Palestine Polytechnic University

College of Engineering

The IoT-Based Heart Disease Monitoring System for Pervasive

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Submited to the College of Engineering in partial fulfilment of the requirements for the Bachelor degree in Biomedical Engineering

21, 2021

Abstract

Heart disease is one of the most common diseases in the world, which requires the use of different techniques to diagnose these diseases, taking into account the cost of these techniques and their suitability for humans. Among these techniques are the ECG signal, the number of heartbeats and the percentage of oxygen in the blood, which will be combined into a system that will be of low cost and will be a non-invasive diagnostic process. Therefore, this project will be diagnosed using Internet of Things technology, where the design will be by connecting the used sensors to the Internet of Things cloud and reading the results to diagnose the patient.

الملخص

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احلان ْ

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List of Abbreviations

ICU	Intensive care units
ECG	Electrocardiogram
IoT	Internet of Things
CVD	Cardio Vascular Diseases
AV	Atroventricular
SA	Sinoatrial
PIV	Posterior Interventricular
PDA	Posterior Descending Artery
SVC	Superior Vena Cava
NIR	Near-Infrared Light
PWM	Pulse Width Modulation
ADC	Analog to Digital Converter
HR	Heart Rate
UART	Universal Asynchronous Receiver/Transmitter
DAC	Digital to Analog converter

Chapter One

Introduction

1.1 Problem Statement and Project Motivation

This project is significant in various ways because in today's world, everyday many lives are affected because the patients are not timely and properly operated. Also for real time parameter values are not efficiently measured in clinic as well as in hospitals.Sometimes it becomes difficult for hospitals to frequently check patient's conditions. Also continuous monitoring of ICU patients is very difficult. To deal with these types of situations, our system is beneficial. Our system is designed to be used in hospitals and homes also for measuring and monitoring various parameters like temperature, ECG, heart rate, blood pressure. The results can be recorded using Arduino. Also the doctors can see those results on android app. The system will also generate an alert notification which will be sent to doctor. Our system is useful for monitoring health system of every person through easily attach the device and record it. In which we can analysis patient's condition through their past data, we will recommend medicines if any emergency occurred through symbolic.

1.2 Project Objective

The system can be used to monitor physiological parameters, such as heart rate and temperature of a human body. The objective of this project is to design and implement a reliable, cheap, low powered, and accurate system that can be worn on a regular basis and monitors the vital signs based on IoT.

1.3 Project Importance

Provides more comfort to the patient it's a way to diagnose also assisting physicians who are in need of continuous monitoring of the patient's condition to reinforce diagnostic procedures and provide medical consultations and low cost for diagnose.

1.4 Plan of work

In the beginning, the main goal of the mechanism used in this project must be determined, which is to know how the cardiac activity proceeds, and then search for the best and safest ways to use this method, and then start the process of designing the components of the device, starting with the sensor of the signal capture to the mechanism for displaying results and what are the stages of signal processing between them.

1.5 The Project Timeline:

Table 1.1:Time Schedule of the semester

Week / Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Finding Project Idea	■	■													
Proposal		■	■	■											
Search and Collecting data		■	■	■	■	■	■	■	■						
Documentation			■	■	■	■	■	■	■	■	■	■	■	■	
Preparing for presentation													■	■	■
Print documentation															■

Table 1. 2:Time Schedule of the semester

Week / Activities	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Collection of components	■	■	■												
Built the project circuit		■	■	■	■										
Print the project on PCB						■	■	■	■						
Built the project codes								■	■	■	■				
Interfacing using Arduino									■	■	■	■			
Testing the project											■	■	■		
Recommendation														■	
Conclusion															■
Documentation				■	■	■	■	■	■	■	■	■	■	■	■

1.6 Budget

Table 1.3:Estimated Budget.

‘The prices	Price $
ECG Sensor	20
HR Sensor	20
SPO_2 Sensor	20
Microcontroller	10
Wire & Other	10
Total	80

Chapter 2

Anatomy and Functionality of Heart

2.1 Overview of the Heart:

The heart is a muscular organ that acts like a pump to continuously send blood throughout your body. The heart is at the center of the circulatory system. Is system consists of a network of blood vessels, such as arteries, veins, and capillaries. These blood vessels carry blood to and from all areas of the body. An electrical system regulates the heart and uses electrical signals to contract the heart's walls. When the walls contract, blood is pumped into the circulatory system. A system of inlet and outlet valves in the heart chambers work to ensure that blood flows in the right direction. The heart is vital to your health and nearly everything that goes on in the body. Without the heart's pumping action, blood can't circulate within the body. Blood carries the oxygen and nutrients that your organs need to work normally. Blood also carries carbon dioxide, a waste product, to your lungs to be passed out of the body and into the air. A healthy heart supplies the areas of the body with the right amount of blood at the rate needed to work normally. If disease or injury weakens the heart, the body's organs won't receive enough blood to work normally.[4]

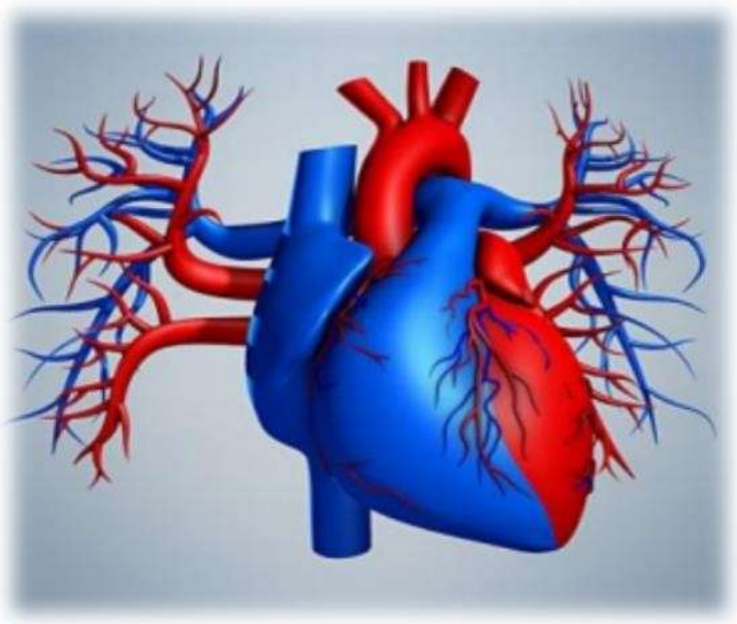

Figure 2. 1:The Heart[4].

2.2 Location, Size and Shape of the Heart

The heart is located underneath the sternum in a thoracic compartment called the mediastinum, which occupies the space between the lungs. It is approximately the size of a man's fist (250-350grams) and is shaped like an inverted cone. The narrow end of the heart is called the apex. It is directed downward and to the left and lie just above the arch of the diaphragm at the approximate level of the fifth or sixth rib. The broad end of the heart is called the base and gives rise to the major blood vessels, which is directed upwards and to the right and lies at the approximate level of the second rib. Surrounding the hearts is a fibrous sac called the pericardium, which performs several functions. Fluid within the sac lubricates the outer wall of the heart so it can beat without causing friction. It also holds the heart in place forms a barrier against infections and helps keep the heart from over expanding. e pericardium is made up of a coronal section which comprises of two walls and a thin intervening space. The outer wall is thickest and consists of two tissue layers. The external layer is formed by a dense irregular connective tissue and is often called the fibrous pericardium. is layer protects the heart and anchors it to nearby organs. At the roots of the major blood vessels, the parietal pericardium reflects back over the surface of the heart to form the inner wall of the pericardium, the visceral pericardium. Because it is the outer layer of the heart wall, the visceral pericardium is referred to as the epicardium. Together, the parietal and visceral paricardial layers are also called the serous pericardium.

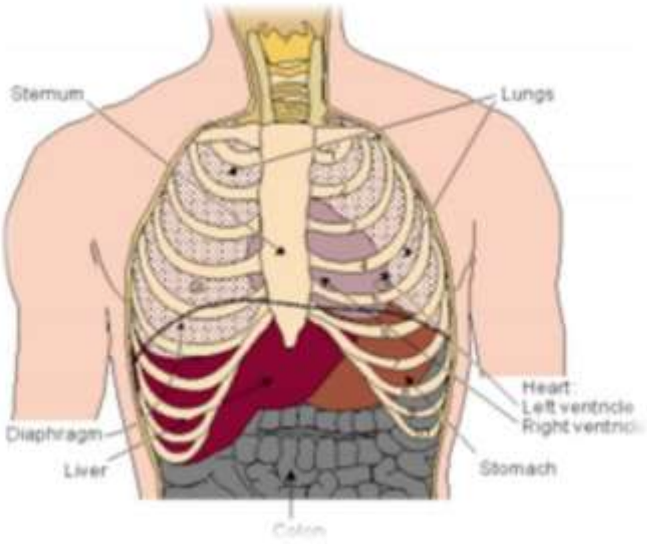

Figure 1. 2:Position of e Heart[5].

2.3 The Chambers of the Hearts

The heart is made up of four chambers. The superior chamber consists of the right atrium and the le atrium, which lie primarily on the posterior side of the heart. Extending anteriorly from each thin walled atrium is a small, ear-shaped appendage called auricle that expands the volume of the chamber. Blood drains into the atria from the pulmonary and systemic circulatory sys- tem. Composing the lower chambers are the right ventricle and le ventricle, which are much larger than the atria. The right ventricle pumps blood through the pulmonary circulatory system and the thicker walled le ventricle pumps blood through the longer systemic circulatory system. Internally, the two ventricles are separated by a thick myocardial wall called the interventricular septum.

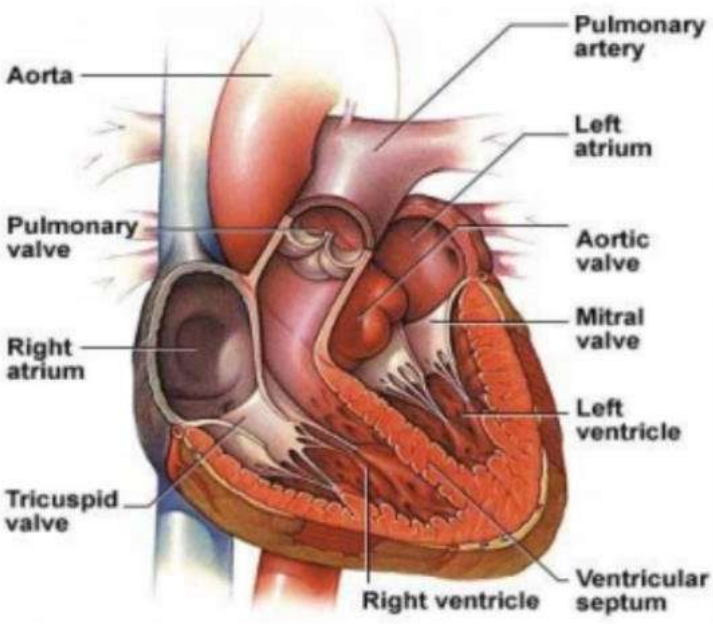

Figure 2. 3:Chambers of Heart[4].

2.4 The Circulation System

The major vessels of the heart are the large arteries and veins that attach to the atria, ventricles and transport blood to and from the systemic circulatory system and pulmonary circulation system. Blood is delivered to the right atrium from the systemic circulatory system by two veins. e superior vena cava transport oxygen-depleted blood from the upper extremities, heard and neck. The inferior vena cava transport oxygen-depleted blood from the thorax, abdomen and lower extremities. Blood exits the right ventricles through the pulmonary trunk artery. Approximately two inches superior to the base of the heart, this vessel branches into the le and right pulmonary arteries, which transport blood into the lungs. the left pulmonary veins and right pulmonary veins return oxygen-ated blood from the lungs to the left atrium.

