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Electronic Heart Monitoring Device

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General Introduction

Heart failure, commonly known as a heart attack, occurs when the blood flow to a part of the heart is blocked for a prolonged period, leading to damage or death of the heart muscle. This condition is usually caused by a buildup of fatty deposits (plaques) in the coronary arteries, which supply oxygen-rich blood to the heart. When a plaque ruptures, a blood clot may form and block the flow of blood to the heart muscle, resulting in a heart attack.

Heart attacks are a leading cause of death worldwide and are often characterized by symptoms such as chest pain or discomfort, shortness of breath, nausea, sweating, and lightheadedness. Prompt medical intervention is crucial to prevent further damage to the heart and improve the chances of survival [1].

Risk factors for myocardial infarction include smoking, high blood pressure, high cholesterol levels, diabetes, obesity, lack of physical activity, and a family history of heart disease. Lifestyle changes, such as quitting smoking, adopting a healthy diet, exercising regularly, and managing stress, can help reduce the risk of heart attacks.

Early detection and treatment of myocardial infarction are essential for saving lives and minimizing heart damage. Advances in medical technology, such as ECG monitoring, cardiac biomarker testing, and coronary angiography, have improved the diagnosis and management of heart attacks.

Designing an electronic device equipped with particular electronic components, proficient not only monitoring heart failures but also dispatching alerts to the patient's family member, plays a pivotal role in the field of prevention and management of heart failure.

Keywords:

Electrocardiogram, SMS sending, GPS positioning, Arduino programming

Chapter I

Heart Disease

I.1. Introduction

This work presents a potential solution for detecting heart failure using a belt equipped with ECG sensor. The system includes a range of features, such as sending alerts and short SMS messages.

The electrocardiogram (ECG) is a physiological signal generated by the body, representing the electrical activity of the heart. It is measurable and used by physicians as a means of diagnosing the cardiovascular system. In this first chapter, we will provide a detailed explanation of the main functioning of the cardiovascular system, the principle of ECG, and how a heart failure detection device works.

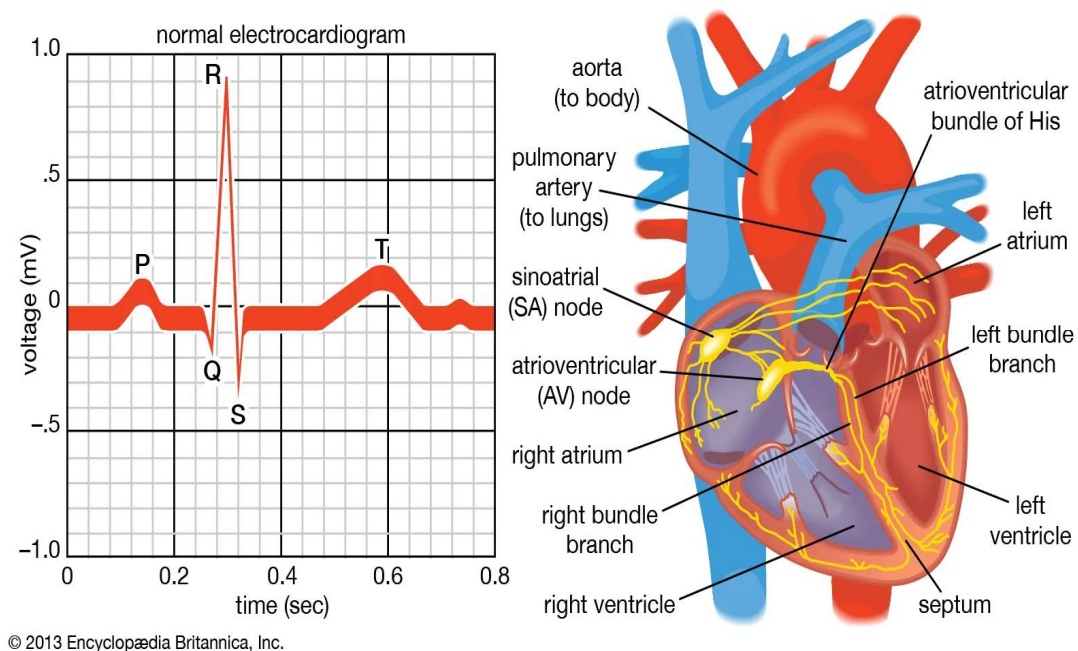


Figure I.1. Human Heart



Figure I.2. Information about heart function for multiple patients

I.2. Anatomy of the Cardiovascular System

The cardiovascular system, which includes the heart, arteries, veins, and capillaries, plays a vital role in pumping and circulating blood throughout the body. Its main function is to distribute oxygen, nutrients, and hormones to the tissues and organs, while removing metabolic waste products and carbon dioxide.

Anatomically, the cardiovascular system can be divided into two main components [2]:

I.2.1. The Cardiac System

The Heart: Comprising four main chambers - the right and left atria, and the right and left ventricles - the heart pumps blood into the blood vessels through its rhythmic contractions.

I.2.2. The Vascular System

- **Arteries:** Transport blood from the heart to the tissues of the body. Arteries branch into smaller arteries called arterioles.
- **Veins:** Collect deoxygenated blood from the tissues and return it to the heart. Veins transport blood from small blood vessels called venules to larger blood vessels.
- **Capillaries:** Connect arteries to veins and facilitate the exchange of nutrients, gases, and waste products between the blood and tissues.

These components work together in coordination to ensure an efficient and effective circulatory system throughout the body.

Here are some key points about the anatomy of the cardiovascular system:

I.2.3. The Heart

- The heart is composed of muscle tissue known as cardiac muscle.
- The left ventricle is considered the main component of the heart, responsible for pumping blood to the body through the arteries.
- The right ventricle pumps blood to the lungs via the pulmonary arteries.

I.2.4. Arteries

- Arteries transport oxygen-rich blood from the heart to the tissues.
- They include pulmonary arteries, which carry blood to the lungs for oxygenation.

I.2.5. Veins:

- Veins collect deoxygenated blood from the tissues and return it to the heart.
- They include systemic veins, which collect blood from the lower body and return it to the right atrium, and pulmonary veins, which collect oxygenated blood from the lungs and return it to the left atrium.

I.2.6. Capillaries:

- Capillaries are small blood vessels that connect arteries to veins and facilitate the exchange of gases and nutrients between the blood and tissues.
- They are considered the primary site for gas and nutrient exchange in the body.

I.3. Electrocardiography

Some heart problems can be challenging to diagnose if your symptoms don't appear during an electrocardiogram (ECG). Some applications on smartphones and smartwatches can reconstruct an ECG from your pulse waveform. This could be useful in diagnosing abnormalities in heart rhythm

It first allows verifying that the impulse originates from the sinoatrial node: the heart rate then said to be sinus, meaning normal, and that the distribution of this impulse in the heart occurs in a rigorously ordered sequence. The electrical pathway must occur without any slowdown or delay. Measuring the amplitudes and durations of the electrical waves allows the diagnosis of hypertrophy of the heart walls, dilatation of the cavities, or absence of depolarization in certain areas (myocardial infarction, etc.). The ECG also allows the diagnosis of abnormal accelerations of heart rate (tachycardias) or abnormal slowdowns (bradycardias).[4]

An electrocardiogram (ECG) is a painless and non-invasive procedure used to assist in diagnosing many common heart problems. Your doctor may use an ECG to determine or detect the following:

- Arrhythmia
- Whether blocked or narrowed arteries in the heart (coronary artery disease) are causing chest pain or a heart attack
- If you've had a heart attack before
- The success of specific treatments for heart conditions, such as pacemakers You may need an ECG if you have any of the following signs and symptoms:
- Chest pain
- Dizziness or lightheadedness
- Heart palpitations
- Increased heart rate
- Shortness of breath
- Weakness or fatigue or reduced ability to exercise The American Heart Association recommends against using ECG to evaluate asymptomatic adults with low risk. However, if you have a family history of heart disease, your doctor may suggest an ECG as a screening test, even if you don't have any symptoms.

If your symptoms come and go frequently, they may not be detected during a standard ECG recording



Figure I.3.Electrocardiography

I.4. Role of Electrocardiography (ECG)

Electrocardiography (ECG) is an important diagnostic tool used in medicine to evaluate and monitor the health and function of the heart. Its primary role is to record the electrical activity of the heart, helping doctors understand how the heart works and identify any potential issues [3].

I.4.1. The main roles of ECG include

1. **Diagnosing Heart Attacks:** ECG can detect the electrical signs of a current or past heart attack, helping to identify the presence of heart muscle damage and determine its location.
2. **Detecting Heart Rhythm Disorders:** ECG helps diagnose various heart rhythm disorders, such as atrial fibrillation, atrial flutter, ventricular tachycardia, and bradycardia.
3. **Evaluating the Effects of Medications:** ECG can be used to monitor the effects of medications on the heart, especially drugs that affect the heart's electrical activity.
4. **Monitoring Heart Health:** ECG is routinely used in regular medical check-ups to monitor heart health and detect any potential problems early.
5. **Evaluating the Function of Implanted Heart Devices:** It helps in monitoring the function of implanted heart devices such as pacemakers and defibrillators.
6. **Identifying Electrolyte Imbalances:** ECG can reveal changes in electrolyte levels in the body, such as potassium or calcium imbalances, which can affect heart activity.

By using this tool, doctors can obtain valuable information about the heart's health and function, enabling them to make precise treatment decisions and improve patient care.

I.5. Principle of Electrocardiography

The principle of electrocardiography relies on measuring the electrical activities arising from the contraction and relaxation of the heart muscle. This is done by placing electrical electrodes on the skin surface, where these electrodes record the electrical activities occurring during the cardiac cycle. These electrical signals are then converted into a graphical representation (ECG) that illustrates the heart's activity over time. Physicians can utilize this recording to evaluate heart health and diagnose any issues.

I.6.Cardiac Electrical Activity

The electrical current originates at a specific point in the heart (measuring a few millimeters) called the sinoatrial node, located at the top of the right atrium. This source consists of a group of cells capable of producing an electrical current of several millivolts. The current starts from the sinoatrial node (SA node) and then spreads rapidly through the heart muscle as if it were spreading oil in water. It travels through the atria until their bases, causing them to contract. It then congregates towards the septum between the atria and ventricles, at a location known as the atrioventricular node (AV node) or the Aschoff-Tawara node. From the atrioventricular node (AV node), the excitation advances synchronously in both ventricles, right and left, through very fast conducting pathways (the His bundle and Purkinje network), reaching the apex of the heart, leading to ventricular contraction. The electrical activity of the heart can be recorded and interpreted as an electrocardiogram (ECG). [4]

The sinoatrial (SA) node generates the primary electrical signal, which then travels to the atrioventricular (AV) node and from there to the heart muscle fibers in the ventricles.

Medical devices such as an electrocardiogram (ECG) record this electrical activity. They can measure the electrical signals generated by the cardiac muscle during the cardiac cycle and record them as waveforms that reflect heart activity and provide information about its function.

Heart Cycle and Electrical Activity: The cardiac cycle is divided into several stages, starting from the beginning of contraction (atrial contraction) until the end of relaxation (completion of ventricular contraction). Each stage coincides with specific electrical activity in the heart.

Electrocardiogram (ECG): This technique records the electrical activity of the heart by capturing the electrical signals generated by cardiac cells during the cardiac cycle. These signals are represented as waveforms, helping doctors diagnose heart problems and monitor its function.

Disorders of Electrical Activity: Disorders in the electrical activity of the heart can lead to problems in contractions and heartbeats. Examples of these disorders include atrial fibrillation, ventricular tachycardia, and abnormalities in the conduction of electrical signals in the atrioventricular node, among others.

Treatment of Electrical Activity Disorders: Treating these disorders involves using antiarrhythmic medications, pacemaker devices, implantable cardioverter-defibrillators (ICDs), and in some cases, surgical intervention.

Current Research: Many studies are conducted to better understand the electrical activity of the heart and to develop more effective treatments for associated disorders. This includes developing new techniques for recording and analyzing electrical activity

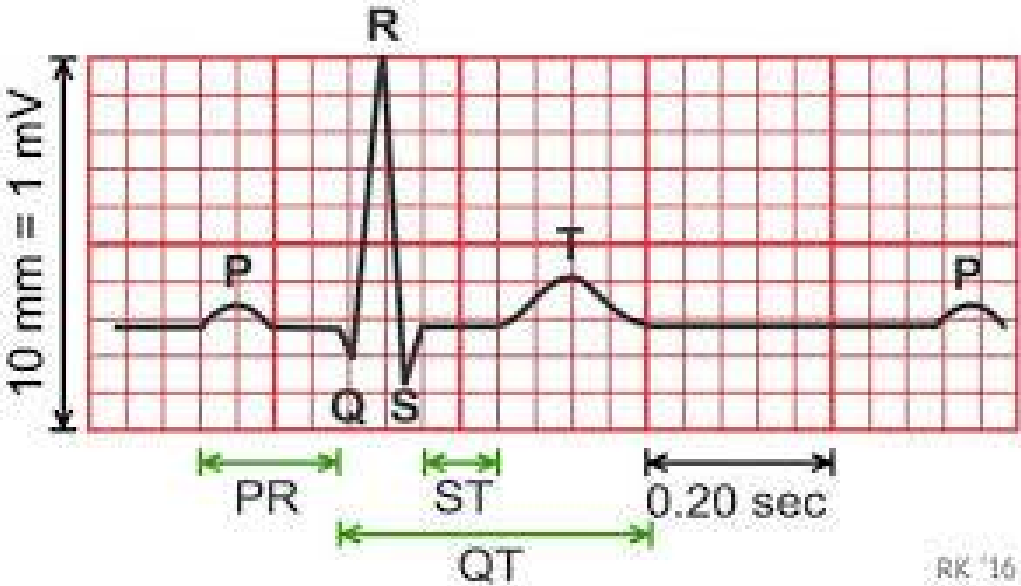


Figure I.4. The electrical activity of the heart

The electrocardiogram (ECG) consists of repetitive waves with a standard shape, containing several components: the P wave, the QRS complex, the ST segment, and the T wave. Additionally, there is the PR interval between the P wave and the QRS complex, and the QT interval between the QRS complex and the T wave.

