Feasibility Analysis of Gesture Recognition based Human Wearable Electronic Accessories

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Declaration

We do here by declare that the thesis titled 'Design and Development of a Wearable Pulse and Oxygen Saturation Monitoring System for COVID-19 People ' is submitted to the Department of Electrical and Electronic Engineering of BRAC University in partial fulfillment of the Bachelor of Science in Electrical and Electronics Engineering. This is our original work and was not submitted elsewhere for thea ward of any other degree or any other publication.

Date: 28/09/2021

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Abstract

The Oximeter is commonly used on the finger tips for better analysis of the oxygen saturation on the blood. Still there are some errors to be aware of during the scans. It has a tendency to be accuracy 90% of the time. Furthermore, if there are possibilities to get some errors from scanning the part of the body with less skin density such as fingers, scanning on the wrist will have far more errors than this. Yet, from comparing the two measurements we can find the difference between the error and add them on the taken analysis to get the actual result. Now it is as simple as adding the error of the analysis gap we get both the wrist and the fingertip. After comparing with the market best oximeter with the reading of different individuals the accuracy has been checked and corrected. This system can be efficient for monitoring the COVID-19 patients as they mostly face the falling oxygen saturation stage.

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List of Abbreviations

HRM Heart Rate Monitor

ESP8266 Wifi Module

MAX30100 sensor

HR Heart Rate

Bpm Beat per

Minute

MCUMicrocontroll

er

MAXHR Maximum heartrate

LED Light EmittingDiode

IoT Internet of Things

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Chapter 1

1.1 Introduction

1.1.1 Background:

In the early years of the twenty-first century, the Corona virus, a disease-causing virus, has swept the globe. It has infected millions of individuals, with nearly a million dying as a result (case: 150.7 million, death: over 3 million) [1]. Only a few diseases have crossed international borders so far. As a result, the World Health Organization (WHO) has declared the disease a pandemic [2]. The Corona virus attacks the respiratory system of a patient, and in severe cases, the patient dies [3]. Because the virus's structure has so many variations [4], scientists have been unable to find a treatment or vaccine that provides 100 percent protection against all strains of corona virus until recently, worsening the problem. Younger people with strong immune systems, on the other hand, are less likely to become infected [5], even though they may be virus carriers. The elderly have a much higher infection rate. During the Covid-19 infection period, they are primarily found suffering from respiratory problems. Doctors prescribe several of the diagnostic and serological tests to determine the exact state of their lungs, which can be exhausting for sick persons. As a major sign, they are advised to use a pulse oximeter to evaluate their oxygen saturation and pulse rate. The operation of this small instrument, as well as the interpretation of its results, can be difficult for the general public. On the other hand, finding an expert to help everyone in need is nearly impossible. So this is where we combine our notion, where we can detect any hazardous scenario of a diseased person from a big distance using a sensor and a Wi-Fi based application.

It is not a novel concept to introduce a health monitoring system. Many scientists have been created in the past. Takaoka City, Toyama Prefecture, Japan, conducted research on health monitoring systems by creating experimental rooms with data gathering equipment. [6] The system was made up of data-collection devices and monitoring devices. According to a research issued by Counterpoint Technology Market Research, the number of smartphone users in Bangladesh in 2015 was 8.2 million [1]. As a result, developing a health monitoring gadget with an app that is accessible and cheap to many people in the country.

Although there are several commercial installations for lifestyle tracking, the evidence basis is every poor. [3] The majority of studies concerned with technical growth and the necessity to deal with practical development and user comfort abilities.

The creation of such a device is prompted by rising health-care costs and a substantial increase in the general population [7]. Despite the efforts of other nations, such a health monitoring system has yet to be implemented in Bangladesh. The implementation of such a system will benefit both the healthcare sector and the country's revered seniors.

1.2 Motivation:

The goal of this study is to look into current advancements in the field of wearable sensors and systems that are important to rehabilitation and medicines. The growing body of research will focus on the application of wearable technology to monitor individuals and subjects with chronic conditions in the home and community settings justifies the focus of this research on summarizing clinical applications of wearable technology currently under evaluation of describing the development of wearable sensors and systems.

1.3 Problem Statement:

Several individuals who are infected with COVID-19 are unsure where to go to get tested since the healthcare has a high risk of spreading the virus and prioritizing them by phoning the infected to learn about their present status [8] is difficult and inconvenient, but this problem may be avoided if patients and healthcare staff are watched and data is continually supplied to the hospital and analyzed to prevent the spread of the healthcare system. COVID-19 may be identified using key symptoms and machine learning models trained on a dataset of symptoms [9]. While measuring the oxygen saturation, the sensor device known as a pulse oximeter is generally put on a thin portion of the patient's body, usually a fingertip. We sought to create a wearable wrist oximeter that could measure SpO2 and pulse at any time. As a result, everyone may be aware of their oxygen saturation at all times.

1.4 Aims and Objectives:

Our objective is to create a wearable system for the individual that will continuously feed two different data: Heart or Pulse rate, and Oxygen Saturation Fall; and will send these data to a web server, which will translate the information on a web application and feed it to care givers and attendants to remotely monitor their loved ones during this pandemic. The system will also include a notification system for emergency medical situations, which would quickly inform rescuers in the event of a medical emergency by mailing.

1.4.1 Our proposed solution:

Wrist oximeters are a novel type of health monitoring device that incorporates biological sensors, microelectronics, and radio frequency (RF) transmission. Here, a wrist oximeter is shown with a novel optical biomedical sensor for reflectance pulse oximetry, allowing the wrist oximeter to monitor both the pulse and the oxygen saturation. The reflectance pulse oximetry system is built around a recently invented annular backside silicon photodiode, which allows the light emitting components to consume very little power. Several individuals who require constant monitoring can always use this gadget to learn more about their health status. If the saturation falls below 94%, a notification will be sent to the email. Besides, we are going to check the pulse rate with which the patient can be in the monitoring whole time.

Figure 1.1: Mechanism of overall system

Purpose of the email notification:

1. Low saturation emergency (hypoxia) ,SpO2 <90%
2. No pulse detected
3. Low pulse rate
4. High pulse rate

The pulse oximeter, which is worn on the fingertip, provides us with an exact oxygen saturation rate. Based on this information, we take measures. With this study, we hope to demonstrate the viability of increasing awareness by wearing a wrist oximeter. For example, if someone wears this wrist oximeter, he or she may assess his or her oxygen saturation at any moment by just pressing the button. The likelihood of achieving the same result is more than 80%.

1.5 Different Aspects:

1.5.1 Electronic Part:

Pulse oximeters determine SpO2 based on the principle of differential light absorption. The device sensor is placed on a region of the body (for example, on a finger or wrist) and transmits different light wavelengths through the skin to the tissue by means of light-emitting diodes (LED); these wavelengths are differentially absorbed by oxy-hemoglobin (HbO2) in the blood, which is red, and de-oxy-hemoglobin, which is blue. A photo detector is also located on the sensor which converts the transmitted light into electrical signals proportional to absorbance. The pulse oximeter microprocessor processes the signals and displays the SpO2 reading in the screen.

1.5.2 Power Requirements:

In the oximeter, the digital signal processor, after digital filtering, calculates the pulse rate using an autocorrelation algorithm. The pulse rate and ratio figures are wirelessly transmitted, together with power measurement data, to a nearby receiver. The receiver software can use a look-up table to convert the infrared ratio to a percentage of oxygen saturation. Further lowering of the power consumption is achieved by implementing a 26% duty cycle, a measurement is made every 15s. Under this condition, the average power consumption of the pulse oximeter is 62μW. This power is distributed between the different components in the system. Given an input to output power efficiency of approx. 70% (including quiescent power), a power of approx.

1.6 **Literature Review**

1.6.1 Heart Rate

The heart is the organ in charge of pumping blood throughout the human body. It is positioned in the center of the thorax, slightly offset to the left, and surrounded by the lungs. The human heart is made up of four chambers: two atriums and two ventricles. The right atrium gets blood that is returning to the heart from all throughout the body. That blood flows via the right ventricle and is pumped to the lungs, where it is oxygenated before returning to the heart via the left atrium, and then through the left ventricle and is pumped again to be dispersed throughout the body via the arteries [10].

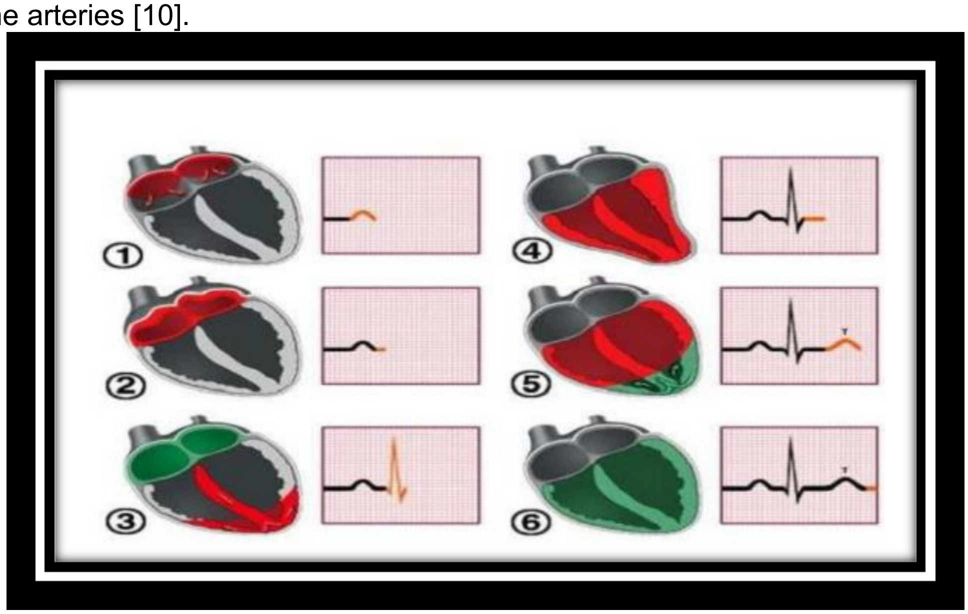


Figure 1.2 heart behavior and part of the generated signal

1.6.2 Measuring the Heart Rate

The heart rate may be estimated and displayed by detecting the R peaks and calculating their frequency. The major measure of a person's fitness is their heart rate before, during, and after activity. Manually measuring this requires a person to stop what they are doing and count the number of heart beats over a period of time. Measuring the heart rate via an electrical circuit is significantly faster and more precise.

One of the most essential characteristics of the human cardiovascular system is heart rate monitoring. A healthy adult's resting heart rate is about 72 beats per minute. Athletes typically have lower heart rates than non-athletes. Babies have a significantly greater heart rate of approximately 120 beats per minute, but older children have heart rates of around 90 beats per minute. The heart rate progressively increases during activity and falls to resting levels afterward. The pace at which the pulse returns to normal is a measure of a person's fitness. Lower than normal heart rates are typically a sign of bradycardia, whilst greater than normal heart rates are an indicator of tachycardia [11].

Endurance athletes frequently have extremely low resting heart rates. The heart rate may be calculated by taking one's pulse. Pulse measurement can be accomplished with sophisticated medical instruments or simply by placing one's fingertips against an artery (typically on the wrist or the neck). Auscultation, or listening to heartbeats using a stethoscope, is widely recognized as a more accurate way of measuring heart rate. There are several alternative ways for measuring heart rates, such as the Phonocardiogram1 (PCG), ECG, blood pressure wave form, and pulse meters, but these procedures are clinical and costly [11].

1.6.3 Maximum Heart Rate

The maximal Heart Rate (Max HR) is the quickest rate at which the heart can beat in one minute. Using a mathematical formula, a generalized rule anchors Max HR. There are several workout modifications that occur inside each zone as a result of spending training time in the zone. Heart zones are stated as a percentage of maximal heart rate, and they reflect exercise intensity and benefit.

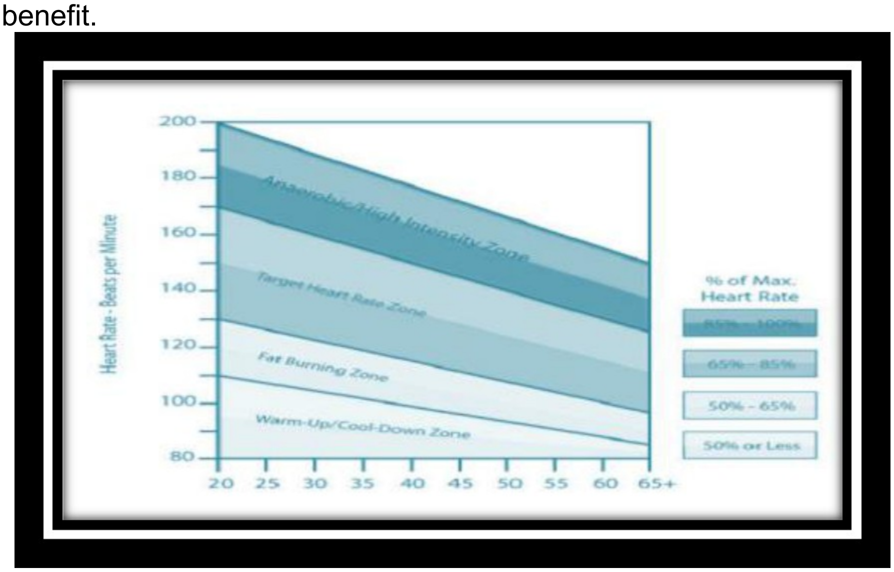


Figure 1.3 Exercise target zone chart

1.6.4 Fingertip sensor

The use of light to monitor heart rate is a topic of study that has received a great deal of attention in recent decades. The fingertip sensor is based on the detection of a physiological signal known as Photo plethysmography (PPG) [12], which is an optical measurement of the change in blood volume in the arteries. The PPG signals are obtained by irradiating a wavelength of light through the tissue and comparing the light absorption properties of blood at these wavelengths. Traditionally, fingertip sensors have been made using two methods: light transmittance and light reflectance. Light is shined through the tissue by an LED in a transmittance fingertip sensor and detected on the other end by a photodetector. In contrast, the reflectance fingertip sensor detects the light reflected by the tissue using a photodetector on the same side as the LED. 2 The time gap between individual beats of the mammalian heart is referred to as inter beat interval. The abbreviation for inter beat interval is "IBI." It is often referred to as the "beat-to-beat" interval. IBI is typically measured in milliseconds. Individual IBI readings in the human heart can range from 5 milliseconds to 70 milliseconds.