Blood passes from the left atrium into the left ventricle and then is pumped into the systemic circulatory system through a large elastic artery called the aorta.

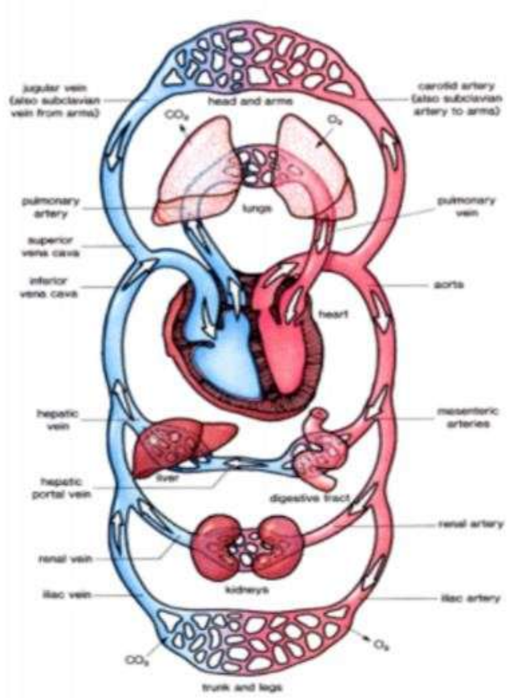

Figure 2. 4:Circulation System[5]

2.5 The Heart Valve Anatomy

Four valves maintain the unidirectional flow of blood through the heart. The valves are located between each atrium and ventricle and in the two arteries that empty blood from the ventricle. These valves are primarily composed of fibrous connective tissues that originate and extend from the heart walls. The external surfaces of the valves are covered by endocardium. The Tricuspid valve (right atroventricular) is composed of three caps or flaps and controls blood flow from the right atrium to the right ventricle. The bicuspid

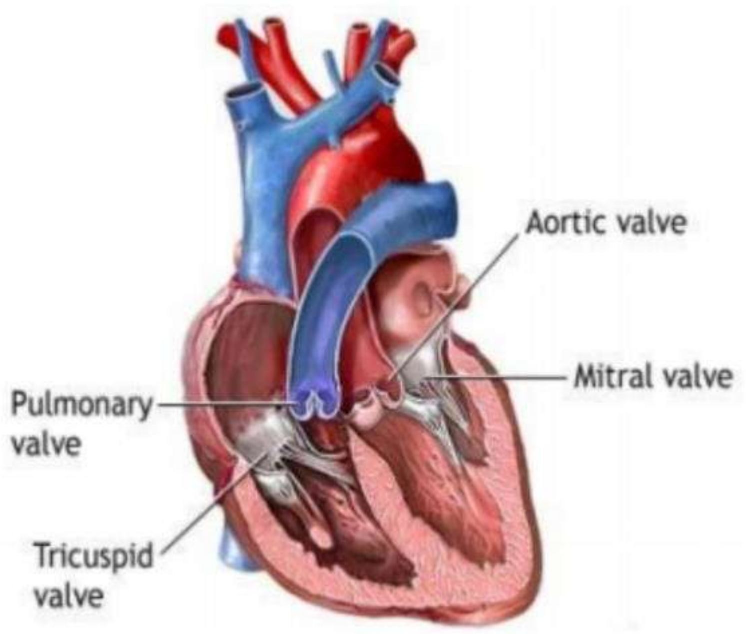

Figure 2. 5:Heart Valve Anatomy[6].

valve is made up of two cusps or aps and controls blood flow from the left atrium to the left ventricle. The term mitral valve is also commonly applied because the left AV valve is shaped somewhat like a bishop’s miter. in tendon like cord called chordae tendineae connect the AV valves to cone shaped papillary muscles that extend upward from the myocardium. The chordea tendineae and papillary muscles tether the AV valves to the ventricular walls. is allows the valves to close properly and not bulge (or prolapse) into the atria. Semilunar valves direct blood flow from the ventricles into the aorta and pulmonary trunk artery. The valves are located in the vessels just above the opening to ventricles. Each consists of three cusps that curve upwards to from small pockets[6]. The four heart valves open and close in response to pressure changes that occur in the ventricles during each cardiac cycle. When the ventricles relax their pressures drop below those of the atria, pulmonary trunk artery and aorta. This

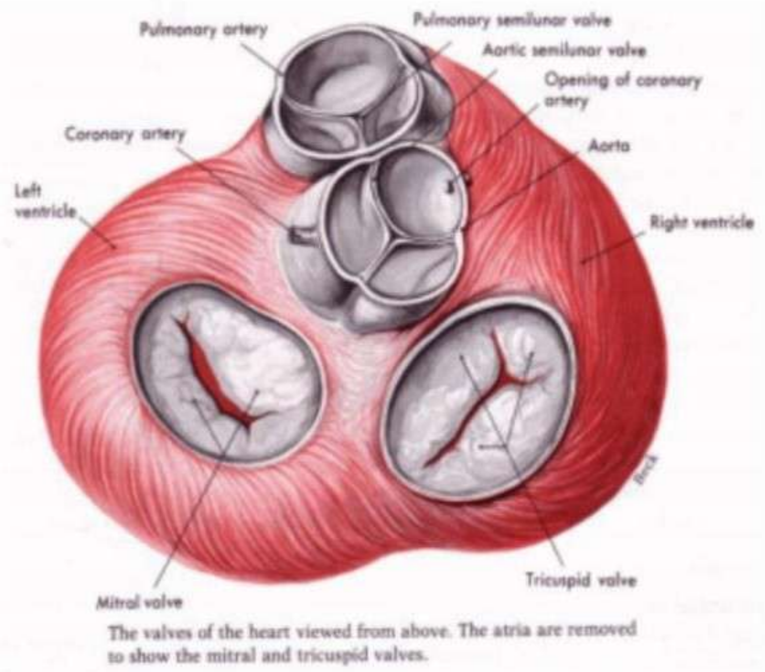

Figure 2. 6:2D Heart Valve Anatomy[6].

allows the AV valves to open as their cusps passively drop downwards. The pressure change additionally permits blood to flow into the ventricles from the atria without restriction. The semilunar valves close during this same period as blood owing toward the ventricles collects in the pockets of the cusps. Closure of the semilunar valves prevents blood from re-entering the ventricles while they are relaxing. After filling with blood, the ventricles contract and their rising pressures forces blood up towards the atria and into the pulmonary trunk and aorta. Blood pushing up under the cusps causes the atrioventricular valves to close. As a result, blood enters the atria from the pulmonary veins but not from the ventricles. At the same time, rising pressure in pulmonary trunk artery and aorta forces the semilunar valves to open and blood flow into systemic and pulmonary circulatory systems. When the ventricles begin to relax, pressure in the chambers drop again and a new cardiac cycle begins.

2.6 Coronary Arteries

The heart receives nutrients and gases from its own set of arteries, veins and capillaries called the coronary circulatory system. Blood enters the coronary circulatory system through the le coronary artery and the right coronary artery, which exit the aorta just above the cusps of the semilunar valves. After running a short distance between the pulmonary trunk artery and le auricle, the le coronary artery emerges onto the anterior surface of the heart. Near this point, it branches into the anterior interventricular artery (left anterior descending artery) and the left circumflex artery. The anterior interventricular artery lies in the anterior interventricular sulcus and gives o branches that supply blood to the anterior ventricles and anterior interventricular septum. The left circumflex artery runs along the coronary sulcus (between the le atrium and ventricle) to the posterior side of the heart, where it usually ends in an anastomosis with the right coronary artery. One or more left marginal arteries typically branch from the le circumflex artery as it travels around the heart. The left circumflex artery and its branches supply blood to the le atrium and the lateral and posterior portions of the left ventricles. The right coronary artery travels along the coronary sulcus (between the right atrium and ventricle) where it typically gives o smaller branches to the right atrium. AV nodes (80% of people) and SA nodes (55% of people). Larger right marginal arteries also diverge from the right coronary artery as it continues around the heart.

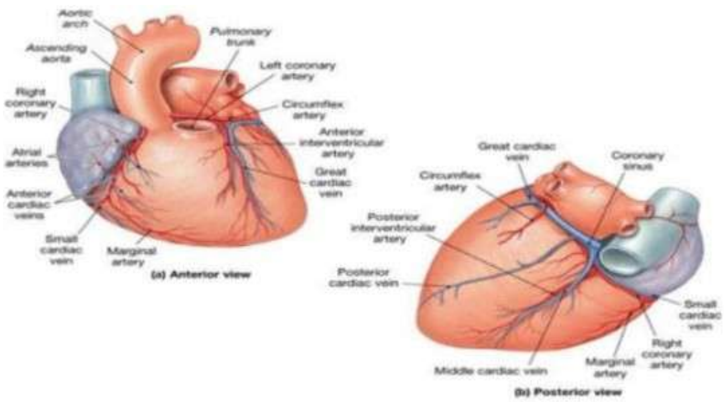

Figure 2. 7:Coronary Arteries Anatomy[4].

The right marginal arteries supply blood to the lateral wall of the right ventricle. On the posterior surface of the heart, the right coronary artery typically (80%-85% of people) give rise to the posrterior interventricular artery (PIV) orposterior descending artery (PDA), which runs along the posterior interventricular sulcus and the posterior interventricular septum[4].

2.7 Coronary Veins

After owing through the myocardium, most (80%) of the oxygen-depleted blood is returned to the right atrium by several prominent veins that run along the surface of the heart. Draining blood from the anterior ventricle is the great cardiac vein. is vessel originates at the apex of the heart and runs superiorly along the anterior interventricular sulcus (next to the anterior interventricular artery). Near the right atrium, the great cardiac vein veers to the le and enters the coronary sulcus (between the left atrium and ventricle), where it extends to the back side of the heart. One or more left marginal veins typically merge with the great cardiac vein as it traverses the lateral ventricular wall. Small anterior cardiac veins also drain blood from the anterior right ventricle directly into the

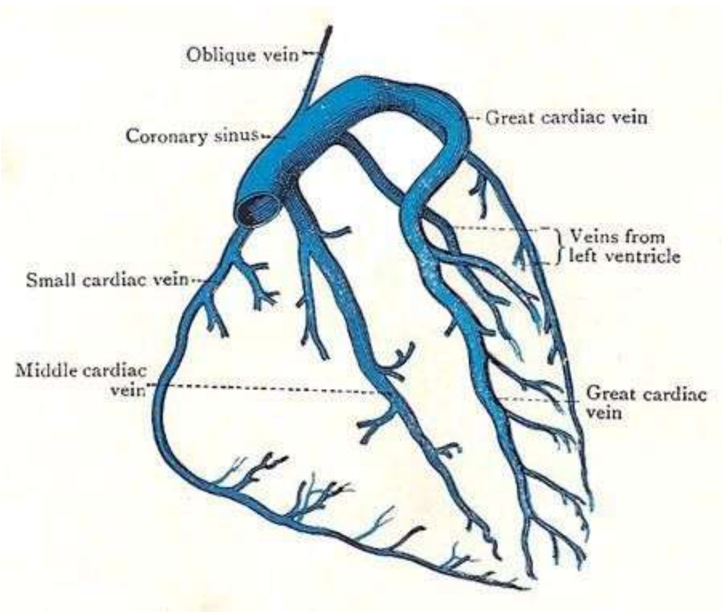

Figure 2. 8:Coronary Veins Anatomy[4].

right atrium. Blood is removed from the lateral and posterior right ventricle (and atrium) by the small cardiac vein, which travels to the posterior surface of the heart in the coronary sulcus. Along its path, the small cardiac vein receives blood from the one or more right marginal veins. One the posterior side of the heart, the great and small cardiac veins merge with the coronary sinus, which empties into the right atrium. The coronary sinuses also receives blood from the middle cardiac vein that ascends along the posterior interventricular groove and the posterior vein of the left ventricle.