I.7. The main waves of an electrocardiogram:

There are five main waves that appear on the results of the electrocardiogram "P, Q, R, S, T" respectively, where each wave represents a specific point in the heart when the electrical current flows through it, starting from the atrium to the ventricle, and the periods between the

waves represent the time it takes for the current to reach from one point to another. The waves appear in order from left to right:

1- Wave (P): It is the first wave that appears and indicates the depolarization resulting from the passage of electrical current through both the right and left atria. The height of the wave indicates the strength of the applied voltage, and the width of the wave indicates the period it takes [5].

2- Wave (Q): It is often mentioned for its difficulty in identification and the challenge lies in its very small size. It usually occurs just before a high wave in the current intensity and indicates the depolarization resulting from the passage of electrical current across the septum between the ventricles [5].

3- Wave (R): It is the highest wave in terms of current intensity and the shortest in time. It is one of the most important waves as it indicates the passage of electrical current resulting in depolarization of both the right and left ventricles.

4- Period between waves P-R: This period is not named P, Q due to the uncertainty of the Q wave in the electrocardiogram results. This period represents the time taken by the current from the start point of wave P to the start point of wave R, i.e., from the beginning of the depolarization of the atrial cells until the current reaches the ventricles.

5- Wave (S): This wave represents the passage of electrical current through the walls of the ventricles upwards, resulting in the depolarization of the cells on both the right and left walls of the ventricles.

6- Wave (T): This wave indicates the recovery of the cells composing both the right and left ventricles. Due to the thickness of the ventricular walls compared to the atria, the wave indicating the recovery of atrial cells is suppressed by the T wave.

7- Wave (U): The appearance of this wave is rare in a healthy heart, as it indicates the passage of electrical current through the Purkinje fibers associated with both the atrioventricular valves and the tricuspid through the chordae tendineae [5]

1.8. Explanation of electrocardiography paper

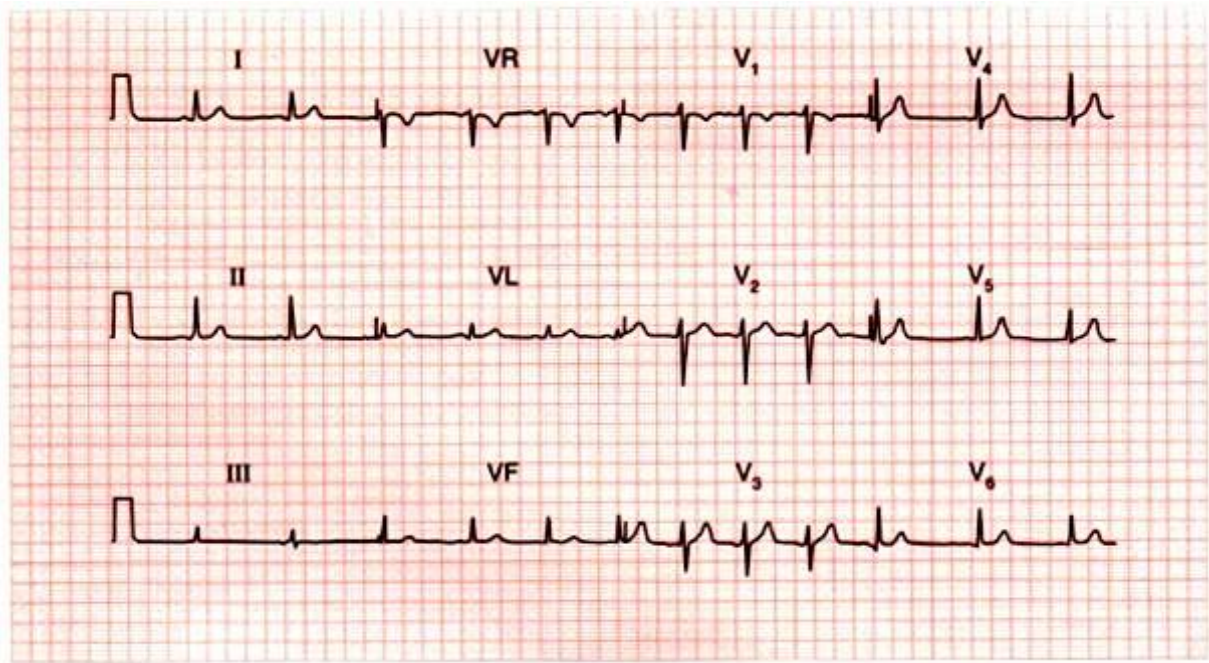


Figure I.5.The electrocardiography of the disease heart

The ECG paper is a graphical representation. After the examination, you are given a paper with waves drawn on it and divided into squares. Each small square equals 0.04 seconds. Each large square equals 0.2 seconds, and the large square contains 5 small squares.

Every 5 large squares equal 1 second. Every 300 large squares equal 1 minute. The heart is divided into 4 chambers or rooms: two at the top called atria and two at the bottom called ventricles [5].

The first wave is labeled as P. This represents the contraction and movement of blood from the top to the bottom of the heart.

In the normal condition, this wave must be present and its length is 2 to 3 small squares, equivalent to 0.12 seconds.

The QRS wave. This wave is composed of three letters and represents the contraction of the ventricle. Its height is always higher than the other waves and its duration is 0.10 seconds.

The T wave. This represents the relaxation of the heart muscles and the end of the heartbeat. Its duration is 3 small squares

Finally, the U wave may sometimes appear and most likely will not appear. If it appears, it means the patient has potassium deficiency or high calcium levels in the blood. If calcium is elevated, the patient is at risk of kidney stones and bone weakness.

Diagnosis after the conditions simply from the waves:

Abnormal P wave: (long and prominent >> right atrial enlargement), (broad and notched >> left atrial enlargement). And clarify what you see this wave in direction II.

Estimate P-R interval: prolonged? Short?

Changes in the QRS complex:

- Broad: Ventricular origin or branch block.
- Elevation: (Long R wave in V1 >> right ventricular hypertrophy), (Long R wave in V6 >> left ventricular hypertrophy).
- Presence of Q waves: Small ones exist in directions I, II, VL, V5, V6 normally.

S-T segment: Elevates in acute myocardial infarction or pericarditis. Decreases in infarction or with digoxin effect.

T wave: (Prominent >> hyperkalemia), (Flat >> hypokalemia).

- (Inverted >> infarction or myocardial infarction, ventricular hypertrophy or pulmonary embolism, branch block, with digoxin effect)."

Five rules for reading electrocardiography:

The first rule: Is this ECG representing a normal heart rhythm or not? Sinus or non-sinus.

The second rule: We need to know if the heartbeats are regular or irregular. Rhythm. Regular or irregular.

The third rule: We must determine the heart rate.

The fourth rule: The heart axis.

The fifth rule: Are the heart waves normal or abnormal?

Heart rate: The normal range is from 60 to 100 beats per minute. To calculate, if it's regular, count the number of large squares between one R and the next R. Then divide 300 by this number to get the result.

First, the P wave. We already know it represents the atrial movement, and its duration is 2 small squares.

The QRS wave represents ventricular movement, and its duration should be 2 small squares. If it's longer, it indicates a problem.

The T wave represents ventricular relaxation, and its duration should be 3 small squares.

A healthy heart must meet the following conditions:

1. Sinus Rhythm: The heart's electrical rhythm appears to be normal sinus rhythm.
2. Regular: There is regular timing between heartbeats.
3. Heart rate: The heart rate falls within the normal range of 60 to 100 beats per minute.
4. Axis: Axis determination is not relevant at the moment.
5. Heart waves: The duration of heart waves appears to be normal.

If these conditions are met, then the heart is considered healthy, as depicted in the image [5].

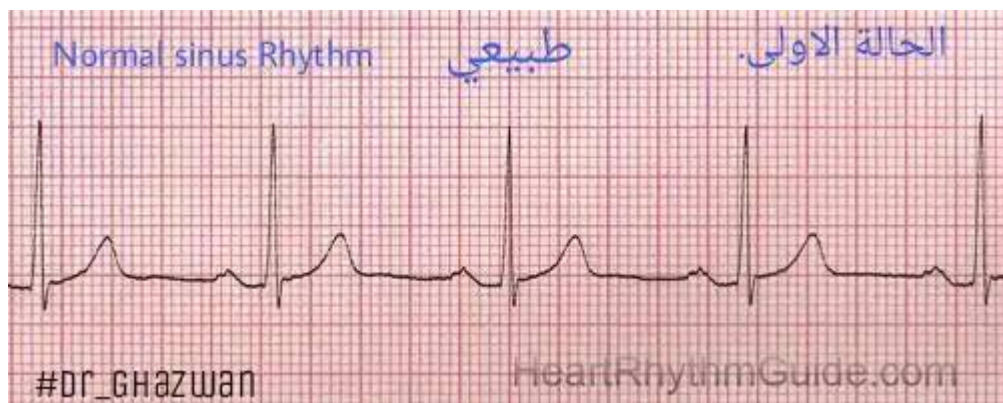


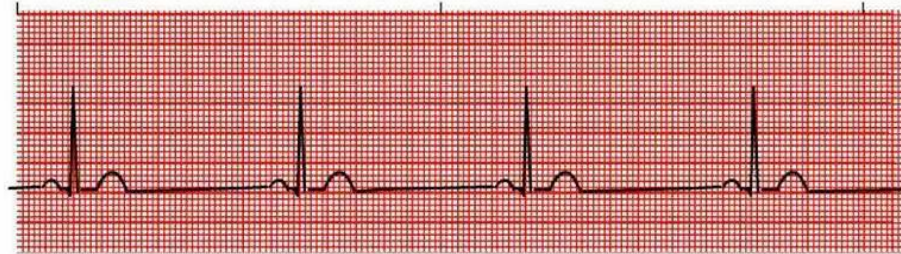
Figure I.6.The first condition is "Normal sinus rhythm."

In the second scenario :The heart has weak heartbeats below 60, which is called bradycardia. The heart rate is slow. How do we know? We apply the five rules. You will find that all five rules are met except for the slow heart rate below 60.

Sinus Bradycardia

بطيء القلب

الحالة الثانية



Rate	40-59 bpm
P wave	Sinus
QRS	Normal (.06-.12)
Conduction	P-R normal or slightly prolonged at slower rates
Rhythm	Regular or slightly irregular

Figure I.7. the second case: weak heart.

1.9. Heart Diseases and Their Detection Methods

Heart diseases, such as coronary artery disease, hypertension, arrhythmias, myocarditis, and heart failure, can vary greatly and may be life-threatening in some cases, making early detection crucial for maintaining heart health. Among the important heart diseases and their detection methods are:

Coronary Artery Disease (CAD): Blockages in the coronary arteries can lead to reduced blood flow to the heart muscle, resulting in a heart attack. Detection methods include electrocardiography (ECG), stress tests, and diagnostic imaging such as cardiac magnetic resonance imaging (CMR) [5].

I.9.1.Hypertension: High blood pressure is a serious risk factor for heart and vascular diseases. It is typically diagnosed through blood pressure measurements and regular monitoring of the heart and blood vessels.

I.9.2.Arrhythmias: Heart rhythm disorders include rapid or slow heartbeats and irregular heartbeats. They can be diagnosed through ECG and continuous cardiac monitoring.

I.9.3.Myocarditis: Inflammation of the heart can occur due to infection or chronic joint inflammation. Detection methods may include medical imaging, physical examination, and blood tests.

I.9.4.Heart Failure: This can result from factors such as high blood pressure or narrowed arteries. It can be diagnosed through medical examinations and diagnostic imaging.

It's important to pay attention to any potential signs of heart problems such as chest pain, shortness of breath, dizziness, palpitations, unexplained fatigue, swelling, and nausea. Detection methods typically include routine medical check-ups, blood tests, and diagnostic imaging such as X-rays

I.10.The tools used in heart diseases

The tools used in diagnosing and treating heart diseases include a variety of different medical devices and tools. Here are some examples of common tools used in the field of cardiology:

I.10.1.Electrocardiogram (ECG) machine

Measures the electrical activity of the heart and records it in a graphical format to assess the heart's electrical activity.

I.10.2.Blood pressure monitor

Measures blood pressure to assess heart and blood vessel health.

I.10.3.Cardiac imaging devices

Such as X-ray imaging, cardiac magnetic resonance imaging (MRI), and computed tomography (CT) scans, which are used to diagnose structural or functional heart problems.

I.10.4.Stress testing devices

Used to evaluate the heart and blood vessels' response during physical exercise or stress.

I.10.5.Pulse monitoring devices

Used to monitor heart rate and electrical activity over extended periods, such as Holter monitors and event monitors.

I.10.6.Cardiac catheterization tools

Used in cardiac catheterization procedures to diagnose and treat narrowed arteries or valve abnormalities.

I.10.7.Surgical intervention tools

Used in surgical procedures such as coronary artery bypass grafting (CABG) and corrective heart surgeries.

These are just some of the tools and devices used in the field of heart diseases, and the tools used may vary depending on the type and condition of the disease and the available technologies in medical institutions.

I.11. Heart failure

Heart failure is a prevalent medical condition globally, affecting millions of people each year. Its prevalence varies depending on factors such as age, gender, and underlying health conditions. In the United States alone, it's estimated that over 6 million adults have heart failure, with approximately 1 in 8 deaths attributed to the condition. As populations age and risk factors such as hypertension, diabetes, and obesity continue to rise, the burden of heart failure is expected to increase. Efforts to prevent and manage heart failure through lifestyle modifications, early detection, and advanced medical therapies are crucial in addressing this significant public health issue [6].

It is a chronic and progressive condition where the heart muscle becomes weakened and cannot pump blood efficiently enough to meet the body's needs. It can result from various underlying causes, including coronary artery disease, high blood pressure, diabetes, and previous heart attacks.

Heart failure can lead to symptoms such as shortness of breath, fatigue, swelling in the legs and ankles, and difficulty performing daily activities. These symptoms can significantly impact a person's quality of life and may worsen over time if left untreated.

Management of heart failure typically involves a combination of lifestyle changes, medications, and sometimes surgical interventions like implantation of devices such as pacemakers or defibrillators. Patient education, regular monitoring, and adherence to treatment plans are essential for effectively managing heart failure and reducing the risk of complications [6].

Despite advances in treatment, heart failure remains a leading cause of hospitalization and mortality worldwide. Therefore, raising awareness about its risk factors, symptoms, and available treatments is crucial for early detection and optimal management. Additionally, ongoing research efforts aimed at better understanding the mechanisms of heart failure and developing new therapies are essential for improving outcomes for individuals living with this condition.