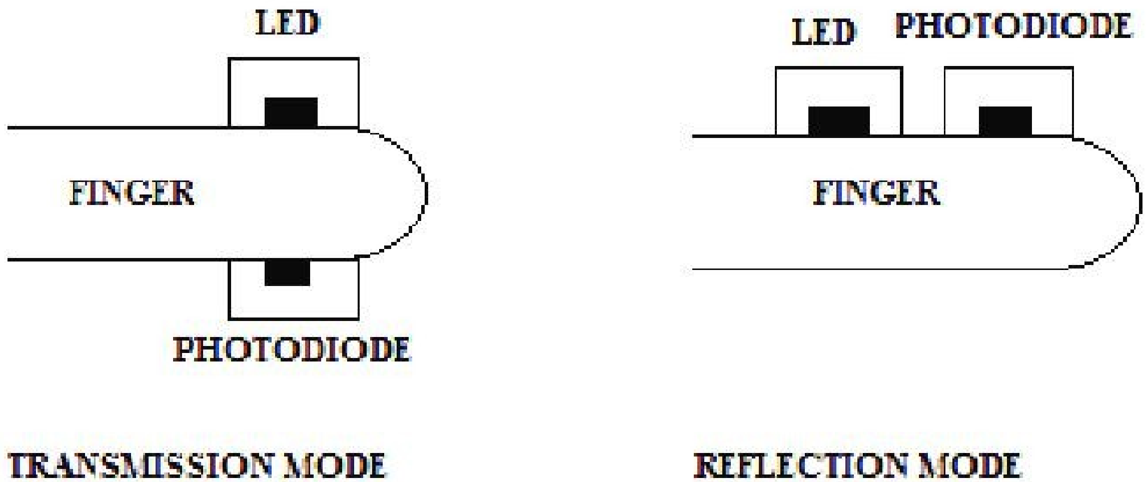


Figure 1.4 Types of fingertip sensors

The reflected light is affected in the opposite way. This makes logical sense, since the more blood there is in the tissue, the more light that passes through it is blocked. As the amount of light reflected back rises, so does the signal detected in the reflectance configuration. Similarly, as the light is obstructed, not enough light reaches the photo-detector in the transmittance arrangement, resulting in a signal drop [13].

The transmittance arrangement is more suited to parts of the body that lend themselves better to light transmittance through them, such as fingers or ear lobes, in terms of applicability. However, the transmittance configuration cannot be employed in other regions of the body because light transmittance is considerably reduced when there are impediments in the way, such as bone or muscle, in addition to the fact that the route of light is much longer than in thin places such as the ear lobes. In such cases, reflectance configuration is more beneficial, assuming vasculature is present close to the skin's surface, such as the forehead, wrist, or forearm.

The usage of the reflectance configuration is not restricted to locations where the transmittance configuration is ineffective. It may be used to measure PPG signals from the earlobes or fingers in the same way as the transmittance setup can. Fingers and ear lobes, on the other hand, transmit much of the light shining through them due to their tiny cross-sectional area, resulting in reduced signal intensity in the reflectance configuration [13].

1.7 Embedded Systems

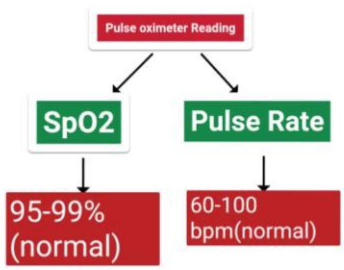
An embedded system is based on a simple concept. If we take any engineering product that requires control and put a microcontroller into that product to provide the control, we have an embedded system. An embedded system is a system whose primary purpose is not computational but is controlled by a computer integrated within it. Ordinary microprocessors and microcontrollers are the two major kinds of embedded processors.

1.8. Microcontrollers

A microcontroller [14] (sometimes known as a microcontroller unit, MCU) is a single-chip computer whose function is governed by the program that is placed into it. Microcontrollers, like other computers, include a central processing unit (CPU), a memory system, an input/output system, a clock or timing system, and a bus system to link component systems. The bus system is made up of three buses: an address bus, a data bus, and a control bus.

1.8.1 PULSE OXIMETER:

Pulse oximetry is a non-invasive method for indirectly measuring the percentage of oxygen saturation (SpO2) carried by hemoglobin in a patient's blood. The medical device used in pulse oximeter, the pulse oximeter, is globally accepted as the standard for detecting and monitoring hypoxemia, a lower than normal level of oxygen in the blood. Pulse oximeter is also used for monitoring oxygen saturation for people in other contexts, such as senior citizen residences, rural areas, and areas with low access to health services. The pulse oximeter may be incorporated into a multi parameter patient monitor. Most monitors also display the pulse rate. Portable, battery-operated pulse oximeters are also available for transport or home blood-oxygen monitoring.
The most common approach trans-missive pulse oximeter. In this approach, a sensor device is placed on a thin part of the patient's body, usually a fingertip, earlobe, or an infant's foot. Fingertips and earlobes have higher blood flow rates than other tissues, which facilitates heat transfer. The device passes two wavelengths of light through the body part to a photo detector. It measures the changing absorbance at each of the wavelength, allowing it to determine the absorbance due to the pulsing arterial blood alone, excluding venous blood, skin, bone, muscle, fat, and (in most cases) nail polish.



Chapter 2
System Description

2.1 System Introduction

A normal wireless sensor gadget is usually made of an Arduino , a designated sensor, broadband, a display ,mounting mechanism and connecting wires. This chapter will discuss about these components which have been used to build the Oximeter. Also this chapter will talk about the various types of these components which could have been and have been used in the wireless device along with their advantages and disadvantages. The device also requires an app to transfer its data to other users so that they can also know about the on goings of the situation of a patient. The operation of the sensor that is being used in the device and how it is suited for the project and what the project is trying to achieve. The components used for the project are given bellow:

Hardware:

1. ESP8266 Module.
2. MAX30100 sensor.
3. Breadboard.
4. Connecting wires.
5. B-type USB cable

Software :

1. Arduino IDE
2. Blynk app

There are a vast number of ways to transfer data and information to vast number of people at a single time. These methods have their own benefits and detriments. Among all these points the WIFI module has the best possibilities of sharing data information to a lot people at the Along with all the other components these points will also be explained in details bellow. The key advantages of wifi over all other networking systems are given bellow,

Efficiency : Wifi have improved data communication which leads to faster transfer rate of information from people to people at an instant. He transfer rate is second to none at this time and age

Access : The wireless technology allows people to stay con the move connected with the internet while on the move, there is hardly any point where anyone is out of touch nowadays. Checking information in one of the attendant’s phone is just a push of a button away.

Flexibility: No one has to sit in a designated pc to use the internet now that WIFI has made things more flexible for human to use internet sitting anywhere.

Cost Saving : Wireless network much more cost saving than any data packs one has to buy. Also it is unlimited use for a certain period of time. So one does not have to worry about running out of internet usage any more.

Through all these points the one was finally selected was the ESP8266 module.

2.2 ESP8266 WiFi Module:

This is a very useful and cheap WIFI module with microcontroller for controlling devices over the internet. The one used in the project had an Arduino of itself but also needed some programming to work according to the requirements.
The internet of Things (IoT) has made this device a much more cheaper and easier to use. It also has its own firmware which allows to control with a standard "AT command". One can easily create and upload their on codes in it which makes it greatly powerful and flexible.

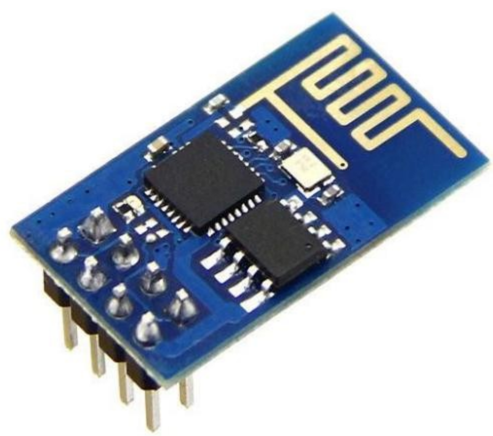


Figure 2.1: ESP 8266 Module

Here are few of the reason why this wifi module was selected :

It supports the 802.11 b/g/n protocol

It can connect to ones router and work as a client or it can be an access point itself

or both!

It is IP addressable and can be a Web Server

The “standard” version has 2 digital pins that can be used for input or output. Eg: to drive LED’s or relays. These pins can also be used for PWM. Other versions have more pins exposed. For example the ESP-12, which is a good option if you need more pins. Either way the programming is still the same.

Analog input is also available on the ESP8266 chip (ADC/TOUT) but it’s not wired up on the ESP-01.

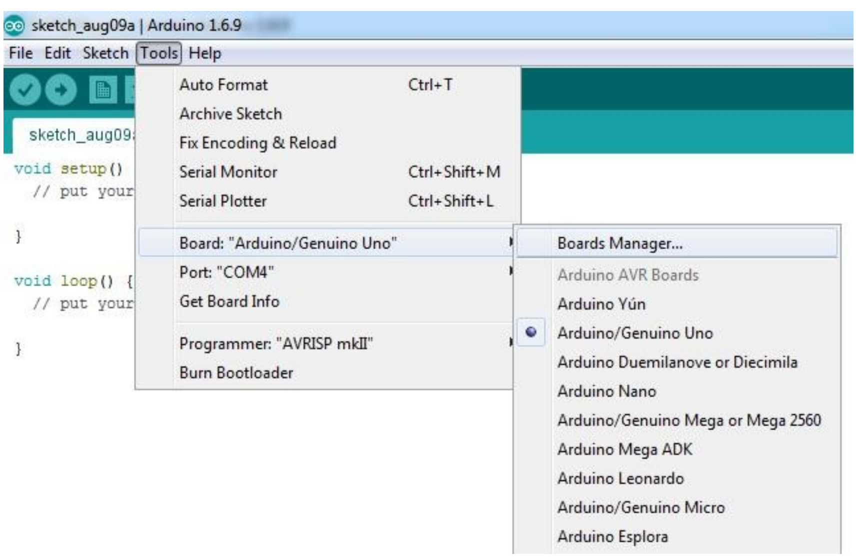
It can be combined with an Arduino or it can be programmed to work on its own

There are various tools and development environments (IDE’s) to program it.

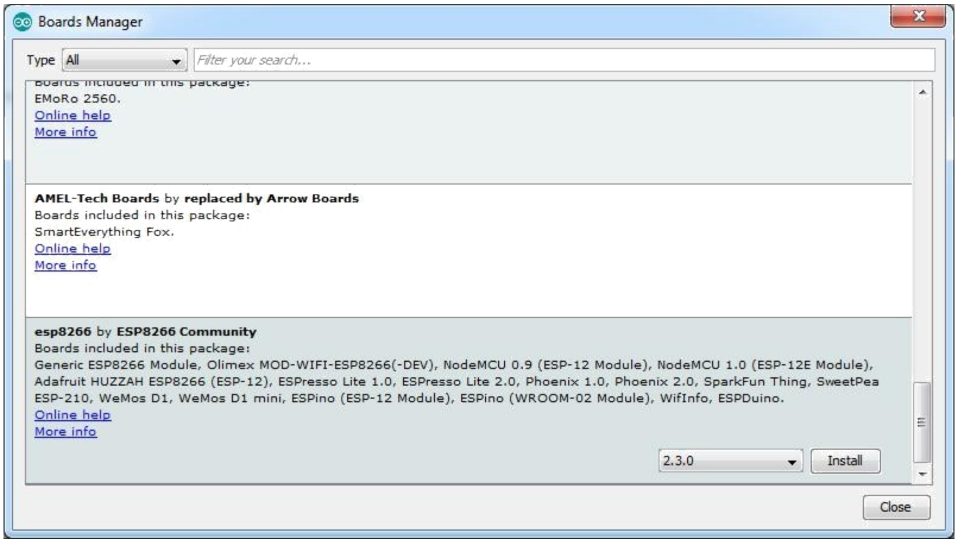
2.2.1 Programming ESP8266 using the Arduino IDE

Various software can be used to program the ESP8266 but the **Arduino IDE** (Integrated Development Environment) is the best and easiest to use.
The latest version of Arduino IDE was used to program the ES8266 and also it is important to note that the IDE software is capable of programming non Arduino Hardware such as ESP8266.

Here are the steps to using the programming software.

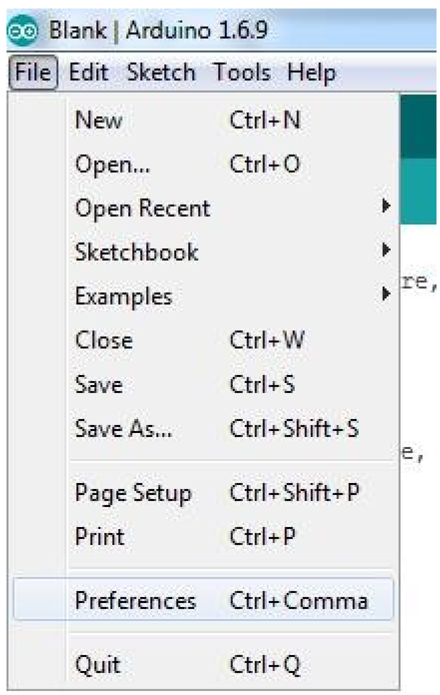


Step 1: Start the Arduino IDE and select the Boards Manager under Tools / Board



Step 2: Then find the esp8266, select it and click install.