2.8 The Conduction System

The conducting system of the heart consists of cardiac muscle cells and conducting fibers (not nervous tissue) that are specialized for initiating impulses and conducting them rapidly through the heart. They initiate the normal cardiac cycle and coordinate the contractions of cardiac chambers. e conducting system provides the heart its automatic rhythmic beat. For the heart to pump efficiently and the systemic and pulmonary circulations to operate in synchrony, the events in the cardiac cycle must be coordinated. The sinoatrial (SA) node is a spindle-shaped structure composed of a fibrous tissue matrix with closely packed cells. It is 10-20 mm long, 2-3 mm wide, and thick, tending to narrow caudally toward the inferior vena cava. e SA node is located less than 1 mm from the epicardial surface, laterally in the right atrial sulcus terminalis at the junction of the an-teromedial aspect of the superior vena cava (SVC) and the right atrium (RA). The middle internodal tract begins at the superior and posterior margins of the sinus node, travels behind the SVC to the crest of the interatrial septum, and descends in the interatrial septum to the superior margin of the AV node.

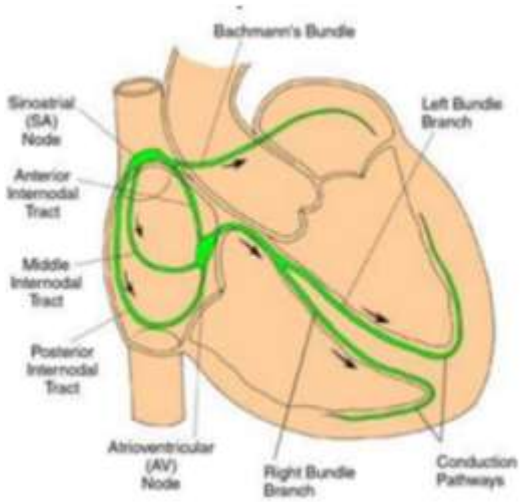

Figure 2. 9:Conduction System[7].

2.9 Cardiac Cycle

The cardiac cycle is the sequence of events that occur when the heart beats. The cycle has two main phases: diastole – when the heart ventricles are relaxed and systole – when the ventricles contract. In a cardiac cycle, blood enters the right atrium of the heart from the superior and inferior vena cava, and flows across the tricuspid valve into the right ventricle. From the right ventricle the blood flows into the pulmonary artery, which is separated from the ventricle by the pulmonary valve.

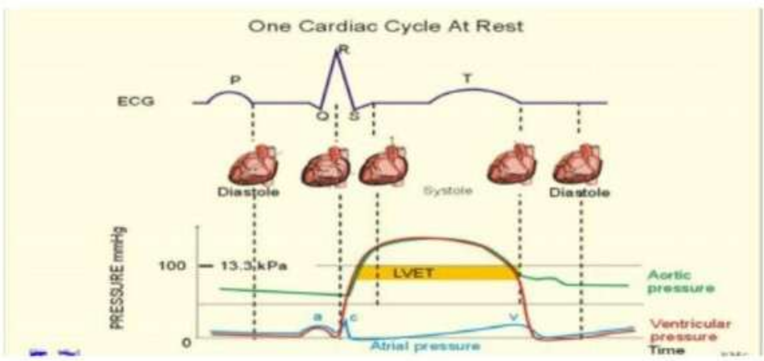

Figure 2. 10:Cardiac Cycle[4].

After oxygenation in the lungs, blood returns to the heart via four pulmonary veins that enter the le atrium. From the le atrium, blood flows across the mitral valve and into the left ventricle. From the le ventricle blood is ejected across the aortic valve into the aorta. Together, the mitral and tricuspid valves are known as the atrioventricular valves and the aortic and pulmonary valves as the semilunar valves[4].

Chapter 3

Theoretical Background

3.1 Overview

This chapter introduces a theoretical background of the system, some descriptions of the hardware and software components used in the system. Specifications of the design system and constraints are discussed too.

3.2 Theoretical background

The main idea of the project is to design a device for the people using ESP32 . Based on the Arduino programming language and c/c++ environment.

To achieve the goals of our project we need several components. At the beginning Sensors are used to measure signs in the body of an elderly person, and then sent to ESP32, and then ESP32 will send it to the application that will display those signs. To achieve the measurement of body ECG signal , we need The AD8232 module allows recording the electrical activity of the heart, by obtaining an electrocardiogram or ECG , ECG sensor obtain signals from heart beats because electrical signals are transmitted through specific pathways within the heart, causing the heartbeat. This electrical activity can be collected through electrodes placed on the skin, specifically on the front of the chest, on the arms and legs. [1]

The AD8232 sensor module is integrated with specially calibrated signal amplifiers and noise filters for ECG signals. The module suppresses the 60Hz noise generated by household electricity. As the output of the module is analog type, it is only necessary to solder the pins and connect the module to a microcontroller which has analog input pins like Arduino, ESP32, ESP8266 Node MCU, or others. Within the program we must perform the analog to digital conversion, So we can observe the ECG on the

Arduino IDE plotter. It is recommended for patient safety to power the module using a battery and not from a source connected to the household power supply.

It also uses an optical sensor MAX30100 to measure the heart rate and oxygen levels in the blood based on what is known as photo plethysmography. This technology is based on a very simple fact: blood is red because it reflects red and absorbs green. The Smart Watch uses red LED lights paired with photosensitive photodiodes to detect the amount of blood flowing through the wrist at any given 12 moment. When the heart beats, blood flows to the wrist, and the red color is more absorbed. While less between each heartbeat and the other. The sensor can calculate the number of times your heartbeat per minute by flashing LED lights hundreds of times every second, thus calculating your heart rate. The optical heart rate sensor supports a range of 30 to 210 beats per minute. In addition, this sensor is designed to measure the percentage of oxygen in the red blood cells that carry oxygen from your lungs to the rest of your body using red LED lights that are reflected on the wrist. A normal heart rate for seniors is between 60 and 100 beats per minute. According to the American Heart Association, the estimated target heart rate numbers for adults ages 45-70 are: 45 years: 88 to 149 beats per minute[8]

50 years: 85 to 145 beats per minute

55 years: 83 to 140 beats per minute

60 years: 80 to 136 beats per minute

65 years: 78 to 132 beats per minute

70 years: 75 to 128 beats per minute.[10]

A normal oxygen saturation level is 97-100% but older adults typically have lower levels than younger adults, so a normal oxygen level for elderly adults may be about 95%, which is acceptable.[11]

SEN-11574 pulse sensor, the working principle of this heartbeat rate sensor is very simple. If we talk about heartbeat rate, then heartbeat rate is the ratio of time between two consecutive heartbeats. Similarly, when the human blood is circulated in human body then this blood is squeezed in capillary tissues. As a result, the volume of capillary tissues is increased but this volume is decreased after each heartbeat. This change in volume of capillary tissues affects the LED light of heart rate pulse sensor, which transmits light after each heartbeat. This change in light is very small but this can be measured by connecting any controller with this pulse sensor. This means the LED light which has every pulse sensor helps for measuring pulse rate.

The working of this sensor could be checked by placing a human finger in front of this pulse sensor. When a finger is placed in front of this pulse sensor then the reflection of LED light is changed based on the volume of blood change inside capillary vessels. This means during the heartbeat the volume of blood in capillary vessels will be high and then will be low after each heartbeat. So, by changing this volume the LED light is changed. This change in of LED light measures the heartbeat rate of a finger. This phenomenon is known as "Photoplethysmogram."

3.3 Literature review

In this section we will talk about some projects similar to the idea of our project:

- **Child monitoring system:**

A system that works to monitor children through the design of bracelets that the child puts on his hand and provides the system (location, acoustic sensors) and all this information is stored and sent to the application on the mobile phone of parents , where the application is also designed to provide parents with a login system , and the application is the link between school and parents.[12]

- **Remote health monitoring of elderly through wearable sensors:**

A system which enables continuous monitoring for elderly people's health in real-time to prevent chronic diseases, thus preventing hospitalization that burden the healthcare systems and costs. This project presents a framework which utilizes a smart-phone app and Wearable Sensors for Smart Healthcare Monitoring System (SW-SHMS) for elderly people. The system accumulates patient's physiological data via wearable sensors (i.e., pulse, oxygen etc.) of elderly people in real-time. The data is transmitted to a data repository, where it will be stored and checked for any abnormality. Thus, any detection of disorder in a patient's vitals will be reported to the patient's doctors and/or hospital in real-time to act on quickly and prevent a number of problems, such as a sudden heart attack. Technologies are capable of providing patients physiological data from their locations to physicians anywhere in real-time, therefore, enabling remote remediation. For example, data such as blood oxygen saturation, heart-rate, and blood pressure can be measured via wearable devices and transmitted from patients locations to their doctors in real-time. This enables doctors and patients to communicate remotely.[13]

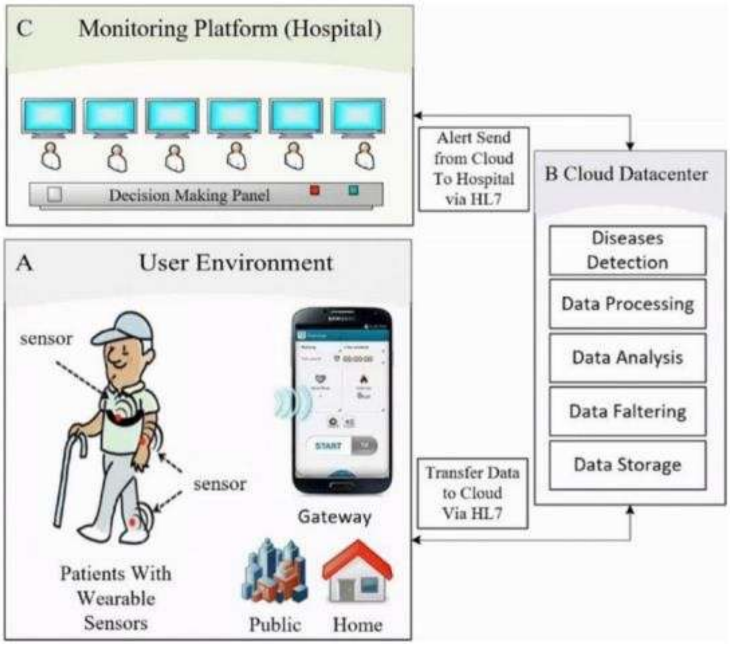

Figure 3.1 : Remote health monitoring of elderly through wearable sensors[13]

3.4 Technologies to be used in the project

This subsection illustrates the main technologies to be used in this project and what tasks they do.