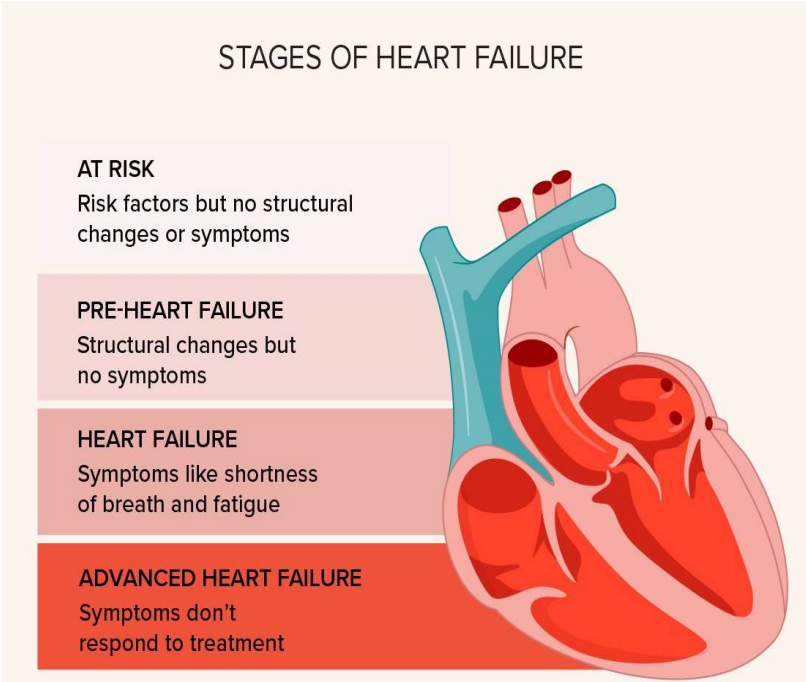


Figure I.8. Stages of Congestive Heart Failure

I.12. Conclusion

In the present chapter we have highlighting on heart characteristics and global reasons lead to malfunction of heart activity, one major point treated is how to reading ECG signals which let us to put some decision about heart activity, this represent our challenge, how can transfer theses knowledge and exploit them to realize our medical device.

Chapter II

Arduino Technology

II.1. Introduction:

Arduino is an open-source hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices, its hardware products are licensed under a CC BY-SA license, while software is licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL) which permit the production of Arduino boards and software distribution by anyone. Arduino boards are available commercially from the official website or through authorized distributors. Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ('shields') or breadboards (for prototyping) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs. The microcontrollers can be programmed using the C and C++ programming languages, using a standard API which is also known as the Arduino language, inspired by the Processing language and used with a modified version of the Processing IDE. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) and a command line tool developed in Go. The Arduino project began in 2005 as a tool for students at the Interaction Design Institute Ivrea, Italy, aiming to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment

Using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats and motion detectors. The name Arduino comes from a bar in Ivrea, Italy, where some of the founders of the project used to meet. The bar was named after Arduin of Ivrea, who was the margrave of the March of Ivrea and King of Italy from 1002 to 1014.

II.2. Overview

The first Arduino ever made was part of a project started at the Interaction Design Institute Ivrea (IDII) in Ivrea, Italy. At that time, students used a BASIC Stamp microcontroller at a cost of \$50. In 2003, Hernando Barragán created the development platform Wiring as a Master's thesis project at IDII, under the supervision of Massimo Banzi and Casey Reas. Casey Reas is known for co-creating, with Ben Fry, the Processing development platform. The goal of the project was to create simple, low-cost tools for creating digital projects by

non-engineers. The Wiring platform consisted of a printed circuit board (PCB) with an ATmega128 microcontroller, an integrated development environment (IDE) based on Processing, and library functions to easily program the microcontroller [7].

In 2005, Massimo Banzi, along with David Mellis, another IDII student, and David Cuartielles, extended Wiring by adding support for the cheaper ATmega8 microcontroller. The new project, which was forked from Wiring, was named Arduino [8].

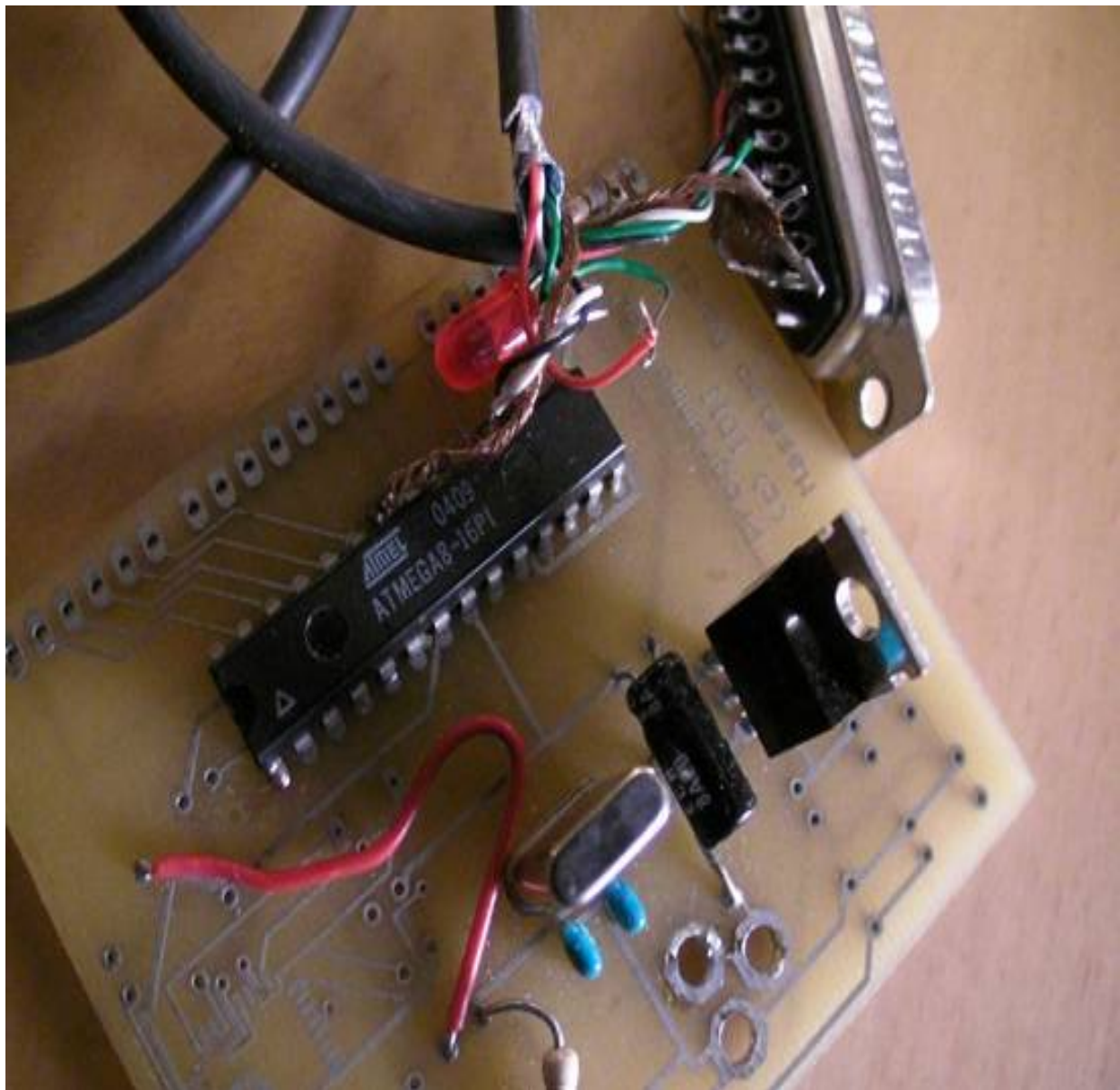


Figure II.1.THE FIRST ARDUINO

The initial Arduino core team consisted of Massimo Banzi, David Cuartielles, Tom Igoe, Gianluca Martino, and David Mellis. Following the completion of the platform, lighter and

less expensive versions were distributed in the open-source community. It was estimated in mid-2011 that over 300,000 official Arduinos had been commercially produced, and in 2013 that 700,000 official boards were in users' hands.

II.3. Hardware

Arduino is open-source hardware. The hardware reference designs are distributed under a Creative Commons Attribution Share-Alike 2.5 license and are available on the Arduino website. Layout and production files for some versions of the hardware are also available

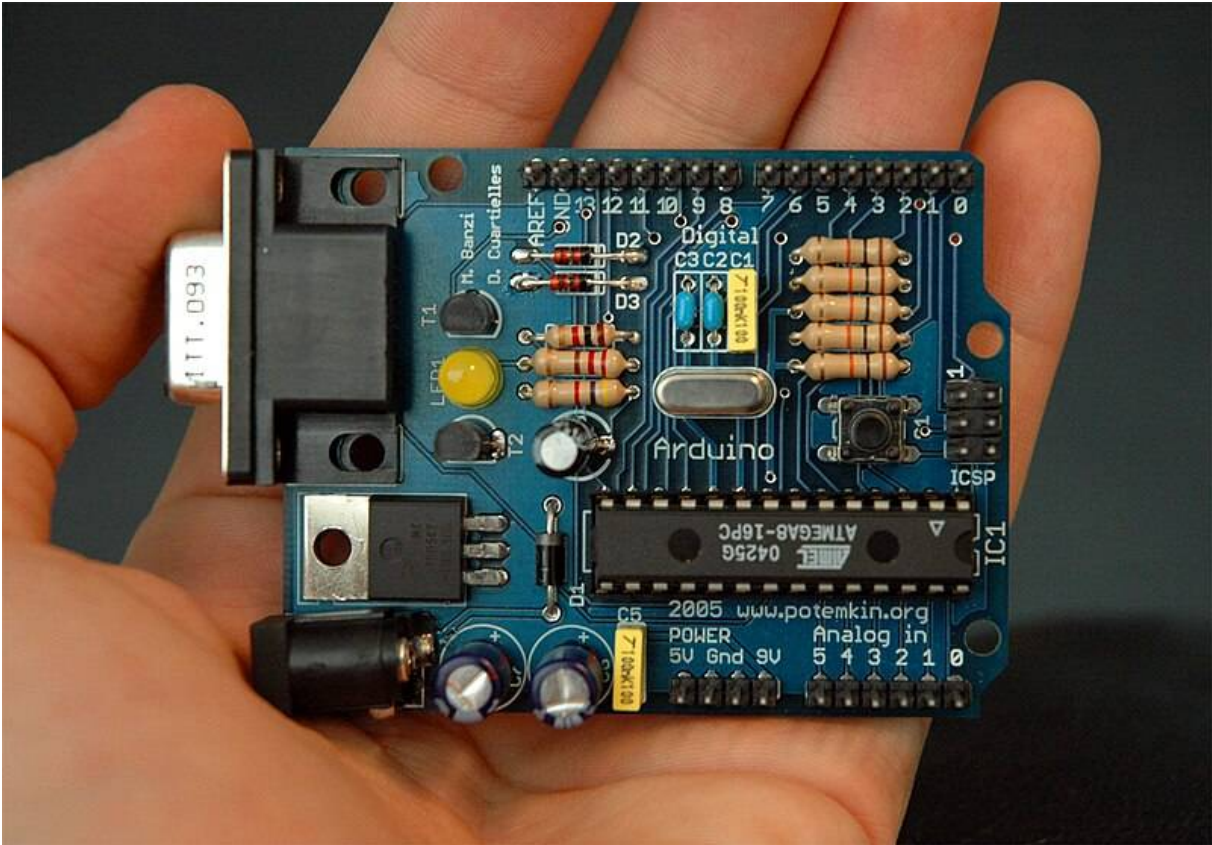


Figure II.2.INPUT/OUTPUT FOR ARDUNO UNO

Although the hardware and software designs are freely available under copyleft licenses, the developers have requested the name Arduino to be exclusive to the official product and not be used for derived works without permission. The official policy document on use of the Arduino name emphasizes that the project is open to incorporating work by others into the official product. Several Arduino-compatible products commercially released have avoided the project name by using various names ending in -duino. An early Arduino board with an RS-232 serial interface (upper left) and an Atmel ATmega8 microcontroller chip (black,

lower right); the 14 digital I/O pins are at the top, the 6 analog input pins at the lower right, and the power connector at the lower left. Most Arduino boards consist of an Atmel 8-bit AVR microcontroller (ATmega8, ATmega168, ATmega328, ATmega1280, or ATmega2560) with varying amounts of flash memory, pins, and features [9].

The 32-bit Arduino Due, based on the Atmel SAM3X8E was introduced in 2012 [10]. The boards use single or double-row pins or female headers that facilitate connections for programming and incorporation into other circuits. These may connect with add-on modules termed shields. Multiple and possibly stacked shields may be individually addressable via an I²C serial bus. Most boards include a 5 V linear regulator and a 16 MHz crystal oscillator or ceramic resonator. Some designs, such as the LilyPad [11], run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions. Arduino microcontrollers are pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory. The default bootloader of the Arduino Uno is the Optiboot bootloader. Boards are loaded with program code via a serial connection to another computer. Some serial Arduino boards contain a level shifter circuit to convert between RS-232 logic levels and transistor–transistor logic (TTL) level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232. Some boards, such as later-model Uno boards, substitute the FTDI chip with a separate AVR chip containing USB-to-serial firmware, which is reprogrammable via its own ICSP header. Other variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to-serial adapter board or cable, Bluetooth or other methods. When used with traditional microcontroller tools, instead of the Arduino IDE, standard AVR in-system programming (ISP) programming is used.

An official Arduino Uno R2 with descriptions of the I/O locations The Arduino board exposes most of the microcontroller's I/O pins for use by other circuits. The Diecimila, Duemilanove, and current Uno provide 14 digital I/O pins, six of which can produce pulse-width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on the top of the board, via female 0.1-inch (2.54 mm) headers. Several plug-in application shields are also commercially available. The Arduino Nano [12], and Arduino-compatible Bare Bones Board and Boarduino boards may provide male header pins on the underside of the board that can plug into solderless breadboards. Many Arduino-compatible and Arduino-derived boards exist. Some are functionally equivalent to an Arduino and can be used interchangeably. Many enhance the basic Arduino by adding output drivers, often for

use in school-level education, to simplify making buggies and small robots. Others are electrically equivalent, but change the form factor, sometimes retaining compatibility with shields, sometimes not. Some variants use different processors, of varying compatibility

II.4. Software

A program for Arduino hardware may be written in any programming language with compilers that produce binary machine code for the target processor. Atmel provides a development environment for their 8-bit AVR and 32-bit ARM Cortex-M based microcontrollers: AVR Studio (older) and Atmel Studio (newer) [13].