Step 3: Next is the Arduino preference setup:



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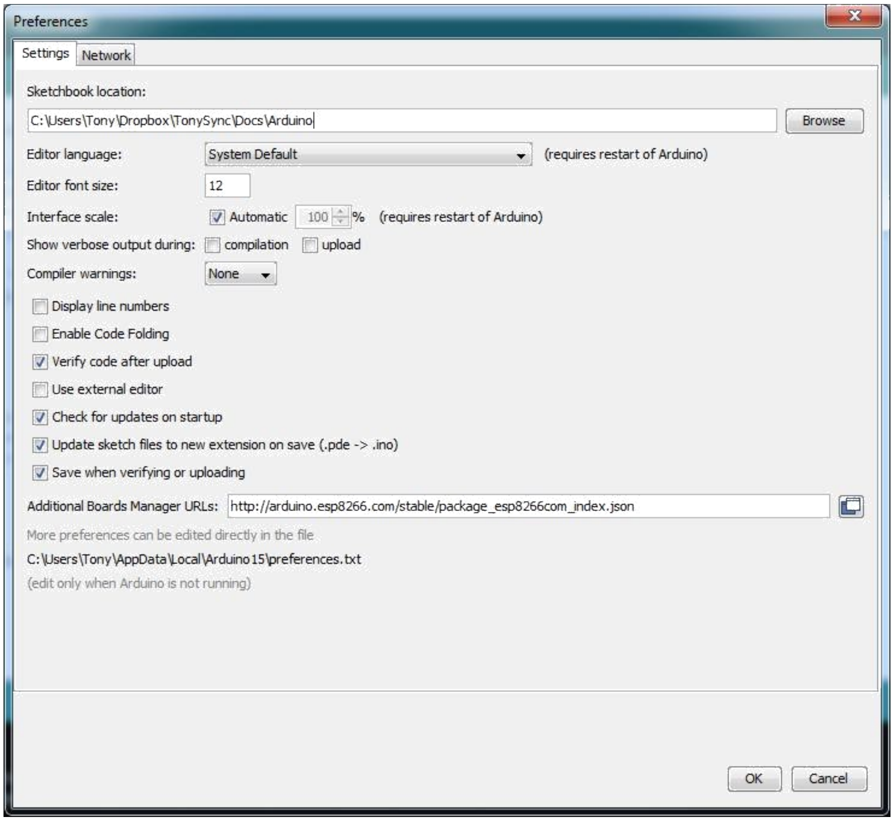
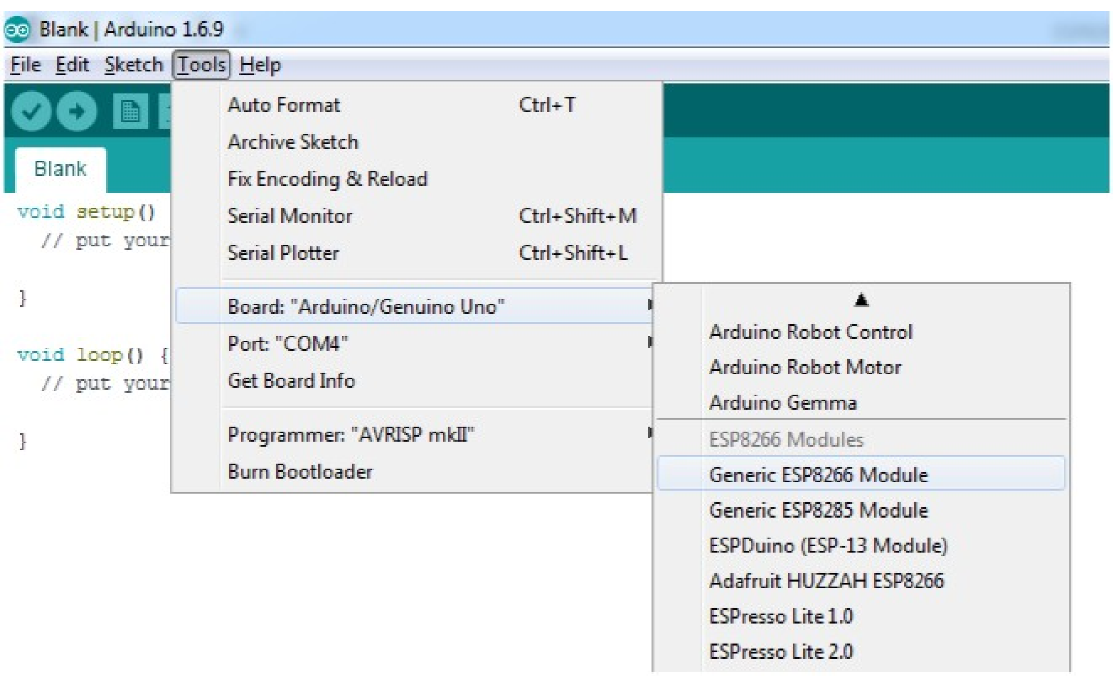
Step 4: Going to File/Preferences one can choose the preferences of Arduino or any other hardware that one wants to write codes for.

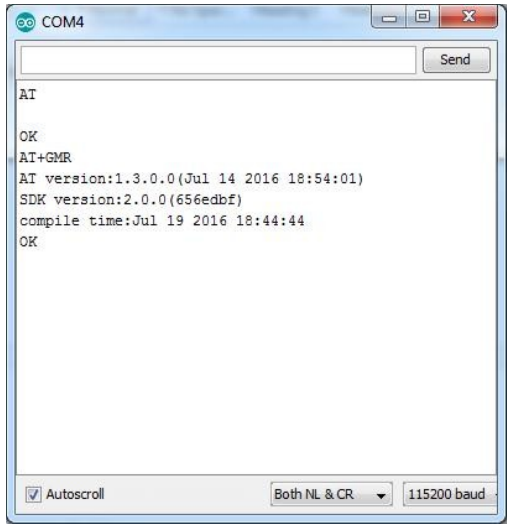


Step 5: In the Additional Boards Manager URLs field enter the URL for the ESP8266 package which is:

http://arduino.esp8266.com/stable/package_esp8266com_index.json



Step 6: To setup the IDE for ESP8266 select the “Generic ESP8266 Module” in tools and go back to board manager again.
Step 7 : Setup the ESP01 options and select the appropriate COM port for the designated PC. This will be used to communicate with the Hardware.



If the original firmware is on the ESP8266 then one can try talking to it with the Serial Monitor.

1. Open the Arduino Serial Monitor:
2. Select the appropriate baud rate which is usually 115200 but could be anything down to 9600 depending on the firmware on the ESP.
3. Also select “Both NL & CR”. Ie: New Line and Carriage Return characters after each “Send”.
4. Type AT and press enter. The ESP should come back with OK. If not press the RESET button or try unplugging the USB cable and starting again. Make sure also that you have the right COM port selected. Also if you don’t have the “standard” firmware on your ESP it may not understand the AT command set. This is not necessarily a problem yet as you’ll be overwriting this with Arduino code later in this instruct able.

5. Type AT+GMR. This should come back with the version numbers of the firmware on your ESP.

   In another instruct able I show you how you can restore the latest version of the “factory” firmware..

   Step 8: Now all that is left is rite the code and upload it into the ESP8266 module using a **B-type USB** cable .

2.3 MAX30100 Sensor

Among different sensor the MAX30100 is the best choice for this project as it is a **Pulse Oximeter** and heart rate monitor sensor solution. The combination of two LEDs, a photo detector, optimized optics and low-noise analog signal processing to detect oxygen in the pulse and heart-rate signals. You can use this sensor with any microcontroller like Arduino**, ESP8266**, or **ESP32** and easily measure the patient’s health parameters.
In this project we will be I**nterfacing MAX30100 Pulse Oximeter Sensor the ESP8266**. The MAX30100 Sensor is capable of measuring **Blood Oxygen** & **Heart Rate**. We will be using the Blyink APP to display I the value of **SpO2** and **BPM**. The blood Oxygen Concentration termed SpO2 is measured in Percentage(%) and **Heart Beat/Pulse Rate is measured in BPM.**

Figure 2.2.1: MAX30100 sensor.

2.3.1 Methodology:

The way this sensor works is that when the oxygen enter lungs and passing through the blood streams the LEDs from the sensor passes through the oxygen carrying hemoglobin cells. **Small beams of light pass through the blood in the finger, measuring the amount of oxygen. It does this by measuring changes in** light absorption **in** oxygenated **or** deoxygenated blood.

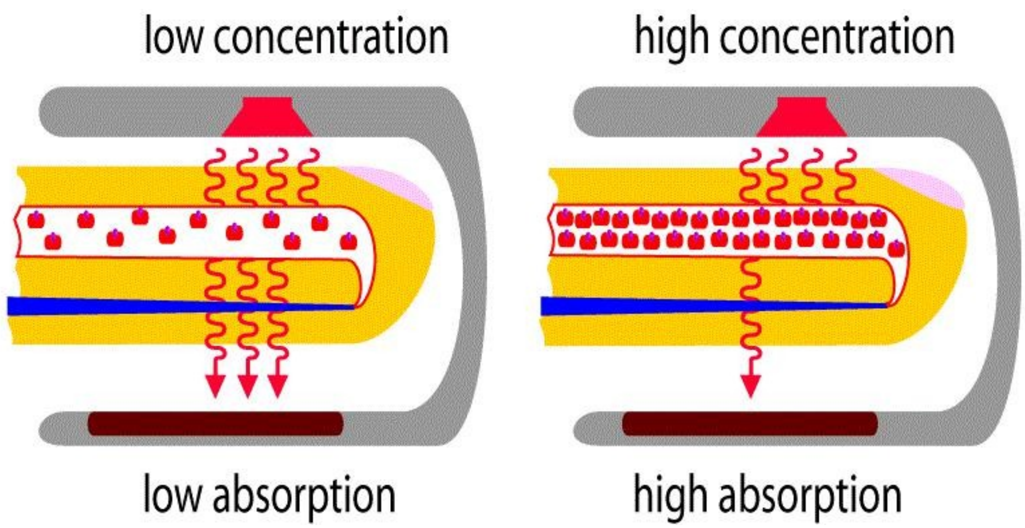


Figure 2.3.1: Difference between low and high concentration

The sensor has **two kinds of LEDs**, one **emitting red light**, another emitting **infrared light**. For pulse rate, only infrared light is used. Both red light and infrared light are needed to measure **oxygen levels** in the blood.

When the heart pumps blood, there is an increase in **oxygen filled blood** as a result of having more blood. As the heart relaxes, the volume of oxygenated blood also decreases. By knowing the time between the increase and decrease of oxygenated blood, the **pulse rate** is determined. It turns out, oxygenated blood absorbs more **infrared light** and passes more red light while deoxygenated blood absorbs red light and passes more infrared light. This is the main function of the MAX30100: it reads the absorption levels for both light sources and stores them in a buffer that can be read via **I2C** communication protocol. These reading ill be displayed on the app BLYNK.

2.4 Blynk app :

This an android app designed to for the IOT (internet of things). It has many uses and they are :

1. It can control hardware remotely.
2. It can store data.
3. It can display sensor data.

This is the perfect app for the project as it is compatible with the ESP8266s IOT interface and usefull in sharing data nd info of the sensor to anyone with the app. Most of all , once the the Blynk app is fully connected with the device with the right login informations anyone can monitor the output data of that device from anywhere as it on need wifi.

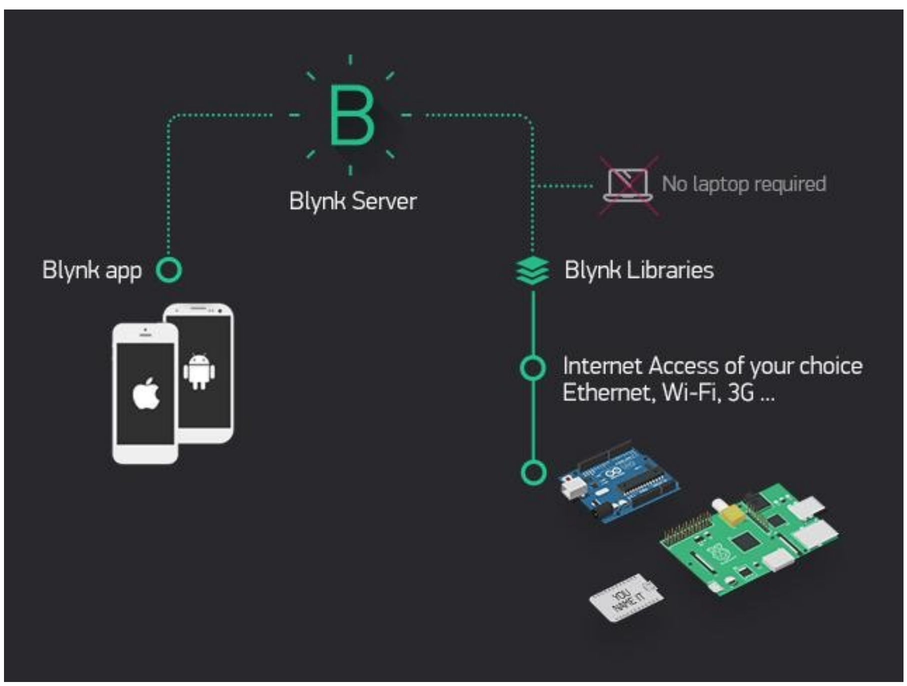


Figure 2.3.2 : working principle of Blynk.

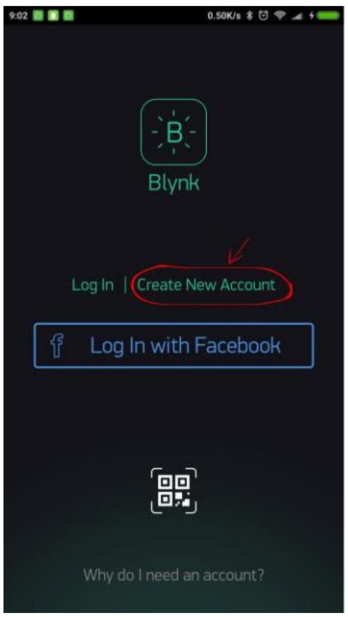
With the ESP8266s wifi module, it is easy to connect with the App and send data.

2.4.1 Methodology of Blynk:

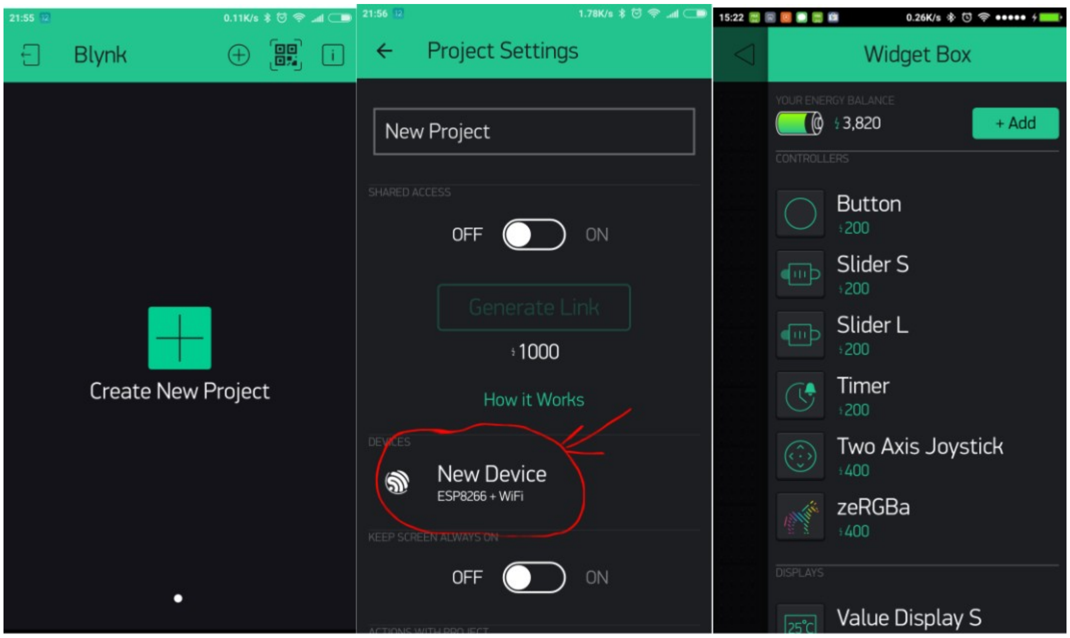
To run the app and acquire the wanted data one has to follow few steps.

