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Design of Warning System Module for Abnormal Heart Rate Detection

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Abstract: Healthcare and the health of people is an important need of the human population. Heart rate is a very important vitals related to the health of a person. The ability to monitor this vital sign is key to ensure proper medical care is delivered early. In this paper, a system to monitor the heart rate of a user and alert the user when these values are abnormal is proposed by using IoT system. Warning System Module (WSM) consists mainly of two components, a hardware unit, and a Telegram application. The hardware unit contains a sensor to monitor the heart rate of the user, which is displayed on an LCD screen and an ESP32 microcontroller that identifies normal/abnormal sensor readings. When the sensor records an abnormal heart rate, an alert message is sent via Wi-Fi to the Telegram application through the ESP32, and the user will also know the exact time that he suffers from a heartbeat above or below the normal limit By the time of the message sent by the telegram bot. From the results recorded using a WSM for different ages and genders, it was concluded that average heart rates did not differ between age groups or gender. But with age when doing exercise, it may take longer for the pulse to increase and then slow down. Heart rate strength decreased with age in both men and women. e.g. The results showed that the average heart rate at moderate exercises for (20-30) age groups is 114.1 bpm higher than the average heart rate for (50-60) age groups is 99.05 bpm.

Keywords: Warning System Module (WSM), ESP32, Internet of Things (IoT), WiFi network, Telegram Bot, Liquid Crystal Display (LCD) screen, tachycardia, bradycardia.

Chapter one

Introduction

1.1 Cardiovascular disease

Cardiovascular disease is one of the main causes of death in many countries and thus it accounts for the over 15 million deaths worldwide. In addition, several million people are disabled by cardiovascular disease [1]. The delay between the first symptom of any cardiac ailment and the call for medical assistance has a large variation among different patients and can have fatal consequences. One critical inference drawn from epidemiological data is that deployment of resources for early detection and treatment of heart disease has a higher potential of reducing fatality associated with cardiac disease than improved care after hospitalization. Hence new strategies are needed in order to reduce time before treatment. Monitoring of patients is one possible solution. Also, the trend towards an independent lifestyle has also increased the demand for personalized non-hospital based care. Cardiovascular disease has shown that heart beat rate plays a key role in the risk of heart attack. Heart disease such as heart attack, coronary heart disease, congestive heart failure, and congenital heart disease is the leading cause of death for men and women in many countries. Most of the time, heart disease problems harm the elderly person. Very frequently, they live with their own and no one is willing to monitor them for 24 hours a day [1].

1.2 Internet of Things

Internet of Things can be defined as "an open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment" [2].

1.3 The Role of IoT in Heart Rate Detection

According to the recent statistics, millions of people suffer from the heart attack in the world. World Health Organization (WHO) reports that heart disease rate might increase to 23.3% worldwide by the year 2030. The treatment of such chronic disease requires continuous and long term monitoring to have proper control on it. IoT (Internet Of Things) helps to move from manual heart rate monitoring systems to remote heart rate monitoring systems A doctor may not be present all the time to provide medication or treatment to the patients or a guardian may not be present all the time to take the patient to the hospital .

Hence, proposed system is the right solution for this problem.The Warning System Module (WSM) is a device to monitor the heart rate and alert the user when a heartbeat occurs above or below the normal limit by sending alarm message to Telegram application through WiFi network.

1.4 Heart Rate Detection

A heart rate detection (HRD) is a detection the number of contractions (beats) of the heart per minute (bpm). The heart rate can vary according to the body's physical needs, including the need to absorb oxygen and excrete carbon dioxide, but is also modulated by a myriad of factors including but not limited to genetics, physical fitness, stress or psychological status, diet, drugs, hormonal status, environment, and disease/illness as well as the interaction between and among these factors [3]. It is usually equal or close to the pulse measured at any peripheral point.

1.5 Motivation and Scope of the Resarch

Motivation of work is the seeing of the new techniques such as Internet of Things (IoT) and other technologies that used in the industrial of developed countries and try to apply it on a prototype of medical device and sensors.

The scope of work is to collect data from people of different genders and ages and monitor their heart health through a mobile device to take advantage of the benefits behind the Internet of Things.

1.6 The aim of project The aim of current study are :

1. Monitoring of heart rate and know the times of tachycardia and bradycardia to prevent cardiovascular disease.
2. Helping people who do not have a guardian by monitoring them from afar via IoT system.
3. Connecting IoT technology in the field of medical devices.

4. Link some social media programs, such as the Telegram application for health monitoring.
5. The device is small in size and easy to use for all age groups.
6. Assist the doctor in diagnosis to know the patient's record and pre-recorded readings.

1.7 Literature Review

Previous Studies:

Nusrat et al. , 2016: A method and apparatus for monitoring heart rate of the heart using a wearable system is de-signed and implemented . A heart rate receives from heart beat signals and stores the data to a database and after a time period this method can determine an idle heart rate of the monitoring body. This idle heart rate is compared with the stored data and can determine the normal and abnormal heart rate variability. After the certain time period this system can detect the heart rate and also can send a signal to the user in time of abnormalities. Consequent estima-tions of heart rate variability are contrasted [4].

Ufoaroh et al. , 2015: This work presents a system that is capable of providing real time remote monitoring of the heartbeat with improvements of an alarm and SMS alert.

Aims of this work is The design and implementation of a low cost but efficient and flexible heartbeat monitoring and alert system using GSM technology. It is designed in such a way that the heartbeat/pulse rate is sensed and measured by the sensors which sends the signals to the control unit for proper processing and determination of the heartbeat rate which is displayed on an LCD, it then proceeds to alert by an alarm and SMS sent to the mobile phone of the medical expert or health personnel, if and only if the threshold value of the heartbeat rate is maximally exceeded. Thus this system proposes a continuous, real time, remote, safe and accurate monitoring of the heartbeat rate and helps in patient's diagnosis and early and preventive treatment of cardiovascular ailments [5] .

P. Srinivasan et al. , 2020: The various heart rate analysis method is available in medical field like ECG and pulse sensing system this pulse analysis is depends on the blood force of heart artery. This artery is closed to the skin in that reason the pulse is identified easily. The proposed system analysis the pulse rate in the way of fingertip using Arduino controller, and it’s based on photo phelthysmo graphy principle. This method to analysis the blood pressure difference and identified the variations of the value of blood pressure and send to the controller. The function of heart beat is occur the whole body blood is pumping, so it depends upon the fingertip blood artery is also change. This type of changes is identified with help of the heart beat sensor is placed in the finger to measure the value, and the signal is send to the controller via serial communication system it is help to monitoring the heart beat range. The photo diode and infra-red led is placed in the sensor to detect the blood volume, the infrared diode is transmit the infrared light to the fingertip, this light passing over the blood inside arteries of finger. The photo diode is analysis the light signal and reflected back to the device, so the difference between the light signal the value is send to the controller. It is continuously processed in the every circulation of blood in the fingertip region, and send the variation of changes in the light signal to the controller via serial communication. The reflected light is converted into the pulse range to easily identify the heart beat range [6].

Poltak et al. , 2020: This study proposes of measuring technique of heart rate by using pulse sensor, Arduino microcontroller, and Android Smartphone. It is based on the principle of measuring the variation of blood volume in our body using a light source and detector. We also measure the heart rate by using the ECG or EKG (electrocardiogram) waveform as the comparison result of the pulse sensor with ECG waveform. The sensor consists of an infrared light-emitting-diode (LED) and a photodiode. The LED transmits an infrared light into the fingertip which is reflected back from the blood inside of finger arteries. The results show that this tool can detect the value of the heart rate and is displayed on the screen of an Android. The sensor takes under 10 seconds to detect the value of the heart rate. Notification via SMS will be sent the heart rate such as under normal conditions (BPM, Beat Per Minute <50, normal (BPM= 60 to 100) or above normal (BPM> 100) [7].

Franchini 2019: In this study, It was designed and implemented a low cost fully portable Electrocardiographic (ECG)monitoring system using android smartphone and Arduino. The results obtained by the device were tested comparing them with those obtained from a traditional ECG used in clinical practice on 70 people, in resting and under activity conditions. The values of beats per minute (BPM), ECG waveform and ECG parameters were identical, and presented a sensitivity of 97.8% and a specificity of 78.52% [8].

Sethuraman et al. , 2019: In this study, an IoT based system has been implemented that can monitor the heartbeat from the output given by a hardware system consisting of a NodeMCU and pulse sensor. Further, an alert system is added which is executed if the heartbeat goes below or above the permissible level given in the devised algorithm. The alert message is received by the doctor through a mobile phone application. By using this prototype the doctors can access the heartbeat data of the patient from any location. The nurses or the duty doctor available at the hospital can monitor the heart rate of the patient in the serial monitor through the real-time monitoring system. The real-time monitoring is done via Adafruit, this platform is more secure to store the information and uses MQTT protocol which has lots of advantages over others. IFTTT protocol is also used to create conditional statements called applets.

The prototype is integrated with GPS technology to monitor the live location of the device from any part of the world and uses a local server to provide security, privacy and low latency. The heartbeat data and other personal details of the patient are stored in the cloud, this can be utilized for future studies on the health condition of the patient. The prototype is realized using NodeMCU, pulse sensor, Adafruit, and Blynk cloud [9].

Grace and Ledisi 2020: This study presents heart attack detection using Electrocardiogram (ECG) signal processing. The methodology adopted for this work is the Dynamic Software Development Methodology. The system was designed using Python programming language and it acquires ECG signal in the form of datasets, processes it and extracts important parameters like PQRST to detect heart abnormalities [10].

Yusuf et al. , 2019: In this study, Any abnormality in the heart rhythm from the normal range is called arrhythmia. It may be due to lower or faster heart rate and the reason of other severe phenomena like Atrial and Ventricular fibrillation which are the most severe arrhythmias. Most of the cardiovascular deaths occurs due to arrhythmogenesis. Therefore, continuous heart rate monitoring is critical for patients who are in the high risk of cardiac events like the patients who have previous heart attacks. ECG based devices are commonly used for this type of monitoring. However, ECG recording needs placement of ECG electrodes and needs at least two limbs for recording. Chest leads ECG are sometimes uncomfortable for continuous monitoring. Therefor. PPG sensors are getting popularity for measuring heart rate as it can easily recorded from only fingertip or earlobe and does not require any adhesive gels. Considering the situations, we proposed a design of a heart rate measuring system using a low-cost available PPG sensor for the patients who need to monitor their heart rate at home especially at rural areas where clinical facilities are not much available. This system will continuously monitor the heart rate and in case of any abnormality of heart rhythm, the system will inform the concerned person immediately through the GSM module as well as an alarm will ring automatically. In the proposed system the MAX30102 pulse oximetry biosensor is used.

Moreover, to check the reliability of the heart rate detection, we have used the KardiaMobile data to compare the PPG sensor based reading, which is an FDA approved clinical grade single-lead ECG monitoring device. Promising results were found which indicate that the low-cost PPG biosensor can be used as portable Arrhythmia detection device [11].

Poltak et al., 2018: In this study , it was propose a method that can detect heartbeats that are detect directly and can be shared to several telephone numbers of family users, hospitals, paramedics, or private doctors. It was developed an internet of thing method that integrates a pulse sensor, microcontrollers and Wi-Fi series data communication device modules ESP8266. The detection of pulse sensors attached of the patient's body (users) and the microcontroller will be sent in a real time by the ESP8266 circuit module to the several smartphone numbers that have been set it before. The result and benefit of this method is that the patient (user) can be helped immediately if there is a heart rate abnormality, because of the heart rate detection results will spread to the several other people so that the patient (user) can be helped immediately before the condition becomes more fatal [12].

Santhanakrishnan et al. , 2019: In this study, a prototype has been created that senses the pulse rate of a patient in need by using a heartbeat sensor that is wearable. The beats per minute are calculated and stored in the microcontroller which then transmits the stored value to the LCD screen for the user to view. This value is also transmitted over the internet to an open sourced platform using a WiFi module.When the pulse rate falls below 60 bpm or crosses over 110 bpm, an alert is sent to the required people that vie patient is in danger. In future, a GPS tracker can also be added in order to transmit addresses of nearby hospitals to the patient at the time of danger or immediate assistance [13].

Chapter two

Theoretical basis

2.1 Introduction

This chapter will describe the general anatomy and electricity of the heart, as well as the working mechanism of heart rate sensors and mathematical models.

2.2 General view of heart anatomy

The heart is a hollow muscular organ that is somewhat pyramid shaped and lies within the pericardium in the mediastinum , It is connected at its base to the great blood vessels but otherwise lies free within the pericardium.

