IoT Based Patient Monitoring System

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Abstract— In today's world of modern medical systems, IoT provides applications for various types of sensors that facilitate individuals in creating contemporary medical attention services at any place, anytime. In today's world, which has so many technological advancements in the health care management system, IoT brings along several medical facilities which can help both, the doctors and their patients. Health monitoring for better and long-life living is one of the paradigms that can use the technology of IoT as an advantage to improve the patient's lifestyle. The aim of the project is to come up with a remote health monitoring system that can be made with domestically available sensors with a view to making it affordable and updatable if it were to be mass produced

I. INTRODUCTION

Several decades and centuries ago, people had little knowledge about different diseases and illnesses, and almost no effective treatment for it, leave alone detecting it at an earlier stage or in other words, health monitoring. Although in today's world cures for many diseases have been found, even then, increasing population is affected by acute as well as chronic diseases, which according to surveys happens due to many different risk factors, which include dietary habits, physical inactivity of people, increased alcohol consumption etc. According to WHO, around 4.9 million people of the total world population die from lung cancer, 2.5(approx.) million from being overweight, around 4.5(approx.) million from elevated cholesterol and about 7.0(approx.) million from High BP (blood pressure) problems. It is also predicted that in the years coming, the death toll from such chronic diseases will rise by 17%, and this 17% is nearly 64 million people. [3]

The main problem in several scenarios is that people with chronic diseases such as cancer, diabetes etc., often don't even know they're facing such deadly diseases until it is too late. Hence, constant monitoring by a doctor and even by people themselves is very much needed, and with the immense amount of technology that is available in today's world, it is quite easy to get access to such technology. Medical scientists are trying hard to find breakthroughs to introduce innovative systems and have been researching since decades to get better health services and happiness in human lives. They make unimaginable contributions to the world which cannot be neglected, and rather should be given way more attention and resources than what is given. Detecting such life-threatening diseases at early stage can prove to be extremely useful. The body temperature and heart rate are two of the prime parameters used to diagnose such diseases. This project gives the patient's temperature and heart rate values by using IoT.[8]

Revised Version Manuscript Received on 10 September, 2019.

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II. SENSOR CONCEPT

a. Pulse Sensor:

Earlier, doctors as well as people themselves used a technique of counting the pulse rate manually which is quite inaccurate.

Here, we have used a pulse sensor, which is designed to give analog output of heart beat when a finger is placed on sensor. An LED on the top side starts blinks with each heartbeat. The output and input pins of the sensor are connected to the controller. The working principle of this sensor is based on the modulation of light by the blood flowing through the nerves at every heartbeat. [8]

b. Temperature Sensor:

Usually, the reason why people measure their temperature is after they've fallen ill, to know the extent of their illness, this project rather employs the technique of measuring the temperature constantly and monitor their body to let them know of any unusual variations so that they can take a timely action towards it.

The temperature sensor used here is the LM35 Sensor, which for a prototype project like ours, has proved to be very economical and feasible.

c. Controller:

The controller we used as the brain for our prototype is the Arduino UNO, which is based on ATMega 328, and is a widely used microcontroller because of its versatility for integrating many features. Here, the Arduino UNO takes an analog input from both the sensors and processes it to produce the output.

d. Our Proposed System:

A brief summary of the implementation of the various components in our prototype occurs as, the sensors take the readings from the patient's body in a certain frequency which is pre-programmed in the controller, the readings are sent to Arduino UNO, which processes them, and relays them to two places, one, the OLED display which will show the patient in real-time, his stats; and the other, to the WIFI module which then via the internet sends it to the ThingSpeak domain, from

which the doctor can monitor his patient at any time, and from anywhere in the world.

III. PROPOSED SYSTEM CONCEPT

The popularity of the terms "Internet of Things"(IoT) as well as "remote monitoring system" is increasing day by day. These concepts are gaining popularity in healthcare sector as well. Health observing is the major drawback in today's world. Due to negligence in correct health monitoring, patient suffer from serious health issues. There are a number of IoT based systems currently being used to monitor the health parameters of patients over the internet. Doctors as well as medical professionals are taking advantage of these services to keep an eye fixed on their patients. With several new health care technology start-ups, IoT is quickly revolutionizing the health care business. Now-a-days, various health monitoring systems are getting wearable. The functions of these wearable devices include body temperature sensors, glucose sensors, ECG displays, pulse, and blood pressure monitoring system just to name a few and are described in [1–12]. A prototype of healthcare system as in [4] is used to track health parameters of soldiers including their positions. A remote healthcare system can be very helpful for older people staying alone.

