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Cost Effective Remote Health Monitoring System Based on IoT Using Arduino UNO

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Abstract—*Remote health monitoring nowadays is seeking great attention among doctors, researchers, IT professionals and engineers. Internet of Things has marked its presence in various sectors like smart home, smart city, smart grid, agriculture, wearables and connected health. IoT is a powerful tool which can be utilized to develop healthcare systems. Remote health monitoring system in which a doctor can keep an eye over the patient's vital parameters via internet is emerging in countries like Malaysia, USA and other developed countries. Remote health monitoring system is very useful and valuable to patients and society especially the senior citizens as it will cut down the cost of visits to their doctors, save time and efforts and most importantly reduce the traffic congestion at hospitals. The objective of the paper is to implement a system for monitoring body vital parameters like temperature, pulse rate using reliable sensors along with Arduino UNO and IoT. System is making the use of wearable sensors, interfaced to Arduino UNO. Since Arduino does not have inbuilt support for internet connectivity therefore, Ethernet shield is used to connect the whole system to internet. The body temperature and pulse rate of a person sensed by the sensors are sent to the cloud with the help of Ethernet shield and will also be displayed on the Blynk mobile application preinstalled on the android phone or ios. Data can be displayed in the form of graphs, tables b using by just drag and drop from the widgets already available in Blynk.*

Keywords*: Healthcare System, Internet of Things, Arduino UNO, Ethernet shield, Blynk Mobile application.*

1. "Introduction"

Heart rate, body temperature and blood pressure are the vital signs/body parameters which need to be monitored to get the information about the health/wellbeing of a person. Internet of Things (IoT) is nowadays finding great use in applications like smart homes, smart cities, smart retail, smart grid, wearables, connected health etc. IoT is a platform where the sensors or devices or objects present in the network can communicate either with each other or with other objects in the network, and send the data over the internet without human interference [1]. This not only reduces the system errors but also make the system more efficient and reliable. The use of IoT in remote health monitoring systems is seeking more attention [5]. The people are conscious for their health and want to keep an eye on their health in order to live long and disease free life, but the lack of time prevent them to go for regular health checkups with their doctors. It becomes rather difficult for the elderly people to stand in long queues waiting for their turns at hospitals. Thus cost effective remote health monitoring is a need of society which will cut down the efforts and also save people's time. National Heart Institute in Malaysia has become the first hospital to launch remote patient monitoring system which will increase the communication between the doctors and through internet according to a report by The Star, June 2013 [4].

With the availability of wireless sensors and WSN (Wireless Sensor Network), it has become possible to design such remote patient monitoring systems. Body temperature, Heart rate and blood pressure all are wireless sensors used in designing medical devices. Doberescu et. al., (2008) stated that with the high growth rate of internet services and wireless sensor network there are ample opportunities in healthcare [14].With these systems, patients will be able to monitor their vital signs and can also send the data to the concerned medical personnel.

The proposed system consist mainly of two sensors- DS18B20 (Temperature sensor) and KG011 (Pulse rate sensor) connected to Arduino UNO. It does not have an inbuilt module for internet connectivity therefore, Arduino Ethernet Shield is used which is mounted at the top of Arduino board to connect the complete system with internet. The health parameters of a person sensed by the sensors are sent to the cloud with the help of Ethernet shield and from the cloud, it can be fetched on the mobile application on the person's side. Blynk app is downloaded and installed on the android and ios mobile phones. Data can be displayed in the form of graphs, tables or just the values being displayed one after another by using widgets already available in Blynk.

In section II research gaps have been described along with solutions possible. Section III provides the details of related work. The details of the proposed system are described in Section IV -VI. The readings of measured parameters being monitored (temperature and heartrate) with the help of **graphs** are shown in Section VII. Section VIII concludes the paper along with the future scope of the study.

II. "Motivation"

Remote health monitoring system proposed focuses on health domain of IoT. With the health monitoring devices based on IoT, we are able to provide quality healthcare services to people mainly senior citizens, sportspersons, athletes at the comfort of their places. This will not only cut down the cost of regular checkups with their doctors but also reduce the traffic congestion of hospitals. Some researchers have already implemented systems to monitor pulse rate and temperature using sensors which were not meant for health monitoring instead suitable for industrial purposes [3].Those who have designed health monitoring systems making the use of wearable sensors have not paid attention to take the cloud services for storing the data to be accessed by the doctors which ultimately fails to fulfill to realize remote monitoring of health [6]. Some authors have implemented their system using cloud computing but compromised with the wearability and accuracy of sensors [4].

By learning about these systems in a detailed manner authors concluded that the quality is lacking in some way. Thus authors have come up with a solution which is taking all the important factors like accuracy, power, cost into consideration. The proposed system sends a person's data at the mobile application provided by Blynk and the data can be retrieved in future from the cloud which fulfills the aim of remote heath monitoring. The system will reduce the costs of regular checkups with doctors and also save time and efforts of people traveling to the hospitals.

III. "Related Work"

Yusoff et al.[15] proposed a system using Peripheral Interface Controller (PIC) to process the information of body temperature of a patient.

