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Self and Tele-monitoring of Human Health System Connected with an Android Application and provided with GPS/GSM Technology

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Author

Nour Elhouda

DEDICATION

To:

My mother: my pearl.

My dear father: my force.

My brother: my secret, my life.

My beloved sisters: my sun, my moon, my everything.

My family: my fortress. Which flooded me with love and prayer.

My friends: my ringtones, my lights. The university wasn't easy, they’re the reason I survived.

To the people who stood beside me, when others broke me. To those who were the cause of my happiness, those who I love.

To every child went to school and learned, every young man at the university attended all his lectures, to their lost dreams despite their fatigue and vigilance. For every stolen opportunity, every right has been looted.

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GENERAL INTRODUCTION

GENERAL INTRODUCTION:

Biomedical engineering aims to improve the quality of health care.
Biomedical engineers are an interesting breed. Their duty is to bridge the gap between engineering skills and medical applications. They are also forced to exploit and harness all modern technologies and traditional engineering to solve a wide variety of problems and of course to preserve human health.
Self-monitoring is the use of intelligent tools by a person, such as portable sensors and mobile applications, to collect, process and display a multitude of personal data that allow people to monitor and manage all aspects of their health.
Ever noticed how much we've all come to rely on GPS (the global positioning system), it's in our Smartphone, built in our cars and some people even use GPS trackers to track their luggage and laptops while travelling. It's everywhere. So many elements of our modern world rely to GPS, the most two famous examples are driving and flying. We can use geolocation technology in the medical field, in Tele-monitoring, for example, which makes it possible to remotely monitor the health status of an individual.
Self-monitoring will save many lives. According to doctors in 2017, millions of inhabitants around the world died, as a result of the rise or fall of one of their vital signs and this number is increasing. Unfortunately, they could not go to the medical emergency or even contact one of their relatives.
to achieve both the self and Tele-monitoring, and as a future biotech engineer, I proposed as a subject for my graduation project a system composed of a non invasive device and an android application, that would help control both the rate of diabetes, blood pressure, heart rate and even body temperature. As an important vital functions that help to know a lot about the health status of the individual.
I have divided my work into three main chapters:

- The first chapter will deal with the generalities of biomedical engineering and physiological parameters.
- The second chapter is devoted to the study, design and realization of the non-invasive glucometer, Heart rate sensors, thermometer and blood pressure monitor circuits, principles and operations of each one. After that I will combine all in one device and I will add the geolocation detection (GPS) and the communication (GSM) module.
- The third one is devoted to the description and operation of the Android application "Healthy Life", which is relinked to the non-invasive device with a Bluetooth connection, and must be installed on a Smartphone to monitor the state of health of the person by making a decision using machine learning.

CHAPTER I

Generality on physiological parameters and its different measurement techniques

1 Introduction

In this first chapter, we tried to emphasize the importance of measuring different physiological parameters during the usual daily life, such as blood glucose, body temperature, arterial blood pressure and the heart rate. We will talk about the danger of not monitoring and neglecting these vital signs which can develop serious health problems. Finally, we will mention some of the different methods, means and techniques invasive or non-invasive developed to measure these parameters.

2 Biomedical Engineering:

2.1 Definition: [1]

Biomedical engineering is a set of technics and sciences applied in the medical field for healthcare purposes. It is a field of practice which brings many, if not all of the classical fields of engineering together to assist in developing a better understanding of the physiology and structures of the human body, and to support the knowledge of clinical professionals in prevention, diagnosis and treatment of disease and modifying or supplementing the anatomy of the body with new devices and clinical services.

Biomedical engineering is considered as the profession responsible for innovation, research and development, design, selection, management and safe use of all types of medical devices, including single-use and reusable medical equipment, prosthetics, implantable devices and bionics, among others.

2.2 Objectives and Roles of Biomedical engineering (BME):

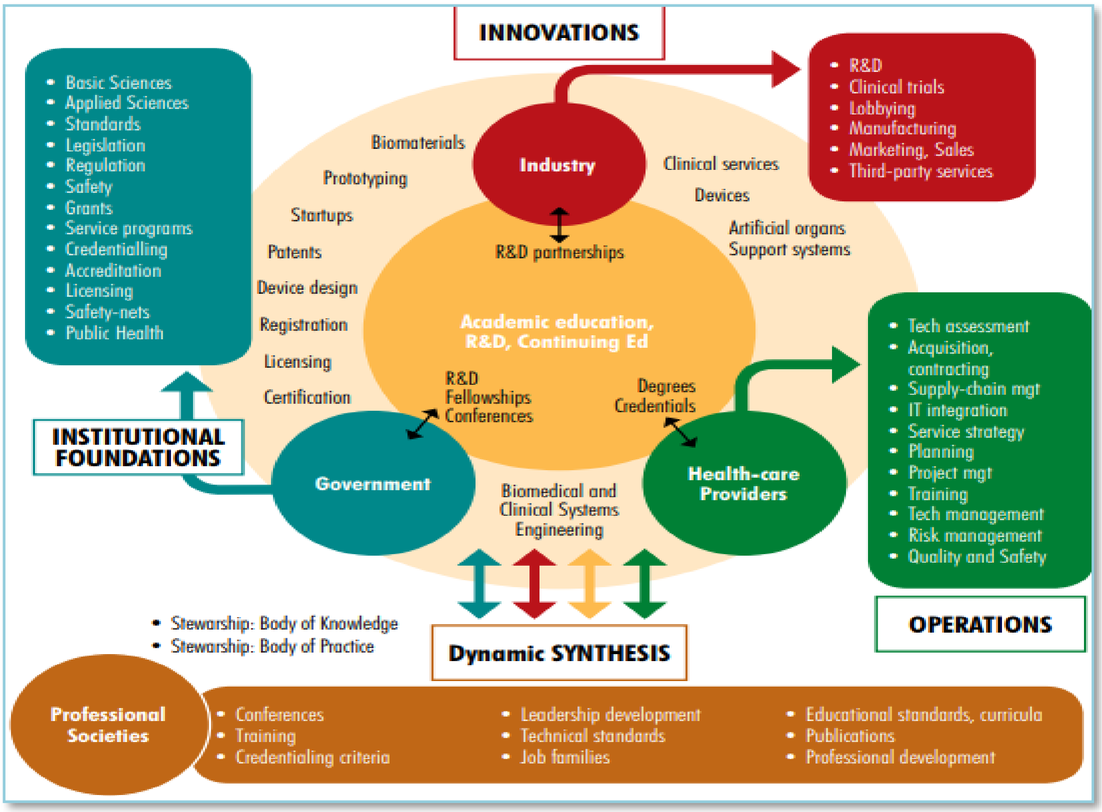
2.2.1 Objectives:

To make a quality device, reliable, effective, available, accessible and affordable, is the main objective of biomedical engineering. When these objectives are met and devices are used safely, patients' lives may be saved, quality of life increased and there will be positive economic outcomes; the final goal is attainment of better levels of care.

2-2-2 Roles: [1]

One of the roles of the biomedical engineering professionals is research and development it consists of bringing together the specialist skills of the other engineering disciplines such as mechanical, materials, signal processing and others, using their broad engineering knowledge, coupled with their knowledge of medical practice, the human physiology and body structures to ensure the end result of their collective work is a product that is safe, effective and performs as intended for the benefit of the patient. As devices become "smarter" through the inclusion of increasingly powerful hardware and software capabilities, devices can take on increasingly comprehensive monitoring, alert and control functions that define clinical best practices. This "smart device" revolution is extending the domain of BME into wider and wider realms of creativity

and professional practice, extending health-care services far beyond the hospital.
The fig(1) represents the principals roles of biomedical engineers:



(Figure 1): Roles of Biomedical Engineers. [1]

Vital Signs are measured to obtain a quick evaluation of the person physical conditions in our study we will focus on the Arterial blood pressure, Blood glucose, Body Temperature and Heart rate.

3 Arterial pressure:

3.1 Definition:

Arterial pressure is determined by the volume ejected by the heart into the arteries, the elastance of the walls of the arteries, and the rate at which the blood flows out of the arteries. Blood pressure is the pressure, measured in millimeters of mercury, within the major arterial system of the body. It is conventionally separated into systolic and diastolic determinations. Systolic pressure is the maximum blood pressure during contraction of the ventricles; diastolic pressure is the minimum pressure recorded just prior to the next contraction.

The blood pressure is usually written as the systolic pressure over the diastolic pressure (e.g., 120/80 mm Hg). The minimum acceptable blood pressure is determined by adequate perfusion of the vital organs without symptoms of hypotension. This is usually more than 90 mm Hg systolic and 60 mm Hg diastolic, although there can be great variation between patients. [2]

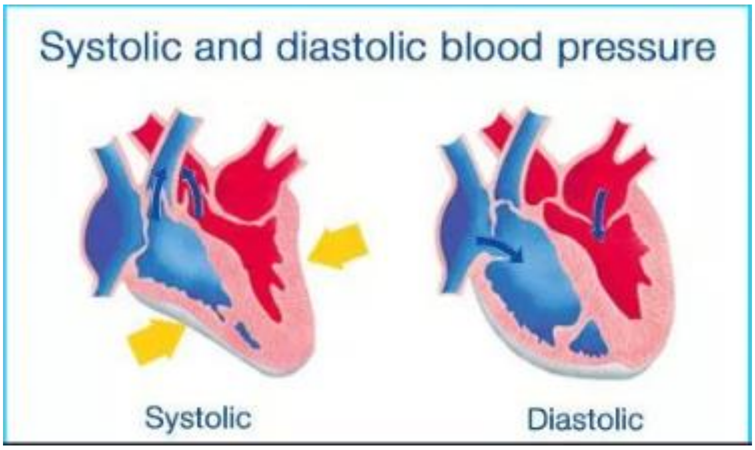


Figure (2): Systolic and diastolic blood pressure

3.1.1 Symptoms of high blood pressure:

The blood pressure has no fixed symptoms, each patient has a way of reacting, for example some will experience symptoms, like Severe headache, nervousness, sweating, Fatigue or confusion, difficulty sleeping or facial flushing, Vision problems, also Chest pain, Difficulty breathing, Irregular heartbeat, Blood in the urine, Pounding in the chest, neck, or ears.

If the patient ignores the blood pressure because he thinks a certain symptoms or signs will alert him to the problem, he is taking a dangerous chance with his life.

3.1.2 Symptoms of low blood pressure:

People with low blood pressure or hypotension may experience symptoms when their blood pressure drops below 90/60.Symptoms of hypotension can include: fatigue, lightheadedness, dizziness, nausea, clammy skin, depression, loss of consciousness, blurry vision.
Everyone's blood pressure drops at one time or another and it often doesn't cause any noticeable symptoms. Certain conditions like pregnancy or diabetes can cause prolonged periods of hypotension that can become dangerous if left untreated. [3].
People can prevent or manage their hypotension or hypertension by being always aware of their blood pressure levels and by understanding the condition and being educated about it

3.1.3 Healthy and unhealthy blood pressure ranges:

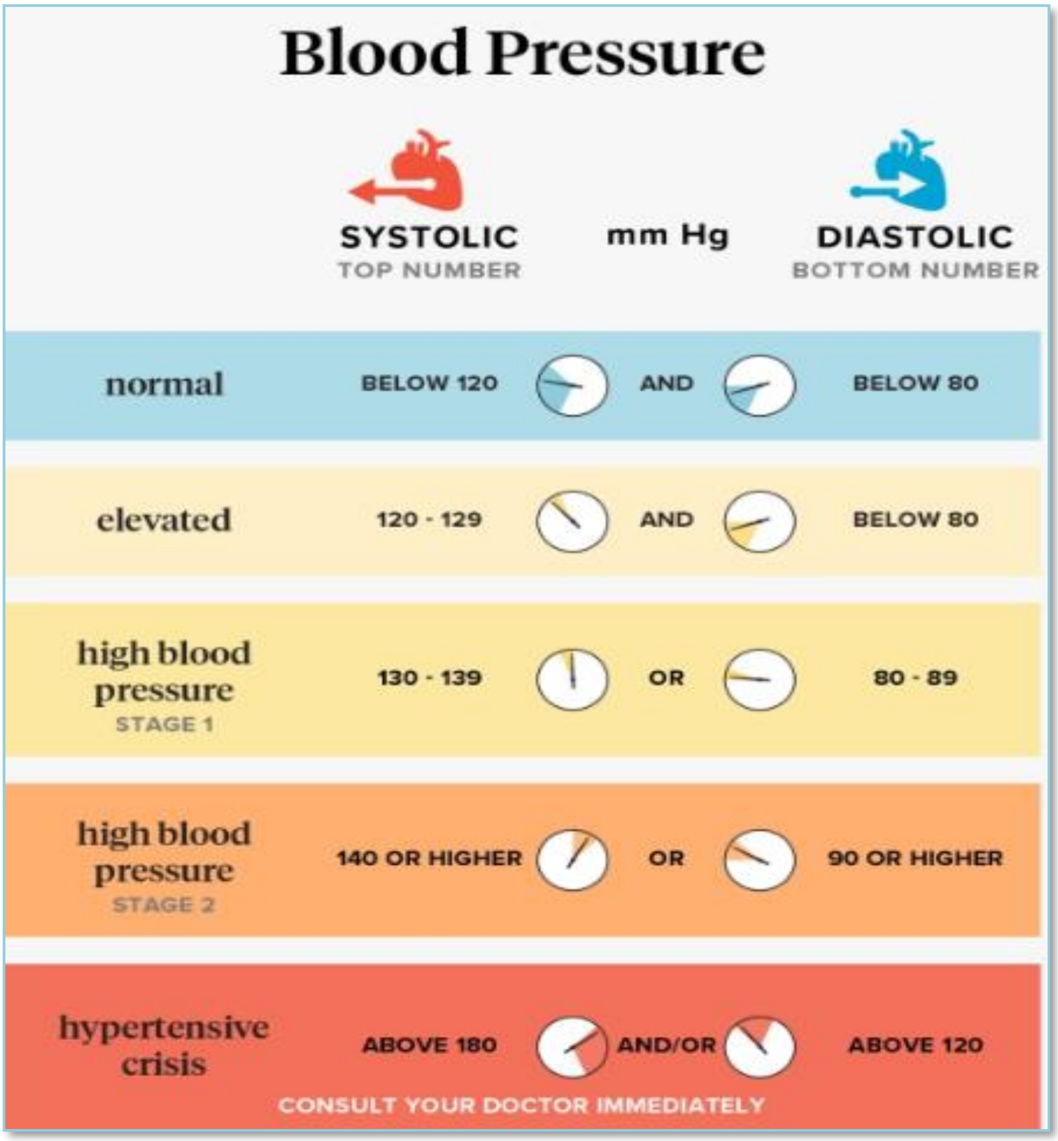


Table (1) Blood pressure categories

The American Heart Association recognize blood pressure ranges to five categories: [4]

1- **Normal**

Blood pressure numbers of below than 120/80 mm Hg are considered within the normal range.