Step 1 : Download and install the Blynk app on an **Android** phone.

Step 2 : Create an account with name and password. Memorize this account as it will be used to share with others to monitor the devices information.

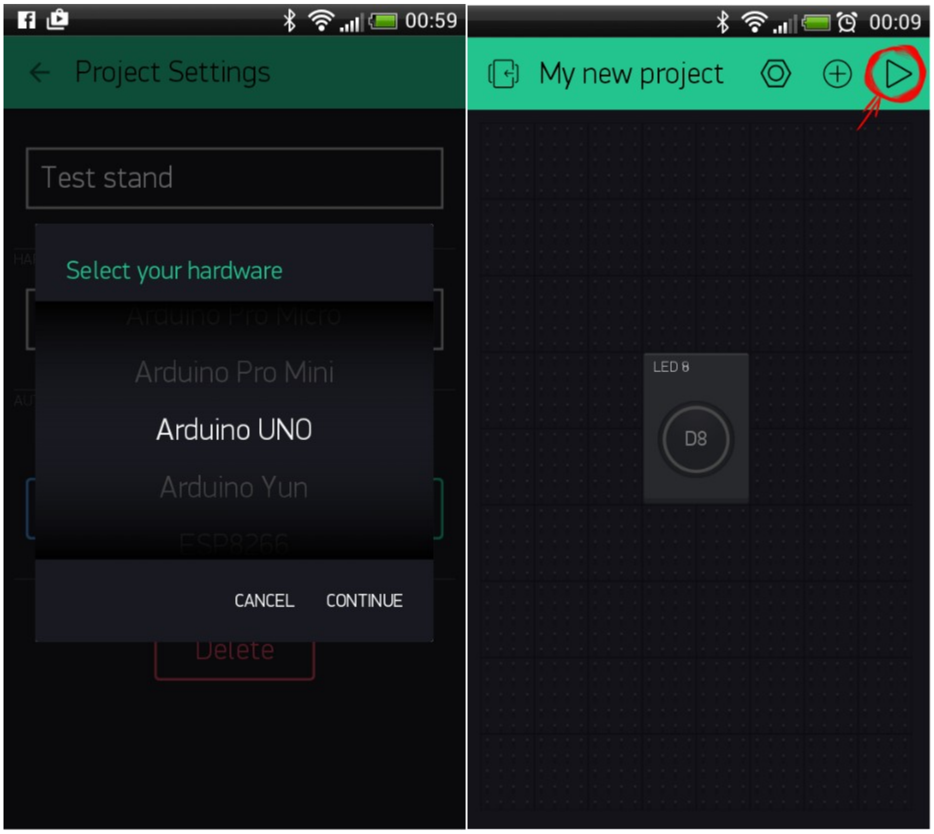


Step 3 : A certain amount of credit will be given in each account which can be used to buy widgets that show the specific types of data the designated device will show.



Step 4 : Buy those widgets and make a project of it as it will work as a display of the device.

Step 5 : Lastly connect the device using the wifi ip cradentials of the microcontroller.



Step 7 : Share the login information with others who these readings may interest and they can monitor them from any corner of the world.

2.5 Conclusion :

After many errors and searching we have come to the conclusion of using these components as they are the most efficient and fastest possible methods of building an Oximeter with IOT capable of transferring data to doctors to monitor at their convenience and get the warning they need to take measures against a critical situation. Setting up the Blynk app will be the main key of this project.

Chapter – 3

System design & Implementation

Our proposed health monitoring system is set up as a wristband that is worn in the hand. Sensors, an Arduino, communication modules, and a battery will make up the band. The data will be sent to the device's server. The demographics can be viewed through a user-friendly interface. On their mobile phone, they can use a web-based app. A device ID will be assigned to each device. The server will be available. Data should be stored in the order of the device ID. To see their demographics, users must sign in with their device ID.

3.1: Specific Requirement

3.1.1. **Heart Rate Measurement**

We used the MAX-30100 Pulse Sensor to determine the heart rate. It's a heart rate sensor that plugs into the Arduino series and is used to collect data. It simply combines a simple optical heart rate sensor with amplification and noise suppression technology to provide accurate pulse measurements quickly and easily. It consumes very little power with only a 4mA current draw at 5V, making it ideal for this project.

3.1.2. **Oxygen Saturation Measurement**

We used the MAX-30100 sensor to determine the oxygen saturation percentage level. It’s a specialized sensor used to measure oxygen saturation levels in the human body. It collects data from the left wrist of a human body and shows the percentage level of oxygen saturation in that human body.
A pulse oximeter is composed of the sensor (or probe) and the monitor with the display. The probe is on the wrist and is detecting the **flow of blood** through the pulse. This is displayed as a pulse wave on the monitor. A pulse wave must be present to demonstrate that a pulse is being detected. It requires very little power with only a 4mA current draw at 5V, making it ideal for this project.

3.1.3:. **Communication Module**

We have carried out the verbal exchange of the wearable tool to the cloud server through the ESP8266 WIFI module. ESP8266 is a self-contained SOC with incorporated TCP/IP protocol which offers it the electricity to embed inside different structures the usage of Wifi competencies in addition to can function as a standalone application. After we join the proposed device to the internet, it's going to ship the information of the studying taken from the elderlies to its non-public server every day. The tool shall shop and replace the information in the cloud at everyday periods from which the app will get entry to the information. In case of emergency scientific conditions, the tool will ship the information to its server straight away to alert the elderly's caregiver and medical doctor to take instantaneous scientific action. The ESP8266 has a running voltage of 3.3v, but the Arduino has a running voltage of 5v. Hence we use a voltage divider circuit among Arduino's TX pin to ESP8266's RX pin to shift the voltage stage from 5v to 3.3v. The proposed device additionally consists of the HC-05 Bluetooth module. HC-05 module is an easy-to-utilize Bluetooth SPP (Serial Port Protocol) module, meant for honest faraway serial connection setup. [12]. The Bluetooth module is attached in a software program serial with Arduino. With this feature, a person can join their clever telecel smartphone to the wearable device to connect to the app

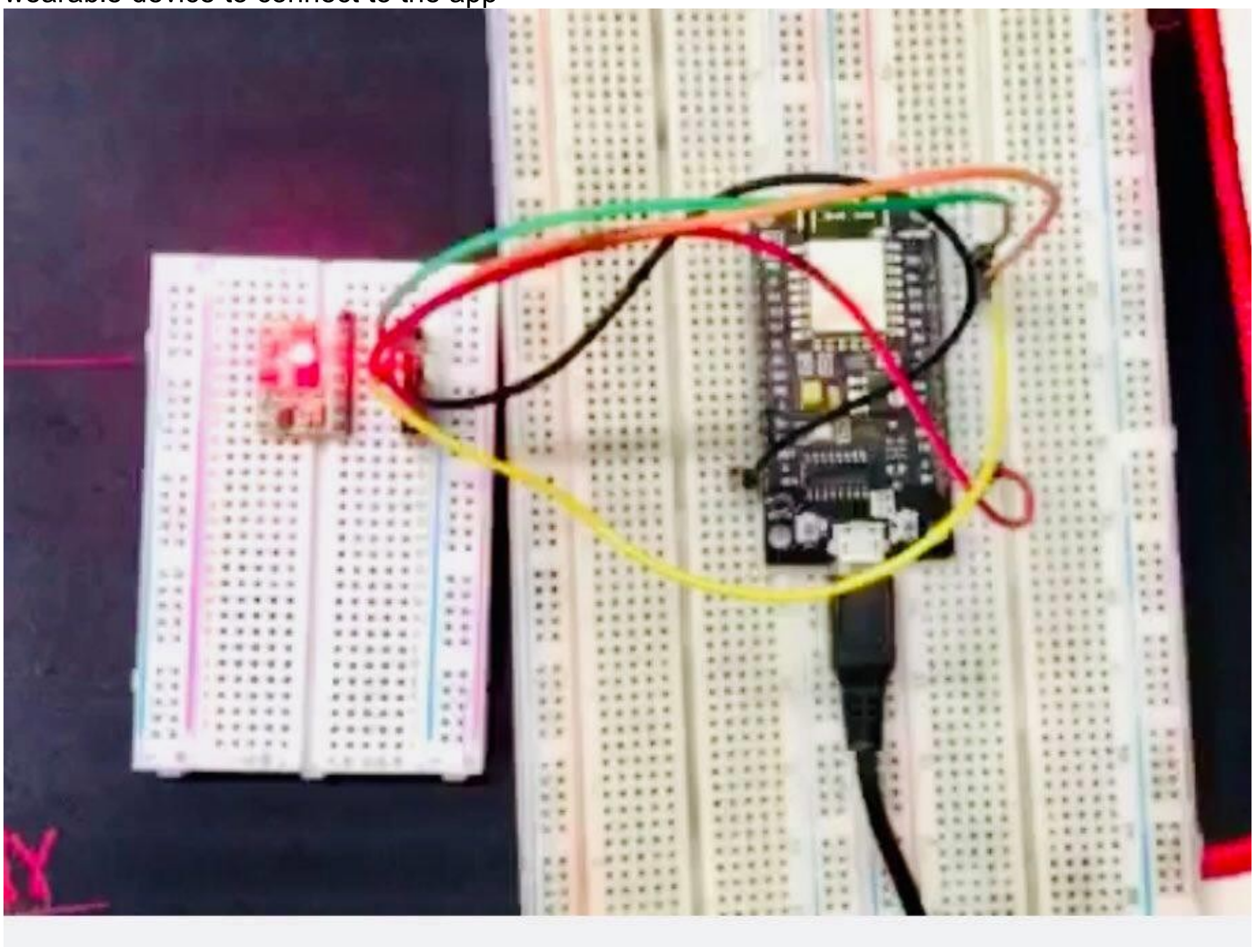


Figure 3.1: Real Circuit diagram of our system

3.1.4 **Control**

The control framework depends upon the system of the sensors perusing the worth precisely. One of the super basic thoughts was to decide whether the sensor was getting any worth. The temperature module exacts the choice of accuracy as the sensors play the most imperative part here and their exactness decides the legitimate execution of the framework.

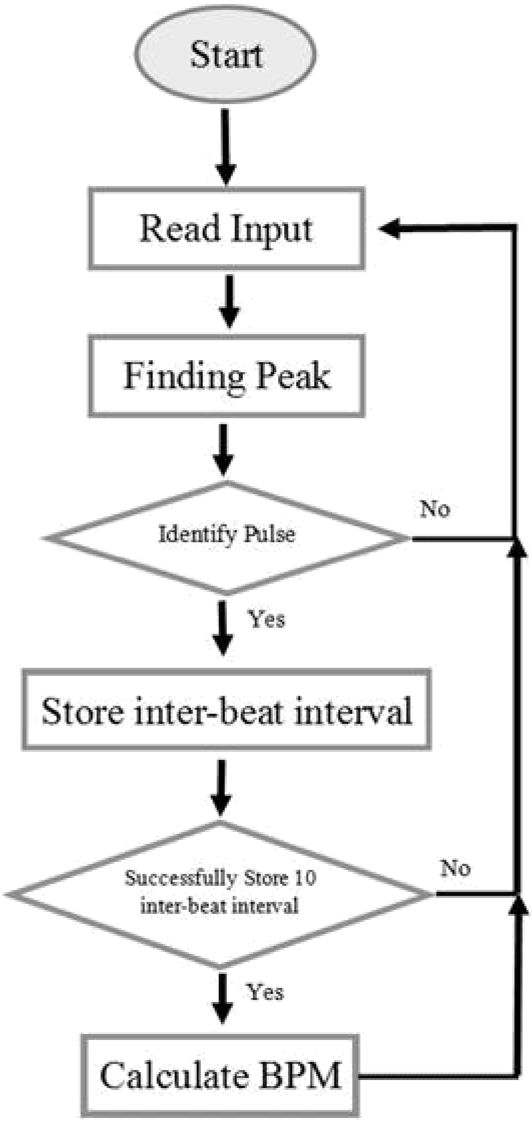


Figure 3.2: Flowchart of the process

To provide a human's health condition, we measure the heart rate and oxygen saturation level and provide the status in a web app. In the critical situation when a person is affected by the covid-19 virus the main priority is to check the oxygen saturation level from time to time.
That's why we determine the heart rate alongside the oxygen saturation level. Through the web app we are trying to develop an alarm system where if the oxygen level drops to a certain number, the app or the device itself will alert the human or the monitoring person.

