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An IoT Based Wireless Body Area Network for Healthcare Applications using Raspberry Pi

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Abstract: ***Wireless Body Area Network is an emerging technology in today's world; it plays a very important role in the field of healthcare services. Now-a-day's person data monitoring is a leading issue for health and disease management. Wireless Body Area Network consists of light weight, ultra low power wearable sensors. This wearable sensors monitor's human physiological activity such as health status. Hence the latest trend in Healthcare communication method using IoT is adapted. Internet of Things serves as a catalyst for the healthcare and plays a prominent role in a wide range of healthcare applications. Our system is designed to be used in hospitals for measuring and monitoring various health parameters like temperature, heartbeat and fall detection. The results are being shown with the help of Raspberry Pi, also the parameters of the patient can be compared with threshold values and if there is any variations immediate alert messages could be sent to the doctor and caretaker. The sensor values are stored in a file in Raspberry Pi and the same file is uploaded to the cloud through internet. Internet is connected to the Raspberry Pi board, So using IP address anybody can monitor patients health status anywhere in the world. When the critical condition arrives SMS alert send to the doctor and also doctor can login to a mobile app and view those results to take the action immediately. Hardware module is developed for displaying the sensor values using Raspberry Pi. The results can be recorded using Raspberry Pi and the sensor values are displayed on a LCD display. The device detects vital parameters of the patient by the use of sensors and displays result on a HDMI screen.***
Keywords: (WBAN) Wireless Body Area Network, Raspberry Pi 3, Temperature sensor, Heartbeat and Fall Detection.

I. INTRODUCTION

Internet of Things (IoT) is a prominent technological paradigm that gains attention from vast research fields in the past few years. Internet of Things is a network of devices which is built with embedded systems, electronic things, actuators, sensors and network connectivity and which enables these objectives to exchange and collect the data from the sensor. In simple words, IoT refers to a network of objects all connected to the internet at the same time. The main principle of Internet of things (IoT) is that the objects/things i.e. sensor nodes identify, sense, process and communicate with each other. Internet of Things is used for an objects can be sensed and controlled from the existing network. In simple words, IoT refers to a network of objects all connected to the internet at the same time. The main principle of Internet of things (IoT) is that the objects/things i.e. sensor nodes identify, sense, process and communicate with each other [1].

Internet of Things are used in many application areas like Smart Home, Smart Phone, Smart Farming, Smart Grid, Industrial Internet, Connected Health, Smart Supply Chain etc. The homecare is provided instead of the expensive clinical care and prevention is provided by the efficient healthcare applications. This service can help every individual by following the basic healthcare, which leads to more advantageous results. The most importance of healthcare on IoT is increasing to support the quality of care, improve the access to care and finally to decrease the cost of care. IoT make the healthcare services by maintaining digital identity for each patient due to which many health problems have been getting undetected in conventional healthcare systems are reduced. Recently, the patient monitoring systems is one of the major advancements because of its improved technology [2]. Currently, there is need for a modernized approach.

In the traditional approach the healthcare professionals play the major role. They need to visit the patient's ward for necessary diagnosis and advising. There are two basic problems associated with this approach. Firstly, the healthcare professionals must be present on site of the patient all the time and secondly, the patient remains admitted in a hospital, bedside biomedical instruments, for a period of time.

In order to solve these two problems, the patients are given knowledge and information about disease diagnosis and prevention. Secondly, a reliable and readily available patient monitoring system (PMS) is required [3]. A major aspect in the healthcare system is the monitoring of the patient's vital signs such as temperature, blood pressure and heart rate. Many monitoring devices that

display the patient's vital signs are commonly present in the critical care units in operating rooms. But there could be instances where the doctor couldn't be alerted in time when there is an emergency, despite of 24 hours of monitoring. Also the data couldn't be shared remotely with the other doctors who are specialists in that field and the family members.

Technology that enables all these activities are available but aren't accessible and affordable by many people in developing nations. Hence the problem can be overcome by just a simple add-on to the current devices lacking these capabilities. IoT is the interconnecting of devices and services that reduces human intervention to live a better life. This paper as showing the advancements in health care management technology, it would save patients from the future health problems that would arise and would also help doctors to take an appropriate measure or action's at a proper time regarding patient's health.

