IoT based Patient Monitoring System Using Raspberry Pi

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***Abstract*—** Health has prime significance in our routine life. Internet of Things (IoT) in healthcare is now the prime research providing better medical facilities to the patients and facilitates the doctors and hospitals as well. The proposed system here consists of various sensors to capture patient data. The project monitors the patient's health condition with the help of heartbeat and temperature sensors. The status of these parameters is display on LCD locally. Moreover, a Web-based or mobile-based application located anywhere can communicate via Wi-Fi to our system consisting of Raspberry Pi and sensors which helps to monitor and record patients' health data and medical information wirelessly. We can also store the patent data on the cloud by using Wi-Fi to maintain the record while continuously monitoring it in the web-based application either on a mobile phone or PC globally anywhere in the world.

Keywords— Internet of Things (IoT), Patient Monitoring Raspberry Pi, Heartbeat Sensor, Wi-Fi.

I. INTRODUCTION

The Internet of Things (IoT) is the network of physical systems, vehicles, and other devices embedded with sensors, software, and network connectivity which enables these systems to collect and exchange data [1]. The IoT allows parameters to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention [2]. When IoT is augmented with sensors and actuators, the technology becomes instances such as smart grids and smart cities. Increasingly, a variety of industries are using IoT to operate more efficiently, to better understand the customers to deliver enhanced customer services, improve decision-making, and thus, in turn, increase the value of the business. In medical systems, hardware and software devices require some investigations once it comes to the concept of the Internet of Things. World Health Organization (2016) indicates that elderly people, who frequently suffer from chronic disease, require a highly effective and efficient provision of care [3].

According to the National Broadband Plan (2015) by the Federal Communications Commission (FCC), the use of remote patient monitoring under IOT technology will save the healthcare industry $700 billion over 15 to 20 years [4]. Then it is important to focus on the IoT technology to get benefit from the most recent technology. In hospitals, where patient's status needs to be regularly monitored, is usually done by a doctor or other paramedical staff by constantly observing some important parameters, such as body temperature, heartbeat, and blood pressure thus, this task turn into tedious after some time [5]. Many researchers have attempted used either SMS service with GSM or RF module to send patient's data from a sender device to a receiver device. Moreover, in these cases the history of the patient cannot be displayed, only current data is displayed [6]. So the purpose of this project is to maintain continuously monitor patient's data and to give an emergency alert if required, using different technology which is the Internet of Things (IoT); where it also allows us to store patient's data on the cloud and the data is also visible anywhere from the world. Thus the history data of the patient will be available for doctors to access at any time from everywhere. By implementing this project we can monitor patients remotely through mobile or PC and we can secure their lives by giving emergency alert in real-time. In [7], authors 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. Authors in [8], focused on monitoring the health of a patient and sending relevant updates and alerts to doctors, family members, and other important people.

Thus fascinated by the application of IoT and work done by other researchers [9]-[11], in this project we will build a prototype to monitor the patient's health condition like monitoring temperature and heartbeat locally and also from a webpage which can be operated from a mobile phone or PC which is different from the work conducted by authors in [7]. The processor used in this project is Raspberry Pi Model B [12]. We can check these value from anywhere on our Smartphone by opening this webpage from Smartphone itself or from PC. The communication between the internet and the microprocessor is established using inbuilt Wi-Fi in Raspberry Pi 3. In this project, the data of the patient is sent to a webpage using the cloud through Raspberry Pi 3. Whenever we open this application it gives the current status of the patient's health. At the patient side, we have kept the hardware with inbuilt Wi-Fi interconnected with temperature sensor [13] and heartbeat sensor [14]. We can check these values from anywhere on our Smartphones by opening this webpage from the phone itself. The communication between the internet and

our hardware is established using inbuilt Wi-Fi and the main processor used in this project is Raspberry Pi 3 Model B. Section 2 describes the system design using different hardware components. Experimental results are explained in Section 3 and the conclusion is presented in Section 4.

II. SYSTEM DESIGN

In the proposed system, we are using the sensors like the temperature sensor and the heartbeat sensor to measure the temperature and the heartbeat of the patient. As Raspberry Pi 3 does not have an inbuilt analog to digital converter (ADC). The sensors data is fetched with a PIC microcontroller [14] and the digital data is transferred to Raspberry Pi 3. Raspberry Pi 3 has an inbuilt Wi-Fi so after processing and displaying the sensor data on LCD, it also enables to store the sensors data on cloud through Wi-Fi. In this Section, the different components and their effectiveness for the project are described. The circuit diagram is prepared with the help of Fritzing [17] as shown in Fig 2.1.