II.5. Integrated development environment:

The Arduino integrated development environment (IDE) is a cross-platform application (for Microsoft Windows, macOS, and Linux) that is written in the Java programming language. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus. The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main()* into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

On October 18, 2019, Arduino Pro IDE (alpha preview) was released. Later, on March 1, 2021, the beta preview was released, renamed IDE 2.0. The system still uses Arduino CLI (Command Line Interface), but improvements include a more professional development environment, autocompletion support, and Git integration. The application frontend is based on the Eclipse Theia IDE. The main features available in the new release are: Modern, fully

featured development environment, Dual Mode, Classic Mode (identical to the Classic Arduino IDE) and Pro Mode (File System view), New Board Manager, etc.

II.6. Sketch

A sketch is a program written with the Arduino IDE [14]. Sketches are saved on the development computer as text files with the file extension *.ino. Arduino Software (IDE) pre-1.0 saved sketches with the extension *.pde. A minimal Arduino C/C++ program consists of only two functions:

- `setup()`: This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch. It is analogous to the function `main()`.
- `loop()`: After `setup()` function exits (ends), the `loop()` function is executed repeatedly in the main program. It controls the board until the board is powered off or is reset. It is analogous to the function `while(1)`.

II.7. Arduino types

Several types of Arduino boards are available, each designed to meet different users' needs. Here are some common types of Arduino boards:

II.7.1. Arduino Uno:

- Considered the most common and easy to use.
- Contains an ATmega328P processor.
- Provides 14 digital pins for input and output and 6 analog inputs.

II.7.2. Arduino Mega 2560:

- Used in large and complex projects.
- Contains an ATmega2560 processor.
- Provides 54 digital pins for input and output and 16 analog inputs.

II.7.3. Arduino Nano:

- Small in size and suitable for projects that require space-saving.
- Contains an ATmega328 processor.

- Provides 14 digital pins for input and output and 8 analog inputs.

II.7.4.Arduino Leonardo:

- Contains an ATmega32u4 processor.
- Can be connected to the computer as an input device (keyboard or mouse).
- Provides 20 digital pins for input and output and 12 analog inputs.

II.7.5.Arduino Due:

- Based on an ARM Cortex-M3 processor.
- Provides 54 digital pins for input and output and 12 analog inputs.
- Operates at 3.3 volts instead of 5 volts.

II.7.6.Arduino Pro Mini:

- Small in size and suitable for final projects.
- Contains an ATmega328 processor.
- Available in two versions: 3.3 volts and 5 volts.

II.7.7.Arduino Lilypad:

- Designed for wearable projects and electronics integrated into clothing.
- Contains an ATmega328 processor.
- Can be sewn into fabrics thanks to its special design.

II.7.8.Arduino MKR1000:

- Contains a built-in WiFi module.
- Suitable for projects that require network connectivity.
- Contains a SAMD21 Cortex-M0+ processor.

II.7.9.Arduino Yún:

- Contains a built-in WiFi module in addition to an ATmega32u4 processor.

- Can connect to the internet directly.
- Contains a built-in Linux operating system.

These are some common types of Arduino boards, each with advantages and features that make it suitable for specific types of projects.

II.8. Arduino Uno

Arduino UNO is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic projects. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards and can control relays, LEDs, servos, and motors as an output. Arduino UNO features AVR microcontroller Atmega328, 6 analogue input pins, and 14 digital I/O pins out of which 6 are used as PWM output.

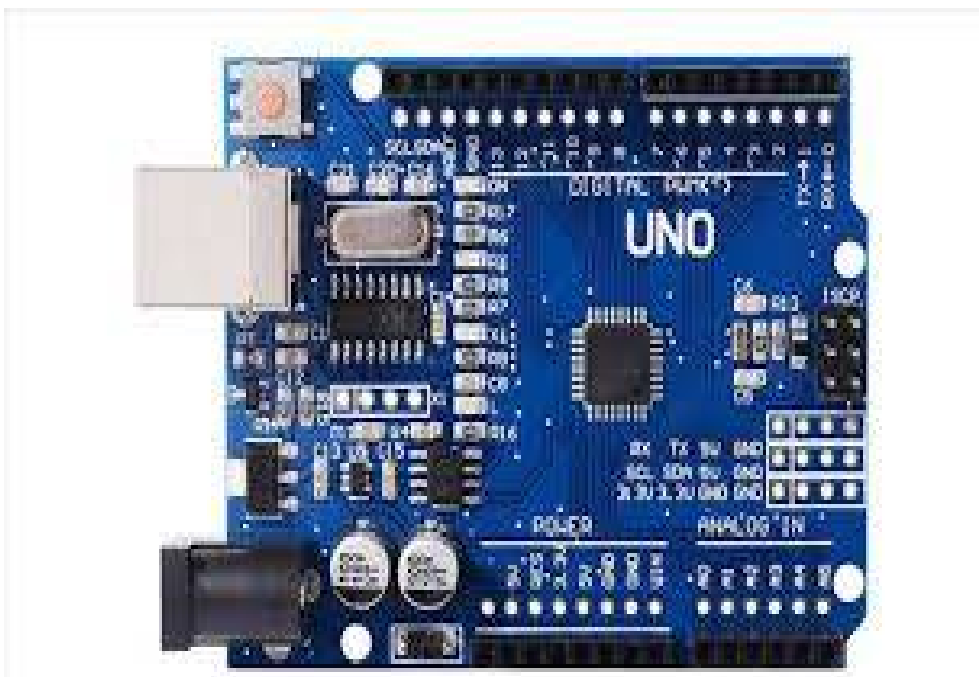


Figure II.3.ARDUINO UNO

This board contains a USB interface i.e. USB cable is used to connect the board with the computer and Arduino IDE (Integrated Development Environment) software is used to program the board. The unit comes with 32KB flash memory that is used to store the number of instructions while the SRAM is 2KB and EEPROM is 1KB. The operating voltage of the unit is 5V which projects the microcontroller on the board and its associated circuitry operates

at 5V while the input voltage ranges between 6V to 20V and the recommended input voltage ranges from 7V to 12V.

II.8.1. Arduino UNO Components

The Arduino UNO board contains the following components and specifications:

- **ATmega328:** This is the brain of the board in which the program is stored
- **PWM:** the board contains 6 PWM pins. PWM stands for Pulse Width Modulation, using this process we can control the speed of the servo motor, DC motor, and brightness of the LED.
- **Digital I/O Pins:** there are 14 digital (0-13) I/O pins available on the board that can be connected with external electronic components.
- **Analogue Pins:** there are 6 analogue pins integrated on the board. These pins can read the analogue sensor and can convert it into a digital signal.
- **AREF:** It is an Analog Reference Pin used to set an external reference voltage.
- **Reset Button:** This button will reset the code loaded into the board. This button is useful when the board hangs up, pressing this button will take the entire board into an initial state.
- **USB Interface:** This interface is used to connect the board with the computer and to upload the Arduino sketches (Arduino Program is called a Sketch)
- **DC Power Jack:** This is used to power up the board with a power supply.
- **Power LED:** This is a power LED that lights up when the board is connected with the power source.
- **Micro SD Card:** The UNO board supports a micro SD card that allows the board to store more information.
- **3.3V:** This pin is used to supply 3.3V power to your projects.
- **5V:** This pin is used to supply 5V power to your projects.
- **VIN:** It is the input voltage applied to the UNO board
- **Voltage Regulator:** The voltage regulator controls the voltage that goes into the board.
- **SPI:** The SPI stands for Serial Peripheral Interface. Four Pins 10(SS), 11(MOSI), 12(MISO), 13(SCK) are used for this communication.

- **TX/RX:** Pins TX and RX are used for serial communication. The TX is a transmit pin used to transmit the serial data while RX is a receive pin used to receive serial data.

II.8.2.Arduino-based medical devices

Arduino boards are increasingly being used in the field of medicine to develop innovative and efficient medical devices and systems. The use of Arduino in the medical field represents an exciting opportunity to develop new technologies and improve healthcare overall

Here are some common uses of Arduino in the medical field:

Health monitoring devices: Arduino can be used to design health monitoring devices such as blood sugar monitors, blood pressure monitors, and heart rate monitors.

Muscle stimulation devices: Arduino can be used to design devices for muscle stimulation for purposes of physical therapy and muscle strengthening.

Assistive devices for disabilities: Arduino can be used to design assistive devices for people with disabilities such as prosthetic limbs and mobility aids.

Sleep monitoring devices: Arduino can be used to design devices for monitoring patient sleep and recording sleep patterns and wakefulness.

Self-diagnostic devices: Arduino can be used to develop self-diagnostic devices such as temperature measurement devices and ear and eye examination devices.

Sterilization and disinfection devices: Arduino can be used to design devices for sterilization and disinfection in hospitals and medical facilities.

Medication control devices: Arduino can be used to design devices for precise medication delivery according to specific doses.

Pain Control Devices: Arduino can be used to design devices for delivering pain control therapy by directing electrical signals to specific nerves.

Assistive Vision Devices: Arduino can be used to design devices to assist individuals with visual impairment, such as obstacle detection and distance determination devices.

Medical Science Research: Arduino can be used in medical science research to develop experimental devices or advanced systems for examining and diagnosing diseases.

Medical Education and Training: Arduino can be used in medical education environments to develop interactive models for training students in medical procedures and understanding the basics of diagnosis and treatment.

The use of Arduino in the medical field helps provide cost-effective solutions to improve patient care and develop medical technologies

II.9. Programming with Arduino

Arduino UNO is easy to program and a person with little or no technical knowledge can get hands-on experience with this board. The Arduino UNO board is programmed using Arduino IDE software which is an official software introduced by Arduino.cc to program the board. The Arduino program is called a sketch which you need to unload into the board. The sketch is nothing but a set of instructions that allow the board to perform certain functions as per your requirements

Each Arduino sketch comes with two main parts: void setup() – this sets up the things that need to be done once and they don't happen again in the running program. void loop() – this part comes with the instructions that get repeated again and again until the board is turned off.

```

sketch_may18a
/* Getting_BPM_to_Monitor prints the BPM to the Serial Monitor, using the least lines of code and PulseSensor Library.
 * Tutorial Webpage: https://pulsesensor.com/pages/getting-advanced
 *
 *-----Use This Sketch To-----
1) Displays user's live and changing BPM, Beats Per Minute, in Arduino's native Serial Monitor.
2) Print: "♥ A HeartBeat Happened !" when a beat is detected, live.
2) Learn about using a PulseSensor Library "Object".
4) Blinks LED on PIN 13 with user's Heartbeat.
-----*/

#define USE_ARDUINO_INTERRUPTS true // Set-up low-level interrupts for most accurate BPM math.
#include <PulseSensorPlayground.h> // Includes the PulseSensorPlayground Library.

// Variables
const int PulseWire = 0; // PulseSensor PURPLE WIRE connected to ANALOG PIN 0
const int LED13 = 13; // The on-board Arduino LED, close to PIN 13.
int Threshold = 550; // Determine which Signal to "count as a beat" and which to ignore.
// Use the "Getting Started Project" to fine-tune Threshold Value beyond default setting.
// Otherwise leave the default "550" value.

PulseSensorPlayground pulseSensor; // Creates an instance of the PulseSensorPlayground object called "pulseSensor"

void setup() {

  Serial.begin(9600); // For Serial Monitor

  // Configure the PulseSensor object, by assigning our variables to it.
  pulseSensor.analogInput(PulseWire);
  pulseSensor.blinkOnPulse(LED13); //auto-magically blink Arduino's LED with heartbeat.
  pulseSensor.setThreshold(Threshold);
}

Compilation terminée.

Le croquis utilise 4750 octets (14%) de l'espace de stockage de programmes. Le maximum est de 32256 octets.
Les variables globales utilisent 283 octets (13%) de mémoire dynamique, ce qui laisse 1765 octets pour les variables locales. Le maximum est de 2048 octets.

15 Arduino Uno sur COM5

```

Figure II.4.programe Arduino

II.10. Conclusion

Embedded systems offer numerous advantages in medical environments, enhancing the efficiency, reliability, and functionality of medical devices and systems such as real-Time Monitoring Control, Miniaturization and Portability, etc.

In next chapter, we will present our medical embedded systems which tailored for medical situation. I strive to design reliable, accurate, user-friendly, and accessible devices.

Chapter III

Heart Monitoring Device

III.1. Introduction

The angina or heart failure detection device is an innovative tool designed to monitor heart conditions and alert in case of signs indicating a potential angina attack. This device is developed using advanced technologies such as Arduino, Global Positioning System (GPS), Electrocardiogram (ECG), and Global System for Mobile Communications (GSM).

Device Components:

- Arduino UNO
- Global Positioning System (GPS)
- HEART BEAT (ECG)
- Global System for Mobile Communications GSM(sim 900D)

By combining these components, the angina detection device becomes an effective tool in providing immediate care and improving the chances of survival in potential angina attack cases.

III.2. Used components description

III.2.1. The Electrocardiogram (ECG)

The Electrocardiogram (ECG) device is a medical device used to record the electrical activity of the heart. These recordings can help doctors diagnose various heart disorders, such as arrhythmias, heart failure, and other cardiac conditions.

III.2.2. Specifications of the ECG in the field of programming

In programming, when working with an Electrocardiogram (ECG) sensor, the specifications developers are concerned with may differ slightly from those important to end-users. Some key specifications that may matter to developers working in the programming field include:

Data Format: The sensor should support sending data in standard formats such as JSON, XML, CSV, or even custom protocols for communication with applications.

Application Programming Interface (API): The sensor should provide a clear and reliable API that allows developers to interact with the sensed data easily and efficiently.

Documentation and Support: The sensor should include comprehensive documentation and technical support available to developers, including usage examples and tutorials on integrating the sensor into their applications.

Live Data Provision: It is preferable for the sensor to be capable of providing real-time data continuously, enabling applications to use the data in real-time.

Language Compatibility: The sensor should be compatible with a variety of programming languages commonly used in application development such as Python, Java, JavaScript, and others.

Data Security: The sensor should have data protection mechanisms in place to ensure the security of the personal and sensitive data collected from users.

Ease of Use: Integration with the sensor should preferably be easy and straightforward to reduce the effort required for developers to include it in their applications.

In summary, the programming specifications for an ECG sensor focus on how to effectively and securely provide and exchange data between the sensor and programming applications.