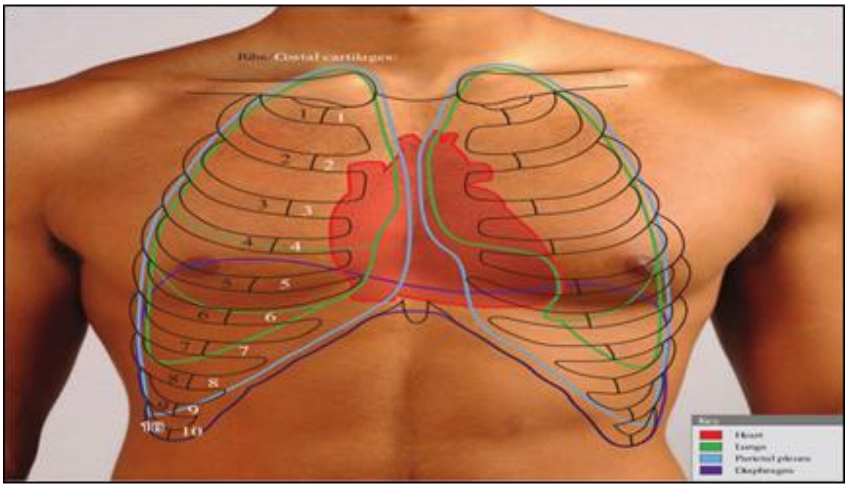


Figure (2.1) location of the heart in the thoracic cavity

2.3 Pericardium

The pericardium is a fibroserous sac that encloses the heart and the roots of the great vessels. Its function is to restrict excessive movements of the heart as a whole and to serve as a lubricated container in which the different parts of the heart can contract. The pericardium lies within the middle mediastinum posterior to the body of the sternum and the 2nd to the 6th costal cartilages and anterior to the 5th to the 8th thoracic vertebrae [14].

2.3.1 Fibrous Pericardium

The fibrous pericardium is the strong fibrous part of the sac. It is firmly attached below to the central tendon of the diaphragm. It fuses with the outer coats of the great blood vessels passing through it namely, the aorta, the pulmonary trunk, the superior and inferior venae cavae, and the pulmonary veins.The fibrous pericardium is attached in front to the sternum by the sternopericardial ligaments [14] .

2.3.2 Serous Pericardium

The serous pericardium lines the fibrous pericardium and coats the heart. It is divided into parietal and visceral layers.

The parietal layer lines the fibrous pericardium and is reflected around the roots of the great vessels to become continuous with the visceral layer of serous pericardium that closely covers the heart.

The visceral layer is closely applied to the heart and is often called the epicardium. The slitlike space between the parietal and visceral layers is referred to as the pericardial cavity Normally, the cavity contains a small amount of tissue fluid (about 50 mL), the pericardial fluid, which acts as a lubricant to facilitate movements of the heart [14].

2.3.3 Pericardial Sinuses

On the posterior surface of the heart, the reflection of the serous pericardium around the large veins forms a recess called the oblique sinus Also on the posterior surface of the heart is the transverse sinus, which is a short passage that lies between the reflection of serous pericardium around the aorta and pulmonary trunk and the reflection around the large veins. The pericardial sinuses form as a consequence of the way the heart bends during development ,They have no clinical significance [14].

2.3.4 Nerve Supply of the Pericardium

The fibrous pericardium and the parietal layer of the serous pericardium are supplied by the phrenic nerves. The visceral layer of the serous pericardium is innervated by branches of the sympathetic trunks and the vagus nerves [14].

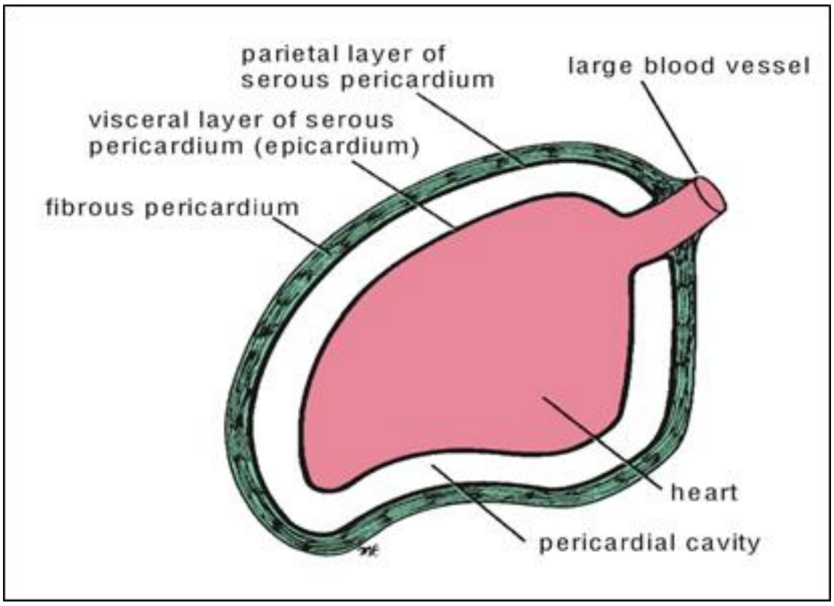


Figure (2.2) Different layers of pericardium

2.4 Surfaces of the Heart

The heart has three surfaces: sternocostal (anterior), diaphragmatic (inferior), and a base (posterior). It also has an apex, which is directed downward, forward, and to the left.

The sternocostal surface is formed mainly by the right atrium and the right ventricle, which are separated from each other by the vertical atrioventricular groove. The right border is formed by the right atrium, the left border, by the left ventricle and part of the left auricle. The right ventricle is separated from the left ventricle by the anterior interventricular groove.

The diaphragmatic surface of the heart is formed mainly by the right and left ventricles separated by the posterior interventricular groove. The inferior surface of the right atrium, into which the inferior vena cava opens, also forms part of this surface.

The base of the heart, or the posterior surface, is formed mainly by the left atrium, into which open the four pulmonary. The base of the heart lies opposite the apex.

The apex of the heart, formed by the left ventricle, is directed downward, forward, and to the left .It lies at the level of the fifth left intercostal space, 3.5 in. (9 cm) from the midline. In the region of the apex, the apex beat can usually be seen and palpated in the living patient. Note that the base of the heart is called the base because the heart is pyramid shaped; the base lies opposite the apex. The heart does not rest on its base; it rests on its diaphragmatic (inferior) surface [14].

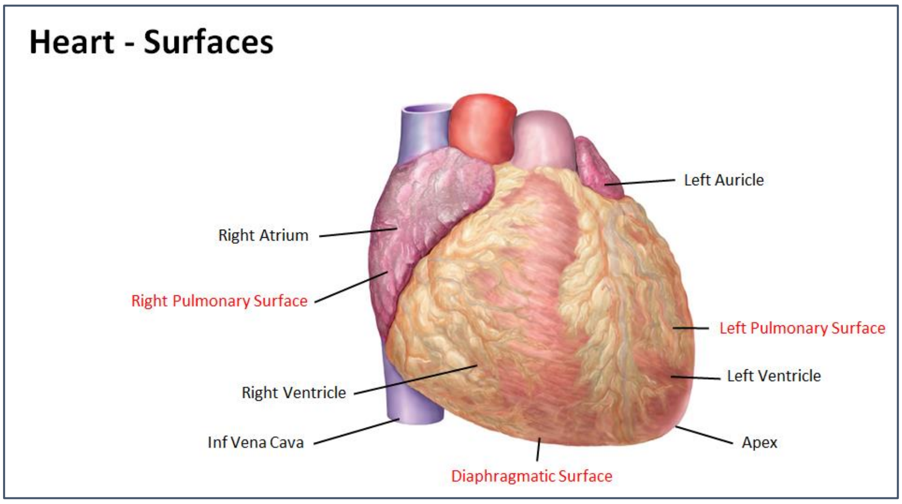


Figure (2.3) Heart Surfaces

2.5 Borders of the Heart

The right border is formed by the right atrium; the left border, by the left auricle; and below, by the left ventricle,The lower border is formed mainly by the right ventricle but also by the right atrium; the apex is formed by the left ventricle. These borders are important to recognize when examining a radiograph of the heart [14].

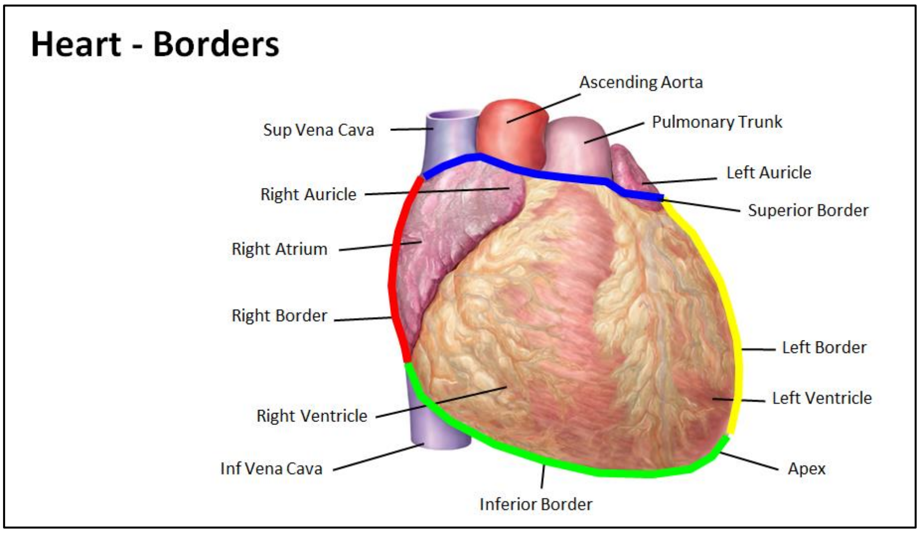


Figure (2.4) Heart Borders

2.6 Chambers of the Heart

The heart is divided by vertical septa into four chambers: the right and left atria and the right and left ventricles. The right atrium lies anterior to the left atrium, and the right ventricle lies anterior to the left ventricle.

The walls of the heart are composed of cardiac muscle, the myocardium; covered externally with serous pericardium, the epicardium and lined internally with a layer of endothelium, the endocardium [14].

Right Atrium

The right atrium consists of a main cavity and a small out- pouching, the auricle .On the outside of the heart at the junction between the right atrium and the right auricle is a vertical groove, the sulcus terminalis, which on the inside forms a ridge, the crista terminalis. The main part of the atrium that lies posterior to the ridge is smooth walled and is derived embryologically from the sinus venosus. The part of the atrium in front of the ridge is roughened or trabeculated by bundles of muscle fibers, the musculi pectinati, which run from the crista terminalis to the auricle. This anterior part is derived embryologically from the primitive atrium [14] .

Openings into the Right Atrium

The superior vena cava opens into the upper part of the right atrium; it has no valve. It returns the blood to the heart from the upper half of the body. The inferior vena cava (larger than the superior vena cava) opens into the lower part of the right atrium; it is guarded by a rudi- mentary, nonfunctioning valve. It returns the blood to the heart from the lower half of the body.

The coronary sinus, which drains most of the blood from the heart wall, opens into the right atrium between the inferior vena cava and the atrioventricular orifice. It is guarded by a rudimentary, nonfunctioning valve.The right atrioventricular orifice lies anterior to the inferior vena caval opening and is guarded by the tricuspid valve. Many small orifices of small veins also drain the wall of the heart and open directly into the right atrium [14] .

Fetal Remnants

In addition to the rudimentary valve of the inferior vena cava are the fossa ovalis and anulus ovalis. These latter structures lie on the atrial septum, which separates the right atrium from the left atrium , The fossa ovalis is a shallow depression, which is the site of the foramen ovale in the fetus ,The anulus ovalis forms the upper margin of the fossa. The floor of the fossa represents the persistent septum primum of the heart of the embryo, and the anulus is formed from the lower edge of the septum secundum [14].

Right Ventricle

The right ventricle communicates with the right atrium through the atrioventricular orifice and with the pulmonary trunk through the pulmonary orifice .As the cavity approaches the pulmonary orifice, it becomes funnel shaped, at which point it is referred to as the Infun-dibulum [14].

Infun-dibulum

The walls of the right ventricle are much thicker than those of the right atrium and show several internal projecting ridges formed of muscle bundles. The projecting ridges give the ventricular wall a spongelike appearance and are known as trabeculae carneae. The trabeculae carneae are composed of three types. The first type comprises the papillary mus- cles, which project inward, being attached by their bases to the ventricular wall; their apices are connected by fibrous chords (the chordae tendineae) to the cusps of the tricuspid valve .The second type is attached at the ends to the ventricular wall, being free in the middle. One of these, the moderator band, crosses the ventricular cavity from the septal to the anterior wall. It conveys the right branch of the atrioventricular bundle, which is part of the conducting system of the heart. The third type is simply composed of prominent ridges.

The tricuspid valve guards the atrioventricular orifice and consists of three cusps formed by a fold of endocardium with some connective tissue enclosed: anterior, septal, and inferior (posterior) cusps. The anterior cusp lies anteriorly, the septal cusp lies against the ventricular septum, and the inferior or posterior cusp lies inferiorly. The bases of the cusps are attached to the fibrous ring of the skeleton of the heart whereas their free edges and ventricular surfaces are attached to the chordae tendineae.

The chordae tendineae connect the cusps to the papillary muscles. When the ventricle contracts, the papillary muscles contract and prevent the cusps from being forced into the atrium and turning inside out as the intraventricular pressure rises. To assist in this process, the chordae tendineae of one papillary muscle are connected to the adjacent parts of two cusps.The pulmonary valve guards the pulmonary orifice and consists of three semilunar cusps formed by folds of endocardium with some connective tissue enclosed. The curved lower margins and sides of each cusp are attached to the arterial wall.

The open mouths of the cusps are directed upward into the pulmonary trunk. No chordae or papillary muscles are associated with these valve cusps; the attachments of the sides of the cusps to the arterial wall prevent the cusps from prolapsing into the ventricle.

