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# IoT in Telemedicine: IoT based Human Vital Signs Monitoring System

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**Abstract:- Human Health Monitoring has gained much importance in the recent years with the advent of the new and novel diseases. It has become very difficult to monitor the vital signs of humans at a regular basis due to the increasing population and the relative number of physicians to deal with enormous population. Our purpose is to design a device which measures the vital signs of humans and send them to the server for the physician for monitoring. This project will also send a message containing the location co-ordinates of the patient to the caregiver mobile number in the case of emergency. For this purpose, we will be using IoT platform namely 'Blynk' to show the vital signs of the patient for the physician to monitor them remotely. IoT is a technology which transforms the medical data into insights for smarter patient care. The sensors which we used are temperature sensor, SPO2 sensor, ECG sensor along with Arduino Nano. The Node-MCU will connect the micro-controller with the WIFI so that the data can be transferred to the IoT platform. The GPS and GSM modules will send a message containing the location co-ordinates to the care-giver mobile number in the case of emergency. The vital signs are successfully shown on the IoT server, OLED and a message is sent to the emergency staff or caretaker in the case the patient is in emergency. The monitoring system is successfully developed for the facilitation of the patient as well as the physician. The future work of this project will be giving the proper and minimum shape to the monitoring system so that it can become portable and increasing the accuracy of the sensors.**

***Keywords***:- *IoT , Telemedicine, patient monitoring and vital signs.*

## I. INTRODUCTION

Hospital is a busy place where doctors and nurses work hard to save the lives and improve the health of patients. In general, patients admitted to the hospital must be watched by a nurse on a frequent basis to ensure that no adverse events occur, the nurses must supervise an excessive number of patients at the same time. Nurses are still required to visit each patient's room one by one to monitor and update their current circumstances. To improve the efficiency of the nurse's work, a new system must be designed [1].

According to the World Health Organization (WHO), hypertension and heart disease are the two most serious health hazards. Furthermore, e-health applications can be used to support health services [4]. Slow handling in analyzing the patient's disease situation is one of the variables generating increased mortality in heart disease.

Despite the abundance of medical facilities, fatal diseases such as heart disease, cancer and pneumonia have increased dramatically and claimed many lives. Patients' health is regularly monitored and observed by a huge number of doctors, therapists, nurses, and other professionals. Patients with chronic illnesses are routinely checked and observed [2]. Monitoring vital signs is a primary goal that health care centers must examine in order to achieve early prevention and lower mortality rates.

IoT-based vital sign monitoring offers a tool for improving real-time health services and overcoming the limitations of traditional medical equipment [3]. The Internet of Things reduces medical physicians' burden by reducing hazards and improving overall performance. This technology can be used by doctors to detect changes in crucial parameters in COVID-19 patients or patients in an emergency rooms [4]. IoT role can be seen in Figure 1:

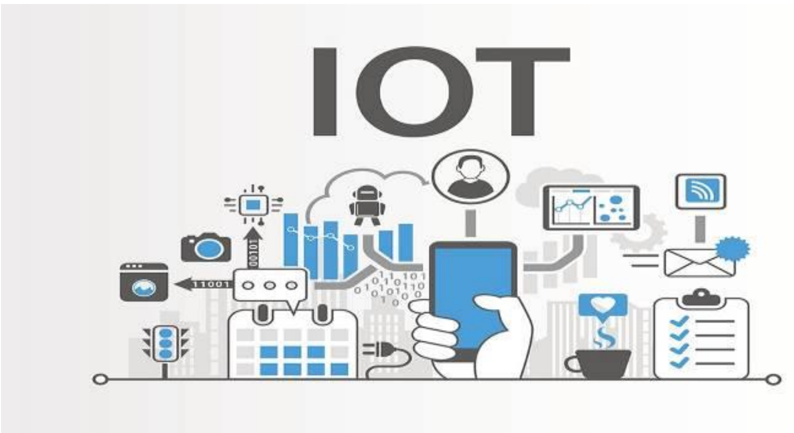


Fig. 1: IoT role [5]

By focusing on the new and fruitful technologies, we can better monitor the health parameters of the patients at their homes or some remote place. For example, during COVID-19, there is an increase in the monitoring of the health parameters remotely so that there is no risk of spread of the disease to the hospital staff.