- **ESP32 programming language**

Is an open-source computer programming language based on the wiring development platform, the Arduino IDE is based upon the Processing IDE, and it is available in several operating systems, which give us a programing editor with integrated libraries support and a way to easily compile and load our Arduino programs to a board connected to the computer. This language is a framework built on top of C++, the main difference from c/c++ is that you wrap all your code into two main functions, any Arduino program must provide at least two main functions .[10]

- **Google Firebase:**

Firebase is a platform developed by Google for creating mobile and web applications , firebase's first product was the Firebase Realtime Database, an API that synchronizes application data across iOS, Android, and Web devices, and stores it on Firebase's cloud. The product assists software developers in building real-time, collaborative applications. The Firebase SDK supports programming in C++, Java, JavaScript, JavaScript/Node.js, Objective-C, and Swift. Angular, Backbone, Ember and React are supported through bindings to the database. Google added a number of helper libraries: FirebaseUI, Geofire, Firebase Queue, FirebaseJobDispatcher , Firebase also supports importing large JSON data sets and integration with Elastic Search. [11] Firebase Realtime Database Security Rules determine who has read and write access to your database, how your data is structured, and what indexes exist. These rules live on the Firebase servers and are enforced automatically at all times. Every read and write request will only be completed if your rules allow it. By default, your rules do not allow anyone access to your database. This is to protect your database from abuse until you have time to customize your rules or set up authentication. The Firebase Realtime Database provides a full set of tools for managing the security of your app. These tools make it easy to authenticate your users, enforce user permissions, and validate inputs.[14]

- **MIT App Inventor**

MIT App Inventor is an intuitive, visual programming environment that allows everyone even children to build fully functional apps for smartphones and tablets. Those new to MIT App Inventor can have a simple first app up and running in less than 30 minutes. And what's more, our blocks-based tool facilitates the creation of complex, high-impact apps in significantly less time than traditional programming environments. The MIT App Inventor project seeks to democratize software development by empowering all people, especially young people, to move from technology consumption to technology creation. A small team of CSAIL staff and students, led by Professor Hal Abelson, forms the nucleus of an international movement of inventors. In addition to leading educational outreach around MIT App Inventor and conducting research on its impacts, this core team maintains the free online app development environment that serves more than 6 million registered users. Blocks-based coding programs inspire intellectual and creative empowerment.[15]

3.5 Hardware System Components:

This section describes all hardware used in my project , it presents figure for each one with short description about its work principle and why it is used in the system :

1. NodeMCU ESP32

The ESP32 is a dual-core 160MHz to 240MHz CPU, whereas the ESP8266 is a single-core processor that runs at 80MHz. These modules come with GPIOs that support various protocols like SPI, I2C, UART, ADC, DAC, and PWM. The best part is that these boards come with wireless networking included, which makes them apart from other microcontrollers like the arduino. This means that you can easily control and monitor devices remotely via Wi-Fi or Bluetooth for a very low price.

We will program this controller to deal with the data coming from the connected sensors and send it to the application for display to the care provider.[9]

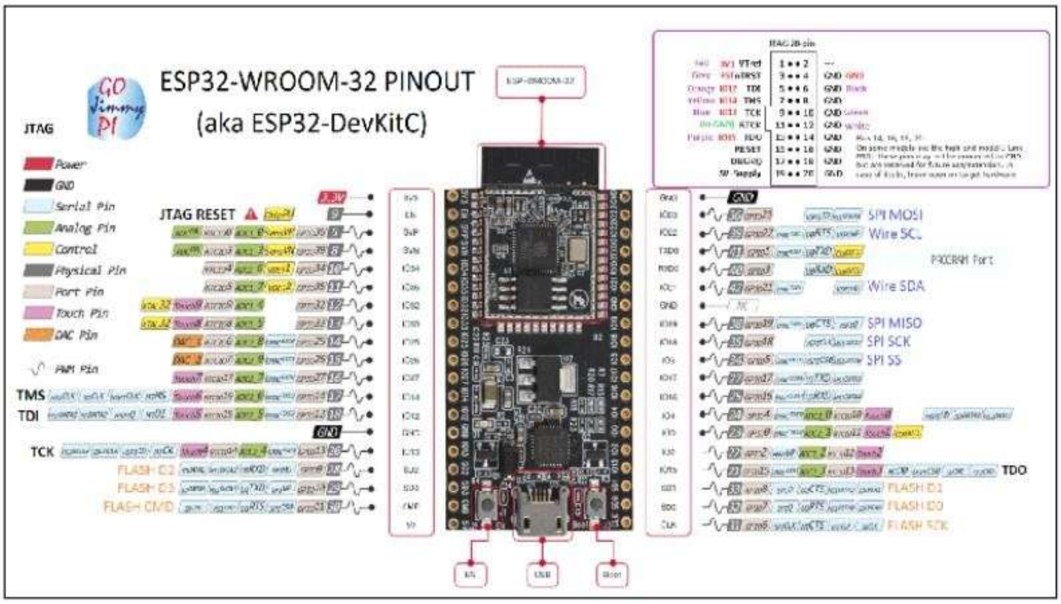

Figure 3.2 : Functions of ESP32 pins[15]

2. AD8232 ECG Sensor

The EKG or ECG (Electrocardiogram) is a non-invasive diagnostic test that assesses heart rhythm and function through a recording of the electrical activity of the heart that occurs with each heartbeat. This electrical activity is recorded from the patient‟s body surface and is drawn on a paper using a graphical representation or tracing, where different waves are observed that represent the electrical stimuli of the atria and ventricles. The device with which the electrocardiogram is obtained is called an electrocardiograph.

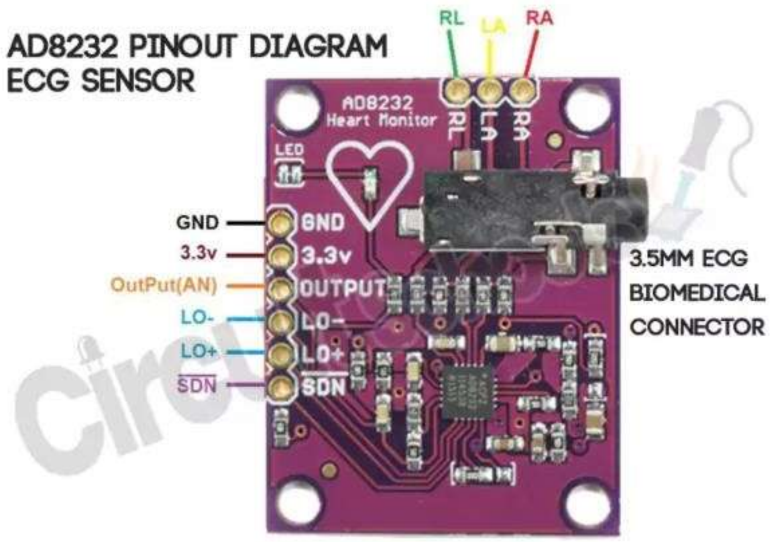

Figure 3.3:AD8232 ECG Sensor

3. The Pulse Sensor / Heartbeat Sensor(SEN-11574)

The working principle of this heartbeat rate sensor is very simple. If we talk about heartbeat rate, then heartbeat rate is the ratio of time between two consecutive heartbeats. Similarly, when the human blood is circulated in human body then this blood is squeezed in capillary tissues. As a result, the volume of capillary tissues is increased but this volume is decreased after each heartbeat. This change in volume of capillary tissues affects the LED light of heart rate pulse sensor, which transmits light after each heartbeat. This change in light is very small but this can be measured by connecting any controller with this pulse sensor. This means the LED light which has every pulse sensor helps for measuring pulse rate.

Figure 3.4:The Pulse Sensor / Heartbeat Sensor

4. The Pulse Oximetry (SPO2) Sensor(MAX30100)

The MAX30100 is an integrated pulse oximetry monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry signal.[12]

Specification:

- Operating Voltage - 1.8V to 3.3V
- Weight (gm) – 2
- Input Current - 20mA
- Integrated Ambient Light Cancellation
- High Sample Rate Capability
- Fast Data Output Capability
- Dimensions – 8*6*4 cm

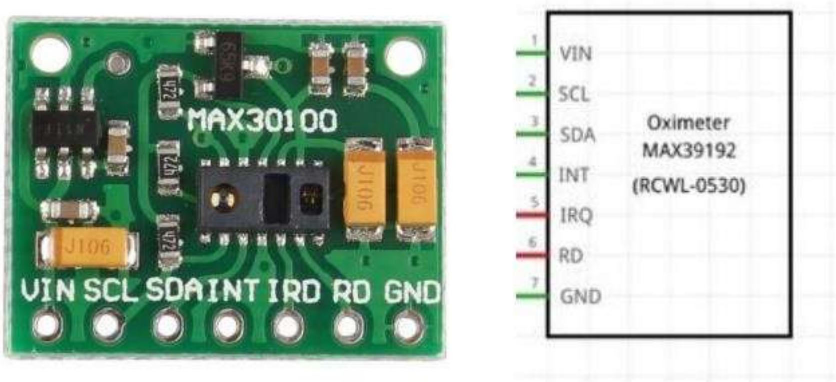

Figure 3. 5:The pulse oximetry (SPO2) Sensor

3.6 Design alternatives.

This subsection illustrates the alternative for NodeMCU ESP32 and explains why we don’t use it. Wemos microcontroller was selected as the microcontroller used in the project in the introduction . But in the introduction discussion it was objected by the Judgement committee and requested to change it to another microcontroller because of its size .

So, Wemos was replaced with Arduino Nano, which is characterized by its small and appropriate size for the project , but it does not support the Internet, so an esp12f was also used to transfer the data to the database using the Internet .

But after working on it for almost a period of two and a half months, we faced many problems in sending the data to the database using the esp21f and In addition to that, the size is not appropriate for the two pieces together to be placed as a watch around the wrist of an elderly person . So the Nano Arduino and esp21f were replaced with a esp32 , as it supports the Internet and is more appropriate to use for the project instead of using two pieces to perform the task of one piece.

Table shows the main difference in specifications for ESP32 and Arduino Nano .

Table 3.1 : ESP32 VS. Arduino Nano

FEATURE	ESP32 NodeMCU	Arduino nano
Price	$11	$29.50
Processor	ESP32	Atmega328P
Clock speed	80 MHz / 160 MHz	16 MHz
Digital I/O Pins	36	14
Analog Input Pins	15	6
WIFI	yes	no
Ethernet MAC Interface	Yes	no
Bluetooth	yes	no

All ESP8266 variants have an ESP8266EX core processor and a Tensilica L106 32-bit microcontroller unit. This is a low cost, high performance, low power consumption, easy to program, wireless SoC(System-On-Chip). Table 2.4 shows the main difference in specifications for ESP8266 and ESP32.

Table 3.2: ESP2866 VS. ESP32

	ESP8266	ESP32
MCU	Xtensa Single-core 32-bit L106	Xtensa Dual-Core 32-bit LX6 with 600 DMIPS
Typical Frequency	80 MHz	160 MHz
802.11 b/g/n Wi-Fi	HT20	HT40
Hardware /Software PWM	None / 8 channels	None / 16 channels
SPI/I2C/I2S/UART	2/1/2/2	4/2/2/2

3.7 Tensor Flow

Tensor Flow is considered an open source library for automated parity, as it is distinguished by its flexibility, start-up and application, and speed, in addition to the most important thing that distinguishes it from being open source for everyone.

"Tensor Flow" has a very high ability to touch on smart services, matching these services nowadays into real products; And that through our agenda, and we learned in the agenda.

“But the most important feature of “Tensor Flow” for a programmer is the ease of expressing his ideas

3.7.1 IoT with firebase

The easy and lightweight way to go about this is to setup an MQTT broker that will act as a hub and reroute all incoming messages published from the device to all subscribed clients like the web application in this case.