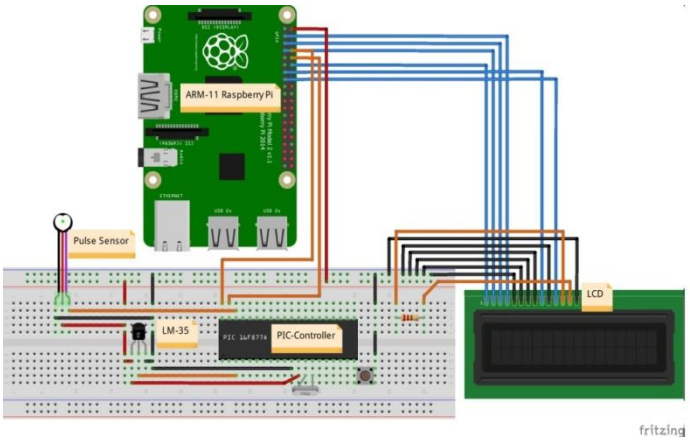

Fig 2.1 Fritzing Circuit Diagram of the Project

A schematic diagram and interfacing of the microprocessor with each component is considered. The main components used in the project are

1. Raspberry Pi 3 Microprocessor
2. PIC Microcontroller (PIC16F72)
3. Heartbeat sensor
4. Temperature sensor (LM35)
5. LCD with the driver board
6. Power supply adapter

A. *Raspberry PI 3*

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It also now supports hot plugging using USB ports. It has 14 more GPIO pins. It has EEPROM readout support for the new HAT expansion boards. No more back powering problems, due to the USB current limiters which also inhibit backflow, together with the ideal power diode. A pictorial view of the Raspberry Pi 3 board is shown in Fig. 2.2

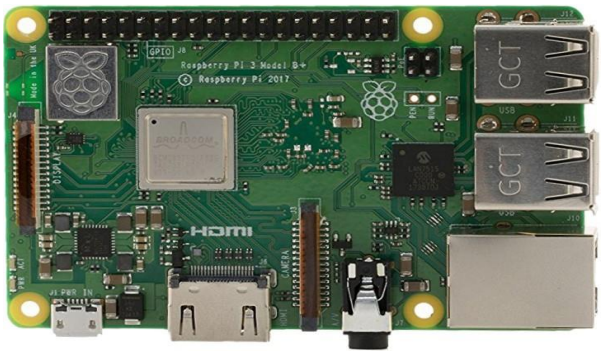

Fig. 2.2 Raspberry Pi 3 Board

B. *PIC Microcontroller*

This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into a 28-pin package [14]. The PIC16F72 features 5 channels of 8-bit Analog-to-Digital (A/D) converter with 2 additional timers, capture/compare/PWM function and the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus. All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications [14].

C. *Temperature Sensor (LM35)*

The LM35 has an output voltage that is proportional to the Celsius temperature. The LM35 temperature sensor can measure temperature more correctly compared with a thermistor. This sensor generates a high output voltage than thermocouples and may not need that the output voltage is amplified. One more significant characteristic of this sensor is that it draws just 60 microamps from its supply and acquires a low self-heating capacity [15]. The operating voltage range of this LM35 ranges from-55˚ to +150˚C and it has low-self heating. This is operated under 4 to 30 volts.

D. *Heart Beat Sensor (Pulse Sensor)*

Heart rate data is useful in designing an exercise routine, monitoring activity or anxiety levels or blinking shirt in sync with your heartbeat. The pulse sensor will measure your heart rate easily. It essentially combines a simple optical heart rate sensor with amplification and noise cancellation circuitry making it fast and easy to get reliable pulse readings from earlobe or fingertip [16]. The 3 pin cable on the pulse sensor is terminated with standard male headers so there's no soldering required as shown in Fig 2.2. The sensor consists of a super bright red LED and a light detector. The LED needs to be super bright as the light must pass through the finger and

detected at another end. It works on the principle of light modulation by blood flow through finger at each pulse. Now, when the heart pumps a pulse of blood through the blood vessels, the finger becomes slightly more opaque and so less light reached the detector. With each heart pulse, the detector signal varies. This variation is converted to an electrical pulse. This signal is amplified and triggered through an amplifier which outputs +5V logic level signal. The output signal is also indicated on top by a LED which blinks on each heartbeat. This analog output can be connected to the PIC microcontroller directly to measure the Beats Per Minute (BPM) rate.