At the root of the pulmonary trunk are three dilatations called the sinuses, and one is situated external to each cusp. The three semilunar cusps are arranged with one posterior (left cusp) and two anterior (anterior and right cusps) [14]. (The cusps of the pulmonary and aortic valves are named according to their position in the fetus before the heart has rotated to the left. This, unfortunately, causes a great deal of unnecessary confusion.) During ventricular systole, the cusps of the valve are pressed against the wall of the pulmonary trunk by the outrushing blood. During diastole, blood flows back toward the heart and enters the sinuses; the valve cusps fill, come into apposition in the center of the lumen, and close the pulmonary orifice.

Left Atrium

Similar to the right atrium, the left atrium consists of a main cavity and a left auricle. The left atrium is situated behind the right atrium and forms the greater part of the base or the posterior surface of the heart Behind it lies the oblique sinus of the serous pericardium, and the fibrous pericardium separates it from the esophagus, The interior of the left atrium is smooth, but the left auricle possesses muscular ridges as in the right auricle [14].

Openings into the Left Atrium

The four pulmonary veins, two from each lung, open through the posterior wall and have no valves. The left atrioventricular orifice is guarded by the mitral valve.

Left Ventricle

The left ventricle communicates with the left atrium through the atrioventricular orifice and with the aorta through the aortic orifice. The walls of the left ventricle , are three times thicker than those of the right ventricle. (The left intraventricular blood pressure is six times higher than that inside the right ventricle.) In cross section, the left ventricle is circular; the right is crescentic because of the bulging of the ventricular septum into the cavity of the right ventricle ,There are well- developed trabeculae carneae, two large papillary muscles, but no moderator band [14].

The part of the ventricle below the aortic orifice is called the aortic vestibule.The mitral valve guards the atrioventricular orifice ,It consists of two cusps, one anterior and one posterior, which have a structure similar to that of the cusps of the tricuspid valve. The anterior cusp is the larger and intervenes between the atrioventricular and aortic orifices. The attachment of the chordae tendineae to the cusps and the papillary muscles is similar to that of the tricuspid valve.

The aortic valve guards the aortic orifice and is precisely similar in structure to the pulmonary valve .One cusp is situated on the anterior wall (right cusp) and two are located on the posterior wall (left and posterior cusps). Behind each cusp, the aortic wall bulges to form an aortic sinus. The anterior aortic sinus gives origin to the right coronary artery, and the left posterior sinus gives origin to the left coronary artery [14].

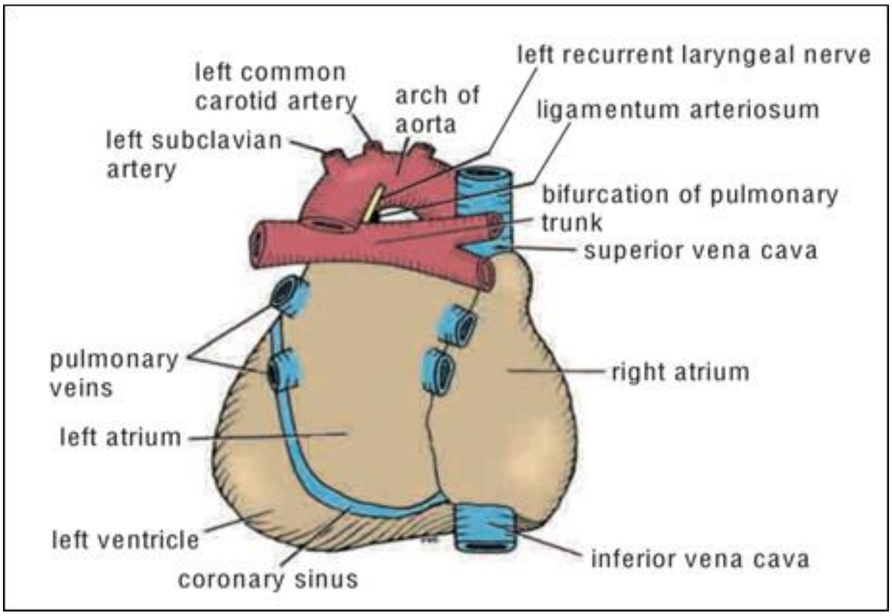


Figure (2.5) the posterior surface of the heart

2.7 Conducting System of the Heart

The normal heart contracts rhythmically at about 70 to 90 beats per minute in the resting adult. The rhythmic contractile process originates spontaneously in the conducting system and the impulse travels to different regions of the heart, so the atria contract first and together, to be followed later by the contractions of both ventricles together. The slight delay in the passage of the impulse from the atria to the ventricles allows time for the atria to empty their blood into the ventricles before the ventricles contract [14].

The conducting system of the heart consists of specialized cardiac muscle present in the sinuatrial node, the atrioventricular node, the atrioventricular bundle and its right and left terminal branches, and the subendocardial plexus of Purkinje fibers (specialized cardiac muscle fibers that form the conducting system of the heart).

Sinuatrial Node

The sinuatrial node is located in the wall of the right atrium in the upper part of the sulcus terminalis just to the right of the opening of the superior vena cava .The node spontaneously gives origin to rhythmic electrical impulses that spread in all directions through the cardiac muscle of the atria and cause the muscle to contract.

Atrioventricular Node

The atrioventricular node is strategically placed on the lower part of the atrial septum just above the attachment of the septal cusp of the tricuspid valve .From it, the cardiac impulse is conducted to the ventricles by the atrioventricular bundle. The atrioventricular node is stimulated by the excitation wave as it passes through the atrial myocardium.

The speed of conduction of the cardiac impulse through the atrioventricular node (about 0.11 seconds) allows sufficient time for the atria to empty their blood into the ventricles before the ventricles start to contract.

Atrioventricular Bundle

The atrioventricular bundle (bundle of His) is the only pathway of cardiac muscle that connects the myocardium of the atria and the myocardium of the ventricles and is thus the only route along which the cardiac impulse can travel from the atria to the ventricles .The bundle descends through the fibrous skeleton of the heart.

The atrioventricular bundle then descends behind the septal cusp of the tricuspid valve to reach the inferior border of the membranous part of the ventricular septum. At the upper border of the muscular part of the sep- tum, it divides into two branches, one for each ventricle. The right bundle branch (RBB) passes down on the right side of the ventricular septum to reach the moderator band, where it crosses to the anterior wall of the right ventricle. Here, it becomes continuous with the fibers of the Purkinje plexus The left bundle branch (LBB) pierces the septum and passes down on its left side beneath the endocardium. It usually divides into two branches (anterior and posterior), which eventually become continuous with the fibers of the Purkinje plexus of the left ventricle.

It is thus seen that the conducting system of the heart is responsible not only for generating rhythmic cardiac impulses, but also for conducting these impulses rapidly throughout the myocardium of the heart so that the different chambers contract in a coordinated and efficient manner.

The activities of the conducting system can be influenced by the autonomic nerve supply to the heart. The parasympathetic nerves slow the rhythm and diminish the rate of conduction of the impulse; the sympathetic nerves have the opposite effect.

Internodal Conduction Paths

Impulses from the sinuatrial node have been shown to travel to the atrioventricular node more rapidly than they can travel by passing along the ordinary myocardium. This phenomenon has been explained by the description of special pathways in the atrial wall .which have a structure consisting of a mixture of Purkinje fibers and ordinary cardiac muscle cells.

The anterior internodal pathway leaves the anterior end of the sinuatrial node and passes anterior to the superior vena caval opening. It descends on the atrial septum and ends in the atrioventricular node. The middle internodal pathway leaves the posterior end of the sinuatrial node and passes posterior to the superior vena caval opening. It descends on the atrial septum to the atrioventricular node. The posterior inter- nodal pathway leaves the posterior part of the sinuatrial node and descends through the crista terminalis and the valve of the inferior vena cava to the atrioventricular node.

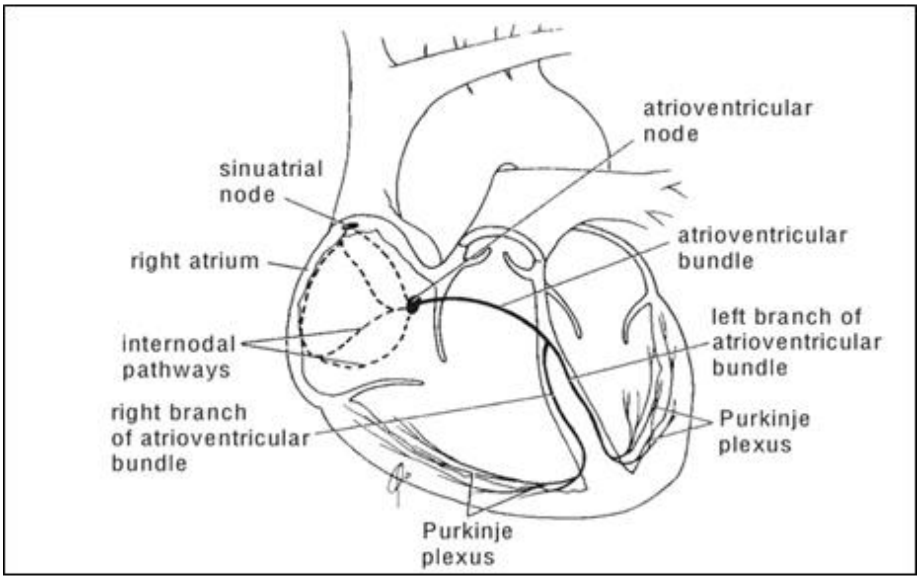


Figure (2.6) the conducting system of the heart (note the intermodal pathways)

Arterial blood supply

The right coronary artery, the left main coronary, the left anterior descending, and the left circumflex artery, are the four major coronary arteries. Blockage of these arteries is a common cause of angina, heart disease, heart attacks and heart failure [14].

2.8 Electrical system of the heart and heart beat

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.

An electrical boost is created by the sinus hub (likewise called the sinoatrial hub, or SA hub). This is a little mass of specific tissue situated in the correct upper chamber (atria) of the heart. The sinus hub produces an electrical boost routinely, 60 to 100 times each moment under typical conditions. The atria are then enacted. The electrical improvement goes down through the conduction pathways and makes the heart's ventricles agreement and siphon out blood. The 2 upper offices of the heart (atria) are invigorated first and agreement for a brief timeframe before the 2 lower offices of the heart (ventricles).

The electrical drive goes from the sinus hub to the atrioventricular hub (additionally called AV hub). There, driving forces are eased back down for a brief period, at that point proceed down the conduction pathway through the heap of His into the ventricles. The heap of His partitions into both ways pathways, called pack branches, to invigorate the privilege and left ventricles. Normally at rest, as the electrical impulse moves through the heart, the heart contracts about 60 to 100 times a minute, depending on a person's age. Each contraction of the ventricles represents one heartbeat. The atria contract a fraction of a second before the ventricles so their blood empties into the ventricles before the ventricles contract [15].

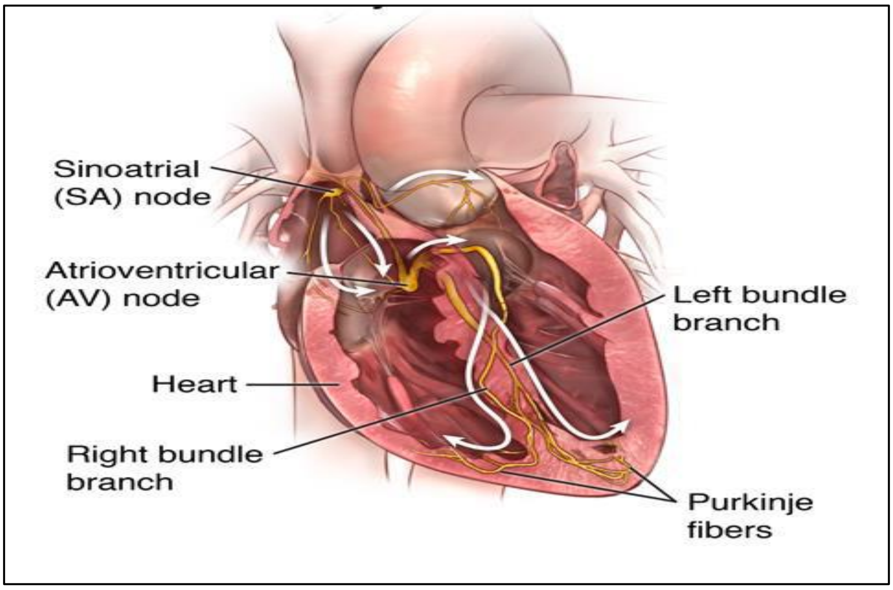


Figure (2.7) Electrical system of the heart

2.9 Heart Rate

Heart Rate is the speed of the heartbeat measured by the number of contractions (beats) of the heart per minute bpm. A normal resting heart rate for adults ranges from 60 to 100 beats per minute..Low heart rate (less than 60) is called bradycardia. High heart rate (more than 120) is called tachycardia.

Heart rate (HR) is an important physiological parameter generated by the spontaneous activity of the sinoatrial pacemaker cells and is chronically toned down by vagal activity It indicates the rhythm at which the heart pumps venous blood into the lungs and oxygenated blood into the systemic circulation, and as such reflects the metabolic need of the body. Because of this inherently vital central function, HR is influenced by a multitude of physiological and behavioral stimuli, such as: blood pressure, respiration, apnea, central motor command, posture, pain, water immersion, arousals, emotions and mechanical, physiochemical and biochemical metabolic changes As described by the Fick principle, HR is directly related to oxygen consumption This relation has been exploited to estimate cardiorespiratory fitness, also called VO2max, and energy expenditure Yet, one of the most common applications of HR monitoring is to be found in sports, where HR is used to monitor exercise intensity [15] .

