the doctor needs to understand the patient's health problem and its source. This will further help in proper treatment and a swift recovery. This database can be maintained by storing the data into the cloud.

C. *Sending alerts to the patient's close relatives and concerned doctors.*

The most useful and the newly proposed feature of this system is the procedure of sending SMS alert to the doctor and the family members of the patient if any of the obtained health parameters cross the threshold value. And in this process the language used is python script. The data can be further viewed through a website. This would then help the doctors to give better treatment to the patient. Also the family member would be able to know the exact health condition of the patient. This system can be used by the doctors even in the remote areas and such notifications and alerts will help them in keeping a better track on the patient's health.

D. Optimized Algorithm to locate the nearby doctor

1) GPS module gives the latitude and the longitude values of the patient and the doctors.

2) Let (lat1, lon1) be the geographical coordinates of the patient and (lat2, lon2), (lat3, lon3) … (lat n, lon n) be the coordinates of the 'n' number of doctors in the given area.

3) The formula to calculate the accurate distance (d) between the patient's coordinates with respect to each doctor is given by

$$d = 2a \sin\left(\sqrt{\sin^2 t_1 + \cos(lt1)\cos(lt2)\sin^2 t_2}\right)$$

where $t_1 = \frac{(lt1 - lt2)}{2}$, $lt1$ and $lt2$ are latitude, and t_2 is the difference between two longitudes.

4) Further, all the distances are compared and are ranked in ascending order.

5) The 1st doctor in the list is contacted, if there is no response from his/her side then the 2nd doctor is contacted and so on.

6) Repeat step 4 until a doctor responds.

7) Patient's health parameter is then sent to the doctor who responds to the call.

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IV. RESULTS

The Fig. 2 shows the final hardware circuit of the proposed system which contains a power supply, different sensors, LCD display, Bluetooth module and GSM module.

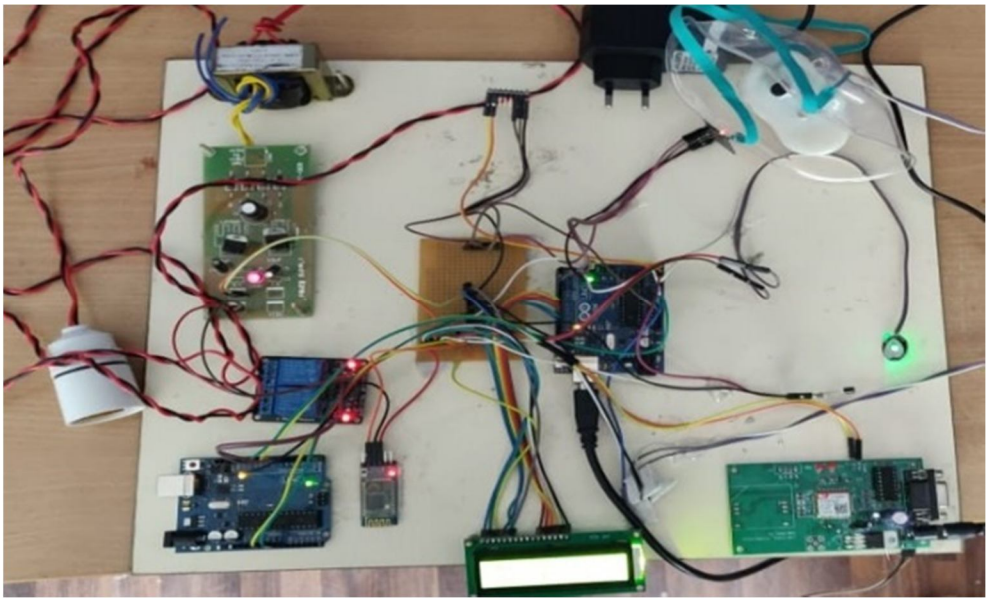

Fig. 2. Hardware circuit

A graphical result containing the different health parameters of two patients is shown in Fig 3, where their temperature, oxygen level and heartbeat rate is recorded. The health parameters of patient 1 is irregular whereas the patient 2 has a normal health record.