Mohammed S. Jasses et al [8] monitors body temperature and pulse rate of a person using raspberry pi. The central idea of the paper is on the integration of wireless health sensor network and cloud computing. Amazon web service is used for storing the important data.

Mathan kumar et al [6] designed a system i.e. remote tele monitoring system using android applications .LM35 temperature sensor and ppm sensors are connected to PIC16F887A microcontroller and via Bluetooth technology and GSM module data is sent to an android based mobile application.

Damodhar and Reddy [16] proposed a system to monitor parameters like body temperature, heart rate, blood pressure and ZigBee is used to send the data through RS-232 serial port to the computer. Not only the data is stored at PC, the data is sent to the mobile phone.

Hasmah Mansor et al [4] used LM35 temperature sensor for monitoring body temperature .Arduino UNO is interfaced with the sensor. A website is developed using SQL for the storage of data so that the data can be further retrieved when required. Furthermore, a patient can also login by using authentic id and password.

IV. "System Design"

Block diagram of the overall remote health monitoring system is depicted in figure. 1. The system can be further divided into three parts – Sensing unit, Data processing unit and Data communication unit.

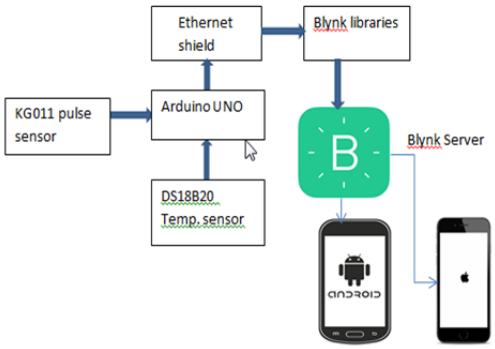

Figure1. Schematic diagram of proposed system

A. "Sensing Unit"

The sensing unit mainly consists of two sensors which are used for the implementation of our system. The sensors are namely DS18B20 (Temperature sensor), KG011 (Infrared pulse sensor). DS18B20, developed by MAXIM IC is one wire sensor with digital output. It has only one data line used for communication and a ground. It requires no external power supply and fetches power from the data line. It measures temperature from -67˚F to 257˚F. It has an accuracy of ±0.5 ˚Cover the range of -10˚C to + 85˚C [4]. KG011 i.e. Pulse rate sensor is based on photo plethysmography. This sensor comes up with the following technical specifications – LED for the indication of heart beat, operating voltage of + 5 V DC, very compact with the digital output.

B. "Data Processing Unit"

Data processing unit consists of Arduino UNO, its IDE (Integrated Development Environment) and Ethernet shield mounted over Arduino board are used for processing the data i.e. health related data and sending over the internet to realize the ultimate aim.

1. "Arduino UNO"

Arduino Uno is a microcontroller board which is based on Atmega 328P. It has 14 digital output/input pins. PWM outputs can be taken with 6 pins. It has a clock of 16 MHz Arduino cab be easily interfaced with USB. Flash Memory of 32Kb provides the space for storing the programs. For directly interfacing Arduino as serial device ICSP header is present [11]. To reset the programs stored in the memory chip of

Arduino, reset button helps. Arduino has an inbuilt A to D converter with the resolution of 10 bits. The pins marked as 'A' are the analog pins. Arduino can accept the analog voltages ranging from 0 to 5 volts. Accordingly, the least value displayed by Arduino will be 4.9 mV.

2. "IDE"

IDE is platform dependent supporting Arduino hardware. Have Arduino coding can be done in any high level machine language. The prime requirement for writing the code is that it should have compiler. IDE is a powerful platform for the engineers, coders who work on hardware based projects using Arduino.

Arduino IDE can run on Linux operating system, MAC OS as well as windows. It was a great invention for those people who knew very little about electronics. Brace matching, Highlighting of text, automatic indexing, cutting –pasting are the important features [8]. IDE provides a very easy mechanism for compiling as well as uploading the codes. Programs written for the Arduino projects are called "sketches". Arduino support languages like C and C++ for writing the codes.

3. "Ethernet shield"

Arduino gets connected to the internet in just a few minutes using Arduino Ethernet shield. In order to connect Arduino to the internet, Ethernet library is used and SD library is used to read and write the codes to SD card. Ethernet shield is mounted over the Arduino board and it is connected to the network with the help of RJ45 cable. As the hardware, software and documentation of Arduino platform are open – source and available free of cost, it becomes easy to learn its design o use it as an initial point for designing own circuits.

The shield operates at 5V DC which it gets from the Arduino board. It relies on W5500 chip with 32K buffer. It has connection speed of 10/100Mb. It is connected to the Arduino board on Serial Peripheral Interface.