III.2.3. Usage areas and ECG components :

ECG, or electrocardiography, is used to record the electrical activity that occurs during the cardiac cycle. This is achieved by placing electrical electrodes on the skin of the chest and limbs. When electrical signals emanate from the heart tissues during its contractions, these signals are recorded on a paper or a screen.

ECG results display a series of waves, deflections, and electrical arcs that reflect the heart's activity. Cardiologists can analyze these results to assess the health and function of the heart, and to detect any electrical or structural abnormalities.

ECG is considered a vital diagnostic tool in several cases, including the evaluation of heart conditions such as angina and arrhythmias, and monitoring the effectiveness of treatments such as cardiac pacing and antihypertensive medications.

Main Components: The ECG consists of several main components including the P wave, QRS complex, and T wave. Each component represents a different part of the cardiac cycle and reflects various electrical activities in the heart.

Clinical Uses: The ECG is used for diagnosing and monitoring various cardiac and vascular conditions. It can aid in diagnosing heart attacks, heart rhythm disorders such as ventricular contractions, and evaluating the effects of medications and treatments on heart activity.

Advanced Techniques: Nowadays, advanced cardiac monitoring techniques such as Holter monitors and event monitors are available, allowing for long-term monitoring of heart activity outside the hospital, helping diagnose heart disorders that may be difficult to detect in standard cardiac exams.

Personal Assessment: Additionally, individuals with cardiac health issues or undergoing cardiac treatment can monitor their heart activity using portable ECG devices, enabling them to monitor and record their heart activity in real-time.

The importance of ECG lies in its ability to provide accurate and detailed information about heart activity, aiding in the diagnosis of cardiac conditions and determining appropriate treatments

III.2.4.HEART BEAT SENSOR(ECG) :

Heart rate sensor, also known as heart rate monitor or heart rate sensor, is a device used to measure heart rate in real-time. These devices typically use various technologies such as optical sensors, electrodes, or piezoelectric sensors to detect heart rate.

Here are some key points about heart rate sensors:

Optical Sensors: Many modern heart rate sensors use optical sensing technology, which involves emitting light onto the skin and measuring changes in light absorption caused by blood flow. This technology is commonly found in wearable devices like smartwatches and fitness trackers.

Electrodes: Some heart rate sensors use electrodes that come into contact with the skin to measure the electrical activity of the heart. These are often used in medical-grade devices such as ECG machines.

Piezoelectric Sensors: These devices measure the mechanical activity of the heart, such as the vibrations produced by the heartbeat. They are less common but can be found in some wearable devices.

Applications: Heart rate sensors have a wide range of applications, including fitness tracking, sports performance monitoring, medical diagnosis, and biofeedback. They can provide valuable insights into cardiovascular health and fitness levels.

Accuracy: The accuracy of heart rate sensors can vary depending on the technology used the quality of the device, and how well it is fitted or positioned on the body. Generally, optical sensors tend to be more convenient for continuous monitoring during daily activities, while electrode-based sensors may offer higher accuracy for medical purposes.

Overall, heart rate sensors play a crucial role in monitoring and managing heart health, fitness, and performance, providing valuable data for individuals and healthcare professionals alike.

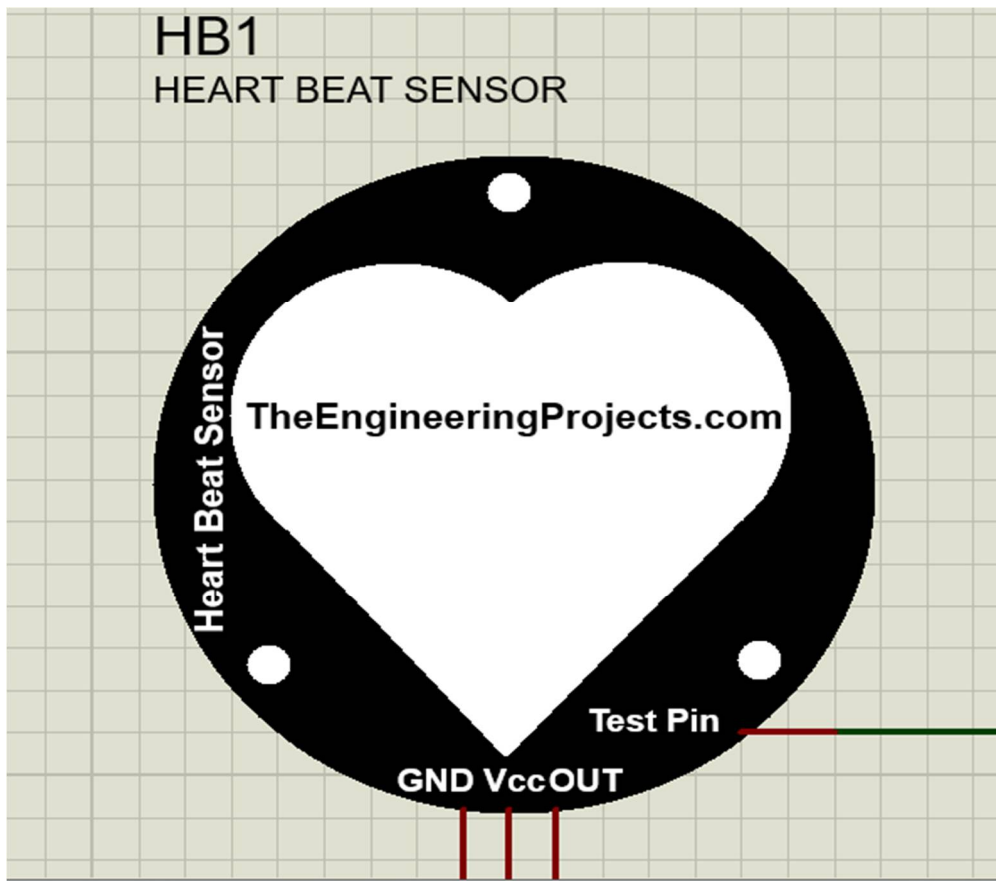


Figure III.1 HEART BEAT SENSOR (ECG)

III.2.5. Electrodes :

Electrodes are components of a heart rate sensor device that come into contact with the skin to measure the electrical activity of the heart. These electrodes work to record the changes in electrical current produced by the heart during its beating cycle. The electrodes convert these electrical signals into digital signals that can be read and analyzed by appropriate devices.

There are several types of electrodes used in heart rate sensor devices, which vary according to their purpose and application:

1. **Adhesive Electrodes:** These electrodes rely on direct adhesion to the skin using a special medical adhesive. They are characterized by providing direct and stable contact with the skin, allowing for accurate recording of heart signals.
2. **Wet Electrodes:** These electrodes require skin preparation with water or a conductive substance to improve electrical conductivity between the skin and the electrode. They are commonly used in medical settings and laboratories.
3. **Dry Electrodes:** These electrodes work without the need for conductive materials and are often easier to use and less discomforting for the patient. They are used in many wearable tracking devices.

Design of Electrodes: Electrodes usually come in different shapes and sizes, suited to the application on the body. They may be in the form of small discs or thin strips and are made of materials that provide good electrical signal conductivity, such as metals.

Skin Preparation: Before placing the electrodes on the skin, the targeted area is thoroughly cleaned to ensure good electrical signal conductivity. In some cases, a conductive gel may be used to enhance conductivity.

Wireless Technologies: In recent years, wireless technologies have emerged using flexible and smart electrodes that enable high-precision monitoring of heart activity without the need for tangled wires.

Multiple Uses: In addition to their use in standard heart monitoring devices, electrodes can also be used in wearable devices to monitor heart rate during daily and sports activities.

Safety and Comfort: Electrodes are designed to be safe for use on the skin and comfortable for the patient. They should be replaced regularly according to the manufacturer's instructions to ensure accurate and reliable readings.

The technologies related to electrodes are continuously evolving, enhancing their accuracy and comfort in monitoring heart activity and diagnosing cardiac conditions.

Sensors used for acquiring ECG signals are measurement electrodes placed directly on the skin. The silver plate of the electrode is covered with a layer of silver chloride. Before placing the

electrodes on the skin, an electrolyte solution is applied to the epidermis to ensure good conduction.

These electrodes are characterized by the following:

- The ability to capture low amplitude signals ranging from 0.05 mV to 10 mV.
- Very high input impedance.
- Very low input current, less than 1 microampere.

In this implementation, only the standard Einthoven leads (DI, DII, D3) will be used. In these leads, two electrodes must be placed on the left and right arms, in addition to a third electrode (reference electrode) placed on the left leg.



Figure III.2 Disposable Adult ECG Electrodes with Round Fabric for All Monitoring, Remote Heart Study via Telemetry



Figure III.3 Medical Safety ECG Electrode

III.3.Short Message Service (SMS)SIM 900D

Short Message Service (SMS) is a service that enables sending and receiving text messages between mobile phones. This service relies on communication protocols that allow mobile phones to exchange text messages over mobile networks.

The SIM 900D is a model of wireless communication modules produced by SIMCom. This module is used in Internet of Things (IoT) applications and projects that require cellular network connectivity. The SIM 900D module allows for connection to cellular networks to send and receive data, including SMS messages.

III.3.1.Features of the SIM 900D Module:

1. **Cellular Network Connectivity:** The module supports GSM/GPRS networks, allowing for internet connectivity and sending and receiving SMS messages.
2. **Full SMS Support:** The module enables sending and receiving SMS messages using AT commands.
3. **Multiple Interfaces:** The module supports several communication interfaces such as UART, SPI, and I2C, making it compatible with most microcontrollers.
4. **Low Power Consumption:** The module is designed to be energy-efficient, making it suitable for battery-powered applications.
5. **Application Flexibility:** It can be used in a wide range of applications such as tracking devices, security systems, remote monitoring systems, and more.

III.3.2. How to Send an SMS Using the SIM 900D:

To send an SMS using the SIM 900D module, a series of AT commands must be executed via the serial interface (UART). Here are the basic steps:

Set Text Mode for SMS:

```
AT+CMGF=1
```

This command sets the module to Text Mode for SMS.

Specify the Recipient's Phone Number:

```
AT+CMGS="phone number"
```

After executing this command, the module waits for the message text to be entered

Enter the Message Text:

After entering the message text, the message should be terminated by sending the Ctrl+Z character (ASCII code 26).

```
sendSMS(latitude, longitude, heartRate);
delay(60000); // Send data every 60 seconds
}
}

void sendSMS(double latitude, double longitude, int heartRate) {
  sim900.println("AT+CMGS="+2136724688855\");
  delay(1000);
  sim900.print("Heart Rate: ");
  sim900.print(heartRate);
  sim900.print(" bpm, ");
  sim900.print("Location: ");
  sim900.print("Lat: ");
  sim900.print(latitude, 6);
  sim900.print(", Lng: ");
  sim900.print(longitude, 6);
  delay(1000);
  sim900.write(26);
  // .....
}
```



Compilation terminée.

Le croquis utilise 8178 octets (25%) de l'espace de stockage de programmes. Le maximum est de 32256 octets.
Les variables globales utilisent 627 octets (30%) de mémoire dynamique, ce qui laisse 1421 octets pour les variables locales. Le maximum est de 2048 octets.

61 Arduino Uno sur COM

Figure III.4.Send an SMS Using the SIM 900D

III.3.3.Applications of the SIM 900D:

Tracking Devices:

- **Personal Tracking:** The module can be integrated into personal tracking devices for children, elderly, or pets, providing location updates through SMS.

Security Systems:

- **Alarm Systems:** The SIM 900D can be used in home or business alarm systems to send SMS alerts in case of intrusion or unusual activity.
- **Remote Monitoring:** It can be utilized in systems that monitor environmental conditions (temperature, humidity, etc.) and send alerts via SMS if certain thresholds are crossed.

Remote Control Systems:

- **Home Automation:** The module can be used to control home appliances remotely by sending SMS commands to turn devices on or off.
- **Industrial Automation:** In industrial settings, the SIM 900D can be used to monitor and control machinery, sending status updates and receiving control commands via SMS.

Health Monitoring:

- **Patient Monitoring:** The module can be part of a health monitoring system that sends patient health data (e.g., heart rate, blood pressure) to medical professionals via SMS.
- **Emergency Alerts:** It can be used to send emergency alerts and health status updates for elderly or patients with chronic conditions.

Consumer Electronics:

- **Smart Gadgets:** The module can be integrated into various consumer electronics, such as smartwatches and fitness trackers, to send data and notifications via SMS.
- **Home Appliances:** It can be used in smart home appliances to send maintenance alerts and usage statistics to users via SMS.

The SIM 900D module is highly versatile and can be applied in numerous fields, providing reliable cellular connectivity for a wide range of applications.

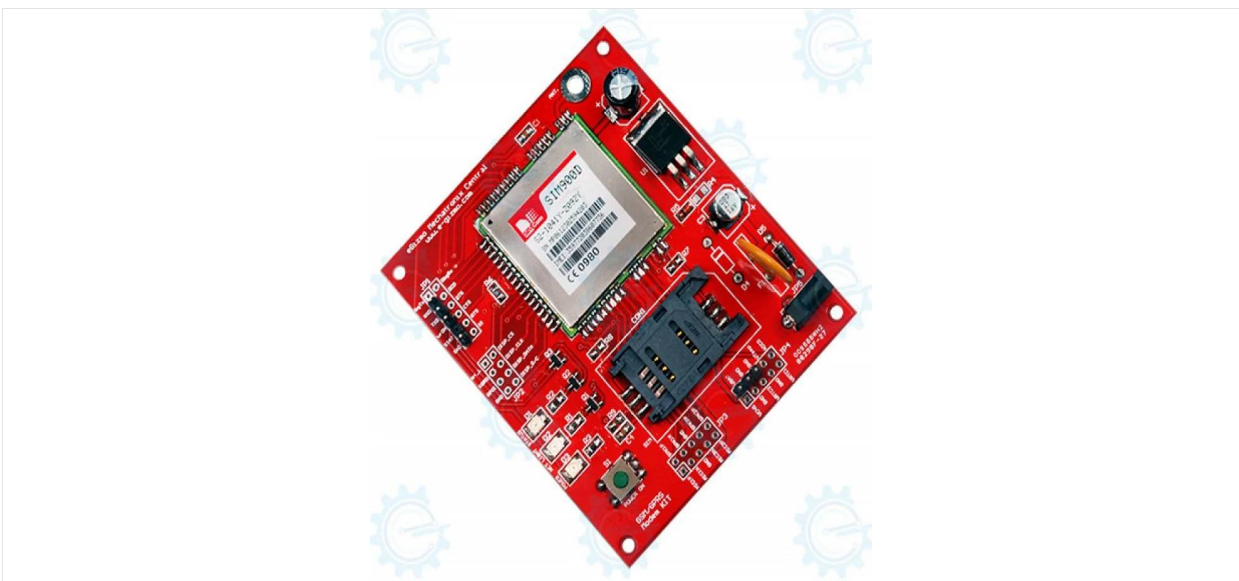


Figure III.5.SIM 900D Red in reality

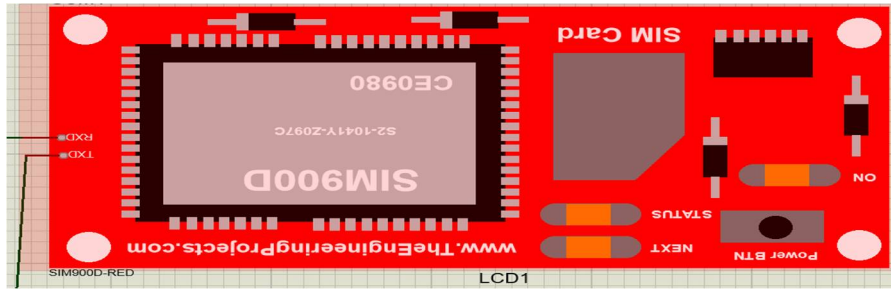


Figure III.6.SIM 900D RED IN PROTEUS

III.4.Global positioning system (GPS) :

Global Positioning System (GPS) is an electronic system used to accurately determine geographic location anywhere on the Earth's surface. It relies on a network of satellites that transmit signals to ground receivers, allowing the calculation of location based on the timing of these signals' arrival. GPS is used in a wide range of applications, including navigation, geographic surveying, and location determination in both military and civilian applications.

