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A Novel Machine to Machine Based Health Monitoring Device using IoT

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Abstract- These days, health monitoring gadgets are assuming an essential role in health services. Such frameworks are considered as the most significant developments because of its creativity and innovation. A compact gadget is used to record imperative parameters of the human body like its temperature, Heart pulsates, and beat rate, and so forth by utilizing embedded innovation. Typically, it is very hard to make sense of the irregularities occurring in the human body. Much of the time an individual surrenders because of off base or an erroneous forecast of infection. Henceforth to follow the inconsistencies occurring in the human body there should be a framework that can screen the progressions occurring in the human body most unequivocally and precisely. In this paper, a novel machine to machine based health monitoring device using IoT technology in health care services is proposed which regularly monitors the health parameters of the patient through an electronic wearable device giving results that are well precise when compared with the standard medical equipment measurements. These data can be assessed over the Internet for precise treatments.

Keywords: Health Monitoring; Medical devices; Internet of Things (IoT) in health care

I. INTRODUCTION

Nowadays, the health monitoring device is playing a pivotal role in health care systems. Such systems are deemed as the most important inventions due to its inventive technology. A portable device is utilized to record vital parameters of the human body like body temperature, Heartbeats and pulse rate, etc. by making use of implanted technology. Normally, it is quite difficult to figure out the anomalies taking place in the human body. In many cases, an individual succumbs to death due to incorrect or inaccurate predictions of disease [1]. Hence to track the anomalies taking place in the human body there need to be a system that can monitor the changes taking place in the human body most precisely and accurately.

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There are various kinds of devices accessible in the market to follow interior changes of the body, however, there are a few restrictions because of their substantial cost, support, size. The Internet of Things (IoT) is redesigning medicinal services as we are probably aware of. We are in a completely fresh era concerning the way that applications, gadgets, and individuals connect while conveying medicinal services. It has given us a new standpoint as new instruments that suit the coordinated health services of better quality. The utilization of IoT in medicinal services takes into account the computerized procedures that have recently gained importance and reduces unacceptable human mistakes. For instance, these days numerous medical clinics utilize associated gadgets to control the wind stream and temperature in operation theaters[2]. The use of IoT technology is growing at a high rate. In the present world, many devices used in different fields are now connected over the Internet and can communicate through this IoT technology. Some of the fields using this technology are Health Care, Automobiles, home appliances, industrial processes, retail commerce, agriculture, etc. Figure 1 shows the utilization of IoT in various domains.

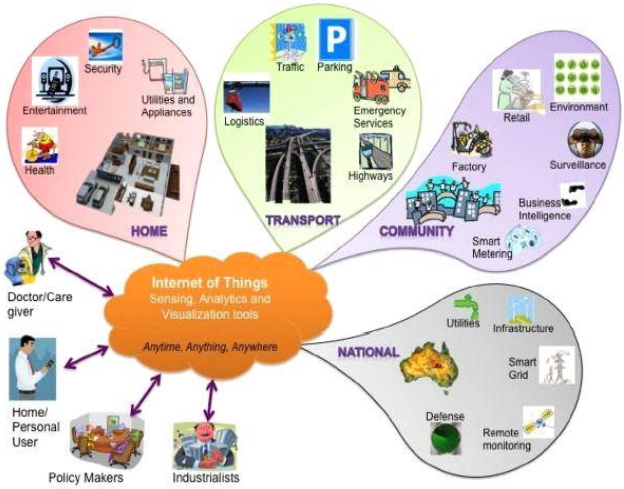

Fig 1. Use of IoT in various domains

A. Coronavirus disease (COVID-19)

Corona viruses are covered un-segmented RNA infections having a place with the family Corona viridae and the Nidovirales and extensively circulated in people and other mammals[3]. Even though in most human corona virus diseases are gentle, the plague of the two beta versions of corona viruses, severe acute respiratory syndrome corona virus (SARS-CoV) and Middle East respiratory syndrome corona virus (MERS-CoV) has caused more than 10,000 total cases in the previous two decades, with death paces of 10% for SARS-CoV and 37% for MERS-CoV.