C. "Data Communication Unit"

Cloud services of Blynk platform are used for storing the health related data. Blynk app can be downloaded in android phones or ios. Blynk can support a variety of hardware like Arduino UNO, Raspberry pi, Texas instruments, Spark fun red board, Beagle bone back etc.. Blynk provides a simple mechanism to create own Graphical Interface by dragging and dropping the history graph widgets , tables or any other suitable representation from the widgets column. Blynk also supports different Arduino connections types like Wi-Fi, Ethernet shield, Bluetooth, GSM technology. Since our Arduino is connected to internet through Ethernet shield, Blynk will get us online and our IoT based project get started. All the relevant health data comes on the Blynk app preinstalled in smartphones.

V. "Methodology"

Remote health monitoring system consists of temperature sensor, pulse rate sensor, low cost ATMEGA 328P Arduino UNO and Ethernet shield [8]. As shown in figure. 1, system has DS18B20 temperature sensor, KG011 pulse sensor used for measuring body temperature and pulse rate. Pulse sensor's output is analog hence, is interfaced to A0 pin of Arduino board, DS18B20 is a digital sensor and connected to Arduino's digital pin. Arduino when connected to the Ethernet shield gets internet connectivity [3]. At the software end Blynk is used to realize our system. Arduino and Ethernet Shield are chosen as Blynk has a good support for this hardware as well as this module. Initially the Blynk app is downloaded in android phones or ios. Auth token is a token provided by Blynk which acts as a connectifier between the mobile application and Arduino. To get this Auth token a new project has to be created in Blynk app by choosing the board which is Arduino in our case and connection which is Ethernet Shield in our system. While creating a new project in Blynk app an email needs to be registered to get the Auth token. Next the Blynk library has to be installed manually. When the latest version of .zip file is unzipped we find several folders and libraries. These folders and libraries are then connected to the sketchbook folder of IDE. Once the Blynk sketch code for the Arduino is ready, Auth token provided manually has to be included in sketch and results start getting displayed on the serial port of Arduino as well as Graphical User Interface based Blynk mobile application.

VI. "Experimental Setup"

The complete setup of the proposed system is shown in Figure. 2. The sensors i.e. temperature sensor and pulse rate sensor are connected to Arduino UNO, which in turn is connected to Ethernet Shield. Shield is mounted over the Arduino board and providing internet connectivity to whole system. Finally the data is displayed on Blynk application preinstalled in the android device or ios.

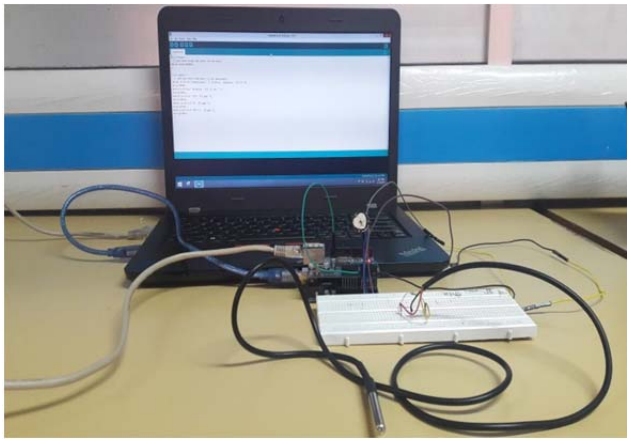

Figure 2. Experimental Setup of Proposed System

VII. "Results"

The graphs for the parameters measured i.e. body temperature and heartrate of a person, coming on the Blynk app are shown in Figure 4. and Variation of heart beats in a minute is shown in Figure. 3. The values are updated continuously on our mobile application. We can keep a constant watch at our heart rate and body temperature by using the Blynk app.

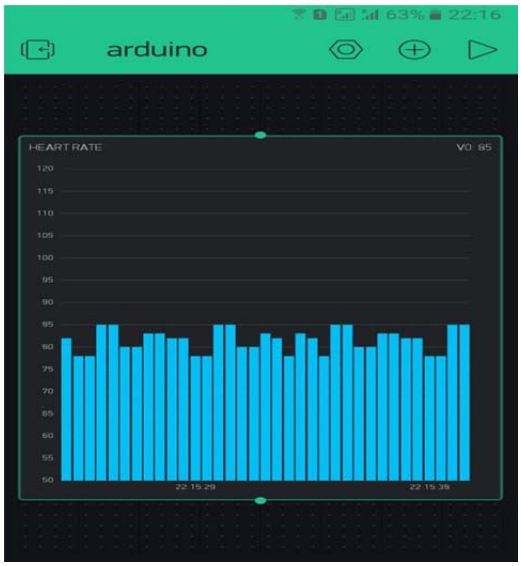

Figure. 3. Variation of heart beat in a minute

Figure 4. Results of Heartrate and Temp. Obtained from Blynk App

VIII. "Conclusion and Future Work"

The objective of the paper has been achieved. Remote health monitoring system based on IoT, bearing low cost and low power has given satisfactory results. The system makes the use of temperature and pulse rate sensor along with Arduino UNO and Blynk. The body temperature and pulse rate of a person sensed by the sensors are sent to the cloud with the help of Ethernet shield and are displayed on the Blynk mobile application preinstalled on the android phone or ios. The system is very useful and valuable to the society especially the senior citizens since they can have a regular check at their health sitting at their homes.

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