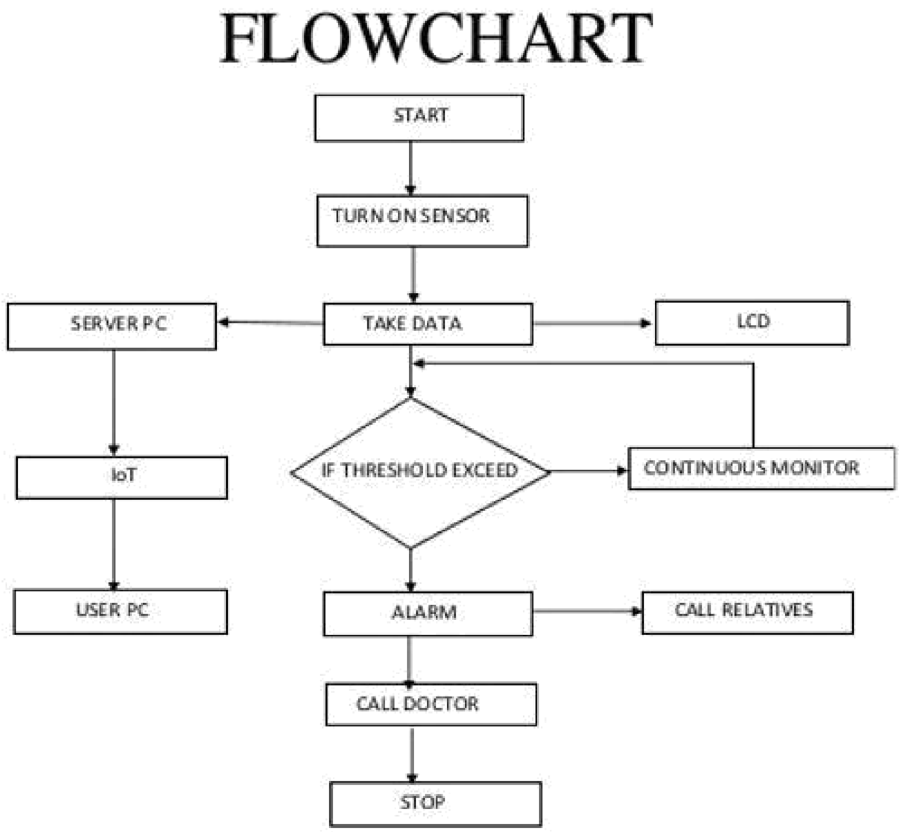


Figure 3.1.3: Flowchart while monitoring

3.2: Block Diagram

Here, the circuit that we have used to complete this project is given:

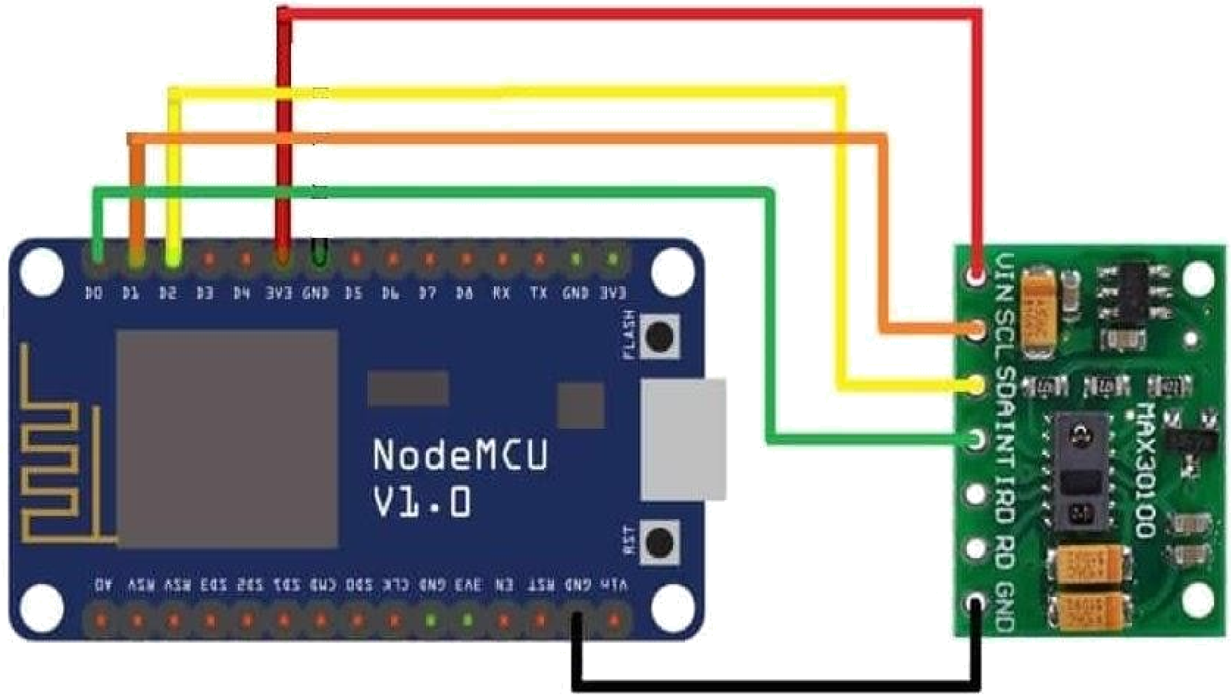


Figure 3.2 Circuit diagram of our system

This total implementation can be shown as the flowchart which can be more reliable to understand as well as if someone wants to process through it he or she can understand the effectiveness.

Flowchart:

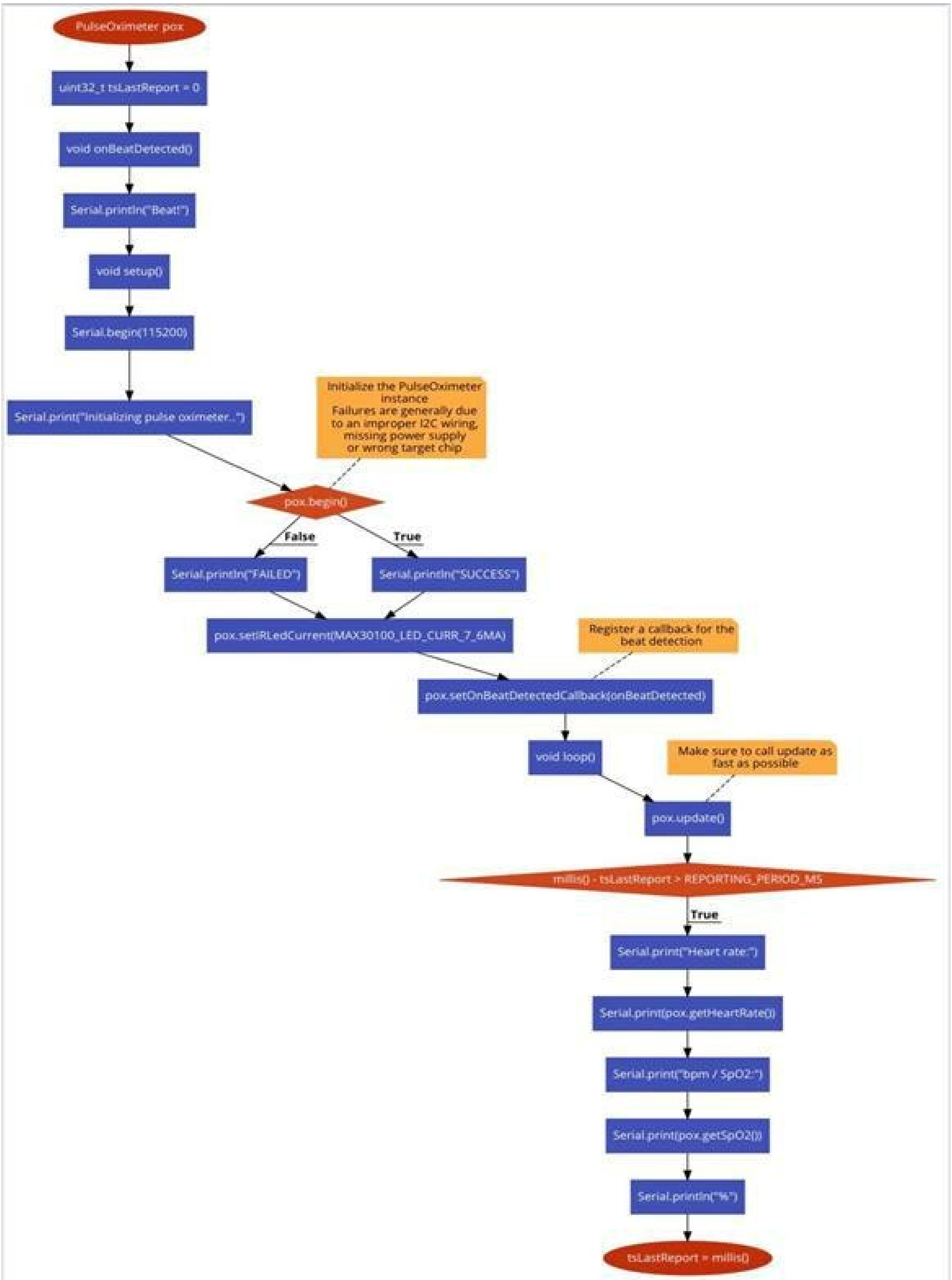


Figure 3.3: Flowchart of our system

Chapter-4
Data Analysis

4.1 Oxygen Level Detection:

Using the MAX30100 sensor we recorded the oxygen level form the finger and the wrist of different people in the same condition. The result is the graph given bellow. The Data comes out differently in case of the wrist and finger but with little error.

Figure 4.1: Graph representation of Finger oximeter vs Wrist oxygen level scans result

4.2 Pulse Sensor

The device can both scan the oxygen level and also the pulse the level of the wearer. When putting the finger on the scanner the procedure becomes more stable whilst the wrist scanning is unstable. The sensor is supplied by 3.3V power. As considering the stable of infrared sensor, finger stays closer than the wrist veins.

4.2.1 Pulse reading.

Comparison of the no constant reading from the wrist of the Project device is very random and the reading from the finger is much more accurate and stable. Using the market Oximeter gives us more accurate answer than that of course but still there is a bit of difference between the finger scan from the project device.
One reading of the pulse from the wrist is given bellow. The reason of this is that the vein which is used for the pulse scanner to detect is quite flexible in the wrist so the scanner has a hard time getting the scans.

Figure 4.2.1: Pulse scan result of the wrist from the Project Device.

Now this is a scan of the finger on the project Device. This part is more stable than the wrist one as we can see bellow.

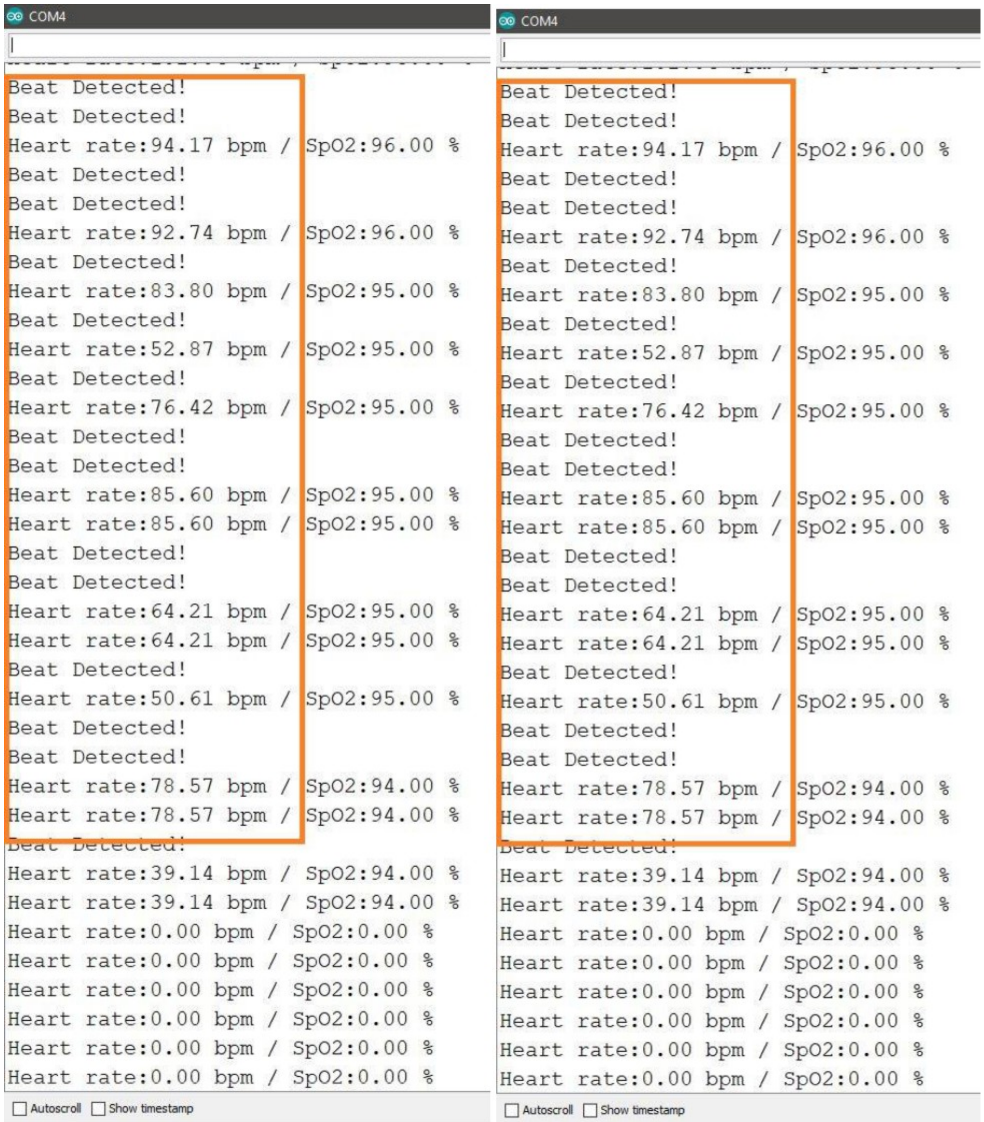


Figure 4.2.2: Finger Scan results from the Project Device.

As it can be seen on the records above the time when using the finger on the scanner gives much more stable readings of pulse level or heart beat rate.
Last but not least the scans from the actual Oximeter. The right side reading the Pulse reading as BPM (Beat per minute)

Figure 4.2.3: Oxygen Saturation and Pulse reading from a market Oximeter

Judging by the two readings from the average rate difference should be counted as preferable data. First calculating the average rate of BPM from the wrist scan with the Market oximeter we get **6.8%.** Now, form the difference between both finger scans we find the error to be more or less of **3.8%.**

4.3 Oxygen level testing:

After acquiring an **Oximeter** from the market we have tried t find the difference in the readings with the **Project Device** and the main machine. The bellow chart will show the difference between them as we took the test with 10 different people both with the main machine and the Project device.
Also it is to be noted that the Dosimeter only scans fingers where the project device scanned the wrist of these 10 different people. The result chart is given bellow.