The corona viruses effectively distinguished may just be a glimpse of something larger, with possibly progressively novel and serious zoonotic occasions to be uncovered. According to WHO COVID-19 is an irresistible infection brought about by a newfound corona virus. A great many people contaminated with the COVID-19 infection will encounter gentle to direct respiratory disease and recuperate without requiring extraordinary treatment. Elderly individuals and those with basic clinical issues like cardiovascular sickness, diabetes, constant respiratory infection, and disease are bound to create genuine ailment. The most ideal approach to forestall and hinder transmission is to detect early symptoms like fever, respiratory issues, etc. At present, there is no particular vaccine or medicines for COVID-19. However, numerous progressing clinical preliminaries are assessing potential medicines. This paper is based on the use of this IoT technology in the Health Care system. In this paper, we have developed a web-enabled wearable device (here we used glove) embedded with electronic components like sensors, controller, and power source. The functionality of this wearable device is that it can sense and record the elementary health parameters of the patients like Body Temperature, Pulse Rate, Blood Oxygen Saturation level, ECG (Electro Cardio Graph) and will send this data over a cloud service through the Internet and the cloud will post this data to prescribed Doctors and health institute, and the near and dear ones of the patient over a smart phone application. During any adverse condition of the patient, the respective health institute will be notified along with the Health parameters and it's the sole responsibility of the Health institute administration to send a medical team for the rescue of the patient and provide necessary treatment.

II. II. LITERATURE REVIEW

IoT technology is now a day is enormously used in various fields like health care, Automobiles, home appliances, industrial processes, retail commerce, agriculture, etc. As mentioned IoT is extensively used in health care services as it helps in a reduction in the time and complexity related to the monitoring of very elementary health parameters of a patient. As per the present time, the application of IoT health care extends from remote health monitoring devices to Health emergency care services and research. As of now, various research works have been carried out on the involvement of IoT in Health Care service and remote monitoring of the health parameters of the patient.

In [4] authors Vitor Nogueira et al. share their thought about the extensive use of IoT technology in health care service. Their thoughts on this topic were that the increase in the development of IoT solutions, health care cannot be outside of this technology paradigm. Their contribution was to give an introduction to the directions to achieve global connectivity between the IoT technology and the medical environments. They also said that this innovative development is redesigning the way one sees healthcare, from a mini sensor to the big data collected.

In [5] Hasmah Mansor et al. mentioned their work that consists of experiments for remote monitoring of body temperature of people using the IoT technology and electronic circuit that consists of a web-enabled Arduino controller and LM35 sensor for Body temperature measurement and monitoring. In this project, the temperature sensors (LM35) will sense the data and will send it to the microcontroller using Xbee communication. The real-time data was sent to the Internet server via the WLAN network, so the doctors can access the patient's data along with the patient's health history over the Internet. This reduced the waiting time for the patient and traffic in the hospital.

In [6] R. R. Adiputra et al. also presented the work that they did in this field. They developed an IoT enabled Low cost and wearable SpO2 measurement device for health monitoring. In their project, they used a SpO2 sensor which was connected to a NodeMCU as a microcontroller and a gateway for the data to travel through the internet and get stored in the cloud. Data sent to the Internet cloud can be accessed via a website for further analysis.