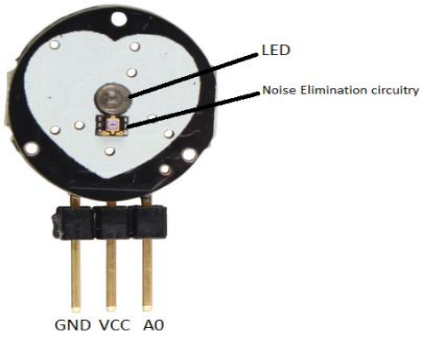

Fig. 2.2 Pulse Sensor

III. SOFTWARE DESCRIPTION

Raspbian is a Debian-based computer operating system (OS) for Raspberry Pi [12]. There are several versions of Raspbian including Raspbian Stretch and Raspbian Jessie [12]. Raspbian is highly optimized for the Raspberry Pi based microprocessors low-performance ARM CPUs. Raspbian uses PIXEL, Pi improved lightweight X-Window environment as its main desktop. It is composed of a modified LXDE desktop environment and the Openbox stacking window manager with a new theme and few other changes. Raspbian is an open operating system based on Debian optimized for the Raspberry Pi hardware with over 35,000 packages, pre-compiled software bundled in a nice format for easy installation on your Raspberry Pi.

The minimum size of 2 GB SD card is required to preinstall the Raspbian OS, but a 4 GB SD card or above is highly recommended for future addition of packages recommended. Figure 2.3 describes the project code in the Raspbian OS. The code for the sensor data reading is burned in the PIC microcontroller and it is interfaced with the Raspberry Pi 3 with I^2C bus interface. The code for further stages is written in Python in the Nano text editor of Raspbian OS. The following piece of code is written to read a sensor value in the text editor. First, a new file is created using the Nano text editor using the command **`$nano sensor.py`** in the terminal window of Raspbian OS. Then following code is written in the file **sensor.py**.

```
import RPi.GPIO as GPIO
import time
pin = 24
GPIO.setmode(GPIO.BCM)
GPIO.setup(pin, GPIO.IN)
while 1:
sensorValue = GPIO.input(pin)
print sensorValue
time.sleep(0.1)
```

Then save and exit nano by clicking ‘Ctrl+o’, ‘return’, then ‘Ctrl+x’.

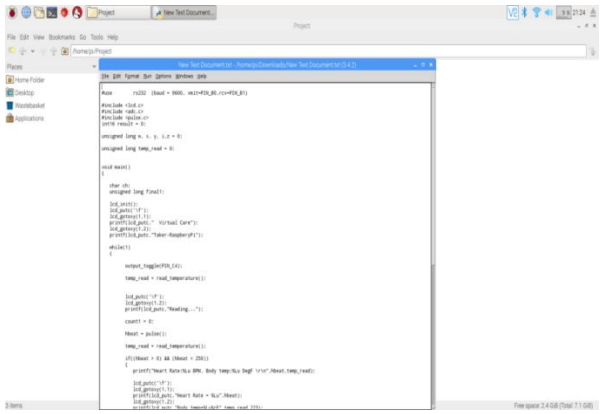

Fig. 2.3 Viewing Program in OS

IV. EXPERIMENTAL RESULTS

This project is designed to monitor the patient’s health condition in terms of heartbeat and temperature virtually through Online application. We can store the patent data in the cloud by using Wi-Fi. The status will display on LCD. Whenever we open this webpage it gives the current status of the patient's health. The following steps explain the project execution procedure for the project. The complete hardware project with a pictorial view is shown in Fig. 3.1

- Turn ON the kit by giving the power supply through a power bank (battery) or it can be connected directly to the main power supply through a power supply adapter.

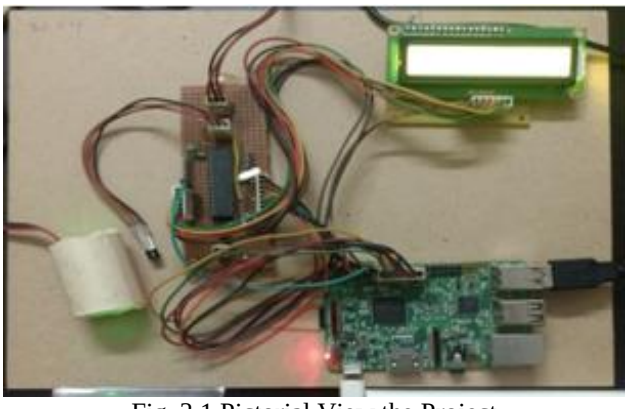

Fig. 3.1 Pictorial View the Project

- Place the finger on the heartbeat sensor for viewing the heartbeat and temperature of the patient on the LCD shown in Fig 3.2.
- The values of heartbeat and temperature are read and displayed on the LCD shown in Fig 3.3.
- If the heartbeat rate is low than the normal heartbeat rate, it displayed as LOW HR on the LCD shown in Fig 3.4
- If the heartbeat rate is high than the normal heartbeat rate, it is displayed as HIGH HR on the LCD shown in Fig 3.5.