Let’s say that you want the app to do both things: display data coming from the broker in realtime and fetch data from the database. In this case you can think of 2 ways (actually there are many different ways) to achieve this:

First solution:

Using this architecture the device will first publish its data to the broker then it will send an HTTP request to the database web-service to save the data. For this solution the device needs to implement 2 clients: an MQTT and an HTTP client.

Second solution:

The other way to go about this is that the device will send or publish its data to the broker, then the broker (as expected) will reroute this message to all connected subscribers like the web app. But this time there’s another subscriber connected which represents an API Engine that will accept this data and send it to the database web-service to be stored.

As you may have noticed in this solution, the HTTP client is decoupled from the device and implemented as a backend service. This way you make the device program much lighter. This is an important thing to keep in mind when developing on constrained IoT devices where resources like CPU and memory are limited.

3.7.2 Firebase to the rescue

Firebase offers many cloud services that ranges from authentication, storage, and cloud functions to hosting your web application. In this article you’ll use 2 services: Realtime Database and Hosting.

what a database is but what does it mean to be realtime here?

A real-time database is a database system which uses real-time processing to handle workloads whose state is constantly changing. This differs from traditional databases containing persistent data, mostly unaffected by time

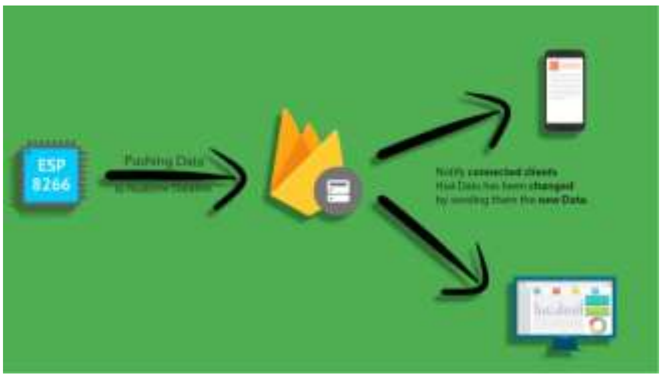

Figure 3.6:Firebase Rescue

Chapter 4

System design

4.1 Overview

The following section has a description of the system, detailed design, and necessary information about the design.

4.2 System block diagram

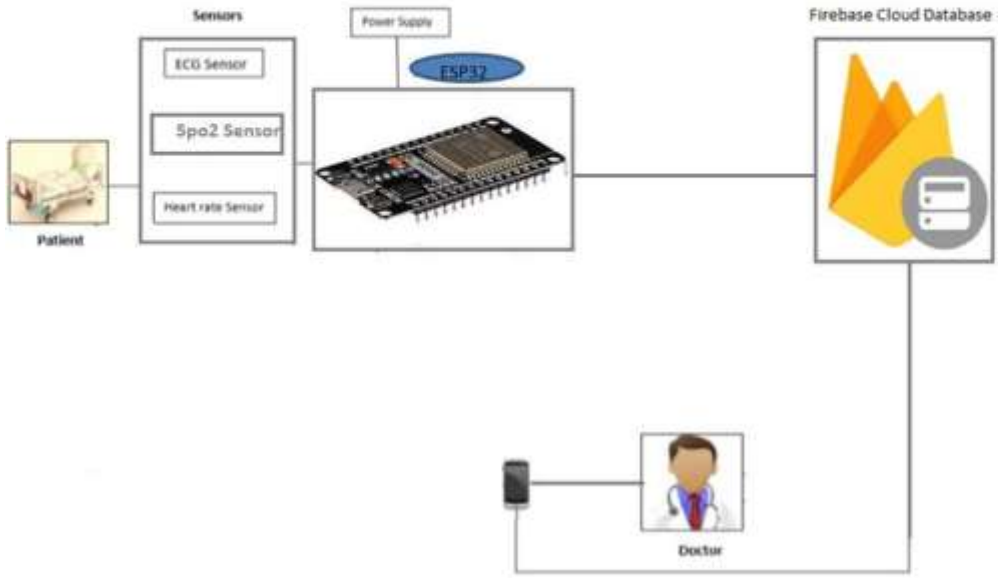

Figure 4. 1:Main block diagram of the The IoT-Based Heart Disease Monitoring System for Pervasive Circuit.

This block diagrams show the project's work, in which vital signs will be taken from the patient using the sensors that we will use, including the ECG sensor, HR sensor, and Spo2 sensor, and then this data will be entered into the IoT network and compared to the database that we have, which is Firebase, and when necessary, Through the wifi network, the process will be delivered to the doctor's device via the ESP32 piece.

4.3 Schematic diagram

Figure 4.2 describes the system elements and how they are connected.

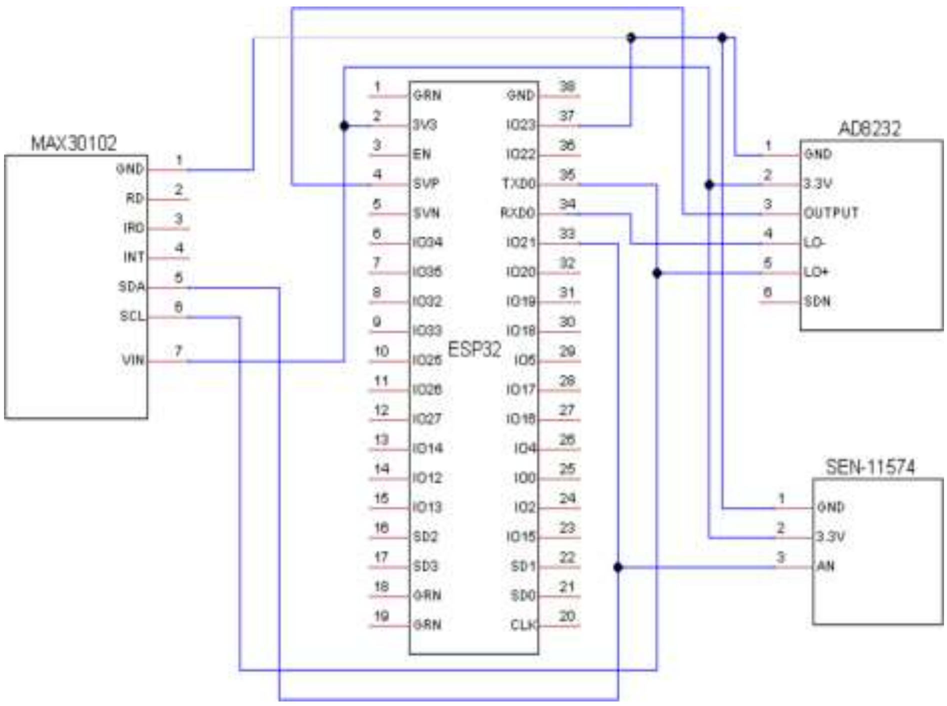

Figure 4.2: Schematic diagram of the The IoT-Based Heart Disease Monitoring System for Pervasive Circuit.

1. **ESP32:** The main component in the system, which will be linked to the other components. Represent the inlet and outlet of the signals and information. It will also send the data to the firebase to display on the care provider mobile application.

2. **AD8232:** It been used to measure ECG signal. ESP32 will receive the sensor analog data readings, then sent it to google firebase to display it to care provider mobile Application.

3. **Pulse Oximeter Sensor :** It been used to measure blood oxygen level. ESP32 will receive the sensor analog data readings, then sent it to google firebase to display it to care provider mobile Application.

4. **Heart Rate Sensor:** It been used to measure heart rate. ESP32 will receive the sensor analog data readings, then sent it to google firebase to display it to care provider mobile Application.

4.4 AD8232 ECG Sensor with ESP32

In this method we are connecting the AD8232 Sensor with ESP32 Wi-Fi and Bluetooth development board to get the ECG graph over Bluetooth with the help of Bluetooth Terminal/Graphics android application found in GooglePlay store. Now Connect the ESP32 with sensor as shown in the below Schematic diagram. Circuit diagram for interfacing ESP 32 and AD8232 Sensor for Bluetooth connection

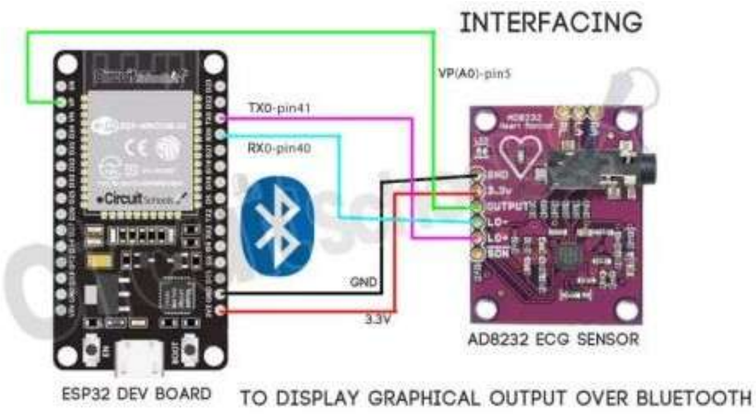

Figure 4.2:AD8232 ECG Sensor Circuit

As per the above connection diagram, we connected 3.3v & GND of sensor to 3.3v &GND of ESP32 respectively, OUTPUT pin of sensor to VP(A0)(pin5) of ESP32 and Finally LO- & LO+ are connected to pin40(RX0) & pin41(TX0) respectively.

4.5 The Pulse Sensor / Heartbeat Sensor(SEN-11574) with ESP32

As we know already that the pulse sensor has three pins that we have to connect with our ESP32. These include the GND, VCC, and signal pin. As the pulse sensor requires an operating voltage in the range of 3.3-5V hence we will connect the VCC terminal of the sensor with 3.3V pin of the ESP32 board. Both the grounds will be in common. Additionally, the analog signal pin of the sensor will be connected with ADC_CH0 pin i.e. GPIO36 of the ESP32.

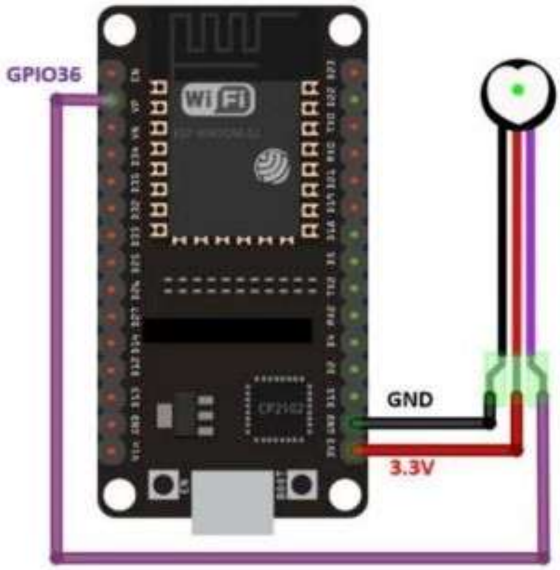

Figure 4.2:The Pulse Sensor / Heartbeat Sensor circuit

4.6 The Pulse Oximetry (MAX30102) Sensor with ESP32

The Circuit assembly for this IoT Pulse oximeter is very simple. Both OLED display and MAX30102 Oximeter Sensor works with the I2C. So, Interface the I2C pins (SCL &SDA) of both modules with D21 and D22 pins of ESP32.