In addition to the aforementioned uses, the Global Positioning System (GPS) is utilized in numerous other scenarios and applications, including:

Sports and Fitness: GPS is used in activity tracking devices such as smartwatches and portable GPS devices to measure distances covered, speed, elevation, and other information relevant to sports activities.

Aviation: GPS is employed in aviation to determine locations, air routes, distances, and altitudes, contributing to the safety and efficiency of aviation operations.

Smart Agriculture: GPS is used in agriculture to pinpoint accurate locations for farming, guide agricultural vehicles, and precisely determine water and fertilizer needs.

Fleet Management: GPS is utilized in fleet management to track vehicle locations, optimize operations distribution, reduce fuel costs, and minimize unplanned downtime.

Travel and Tourism: GPS is integrated into smartphones and tablets to guide users to destinations, identify tourist landmarks, and provide information about nearby distances and locations.

These are just some of the common uses of the Global Positioning System (GPS), and it can be employed in many other scenarios and applications according to different needs and requirements

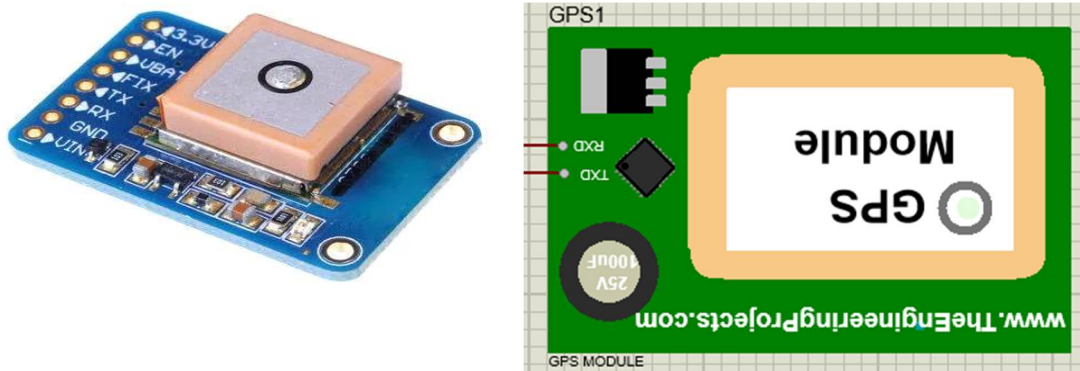


Figure III.7. Global positioning system (GPS)

III.4.1. GPS in the medical field :

Technology such as Global Positioning System (GPS) has multiple applications in the medical field, contributing to improving healthcare and increasing its efficiency. Here are some key uses:

Patient tracking: GPS can be used to track the locations of patients at risk of wandering, such as those with Alzheimer's or autism spectrum disorder. This can help quickly locate missing individuals and provide necessary assistance.

Emergency coordination: GPS can pinpoint the locations of accidents or emergencies accurately, enabling emergency response teams to reach the scene quickly and provide medical care.

Medication adherence tracking: GPS technology in medical devices can track medication intake, helping ensure that patients adhere to their medication schedules accurately.

Precise surgical planning: GPS can be used in surgery to precisely locate tumors or sensitive internal structures, enabling surgeons to perform procedures accurately and safely.

Medical research: GPS can be used in medical research to analyze individuals' lifestyles, such as levels of physical activity and mobility. This can provide valuable data for understanding factors influencing health and disease.

Despite the numerous benefits, privacy and security considerations must be taken into account when using GPS technology in the medical field, ensuring the protection of patient data and striking a balance between medical benefits and security and privacy challenges.

Tracking infectious diseases: GPS can be used to track the spread of infectious diseases such as epidemics. By analyzing GPS data, patterns of movement and social interactions can be understood, allowing for the identification of high-risk areas and the implementation of preventive measures.

Healthcare delivery: GPS can improve healthcare delivery services, such as delivering medications to homes or efficiently transporting patients to hospitals in a timely manner.

Fitness tracking: GPS technology in wearable devices can track physical activity and sports performance, helping individuals exercise more effectively and determine their fitness levels.

Assistance in international medical relief: GPS can be used to locate emergency medical cases in remote or disaster-stricken areas, enabling relief teams to reach affected areas and provide medical care.

Improving hospital and clinic management: GPS technology can improve resource planning and patient guidance within hospitals and clinics, enhancing patient experience and reducing waiting times.

These are just some common uses of GPS technology in the medical field, and technological advancements are expected to continue expanding its applications and improving its efficiency in healthcare delivery

III.5.Used software:

First Program

III.5.1.Arduino Compiler

Function

- It is a software used to write code in Arduino C language and upload it to the Arduino board.

How to Use

- The programmer writes the code in the integrated development environment (IDE) specific to Arduino.
- After writing the code, it is compiled (translated) into a language that the Arduino board can understand.
- The compiled code is then uploaded to the board via a USB cable, allowing the board to start executing the programmed commands.

III.5.2.Importance in the Project

- It is used to write and program the code that controls the reception of ECG signals, data analysis, and detection of any abnormal patterns indicating heart failure.
- It is used to compile and upload the code to the Arduino board to run the system.

III.5.3.Proteus

Function

- It is a simulation and design software for electronic circuits, used to create and test electronic circuit simulations before actual implementation.

How to Use

- Users can design electronic circuits using a wide library of electronic components available within the software.
- After designing, they can run simulations to see how the circuit works, test its functions, and analyze its performance.
- The design can be modified based on simulation results to improve performance or fix errors.

III.6.Device schematic in Proteus

This is the device schematic in Proteus and the method of connections.

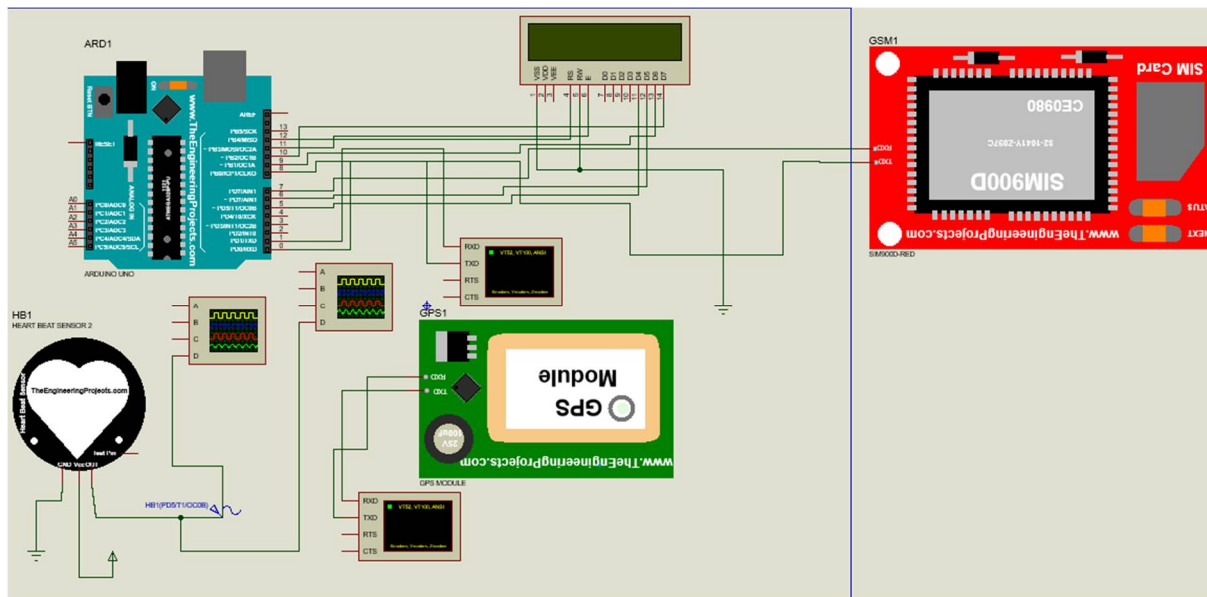


Figure III.8. Device schematic in Proteus

III.6.1. Components Table

Name	Description	Function
Arduino Board	Control board like Arduino Uno or any other Arduino board	Main unit to control and run the code
GPS Module	GPS module (e.g., Neo-6M GPS)	To read geographic location coordinates
GSM Module	GSM communication module (e.g., SIM900)	To send SMS messages
LCD Display	Display screen (e.g., 16x2 LCD)	To display heart rate and other data
Heartbeat Sensor	Heart rate sensor (e.g., SEN-11574)	To read the heart rate
Connecting Wires	Wires for connections	To connect different components together
Power Supply	Power source (e.g., battery or power adapter)	To supply power to the system

3.6.2.Additional details

Arduino Board:

- Used for controlling all components and performing read and write operations.
- The code must be uploaded to the Arduino board after ensuring all components are properly connected.

GPS Module:

- Connects to Arduino using serial pins (TX, RX).
- Requires a GPS antenna to accurately capture signals.

GSM Module:

- Connects to Arduino using serial pins (TX, RX).
- Requires an activated SIM card to send text messages.

LCD Display:

- Connects to Arduino using a set of pins (usually 6-8 pins).
- Used to display information to the user.

Heartbeat Sensor:

- Connects to Arduino using analog pins (like A0).
- Used for measuring heart rate and sending data to Arduino.

Connecting Wires:

- Used to connect various components together.
- Ensure wires are properly connected to avoid malfunctions.

Power Supply

Verify that the power source meets the requirements of Arduino and all connected components.

These details provide a deeper understanding of the roles and connections of each component in the system. Refer to individual component datasheets for specific instructions on usage and connection.

Importance in the Project

- It is used to simulate the electronic circuit of the system that captures ECG signals, processes them, and sends alerts via SMS and GPS.
- It allows designers to test the system and analyze its performance before actual implementation, saving time and resources.

- It helps verify that all electronic components work correctly and integrate seamlessly to ensure the system's accuracy and efficiency.

By using these two programs together, developers can design a reliable heart failure detection system, test it, and improve it before real-world deployment.

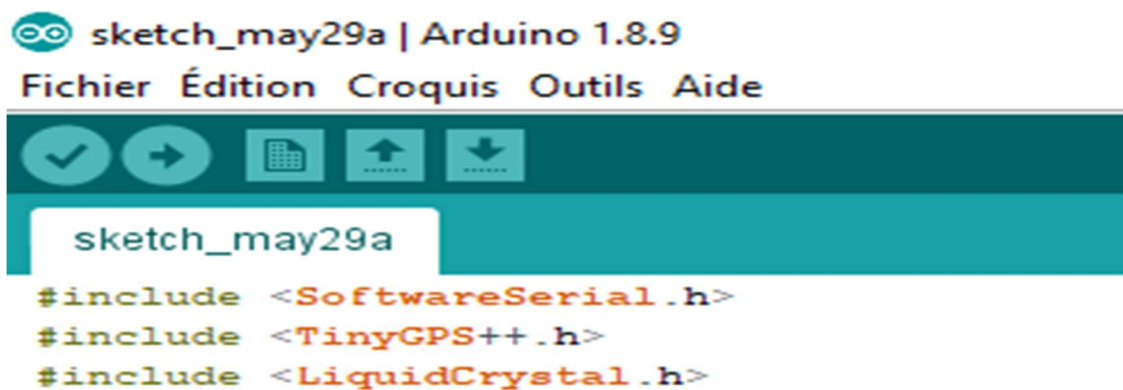
III.6.3. Program overview and how it works to detect heart failure

Stage 1: Data Collection ECG sensors are connected to the patient to record heart signals.

Stage 2: Data Processing The ECG signals are sent to an Arduino board where they are processed and analyzed. The code written in the Arduino Compiler is used to analyze the data and detect patterns indicating a heart malfunction or failure.

III.7. Code Explanation :

III.7.1. Including Libraries :



The image shows a screenshot of the Arduino IDE interface. At the top, it displays 'sketch_may29a | Arduino 1.8.9' and a menu bar with 'Fichier', 'Édition', 'Croquis', 'Outils', and 'Aide'. Below the menu bar is a toolbar with icons for a checkmark, a right arrow, a document, an upload arrow, and a download arrow. The main workspace shows the filename 'sketch_may29a' and the following code:

```
#include <SoftwareSerial.h>
#include <TinyGPS++.h>
#include <LiquidCrystal.h>
```

Figure III.9. Code Including Libraries

•**SoftwareSerial:** This library allows you to create additional serial ports to communicate with serial devices (like GPS and SIM900D) using any of the digital pins of the Arduino.

•**TinyGPSPlus:** This library is used to decode the NMEA sentences from the GPS module and make the GPS data easy to use.

•**LiquidCrystal:** This library is used to control the LCD display.