The basic functions of the body are measured using vital signs. The parameters that show that how the body is working, whether the body is functioning properly or not, are called vital signs. By measuring these parameters, we can monitor the health conditions of the patient and can also predict many diseases that are on their initial stages [4].

The typical ranges for vital signs vary depending on a person's age, weight, gender, and overall health. Body temperature, blood pressure, pulse (heart rate), SpO2 level and ECG are the five main vital signs [6]. The suggested IoT based vital signs monitoring system is projected to reduce medical personnel's burden and aid in the real-time diagnosis of a patient's disease [7].This project is based on measuring four main vital signs, heart rate temperature, SpO2 and ECG with SMS system for sending messages and location of patient in emergency situations.

### *A. Objective*

The objectives of this project are as follows:

- The aim of this project is to design hardware system for measurement of vital signs.
- To develop mobile app to transfer data wirelessly.
- To design innovative system for accurately detecting the patient's position and emergency alert system to notify medical staff.

### *B. Significance*

The main contribution of this project is to send the bio-signal to IoT platform and text on SMS to the family members and emergency care staff in case of emergency. This project provides an experimental model to achieve portable, real time remote monitoring of bio-signals based on IoT technology. IoT applications are on the increase in the different fields of life like home automation and health facilities etc. [9]. The IoT platform is Blynk app. This platform provides communication channel between our project's hardware and the Blynk server. This app is installed and logged in on the emergency response team or caregiver's smartphone. So, no one can see the data of patient except caregiver. In this project the SMS alert system and four health parameters are namely SpO2, heart rate, temperature and ECG are monitored.

- This IoT base device can be used in hospitals, clinics and rehabilitation centers for real time monitoring of patient's health [10].
- This project provides an innovative system for rural areas. The people living in remote areas (rural areas) suffer from poor medical care and lack of medical resources. So, this device is beneficial for people who live in rural areas.
- This project is effective equipment for patients who are recovering from heart attack or the elderly or disabled people [10].
- This device is easy to use and provide real time information of patient.
- This device provides the location of patient in emergency situation and send message to doctor or caretaker such as patients with heart diseases need proper health care, so this device plays a key role in detecting abnormal situation and alerts the doctor and emergency staff to deal with critical situation.
- During an emergency like the COVID-19 pandemic, an IoT based health management system can improve overall healthcare performance [4].

The findings of this thesis deal with two main concepts: vital signs monitoring and early identification and interpretation of aberrant vital signs The scope of the project can be seen in Figure 2:

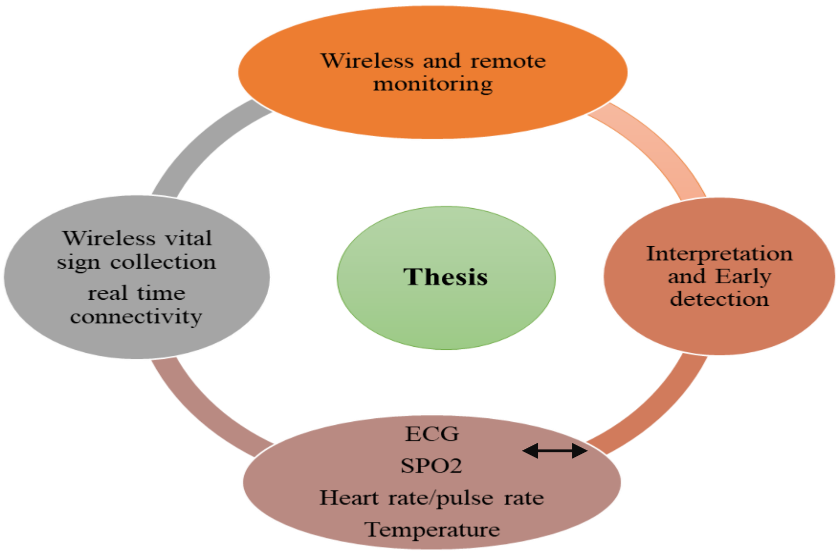


Fig. 2: Scope of project

## II. LITERATURE REVIEW

### *A. VITAL SIGNS*

Vital signs defined as the monitoring of most basic functions of the body of humans. These vital signs play an important role in the life of human beings. There are different methods to measure the vital signs and most important vital signs recommended by the healthcare specialists are [14]:

- Temperature
- Pulse Rate
- Oxygen Saturation
- Blood Pressure
- ECG

Today, Vital signs play an important role in ICU (Intensive care unit) and on the wards, to determine the range of danger to the patient. Despite the fact that it is precisely anticipated by essential sign changes, clinical crumbling frequently goes unrecognized or isn't distinguished until it is past time to treat. This is chiefly brought about by deficient recording of imperative signs or because of an improper reaction to unusual qualities. Among medical caretakers and specialists, there is lacking information and enthusiasm for vital sign changes and their suggestions for patient consideration [16]. The significance of observing vital signs in clinical practice is unquestionable, however how-to best screen and decipher them. In case of chronic diseases, the remote health monitoring system has great quality and ability to improve the quality of the life of patients. And nowadays these techniques are becoming popular all over the world. Remote Health Monitoring device uses sensors which are required to measure the vital signs of human body that collects the physiological data from the body and send it wirelessly to IoT Platforms. . The term 'vital' in vital signs is because they influence medical decision making. Vital signs can be measured by the medical staff or can also by the individual himself. Oxygen saturation, pulse rate, respiration rate, blood pressure and temperature are the simplest and important vital signs and also the most necessary information stored by the patients admitted in hospitals. Although they have been introduced in the medical field for more than a century ago but unfortunately only few attempts have been done on it. Vital signs have become most active area in the medical field in last few decades [15] .

Vital signs monitoring is shown below:


Fig. 3: Patient Monitor

- ➢ *Temperature*

The most important vital sign of the human body is temperature. Keeping the body temperature in safe range is very important for survival. If body temperature is out of the safe range, then the human body is unable to perform normal functions. So, measuring body temperature is necessary for monitoring human health. Thermoregulation is a process in which body attains the normal temperature. This process is very beneficial to lead homeostasis. Many enzymes work at specific temperature to catalyze the biochemical reactions in the human body. If the temperature is below or high from the specific condition then, these enzymes cannot do their work properly and the whole human body disturbs and human feels uncomfortable. High temperature causes dehydration and low temperature causes shivering of body. Temperature has most important influence in human body because it determines physical state of water. When the body temperature is too high then, body sweats due to this sweat body lose fluid and blood vessels dilate to increase heat dissipation and consequently sweeting. Due to this process human body can drop its blood pressure in most cases.

The Standard temperature of the body is 37℃.A person with body temperature above than standard temperature has condition called fever and the person having temperature less than standard temperature like below 35℃ is considered hypothermia. The condition that occurs when the body temperature produces more heat than its capacity is called hyperthermia [19]. Low body temperature causes vasoconstriction thermogenesis, shivering, piloerection [20] (hairs on skin stand up) and curling up while high temperature causes vasodilation, sweating, pilorelaxation [21] (hair flatten) and stretching out.

- ➢ *Oxygen Saturation (Spo2)*

Oxygen saturation or SpO2 is the amount of oxygen which is traveling with the red blood cells through the body. Normal range of Oxygen Saturation is from 93% to 100%. Below this percentage the person need immediate medical care because below this level the organs, cells and tissues of the body are not getting required amount of oxygen to function properly. The oxygen saturation conditions begin with the microscopic structures present in the lungs called alveoli. There are millions of these alveoli in the lungs and

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their function is to exchange Oxygen and carbon dioxide molecules to and from the blood stream. When the molecules of oxygen pass through these sacs, they bind with the molecule hemoglobin present in the blood. After this as hemoglobin circulates in the body the oxygen molecule detached with the hemoglobin and a molecule of carbon dioxide is attached from the tissues and this CO2 is transported back to the alveoli and the cycle is completed. Some diseases decrease the ability of hemoglobin to bind Oxygen [33].

Factors on which level of oxygen in blood depends is given

- Amount of Oxygen breathe in
- Ability of alveoli to swap CO2 for Oxygen
- Amount of concentrated hemoglobin in red blood cells.
- Ability of hemoglobin to attract Oxygen.