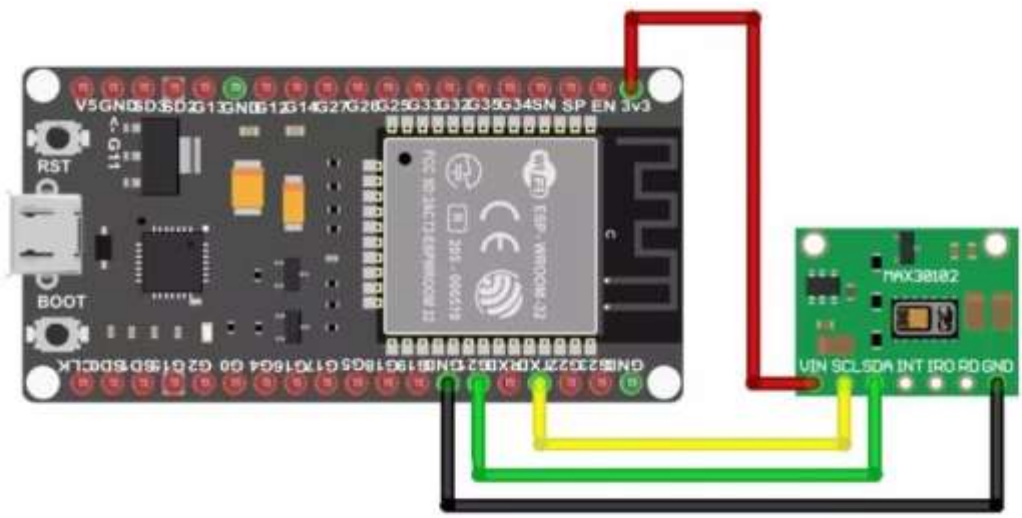

Figure 4. 3:The pulse oximetry (SPO2) Sensor circuit

Similarly, provide 3.3V power to the VCC and Ground the GND pin of both sensors. Basically, you can follow the circuit diagram to make your connections.

4.7 Power Supply

Power banks are used for providing portable power to charge battery powered items like mobile phones and other similar items that have a USB interface: they can charge via USB. Ranging in size from slim, pocket-sized devices up to larger, higher-capacity Power Banks. The industry standard cell used within the Power Bank commonly output 3.7 Volts. This voltage has to be boosted up to 5 Volts via the Power Bank's internal circuitry as this is the standard voltage of a USB interface.

Figure 4.4 : Power Bank

4.8 System Flowchart

An ESP32 microcontroller is necessary in the project to acquire the data from the sensor, analyze them, and provide the display system with the results. It is programmed to work according to the following flowchart.

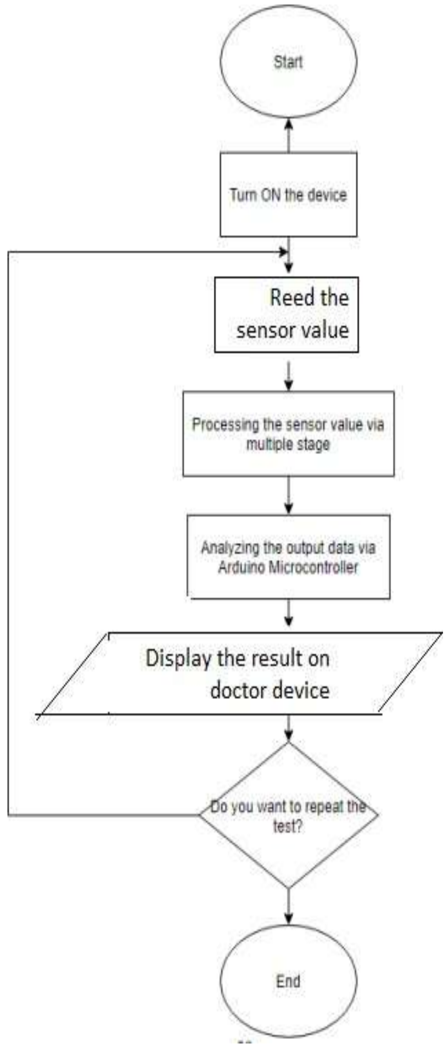

Figure 4. 5:System Flowchart.

Chapter Five

Test and Implementation

In this chapter the hardware system designed in the preceding chapter is implemented to accomplish the project as a one unit which achieves the purpose of the project. In this section, the system circuits will be implemented before final implementations to the system.

5.1 Project Implementation

5.1.1 Sensors Circuit

It is the first stage where the patient is connection with the sensors to measure vital signs through these sensors used in this system

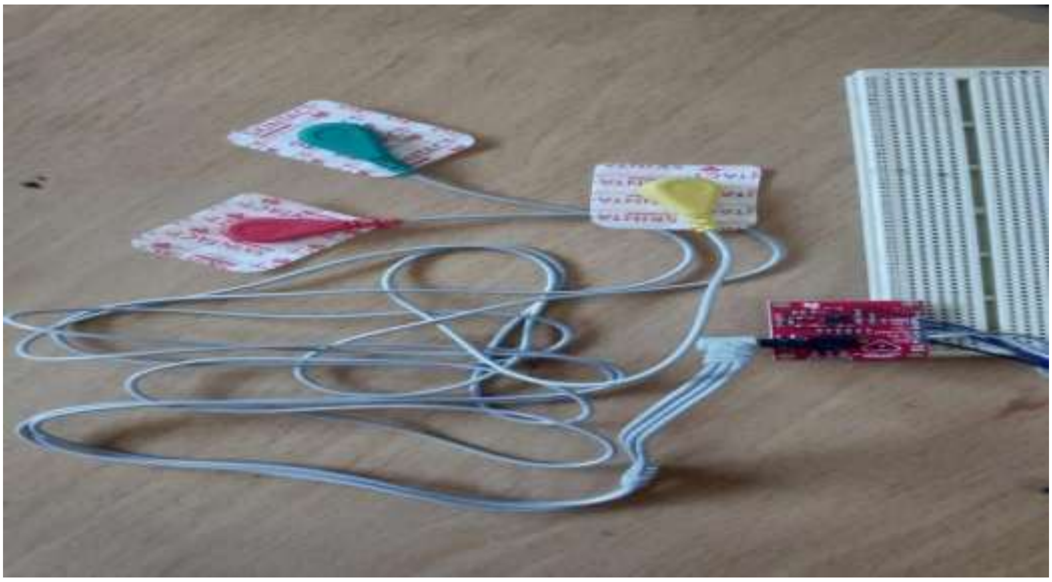

Figure 5.1: ECG Circuit

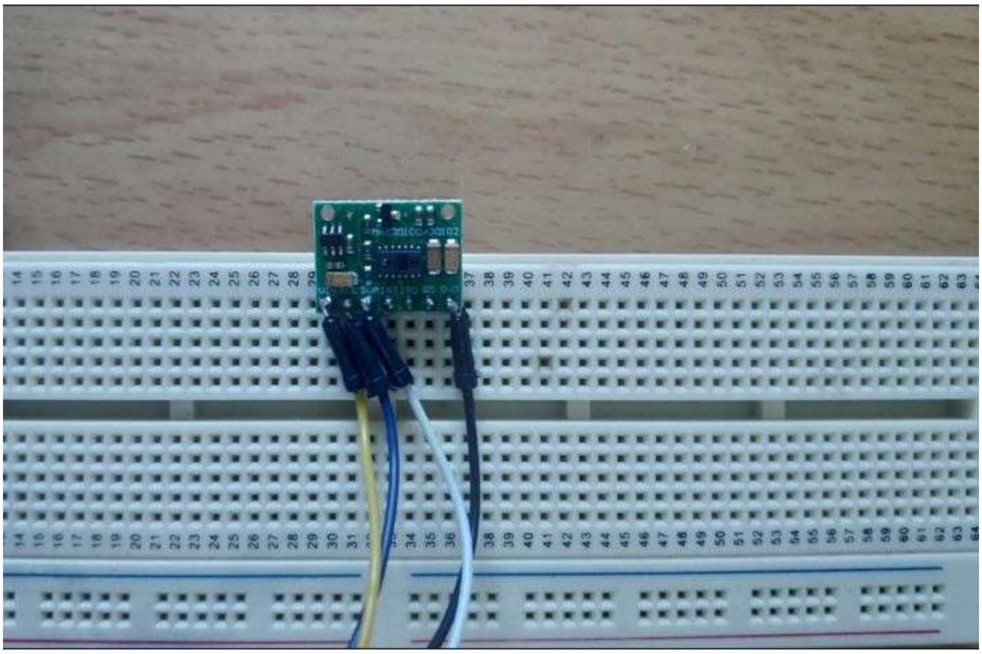

Figure 5.2:Pulse Oximetry Circuit

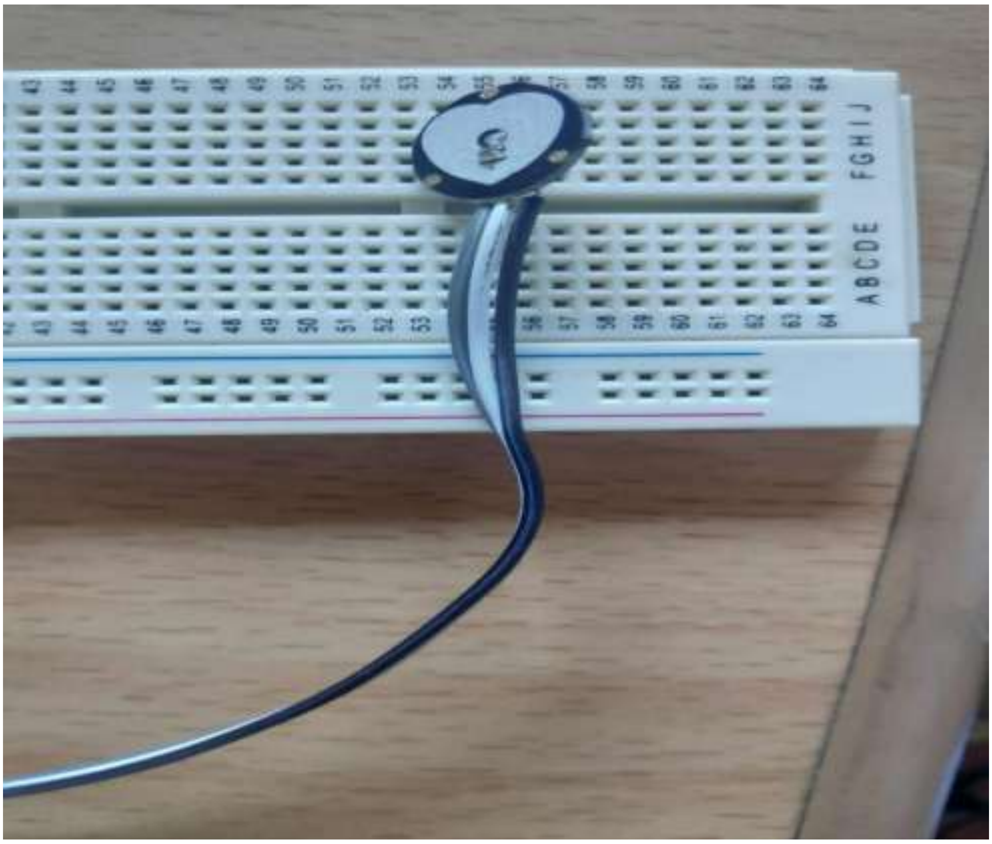

Figure 5.3 :Heart Rate Circuit

5.1.2 Processing circuit

In this stage, all the stages of the system were examined separately by applying the sensors on person to ensure that they performed the required task, as was applied to all stages, and then all the electronic parts were welded to a metal face, and the pieces