2- **Elevated :**

Elevated blood pressure is when the range is from 120-129 systolic and below than 80 diastolic.

3- **Hypertension Stage 1 :**

Hypertension Stage 1 is when blood pressure consistently ranges from 130-139 systolic or 80-89 mm Hg diastolic.

4- **Hypertension Stage 2 :**

When the blood pressure consistently ranges higher or at 140/90 mm Hg.

5- Hypertensive-Crisis:

This stage of high blood pressure requires medical attention. If the blood pressure readings suddenly exceed 180/120 mm Hg, the patient has to wait five minutes and then tests his blood pressure again. If his readings are still unusually high, the person has to contact the doctor immediately.

3.2 Means and methods of measuring Arterial Blood Pressure:

People with elevated blood pressure are identified as 'AT RISK'cause they are likely to develop high blood pressure. Even without symptoms, damage to blood vessels and the heart continues and can be detected. Uncontrolled high blood pressure increases the risk of serious health problems such as heart failure, Stroke, heart attack and even death.

The regular in-home blood pressure monitoring is recommended by the majority of healthcare professional. The self-monitoring is very important; it can be used to determinate if person's health is in danger of developing hypertension or other diseases. Self-test of the blood pressure at home present a variety of benefits, not just for individual at risk, but also for normal people.

There are many means and techniques invented and developed to measure arterial blood pressure. Among these different methods in our study we are interested with the **Oscillometric method**.

a- Invasive method:

To obtain a more precise measurement of blood pressure, there are direct methods using sophisticated and expensive equipment, as well as the cannulation of an artery, It's called Invasive blood pressure monitoring: Invasive (intra-arterial) blood pressure (IBP) monitoring is a commonly used technique in the Intensive Care Unit (ICU) and is also often used in the operating theatre.

b- Non-invasive method:

Currently there are several non-invasive methods can be used to measure Arterial Blood Pressure. Monitoring techniques can be classified according to their ability to measure BP intermittently or continuously.

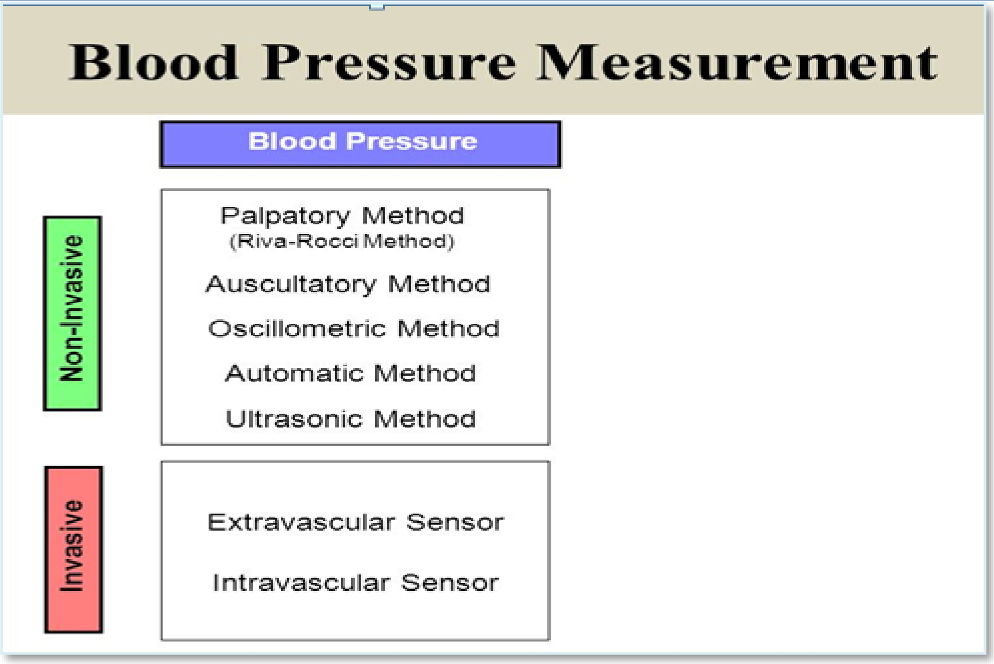


Figure (3): Blood Pressure Measurement [4]

The non-invasive Auscultatory and Oscillometric measurements are simpler and quicker than invasive measurements, require less expertise, have virtually no complications, are less unpleasant and less painful for the patient. Non-invasive measurement methods are more commonly used for routine examinations and monitoring.

3.2.1 Auscultatory:

Initially the cuff is inflated to a level higher than the systolic pressure. Thus the artery is completely compressed, there is no blood flow, and no sounds are heard. The cuff pressure is slowly decreased. At the point where the systolic pressure exceeds the cuff pressure, the Korotkoff sounds are first heard and blood passes in turbulent flow through the partially constricted artery. Korotkoff sounds will continue to be heard as the cuff pressure is further lowered. However, when the cuff pressure reaches diastolic pressure, the sounds disappear. Now at all points in time during the cardiac cycle, the blood pressure is greater than the cuff pressure, and the artery remains open.

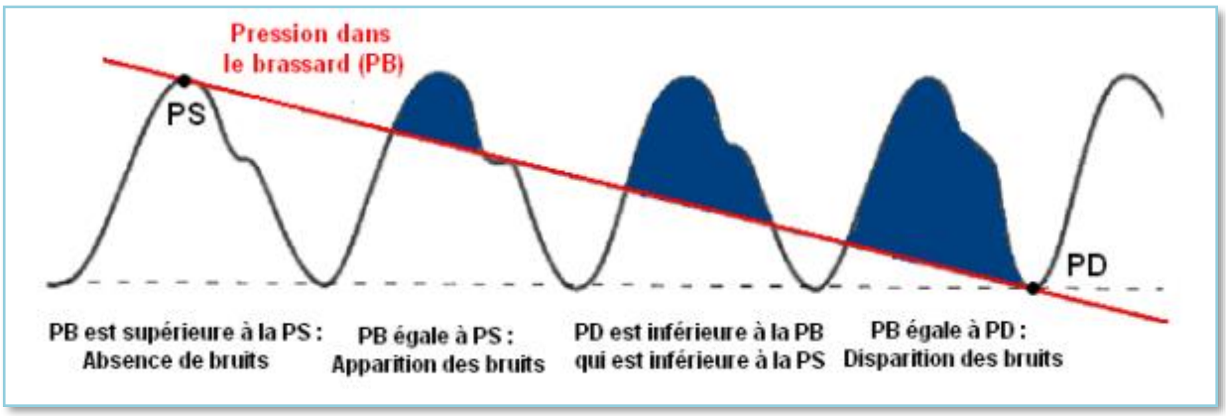


Figure (4): The relationship between Arterial BP, cuff pressure and Korotkoff sounds. [5]

3.2.2 Oscillometry:

The technical difficulties associated with the Auscultatory method led to the development of the Oscillometry method by the use of semi-automatic or automatic Sphygmomanometer which reduces the risk of errors related to the person who makes the measurement. With these devices, inflation and deflation of the cuff are automatic and the Arterial BP is determined from the recording of pressure oscillations related to the movements of the arterial walls compressed by a pneumatic chamber (the cuff) when deflated.

It is a popular method for non-invasive monitoring of blood pressure. This method determines systolic, diastolic and mean arterial pressure using an occlusive brachial artery cuff, which acts as both an external pressure applicator and an arterial volume sensor. [6]

Oscillometry is a popular method for non-invasive monitoring of blood pressure. This method determines systolic, diastolic, and mean arterial pressures using an occlusive brachial artery cuff, which acts as both an Oscillometry is a popular method for non-invasive monitoring of blood pressure. This method determinessystolic, diastolic, and mean arterial pressures using an occlusive brachial artery cuff, which acts as both an Oscillations begin before the actual value of the systolic pressure and continue beyond the actual value of the diastolic pressure the maximum amplitude of the oscillations corresponds to the average BP which can thus be directly measured by this method.

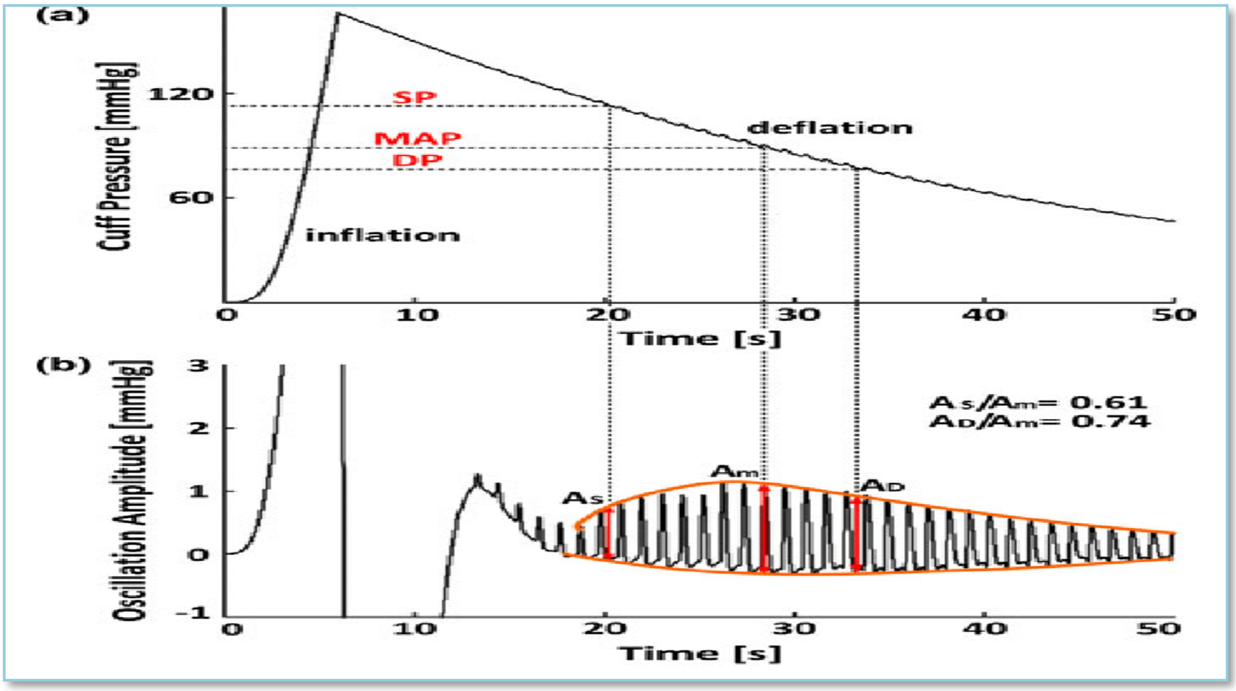


Figure (5) [6]: Oscillometric method for non-invasive blood pressure measurement. (a) Cuff pressure during cuff inflation and deflation. (b) Estimation of SP, DP, and MAP from cuff pressure oscillations via fixed-ratio method and maximum oscillation amplitude.

The measurement of the arterial pressure by the Oscillometric method consists of obtaining the parameters of a decreasing curve modulated by the heart rate that appear when the cuff is inflated or deflated. In fact, this progressive swelling or deflation makes it possible to transmit variations of pressure oscillations from the artery to the cuff. These pressure oscillations are related to the movements of the arterial wall, these movements of vibration are due to the occlusion of the artery by the inflation / deflation of the cuff. The parameter having the size of the cuff has more influence on the Oscillometric measurement of SP and DP. The larger the inflatable cuff pocket, the larger the brachial artery will be compressed for low pressures. In this case, the oscillations will be perceived for lower pressures of the cuff, hence an underestimation of the BP.

Conversely, in obese subjects, for example, the use of a cuff too small induces overestimation of the BP. [7, 8]

3.2.2.1 Calculate the SP and DP of an Oscillometric Signal:

An Oscillometric pressure signal comprises a component related to the arterial pressure signal resulting from the occlusion of the artery following the inflation / deflation of the cuff and, secondly, a component induced by the linear inflation pressure law / deflation of the cuff. Thus, to calculate the systolic and diastolic blood pressure, it is first necessary to extract the oscillations induced by the arterial pressure of the signal.

There are two methods of calculating SP and DP. The first method is based on the calculation of the peak-to-peak amplitudes of pressure oscillations known as "height-based (HB)". The second one is based on the calculation of derivatives of the signal envelope Oscillometric known as "sloped-based (SB)".

4 Body Temperature

4.1 Definition

Body temperature is the degree of coldness or hotness of the body, it is a measure of the human body's capacity to make and get rid of heat. The body is very good at keeping its temperature within a safe range, whatever the temperature of the environment.

- When the person is too hot, the blood vessels in skin widen to carry the excess heat to skin's surface. The person may start to sweat. As the sweat evaporates, it helps cool the body.
- When the person is too cold, the blood vessels narrow. This reduces blood flow to skin to save body heat. The person may start to shiver. When the muscles tremble this way, it helps to make more heat. [9]

4.2 Normal and abnormal body temperature:

Normal body temperature is depending on different factors like person’s sex, age, activity levels, food, and the time of the day. It’s also very sensitive to hormone’s levels and especially for wemen, so a lady’s temperature may be lower or higher when she is ovulating or having her menstrual period [9] and of course without forget the method of measurement.

The table below (2) shows the normal range of body temperature for adults, children and babies according to the different factors:

Type-of reading	0–2 years	3–10 years	11–65 years	Over 65 years
Oral	35.5- 37.5 °C	35.5-37.5 °C	36.4-37.6 °C	35.8-36.9 °C
Rectal	36.6-38°C	36.6-38°C	37.0-38.1°C	36.2-37.3°C
Armpit	34.7-37.3°C	35.9- 36.7 °C	35.2-36.9 °C	35.6-36.3 °C
Ear	36.4-38°C	36.1-37.8°C	35.9-37.6°C	35.8-37.5°C

Table (2) the normal range of body temperature.

The body temperature can give a lot of information about the health of the person. If the temperature reading is unusually high or low, it may indicate a hazard (an anomaly).

A dangerous body temperature depends to person's age table (3) Shows that:

Dangerous ranges	High body temperature	Low body temperature
Adults	104°F	95 °F
Children	102.2°F	102°F
Babies	100.4°F OR ABOVE	100.4°F OR LESS

Table (3): the abnormal range of body temperature.

When the body temperature is higher than the normal range is a signal of a fever. Appetite loss chills, a headache, irritability, muscle aches, shivering, sweating, and weakness are also symptoms of a fever and it's may occur as a reaction to:

- Infection, the most common cause of a fever
- Medicines. These include antibiotics, opioids, antihistamines, and many others. This is called a "drug fever." Medicines like antibiotics raise the body temperature directly. Other medicines keep the body from resetting its temperature when other things cause the temperature to rise.
- Severe trauma or injury. This may include heart attack, stroke, or burns.