Through this project, we have developed a prototype of a Health Monitoring System with IoT feature, using Arduino as a controller strategy, which records the patient heart beat rate and body temperature and send an email alert whenever those readings go past the critical values. Pulse rate and body temperature readings are recorded through sensors and sent to ThingSpeak which is an IoT interface platform. From this platform recorded data can be visualized over graphs or can be downloaded in many different formats for example excel sheets so that health parameters can be monitored from anywhere in the world through internet. A panic button is also connected so a patient can press it in case of an emergency to send email to their relatives/doctors. An OLED display has also been introduced in this prototype so that even the patient can be aware about his/her condition [Fig-1]. The figure below [Fig-2] shows the block diagram of the code which helps run the whole system.

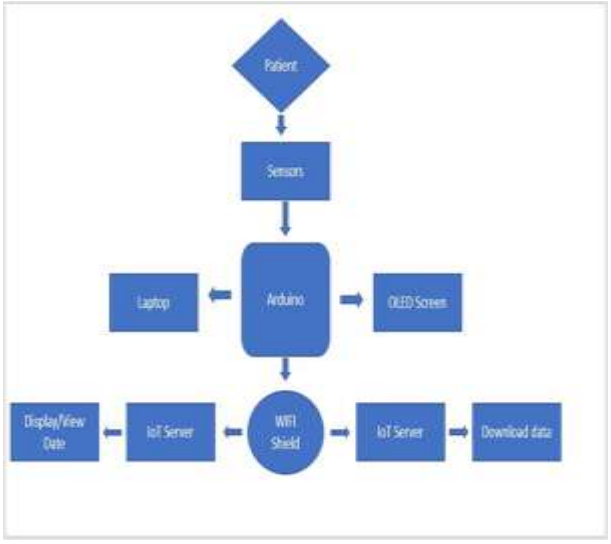


Fig.1. Block Diagram of our system

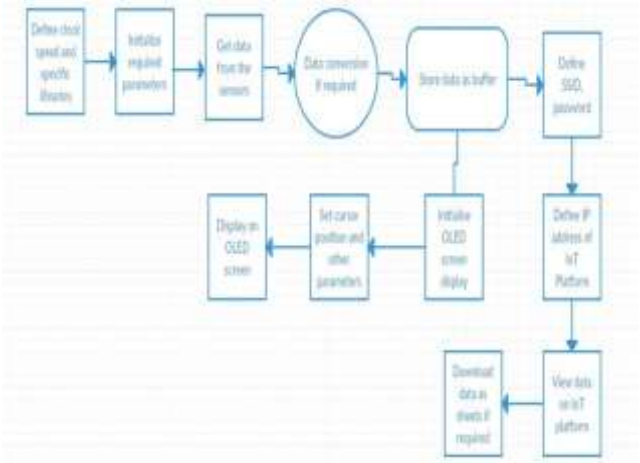


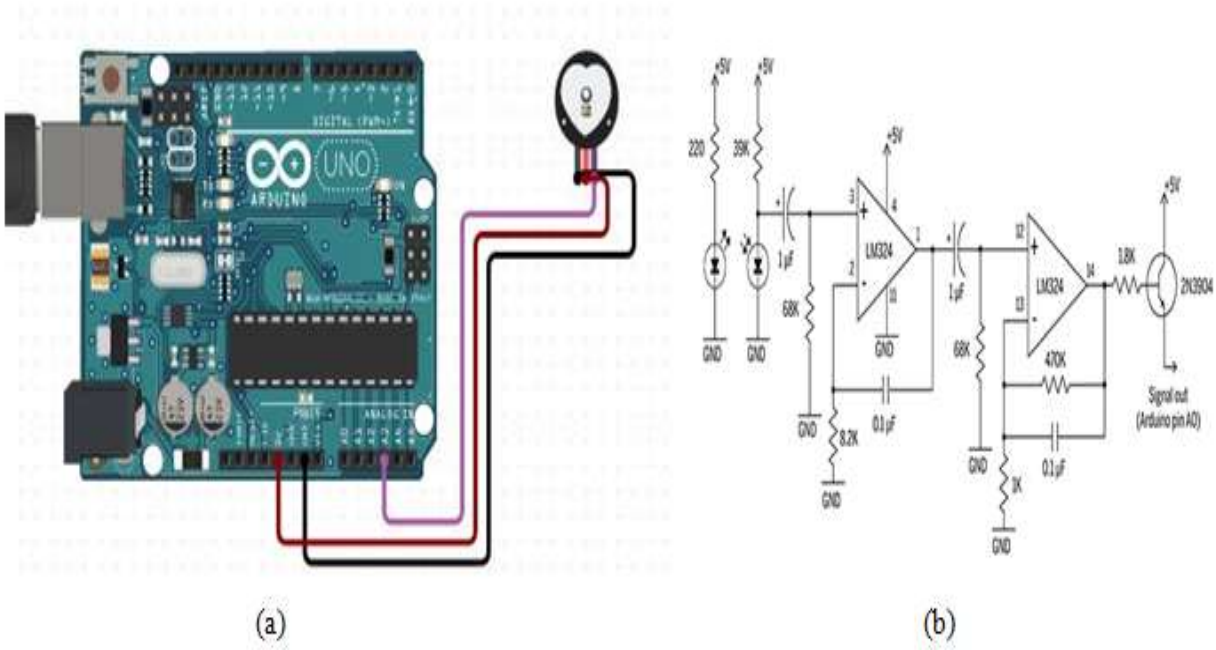
Fig.2. Block diagram of code generation system