The rest of the paper is organized as follows. Section II describes the proposed method. Section III illustrates the implementation methodology. Section IV explains the experimental results. Section V concludes the work.

II. PROPOSED METHOD

Our proposed method is based on automating the method of gathering patients data via sensors connected to medical devices and conveying this information to the medical center cloud for the purpose of storage and processing using Raspberry Pi. The proposed method of patient health monitoring system is to monitor patient's body temperature, heart rate using Raspberry Pi3. The temperature sensor (DHT11) senses the temperature from the patient's body and sends the information to the Raspberry Pi3.

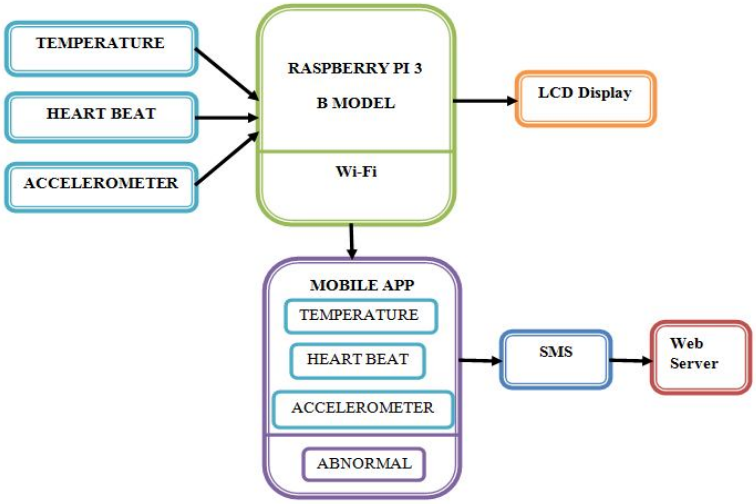

Fig.1. Block diagram of Healthcare Monitoring System

The heart Rate sensor collect the heart beat from the patient, the information obtained from the heart beat sensor is in the analog form, in order to convert it into digital form Analog-to-Digital Converter is used. This obtained Digital output send to the Raspberry Pi3. The output obtained from Raspberry Pi3 is displayed at the HDMI display and also the values are displayed in the LCD display. This System is made to avoid critical situations and treatment on time and immediately. When abnormal data is indicated, message will be send to doctor's mobile. And it can avoid risk and handle critical situation. It also gives advantage that it reduces time laps between situation and their alert to doctor, that means doctor will know situation as immediately it happens. The block diagram of Healthcare Monitoring system is shown in Fig. 1.

III. IMPLEMENTATION METHODOLOGY

A. Hardware Description

This deals with the physical entities used in the system. The heart of the system is Raspberry Pi, which controls and monitors the overall behaviour of the system. The Hardware's are

1) Raspberry Pi 3 B Model
2) Heart Beat Sensor
3) Temperature Sensor
4) Accelerometer Sensor
5) LCD Displa

6) *Heart Beat Sensor (TCRT1000):* The Heart Beat Sensor is based on the principle of photo phlethysmography. It measures the variation in the volume of blood through any regions of the body which causes a change in the light intensity through that region (a vascular region). When the index finger is placed on the heart beat sensor, the variation in an optical power takes place when the light falls on the index finger is scattered or absorbed during the path through the blood as the change in heartbeat.

7) *Raspberry Pi 3 B Model :* This powerful credit - card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Raspberry pi 3 is a credit card size single board computer with 40 pin extended GPIO, Broad cam BCM2387 chipset, 1.2GHz Quad-core ARM Cortex-A53(64Bit), 802.11 B/G/N Wireless LAN and Bluetooth 4.1, GPU(Dual Core Video Core IV Multimedia Co-Processor), Camera connector, Display connector, Memory card slot,1GB LPDDR2 memory, Ethernet port, USB host, Micro HDMI on it. Raspberry pi3 is a general purpose computer usually with Linux OS.