Factors affect heart rate

- **Air temperature:** When temperatures (and the humidity) soar, the heart pumps a little more blood, so the pulse rate may increase, but usually no more than five to 10 beats a minute.
- **Body position**: Resting, sitting or standing, the pulse is usually the same. Sometimes as it stand for the first 15 to 20 seconds, the pulse may go up a little bit, but after a couple of minutes it should settle down.
- **Emotions:** If the person was stressed, anxious or "extraordinarily happy or sad" the emotions can raise the pulse rate .
- **Body size:** Body size usually doesn't change pulse. If the person was very obese, he might see a higher resting pulse than normal, but usually not more than 100 .
- **Medication use:** Meds that block the adrenaline (beta blockers) tend to slow the pulse rate, while too much thyroid medication or too high of a dosage will raise it.
- **Age group :** children usually have higher heart rate than old people because their body metabolism is faster.

2.10 Principle work of heart rate sensor

The heart rate sensor measures the heart rate in beats per miute (BPM) and there are many types of heart rate sensors:

Electrical heart-rate sensor

The thumping sound of a heart beat is caused by valves that open and close as the heart pumps blood, but an electrical heart-rate monitor isn't capturing audio. Like the nickname implies, this monitor senses electrical activity that's created by the heart. The underside that rests on the chest has electrodes that carry this electrical activity from the surface of the skin into the device [16].

Optical heart-rate sensor

Using an optical LED light source and an LED light sensor. The light shines through the skin, and the sensor measures the amount of light that reflects back. The light reflections will vary as blood pulses under the skin past the light. The variations in the light reflections are interpreted as heartbeats.

This type of sensor can be positioned on wrists, arms, and other extremities, making them more versatile than electrical monitors which need to be placed close to the heart [17].

2.11 Calculating threshold values for heart rate

Single Exponential Smoothing (SES) statistical algorithm was applied in the analysis of heartrate reading. Also, it is used to make forecast of the values being received from the pulse sensor. More weight was given to present values as compared to past values. This statistical method was chosen because it is one of the best method to produce a Smoothed Time Series (STS) and it is not computationally intensive for the android app that does the computations and data storage.

For any time period t, the smoothed heartrate reading St is given as [18] :

$$\mathrm{St} \;=\; \alpha\, Yt + (1-\alpha)\,\mathrm{St}-1\;0<\alpha\leq 1$$

where

α = smoothing parameter

Yt = current predicated heartrate reading

$\mathrm{St}-1$ = current observed heartrate readings

In other to make sure the predicted heartrate reading as close in value to the current observed heartrate reading, an error value thus differences between current observed heartrate reading and predicted heartrate reading of 10 is used. With this assumption the individual's heartrate reading is monitored for a certain period of time and the threshold taken as the predicted heartrate reading. Based on the age and sex of the individual this value is compared to standard values and if abnormal, alerts are sent to confidants.

The Mean Square Error (MSE) is also calculated to help make the heartrate reading and smoothed value close, also it helps to decide whether to give more priority to the current observed heartrate reading or predicted heartrate reading in terms of choosing the smoothing parameter [18].

The Mean Square Error (MSE) is calculated using the formula :

$$MSE = \frac{1}{N} = \sum_{t=1}^{N} e^2$$

Where,

N = number of observation

e = error

Chapter Three

Experimental work

3.1 Introduction

This chapter will describe the background of the practical part of the project from the design process and hardware parts and how they work as well as the project programming process.

3.2 Block Diagram

A block diagram of Warning System Module (WSM) is a diagram of a system in which the principal parts or functions are represented by blocks connected by lines that show the relationships of the blocks as shown in the figure below.

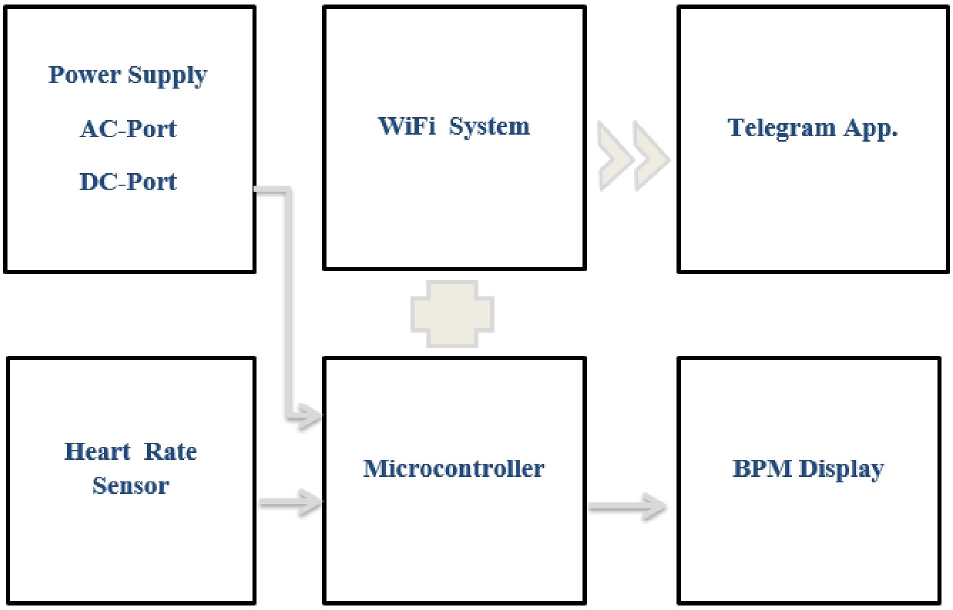


Figure (3.1) Block diagram of a Warning System Module (WSM).

3.3 Schematic Diagram

A schematic is a structural or procedural diagram used to graphically represent the connection of hardware and what a circuit is doing and how it is functioning as shown in the figure below.

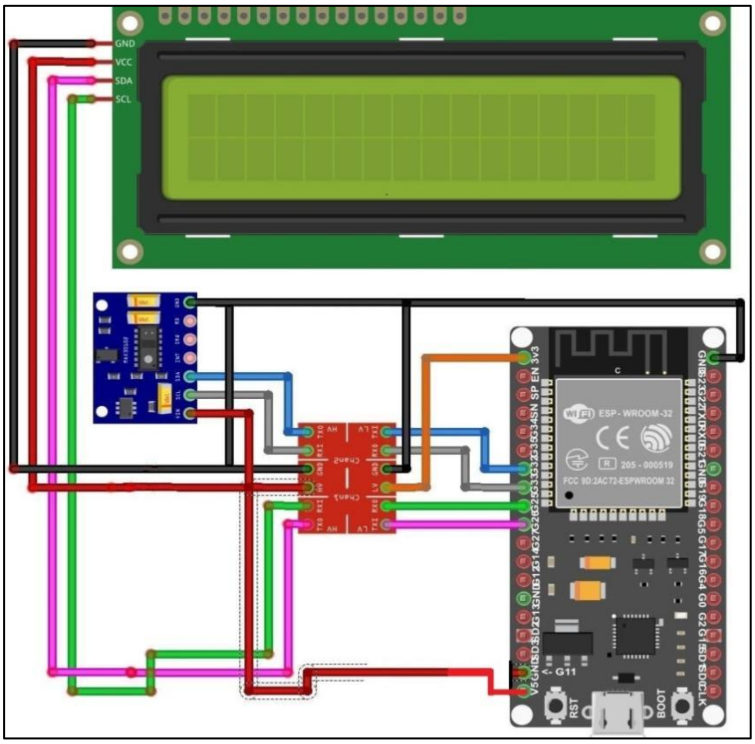


Figure (3.2) Schematic diagram of a Warning System Module (WSM).

3.4 The hardware of the system

Proposed work used several components that can be explained as the following:

3.4.1 ESP32 microcontroller module

It is a less-cost, little power system on a chip microcontroller with included Wi-Fi and dual mode Bluetooth. The ESP32 is the heart of the project. It is a microcontroller board used to connect the heart rate sensor and lcd screen. The board is programmed with the source code in order to perform the operations of the project. The source code is stored on-chip memory available on the

ESP32. This block can be considered as an interface between the programmer and the user. So, it is considered as the heart of the project.

The ESP32 operating voltage range is 2.2 to 3.6V. Under normal operation the ESP32 thing will power the chip at 3.3V. The pin description of ESP32 is shown in the figure below.

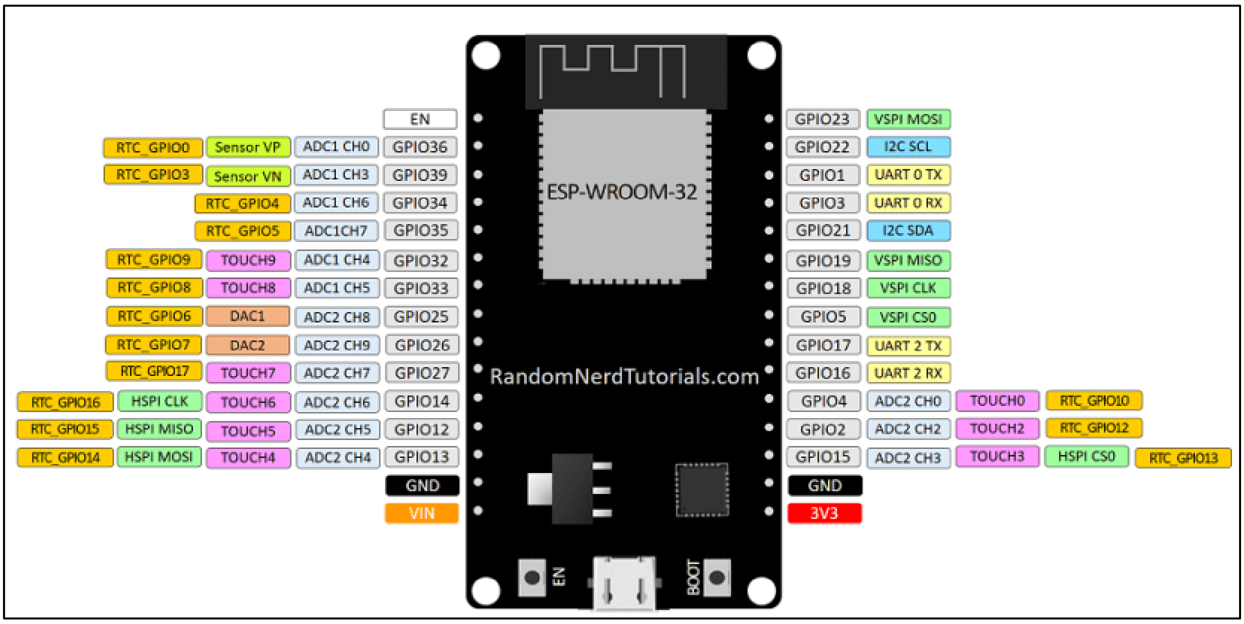


Figure (3.3) Pin description of ESP32 [19]**.**

The good thing about ESP32, like ESP8266 is its integrated RF components like Power Amplifier, Low-Noise Receive Amplifier, Antenna Switch, Filters and RF Balun. This makes designing hardware around ESP32 very easy as it require very few external components.

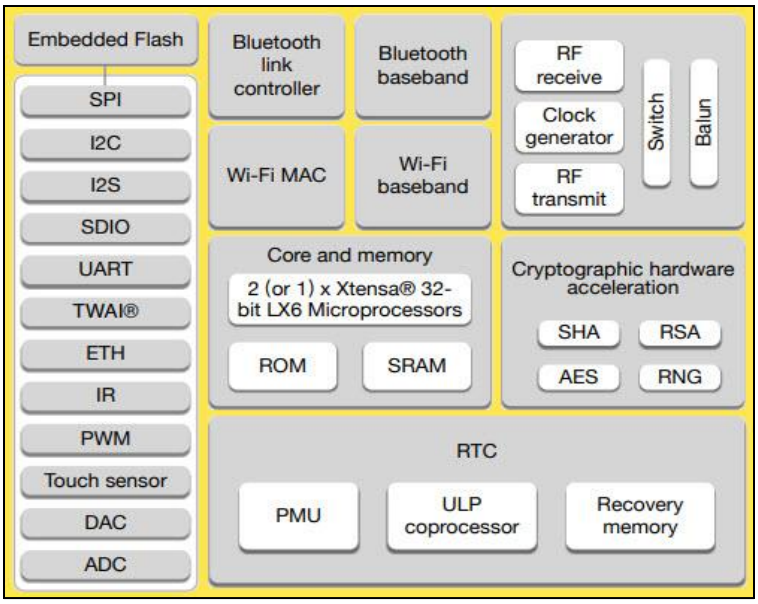


Figure (3.4) The Internet of Things (IoT) with ESP32 [20]**.**

Working principle of ESP32

ESP32 Microcontroller has an important role in receiving the readings from the heart sensor and determining its quality if it is within the normal limit or not. If the readings of the sensor range from 60-100bpm, ESP32 microcontroller will display the readings on the LCD screen and does not send a warning message via WiFi to the user through Telegram application. But if the sensor readings are less than or higher than the normal limit, ESP32 microcontroller will show the readings on the LCD screen and send a warning message to the Telegram application via Wi-Fi, as shown in the figure.