- Other medical conditions: arthritis, hyperthyroidism, and even some cancers, such as leukemia and lung cancer.[10]

When a low body temperature is the only symptom, so the person doesn’t have to worry about it because it’s generally caused from being out side in a cold weather. A low body temperature with other symptoms such as chills, shaking, breathing problems, or confusion, then this may be a sign of more serious illness. This is most common in newborns, older adults, or people who are frail. [9]

4.3 Scales of temperature:

Temperature scales provide a way to measure how cold or heat the materials are, around the world there are four major scales that are used. Fahrenheit, Celsius, the absolute zero-based Kelvin and Rankine scales.

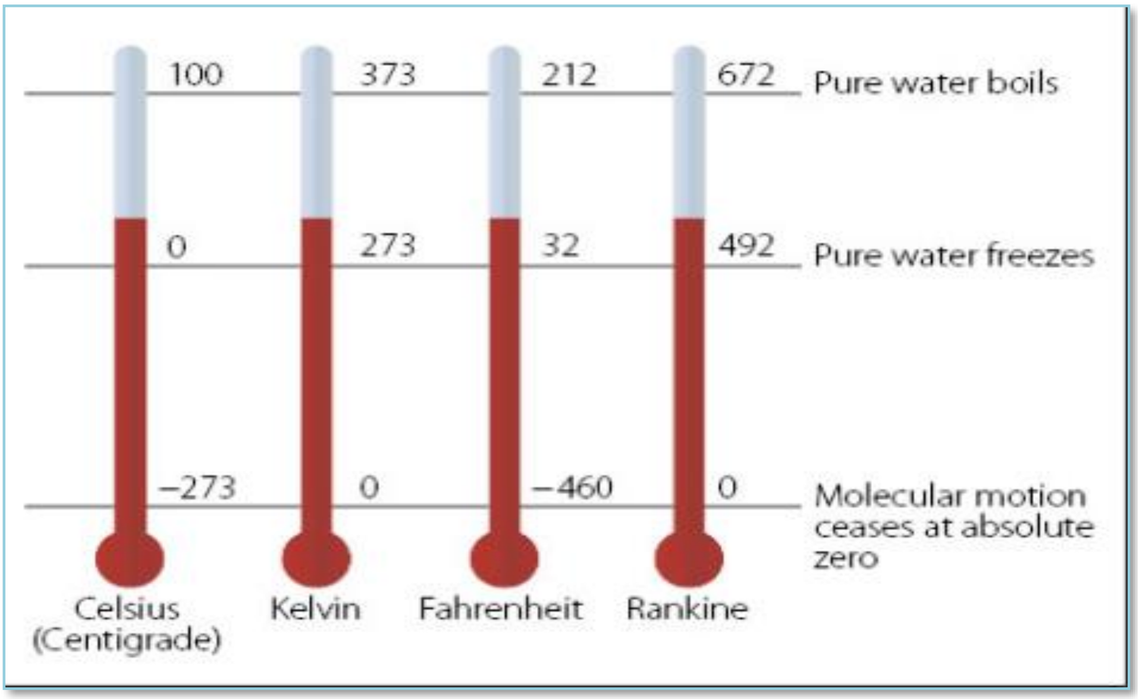


Figure (6): Comparison of the four temperature scales.

4.3.1 Fahrenheit Scale: [9]

This scale is the oldest one. In the Fahrenheit scale, the freezing of water is defined at 32 degrees, while the boiling point of water is defined to be 212 degrees. To convert °F to °C, you can use the following formula:

$$TC=59(TF-32)$$

4.3.2 Celsius Scale: [11]

Celsius, or centigrade, is a scale and unit of measurement for temperature. It is one of the most commonly used temperature units. In degree Celsius 0°C was defined as the freezing point of water, and 100°C was defined as the boiling point of water, both at a pressure of one standard atmosphere, with mercury as the working material. The temperature in Celsius (C) is related to the temperature in Fahrenheit (TF) by the relation:

$$TF = 32 + 1.8 * TC$$

4.3.3 Kelvin Scale: [11]

The Kelvin is a unit of measurement for temperature, the null point of the Kelvin scale is absolute zero, the coldest possible temperature. To convert Kelvin to degree Celsius uses the following formula:

$$TC = TK - 273.15$$

4.3.4 **Rankin scale**: [11]

The Rankine scale also starts at absolute zero. It is like the Kelvin scale, but its degrees are the same size as a Fahrenheit degree. In this scale water freezes at 491.67 and boils at 671.67 degree R. Fahrenheit and Rankin are relied by the following formula:

$$TR = TF + 459.67$$

4.4 Means and methods of measuring human body temperature:

A thermometer is an instrument that measures and indicates temperature, it determines how hot or cold objects are, the operation of it is based on the variation of the physical properties. It has two essential elements:

1- A temperature sensor : in which some change occurs with a change in temperature;
2- Some means of converting this change into a numerical value ;

Thermometers are widely used in technology and industry to monitor processes, in meteorology, in medicine, and in scientific research.

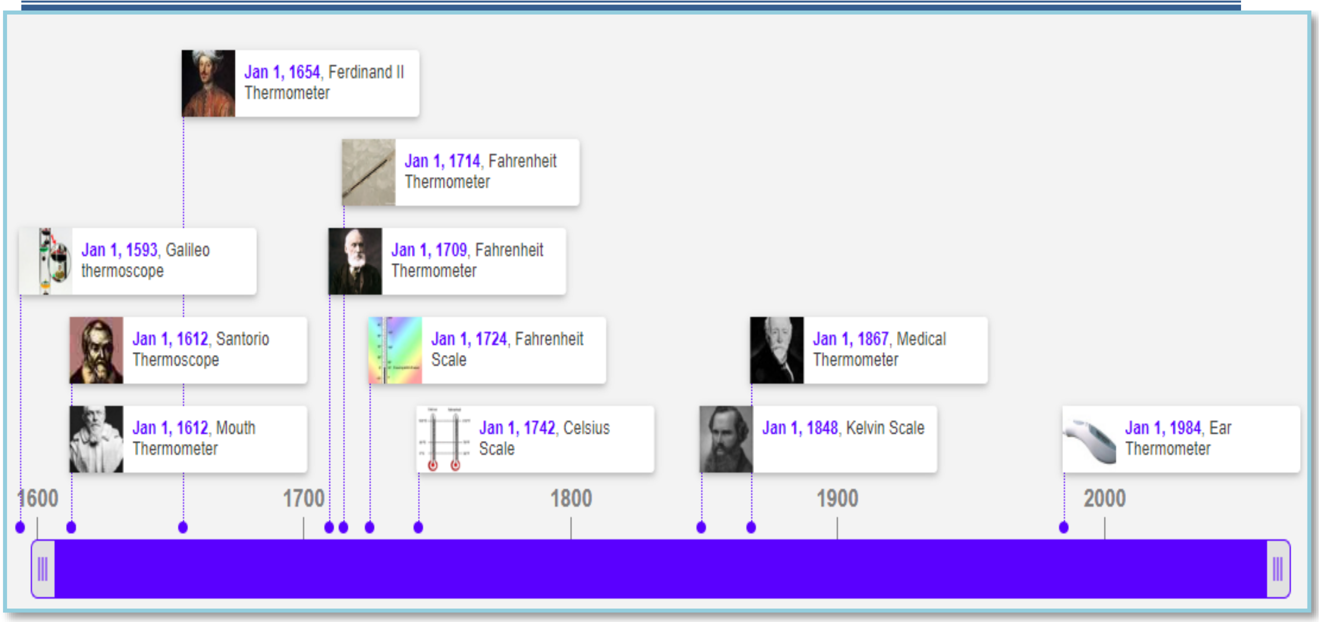


Figure (7): Time line show the history of thermometer [12]

A medical thermometer or clinical thermometer is used for measuring human or animal body temperature. There are a different type of thermometer and we can classified them by: [13]

a- Location : The temperature can be measured in various locations on the body which maintain a fairly stable temperature (mainly sub-lingual, axillary, rectal, vaginal, forehead, or temporal artery)

b- Thechnology :

01- Liquid-filled

02- Mercury

03- Phase-change (dot matrix) thermometers

04- Liquid crystal

05- Basal thermometer

06- Electronic

A- Resistance temperature detectors (RTDs).

B- Thermocouples.

C- Thermistor.

D- Contact.

E- Accuracy.

F- Remote.

07-Basal thermometer.

5 Blood glucose

5.1 Definition:

Blood glucose is a sugar that the bloodstream carries to all cells in the body to supply energy, people obtain this sugar from the diet.

The human body regulates blood glucose levels so that they remain moderate, to support vital bodily functions.

A person needs to keep blood sugar levels within a safe range to reduce the risk of diabetes and heart disease. [14]

5.2 Blood glucose chart:

Blood glucose chart identifies a person's ideal blood sugar levels throughout the day, including before and after meals, it can help a person with glucose management if they need to keep levels within a normal range, such as those with diabetes.

It is generally accepted that target blood sugar measurements for people with diabetes will be slightly higher than those without diabetes, health authorities consider a normal fasting blood sugar level to be below 99 milligrams per deciliter (mg/dL).

In people with diabetes, the levels will change more. Instead of targeting a specific level, the aim of managing blood sugar is to keep the levels within a healthy range.

People with diabetes who have well-controlled glucose levels with medications have a different target glucose range. These people may have a fasting range of about 100 mg/dL or less and 180mg/dL about 2 hours after eating. If a person's diabetes is not well controlled, the person may have much higher glucose ranges or hypoglycemia (for example, 200 -400 mg/d; however some people with diabetes have blood sugar levels that are much higher. [16]

Physiological Fluid	Biomarker	Concentration for Healthy Patients'	Concentration for Diabetic Patients'	pH
Blood	Glucose	4.9–6.9 mM [19]	2–40 mM [20,40]	7.35–7.45 [14]
Interstitial Fluid	Glucose	3.9–6.6 [53]	1.99–22.2 [54]	7.2–7.4 [14]
Urine	Glucose	2.78–5.55 mM [18]	>5.55 mM [18]	4.5–8 [14]
Sweat	Glucose	0.06–0.11 mM [55]	0.01–1 mM [55]	4.5–7 [56]
Saliva	Glucose	0.23–0.38 mM [57]	0.55–1.77 mM [57]	6.2–7.6 [58]
Ocular Fluid	Glucose	0.05–0.5 mM [21]	0.5–5 mM [20,21]	6.5–7.6 [18]
Breath	Acetone	0.1–2 ppm [59]	0.1–103.7 ppm [59]	7.4–8.1 [60]

Table (4) Summary of glucose concentrations postprandial and pHvalues measured in physiological fluids of healthy and diabetic patients.

5.3 Means and methods of measuring blood glucose

5.3.1 Invasive methods

Currently, the most widely used self-monitoring method involves this 'finger-pricking' approach, is enzymatic-based, and involves sampling blood from a finger via pricking, to be analysed by in vitro methods using test strips and a glucometer . The effectiveness of this method relies on strict compliance, which can be negatively influenced by time constraints, pain, and inconvenience. (Clarke A., O'Kelly S. Glucose Monitoring Systems. accessed on 8 October 2014)

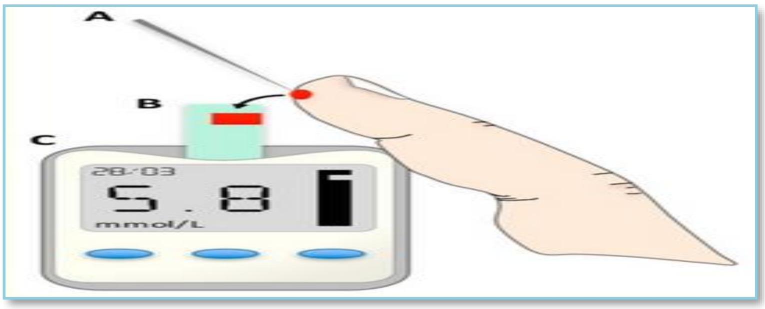


Figure (8): Finger pricking device (left). A. Lancet needle; B. Blood sample on test-strip; C. Glucose meter displaying glucose concentration in mmol/L.

Microneedles and microneedle arrays have also garnered a lot of interest over recent years for interstitial fluid sensing, since this approach can offer minimally invasive methods for bio-sensing. This concept was used in the development of a glucose-sensing patch by Jina et al.The sensing device was attached to the skin by an adhesive layer contouring the perimeter of the sensing pod. Detection was performed upon glucose diffusion into the microneedle array, wherein GOx could react to produce hydrogen peroxide. The production of hydrogen peroxide detected by the working electrode was proportional to the glucose concentration. The electronics module of this device required the use of an external potentiostat, a microprocessor and a battery to power the device. [17]

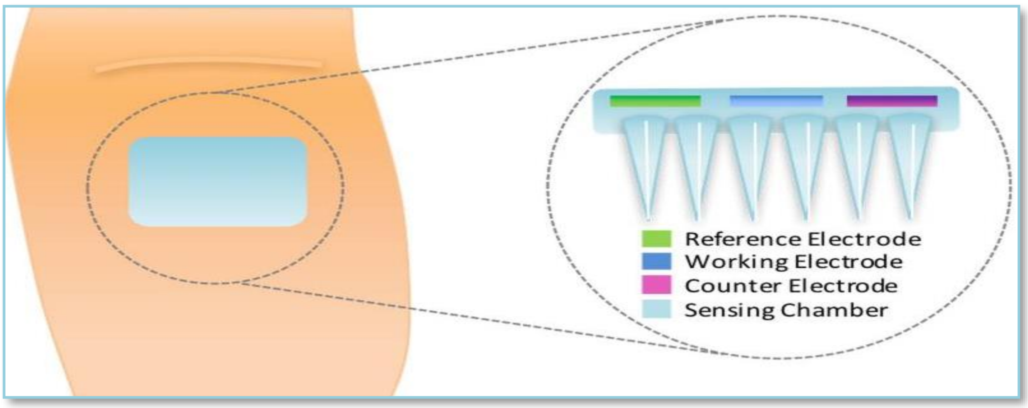


Figure (9): Schematic of the microneedle glucose-sensing patch on the forearm

5.3.2 Invasive methods:

Wang et al. have also recently been working towards the development of a continuous and non-invasive sensing device for detecting specific analyts in sweat using electrochemical sensing.

The device could successfully sense lactate and potassium ions in sweat for a few hours continuously. The positioning of the sensors on separate nose pads also minimised cross-talk and facilitated separate fabrication and replacement. These instrumented eyeglasses were coupled by Bluetooth wireless data to a remote mobile host device for data analysis and visualisation.