Fig.2. Raspberry Pi 3 B Model

The Raspberry Pi 3 B Model is the Third generation Raspberry Pi as shown in Fig. 2. It has 10/100 Base Ethernet socket to quickly connect the Raspberry Pi to the Internet and Micro USB power source socket with 5V voltage and 2A current. The Raspberry Pi board comes equipped with an SD card. This slot permits us to insert an SD card and that can use it as our devices. The SD card is a main storage device for Raspberry Pi board like a hard disk of a personal computer.

8) *Temperature Sensor (DHT11);* The DHT11 sensor is digital temperature and humidity sensor. It is very popular because it is very cheap but still providing great performance. The temperature ranges from0 to 50 degrees Celsius with+/- 2degrees accuracy. And the Humidity range is from 20 to 80% with 5% accuracy. The sampling rate is 1Hz or one reading every second. The operating voltage is 3 to 5 volts, the max current used when measuring is 2.5mA. It includes humidity measurement component in order to measure the humidity and an NTC temperature measurement component for measuring Temperature. It offers excellent quality, fast response, anti-interference ability and cost-effectiveness.

9) *Accelerometer Sensor (ADXL345):* The recently introduced ADXL345 is an iMEMS 3-axis accelerometer with digital output. It features a selectable ±2-g, ±4-g, ±8-g, or ±16-g measurement range, resolution of up to 13 bits; fixed 4mg/LSB sensitivity; a tiny 3mm × 5mm × 1mm package, ultralow power consumption (25 µA to 130 µA). iMEMS semi semiconductor technology combines micromechanical structures and electrical circuits on a single silicon chip. Using this technology, iMEMS accelerometers sense acceleration on one, two, or even three axes, and provide analog or digital outputs. Depending on the application, the accelerometer may offer different ranges of detection, from several g to tens of g. Digital versions may even have multiple interrupt modes. These features offer the user convenient and flexible solutions.

10) *LCD Display:* Liquid Crystal Display a type of display used in digital watches and many portable computers. It is used to display the measured data. In this project 16 x 2 Alphanumeric Display are used, it can display two lines with maximum of 16 characters in one line. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix.

This LCD has two registers, namely, Command and Data. Liquid Crystal Display has the distinct advantage of having low power consumption than the LED. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc.

B. Software Description

It deals with the Raspbian Operating System (OS) that is used in the Raspberry Pi, python language which is used for programming of Raspberry Pi and putty simulator.

1) *Python:* Python is an interpreted, object oriented, high-level programming Language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding makes it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together. Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance. Python supports modules and packages, which encourage modularity and code reuse. The python interpreter and the extensive standard library are available in source or binary form without charge for all major platforms, and can be freely distributed. Python 2.7 version, which is pre-installed in Raspbian OS, is used in the project for programming of Raspberry Pi.
2) *Putty Simulator:* The name "Putty" has no definitive meaning. Putty was originally written for Microsoft Windows, but it has been ported to various other operating systems. Official ports are available for some Unix-like platforms, with work-in-progress ports to Classic Mac OS and macOS, and unofficial ports have been contributed to platforms such as Symbian, Windows Mobile and Windows Phone.
3) *Raspbian Operating System (OS*: Raspbian is a free operating system based on Debian optimized for the Raspberry Pi hardware. An operating system is the set of basic programs and utilities that make Raspberry Pi run. However, Raspbian provides more than a pure OS: it comes with over 35,000 packages; pre-compiled software bundled in a nice format for easy installation on Raspberry Pi. Raspbian is highly optimized for the Raspberry Pi line's low-performance ARM CPUs.

IV. EXPERIMENTAL RESULT

The Fig.3 shows the Hardware working module. It consists of Raspberry pi3 board, Temperature sensor (DHT11), Heart Beat sensor, Accelerometer sensor and LCD Display.