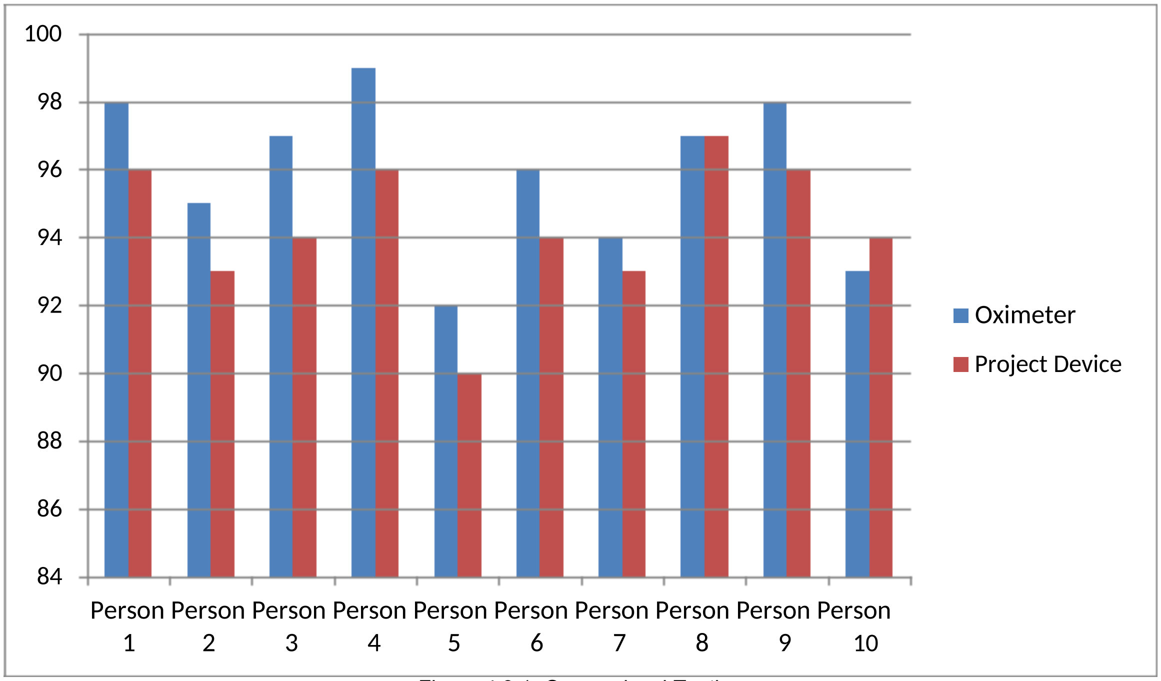


Figure 4.3.1: Oxygen level Testing

Here in the chart it is obvious that the market oximeter is much more accurate than the project device. The error rate can be calculated from the difference of the two readings and by calculating the average difference the **approximate error** of the Project Device is well around **2.05%-2.07%**. The average of the error should be **2.06%**. Considering this error we are safe to say that after adding 2.06% to the reading of the project device we can get the actual but approximate result of the reading.

4.4 Email Test:

This is the email test where from the **Blynk App** any ONE person will be notified Via email of a the person wearing the Project Device when they enter a critical condition of their Oxygen level. The Alert system is device in such a way that when the patients oxygen level goes below **90%** an email will be sent to the doctor or to the nurse about the situation so they can react immediately . The Email address can be fixed from the app. Here is the mail that will be sent to the persons email which was registered in the app.

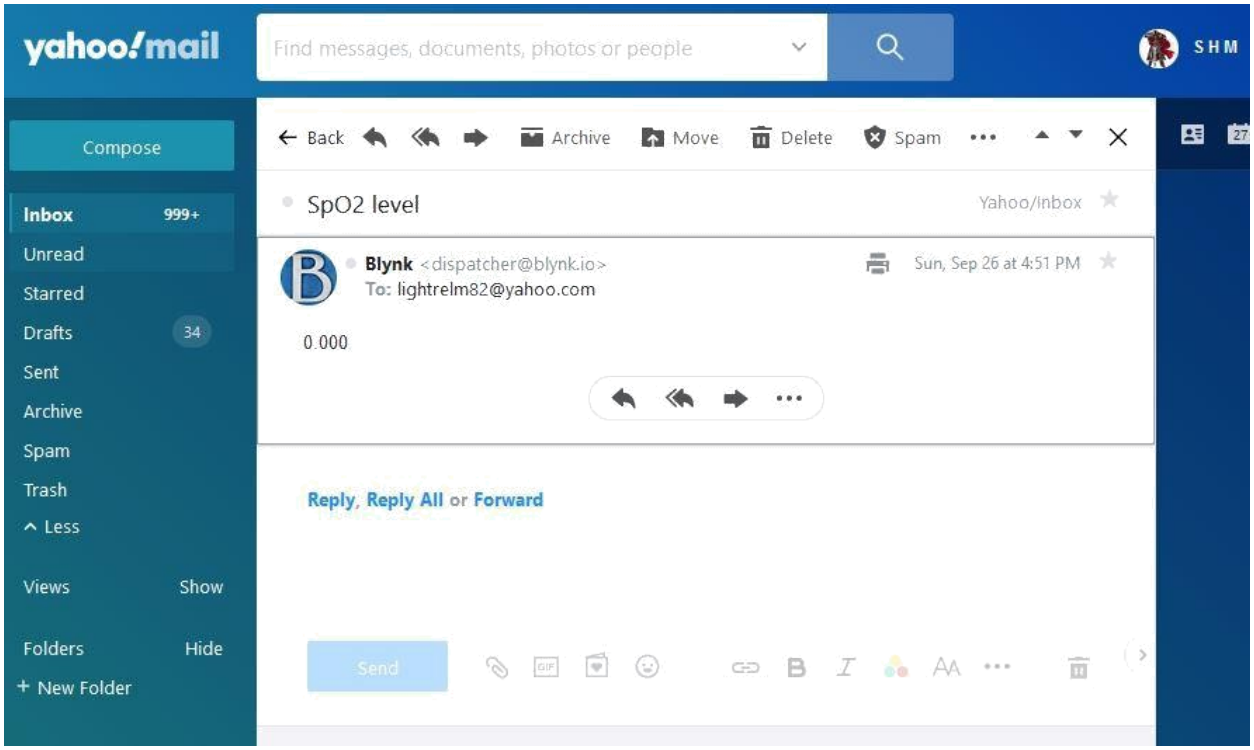


Figure 4.4.1: Notification mail.

And here is the continuous emails of the patient from the app that their condition is critical.

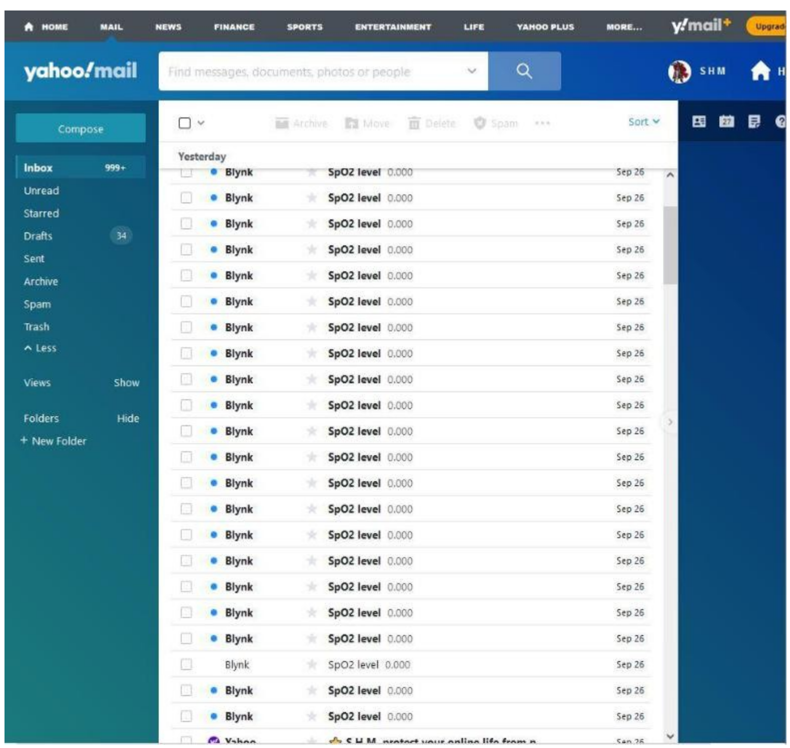


Figure 4.4.2: All the Notification Mails.

The timing of these mails can be controlled from the code written in the Arduino but the one that is being used in the Project Device is with the interval of 10 seconds.

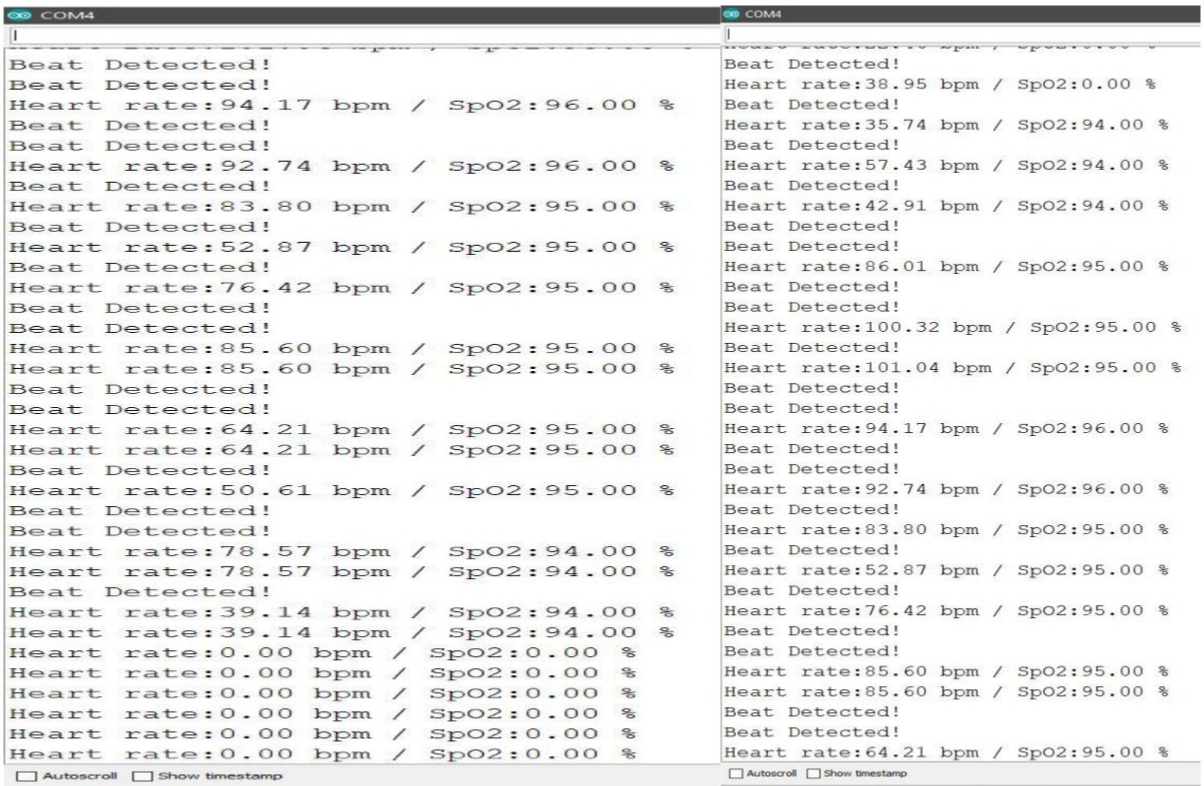


Figure: 4.4.3: First Sequence of the experimented data

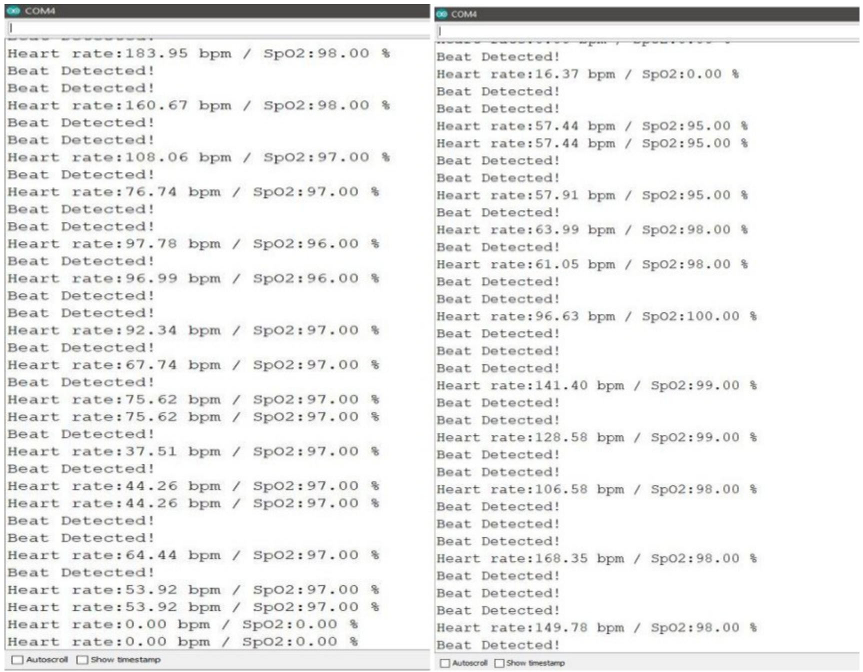


Figure 4.4.4: Sequence of experimented data

Figure4.4.5: Sequence of experimented data

Chapter-5
Result & Discussion:

5.1 Accuracy of our system and the market best oximeter:

The accuracy can be understood while it gets compared with the market best oximeter or the pulse meter. To get the better results and the accuracy we took a market best oximeter and experimented with that one too.
The Market Oximeter had some point in which it can be operated such as: Temperature should be in between +10 Degree to +40 degree. Humidity should be less than or equal to 70%. This oximeter has some features including low power consumption, high accuracy, handy and easy to operate.