Wang and co-workers also demonstrated that by interchanging the lactate sensing pad for a glucose sensitive one, the spectacles could be used to monitor glucose concentrations in human sweat. The results showed good blood-sweat glucose correlations in healthy individuals when the blood levels were compared with a commercially available blood-glucose meter

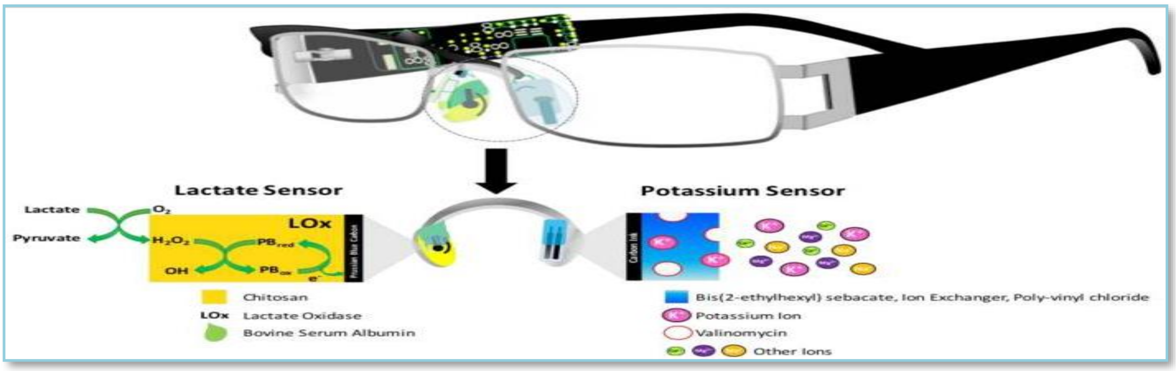


Figure (10): Schematic representation of the eyeglasses biosensor system.

The fluid surrounding the eye and ocular tissue, also known as the aqueous humour, contains many analytes present in blood. This complex fluid can be excreted from the body as an extracellular fluid in the form of tears. Analytes found in this fluid, such as glucose, ascorbic acid, lactate, proteins, peptides, hormones, carbohydrates, electrolytes, lipids and chloride, can offer great insight into an individual's health status. As a result, this fluid has been investigated for non-invasive and continuous glucose monitoring.

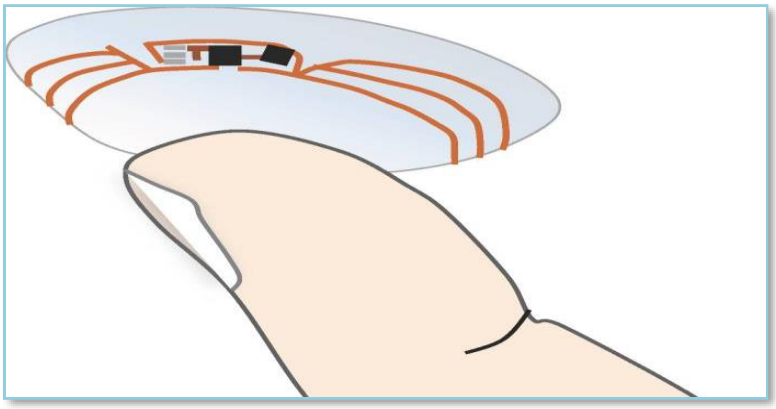


Figure (11): Google and Novartis smart-contact lenss

6 Heart Rate:

6.1 Definition:

The heart rate, or pulse, is the number of times the heart beats per minute. Normal heart rate can vary from person to another, according to the body's needs. The heart rate is an important vital sign; it is an indicator of health in the human body.

6.2 Physiology:

The human heart is an organ that pumps blood throughout the body via the circulatory system, when it beats, the heart pumps blood containing oxygen and nutrients around the body and brings back waste products. A healthy heart supplies the body with just the right amount of blood at the right rate for whatever the body is doing at that time. [18, 19]

Figure (12): Human heart [19]

6.3 Values of heart rate:

Heart rate can vary from one person to another according to body's need, age, physical activities. There is also other factors affect heart rate such as Air temperature, Body position, Emotions, Body size, Medication use and Taking Drug.

All this factors can produce a higher or a lower resting pulse than normal but usually not more the average.

6.3.1 Normal values of heart rate:

Newborns 0 to 11 month old	Children 1 to 2 years old	Children 3 to 9 years old	Children 10 years and older, and adults	Well-trained athletes:
70 to190 (BPM)	80 to 130 (BPM)	80 to 120 (BPM)	60 to 100 (BPM)	40 to 60 (BPM)

Table (5) Normal pulse rates at rest, in beats per minute (BPM) [20]

6.3.2 Fast heart rate:

It's also called tachycardia, it's generally defined when the value of the heart rate is over than 100 (BPM) for adults. There are many different causes of tachycardia can include: an underlying health condition, anxiety or stress, fatigue, heavy caffeine consumption, heavy alcohol consumption, electrolyte imbalance, fever, intense or strenuous exercise or physical activity, side effects from medication, cigarette smoking and certain drug use. [21]

The upper threshold of a normal human resting heart rate is based on age. Cutoff values for tachycardia in different age groups are fairly well standardized; the table below shows the different values of tachycardia: [22]

Age	Tachycardia (BPM)
1-2 days	Greater than 159
3-6 days	Greater than 166
1-3 weeks	Greater than 182
1-2 months	Greater than 179
3-5 months	Greater than 186
6-11 months	Greater than 196
1-2 years	Greater than 179
3-4 years	Greater than 137
5-7 years	Greater than 133
8-11 years	Greater than 130
12-15 years	Greater than 119
16 years, older and adults	Greater than 100

Table (6) values of tachycardia.

6.3.3 Slow heart rate

Bradycardia , is when the heart rate value is less than 60 Beats per minute. For athletes and people that exercise regularly, a heart rate of fewer than 60 beats per minute is normal and even healthy. There are other possible causes of Bradycardia such as side effects from medications, electrolyte imbalance, obstructive sleep apnea and an underlying health condition.

As mentioned earlier, heart rate is an important vital sign. If someone experiences a heart rate that's consistently too high or too low (not for Athlete) accompanied with one of the symptoms below should visit doctor:

Symptoms : [21]

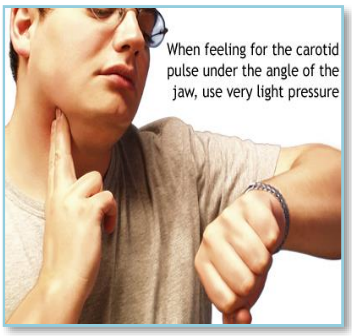
- being short of breath
- feeling dizzy or lightheaded
- feeling fluttering or palpitations in your chest
- having pain or discomfort in your chest
- fainting

Tachycardia and bradycardia indicate other health problems in the body. If left untreated, they can develop to a serious health complication.

6-4 Means and methods of measuring Heart Rate:

Heart beat can be measured at different places in the body. And it's easier and more reliable at the areas where arteries pass close to the skin, such as: Back of the knees, Neck, Temple, Top or inner side of the foot, Wrist and even finger.

There are manual methods in which the person gets the beats per minute. By the index, the middle finger and a simple pulse count for 1 minute or 30 seconds and multiply the value by 2. [23]



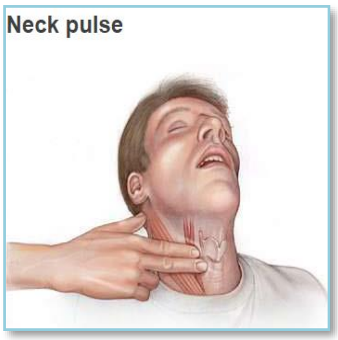


Figure (13): Wrist pulse   Figure (14): Carotide pulse   Figure (16): Neck pulse

6.4.1 Optical heart rate monitoring:

In a few years, it is expected that millions of wireless devices will be able to track personal health status. Optical heart rate monitoring (OHRM) on an intelligent platform like a Smartphone or a Smartwatch offers the possibility to monitor permanently and discreetly the physiological metrics.

The principle of OHRM is so simple. Light from an LED is made incident on the human skin at a finger or the wrist. As the light enters the skin, it gets reflected from components like tissue, bones, veins, arteries. However, the light getting reflected from all components other than the arteries is time-invariant and contributes only to a DC level. Only light reflected from the arterial blood has a time variant (AC). A photodiode receives the reflected light and converts it to a current. [24]

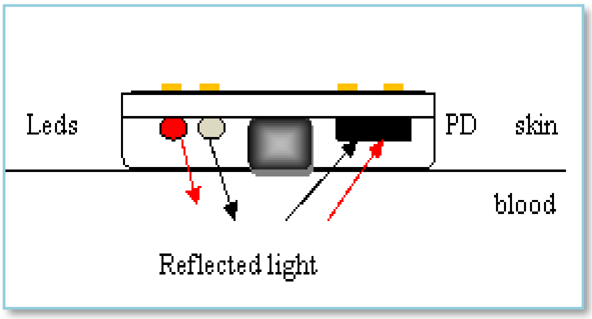


Figure (16): reflective optical heart rate monitoring [25]

7 Conclusion:

Through the information previously mentioned in this chapter, we have understood that monitoring of physiological parameters may be useful in assisting earlier detection of several serious health problems. However the real challenge that remains is the creation of biosensors for daily use by individuals in personalized monitoring.

Therefore, the subject of our thesis, which deals with the recommendation of a self-monitored and non-invasive telemonitoring solution, is a response to everyone's expectations.

CHAPTER II

Design and implementation of the connected Non-invasive device

1 Introduction:

In this chapter, we will detail our method of work, present the various tools we have used and will see step by step the design and realization of our device, then we will show the measures taken and provide an interpretation.

2 The Physical Components used to achieve the non-invasive device:

Like HARDWARE's tools we used:

2.1 Data acquisition and gathering:

2.1.1 Arduino module:

All the actual output voltage in this project are transmitted to the microcontroller. The acquisition is carried out using the ARDUINO UNO card.

The UNO model from ARDUINO represents an electronic card whose core is an ATMEL ATMega328 reference microcontroller. The ATMega328 microcontroller is an 8bits microcontroller from the AVR family all processors in this family have the same core that runs a powerful set of instructions in RISC mode, one instruction per clock cycle. The main interest of ARDUINO cards is their ease of implementation. ARDUINO provides a development environment based on open source tools. The loading of the program into the memory of the microcontroller is very simple by USB port.

This card is a platform for interactive object prototyping for creative use, consisting of an electronic card and a programming environment. It can serve:

1) For simple autonomous interactive devices.
2) As programmer of some microcontrollers.
3) As interface between sensors / actuators and computer.[26]

Figure (1): Arduino-UNO board

A printed circuit comprising all the electronic components necessary for the operation of a microcontroller (ATmega 328) associated with a USB interface enabling it to communicate with a computer. Microcontroller: (ATmega328) Programmable circuit: stores the program and executes it. [27]

- Jack plug: external power (9v, + center), connect the power supply (battery, AC adapter).
- Power pins: To power sensors and actuators.
- Analog input pins: Allows connection of sensors and detectors.
- Digital inputs and outputs: Allows connecting actuators and detectors.
- Reset button: For the reset.
- Universal Serial Bus (USB) connection: is used to power the board with electrical energy (5V). Allows to upload the program into the card and also to communicate with PC.

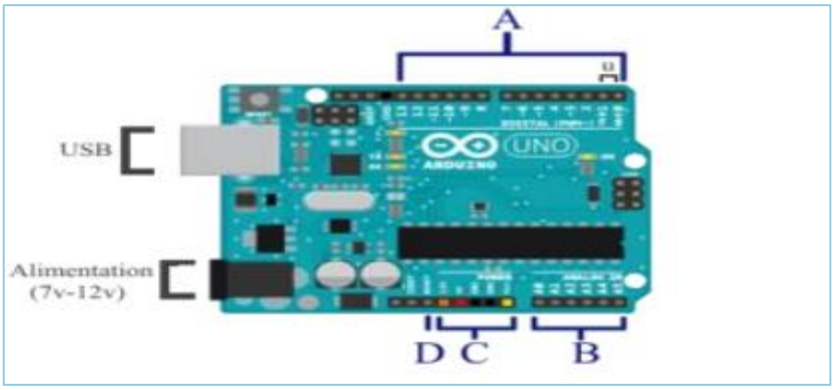


Figure (2) [27]: Diagram of an Arduino.

The Arduino system gives us the opportunity to combine the performance of the programming to our device. More specifically, it allows us to program our electronic system. The big advantage of programmed electronics is that it greatly simplifies the electronic schemes and thus the cost of implementation, but also the workload associated with the design of an electronic card. [4] Programmable interface board capable of controlling the device. Programming software allows programming the card according to the desired behavior.

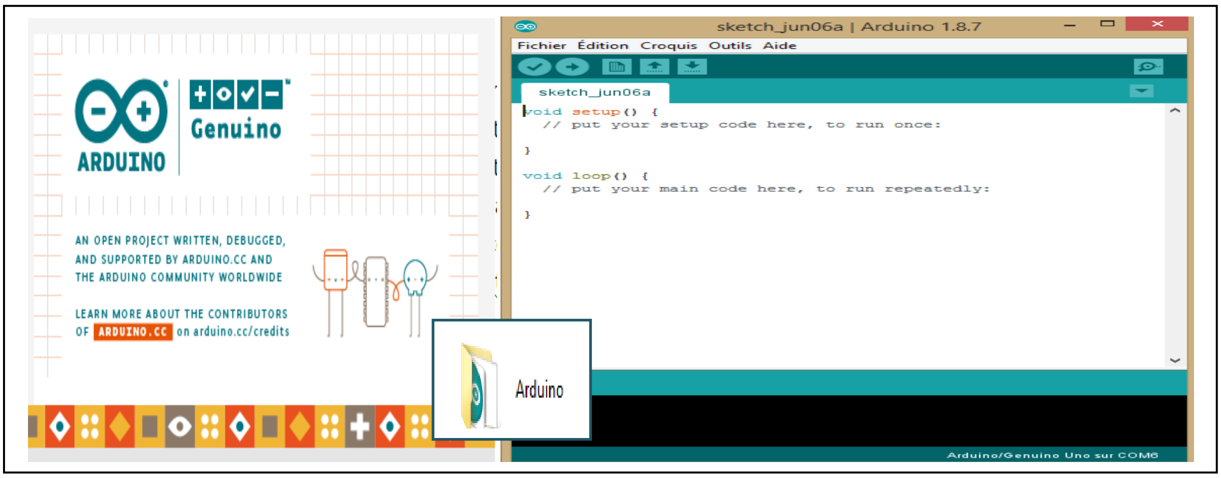


Figure (3): The software that allows the programming of an Arduino board

By connecting the Arduino with a computer to power it and in order to program our card to accommodate the voltage coming from the sensors, after the implementation of the program the result is displayed on the Arduino serial monitor as the figure (4) shows:

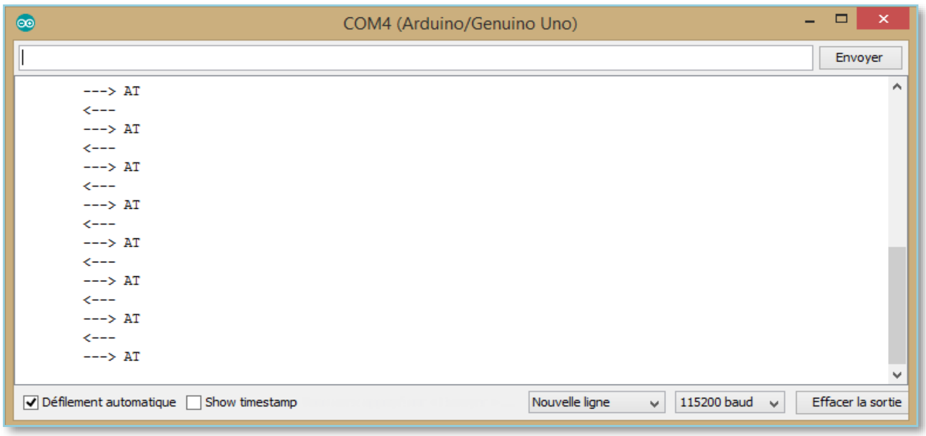


Figure (4): Displaying Measured Values on the Serial Monitor

2.2 Data transmission

2.2.1 Bluetooth:

The Bluetooth module: allows establishing a Bluetooth connection (serial link) between an Arduino board and another device with a Bluetooth connection (Smartphone, tablet, second Arduino board, etc...).