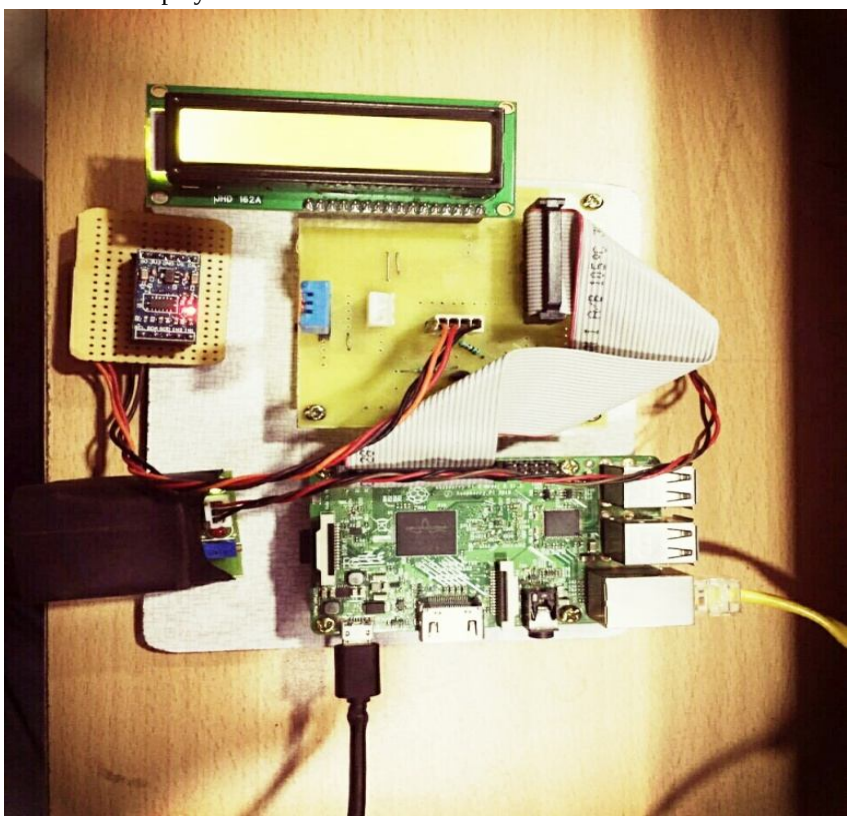

Fig.3. Hardware Working Module

The Fig. 4 shows that temperature, fall detection and heart beat values are displayed in the LCD display using Raspberry Pi.

Fig.4. Hardware Result

The Fig. 5 shows that Result for Temperature in HDMI Display. The information obtained from temperature Sensor (DHT11) at Raspberry Pi 3 is visible at the HDMI display.