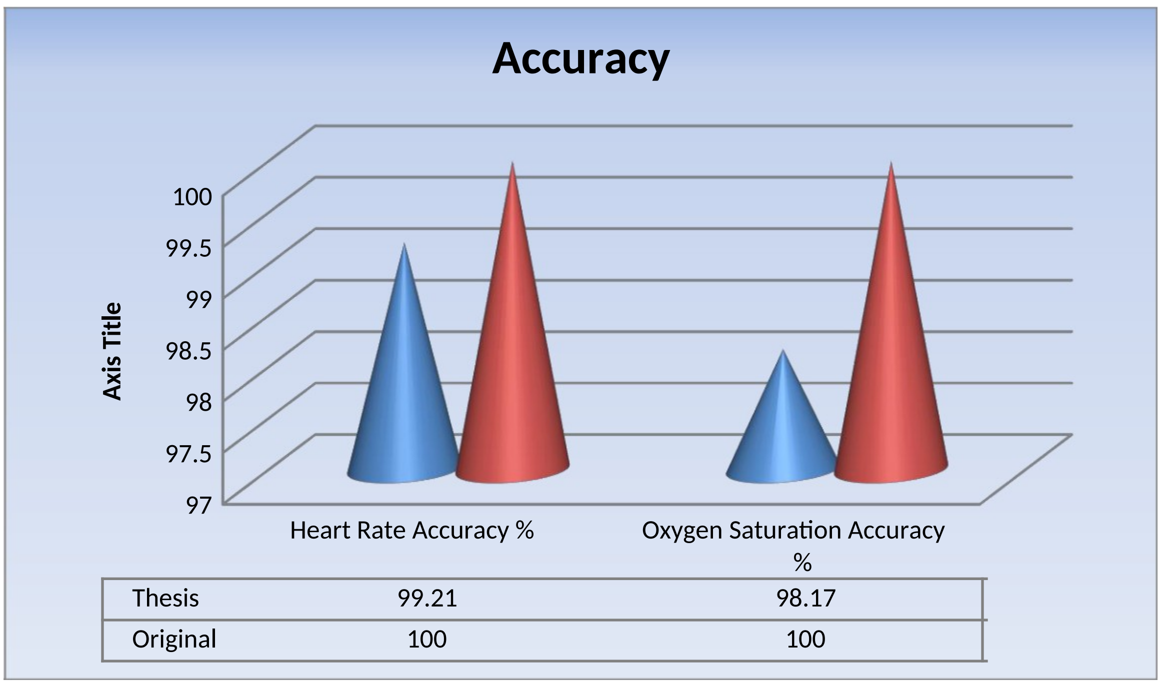


Figure 5.1: Accuracy of heart rate and oxygen saturation of our system

5.2 Accuracy between right and left wrist:

This is better to use the left wrist of the patient while monitoring the total process. As per our experiment we've found out that 55% correct data comes when we take the left wrist for our experimental setup. On the other hand 45% accurate result comes while receiving the right wrist.

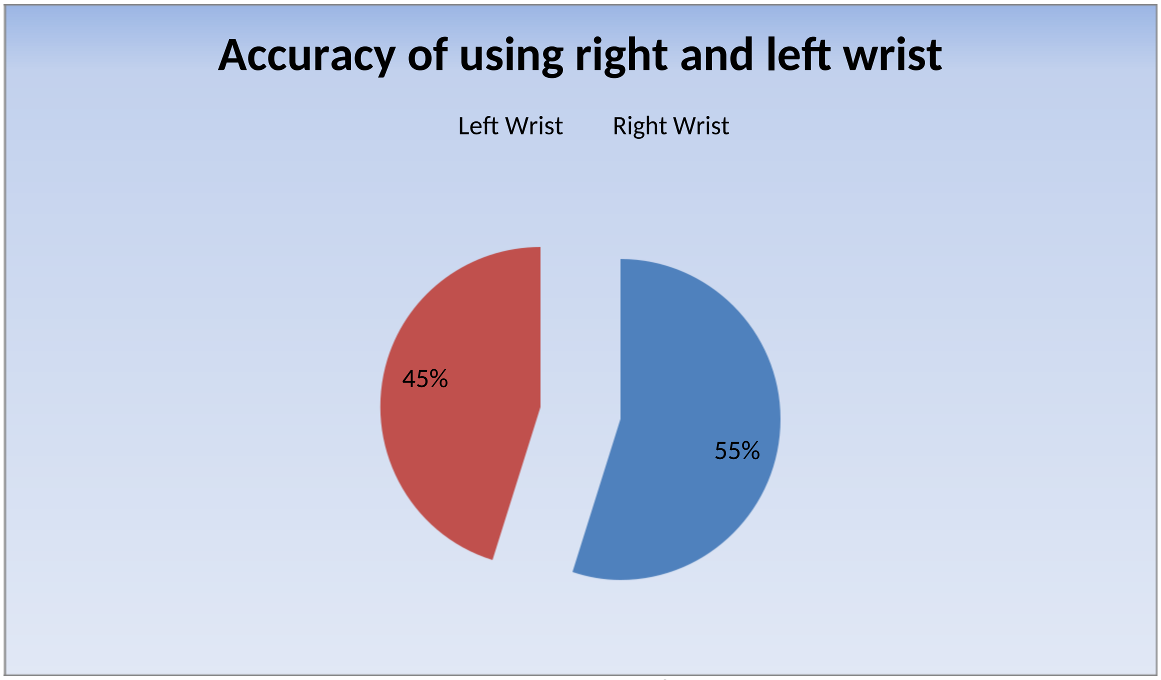


Figure 5.2: Accuracy between left and right arm

5.3 **Achievement**:

Overall, this initiative met a lot of its objectives. Using microcontroller technology, the team created a low-cost, low-power heart rate monitoring device with fall detection and alarm. The following are examples of accomplishments:

1. Obtaining a sufficient amount of biological signal

2. Increasing the strength of a biological signal

3. Analog signal -> ADC conversion

4. Heart rate measurement that is just partially effective

5. Notification and alarm system designed

6. The status of a web application is displayed.

7. Notification of an emergency via Email.

5.4 **Limitations**:

Our project has some limitations which was the direct result of the challenges we faced during the research. Here we are discussing those limitation:

1. We didn’t find any patient whose oxygen saturation was less than 80 for which we couldn’t set the alarm.

2. We couldn’t do the SMS part as we were in need of permission.

5.5 Discussion:

This chapter outlines the project's future work suggestions, and a conclusion will be reached based on the project's progress. This thesis described the construction of a wearable health monitor system that collects the patient's heart rate and oxygen saturation rate and sends the data to a web application for visualization to the Blync application to the emergency contacts and emergency notice by email .

CHAPTER 6:
Conclusion & Future Works

6.1 Conclusion:

Pulse oximeters are capable of measuring both Sp02 and Pulse rate, **current wrist-worn devices use them only to determine heart rate**, as Sp02 measurements collected from the wrist oximeter. In this paper, we have presented a system that has the ability to predict and monitor in advance the Coronavirus cases with the help of health informatics. The sensors used to collect the symptom data are all wearable sensors. We've described the framework such that the data obtained from the sensors is passed to the data 10 different individuals.

The physician will benefit much from the results of the infection since they will gain a better grasp of the virus. The patient is then allocated to a physician or attendant, who is subsequently summoned by the healthcare center to do the Polymerase Chain Reaction (PCR), which determines if a person is COVID-19 positive or negative. If the test results are positive, the patient is placed in an isolation center for treatment.

We've created a simple wristband device that can monitor the vital signs of the elderly. A lot of changes and improvements can be made in the long term based on requirements. For COVID-19 patients, a global positioning system can be installed to track the whereabouts of the patients, as well as a WIFI connection to maintain contact continuously. Additionally, extra sensors can be added to improve accuracy in order to check other requirements. This can be super beneficial for the attendants who works outside and want to know about their elder's health or the COVID-19 patients. They can immediately take them to the hospital if they get any notification of the fallen oxygen saturation. After comparing with the market best oximeters and experimenting with left and right hand of 10 individuals, we've come up with this system which can be efficient for this situation.

6.2 Scope of study:

In this pandemic situation, the world health system is meeting up with new and advanced technology so that they can be used in case of emergency. Like other initiators, we have also focused on the health emergencies of this recent time and approached to build a technology which will help us to detect saturation level and pulse rate of the diseased within a minute. After a bunch successful attempts, we will let this technology being used by health professionals as well as the national health institutions. It is quite hard for one health worker to provide proper care to thousands of patients. So, with our little effort, they will get to observe multiple patients at same possible time. Moreover, this will allow the hospitals to keep a quick record which demands to be accurate mostly. This can also help the patient to understand its heart rate falling or oxygen saturation falling immediately that will help the individual to take any primary action before it's too late. During this pandemic, as the attendants cannot stay beside the patient all the time the most efficient way of monitoring can be done with this system.

Chapter 7
References

esp8266

[1] TonesB, & Instructables. (2017, September 25). *Esp8266 wifi module for dummies*. Instructables. Retrieved September 28, 2021, from https://www.instructables.com/ESP8266-WiFi-Module-for-Dummies/.

[2] Admin, says:, F. A., Says:, H., says:, A. N., says:, G. L. P., says:, A., says:, M., says:, S., says:, M. A., says:, M. B., says:, S., says:, G. H. J., says:, A. Y., says:, M. A., says:, T. G., says:, B., Says:, E., Says:, R., says:, M., … Says:, M. (2021, August 3). *Interfacing MAX30100 pulse Oximeter sensor with Arduino*. How To Electronics. Retrieved September 28, 2021, from https://how2electronics.com/interfacing-max30100-pulse-oximeter-sensor-arduino/.

[3] *Measure SpO2, heart rate AND BPT using arduino*. Arduino Project Hub. (n.d.). Retrieved September 28, 2021, from https://create.arduino.cc/projecthub/iasonas-christoulakis/measure-spo2-heart-rate-and-bpt-using-arduino-68724d?ref=part&ref_id=10308&offset=9.

[4] Oxullo. (n.d.). *oxullo/Arduino-MAX30100: Arduino library for Max30100, integrated oximeter and heart rate sensor*. GitHub. Retrieved September 28, 2021, from https://github.com/oxullo/Arduino-MAX30100.

[5] *1. what IS BLYNK?* Tech Explorations. (2021, June 20). Retrieved September 28, 2021, from https://techexplorations.com/guides/blynk/1-what-is-blynk/.

[6] *ESP32 & esp8266*. Tech Explorations. (2021, July 8). Retrieved September 28, 2021, from https://techexplorations.com/pc/esp32/.

[7] *Blynk email and push NOTIFICATIONS tutorial – ESP8266 ARDUINO EXAMPLE*. Blynk Email and Push Notifications tutorial - ESP8266 Arduino Example. (n.d.). Retrieved September 28, 2021, from https://www.geekstips.com/esp8266-email-and-push-notifications-iot-blynk/.

[8] YouTube. (2017). *YouTube*. Retrieved September 28, 2021, from https://www.youtube.com/watch?v=V1jPY5s2yzw.

[9] RaphaelP24, & Instructables. (2017, November 25). *Send notifications to your phone from an esp8266.* Instructables. Retrieved September 28, 2021, from https://www.instructables.com/Send-Notifications-to-Your-Phone-From-an-ESP8266-1/.

[10] Admin, says:, C. S., says:, M. A., Says:, J. A., Says:, M., Says:, A., says:, K. S., Says:, M., says:, U. D., says:, N. Q. P., Says:, P., says:, S., & says:, K. A. U. S. A. G. E. N. (2020, May 10). *MAX30100 pulse OXIMETER with ESP8266 ON BLYNK IoT App*. How To Electronics. Retrieved September 28, 2021, from https://how2electronics.com/max30100-pulse-oximeter-with-esp8266/.

[11] —, E. F., & says:, P. (2021, September 14). *Max30100 ESP8266 Nodemcu based blood oxygen & BPM monitoring ON Blynk*. Electronic Clinic. Retrieved September 28, 2021, from https://www.electroniclinic.com/max30100-esp8266-nodemcu-based-blood-oxygen-bpm-monitoring-on-blynk/.

[12] Admin, says:, C. S., says:, M. A., Says:, J. A., Says:, M., Says:, A., says:, K. S., Says:, M., says:, U. D., says:, N. Q. P., Says:, P., says:, S., & says:, K. A. U. S. A. G. E. N. (2020, May 10). *MAX30100 pulse OXIMETER with ESP8266 ON BLYNK IoT App*. How To Electronics. Retrieved September 28, 2021, from https://how2electronics.com/max30100-pulse-oximeter-with-esp8266/.

[13] Parajuli, A. (2021, September 20). *MAX30100 pulse Oximeter webserver Using NODEMCU ESP8266*. The IOT Projects. Retrieved September 28, 2021, from https://theiotprojects.com/max30100-pulse-oximeter-webserver-using-nodemcu-esp8266/.

[15] YouTube. (2020). *YouTube*. Retrieved September 28, 2021, from https://www.youtube.com/watch?v=_CWLcbRIWFc.

[16] Coronavirus disease (COVID-19) in Neonates: Current perspectives. (2020). *Journal of Pediatrics & Neonatal Biology*, *5*(4). https://doi.org/10.33140/jpnb.05.04.04

[17] Marcustamfitness. (2013, June 2). *Exercise and target heart rate*. Marcus Tam's Fitness. Retrieved September 28, 2021, from https://marcustamfitness.com/2013/05/26/exercise-and-target-heart-rate/.

[18] Ibrahim, A. A. (2020). Analysis of coronavirus covid-19 pandemic model with discrete time delays. *Journal of Advanced Research in Dynamical and Control Systems*, *12*(SP7), 1455–1462. https://doi.org/10.5373/jardcs/v12sp7/20202248

[19] Chirakanphaisarn, N., Thongkanluang, T., & Chiwpreechar, Y. (2016, September 1). *Heart rate measurement and electrical pulse signal analysis for Subjects span Of 20–80 years*. Journal of Electrical Systems and Information Technology. Retrieved September 28, 2021, from https://www.sciencedirect.com/science/article/pii/S2314717216300265.

[20] Matsushita, S., Oba, T., Otsuki, K., Toji, M., Otsuki, J., & Ogawa, K. (n.d.). A wearable sense of balance monitoring system towards daily health care monitoring. *Seventh IEEE International Symposium on Wearable Computers, 2003. Proceedings.* https://doi.org/10.1109/iswc.2003.1241409

[21] Cascella M;Rajnik M;Aleem A;Dulebohn SC;Di Napoli R; (n.d.). *Features, evaluation, and treatment of Coronavirus (COVID-19)*. National Center for Biotechnology Information. Retrieved September 28, 2021, from https://pubmed.ncbi.nlm.nih.gov/32150360/.