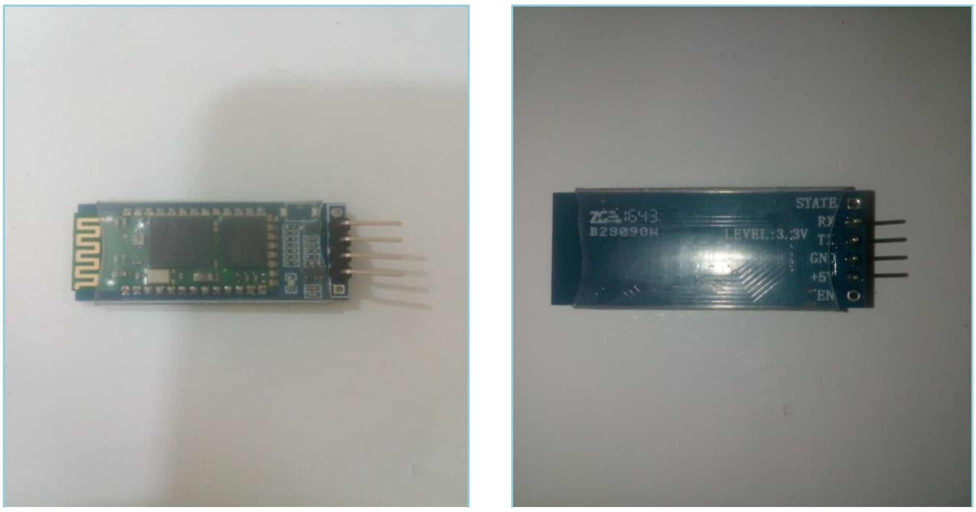


Figure (5): The HC-06 Bluetooth module

The HC-06 module is a "slave" module unlike the HC-05 module which is "master". A "master" module can ask another Bluetooth element to pair with it while a "slave" module can only receive pairing requests. This module can be configured to test the communication, to modify the PIN code of the module, to change the transmission speed of the module [28]. In our case we have configured the module under the name (Hc-06) and a password (1234) and a transmission speed (9600 bauds).

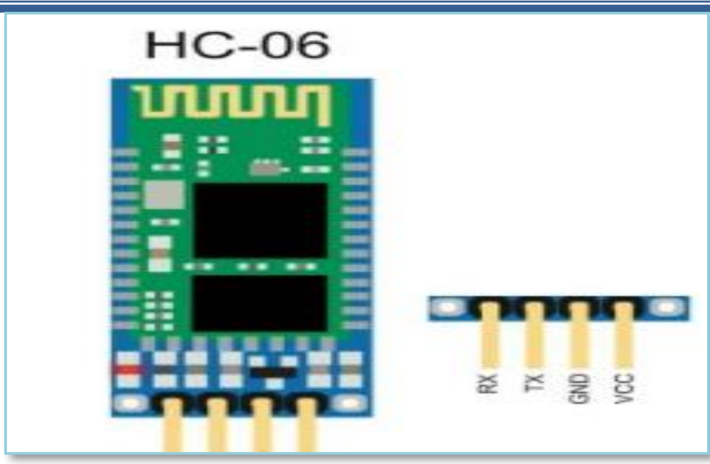


Figure (6): HC-06 module's pins

- Pin (1) VCC → Connect to +5V supply voltage.
- Pin (2) GND → Connected to the ground of the system.
- Pin (3) TX and Pin (4) RX → Connected to control the I/O inputs.

2.2.2 SIM808 module:

SIM808 module is a complete Quad-Band GSM/GPRS module, which combines GPS technology for satellite navigation. The GSM/GPRS works on frequencies GSM 850MHZ, EGSM 900MHZ, DCS 1800MHZ and PCS 1900MHZ [29] GPS Tracker allows the track seamlessly at anytime and any location with signal coverage.

SIM 808 integrates TCP/IP protocol and extended TCP/IP/AT Commands which are used for the data transfer. The programation of SIM808 GPS Tracker is based on the Arduino

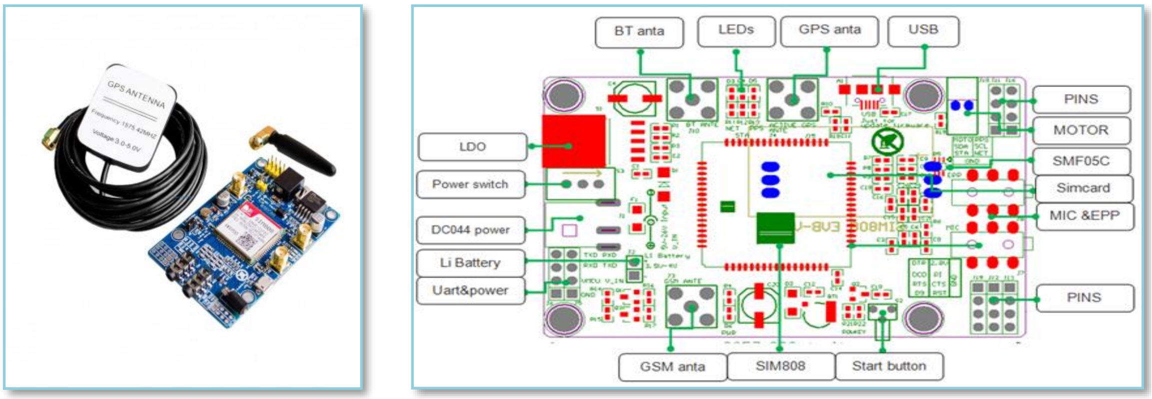


Figure (7) **[30]**: SIM808 module

As an advantage, this module has a small size of 54 * 42mm and available worldwide, it operates on four frequencies with several interfaces of TTL level, these interfaces can manage all the functions of this module (messaging 'call, GPRS data transmission, GPS) and other functions, it has perfectly met the needs of wireless data transmission and positioning function.

2.2.2.1 SIM808 Features: [30]

- BAT Input Voltage: 3.4-4.2V
- ATmega328: 8MHz, 32KB flash, 2KB SRAM

- Micro SIM connector
- Integrated Power Control System
- AT command interface with "auto baud" detection Quad-band: 850/900/1800/1900Mz
- Send and receive GPRS data (TCP/IP, HTTP, etc.)
- GPS L1 C/A code
- 22 tracking /66 acquisition channels
- Tracking: -165 dBm
- Cold starts: -148 dBm
- Time-To-First-Fix : Cold starts-32s (typ.), Hot starts-1s (typ.), Warm starts-5s (typ.)
- Accuracy: approx. 2.5 meters
- Interface: I2C/SPI/UART/18*GPIO
- Arduino compatible
- Working Temperature: -40 – 85℃
- Default baud rate: 115200
- Size: 40*55mm

2.3 Tools for the non invasive device

Tools used for Non-invasive Glucometer:

- LASER MODULE KY-008 650NM 5V
- Phototransistor

Tools for the Non-invasive Thermometer:

- LM35 temperature sensor.

To detect the Heart Rate:

- Pulse sensor

Sphygmomanometer "Blood Pressure meter":

- 5V RELAY module.
- Instrumentation Amplifier. AD620
- Armband.
- Pression sensor mpx 2200 GP.
- Microphone HXJ-17.
- Air pump.
- Power Supply (±9V).
- Resistor 10kΩ,
- Voltage-controlled valve.

For the **SOFTWARE** we used Arduino C, MATLAB, Excel.

In this project, we tried to combine the 4 non-invasive devices into one to facilitate the measurement for the users.

3 Non-Invasive Glucometer Based on Photo-acoustic Method

3.1 Definition and History

Spectroscopy is the measurement of the effect of absorbed electromagnetic energy on matter (especially light). The discovery of the effect of spectroscopy occurred in 1880, when Alexander Graham Bell showed that thin discs sounded when exposed to a ray of sunshine
was quickly interrupted by a rotating slit disc. The energy absorbed by the light causes local heating and by thermal expansion a pressure wave or sound. Later, Bell showed that the materials exposed to the non visible parts of the solar spectrum can also produce sounds. A spectrum of a sample can be recorded by measuring sound at different wavelengths of light. This spectrum can be used to identify the absorbance components of the sample. Spectroscopy can be used to study solids, liquids and gases.

In the 1970s, spectroscopy made great progress in the analysis of traces of gas and condensed matter. Its range of applications quickly embraces the food industry, atmospheric inspection, semiconductor process, material testing and in the oil industry, with particular emphasis on the study of powders, gels, emulsions, suspensions and others. Materials highly diffusing or opaque. The method allows for a range of measurements, including non-invasive online measurements in vitro and in vivo. Unlike ordinary acoustics, sound waves produced by the spectroscopy method carry information about the material properties of the substance in which they are generated. So, they can be used to study both the propagation medium and the substance excited directly by energy radiation. Since the 1990s, the technique of spectroscopy pulsed has found frequent use in biomedicine, where it has made great strides in non-invasively measuring the optical properties of tissues, tissue diagnostics, and imaging. However, the method faces difficulties similar to those of the aforementioned optical approaches in non-invasive blood glucose measurements. [31]

The results are also useful for some other forms of trace detection. In addition, the experiences gained during the study may also be used for the future development of non-invasive glucose determination methods.

3.2 Theoretical study of the non invasive glucometer:

3.2.1 Theoretical operating principle:

Glucose molecules have the ability to vary the angle of refraction of light to a degree proportional to its concentration, and the refractive index
of a given environment. The estimate is based on the principle of Snell's law [32]. According to Snell's law, the refraction angle is inversely proportional to the glucose concentration in the aqueous sample. The light beam (ab) of Fig. 1 tends to switch to normal alternativ curent and decrease the angle of refraction ($\theta 2$) as the glucose concentration increases, so more photons hit the photodetector.

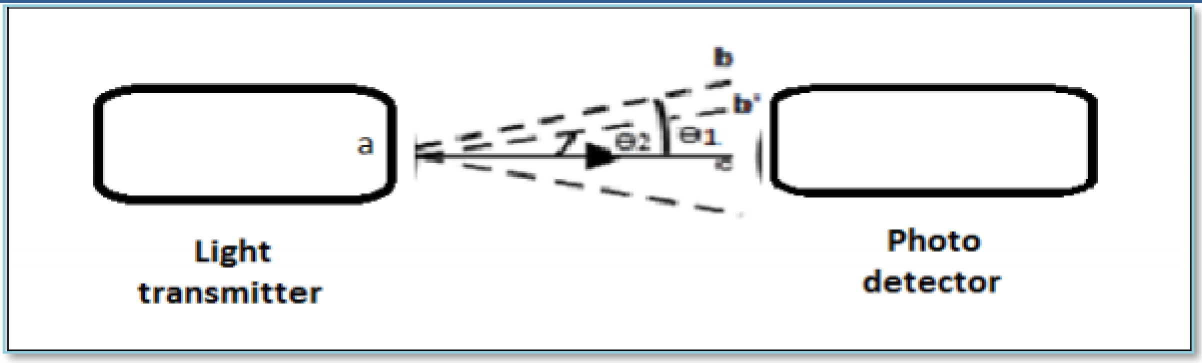


Figure (8): The angle of refraction decreases with the increase of the glucose concentration in the glucose solutions.

More photons striking the surface of the photo detector backwards generates a higher output voltage (Voc ') The relationship between the output voltage (Voc') and the light intensity (X) is expressed in the first equation (1):

$$V_{oc'} = \frac{nKT}{q} \ln\left(\frac{X I_{sc}}{I_0}\right) = \frac{nKT}{q}\left[\left(\ln \frac{I_{sc}}{I_0}\right) + \ln X\right] \qquad (1)$$

The simplification of equation (1) leads to a direct relationship between the light intensity and the output voltage, as indicated in the second equation (2):

$$V_{oc'} = V_{oc} + \frac{nKT}{q} \ln X \qquad (2)$$

•$I0$: Inverse saturation current

•Is : Short circuit current.

•$\frac{\mathrm{nKT}}{\mathrm{q}}$: Constant at a temperature (T) and $q = 1.602 \times 10^{-19}$ and $K = 1.380 \times 10^{-23}$

•Voc : Initial tension.

All the parameters except the intensity of the light (X) are constant therefore

•$Voc' \propto \ln X$.

The refractive index ($n2$) is calculated using a mathematical form of the Snell's law in the third equation (3):

$$n2 = \frac{n1\ (\sin \theta 1)}{\sin \theta 2} \qquad (3)$$

Where :

- $n1$: the refractive index of water $n1$ = 1.333.

- $n2$: the refractive index of the aqueous glucose solution that must be determined
- θ1: the angle of refraction of the water
- θ2: the refraction angle of the glucose solution.

The refractive angles θ1, θ2 are calculated using the following equations (4a) and (4b) which are derived from the triangles Δabc and Δab'c respectively of Fig 1:

$$\theta 1 = \tan^{-1}\left(\frac{bc}{ac}\right) \qquad (4a)$$
$$\theta 1 = \tan^{-1}\left(\frac{bc}{ac}\right) \qquad (4b)$$

- bc: the radius for water.
- b'c: the radius for the glucose concentration solution.
- ac: a fixed distance of 279.4 mm.

The parameter θ2 for the glucose concentration solution is a variable that changes with glucose concentration.
The refractive index ($n2$) is calculated only for the glucose concentration solution (in-vitro). In the case of the human finger, the effect of the refraction of light due to changes in the level of glucose in the blood is observed in terms of variations in the output voltage.

3.2.2 Optimal selection of light:

Unlike ordinary acoustics, sound waves produced by the photo acoustic method convey information about the properties of the substance in which they are generated [32].
However, equation (5) shows that the energy possessed by the photon depends on the wavelength.