Every blood cell contains 270 million molecules of hemoglobin and any condition that reduce the ability of body to produce red blood cells results low hemoglobin levels and due to this reduction, the amount of oxygen also reduced. Circulatory problems, blood disorders and some lung diseases may cause the reduction in absorption and transportation of oxygen by hemoglobin which results in lower blood oxygen level. There are some conditions that can affect the oxygen saturation level includes [34]. The Figure 4 presents SpO2 of blood:

Blood oxygen saturation ($SpO_2$)

| | | |
|---|---|---|
| 100 - 98 % | | Normal |
| 97 - 95 % | | Insufficient<br>Tolerable, patient hardly notices any influence |
| 94 - 90 % | | Decreased<br>Immediate intervention (eating, exercise) |
| < 90 % | | Critical<br>Referral to specialist |
| < 80 % | | Severe hypoxia<br>Hospitalization |
| < 70 % | | Acute danger to life |

Fig. 4: Blood Oxygen Saturation ($Spo_2$)

➢ *ECG*

ECG is an electrical signal of heart which provides us the electrical activity of heart. It can be recorded with placing the electrodes on the surface of the body of patients. Due to the action potential of cardiac cells, changes in voltage occurs and it is measured by these electrodes. This results in propagation of heartbeat and produces series of waves [23].

In 1842, the electric current produced by every heartbeat of the frog was firstly observed by Dr. Carlo Patitucci [24]. Augustus Waller, a British physiologist, is the first person who measures the human electrocardiogram (ECG) by using the capillary electrometer and placing the electrode on the chest and back of the person. He also proved that this electrical activity occurs right before the ventricular contraction [25]. The tri-phasic electrical activity of the heart is determined by William Bayliss and Edward Starling in 1891 using an improved capillary electrometer. Improvements were made to make the string galvanometer electrocardiograph more practical as it became available for clinical usage Waller previously recorded electrocardiograms using five electrodes. Einthoven reduced these number of electrodes to just three, which he considered produced the lowest yield. Einthoven's triangle was built using the three leads On his work and production of electrocardiographs [26]. Einthoven received the Nobel Prize in Physiology or Medicine in 1924. The initial electrodes were rinsed-out cylinders of electrolyte solution. In 1908, Sir Edward Schafer purchased the first ECG machine and a string galvanometer electrograph for therapeutic usage [27].

The three-lead electrocardiogram became more popular in the first three decades of the twentieth century, especially after advancements were made to make it more portable [23]. Sir Thomas Lewis used the ECG to determine the clinical diagnostic of abnormal and irregular heartbeat (Delirium Cordis'), which was caused by the fibrillation of atria in 1909. After myocardial infarction was recognized as a clinical entity in 1910, ECG patterns indicating ischemic heart disease were attempted to be recognized. By 1930, the ECG had shown its value in distinguishing non-cardiac chest pain from cardiac pain. . This conduction system's electrical activity is as follows [29].

- The conduction system is in a condition of rest.
- SA node is made up of bulk of myocardial conducting cells which are responsible for production of cardiac rhythm. Hence it starts the electrical activity and sinus rhythm.
- The impulse passes from the SA node to the left atrium and then to the AV node through the Bachmann's bundle (interatrial bundle).

- Impulse then approaches AV node and it is delayed to ensure that this blood is effectively pumped through atria to ventricles.
- The conduction system is in a condition of rest.
- After some delay, the impulse goes to the Purkinje fibers via the bundle branches. Then, through the moderator band, it reaches the right papillary muscle. Approximately at the same time, the impulse reaches the left papillary muscle. The left ventricle, on the other hand, lacks a similar moderator band [30].

The ventricles begin to contract, pumping blood to one's body or lungs to be oxygenated. The ECG waveform can be seen in Figure 5:

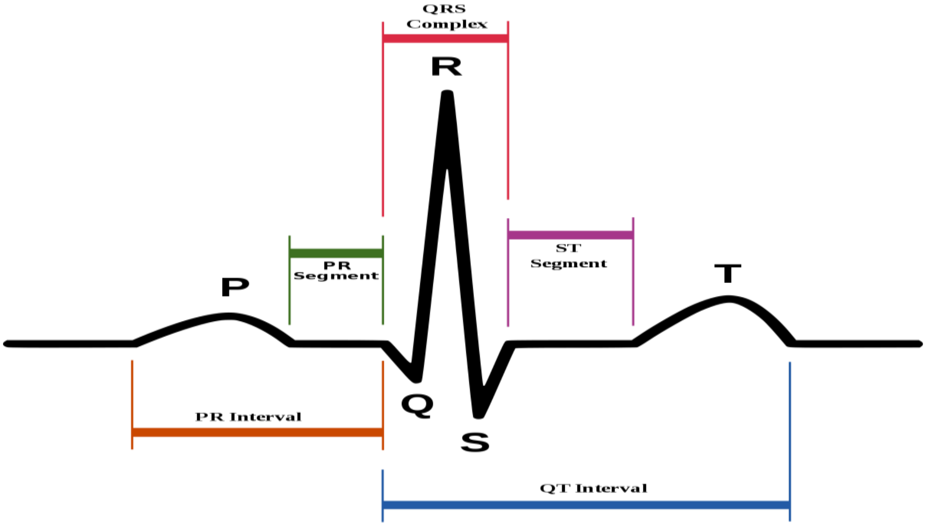


Fig. 5: QRS complex [31]