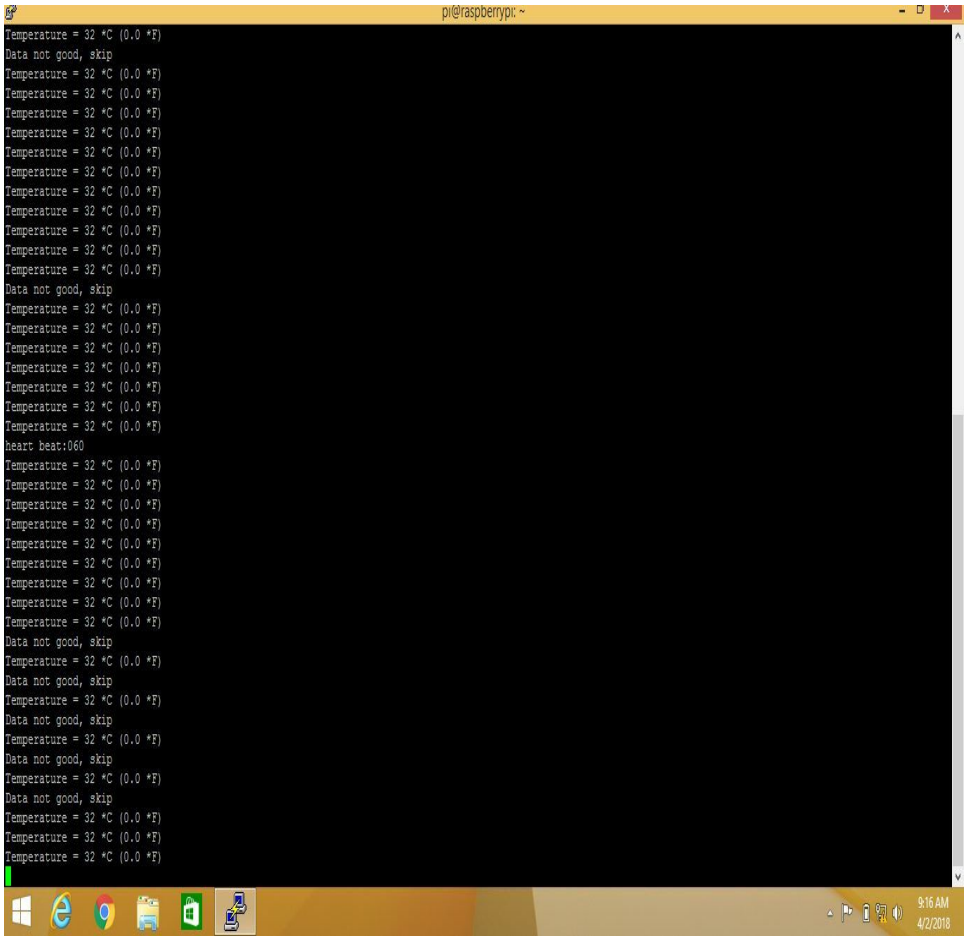

Fig.5. Result for Temperature in HDMI Display

The Fig. 6 shows that Result for Heart Beat in HDMI Display. The information obtained from the Heart Beat Sensor (TCRT1000) at Raspberry Pi 3 is visible at the HDMI display.

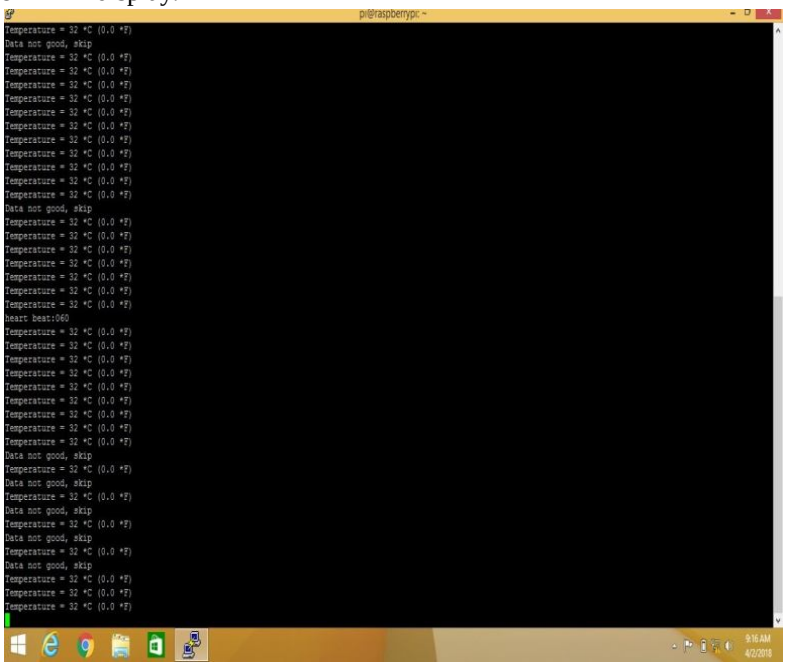

Fig.6. Result for Heart Beat in HDMI Display

The Fig. 7 shows that Result for Fall Detection in HDMI Display. The information obtained from Accelerometer Sensor (ADXL345) at Raspberry Pi 3 is visible at the HDMI display.