The amount of energy each photon carries is (5):

$$E = \frac{hC}{\lambda} \qquad (5)$$

- h: $6.6260 \times 10^{-34}\ m^2$Kg/s
- C: 2.9×10^8m/s
- λ : wave length

This mathematical analysis potentially suggests that red light is suitable for biomedical applications because the absorbance of red light will be lower than Near-infrared (NIRS) because of its higher energy. That's shown in the equation (6):

$$Absorbance\ (A) = -log\left(\frac{\%T}{100}\right) \qquad (6)$$

$$Transmitance\ (T) = \left(\frac{p}{p_0}\right) \qquad (7)$$

With:

p : Radiant power of rays leaving water or human finger.

p_0 : The radiant power of monochromatic laser light.

3.3 Laser Sources:

Due to the higher detection sensitivity that offers, the technique of laser spectroscopy was used for the detection of trace. Near-infrared laser sources such as the Nd: YAG laser and the diode laser have been widely used in research in biomedicine and protection of the environment. These devices make it possible to study the internal properties and structure of weakly absorbing materials in the near infrared, including aqueous substances and most bio-tissues. [32]

Laser diode or Light Amplification by Stimulated Emission of Radiation, is an optoelectronic component based on semiconductor materials. It emits a coherent monochromatic light (optical power) intended, among other things, to convey a signal containing information. Laser diode is an essential component of disk drives and recorders optical; in this case, it emits the light beam whose reflection on the disk is detected by a photodiode or a phototransistor. It has a wide range of applications, due to its light weight, low volume, high performance, low price and ease of use of compaction.

3.4 Methodology:

3.4.1 Conception:

The non-invasive blood glucose monitoring device is used on the finger to measure the glucose level. It is a light source and a light detector positioned on each side of the finger. The amount of light passing through the finger depends on the amount of blood glucose in that region. Light is applied to one side of the finger, while a receiver on the other side receives attenuated light.

A laser diode with a wavelength of 650nm is used as an emitter (a light source). During the propagation phase of the laser light through the sample / finger unit, the laser light interacts with the molecules present in the area.

a phototransistor with a high response and wavelength sensitivity of 600 nm at 800 nm, which detects the output signal. This phototransistor measures the intensity of the light in voltage (V), in order to be read through a microcontroller Arduino UNO.

After that, the results will be calibrated, and finally they are sent via Bluetooth to an Android application. The following block diagram shows the process.

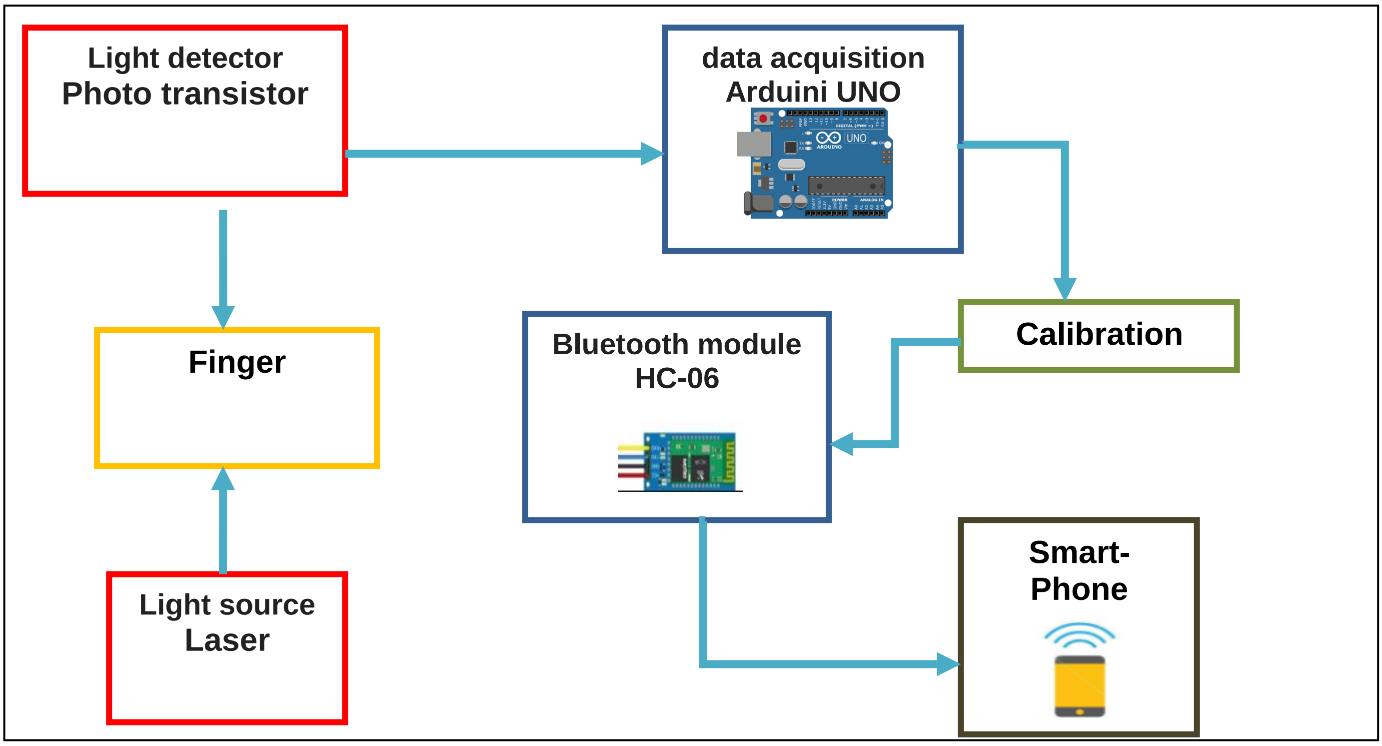
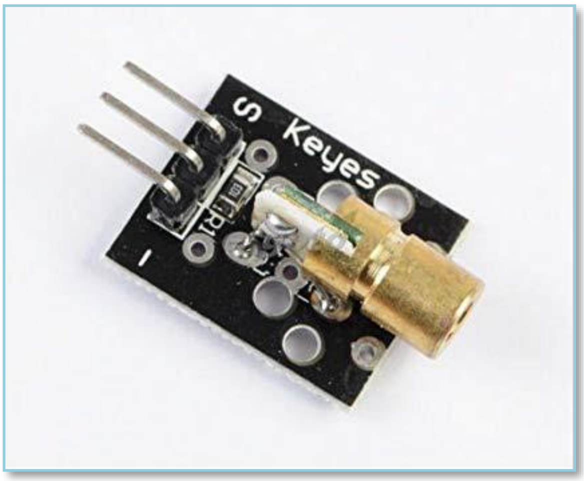


Figure (9): Block diagram illustrates the non-invasive glucose monitoring device

3.4.2 Implementation:

A- Emission:

The light source (Laser) used in this work is the LASER MODULE KY-008 650NM 5V



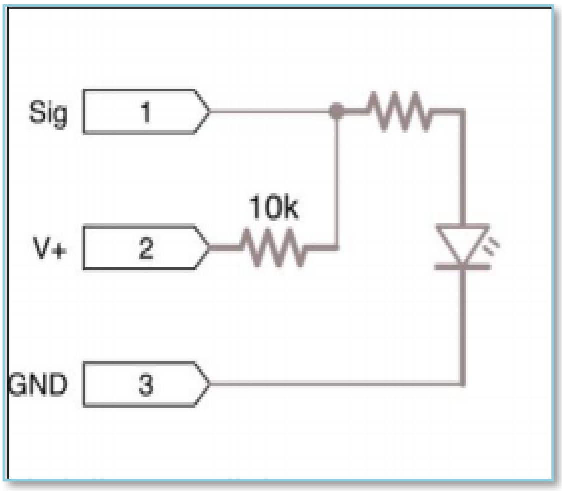


Figure (10): laser diode module and its pinning.

The transmission percentage of red laser light with a wavelength of 650 nm is the highest compared to other wavelengths, which is why it has the ability to penetrate water and even into the finger human. The red laser light has the highest transmittance of 95% and the lowest absorbance of 0.022 calculated using equation (6). And for our application it's the most appropriate wavelength and the ideal choice.

B-Reception:

The reception of the laser lights is performed by a photo detector which is in fact a phototransistor. The phototransistor detects the laser light transmitted through the glucose sample to convert the optical energy into electrical energy. The detected output voltage depends on the intensity of the laser light received.

The fourth Figure shows the pinning of the photo detector:

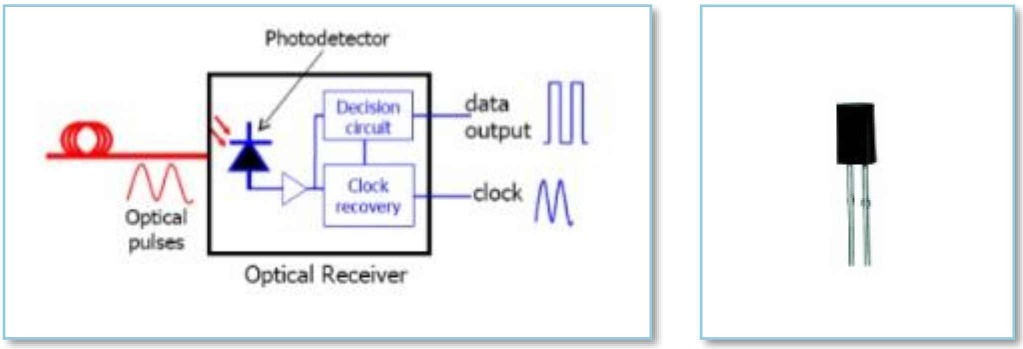


Figure (11): A phototransistor and its pinning

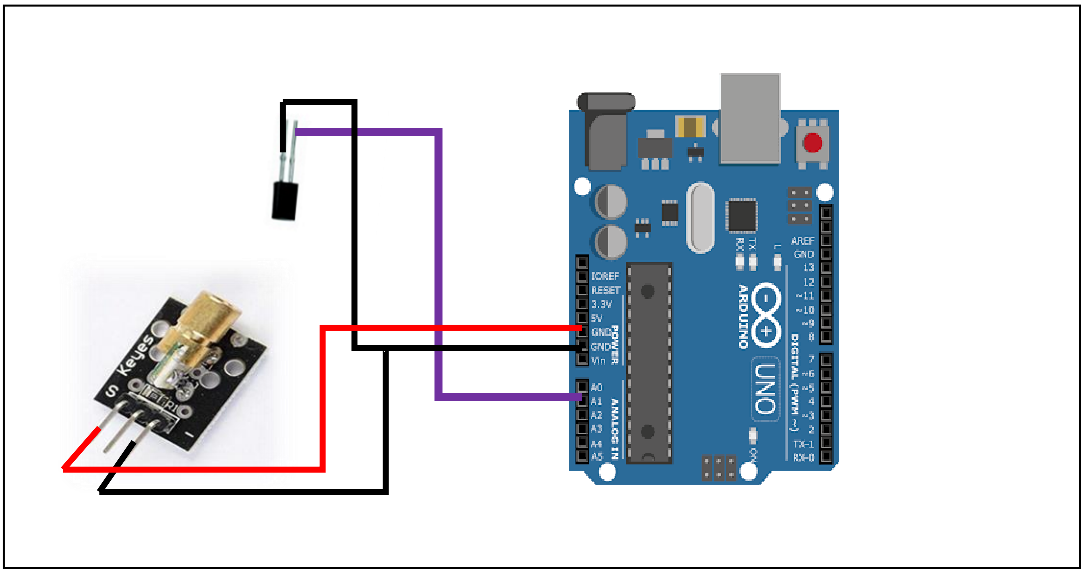


Figure (12): Arduino UNO, phototransistor and laser diode connection.

3.4.4 Calibration:

The output voltage is measured in (mv) so the device has been calibrated to display the glucose level in the blood in mg / dl. This part presents a non-invasive method of estimating blood glucose using the principle of digital plethysmography.

The calibration of the prototype was performed by comparing the intensity of the signal obtained with the invasive test method (ACCU-CHEK Performa glucometer).

Figure (13): ACCU-CHEK Performa glucometer/ PPG forceps

The test was carried out on 50 healthy and sick subjects in order to calibrate the device by drawing the most appropriate curve;

The effectiveness of this method used to measure blood glucose is to facilitate the patient's life by avoiding finger pricking which can negatively influence them by pain, time constraints and inconvenience.

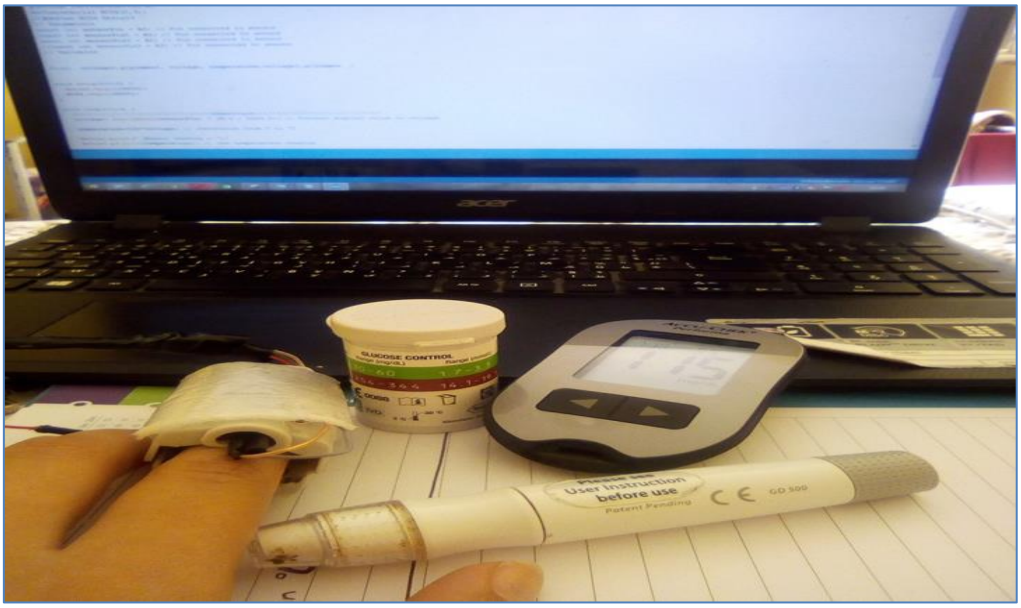


Figure (14): photo took when the test for the calibration

Subjects	Glucose(mv)	Glucose(mg/dl)
1	200	166
2	140	41
3	190	145
4	190	140
5	180	116
6	170	100
7	150	64
8	180	116
9	180	117
10	190	140
11	190	141
12	180	129
13	170	101
14	180	116
15	170	100
16	160	70
17	170	98
18	200	167
19	180	116
20	170	99
21	190	140
22	180	116
23	220	209
24	180	115
25	210	186
26	170	100
27	180	116
28	180	126
29	180	117
30	150	60
31	180	116
32	200	169
33	230	301
34	220	209
35	150	58
36	190	140
37	230	300
38	140	54
39	220	208
40	170	100
41	130	0
42	240	420
43	160	71
44	180	116
45	180	117
46	140	50
47	150	60
48	160	73
49	160	74
50	170	104

Table (1) values measured of blood glucose.