## III. METHODOLOGY

### A. Block Diagram

The project is based on two steps i.e. information and intervention. the information is taken by the patient by using different sensors. in our project we used three sensors for taking information from the patient i.e. ECG sensor, temperature sensor and SPO2 sensor. Then these data send to the processor for further processing. processed data being shared to family and to the website also shown on the OLED [14]. All these are shown in the Figure 6:

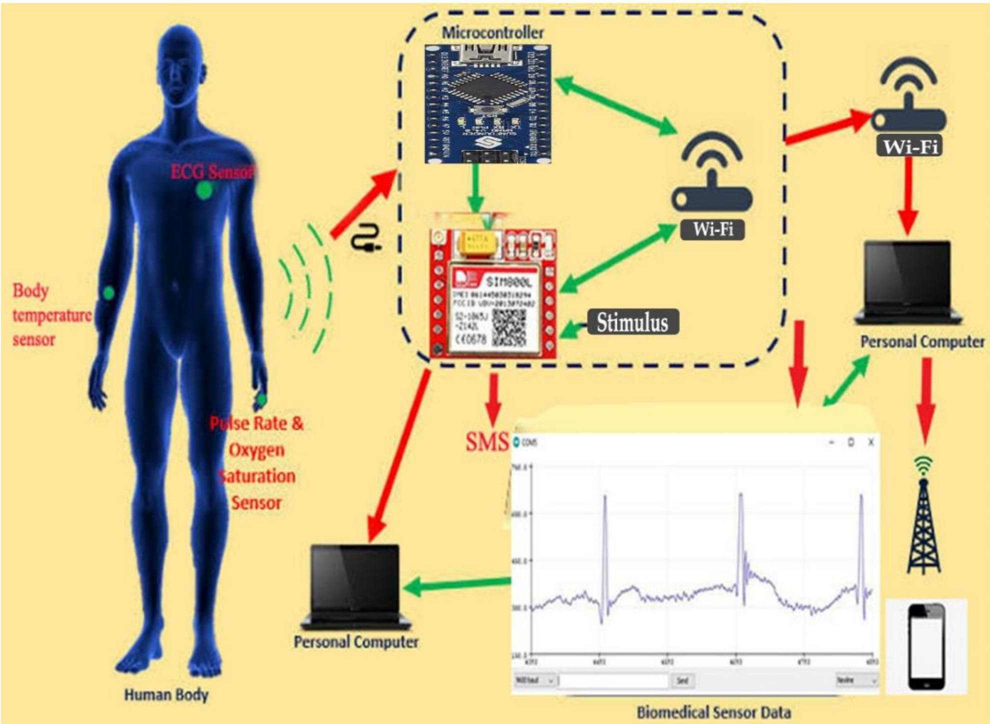


Fig. 6: Block Diagram

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### *B. Flow Chart*

The flow chart that is shown in the figure 6 is described the methodology that utilized to complete our project. The project starts with the sensor's integration and data acquisition from the patient. The data that is acquired from the patient then send to the processor for signal processing. the processed data is then classified using features or the nature of the data. All these results are being displayed on LED and website and is shared to the family in emergency situation.

### *C. Final Circuit Diagram*

We used bridge rectifier that convert AC to DC. After that we use two voltage regulator that give 5V to all the components. One voltage regulator gives 5V to GPS module, Wi-Fi module and Arduino nano. The other one is used to give the 5V to SpO2 sensor, Arduino mini, OLED and temperature sensor [69]. We are also using buck converter that gives 3.7V to GSM module. The RX of GSM module is connected with the TX of Arduino nano it means Arduino nano transfer the data and GSM module receive the data. While the TX of GPS module is connected with the RX of Arduino nano it means GPS module transfer the data and Arduino nano receive the data. The Arduino mini also send the data to Arduino nano and Arduino nano is connected to the Wi-Fi module that will send the sensors data to the IoT platform namely Blynk application [17]. The circuit diagram can be seen in Figure 7.