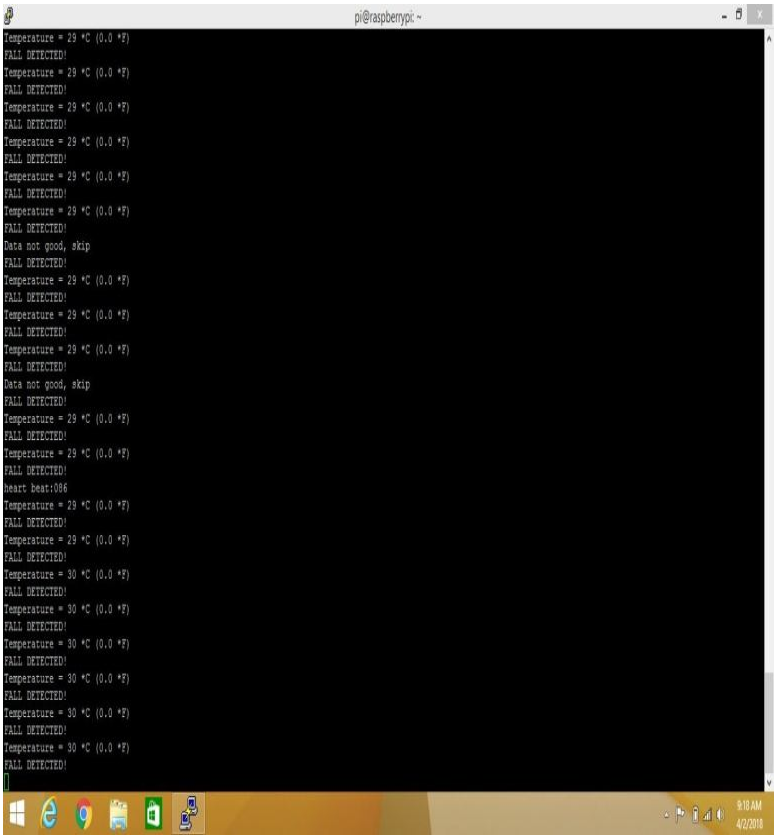

Fig.7. Result for Accelerometer in HDMI Display

These parameters values are goes to abnormal it will automatically sends alert message to the doctors and also sends history of data's to mail. Fig.8 shows that design of Android App. Using unique IP address can anybody monitoring the patient health condition.