The values are plotted to obtain a regression equation: (under Excel)

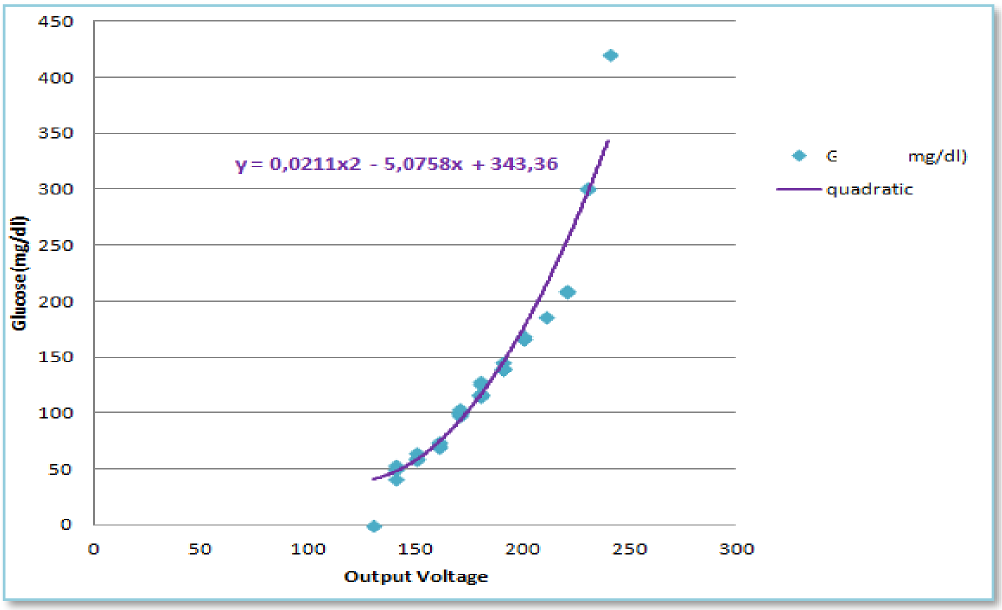


Figure (15): Calibration Chart

After calibration, the glucose level is sent to the android app via Bluetooth in mg/dl;

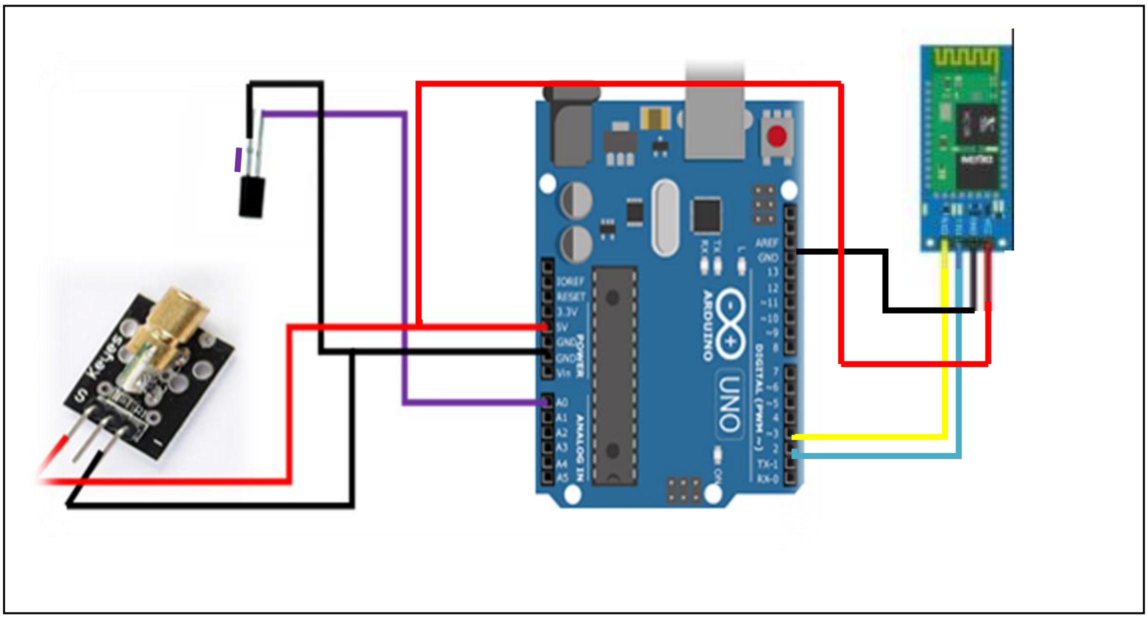


Figure (16): Arduino UNO, phototransistor, laser diode and Bluetooth connection.

4 Body temperature sensor:

4.1 Lm35:

This component measures the temperature around the sensor. It is inexpensive, accurate, very easy to use and reliable. The LM35 series is a precision integrated circuit temperature sensor with an output voltage linearly proportional to temperature in degrees centigrade. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin because the user does not need to subtract a high constant voltage from the output to obtain convenient centigrade scaling.[33] The LM35 has an analog output directly proportional to the temperature.

There are 3 different references for the LM35 in our projects we use the LM35 DZ, this reference is the easiest to find on the market and the cheapest. Its operating range is less wide (from 0 ° to 100 ° Celsius), so the LM35 DZ is enough to measure body temperature.

4.1.1 Features: [33]

1. Calibrated directly in Degree Celsius (Centigrade)
2. Linear at 10.0 mV/°C scale factor
3. 0.5°C accuracy guarantee-able (at a25°C)
4. Rated for full -55°C to a 150°C range
5. Suitable for remote applications
6. Low cost due to wafer-level trimming
7. Operates from 4 to 30 volts
8. Less than 60 mA current drain
9. Low self-heating, 0.08°C in still air
10. Non-linearity only 0.25°C typical
11. Low impedance output, 0.1Ωfor 1 mA load

4.1.2 Transfer Function of LM35:

The precision specifications of the LM35 are given with respect to a simple linear transfer function: VOUT = 10 mv/°C × T where:

• VOUT is the output voltage.

• T is the temperature in °C.

4.1.3 Pin Configuration

Pin (1): VCC → Connect to +5V supply voltage.

Pin (2): Signal → Analog voltage output 10mv/C.

Pin (3): GND → Connected to the ground of the system.

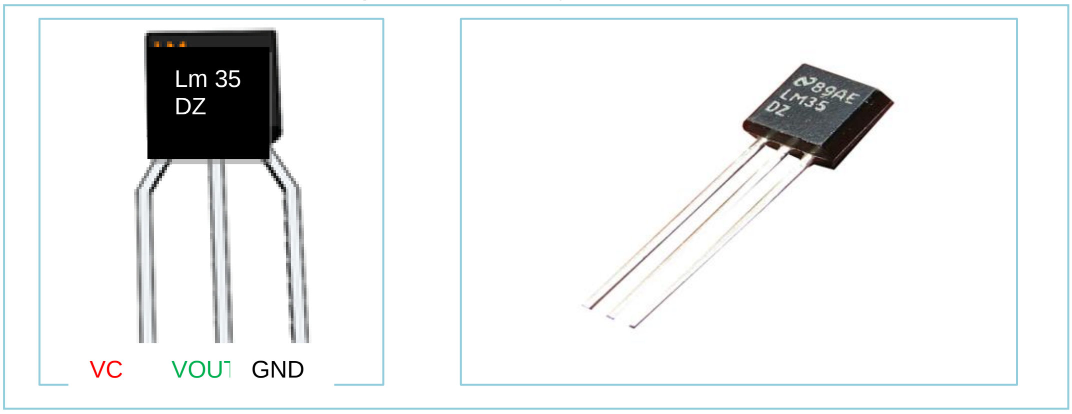


Figure (17):LM35 Pinout

4.2 Methodology:

4.2.1 Conception:

To measure the body temperature, it is necessary that the sensor is placed on the skin of the human body, in our case, the finger. The sensor will measure the body temperature. The high response of the LM35DZ, which detects the output signal (temperature in ° C). This value is transmitted to the microcontroller. The acquisition is done using the ARDUINO UNO card, and sent to an Android application via Bluetooth. The whole process is shown on the diagram below:

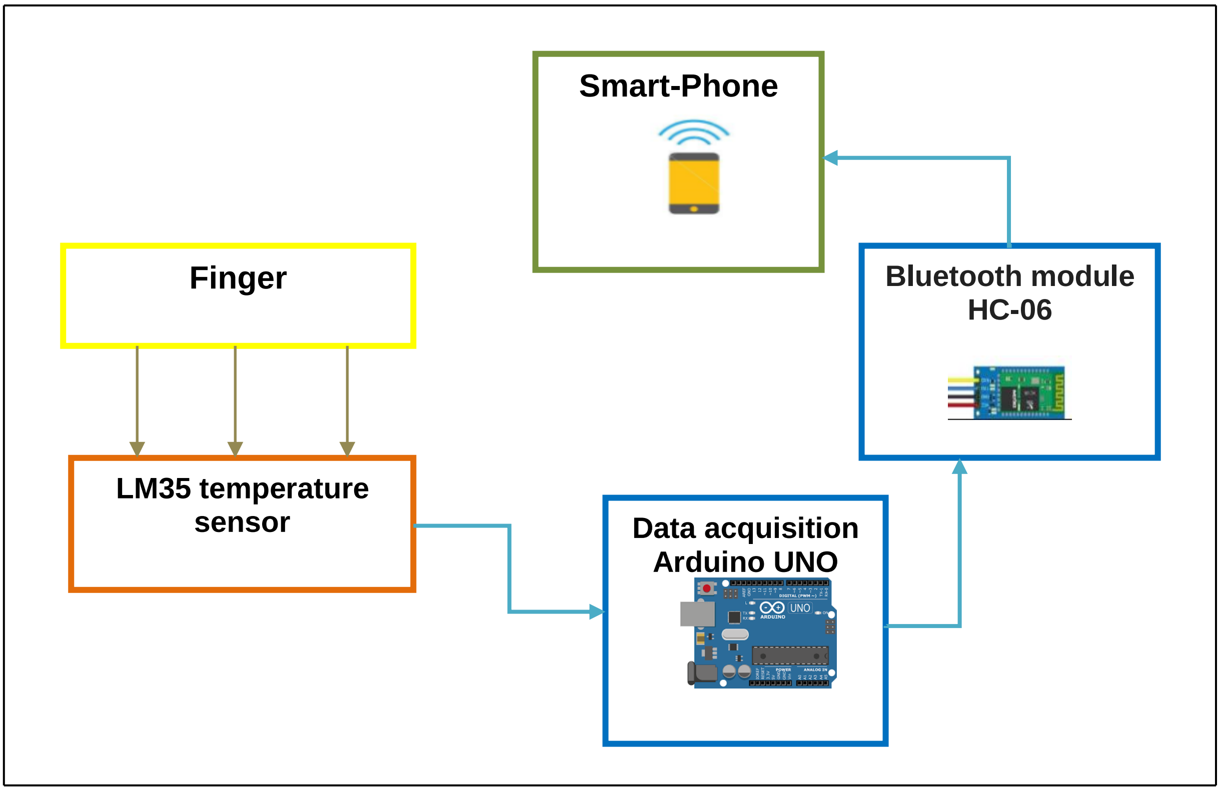


Figure (18): Block diagram illustrates the Temperature sensor

4.2.2 Implementation:

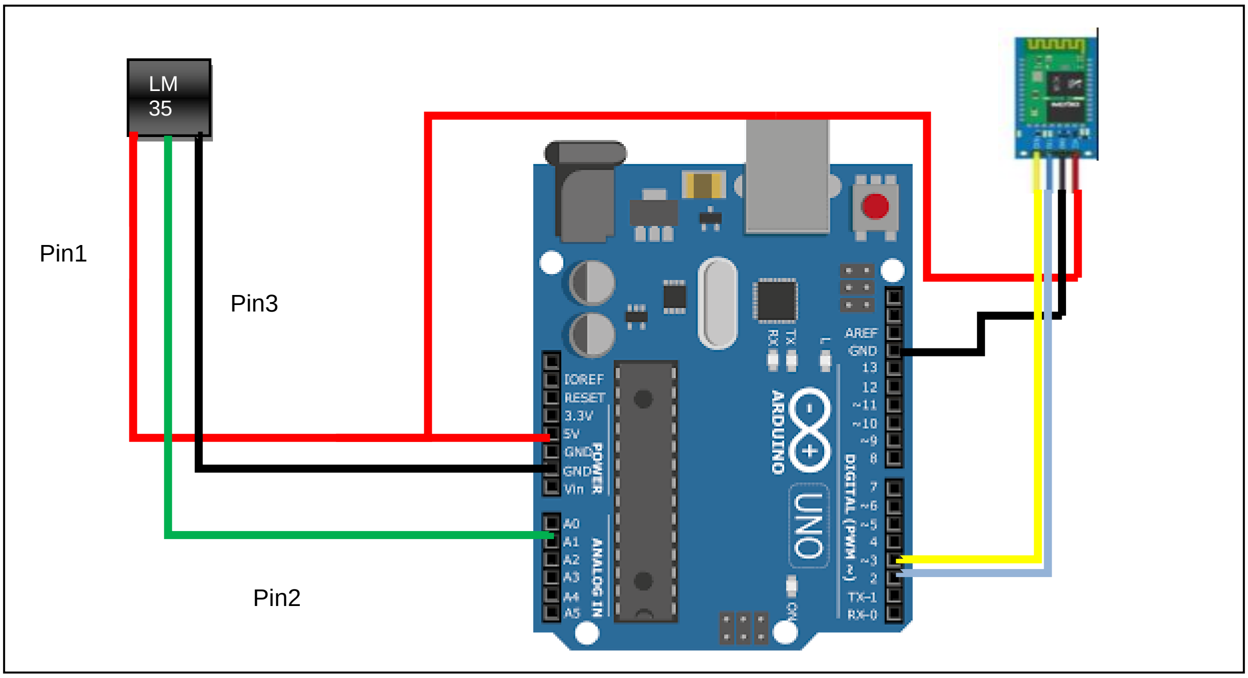


Figure (19): Arduino UNO, Bluetooth and Temperature sensor connection.

5 Heart-Rate Sensor (HRS):

5.1 Definition

The sensor that we will use has two sides, in the first; there is the LED which is placed with an ambient light sensor and on the other side, circuitry which is responsible for the amplification and noise elimination.