IV. MEASUREMENT OF HEALTH PARAMETERS

a. Pulse rate

Pulse or heart rate is the measure of the number of times our heart beats every minute. This pulse rate is different for each individual, but in general it is low at rest and high on exertion. A disturbed pulse rate can tell tons of information about one's health condition. A high pulse rate can mean any heart disease, fever, etc., whereas a low or weak pulse rate may be a blood clot or disease of blood vessel.

In our project we have used a "Sparkfun Pulse rate sensor" which is infrared based. It's a well-designed and built plug-and-use heart rate sensor for Arduino [Fig-3]. The sensor is placed on the fingertip or earlobe. The front of the sensor consists of a heart shaped logo which makes a contact with skin. The logo houses a small LED in a hole. The LED shines light onto the finger or the earlobe, and the sensor reads the amount of light bounced back from the surface of the skin. This in converted to analog signal through the circuit on the back side of the sensor. [Fig-4] shows the internal circuitry of the pulse sensor.



(a) (b)

Fig.3. (a) Arduino system (b) Connection of Pulse sensor

b. Temperature measurement

Measurement of body temperature is very important for health care and medicine. Several symptoms and diseases can be characterized by body temperature or the change in the pattern of body temperature. With different disease, the course of sickness is often followed by change in body temperature. Temperature measurements enable the doctor to analyze the effectiveness of treatments supported by body temperature.

In this project we have made us an easily available temperature sensor, that is, LM35 temperature sensor [Fig-5]. LM35 is an analog linear sensor. The output of the sensor is quite proportional to the temperature in degree Celsius. For output voltage varies by 10mV there is a change in temperature by 1 ^{o}C. A LM35 temperature sensor is employed to observe precise temperature in centigrade. The output of this sensor changes describes the dimensionality. The output voltage of the IC sensing element is linearly comparative to the astronomer temperature. The operational voltage of LM35 ranges from -55˚ to +150˚C. The sensor is often operated underneath 4 to 30 V. The sensing circuit consists of operational amplifier which converts the heat to electrical quantity. The terminals of sensor namely GND, VCC and OUT, with GND connected to ground, the sensor amplifies the difference between its two other terminals which is shown as the temperature in ˚C [Fig-6].