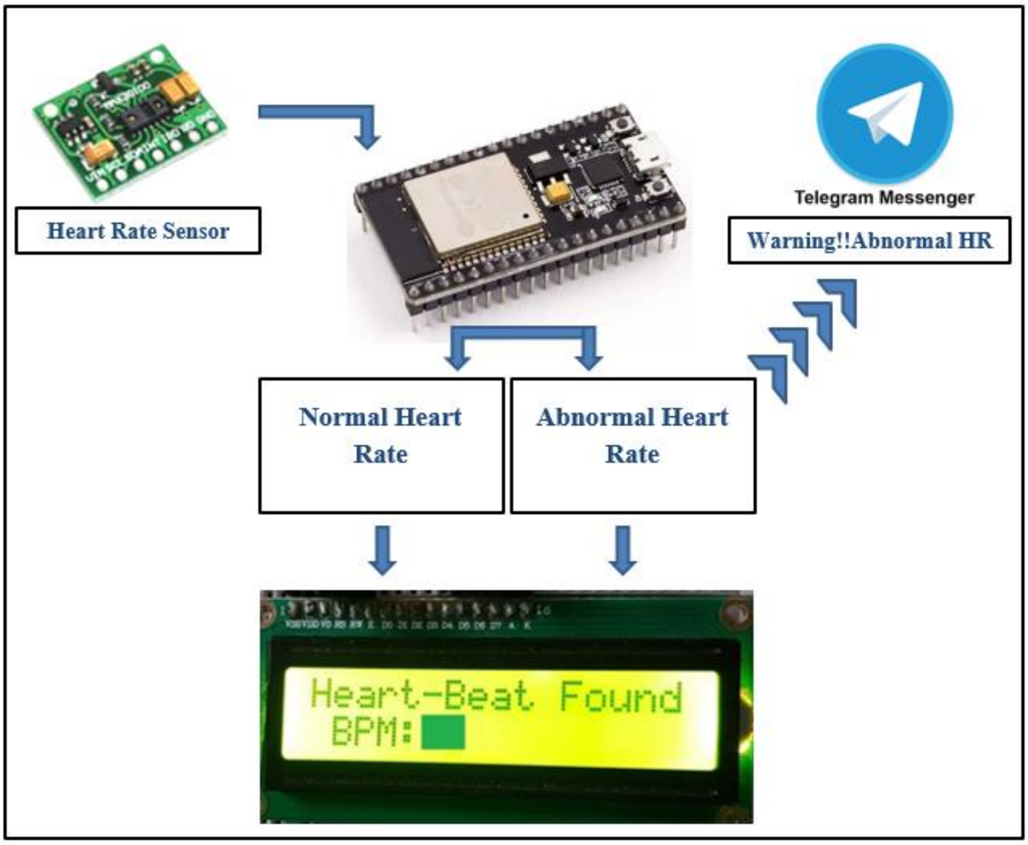


Figure (3.5) Principle Work of ESP32

3.4.2 Max30100 Pulse Oximeter Heart-Rate Sensor Module

MAX30100 is an integrated pulse oximetry and heart-rate monitor sensor solution. It integrates two LEDs (IR and Red), a photodetector (Red), optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. It is fully configurable through software registers and the digital output data is stored in a 16-deep FIFO within the device.It has an I2C digital interface to communicate with a host microcontroller.

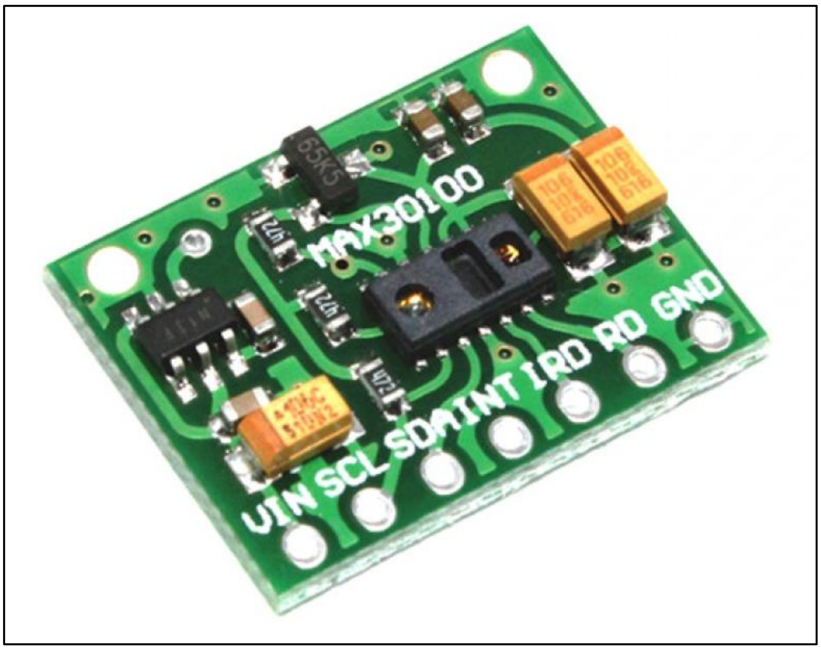


Figure (3.6) Max30100 Pulse Oximeter Heart-Rate Sensor Module.

Max30100 has an ultra-low-power operation which makes it ideal for battery operated systems.MAX30100 operates on a supply in the range of 1.8 to 3.3V.It can be used in wearable devices, fitness assistant devices, medical monitoring devices, etc. Max30100 sensor is programmed by Arduino IDE through the ESP32 microcontroller to measure the heart rate only and neglect the part related to measuring the SPO2 in sensor.

3.4.3 16x2 LCD (Liquid Crystal Display) screen

LCD modules are very commonly used in most embedded projects, the reason being its cheap price, availability and programming friendly. 16×2 LCD is named so because it has 16 Columns and 2 Rows. There are a lot of combinations available like, 8×1, 8×2, 10×2, 16×1, etc. but the most used one is the 16×2 LCD. So, it will have (16×2=32) 32 characters in total and each character will be made of 5×8 Pixel Dots. A Single character with all its Pixels is shown in the figure below.

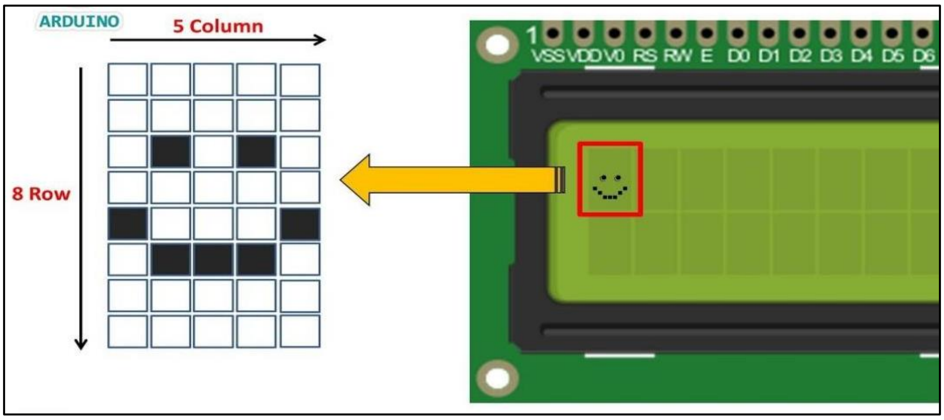


Figure (3.7) 2D model of 16×2 LCD module

The 16x2 LCD is very popular because of its built in HD44780 interface module. This module makes it extremely easy to add an LCD to any project with its built in character Set and easy command structure LCD – Liquid Crystal Display Lower power than LED display. More flexible in size and shape slower response time The LCD's internal controller can accept several commands and modify the display accordingly. The 16x2 LCD interface has 8 data bits (DB0~DB7) and 3 control pins (RS, R/W*, E) as shown in figure (3.8). The data bits are connected to the 8 pins of I2C.

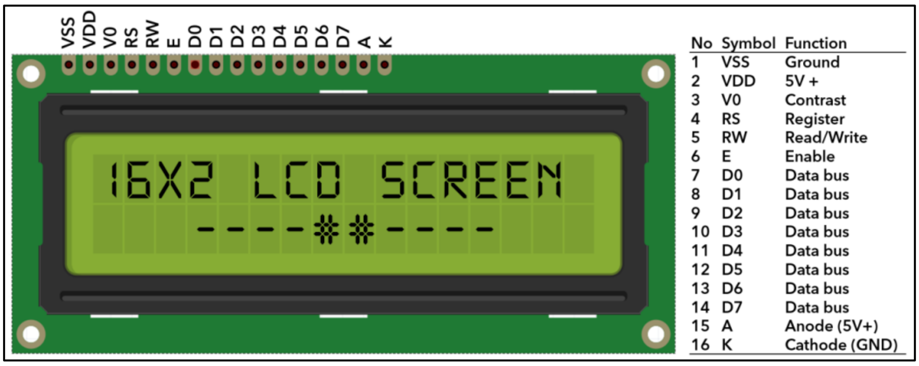


Figure (3.8) Pin of LCD 16X2 Module

3.4.4 I2C Liquid Crystal Display Adapter

At the heart of the adapter is an 8-Bit I/O Expander chip – PCF8574. This chip converts the I2C data from an ESP32 into the parallel data required by the LCD display.

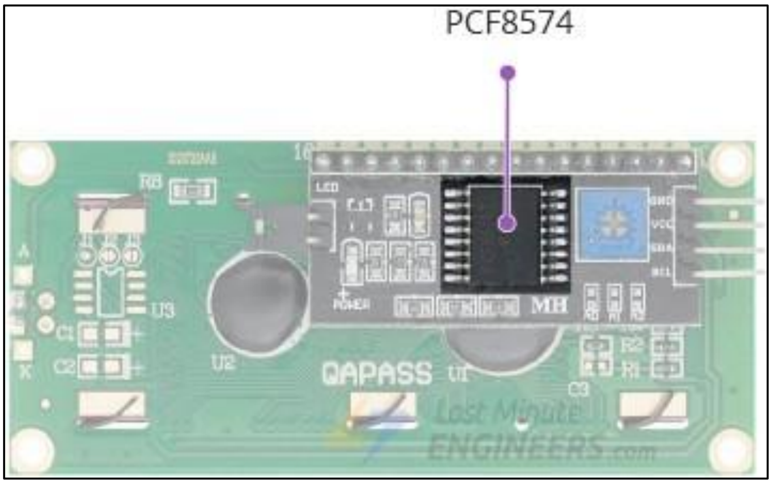


Figure (3.9) Expander chip – PCF8574 OF I2C LCD adapter.

The board also comes with a small trimpot to make fine adjustments to the contrast of the display.

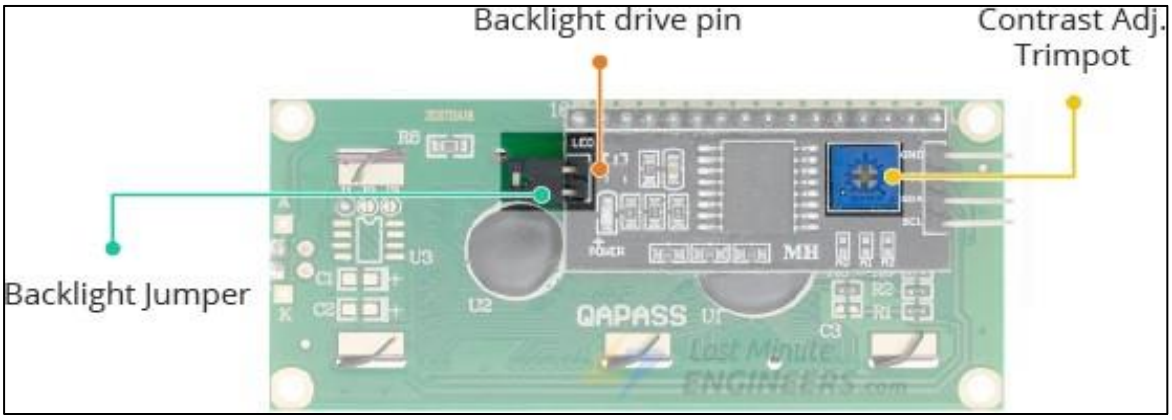


Figure (3.10) Contrast adjustments Trimpot and Backlight Jumper.

In addition, there is a jumper on the board that supplies power to the backlight. To control the intensity of the backlight, it can remove the jumper and apply an external voltage to the header pin that is marked as 'LED'.

I2C LCD display Pinout

An I2C LCD has only 4 pins that interface it to the outside world. The connections are as follows:

GND is a ground pin and should be connected to the ground of ESP32 microcontroller.

VCC supplies power to the module and the LCD. Connect it to the 5V output of the Logic level converter.

SDA is a Serial Data pin. This line is used for both transmit and receive. Connect to the SDA pin on the ESP32 through Logic level converter.

SCL is a Serial Clock pin. This is a timing signal supplied by the Bus Master device. Connect to the SCL pin on the ESP32 through Logic level converter.