Mehmet Taştan in [7] shared his views on the importance and benefit of remote health monitoring devices based on IoT. In his project, he developed a system in which the pulse rate and body temperature of the patient can be measured and can be monitored over the Internet by the doctors and family members. In his project, he used wearable sensors to sense body temperature and pulse rate that will sense the respective data and will send to the microcontroller which is attached with the HC-05 blue-tooth module which will send the data to an Android Smartphone application. At the time of abnormalities, this application will send this data to an Internet cloud along which will generate an alert. And this alert message will be sent to the doctors and family member's mobile system. C. K. Das et al. [8] have described their work on the remote health monitoring system, in which they measured heart rate and body temperature and displayed the processed data on an LCD monitor and also send this data to a remote location by a wireless communication system. They used a finger-tip sensor to measure the heartbeat in BPM and an LM35 temperature sensor attached to a microcontroller to measure the body temperature of the patient. Their system then transmits this data through the wireless communication system and then displayed the processed data on an LCD monitor connected on the receiving end. In [9] Mohamed T A et al. published their work in which they present how they developed a remote patient monitoring system that can measure the patient's blood oxygen saturation level and body temperature and this data can be accessed by the doctors and family members. In this project, they use a SpO2 sensor, along with an LM35 temperature sensor. Both these sensors are connected to a microcontroller (Arduino Mega) to which a GSM module is attached which will help in wireless transmission of data. In this project, they used the *"Photoplethysmography"* technique to measure the blood oxygen saturation level. They also added the benefit of this system as it will reduce the waiting time for the treatment of the patient. All these recognized work motivated us and gave us an innovative idea of developing our IoT based health monitoring gloves. And as of now (April 2020), the world is going through a pandemic caused by the COVID-19 virus; this also helped us in developing our project in such a way that this product can be highly used in this pandemic situation. And with the help of this, we can contribute our engineering knowledge and efforts in the field of technology that can be beneficial for society.

III. METHODOLOGY

A Health Monitoring Glove is a web-enabled user-friendly wearable device, which facilitates the regular monitoring of elementary health parameters and these data will be sent to the system of the prescribed health care institutions and the Smartphone application of near and dear ones. As shown in figure 2 this health glove is equipped with sensors that sense pulse rate, body temperature, blood oxygen saturation level (SpO2), and ECG (Electro Cardio Graph) and sends the data to the cloud storage and from there these processed data will be sent to the caretaker of patient and prescribed hospitals who is taking care of that patient.

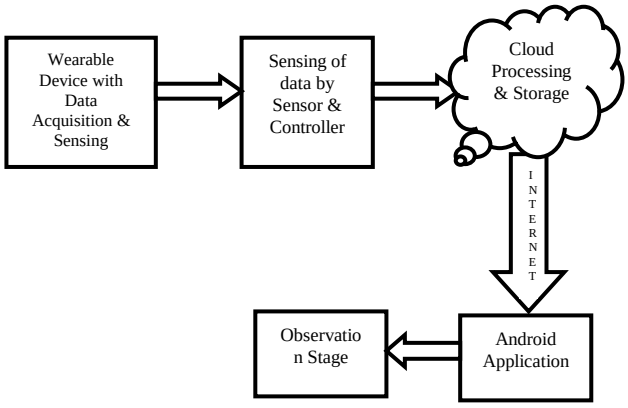

Fig 2. Block Diagram of the data flow of the proposed system

As of now, the world is going through COVID-19 pandemic we have considered this situation and have developed this device in such a way that it can be used to detect the presence of the symptoms occurred due to the COVID-19 disease. In this paper, IoT based Medical Hand Gloves equipped with Temperature Sensor (LM35), Pulse Oximeter Sensor (MAX30100), Pulse Rate Sensor, ECG sensor has been proposed. The glove is equipped with NodeMCU to play the role of the controller board.

A. Hardware

NodeMCU: The NodeMCU is a microcontroller development board that is developed as an Arduino controller board. This controller board is an open-source development board that is based on the ESP8266 Wi-Fi module. This is pre-installed Wi-Fi enabled board and is compact. This helps in the reduction of the circuit complexity that can be caused by the addition of a separate Wi-Fi module (ESP8266). This controller board uses the Arduino IDE development environment for programming the board. In this Embedded C programming language is done. This board shown in figure 3 is increasingly used in many IoT prototypes.

Fig 3. NodeMCU Board (Wi-Fi Enabled)

B. Sensors

Temperature Sensor (LM35): Temperature Sensor is used for measuring temperature variations around the sensor. LM35, as shown in figure 4, is a highly accurate temperature sensor used for research purposes. LM35 has varied features like Direct calibration in Celsius degree; measures body temperature ranging from -55 to +150^{o}C according to the programming logic.