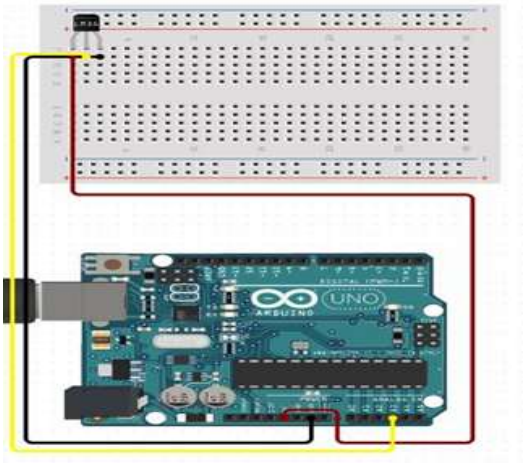


Fig.5. LM35 internal circuit

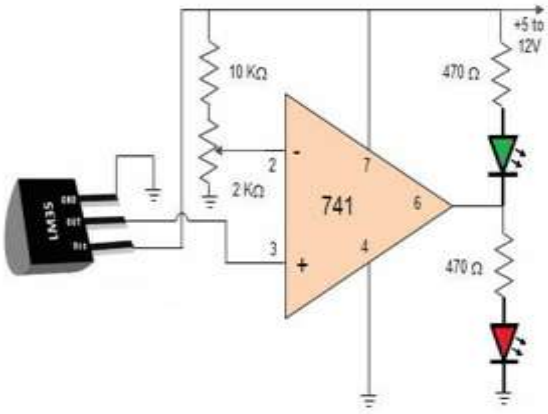


Fig.6.Connection of Temperature sensor

V. CONTROL STRATEGY

Having a good control strategy for a complex environment is of utmost importance. Here in our project also a controller is used to control and operate the complex environment around it. In this project we have used Arduino Uno Rev3 as a microcontroller unit to control our desired operations in the way we want them to be controlled. Arduino UNO is an open source microcontroller board based on the ATmega328P microprocessor designed by Microchip. Apart from ATmega328P, it has some more components, namely, a crystal oscillator, a Serial COM unit, voltage regulator, etc. for supporting the proper operation of the microcontroller. The UNO has 14 digital I/O pins, of whom 6 can be used for a PWM output, 6 for analog I/P, a power supply port, an ICSP header, a reset pushbutton and also a USB connection. It can be powered by a USB cable connector connected to a computer, or through an external supply connected to a 9-12V battery. It can however accept voltages between 6-20V.

a. Arduino Board

The 20 I/O pins can be used by the following commands, pinMode(), digitalRead(), digitalWrite(), just to name a few, which are commands used for programming the Arduino. Each of the pin operates at precisely about 5V, having a capability to give or receive a maximum of 40mA current. Each pin consists of an internal pull-up resistor having a rating of 20-50 KOhms, which is not connected by default. Among these 20 pins, some special pins have certain specific functions which are given below:

Serial Pins 0 (Rx) and 1 (Tx): These pins are used for the function of receiving and transmitting the serial data. These are connected to the corresponding ATmega328P USB to serial chip.

External Interrupt Pins 2 and 3: They can be configured for the triggering of an interrupt on a low, a rising or a falling edge, and even for a change in value.

Pulse Width Modulation (PWM) Pins 3, 5, 6, 9 and 11: They provide an 8-bit pulse width modulated output by using analog Write.

Serial Peripheral Interface (SPI) Pins 10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK): These pins are used for serial communication.

In-built LED Pin 13: This pin is connected to a built-in LED, when the signal received is HIGH, the LED is ON and when it is LOW, the LED is OFF. The controller consists of 14 I/O pins with digital values as I/O and 6 pins with analog I/O, each of which has a resolution which can go up to10 bits (or) 1024 different values. This measure from 0-5 volts. However, this limit can be increased by using AREF pin.

Analog pin 4 (SDA) and pin 5 (SCA) are also used for communication (TWI) which requires specific libraries for specific related operations.

Arduino Uno constitute of a couple of other pins as explained below: AREF: Is used to provide reference voltage for analog inputs with analog Reference() function. Reset Pin: Pressing this pin, resets and formats the microcontroller.

b. Arduino Uno Pin Mapping

The mapping below shows the pin mapping of ATmega328P to Arduino UNO board. [Fig-7].

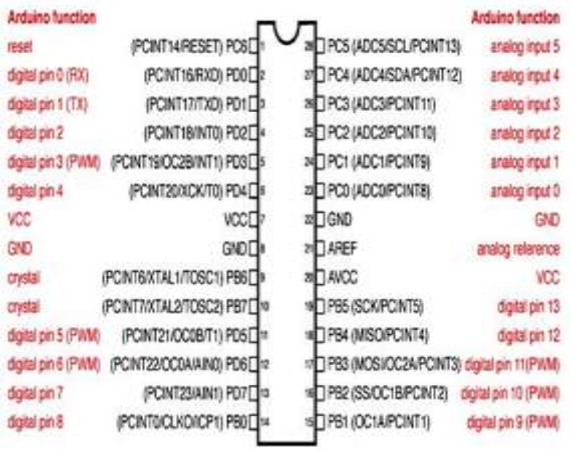


Fig.7.Arduino UNO Mapping with ATmega328 pin diagram

Arduino is playing a role of intermediate or as an interface between the human body, the OLED display and the IoT platform (ThingSpeak). Arduino collects the data sensed by the pulse and temperature sensor through analog pins A0-A5. The data is converted to digital signals by the built in ADC. The digital data is then processed by the processing unit of Arduino. Data is displayed in the OLED screen by specific codes, instructions and libraries. Arduino connects though the internet with the help of ESP-8266 which is a Wi-Fi module. This allows Arduino to communicate with the IoT server. When a communication is established the data collected by Arduino from the sensors can be transferred to the IoT platform through the internet.