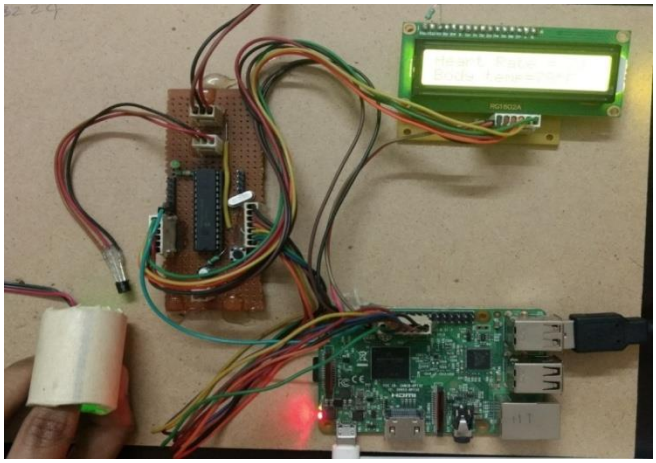

Fig 3.2 Heartbeat and Temperature Detection

Fig 3.3 Normal Heartbeat and Temperature

Fig 3.4 Display for Decrease in the Heartbeat

Fig 3.5 Display for Increase in the Heartbeat

- A web application is developed for viewing the health status of the patient online i.e; heartbeat and temperature of the patient.
- The patient's data is stored online and can be viewed by the doctor and relatives of the patient.
- Switch ON the Hotspot of the mobile and change the username to say "abcdefghi" and passwords to say "123456789", the Raspberry Pi 3 automatically gets connected to the mobile shown in Fig 10.

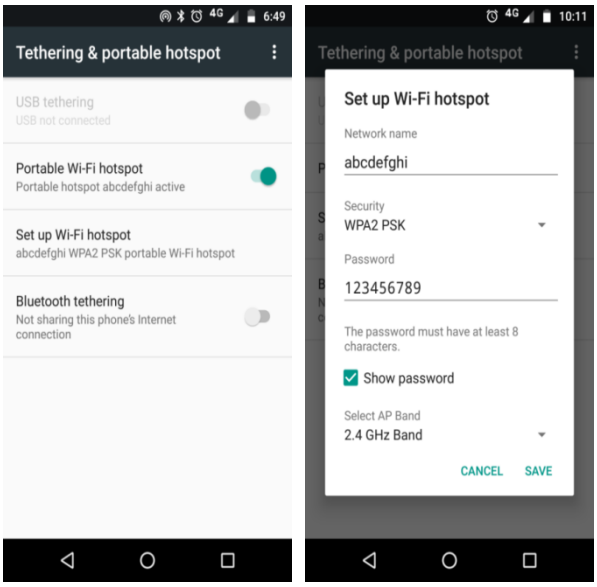

Fig 3.6 Connecting mobile and Raspberry Pi 3 through hotspot

- The patient data is stored online, for viewing the data the IP address 192.168.43.119:5000 is typed in the browser link as shown in Fig 3.7.

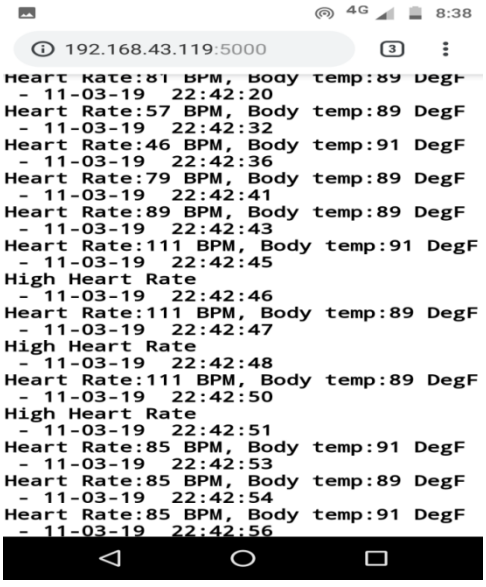

Fig.3.7 Data Visibility on Web-Page

V. CONCLUSION

This project is developed as a prototype to monitor the health parameters of the patient i.e; heartbeat and temperature using Raspberry Pi 3. This work is designed to provide a safety system for the patients. We proposed continuous monitoring of the patient conditions and store the patient's data in the server using the IoT concept. Heartbeat sensor and temperature sensor are interfaced with Raspberry pi 3 via PIC microcontroller. LCD displays the heartbeat and temperature of the patient continuously. It has inbuilt Wi-Fi so it stores the sensors data in the cloud through Wi-Fi web server for access from anywhere in the world by opening the web server in mobile or laptop. The status will display on LCD. This Intelligent process can be done by using Embedded LINUX programming language. In the future, we can also interface several other health-based sensors like ECG sensors and EMG sensor. At the same time, we can also use a touch sensor which is used to get the information from the patient when he is in a panic. The touchpad is used in such a way that the patient can touch the pad to inform others about his needs in the form of audio.

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