III.7.2. Defining Objects and Pins

```
TinyGPSPlus gps;
SoftwareSerial gpsSerial(4, 3); // RX, TX for GPS
SoftwareSerial sim900(7, 8);    // RX, TX for SIM900D

LiquidCrystal lcd(12, 11, 5, 6, 9, 10); (LCD (RS, E, D4, D5, D6, D7 تعريف شاشة //
const int heartBeatPin = A0; // Heart rate sensor connected to analog pin A0
```

Figure III.10.Code GPS

'gps': Object for handling GPS data.

'gpsSerial': SoftwareSerial object for GPS communication (using pins 4 for RX and 3 for TX).

sim900: SoftwareSerial object for SIM900D communication (using pins 7 for RX and 8 for TX).

'lcd ': LiquidCrystal object to interface with the LCD (using pins 12, 11, 5, 6, 9, 10).

'heartBeatPin ': Pin connected to the heart rate sensor.

III.7.3.Setup Function

Initializes serial communication for debugging and communication with GPS and SIM900D modules.

Initializes the LCD.

Sets up the SIM900D module to send SMS in text mode

```
void setup() {
  Serial.begin(9600);
  gpsSerial.begin(9600);
  sim900.begin(9600);
  lcd.begin(16, 2); 16x2 حجم LCD // تعريف شاشة LCD
  // Initialize SIM900D
  sim900.println("AT");
  delay(1000);
  sim900.println("AT+CMGF=1"); // Set SMS mode to text
  delay(1000);
}
```

Figure III.11.Code GSM

III.7.4. Loop Function :

```
void loop() {
  while (gpsSerial.available() > 0) {
    gps.encode(gpsSerial.read());
  }

  int heartRate = analogRead(heartBeatPin);

  // Simulate normal and abnormal heart rates
  // Normal heart rate range: 60 - 100 bpm
  // Abnormal heart rate range: 100 - 180 bpm
  int simulatedHeartRate = random(60, 101); // Simulate normal heart rate
  if (random(0, 100) < 20) { // 20% chance of simulating abnormal heart rate
    simulatedHeartRate = random(100, 181); // Simulate abnormal heart rate
  }

  if (gps.location.isUpdated()) {
    double latitude = gps.location.lat();
    double longitude = gps.location.lng();
    sendSMS(latitude, longitude, simulatedHeartRate);
    displayData(simulatedHeartRate); LCD عرض البيانات على شاشة //
    delay(60000); // Send data every 60 seconds
  }
}
```

Figure III.12 Loop Function for Heart Rate Monitoring and SMS Alerts

Reading GPS Data: Continuously reads data from the GPS module and processes it using the 'gps.encode' method.

Reading Heart Rate: Reads the heart rate from the sensor connected to heartBeatPin. Here, it is simulated for demonstration purposes.

Simulating Heart Rate:

Generates a normal heart rate value between 60 and 100 bpm.

Introduces a 20% chance to simulate an abnormal heart rate between 100 and 180 bpm.

Checking GPS Data: If the GPS location data is updated, it retrieves the latitude and longitude.

Sending SMS and Displaying Data:

- Calls sendSMS to send the heart rate and location via SMS.
- Calls displayData to show the heart rate on the LCD.
- Delays for 60 seconds before repeating the process.

III.7.5.SendSMS Function

```
void sendSMS(double latitude, double longitude, int heartRate) {
  sim900.println("AT+CMGS=\"+213672458885\"");
  delay(1000);
  sim900.print("Heart Rate: ");
  sim900.print(heartRate);
  sim900.print(" bpm, ");
  sim900.print("Location: ");
  sim900.print("Lat: ");
  sim900.print(latitude, 6);
  sim900.print(", Lng: ");
  sim900.print(longitude, 6);
  sim900.print(", anoir please help me");
  delay(1000);
  sim900.write(26);
  delay(1000);
}
```

Figure III.13 Function to Send Health and GPS Data through SMS

Nitiating SMS Command: Sends 'AT+CMGS' command with the recipient's phone number to start the SMS process.

Constructing the Message: Builds the SMS content including heart rate, latitude, longitude, and an additional message.

Sending the Message: Ends the SMS with 'Ctrl+Z' (ASCII code 26) to send the message.

3.7.6.display Data Function :

```
void displayData(int heartRate) {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Heart Rate: ");
  lcd.print(heartRate);
  lcd.print(" bpm");
}
```

Figure III.14 Displaying Heart Rate Using LCD

- **Clearing LCD:** Clears any previous data displayed on the LCD.
- **Setting Cursor:** Positions the cursor to the first row and first column of the LCD.
- **Displaying Data:** Displays the heart rate and its unit on the LCD.

Key Points Summary:

1. **Library Inclusion:** Includes necessary libraries for serial communication, GPS data processing, and LCD control.
2. **Object and Pin Initialization:** Defines and initializes objects and pins for GPS, SIM900D, LCD, and heart rate sensor.
3. **Setup:** Initializes serial communication, LCD, and configures the SIM900D for SMS text mode.
4. **Loop:**
 - Continuously reads and processes GPS data.
 - Reads and simulates heart rate data.
 - Checks if GPS location data is updated and then sends an SMS with the heart rate and location information.
 - Displays the heart rate on the LCD.
 - Waits for 60 seconds before repeating.
5. **sendSMS Function:** Constructs and sends an SMS containing heart rate and location data.
6. **displayData Function:** Clears the LCD and displays the heart rate.

This code integrates multiple electronic components and software to create a health monitoring system that can send alerts via SMS and display real-time data on an LCD screen.

III.7.7.Global code

```

sketch_may29a | Arduino 1.8.9
Fichier Édition Croquis Outils Aide

sketch_may29a
#include <SoftwareSerial.h>
#include <TinyGPS++.h>
#include <LiquidCrystal.h>

TinyGPSPlus gps;
SoftwareSerial gpsSerial(4, 3); // RX, TX for GPS
SoftwareSerial sim900(7, 8); // RX, TX for SIM900D

LiquidCrystal lcd(12, 11, 5, 6, 9, 10); // LCD (RS, E, D4, D5, D6, D7) تعريف شاشة //

const int heartBeatPin = A0; // Heart rate sensor connected to analog pin A0

void setup() {
  Serial.begin(9600);
  gpsSerial.begin(9600);
  sim900.begin(9600);
  lcd.begin(16, 2); // 16x2 تعريف شاشة LCD بحجم //

  // Initialize SIM900D
  sim900.println("AT");
  delay(1000);
  sim900.println("AT+CMGF=1"); // Set SMS mode to text
  delay(1000);
}

void loop() {
  while (gpsSerial.available() > 0) {
    gps.encode(gpsSerial.read());
  }

  int heartRate = analogRead(heartBeatPin);

  Compilation terminée.

Le croquis utilise 9542 octets (29%) de l'espace de stockage de programmes. Le maximum est de 32256 octets.
Les variables globales utilisent 695 octets (33%) de mémoire dynamique, ce qui laisse 1353 octets pour les variables locales. Le maximum est de 2048 octets.

```

Figure III.15 general code part 1

```

int heartRate = analogRead(heartBeatPin);

// Simulate normal and abnormal heart rates
// Normal heart rate range: 60 - 100 bpm
// Abnormal heart rate range: 100 - 180 bpm
int simulatedHeartRate = random(60, 101); // Simulate normal heart rate
if (random(0, 100) < 20) { // 20% chance of simulating abnormal heart rate
  simulatedHeartRate = random(100, 181); // Simulate abnormal heart rate
}

if (gps.location.isUpdated()) {
  double latitude = gps.location.lat();
  double longitude = gps.location.lng();
  sendSMS(latitude, longitude, simulatedHeartRate);
  displayData(simulatedHeartRate); // عرض البيانات على شاشة LCD //
  delay(60000); // Send data every 60 seconds
}

void sendSMS(double latitude, double longitude, int heartRate) {
  sim900.println("AT+CMGS="+213672458885+"\r\n");
  delay(1000);
  sim900.print("Heart Rate: ");
  sim900.print(heartRate);
  sim900.print(" bpm, ");
  sim900.print("Location: ");
  sim900.print("Lat: ");
  sim900.print(latitude, 6);
  sim900.print(" , Lng: ");
  sim900.print(longitude, 6);
  sim900.print(" , anoir please help me");
}

Compilation terminée.

Le croquis utilise 9542 octets (29%) de l'espace de stockage de programmes. Le maximum est de 32256 octets.
Les variables globales utilisent 695 octets (33%) de mémoire dynamique, ce qui laisse 1353 octets pour les variables locales. Le maximum est de 2048 octets.

```

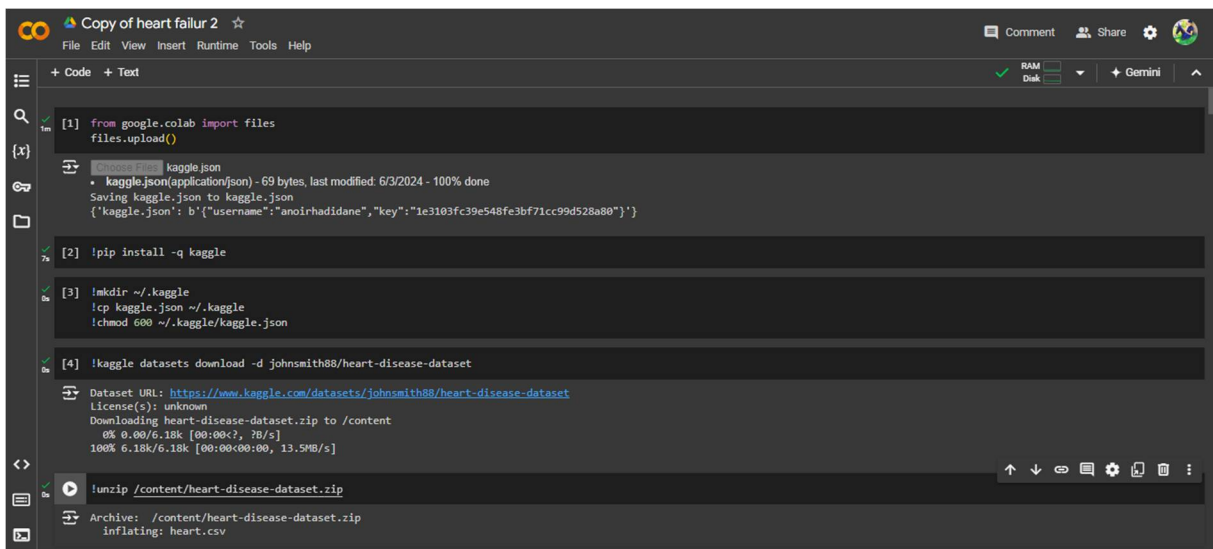
Figure III.16 general code part2

SecondProgram

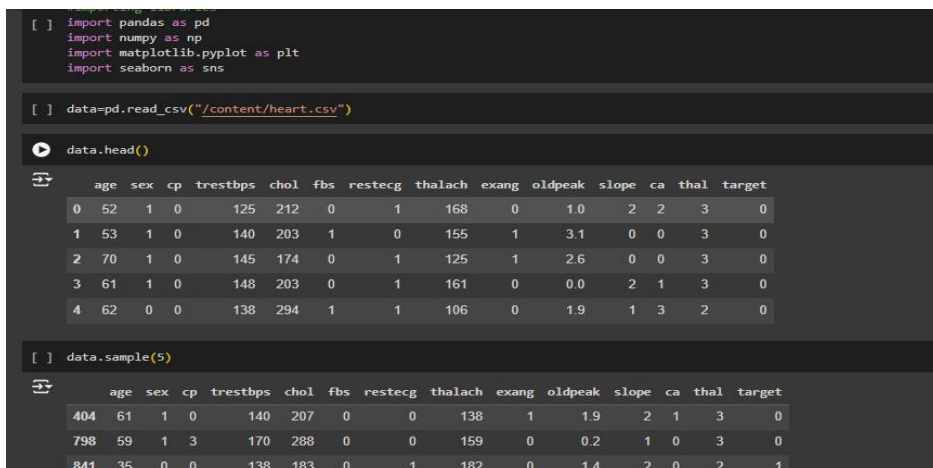
On the other hand, I have used the Python program (Python; Google Colab) to address the difficulty in extracting the heart chart from an ECG dataset. This is for downloading data of both healthy and diseased hearts, along with other conditions a person may already have, such as cholesterol levels. It also determines the gender of the individual, whether male or female. During this, I display the Python code in images.

Afterwards, I converted the file to CSV.

3.8. Python



```
Copy of heart failur 2
File Edit View Insert Runtime Tools Help
+ Code + Text
[1] from google.colab import files
files.upload()
kaggle.json
• kaggle.json(application/json) - 69 bytes, last modified: 6/3/2024 - 100% done
Saving kaggle.json to kaggle.json
{'kaggle.json': b'{"username": "anoirhadidane", "key": "1e3103fc39e548fe3bf71cc99d528a80"}'}
[2] !pip install -q kaggle
[3] !mkdir ~/.kaggle
!cp kaggle.json ~/.kaggle
!chmod 600 ~/.kaggle/kaggle.json
[4] !kaggle datasets download -d johnsmith88/heart-disease-dataset
Dataset URL: https://www.kaggle.com/datasets/johnsmith88/heart-disease-dataset
License(s): unknown
Downloading heart-disease-dataset.zip to /content
0% 0.00/6.18k [00:00<, ?B/s]
100% 6.18k/6.18k [00:00<00:00, 13.5MB/s]
!unzip /content/heart-disease-dataset.zip
Archive: /content/heart-disease-dataset.zip
inflating: heart.csv
```



```
[ ] import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

[ ] data=pd.read_csv("/content/heart.csv")

data.head()

age sex cp trestbps chol fbs restecg thalach exang oldpeak slope ca thal target
0 52 1 0 125 212 0 1 168 0 1.0 2 2 3 0
1 53 1 0 140 203 1 0 155 1 3.1 0 0 3 0
2 70 1 0 145 174 0 1 125 1 2.6 0 0 3 0
3 61 1 0 148 203 0 1 161 0 0.0 2 1 3 0
4 62 0 0 138 294 1 1 106 0 1.9 1 3 2 0

[ ] data.sample(5)

age sex cp trestbps chol fbs restecg thalach exang oldpeak slope ca thal target
404 61 1 0 140 207 0 0 138 1 1.9 2 1 3 0
798 59 1 3 170 288 0 0 159 0 0.2 1 0 3 0
841 35 0 0 138 183 0 1 182 0 1.4 2 0 2 1
```

Figure III.17 python program

This is a simplified overview of the Python program used to convert an ECG file for use in simulations in Proteus.