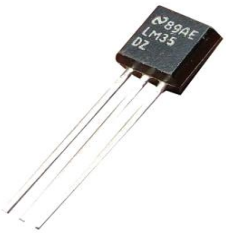

Fig 4. Body Temperature Sensor (LM35)

Pulse Oximeter Sensor (MAX30100): Pulse oximeter sensor MAX30100 shown in figure 5 is integrated pulse oximetry and a heart-rate sensor. It is an optical sensor that senses the health parameter i.e. pulse rate and blood Oxygen saturation level by emitting two wavelengths of light from two LEDs i.e. a red and infrared light, then measuring the absorption of pulsing blood through a photo-detector. This particular LED color combination is used for reading the data through the tip of a human being's finger.

Fig 5. Pulse Oximeter Sensor (MAX3010)

Pulse rate Sensor: Pulse rate sensor is a sensor that is used to give the analog or digital output of the heart pulse rate when a finger is placed on it. When the pulse rate sensor is working, the pulse LED flashes in a paradigm with each heartbeat. This digital output can be connected to the microcontroller board to measure the pulse rate in Beats per Minute (BPM). It operates on the principle of light modulation by blood flow through fingertip at each pulse and shown in figure 6.

Fig 6. Pulse Rate Sensor

ECG sensor: ECG stands for Electro Cardio Graph. This project uses the AD8232 module which is used to measure the electrical activity of the heart is installed with three electrodes. This electrical activity can be recorded as an ECG of the patient. This module presented in figure 7 is installed with 3 electrodes which the patient is required to stick it at three different human body location and record the electrical activity of the heart.

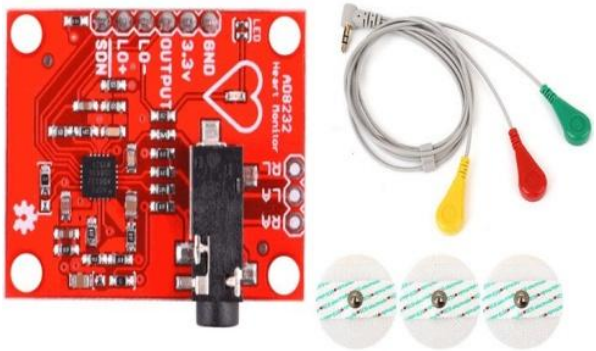

Fig 7. ECG Sensor with Electrodes

C. Software Implementation

Arduino IDE: Arduino IDE is an open-source software facilitating users to write source code for Arduino Boards. Arduino IDE software is being used in our proposed data glove for capturing data from varied sensors embedded in the proposed data glove and is used for reading the sensor values. Figure 8 shows the screenshot if GUI Interface of Arduino IDE software:

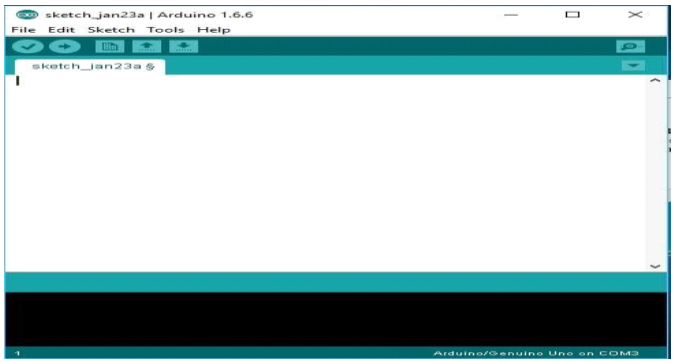

Fig 8. Window Showing GUI of Arduino IDE

Android Application: As discussed in the previous section the patient's health will be monitored by displaying their health parameters on a developed android application that is installed on the Smartphone. The android application used in this project is developed on the Android Studio IDE the screenshot of which is shown in figure 9.