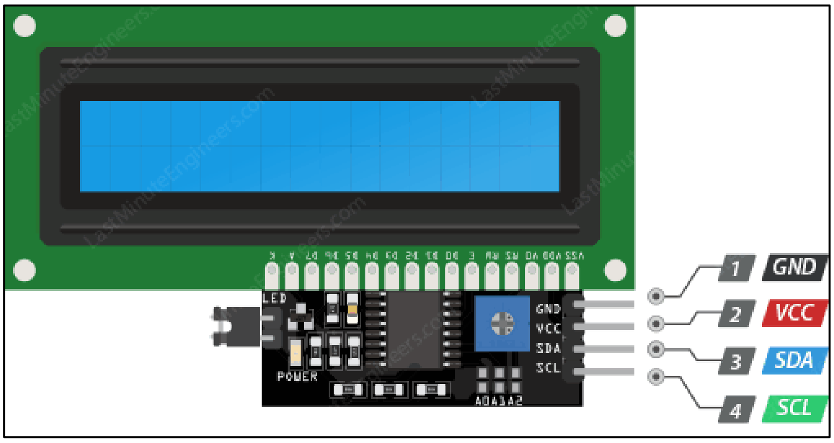


Figure (3.11) Pinout of I2C LCD 16X2 Module.

3.4.5 Logic Level Converter

Logic level converter is a small device that safely steps down 5V signals to 3.3V and steps up 3.3V to 5V at the same time. This level converter used to voltage distribution between LCD , Max30100 sensor and ESP32 microcontroller.

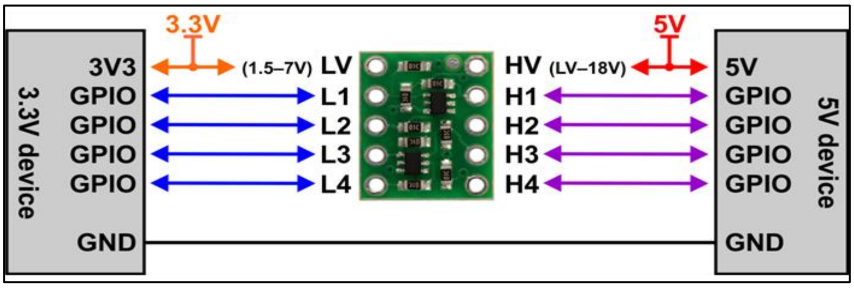


Figure (3.12) Bi-Directional Logic Level Converter (4 Channel)

3.4.6 Power circuit (Dual 18650 Lithium Battery Shield)

18650 battery shield is a portable mobile power supply that supports 3V / 1A and 5V / 2.2A two voltage outputs. 5V voltage output rated current is 2.2A, maximum support 3A current as shown in Fig.13 . It was used in the warning system model (WSM) device to charge and power an ESP32 expansion board via the USB output.the output of current depends on the quality of the 18650 battery.

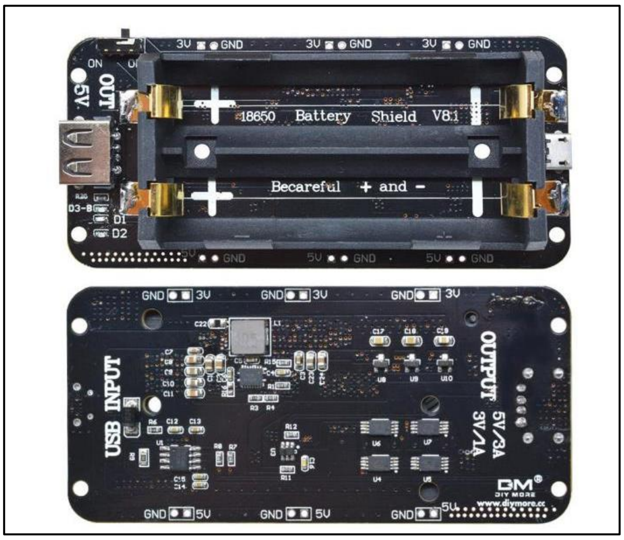


Figure (3.13) Dual 18650 Lithium Battery Shield.

18650 battery

A lithium-ion battery or Li-ion battery is a type of rechargeable battery. Lithium-ion batteries are commonly used for portable electronics. In the batteries, lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge, and back when charging. Li-ion batteries use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode. The 18650 battery have a high energy density,low cost and it can be replaced if damaged.

Figure (3.14) 18650 Lithium Battery

3.4.7 Power circuit (AC/DC Adapter)

Another power source use for supplies WSM device is AC/DC adapter. It's an external power supply convert AC 220 volt to DC 5V , 3A.consist of two parts:

1-Female Terminal Connector (FTM) : Soldered directly to the circuit.

2-Adapter : Connected directly with 220V AC Power.

Figure (3.15) AC/DC Adapter and FTM.

3.5 Blank PCB Board

A blank PCB is quite simply an empty circuit board free from any of the components that are installed to create a WSM circuit board. A blank circuit board is sometimes known as a 'copper-clad' circuit board, due to the coating of copper the board has around it. A printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate.

The process of soldering the hardware components of WSM device (LCD & I2C, ESP32, Logic Level Converter, Female Adapter Terminal Connector and MAX30100 Sensor) and linking them to each other is done by relying on the schematic diagram as shown in Figure (3.16).

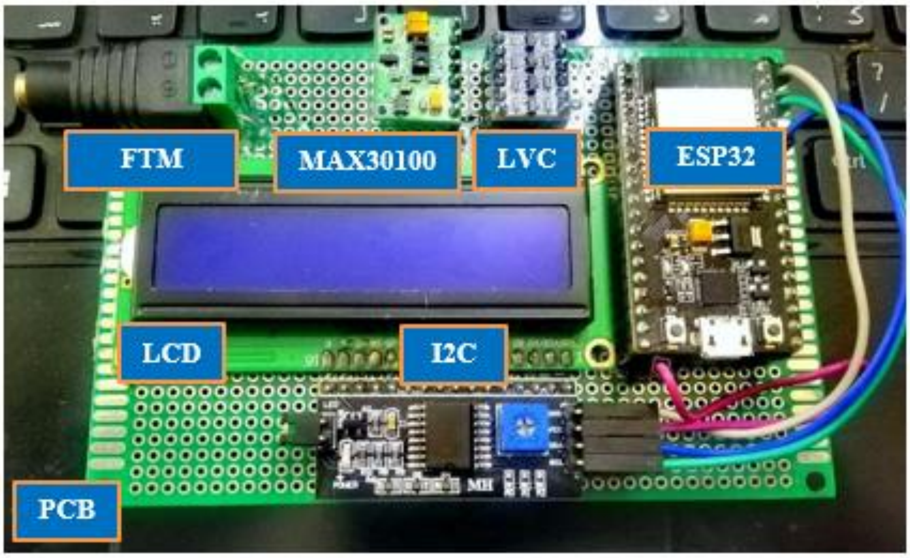


Figure (3.16) PCB board of WSM device.

3.6 Cover design of warning system module

The external shape of the device is designed to contain a suitable slot for the LCD screen that shows the heart rate readings, and a slot for the heart rate sensor, in addition to other slots such as the power circuit charging port and the adapter port.

The outer case of the device is made of MDF and coated with a waterproof coating. In general, MDF is inexpensive, can be easily painted, and can be easily modified to fit device components.

Figure (3.17) Cover design of warning system module.

3.7 System operation

The WSM automatically monitors the heartbeat after place the index finger on heart rate sensor and sends an alert to the confidants of the user when the heartbeat is abnormal.The telegram bot sends the alert meassages and stored it on the telegram application memory. The operations carried out by the device from monitoring and display of the heart rate were implemented by programming ESP32 microcontroller using Arduino IDE software An overview of how the entire system works is shown in figure below.

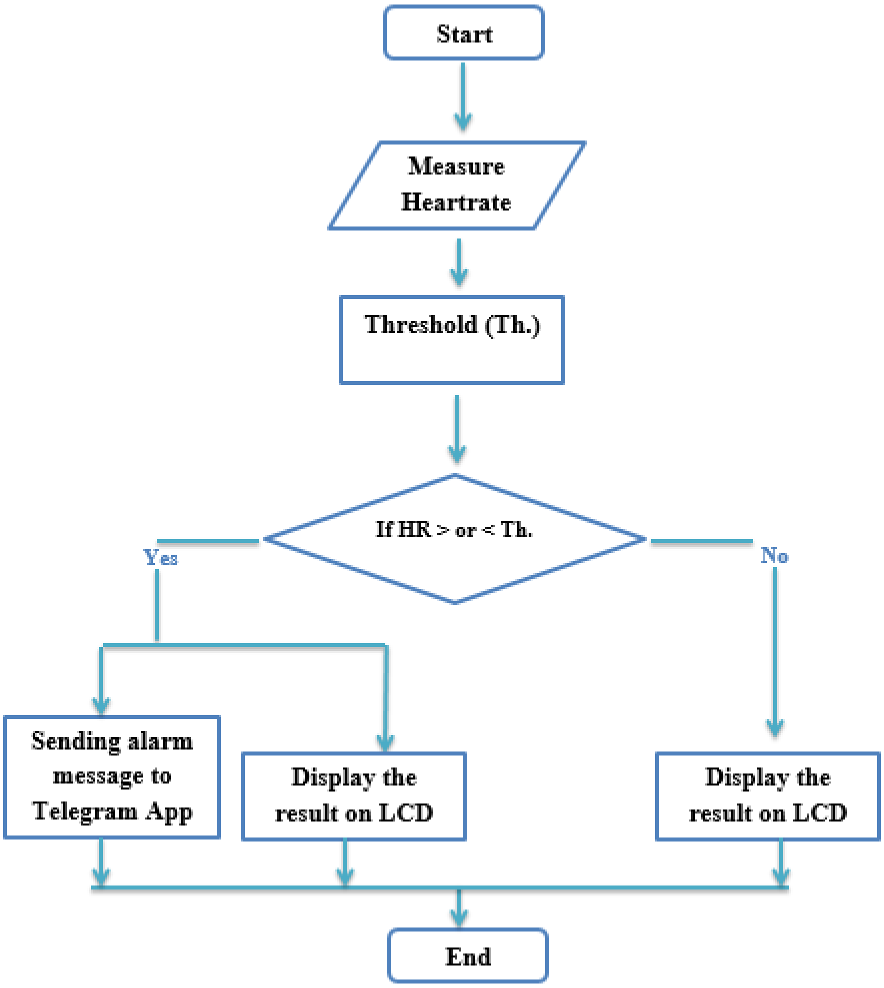


Figure (3.18) Overview of WSM operation (Flowchart)

Chapter Four

Result and Discussion

4.1 Introduction

In this chapter, the results section is a section containing a description about the main results of the research as well as a discussion of the results and all the problems encountered in choosing the components of the project.

4.2 Overview of warning system module

The proposed system is based on the working of infrared light is passing to the blood value and analysis the heart rate. In this device is placed on the human fingertip and measure the heart rate through MAX30100 sensor as shown in figure (4.1) and send the signal to the controller. First the sensor is fix into the human fingertip the blood is circulated to the fingertip at the time sensor infrared light is passing to the photo diode via blood value to measure the pressure of blood and this measured value is given to the ESP32 controller. The controller analysis the sensed value and threshold value if any difference occur in the output the controller send the signal to user via WiFi network, also the ESP32 display the value of sensor output in the LCD display.

The heart beat sensor having the photo diode and IR sensor, the working of this sensor is IR passed to the finger one side and the photo diode is receiving the signal and measure the pulse, blood count for 30 seconds. The intensity of the blood is decrease and increase is respect to the heart rate, so easily found the heart is normal or abnormal.

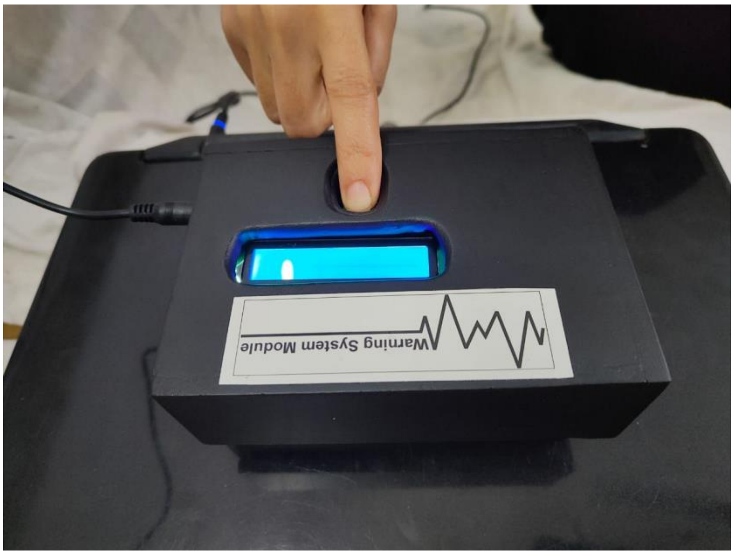


Figure (4.1) Measuring heart rate by warning system module.

4.3 Bill of Quantities (BOQ)

A bill of quantities (commonly known as BOQ or BQ) is a document prepared to define the quality and quantity of works required to be carried out to complete a project as shown in table below.

Item	Description	Qty.	price	Notes
1	MAX30100	1	25$	Local Market
2	ESP32	1	20$	Local Market
3	Jumper wires	1set	5$	Local Market
2	Blank PCB board	1	8$	Local market
3	Adapter& FTM	1	20$	Local market
4	DC Power circuit	1	30$	Local Market
5	LCD screen 16x2	1	10$	Local Market
6	Logic level converter	1	10$	Local Market
7	Cover design	1	72$	…
7	The total cost		200$	

Table (4.1) Bill of Quantities (BQ).