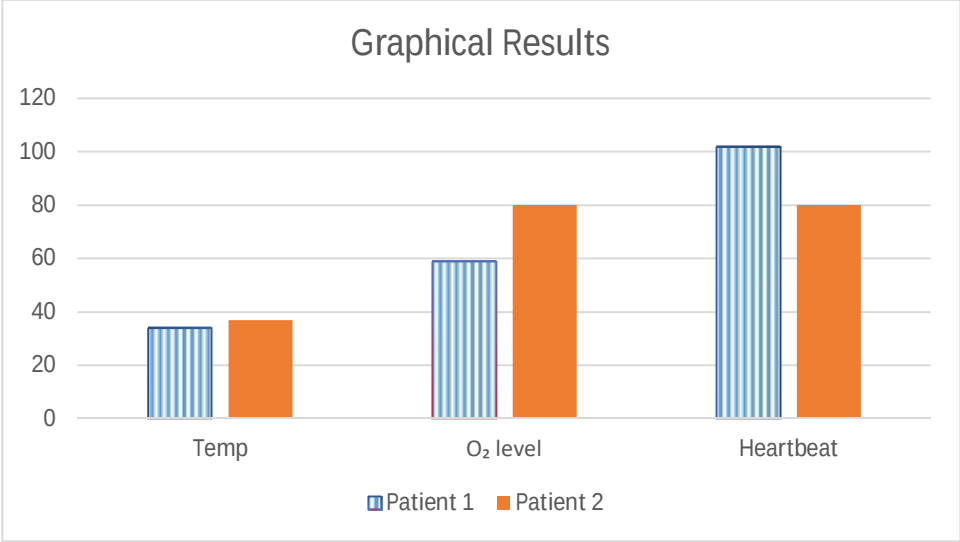

Fig. 3. Health record of 2 patients

V. CONCLUSION

In this paper, we have successfully designed an advanced Bluetooth, IoT, GPS module and GSM based heath care monitoring system which contains the feature of SMS notification of the prescribed medicine along with heartrate, temperature and oxygen level being displayed on the LCD screen. This data can also be read on the web server. The GPS module is used to locate nearby doctors in case of emergencies depending upon their availability. The major feature of this system is that it can be accessed from the remote areas as well. Sensors used in this project help to reduce the human error and provide accurate data. The focus of this system is also to provide automatic appliance control which makes a comfortable environment for the patient depending upon his/her condition.

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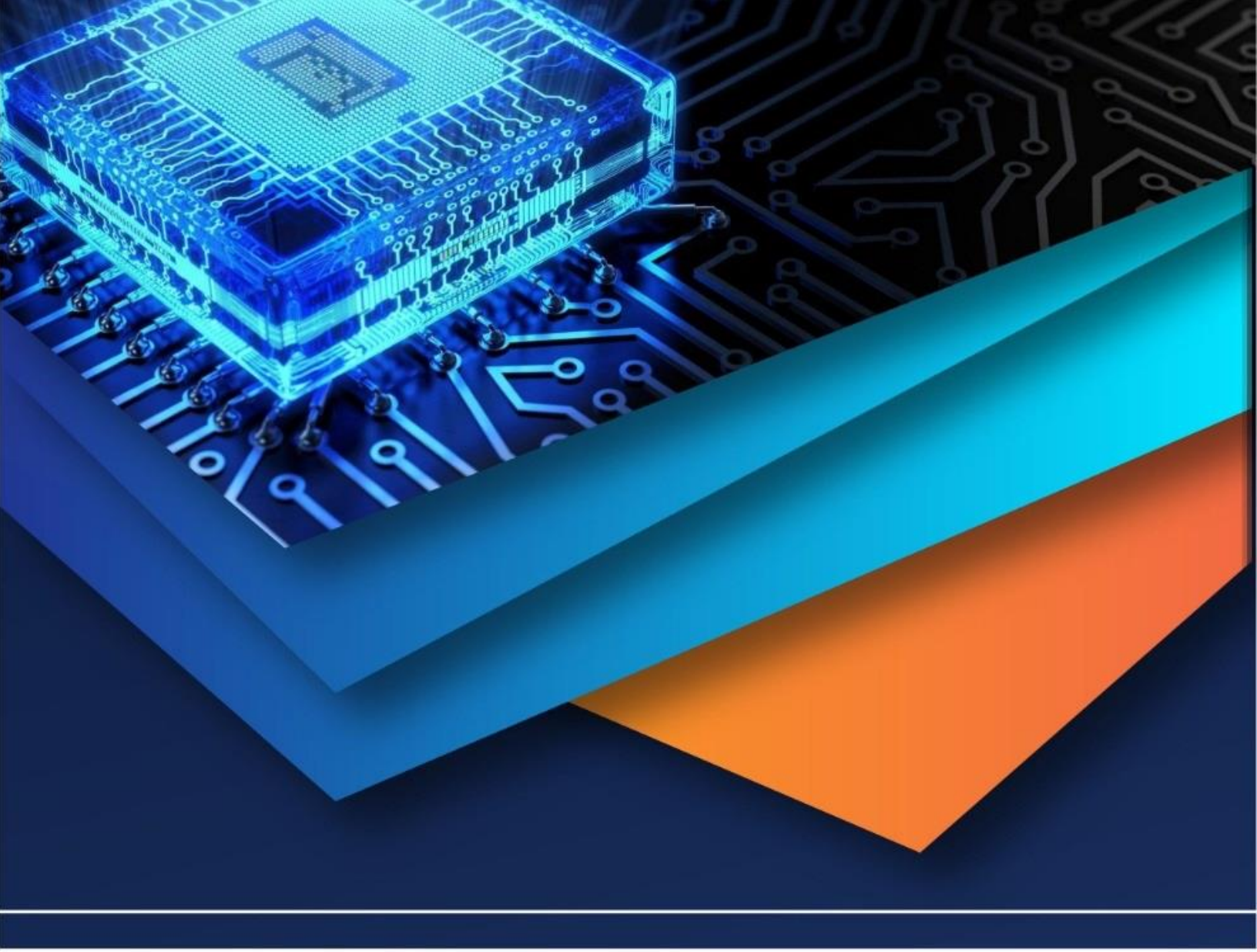

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