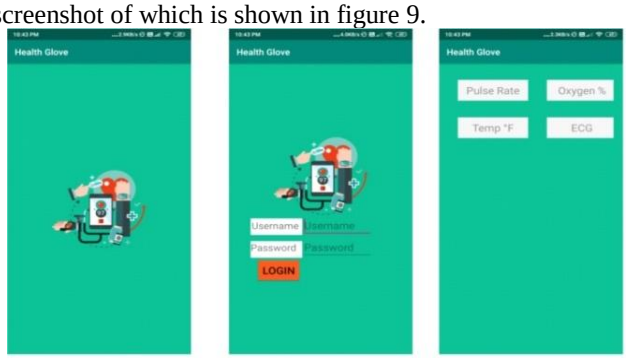

Fig 9. Preview of Android App

IV. PROPOSED DEVICE OPERATION

The operation of this whole system is based on the principle concept of IoT in which two hardware and software communicate with each other and share the data through the popular and effective channels of the Internet.
As we can refer to the block diagram of the system:

- At first, the patient will wear this wearable device (glove) on which the sensors and controllers are embedded.
- The sensors embedded on the glove will measure the elementary parameters of the patient like the body temperature, the patient's blood oxygen level, heartbeat, and the ECG.
- Then these health-related data will be sent to the controller here (NodeMcu) which is a Wi-Fi enabled module connected to the Internet.
- During the adverse condition of the patient his\her data will be sent to the systems of the nearby hospital.
- This system can be installed in an android app that will be installed on the smart-phone of the patient's near and dear ones for notifications about the patient's health conditions.
- The hospital may send their medical team to the patient's location for first aid and immediate procedure to be carried on.
- And thus this device will not only be a new technology product or smart device but will also be beneficial for the health safety of the society. Figure 10 shows the image of the proposed Health Glove.

Fig 10. Proposed Health Glove

A. COVID-19 into consideration:

- When the COVID-19 virus infects a person then, at first it causes a high fever of more than 101 degrees Fahrenheit in the infected body.
- Then after a few days, this virus will cause the reduction of respiration rate in the infected person.
- This reduction in the respiration rate results in the decrease in SpO2 level of blood and the pulse rate will fluctuate.
- The proposed device has sensors that can sense the body temperature, pulse rate, and blood oxygen saturation level.
- And if there are symptoms of COVID-19 in the suspected person then these abnormal values will be recorded and reported to the Health Institute about the suspected COVID-19 symptoms in the person.

V. EXPERIMENTAL RESULTS

A. Pulse Rate Sensor

In this project, we used a pulse rate sensor which senses the pulse rate of the patient. When we slightly press our fingertip on the pulse LED, after a few seconds it will display the pulse rate the sample of the measured value is shown in the table 1 as well as in the screenshot in figure 11 and figure 12. Another screenshot also shows the pulse rate data in the form of a graph.