4.4 Problems encountered in the project

It includes the problems and challenges encountered in the design and selection of appropriate components for the project.

4.4.1 Microcontroller

4.4.1.1 Arduino Uno

Microcontroller initially proposed is Arduino Uno because of its popularity and availability. Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button as shown in figure (4.2).

4.4.1.2 Arduino UNO+WiFi R3

Another microcontroller was suggested because it contains a built-in Wi-Fi system. It is a customized version of the classic ARDUINO UNO R3 board. Full integration of microcontroller Atmel ATmega328 and IC Wi-Fi ESP8266 with 32 MB flash memory, and USB-TTL converter CH340G on one board. All modules can work together or independently. On the board where the switch of mode of operation with 8 position as shown in figure (4.2).

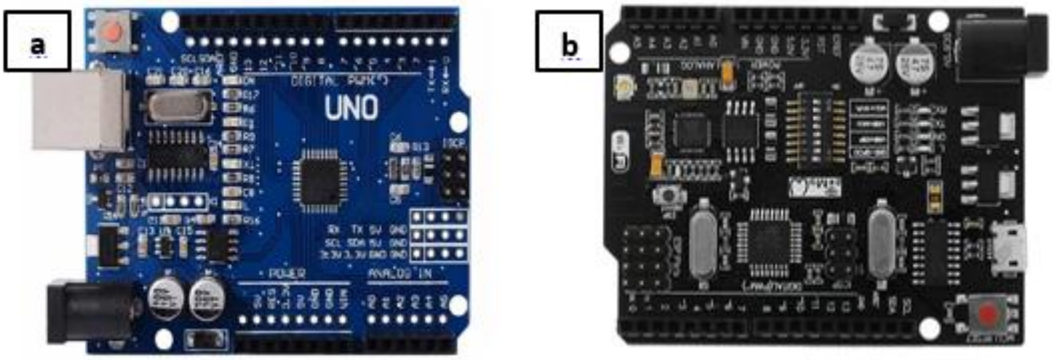


Figure (4.2) (a)Arduino Uno (b) Arduino UNO+WIFI R3

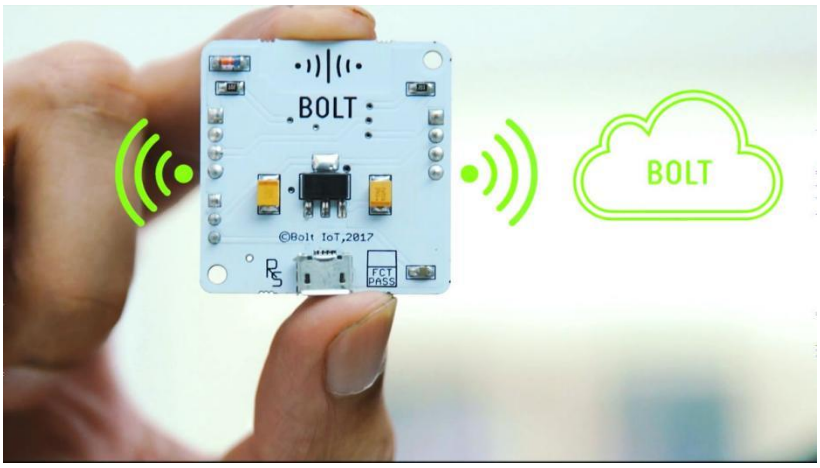
4.4.1.3 ESP32 microcontroller vs Arduino Uno/Uno+WiFi

ESP32 is a low cost, small in size, low power consuming System on Chip (SoC) with integrated Wi-Fi and Bluetooth compatible with Arduino IDE. In other words, an ESP32 board can be used as “Arduino” . ESP32 is developed by Espressif Systems and has a Tensilica Xtensa LX6 microprocessor. By the phrase “Arduino”, we mean the boards which are designed and manufactured by the company named Arduino and officially supported by the Arduino IDE. While Arduino UNO are commonly used, Arduino has a wider variety of boards like Arduino Uno+WiFi R3 which has Wi-Fi . The cost of Arduino is higher when the features are compared with ESP32.

4.4.2 Bolt Iot WiFi module

The wifi system initially proposed is the Bolt IoT Wifi module shown in figure (4.2). Internet of Things (IoT) one of the most important technologies these days. It became an essential component of many hardware projects core. And in order to make it easier for developers, Bolt IoT platform appeared as a complete solution for IoT projects.

Bolt is a combination of hardware and cloud service that allow users control their devices and collect data in safe and secure methods. It also can give actionable insights using machine learning algorithms with just some few clicks.



Figuer (4.3) Bolt IoT Platform with WiFi Module.

Advantages of Bolt Iot WiFi module

- **A Wifi or a GSM chip**

An easy interface to quickly connect the hardware to cloud over GPIO, UART, and ADC. Also, connects to MODBUS, I2C, and SPI with an additional converter.

- **Robust Communication**

Bolt is equipped with industry standard protocols to ensure a Secure and fast communication of device data with cloud.

- **Security**

Bolt has built-in safeguards to secure all user data from unwanted third party intrusions and hacks.

- **Alerts**

Utilize Bolt's quick alert system providing invaluable information sent directly to the phone or Email. It can config the contact details and set the threshold.

- **Mobile App Ready** .

Customize and control the devices through Mobile apps. Bolt gives full freedom to design the own mobile app centered around requirements to monitor and control.

Disadvantages of Bolt Iot WiFi module

Unavailability within the country and to use it requires transferring it to Iraq, which means more time and cost to complete the project, so it was replaced with an ESP32 WiFi module.

4.4.3 Heart Rate sensor

4.4.3.1 Pulse sensor

For ESP32 microcontroller, the pulse sensor is plug and play heart rate sensor. It can be utilized by any persons who want to simply include live heart rate information into their developments. The sensor displays the movement of blood through the finger and is intended to give numerical output of heart beat once a finger is positioned on it.

Figure (4 .4) Pulse Sensor with ESP32.

4.4.3.2 Pulse sensor vis MAX30100 sensor

In the proposed system, MAX30100 sensor was used instead of pulse sensor for the following reasons:

1. MAX30100 sensor gives more accurate readings of heart rate than pulse sensor.
2. If the pulse sensor is used to monitor heart rate continuously, it is not necessarily accurate in sports when the hand is vigorously moved or the muscles and tendons flexed near the wrist.
3. Limited ability of pulse sensor to accurately measure heart rate through dark or tattoed skin.
4. More likely to pulse sensor is worn incorrectly, either not tight enough or too tight.

4.4.4 Software

4.4.4.1 Sending the alarm meassage with the SMTP server

The SMTP (Simple Mail Transfer Protocol) server is an application that's primary purpose is to send, receive, and/or relay outgoing mail between email senders and receivers as shown in figure (4.5).

The purpose of its use is to link two Gmail accounts, the first Gmail account sends abnormal sensor detection to the second account. The second Gmail account is the user account that receives alerts.

SMTP server disadvantages

Usually requires more back and forth conversation between servers in order to deliver your message, which can delay sending and also increase the chances of the message not being delivered. Some firewalls can block ports commonly used with SMTP.

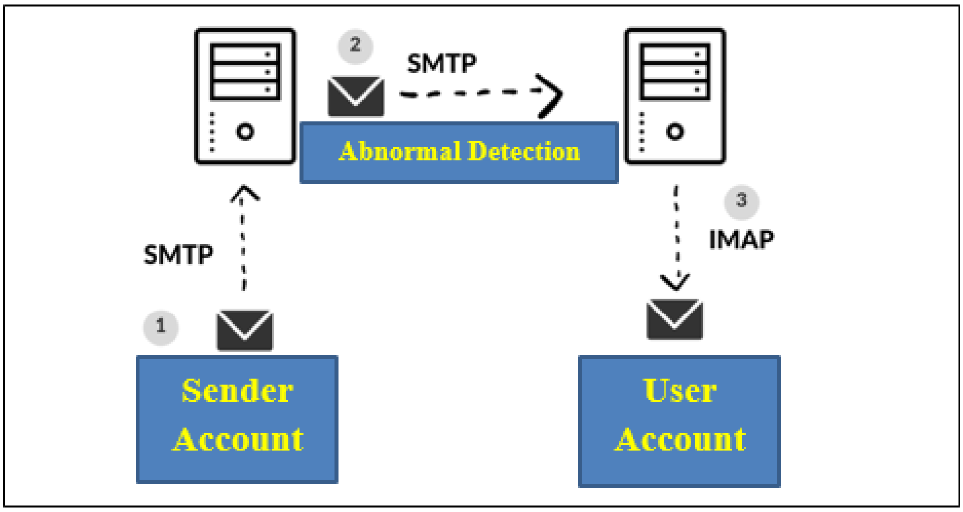


Figure (4 .5) SMTP server

4.4.4.2 Sending the alarm meassage with the Blynk application

Blynk is android/ios application to control on ESP32 messages , Raspberry Pi and the links over internet. It is a digital dashboard where it can build a graphic interface for project by simply dragging and dropping widgets.

Through the BLYNK app, It can display the heart rate and receiving the warning messages if an abnormal heart rate occurs. But this program is undesirable because the user needs to open the application every time to receive a warning message and this does not work if the Warning System Module (WSM) is used for continuous monitoring.

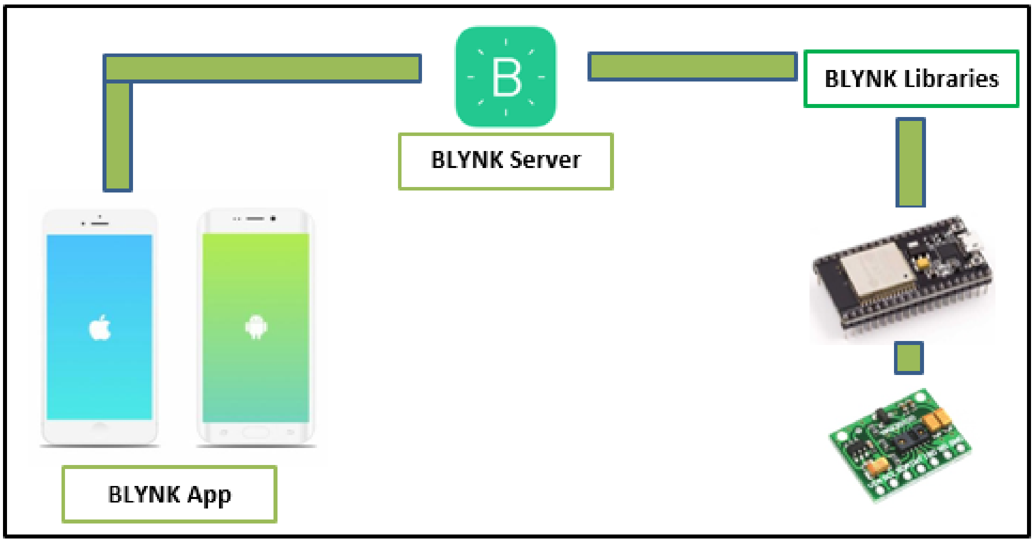


Figure (4 .6) BLYNK Server

4.4.4.3 Telegram Bot vs SMTP & BLYNK server

A Telegram bot is a device or piece of software that can execute commands, return messages, or perform routine tasks. It is programmed with the ESP32 microcontroller to show the warning messages. The advantage of the Telegram bot compared to the Blynk and SMTP server, it is fast, easy to use, easy to start and secure.

4.5 Testing and Results

After setting up the system and upload the source code, the device is ready for use after connecting the ESP32 to WiFi network as shown in figure (4.7). And by placing the index finger on heartbeat sensor. The heartbeat sensor will start monitoring the pulse rate and LCD screen will display the values.

Figure (4 .7) ESP32 Connecting to WiFi when turn on the WSM.

When the device is turned on, the ESP32 segment starts searching for the WiFi network, and when it is connected to it, the telegram bot sends a message to the user " <<Starting Heart Rate Monitoring >> " with a message that there is a heart rate below the normal limit " Warning!!Low Heart Rate " and this represents the first reading of the sensor, which is zero. After that, when placing the index finger on the sensor, the readings appear on the LCD screen, and when any abnormal heart rate occurs below or above the threshold (60-100)bpm, it is sent a message by the telegram bot to the user as shown in the figure below.

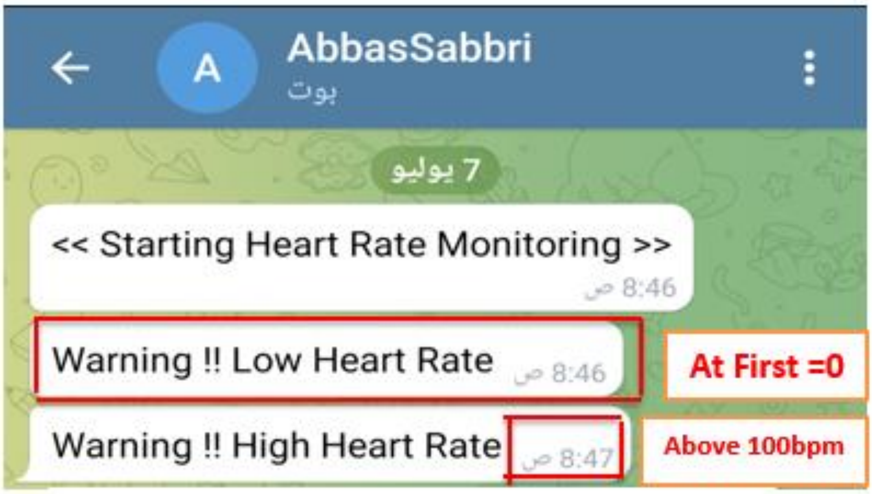


Figure (4 .8) Alarm message sent by Telegram Bot

After applying the device to different age groups, recording their heart rate and then comparing the accuracy of the results with accurate and approved devices. The results were after plotting them using the Excel program shown in the figure below.