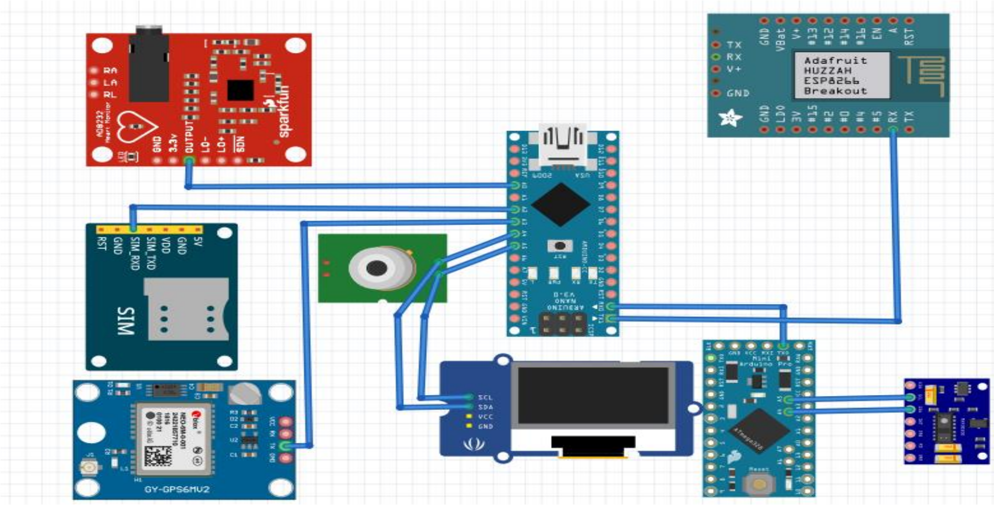

Fig. 7: Final circuit diagram

### *D. IoT Integration*

The IoT platform that we have used is 'Blynk' mobile application. This app needs to be modified according to our requirements. We added 3 'Gauges' and 1 'Super Chart'. The Super Chart is for the display of the ECG waveform and the 3 gauges are for displaying the value of the temperature, SpO2 and heart rate. The input we used for the ECG waveform is V4. The input we used for the temperature, heart rate and SpO2 are V0, V1 and V2 respectively. The Blynk app is now set for receiving and displaying our data.

We receive an email from the Blynk app containing the authentication token number. We put this specific number in our code part so that our hardware sends data to the Blynk layout that we set. The hardware of the project is connected to the server through Wi-Fi module named ESP8266. This Wi-Fi module will send the data to the Blynk server so that the provided data can be seen on the app.

## IV. RESULT

Result of our project like temperature, heart rate and oxygen concentration are shown on the OLED

Fig. 8: OLED

We took the temperature values of a person and presented them as a graph. As we can see in the graph that the person's temperature is approximately at 97F that is the normal range of temperature of a human body. When we started to take the values of temperature of the person, the temperature first appeared to be 96.8F and it keeps on fluctuating between 96.8-98. As the normal temperature of the human body is 98.6F, we can see that the temperature of the person is in the normal range. We plotted the temperature of the person with respect to the time on the x-axis as can be seen in the Figure 9:

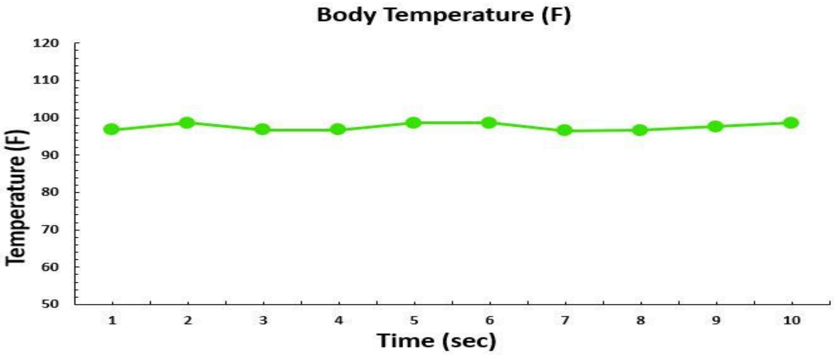


Fig. 9: Body Temperature Graph

We took the SpO2 values of a person and presented them as a graph. As we can see in the graph that the person's SpO2 level is approximately at 96% that is the normal range of SpO2 of a human body. When we started taking the values the person's SpO2 level was 95%, and then it keeps on fluctuating between 95 and 96. As it is the normal range of SpO2 of a healthy person so we can conclude that the person is healthy. We plotted the SpO2 level of the person with respect to the time (on x-axis) and shown it in the Figure 10:

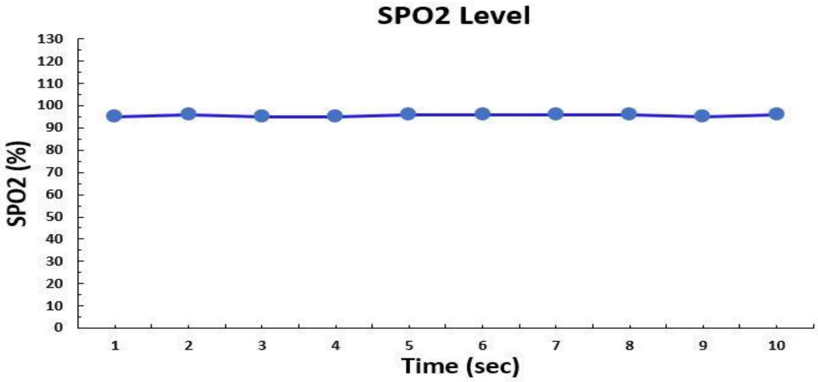


Fig. 10: SpO2 level of a person

We took the heart rate values of a person and presented them as a graph. As we can see in the graph that the person's heart rate is approximately in the range of 70-80 that is the normal range of heart rate of a human body. When we started taking the BPM values, it appeared 73 BPM and with time it keeps on fluctuating between 70-76 BPM. So, we can conclude that the person is healthy and BPM is in safe range. We plotted the heart rate of the person with respect to the the time (on x-axis) and showed it in the Figure 11:

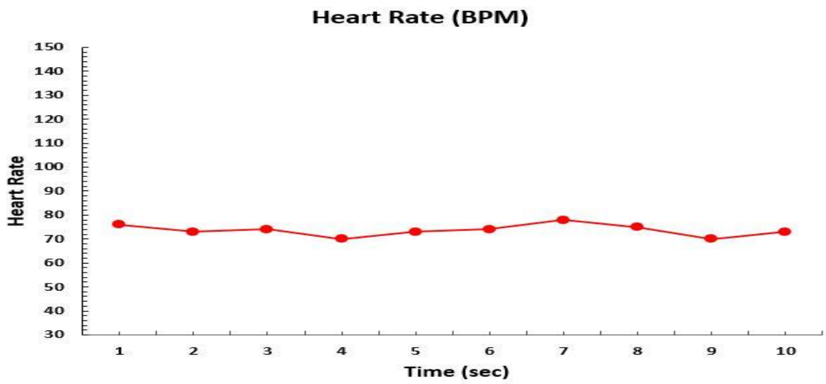


Fig. 11: Heart rate of a person

We can see in the figure that there is firstly P wave, and then QRS complex and at the end there is T-wave. There is a little noise in the ECG signal shown above, it is because of the low accuracy of the sensor and also due to the fact that we are using local electrodes to measure the ECG signal.

The Figure below presents the ECG on the serial plotter:

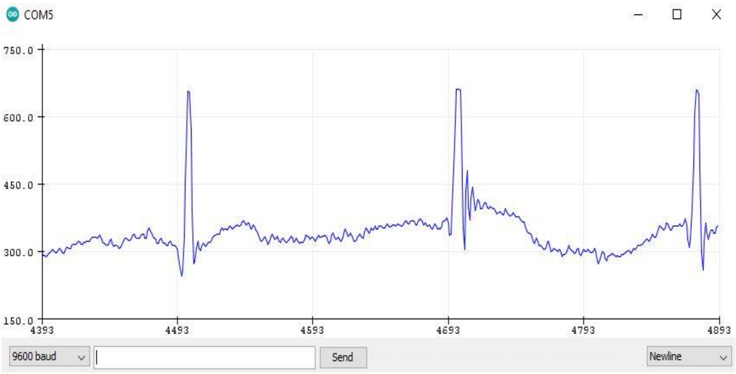


Fig. 12: ECG waveform on the serial plotter

*A. On Blynk App*

After the ESP8266 is connected to the Wi-Fi, its blue LED that was blinking before will turn off and it will start to send the data to the Blynk app [11]. The parameters it will send to the Blynk app are:

- ECG Waveform
- Temperature Value in Celsius
- SPO2 Level in %
- Heart Rate (BPM)

The screenshot of the Blynk app showing all these parameters is attached in Figure 12.