[22] Wearable heart rate monitor with emergency support. (2018). *International Journal of Recent Trends in Engineering and Research*, 114–121. https://doi.org/10.23883/ijrter.conf.02180328.018.inw2x

[23] Hashem, M. M., Shams, R., Kader, M. A., & Sayed, M. A. (2010). Design and development of a heart rate measuring device using fingertip. *International Conference on Computer and Communication Engineering (ICCCE'10)*. https://doi.org/10.1109/iccce.2010.5556841

[24] Al-Sidani, A., Ibrahim, B., Cherry, A., & Hajj-Hassan, M. (2018). Biometrie identification Using photoplethysmography SIGNAL. *2018 Third International Conference on Electrical and Biomedical Engineering, Clean Energy and Green Computing (EBECEGC)*. https://doi.org/10.1109/ebecegc.2018.8357125

Chapter 8
Appendix

Code Section:

```
#include <Wire.h>

#include

"MAX30100_PulseOximeter.h"

#define BLYNK_PRINT Serial

#include <Blynk.h>

#include <ESP8266WiFi.h>

#include

<BlynkSimpleEsp8266.h>

#include "Wire.h"

#define REPORTING_PERIOD_MS 1000

char auth[] =

"TU5SXgYXDLjn0tMJKMhSmDyyH9Yz-hN5";

 /  You should get Auth Token in the Blynk

 App. char ssid[] = "dlink-7EFF";

 /  Your WiFi credentials. char pass[] = "wmwxv98937";
```

```
/  Connections : SCL PIN - D1 , SDA PIN - D2 , INT PIN - D0 PulseOximeter

 pox; float BPM, SpO2;

uint32_t tsLastReport = 0;

const unsigned char bitmap []

PROGMEM=

{
 0x00, 0x00, 0x00, 0x00, 0x01, 0x80, 0x18, 0x00, 0x0f, 0xe0, 0x7f, 0x00, 0x3f, 0xf9, 0xff, 0xc0, 0x7f,
0xf9, 0xff, 0xc0, 0x7f, 0xff, 0xff, 0xe0, 0x7f, 0xff, 0xff, 0xe0, 0xff, 0xff, 0xff, 0xf0, 0xff, 0xf7, 0xff,
0xf0, 0xff, 0xe7, 0xff, 0xf0, 0xff, 0xe7, 0xff, 0xf0, 0x7f, 0xdb, 0xff, 0xe0, 0x7f, 0x9b, 0xff, 0xe0, 0x00,
0x3b, 0xc0, 0x00, 0x3f, 0xf9, 0x9f, 0xc0, 0x3f, 0xfd, 0xbf, 0xc0, 0x1f, 0xfd, 0xbf, 0x80, 0x0f, 0xfd,
0x7f, 0x00, 0x07, 0xfe, 0x7e, 0x00, 0x03, 0xfe, 0xfc, 0x00, 0x01, 0xff, 0xf8, 0x00, 0x00, 0xff, 0xf0,
0x00, 0x00, 0x7f, 0xe0, 0x00, 0x00, 0x3f, 0xc0, 0x00, 0x00, 0x0f, 0x00, 0x00, 0x00, 0x06, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00
 };

void onBeatDetected()

{

Serial.println("Beat Detected!");

}

 void setup()

{

Serial.begin(115200);

pinMode(16, OUTPUT);

Blynk.begin(auth, ssid, pass);

Serial.print("Initializing Pulse Oximeter..");

if

(!pox.begin())

{
Serial.println("FAILED");

for(;;);

 }
```

```
Else

{
Serial.println("SUCCESS");

 pox.setOnBeatDetectedCallback(onBeatDetected);

 }

 /  The default current for the IR LED is 50mA and it could be changed by uncommenting the
following line. //

pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);

 }
void loop()
 {
 pox.update();

 Blynk.run();
 BPM = pox.getHeartRate();

 SpO2 = pox.getSpO2();

If
 (millis() - tsLastReport > REPORTING_PERIOD_MS)

{
Serial.print("Heart rate:");

 Serial.print(BPM);

 Serial.print(" bpm / SpO2:");

 Serial.print(SpO2);

 Serial.println(" %");

 Blynk.virtualWrite(V7, BPM);

 Blynk.virtualWrite(V8, SpO2);

 tsLastReport = millis();
 }
 }
```

oximeter_3 | Arduino 1.8.12

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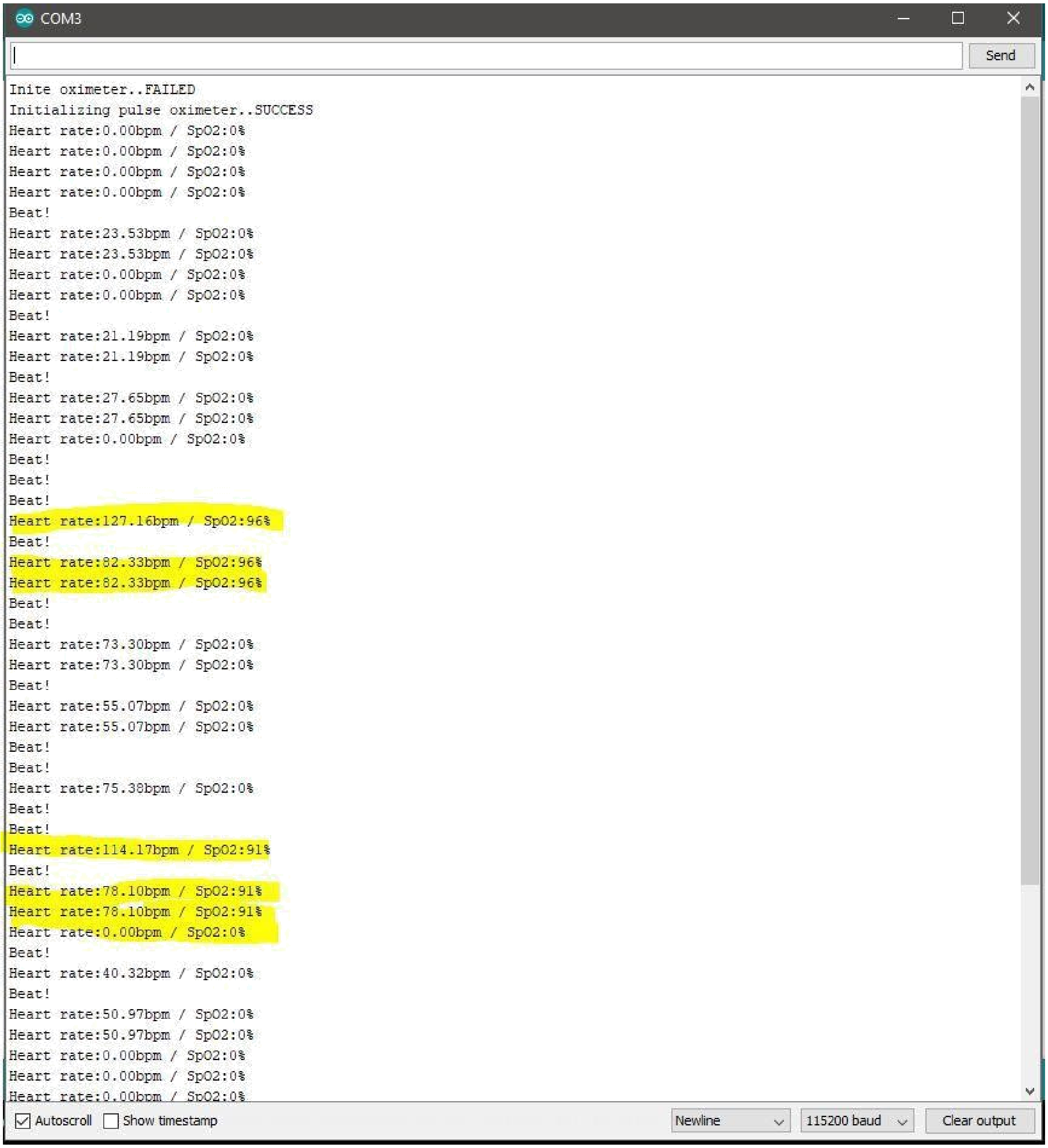
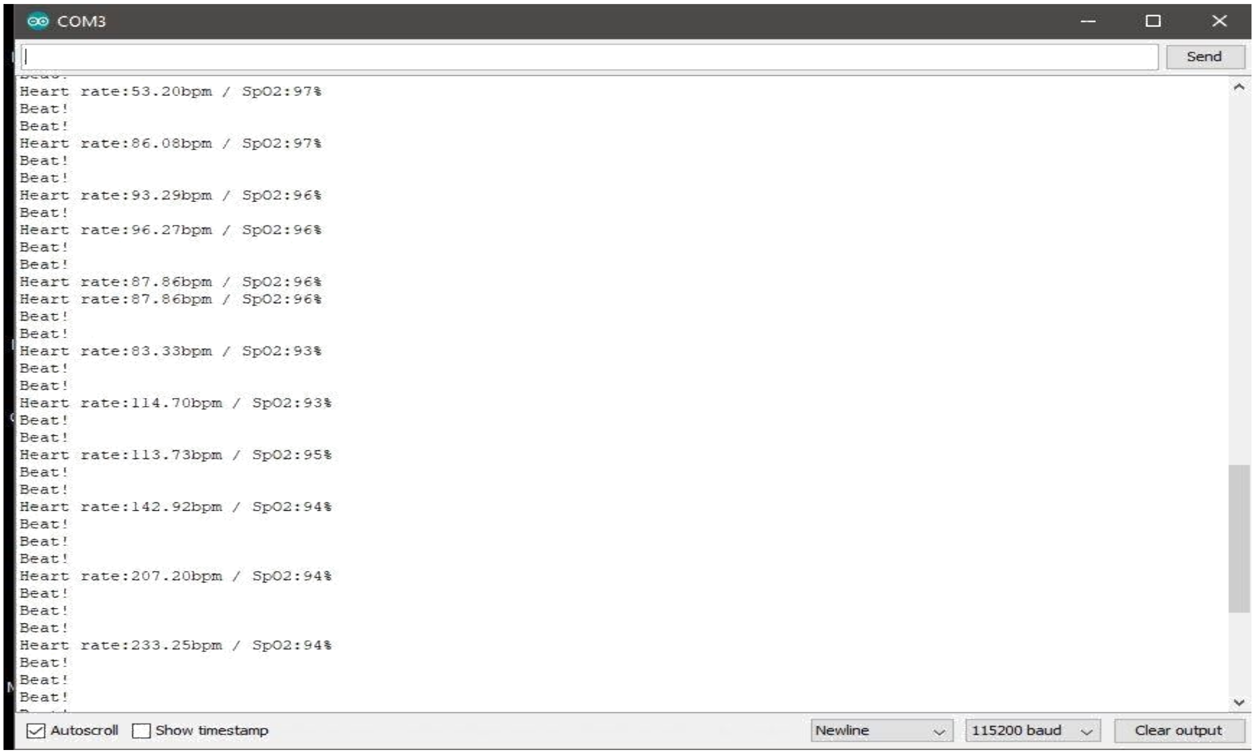
oximeter_3

```
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"

#define REPORTING_PERIOD_MS     1000

PulseOximeter pox;
uint32_t tsLastReport = 0;

void onBeatDetected()
{
    Serial.println("Beat!");
}

void setup()
{
    Serial.begin(115200);
    Serial.print("Initializing pulse oximeter..");

    // Initialize the PulseOximeter instance
    // Failures are generally due to an improper I2C wiring, missing power supply
    // or wrong target chip
    if (!pox.begin()) {
        Serial.println("FAILED");
        for(;;);
    } else {
        Serial.println("SUCCESS");
    }
     pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);

    // Register a callback for the beat detection
    pox.setOnBeatDetectedCallback(onBeatDetected);
}

void loop()
{
    // Make sure to call update as fast as possible
    pox.update();
    if (millis() - tsLastReport > REPORTING_PERIOD_MS) {
        Serial.print("Heart rate:");
        Serial.print(pox.getHeartRate());
        Serial.print("bpm / SpO2:");
        Serial.print(pox.getSpO2());
        Serial.println("%");

        tsLastReport = millis();
    }
}
```

```
Global variables use 729 bytes (35%) of dynamic memory, leaving 1319 bytes for local variables. Maximum is 2048 bytes.
```


COM3
Send
Inite oximeter..FAILED
Initializing pulse oximeter..SUCCESS
Heart rate:0.00bpm / SpO2:0%
Heart rate:0.00bpm / SpO2:0%
Heart rate:0.00bpm / SpO2:0%
Heart rate:0.00bpm / SpO2:0%
Beat!
Heart rate:23.53bpm / SpO2:0%
Heart rate:23.53bpm / SpO2:0%
Heart rate:0.00bpm / SpO2:0%
Heart rate:0.00bpm / SpO2:0%
Beat!
Heart rate:21.19bpm / SpO2:0%
Heart rate:21.19bpm / SpO2:0%
Beat!
Heart rate:27.65bpm / SpO2:0%
Heart rate:27.65bpm / SpO2:0%
Heart rate:0.00bpm / SpO2:0%
Beat!
Beat!
Beat!
Heart rate:127.16bpm / SpO2:96%
Beat!
Heart rate:82.33bpm / SpO2:96%
Heart rate:82.33bpm / SpO2:96%
Beat!
Beat!
Heart rate:73.30bpm / SpO2:0%
Heart rate:73.30bpm / SpO2:0%
Beat!
Heart rate:55.07bpm / SpO2:0%
Heart rate:55.07bpm / SpO2:0%
Beat!
Beat!
Heart rate:75.38bpm / SpO2:0%
Beat!
Beat!
Heart rate:114.17bpm / SpO2:91%
Beat!
Heart rate:78.10bpm / SpO2:91%
Heart rate:78.10bpm / SpO2:91%
Heart rate:0.00bpm / SpO2:0%
Beat!
Heart rate:40.32bpm / SpO2:0%
Beat!
Heart rate:50.97bpm / SpO2:0%
Heart rate:50.97bpm / SpO2:0%
Heart rate:0.00bpm / SpO2:0%
Heart rate:0.00bpm / SpO2:0%
Heart rate:0.00bpm / SpO2:0%
Autoscroll
Show timestamp
Newline
115200 baud
Clear output


COM3
Send
Heart rate:53.20bpm / SpO2:97%
Beat!
Beat!
Heart rate:86.08bpm / SpO2:97%
Beat!
Beat!
Heart rate:93.29bpm / SpO2:96%
Beat!
Heart rate:96.27bpm / SpO2:96%
Beat!
Beat!
Heart rate:87.86bpm / SpO2:96%
Heart rate:87.86bpm / SpO2:96%
Beat!
Beat!
Heart rate:83.33bpm / SpO2:93%
Beat!
Beat!
Heart rate:114.70bpm / SpO2:93%
Beat!
Beat!
Heart rate:113.73bpm / SpO2:95%
Beat!
Beat!
Heart rate:142.92bpm / SpO2:94%
Beat!
Beat!
Beat!
Heart rate:207.20bpm / SpO2:94%
Beat!
Beat!
Beat!
Heart rate:233.25bpm / SpO2:94%
Beat!
Beat!
Beat!
Autoscroll
Show timestamp
Newline
115200 baud
Clear output