Table I. Heartbeat value comparison

S.N.	MINDRAY (BPM)	PROPOSED DATA (BPM)
1	85	85
2	86	86
3	82	80
4	88	87
5	86	86

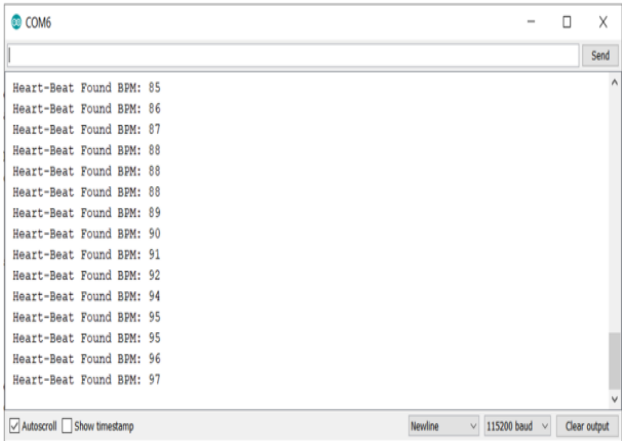

Fig 11. Screenshot of the Pulse Rate recorded by our device

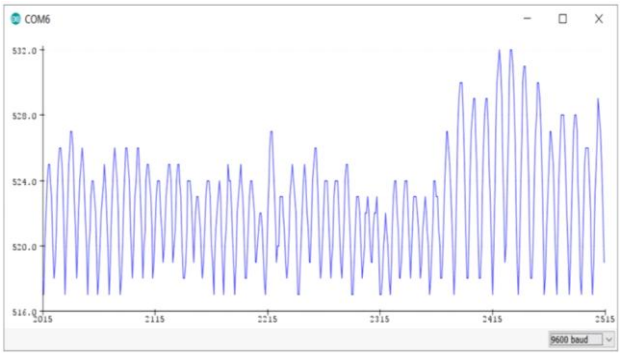

Fig 12. Sensed Pulse rate data in Graph form

B. Temperature Sensor:

This sensor consists of an IC chip in which when the temperature is applied on the junction, this chip converts this heat into a potential difference which when processed according to certain logic used in programming the microcontroller, then the output is the exact temperature of the surrounding or body. The table 2 presents the temperature values recorded by the device and figure 13 shows the screenshot of the output in the form of temperature in ^{o}C and ^{o}F.

Table 2. Actual and Measured temperature values

S.N.	TEMPERATURE BY THERMOMETER	TEMPERATURE BY PROPOSED DEVICE
1	31.73 / °C	31.74 / °C
2	31.74 / °C	31.74 / °C
3	31.20 / °C	31.25 / °C
4	31.74 / °C	31.74 / °C
5	31.25 / °C	31.25 / °C

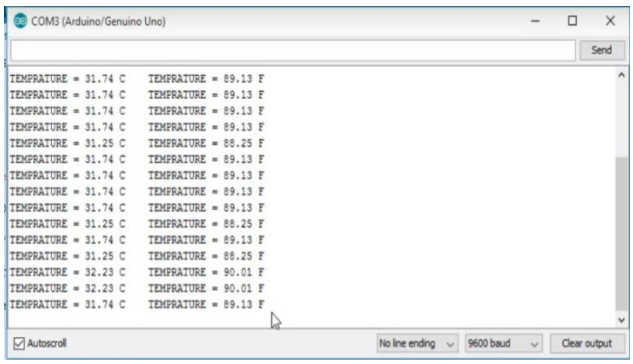

Fig 13. Body Temperature Data Sensed by the LM35 sensor installed in our device

C. Blood Oxygen saturation level sensor (MAX30100):

This sensor uses a combination of light LED i.e. red and infrared. The red LED senses the pulse rate and the Infrared LED senses the SpO2 level. When a patient places his/her fingertip on the LED pairs, after few seconds the device becomes stable and then at first the pulse rate is sensed and then the SpO2 level is sensed. The table 3 shows the measured SpO2 value along with the instantaneous value of the Pulse rate in BPM and blood saturation level in SpO2 percentage recorded by the MAX30100 sensor is shown in figure 14.

Table 3. SpO2 values measured by proposed device

S.N.	MINDRAY SpO_2(%)	PROPOSED DEVICE SpO_2(%)
1	96	95
2	96	94
3	96	96
4	96	97
5	96	95

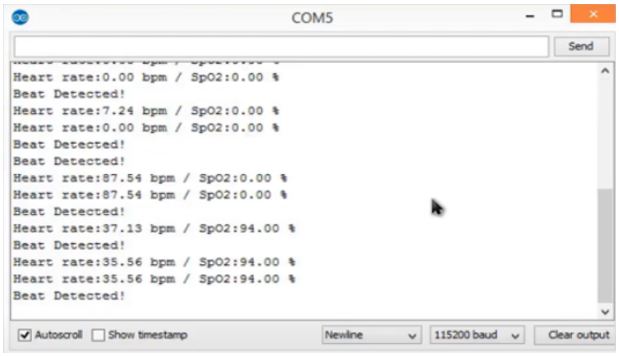

Fig 14. Blood Oxygen Saturation Level and Pulse Rate sensed by MAX30100 sensor installed in our device

The graphical comparison of various measured parameter values to those of actual value is shown in figure 15,16,17.