Fig. 13: Blynk app showing all parameters

All parameters namely temperature, heart rate, SpO2 and ECG are clearly can be seen on the Blynk app. The reason the ECG waveform is not correctly shown on the app is that the Blynk app shows the value of the variable after every 1 second and the normal duration of one ECG waveform is 0.4 sec in males and 0.44 sec in females. So, the blynk is not showing the proper ECG waveform due to its duration of showing the signal value.

The message will be sent through the GSM module. The message will contain the location coordinates of the patient as shown in Figure.

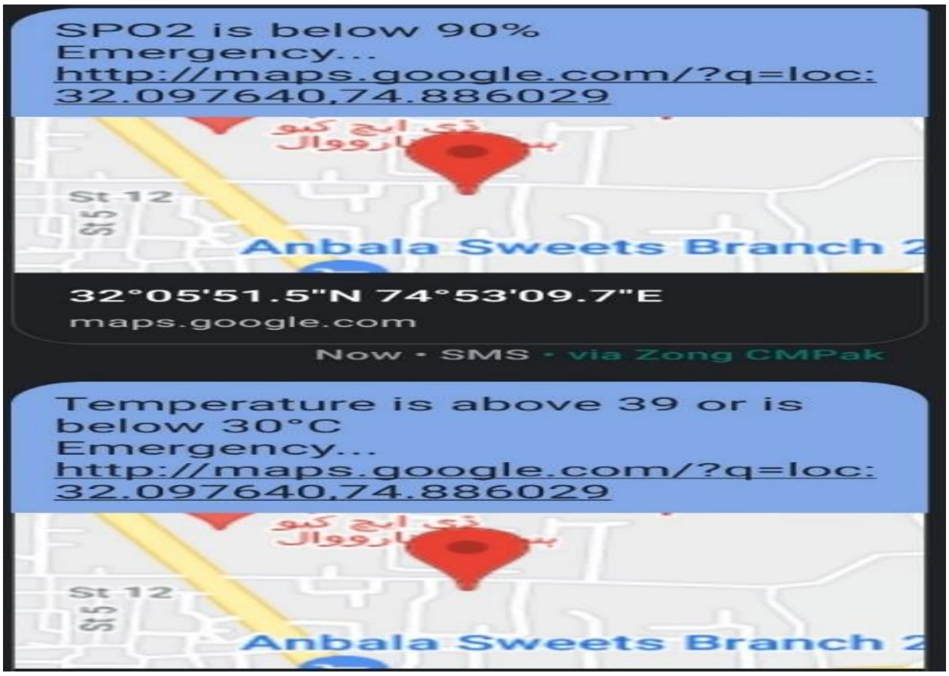


Fig. 14: Location coordinates

## V. CONCLUSION

Our primary goal was to provide a low-cost diagnostic and monitoring system that would be in reach of everyone. This project provides an experimental model to achieve portable, real-time remote bio-signals monitoring system based on the IoT technology. the bio-signals are uploaded successfully to blynk mobile app the makes health professionals to monitor and diagnose more than one health parameters at the same time in this project we also focused on establishing a 24-hr link between patient, his relatives and doctors in the form of mobile app. We measured the values of temperature, SpO2 and heart beat and shown these all values on OLED. Along with these vital signs we also plot the ECG Signal on Serial Plotter and as well as on LED. We also used the GSM module for conveying the message to the patient's relatives and doctors in emergency conditions and also used the GPS module for the patient location. Finally, this project can be used by the elderly, disable and patients in the emergency situations.

## VI. FUTURE WORK

- In this project we only measured the ECG signal and plot the signal on Serial Plotter and blynk app but in future this can be improved by removing the noise from the ECG signal by applying the different filters on the ECG signal in MATLAB.
- The ECG lead we are now using is not wireless, we can take a step further and can use wireless lead system which needs no wire connection with the main hardware setup, but the ECG signal is transmitted to the hardware wirelessly.
- We can take this project to use in proper medical field by using accurate and medically approved sensors

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