The UNO is the best board to make projects based on electronics, embedded system, and IoT. The Arduino UNO is a very robust board and is also a very widely implemented board among the Arduino family.

- Its most laudable advantage is that the board can be connected to computer by the simple means of a USB cable which serves not only acts as a serial port for interfacing with the computer but also for power supply.
- It is completely open-source thus making it an extremely accessible product which highly flexible to innovation and customization.
- It's flexibility offers a wide range of digital and analog I/O pins, SPI and serial interface including the PWM outputs.
- It is quite easy to work with, and can be interfaced with a computer through a USB cable and can communicate with standard serial protocols. It can also run as standalone and can be interfaced with Windows/Mac computers.

c. Thing Speak – IoT platform

ThingSpeak [Fig-8,9] is a platform having IoT analytics which allows people to collect, visualize and then finally, analyze live data streams in a cloud platform. It is an open source IoT platform and an API to store, visualize and retrieve data from its server using the IP address and an HTTP protocol which are used over the internet or also on a local area network. It enables the development of

sensor-based applications, tracking locations, and notifications like message and e-mail with status update. This provides a virtually instant way of visualizing data posted by our devices to the ThingSpeak platform. Also, ThingSpeak work with MathWorks, specifically MATLAB which makes custom visualizations on it very easy to create and make it more interactive. It can perform executions in MATLAB code in its environment, to perform online analysis and processing of the data as it is received. It is often used to create a prototype and proof of concept IoT systems that require analytics.

Fig:8 – Thing Speak (IoT server) main page

Fig.9.Thing Speak Channel list

VI. EXPERIMENTAL RESULTS AND DISCUSSION

The main component of our system is Arduino UNO microcontroller board. It allows many peripherals to connect to it with an ease. In case for the IoT part the peripheral used is ESP-8266, which a WIFI module. The system is powered by a 9V battery. The data recorded from the sensors is transferred to the IoT server through ESP-8266 which is connected to the internet. The data collected is also shown on an OLED screen mounted on the wearable case which encloses the circuitry of the system. A unique account (ThingSpeak) with IP address and API key is provided to both the doctor and the patient's family and the patient itself. Once logged in the homepage shows the channel in which we can view the data collected.

Opening the "Private" channel on the "Patient Monitor" [Fig-9] tab takes us to the visualization of our data in form of a line plot of the data collected from sensors between time at which data was collected and the date[Fig-10].

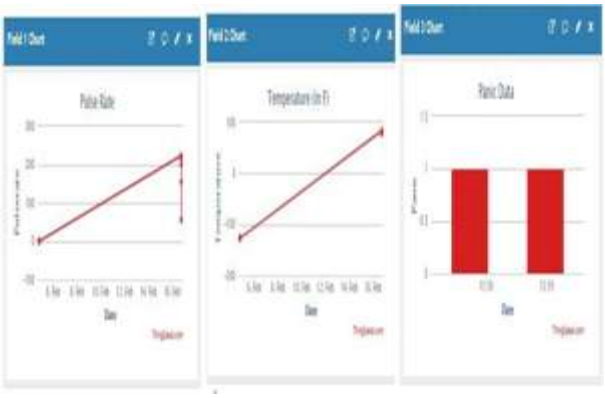


Fig:10 – ThingSpeak Parameters and data from the system

The data can be downloaded in many formats by clicking the "Export recent data" shown on the main screen. After that it opens a dialog box which asks in what format data is to be downloaded. For result below shown is the data in excel sheet[Fig-11].

Table.1. Patient monitoring system using IoT

VII. CONCLUSION

This work is a prototype of a patient health monitoring system. It makes use of IoT technology which allows data transfer in a faster and secured way over the internet. IoT holds and integrates the patients, their doctors and devices, all into one system, thus making it highly convenient to operate and use. Introduction of OLED display in the same system for patient to keep track of his/her vital body status during any medical issues. It also saves time for doctors as well and is most useful in rural areas here people with limited to no access to enough resources for making frequent hospital trips. It is suitable for immediate use for the doctors to provide diagnosis as soon as possible to their patients. In combination with the IoT technology, Arduino UNO is used as a microcontroller. It consumes low power, has less complexity than a DSP system and is best suited for embedded system applications.

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