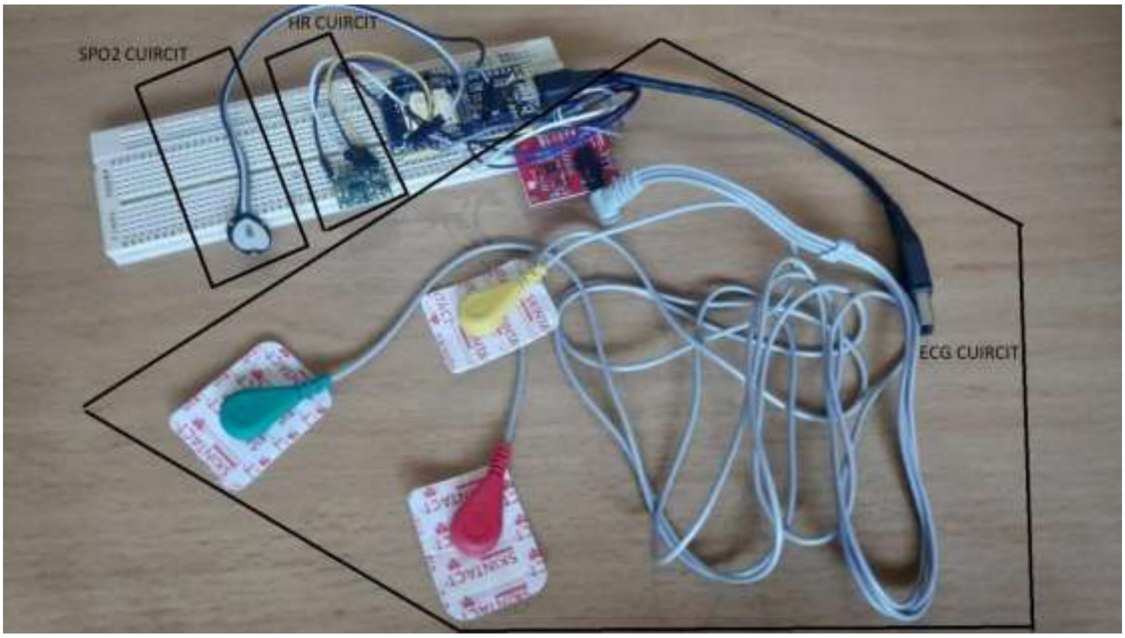

Figure 5.4 Processing circuit

5.1.3 Controller and Display

The app was developed using Mit App Invertor , as it is an excellent tool for implementing mobile applications, whether, for Android. The firebase real-time databases was connected with the app through entering the Firebaase Token and FireBase URL in the Mit App Inverter. When the care provider opens the application, he logs in, through entering user and its password to be checked by DB, and if he does not have an account, a new account can made from entering user and a new password to be added to the Database. With it, after registration, the care provider will be directs to the home page, which contains the ECG signal , heart rate , blood oxygen level.

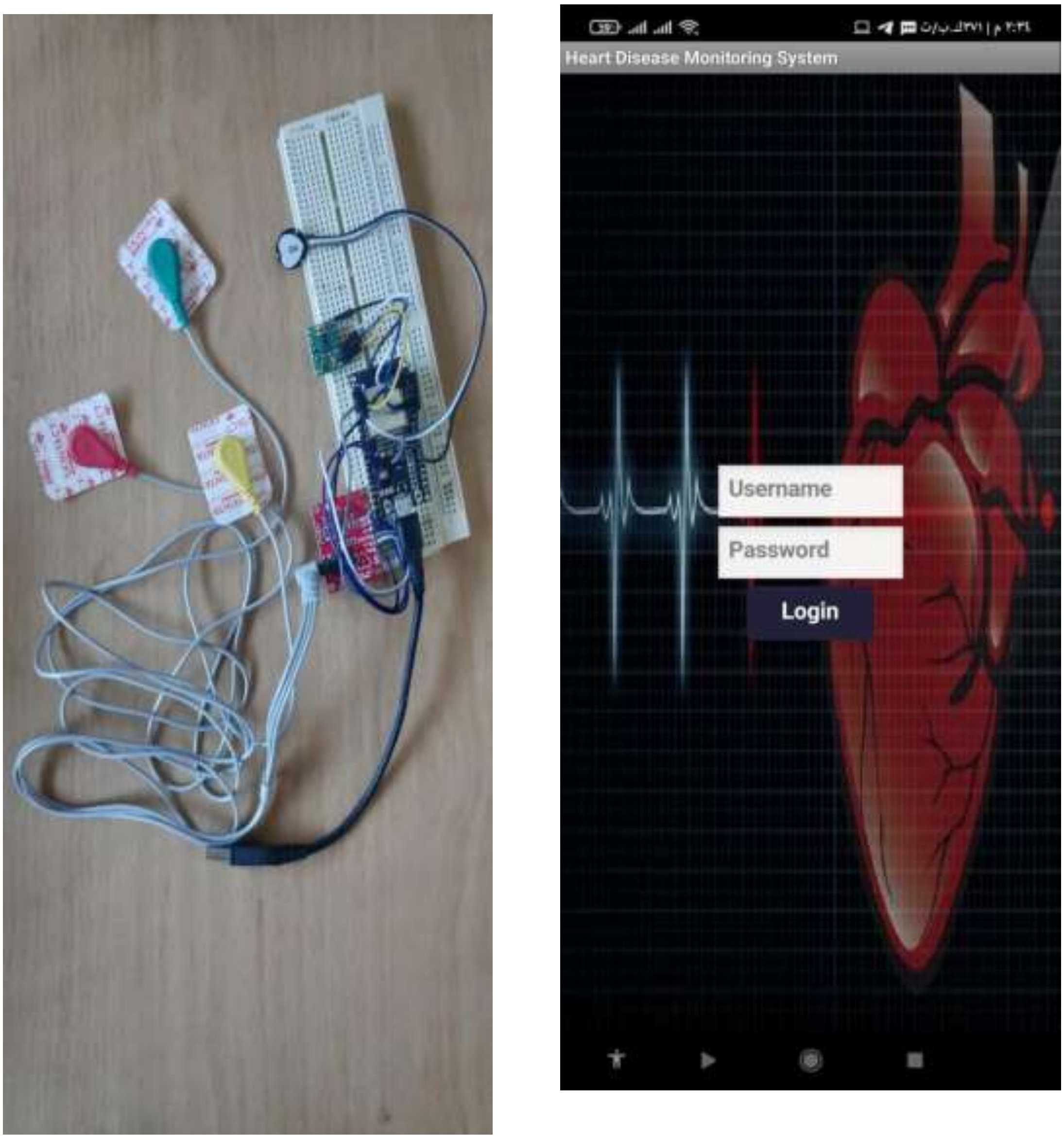

Figure 5.5 Controller and Display

5.2 Project Testing

According to the project objectives, the system is supposed to provide the user with ECG signal and HR and SPO2 value , and The data is stored in the Database in the fields shown in the following figures on the Firebase Realtime Database website:

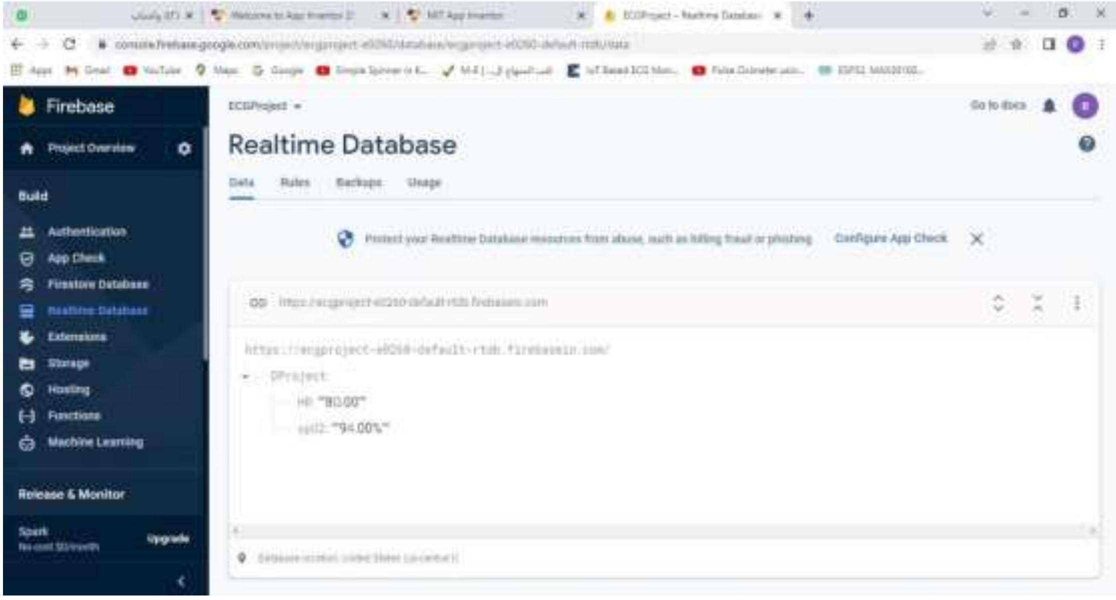

Figure 5.6:Testing data

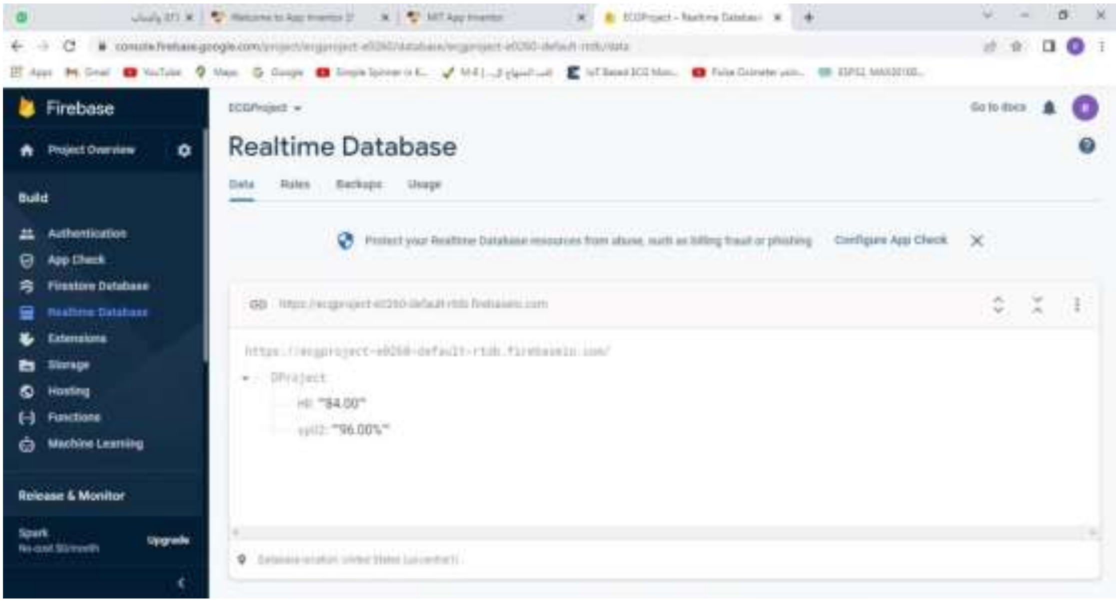

Figure 5.7:Testing data

5.3 Project system

In the fig   shows the parts of the entire project, beginning with the patient placing on the sensors , then on the processing circuit, and then to the ESP32, and then displaying the signal of ECG and HR and SPO2 value related to the patient.