III.9.Simulation and results:

The Proteus software is used to simulate the system and test its effectiveness. The simulation model demonstrates how to record ECG signals, process them, and utilize SMS and GPS for sending alerts.

Expected results include the ability to accurately detect cases of heart failure and send real-time alerts along with the patient's geographical location.

III.9.1.Discussion of results:

- Accuracy:** The system's accuracy in detecting cases of heart failure depends on the sensitivity of the sensors and the precision of the software codes used in processing.
- Efficiency:** The system's efficiency relies on the speed of sending alerts and the response time of medical emergency teams.
- Challenges:** The system may encounter challenges related to noise in electrical signals, delays in sending SMS messages, or difficulties in locating the patient due to network issues.

Cardiogram of a natural person

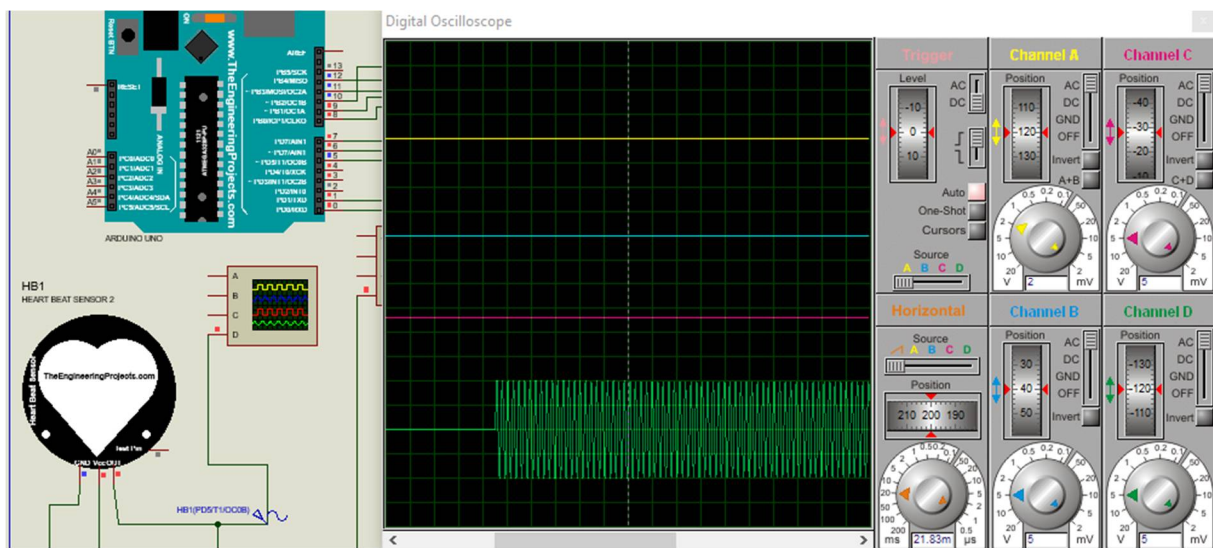


Figure III.18 Cardiogram of a natural person

Normal Pulse Pattern: It is evident from the heart chart that heartbeats occur regularly and with a consistent frequency, indicating the presence of normal and regular electrical activity in the heart.

Contraction and Relaxation Duration: The heart chart exhibits balanced and symmetrical contractions and relaxations, indicating the heart's effectiveness in pumping blood and relaxing properly.

Amplitude and Maximum Relaxation Duration: The heart chart shows appropriate amplitude for each heartbeat, and the duration of relaxation and contraction appears within the normal range, indicating a healthy heart function.

Absence of Wave Abnormalities: The heart chart does not show any significant abnormalities in the shape of the electrical waves, indicating the absence of structural or functional defects in the heart.

Minor Natural Fluctuations: Some minor fluctuations may appear in the waveform on the chart, which are normal in a healthy heart and reflect natural physiological reactions within the heart.

Based on the heart chart on the oscilloscope, it can be concluded that the heart condition in the simulation reflects a healthy heart overall, with normal and balanced electrical activity and efficient pumping and distribution of blood throughout the body.

Cardiogram of a sick

Irregular Pulse Pattern: The heart chart exhibits irregular fluctuations in the pulse frequency, indicating a disturbance in the heart's electrical activity.

Waveform Abnormalities: Noticeable distortions in the shape of the electrical waves can be observed on the chart, such as significant deviations or abnormal interruptions, indicating structural or functional changes in the heart.

Shortened Duration of Contraction or Relaxation: The heart chart may show a decrease in the duration of contraction or relaxation, indicating weakness in the heart's ability to efficiently pump blood or relax after contraction.

Large Fluctuations in Amplitude: Significant fluctuations in the strength of the electrical waves may appear, indicating instability in the heart's contraction and relaxation processes.

Abnormally High Heart Rate: The heart rate may be higher than the normal range, indicating unbalanced stimuli or disturbances in heart activity.

Based on the heart chart on the oscilloscope, it can be concluded that the heart condition in the simulation reflects a diseased heart, with structural and functional changes negatively affecting its function and performance

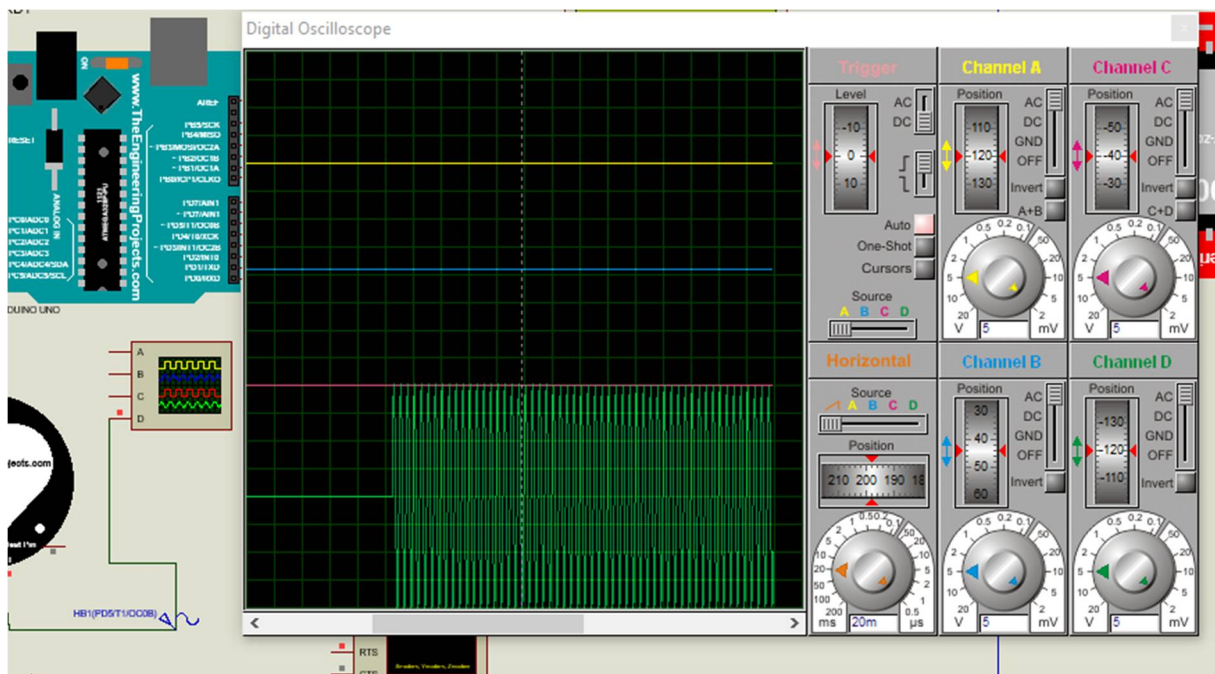


Figure III.19 Cardiogram of a sick

GPS Simulation

The GPS technology is enabled and synchronized with heart simulation in the Proteus system, determining the person's location every 60 seconds as shown in the illustrated image **Figure III.20**

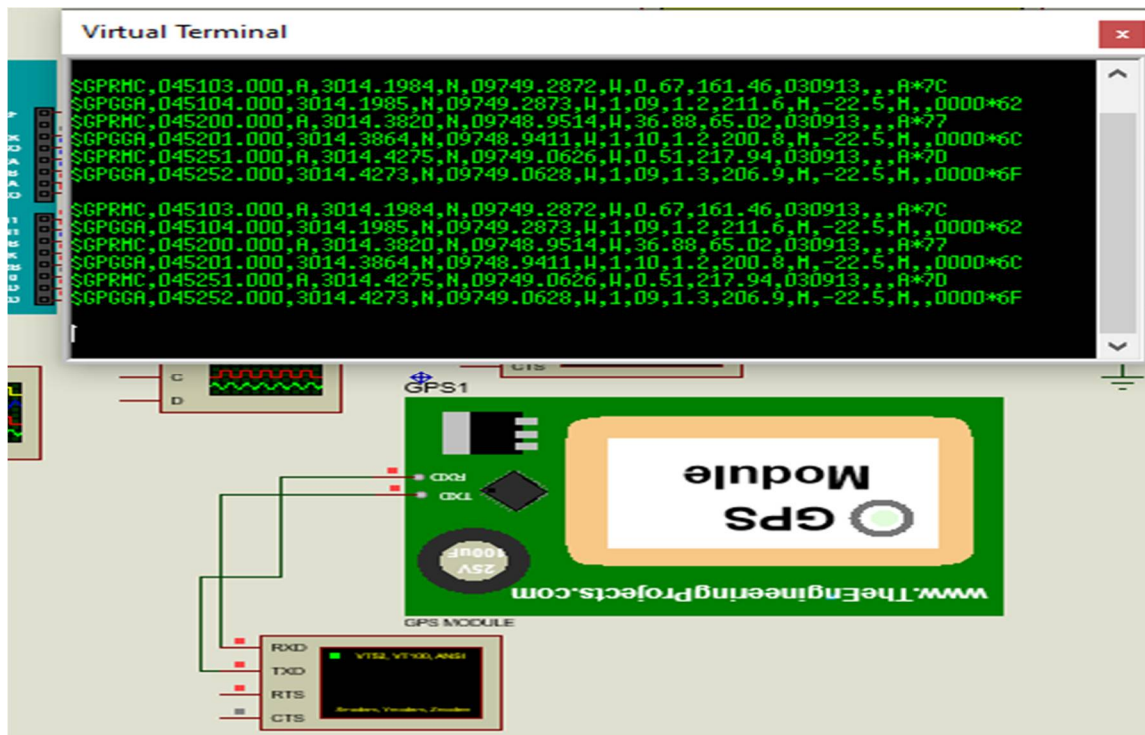


Figure III.20 GPS

LCD

As for the LCD screen, we can leave it displaying a digital heart plot or we can change it to show distress message such as "Anoir please help me" just to illustrate the project.

III.10. Conclusion

In this chapter, we presented the simulation of our project. We provide the simulation result with both used components software and hardware. The result showing that this device in very impactful in medical field which provide a cost-effective and practical tool for heart health monitoring

Conclusion

General Conclusion

In this work, we aim to contribute a practical and accessible tool for heart health monitoring, potentially improving response times in emergencies and saving lives.

Initially, we present a comprehensive overview of heart diseases, including their causes, symptoms, and preventive measures, highlighting the critical importance of early detection and timely intervention.

The subsequent section of the paper introduces Arduino technology, explaining its functionality, versatility, and the vast array of applications it supports. Arduino's open-source platform and extensive library support make it an ideal choice for developing custom health monitoring solutions. The technology's flexibility allows for seamless integration with various sensors and modules, facilitating the creation of complex systems with relative ease and affordability.

Our work presents a conceptual design and simulation of a heart failure detection device that integrates an Arduino microcontroller, ECG sensor, SMS module, and GPS sensor. This device is designed to monitor heart activity, detect anomalies indicative of heart failure, and promptly alert family members via SMS, while also providing the geographical location of the individual in distress. The simulation of our device using the Proteus platform demonstrates its feasibility and functionality in a controlled environment.

By pursuing the development of this heart failure detection system, we aspire to make a significant contribution to the field of healthcare technology. Our ultimate goal is to provide a practical, cost-effective solution that enhances patient care and safety. Looking forward, our future work will focus on transitioning from simulation to the practical realization of the device. This will involve rigorous testing and validation in real-world conditions to ensure its reliability, accuracy, and effectiveness in providing timely alerts and location information.

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ملخص

يتمثل العمل الحالي في تطوير جهاز إشعار يستند إلى الكشف عن فشل عضلة القلب عن طريق إشارة (ECG) التي تعكس النشاط الكهربائي للقلب باستخدام أقطاب كهربائية للاستخدام الفردي المثبتة على التوالي على المعصم الأيسر، المعصم الأيمن، والقدم اليمنى. تم قياس هذه الإشارة وتم تصميمه لتقليل مخاطر التأخيرات وضمان استجابة وتدخّل في الوقت المناسب في الحالات الطبية الحرجة. تكمن أهمية هذا الجهاز في قدرته على الكشف السريع عن احتشاء عضلة القلب وتنبيه الأفراد بسرعة لاتخاذ التدابير اللازمة.

الكلمات المفتاحية

« Arduino ، برمجة GPS تخطيط القلب الكهربائي، إرسال الرسائل النصية القصيرة، تحديد المواقع باستخدام »

Résumé

Le travail actuel consiste à développer un dispositif de notification basé sur la détection de l'infarctus du myocarde à travers le signal ECG (électrocardiogramme) qui reflète l'activité électrique du cœur, en utilisant des électrodes à usage unique fixées successivement sur le poignet gauche, le poignet droit et le pied droit. Ce signal a été mesuré et conçu pour réduire les risques de retards et garantir une réponse et une intervention en temps opportun dans les situations médicales critiques. L'importance de cet appareil réside dans sa capacité à détecter rapidement l'infarctus du myocarde et à alerter rapidement les individus pour prendre les mesures nécessaires.

Mots-clés

"Électrocardiogramme, envoi de SMS, positionnement GPS, programmation Arduino"

Abstract

The current work aims to develop a notification device based on the detection of myocardial infarction through an ECG signal that reflects the heart's electrical activity using disposable electrodes attached sequentially to the left wrist, right wrist, and right foot. This signal is measured, and the device is designed to reduce the risk of delays and ensure timely response and intervention in critical medical situations. The significance of this device lies in its ability to swiftly detect myocardial infarction and promptly notify individuals to take the necessary measures.

Keywords

"Electrocardiogram, SMS sending, GPS positioning, Arduino programming"