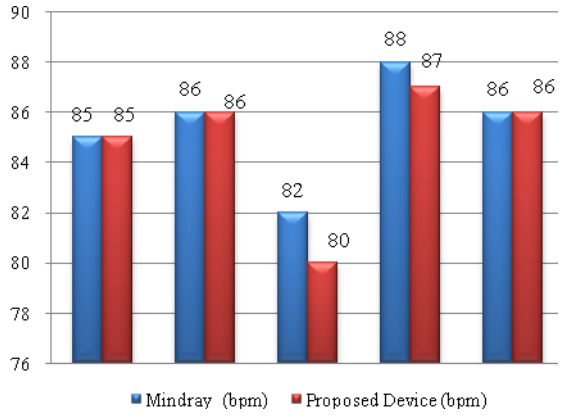

Fig 15. Comparison among bpm values of proposed devise to the one measured by Mindray Medical Instrument.

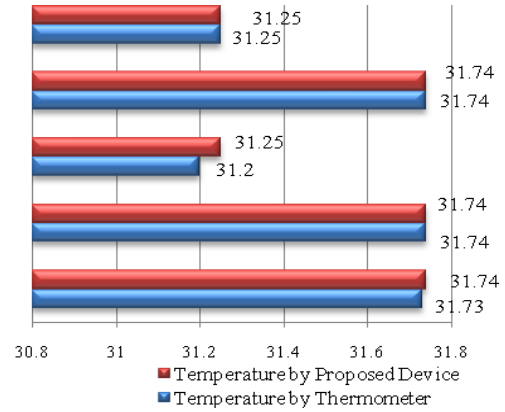

Fig 16. Comparison amid temperature values of proposed devise to the one measured by Thermometer

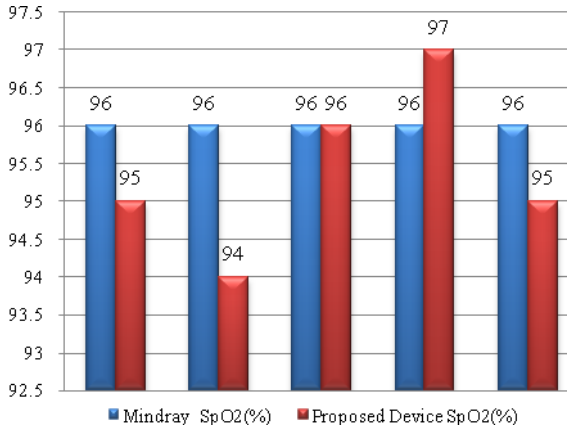

Fig 17. Comparison amid SpO2 values of proposed devise to the one measured by Mindray Medical Instrument

VI. CONCLUSION AND FUTURE SCOPE:

In this paper, a novel IoT based Medical Hand glove equipped with various sensors like Temperature, Heart Beat, ECG, and Oximetry is proposed. The glove is powered via 9V Battery (Yielding 1 Month Data Glove Battery Life) and Node MCU. The data delivered by the proposed Glove using various sensors is highly accurate as well as efficient and the data can be read via Serial Monitor on Arduino IDE software and to the cloud Database. Moreover, it can act as a solution for accessing COVID-19 symptoms so that the suspected person will be further tested and can be provided with proper treatment if found positive. In the future, this work would be more focused on the use of more advanced hardware like VLSI chip developed for particularly this purpose along with an integrated power supply module along with enhanced security measures for keeping the patient's data secure. The work would also be carried out on the security of health parameter like an end to end encryption transmission of data. Added sensors like Ultrasonic sensor for deaf and dumb etc. can be integrated to make it a more multi-functional device.

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