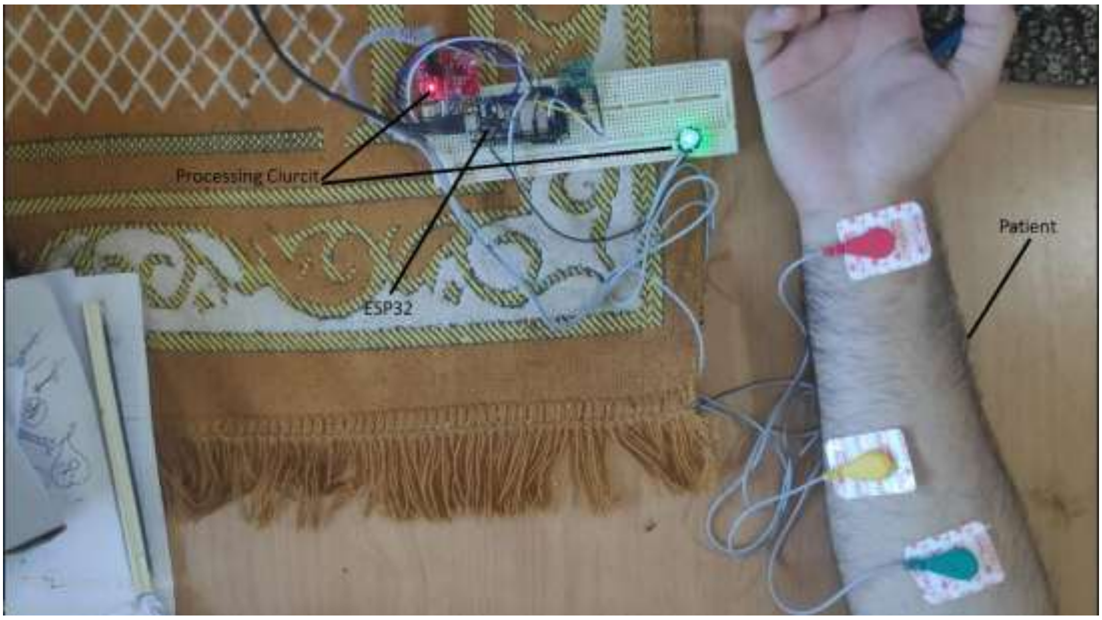

Figure 5.8:System Project

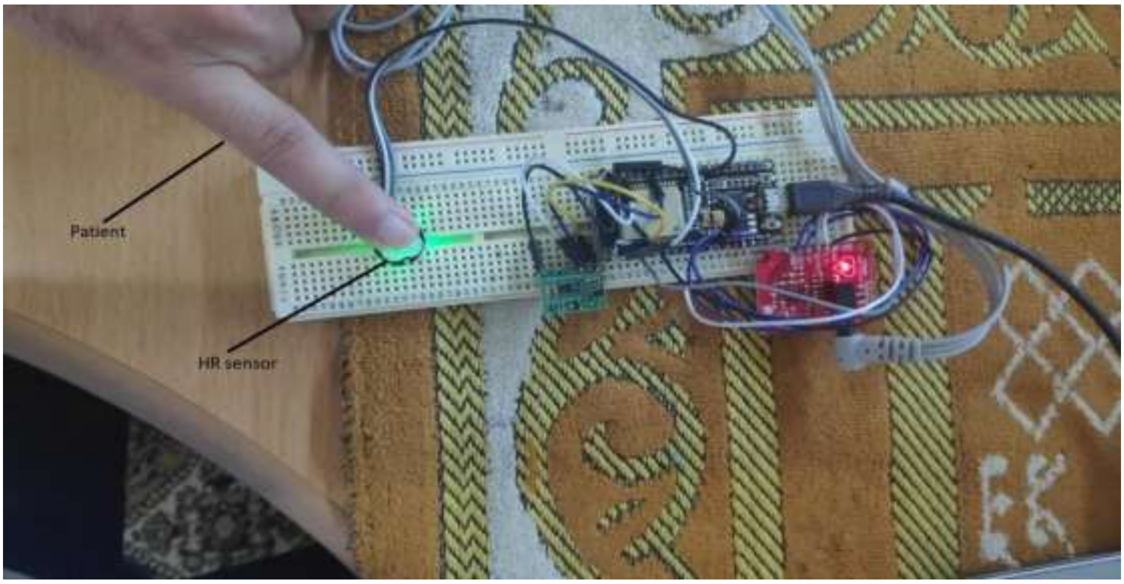

Figure 5.9:Project system

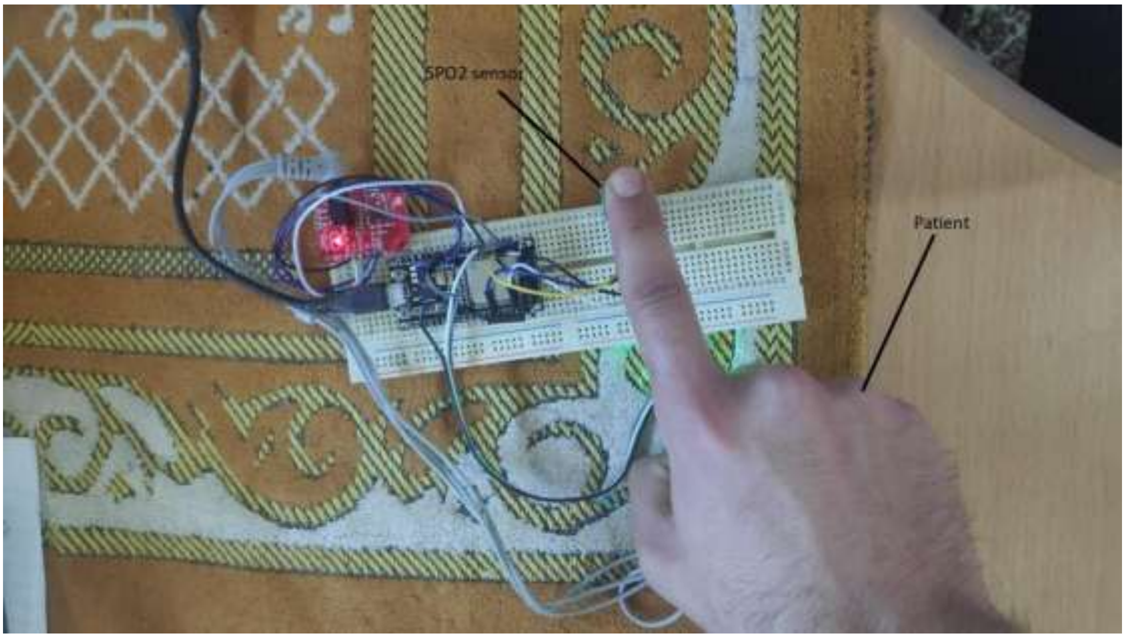

Figure 5.10:Project system

Chapter six

Result and conclusion

6.1 System result

After installing the project, its readings are examined on three people, their ages range from 23 to 50 years old, and then compared with the doctor's result. The result of all readings is close to the true readings. Table shows these readings, also the signal of ECG signal and HR and SPO2 value for normal persons shows in figure.

Table 2. 1:The Result of the System

#	Age	Gender	Result
1	23	Male	Normal
2	35	Male	Normal
3	48	Male	Normal

Figure 6.1:The Result of the System

Figure 6.2:The Result of the System

Figure 6.3:The Result of the System

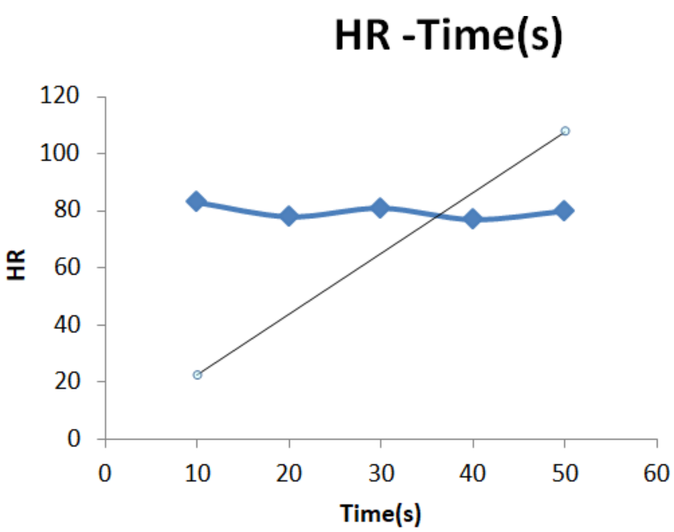

Figure 6.4:The curve of Heart Rate

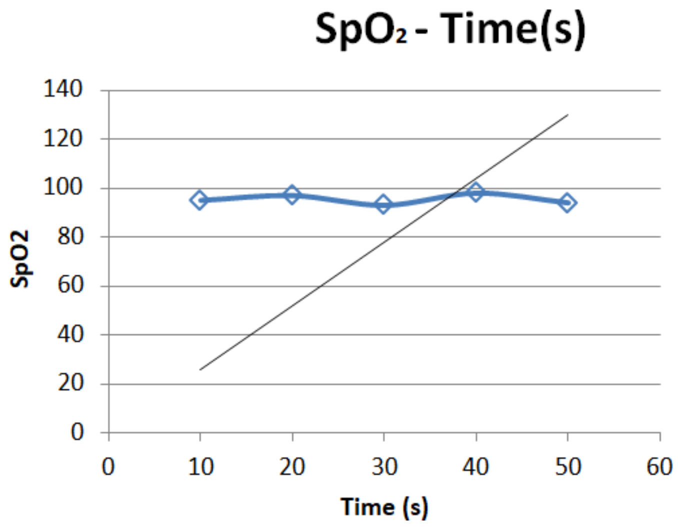

Figure 6.5:The curve of SpO_2

6.2 Conclusion

A Heart Disease Monitoring System can solve many of the problems facing care providers , and that may cause anxiety problems for them because the inability to be around patient all the time due to their daily concerns . In this system, care providers can view all patient data through the mobile application and from wherever they are . This system has been built and verified to work as required to achieve the requirements of this project, and it was found that it works as required and meets the needs of this project.

6.3 Future Work

In the future, we look forward to adding important features to the system, the most important of which are:

- System development for making calls and sending messages error.
- Developing the system to determine the patient's temperature and location.
- Provide the system with a fall sensor so that it detects the moment the user falls to the ground to issue an audible alarm.
- Develop the system to deal directly with emergency cases and call the ambulance.

6.4 Challenges

Challenges is normal, especially when one develops their first project, but solving these problems is a success. Below are the main challenges that were raised during the development of the system.

- Some project components are not available at the beginning of the semester, and the procurement process for components took a lot of time.
- Some devices were damaged because of their high sensitivity, so new devices were purchased.
- Heart rate and pulse oximeter sensor (MAX30100) and temperature sensor (MLX90614) works perfectly in separate, but when combining the two sensors, MAX30100 sensor gives zeros.
- Heart rate and pulse oximeter sensor (MAX30100) works correctly, but when trying to send these readings to the firebase, it gives zero for both heart rate and blood oxygen level in the firebase. This problem cost us a long time and a lot of effort to solve.

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Appendix A

AD8232 ECG SENSOR

Appendix B

THE PULSE SENSOR

Appendix C

THE PULSE OXIMETER SENSOR

Appendix D

ESP32