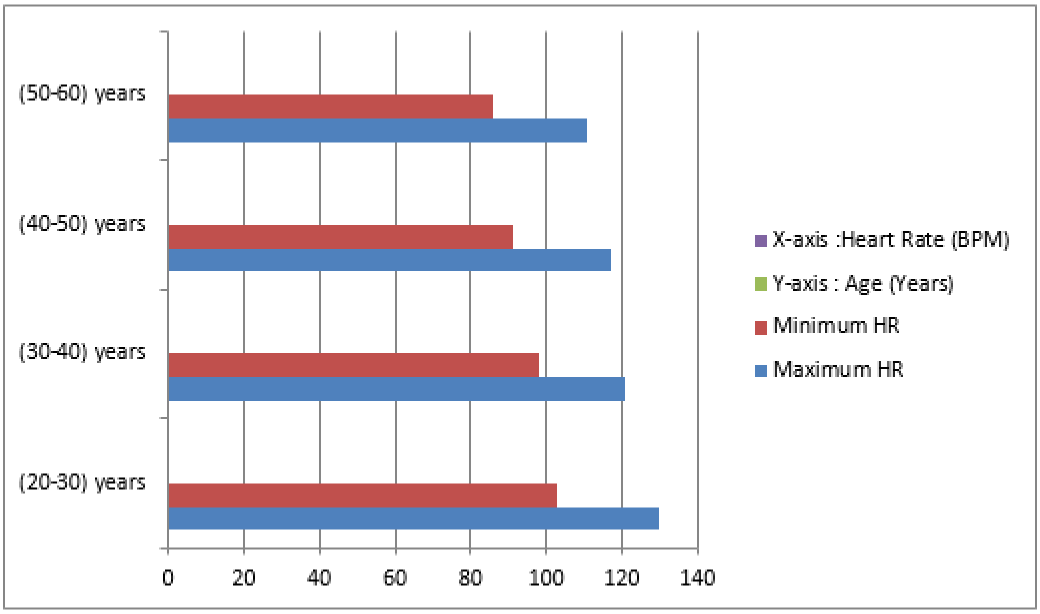


Figure (4 .9) The averging Heart Rate for different age groups at moderate exercise

It was observed from the results that the averaging heart rate for the ages (20-30) years is higher than the averaging heart rate for the ages (50-60) years at moderate exercise. From the results shown in the figure (4.9) that recorded by the WSM device, it is concluded that with age, the pulse rate is almost the same as before. But when doing exercise, it may take longer for the pulse to increase and then slow down. The highest heart rate with exercise is also lower than at a younger age.

Chapter Five

Conclusion and Future work

5.1 Introduction

The connculsion from this work and recommenations for future work established on the finding of the study are presented in this chapter.

5.2 Conclusions

In this exploration It was attempted to propose a total paper on detecting heart attack by monitoring the heart beat of the person. The heart beat sensor which is interfaced with ESP32 microcontroller senses the pulse of the person and transmits them over the internet using Wi-Fi network to Telegram application. The system allows setting limits of heart beat. After setting these limits person can start monitoring the heart beat and whenever the person's heart beat goes above certain set point they can get an alert on high heart beat. Also, the system alerts for lower heart rate.

The use of the proposed system measures the patient health and the data noted for the record on Telegram application, so the patient is no need to go to the hospital in a more time. If the heart attack occurs in the patient side the message is passed through the mobile to the doctor, and this is done, though a comparison of sensor value and threshold value if any variation is occurring to alert the user.Also the monitoring of the patient is available in everywhere so it is more helpful in rural areas user, and the proposed system is given the accurate value and faster operation of this system.

5.3 Recommendations for Future Work

The improvement of the proposed system performance is enhanced in future work:

1. To implement the device accuracy is done on various people in different ages and more testing is taken to the system is developed.

2. In future more health parameters are find patient and monitor in single device is implemented, so the time is save and identify more problems in patient health.
3. This proposed system is implemented in the minimizing of the PCB space is very useful to wear the sensor in patient body.
4. Minimizing the size of the device and making it in smartwatch design with a small screen.
5. In future work it can connect a group of patients whose number does not exceed ten patients in the same system. Through a specialized internet system that is present at the doctor, so the doctor can check on them and monitor their condition daily.
6. Enhance the warning system module by recording the heart beat continuously.

Appendix A

Code for the ESP32 microcontroller by Arduino Software (IDE)

```
#include <WiFi.h>
#include <Wire.h>
#include <WiFiClientSecure.h>
#include "MAX30100_PulseOximeter.h"
#include <UniversalTelegramBot.h>
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x3F,16,2);

#define WIFI_AP "MA MA Khan"
#define WIFI_PASSWORD "10203040"
#define BOT_TOKEN "1869367190:AAEYHGOBHKeIwKB1vjJ1qWTR7u6V-nsQlts"
#define TG_CHAT_ID "156922273"


WiFiClientSecure sClient;
UniversalTelegramBot bot(BOT_TOKEN, sClient);

int status = WL_IDLE_STATUS;
unsigned long lastSend = 0;

#define REPORTING_PERIOD_MS 1000
PulseOximeter pox;
uint32_t tsLastReport = 0;
void onBeatDetected(){Serial.println("Beat!");}


int HeartRate;
int alert = 0;
String lowHR =  "Warning !! Low Heart Rate";
String highHR = "Warning !! High Heart Rate";
```

```
void setup(){
 Serial.begin(115200);
 lcd.init();
 lcd.backlight();
 lcd.setCursor(0,0);lcd.print("   Heart Rate    ");
 lcd.setCursor(0,1);lcd.print("   Connecting    ");
 InitWiFi();
 setupmax30100();
 bot.sendMessage(TG_CHAT_ID, "<< Starting Heart Rate Monitoring >>");
}


void loop(){
   pox.update();
   getHR();
   if ( millis() - lastSend > 1000 ) {printdata();
     lastSend = millis();}
}

void getHR(){
if (millis() - tsLastReport > REPORTING_PERIOD_MS) {
        HeartRate = pox.getHeartRate();
        tsLastReport = millis();}
}

     void printdata(){
       String info = "HR = ";
       info += String(HeartRate);
       info += " bpm   ";
       Serial.println(info);
       lcd.setCursor(0,1);lcd.print(info);

       if(HeartRate > 100 && alert == 0){sendlowalert();}
       else if(HeartRate < 60 && alert == 0){sendhighalert();}
       if (HeartRate > 60 && HeartRate < 100){alert = 0;}
     }


void InitWiFi(){
  WiFi.begin(WIFI_AP, WIFI_PASSWORD);
  sClient.setCACert(TELEGRAM_CERTIFICATE_ROOT); // Add root certificate for api.telegram.org
  while (WiFi.status() != WL_CONNECTED) {delay(500);Serial.print(".");}
  Serial.println("Connected to AP");
}


void setupmax30100(){
  if (!pox.begin()) {Serial.println("FAILED");for(;;);}
    else {Serial.println("SUCCESS");}
  pox.setOnBeatDetectedCallback(onBeatDetected);
}
```

```
void sendhighalert(){
  bot.sendMessage(TG_CHAT_ID, lowHR);
  alert = 1;
  setupmax30100();
}

void sendlowalert(){
  bot.sendMessage(TG_CHAT_ID, highHR);
  alert = 1;
  setupmax30100();
}
```

Appendix B

Tables of figure (4.9) The averging Heart Rate for different age groups at moderate exercise recorded by Warning System Module (WSM)

Heart Rate (Beats Per Minute) for (20-30) age gruops							
No.	HR (BPM)	No.	HR (BPM)	No.	HR (BPM)	No.	HR (BPM)
1	106	6	112	11	117	16	108
2	117	7	104	12	104	17	130'
3	104	8	107	13	113	18	120
4	120	9	130'	14	127	19	113
5	122	10	119	15	106	20	103'
Average = 114.1 bpm							

Heart Rate (Beats Per Minute) for (30-40) age gruops							
No.	HR (BPM)	No.	HR (BPM)	No.	HR (BPM)	No.	HR (BPM)
1	100	6	110	11	120	16	114
2	114	7	112	12	98'	17	118
3	121'	8	119	13	111	18	101
4	99	9	114	14	99	19	100
5	108	10	105	15	105	20	115
Average = 109.15 bpm							

Heart Rate (Beats Per Minute) for (40-50) age gruops							
No.	HR (BPM)	No.	HR (BPM)	No.	HR (BPM)	No.	HR (BPM)
1	116	6	96	11	116	16	98
2	111	7	107	12	109	17	113
3	91'	8	111	13	99	18	107
4	100	9	101	14	112	19	114
5	98	10	103	15	117'	20	96
Average = 105.75 bpm							

Heart Rate (Beats Per Minute) for (50-60) age gruops							
No.	HR (BPM)	No.	HR (BPM)	No.	HR (BPM)	No.	HR (BPM)
1	110	6	88	11	104	16	95
2	98	7	86'	12	108	17	109
3	89	8	90	13	90	18	101
4	109	9	100	14	102	19	104
5	111'	10	105	15	90	20	92
Average = 99.05 bpm							

References

1. Singhal, Mohit and et al, "GSM Based Heart Beat Monitoring System," International Journal of Advanced Technology in Engineering and Science, vol. 2(5), no. 2.5, pp. 69-73, 2014.
2. Madakam, Somayya and et al, "Internet of Things (IoT): A Literature Review," Journal of Computer and Communications, vol. 3, no. 05, p. 164, 2015.
3. Zhang, Gus Q. and and Weiguo Zhang, "Heart rate, lifespan, and mortality risk," Ageing research reviews, vol. 8, no. 1, pp. 52-60, 2009.
4. Farin, Nusrat J., S. M. A. Sharif and Iftekharul , "An intelligent sensor based system for real time heart rate monitoring (HRM)2016," .
5. Ufoaroh, S. U., C. O. Oranugo and M. E. Uchechukw, "HEARTBEAT MONITORING AND ALERT SYSTEM USING GSM," International Journal of Engineering Research and General Science, pp. 26-34, 2015.
6. Srinivasan, P. and et al, "HEART BEAT SENSOR USING FINGERTIP THROUGH ARDUINO," Journal of Critical Reviews, vol. 7(7), p. Journal of Critical Reviews, 2020.
7. Sihombing, Poltak and et al, "The Development of Heart Rate Detection Using Arduino," Journal of Physics, vol. 1566, no. 1, p. 012027, 2020.
8. Roberto and Franchini, "Automatic heartbeat monitoring system," 2019.
9. Sethuraman, T. V. and et al, "IoT based system for Heart Rate Monitoring and," Int. J. Eng. Adv. Technol.(IJEAT), pp. 1459-1464, 2019.
10. Diri, Grace O. and Ledisi G. Kabari, "Abnormal Heart Rate Detection Using Signal Processing," International Journal of Latest Technology in Engineering, 2020.
11. Ahmed, Yusuf and et al, "Design of an Arrhythmia Detection System Using Wearable PPG Sensor," nternational Conference on Biomedical Engineering, Computer and Information Technology for Health (BECITHCON), pp. 73-76, 2019.
12. Sihombing, Poltak and et al, "The Heart Attack Detection by ESP8266 Data Communication at a Real Time to Avoid Sudden Death," Journal of Physics, vol. 1235, no. 1, p. 012044, 2019.
13. Santhanakrishnan, C., Poojitha, N. G., & Reddy and L., "A Survey on Tracing Heart Attacks by Pulse Monitoring in IoT," Journal of Physics: Conference Series, vol. 1362, no. 1, p. 012093, 2019.
14. Richard S. Snell, Snell Clinical Anatomy by Regions, Lippincott Williams & Wilkins, 2011-10-28.

15. Anne M. R. Agur BSc(OT) MSc PhD and Arthur F. Dalley II PhD FAAA, Grant's Atlas of Anatomy, LWW, February 24, 2016.
16. "https://www.bicycling.com/bikes-gear/a25919409/best-heart-rate-monitors/".
17. "https://valencell.com/blog/optical-heart-rate-monitoring-what-you-need-to-know/".
18. Kommey, Benjaminp, Seth Djanie Kotey and Daniel Op, "Patient Medical Emergency Alert System," International Journal of Applied Information System, vol. 12, no. 17, December 2018.
19. Pravalika, V., & Prasad and R, "Internet of things based home monitoring and device control using Esp32," International Journal of Recent Technology and Engineering, vol. 8, no. 1S4, pp. 58-62, June 2019.
20. "https://circuitdigest.com/microcontroller-projects/esp32-dual-core-programming-using-arduino-ide".
21. "https://valencell.com/blog/optical-heart-rate-monitoring-what-you-need-to-know/".