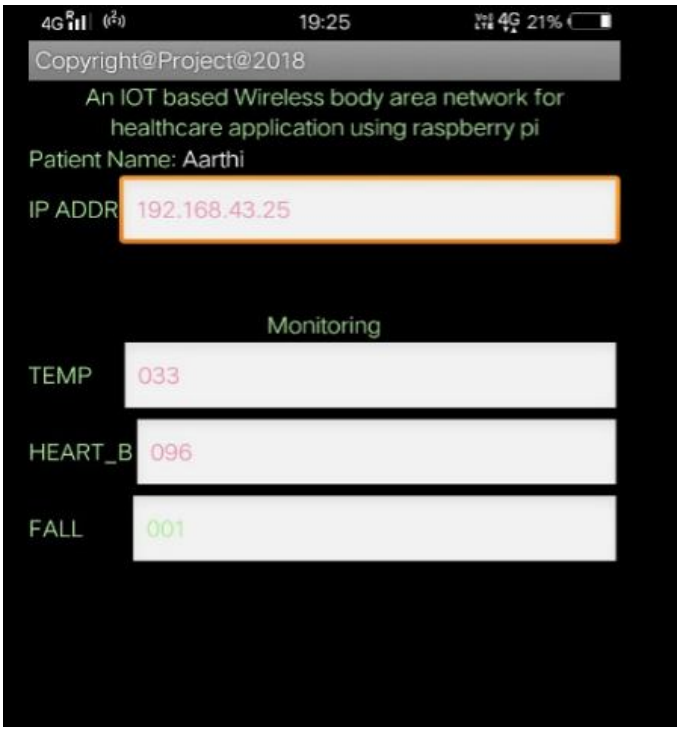

Fig.8. Design of Android App

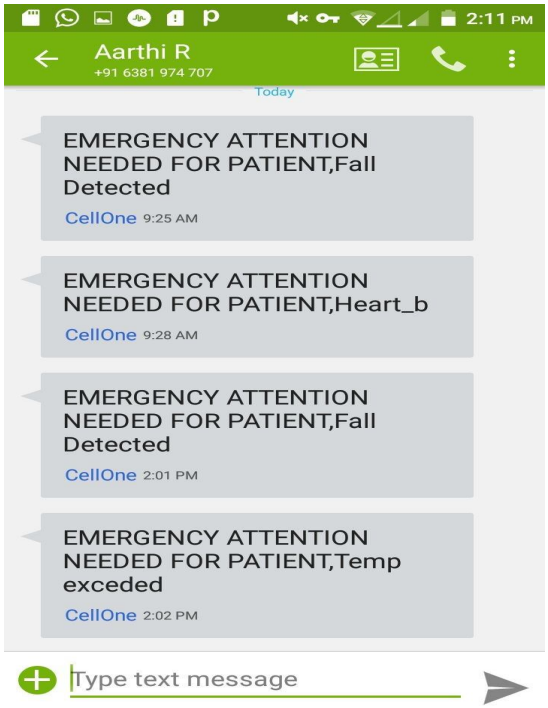

Fig.9. SMS alert to the doctor

Fig.9 shows that SMS alert sends to the doctor. Human beings normal body temperature is 35º C. The temperature value is goes to 36º C the mail is sent and also SMS alert sends to the doctor. Normal heart rate is 72, if it goes to 85 it will automatically send mail and SMS alert is sends to doctor. At the same fall is detected it will automatically send mail and SMS alert to the doctors. Fig.10 shows that History of data sends to the doctor.

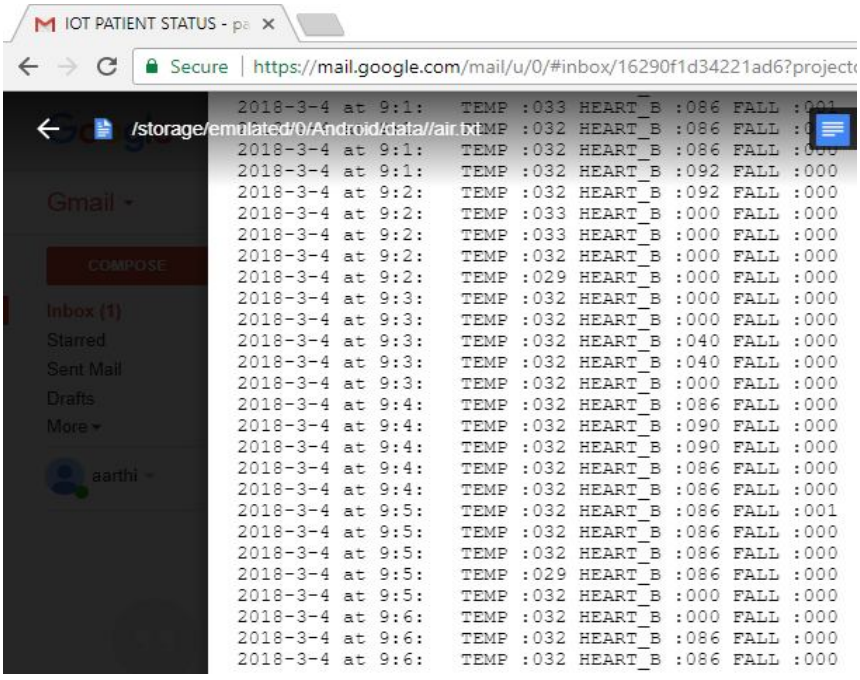

Fig.10. History of data sends to the doctor

V. CONCLUSION

The outcome of project has showed that it works on real time monitoring and when abnormalities occurred, message alert goes to registered number. Hence, we can avoid critical situations and can be able to give treatment on time. Patient Monitoring System is a telemedicine application which allows the doctor to view the patient's vital signs and parameters remotely and dynamically in real time. An health monitoring system has been presented in this project. By using the system, the healthcare professionals can monitor, diagnose, and advice their patients all the time. The physiological data are stored. Hence, the healthcare professional can monitor their patients from a remote location at any time.

In future more parameters will be added to monitor patient's health status. Web cam is also possible connect to the Raspberry Pi. After connecting webcam to the Raspberry Pi anybody can monitor patient's directly anywhere in the world. Wi-Fi adapter is also available for Raspberry Pi. So after connecting wifi adapter it act as a server. So within a small circle there is no extra internet connection for monitor patient's parameters. Switch on to wifi in your laptop, mobile phone and connect wifi internet from Raspberry Pi and monitor these values using the IP address.

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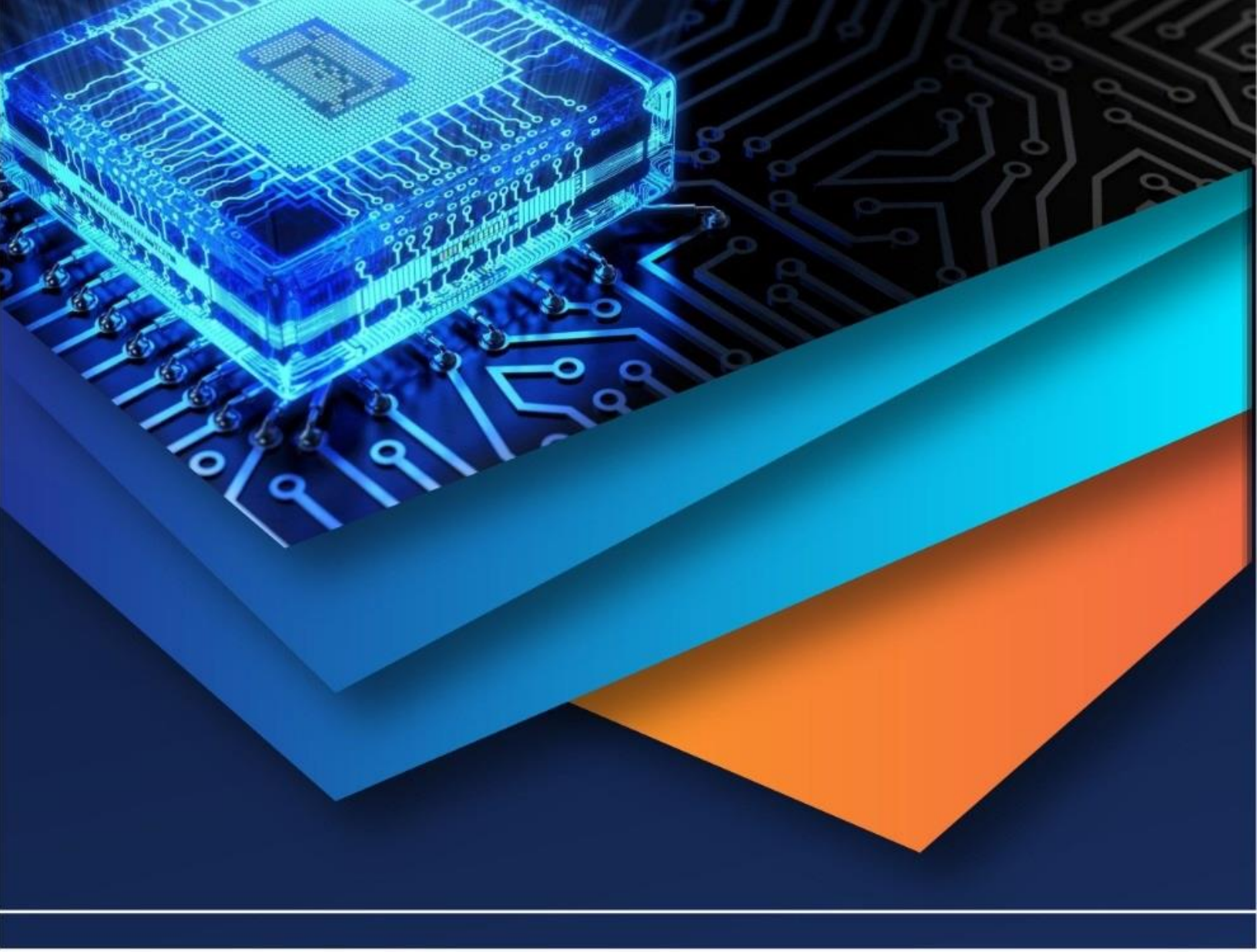

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