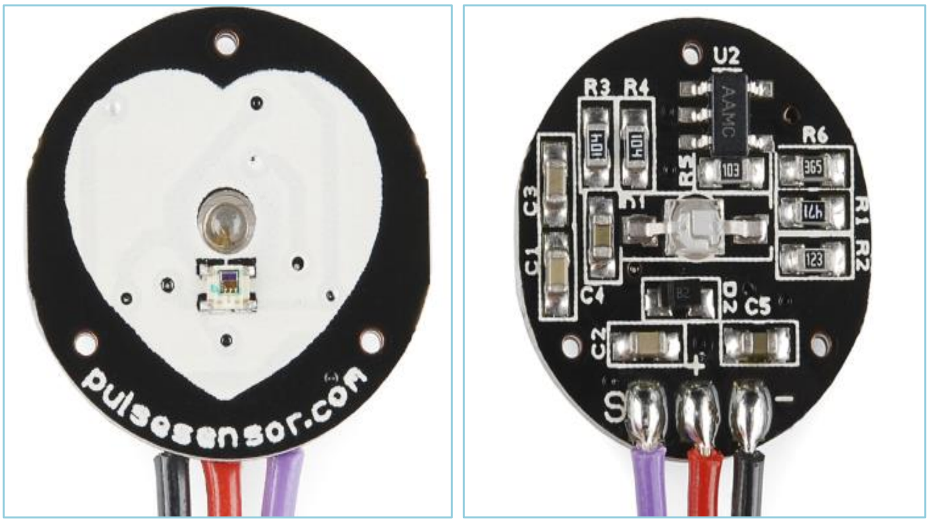


Figure (20): sides of the heart rate sensor

5.1.1 Features: [34]

- Biometric Heart Rate detecting sensor
- Plug and Play type sensor
- Operating Voltage: +5V or +3.3V
- Current Consumption: 4mA
- Inbuilt Amplification and Noise elimination circuitry.
- Diameter: 0.625”
- Thickness: 0.125” Thick

5.1.2 Pin Configuration

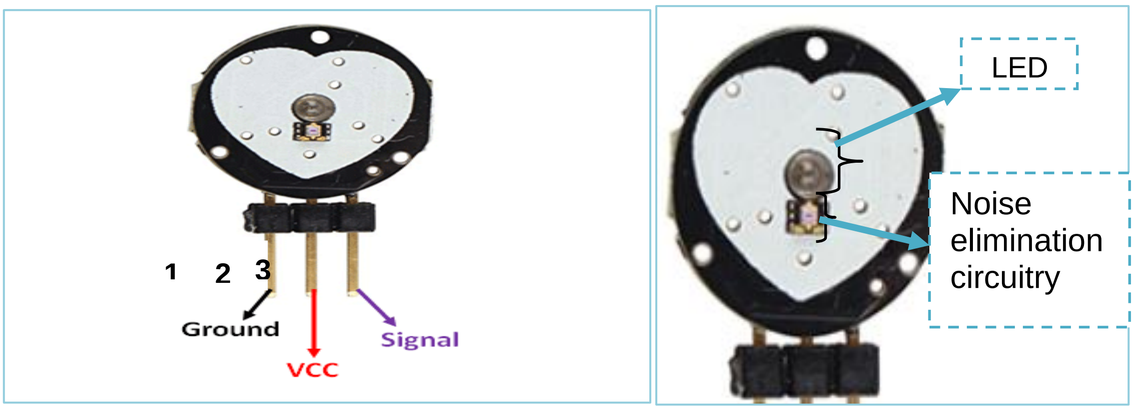


Figure (21): Heart Rate sensor Pinout

Pin (1): GND → Connected to the ground of the system.
Pin (2): VCC → Connect to +5V or +3.3V supply voltage.
Pin (3): Signal → Pulsation output signal.

5.2 Methodology:

5.2.1 Conception:

The light at the front of the sensor is placed on the skin of the human body, in our case, the finger. It should be placed directly on a vein.

When the LED emits a light that will fall on the vein. Blood circulation will be monitored and heart rates will also be detected. If blood flow is detected, the ambient light sensor captures more light since it will be reflected by the blood. This minor variation in the received voltage (V) is analyzed over time to be read using an Arduino UNO microcontroller to determine the heart beat. These values in (BPM) will be sent to an Android application in a Smart-Phone via the Bluetooth module. The following diagram shows the process.

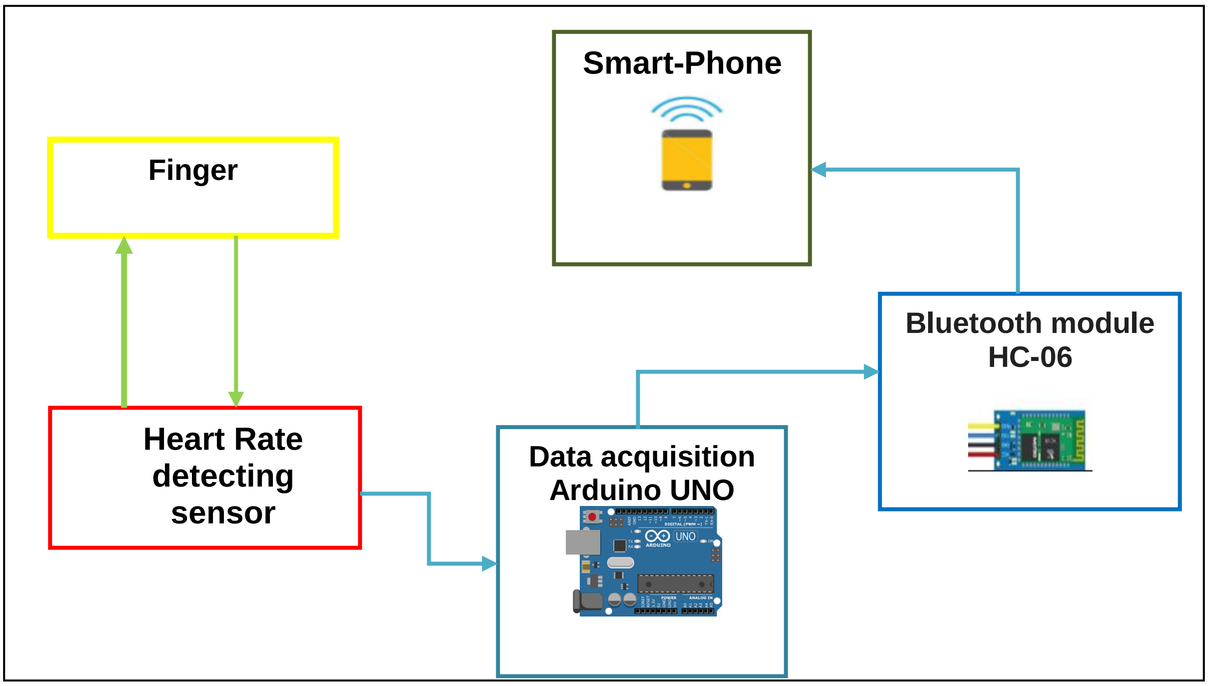


Figure (22): Block diagram illustrates the Heart Rate sensor

5.2.2 Implementation:

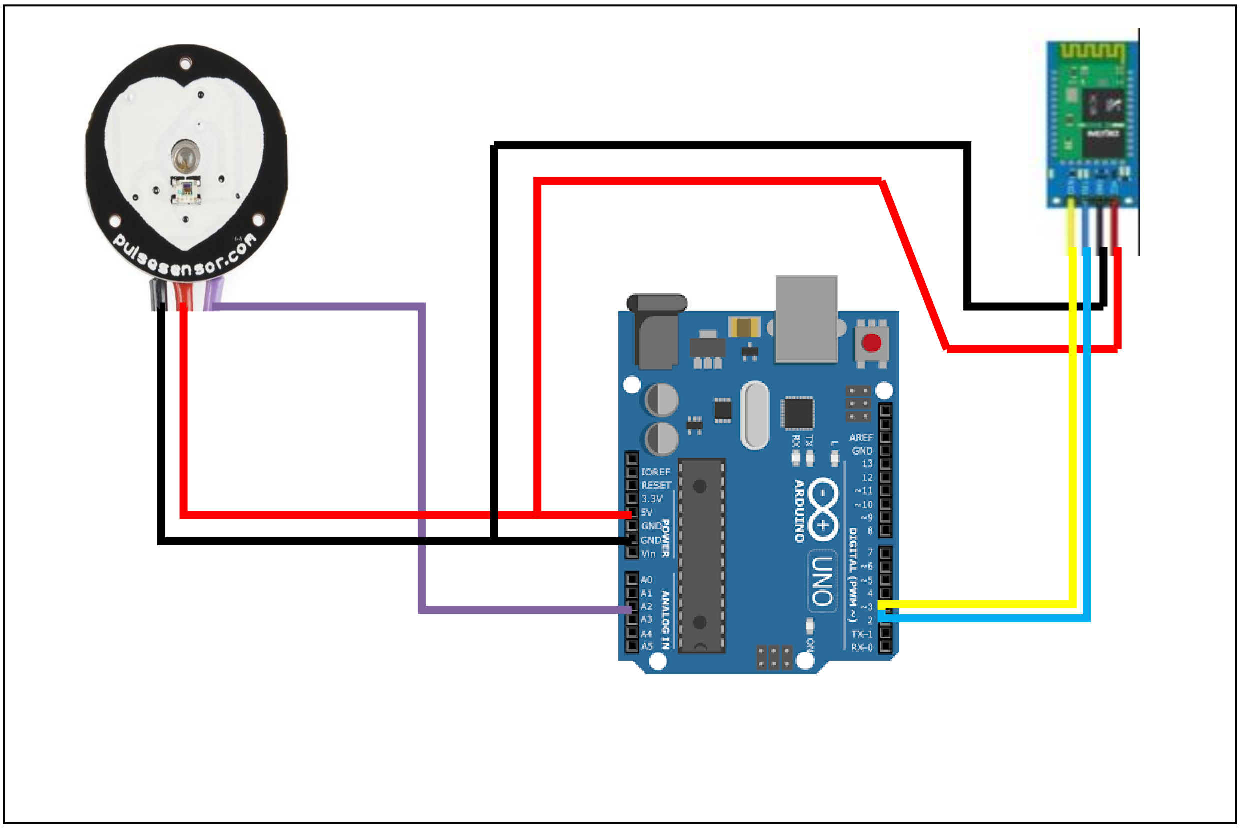


Figure (23): Arduino UNO, Bluetooth and Heart Rate sensor connection.

6 Sphygmomanometer:

6.1 Conception:

To complete our device, we created a blood pressure monitor. This sphygmomanometer measures mean arterial pressure (MAP) and approximates systolic and diastolic pressures. It requires the use of a pressure transducer (mpx2200), an Arduino Uno and a coding to control the valve and the air pump.

Sphygmomanometers are mainly used to analyze a person's blood pressure and to prescribe the best monitoring. This low-cost monitor inflates and deflates the blood pressure cuff to determine average blood pressure. It then approximates diastolic and systolic pressures based on the mathematical relationship between mean arterial pressure, diastolic and systolic pressures. The results are then sent to an Android application.

The following diagram shows the design of this blood pressure monitor**:**

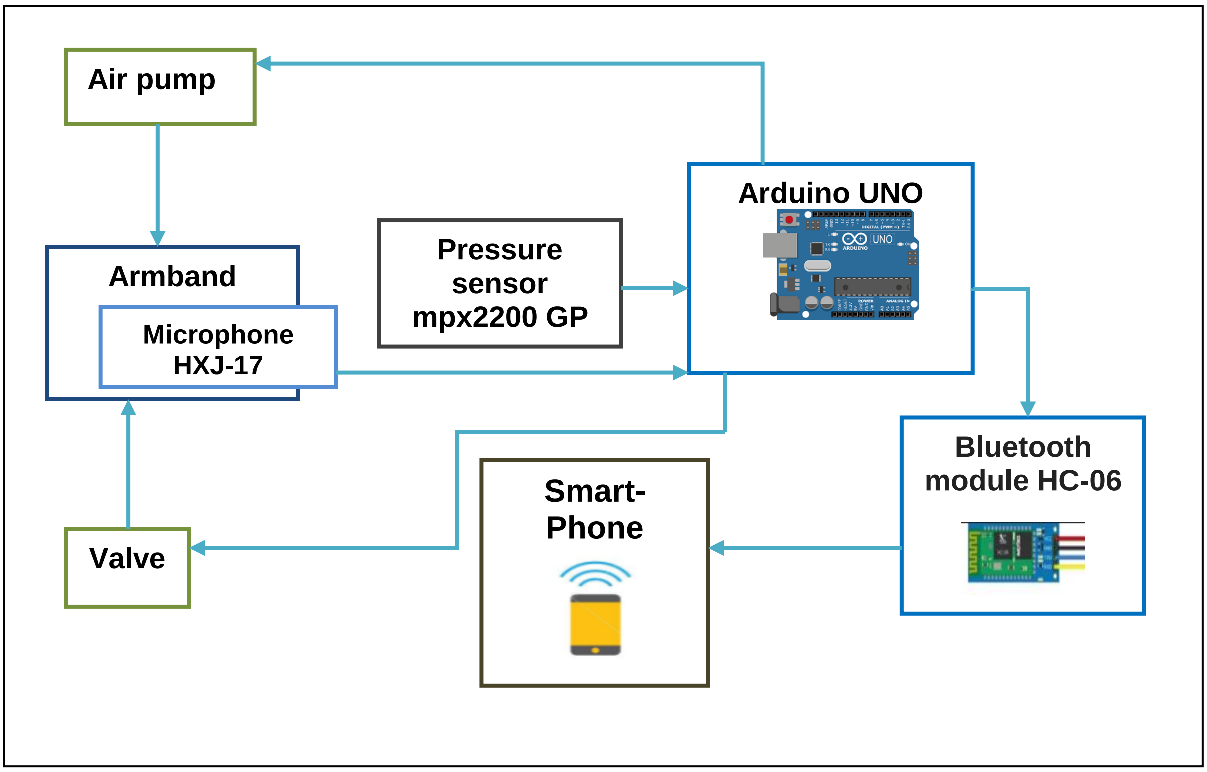


Figure (24): Block diagram illustrates the Blood pressure monitor

6.2 Implementation:

For the Sphygmomanometer we used as a componontes:

a. **Air Pump:** This provides air to the system to inflate the armband.

Figure (25): Electronic valve

b. **Valve**: Deflation is done with a small electronic valve.

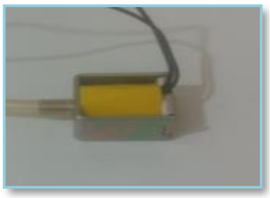


Figure (26): Electronic valve

c. **Armband:**

-

Figure (27): Armband for sphygmomanometer

d. **5v Relay:** The relay module is a power switch that turns on or off a circuit that uses a much higher voltage and / or current than a microcontroller manipulate. There is no connection between the low voltage circuit operated by the microcontroller and the high power circuit. The Relay protects each circuit from each other.

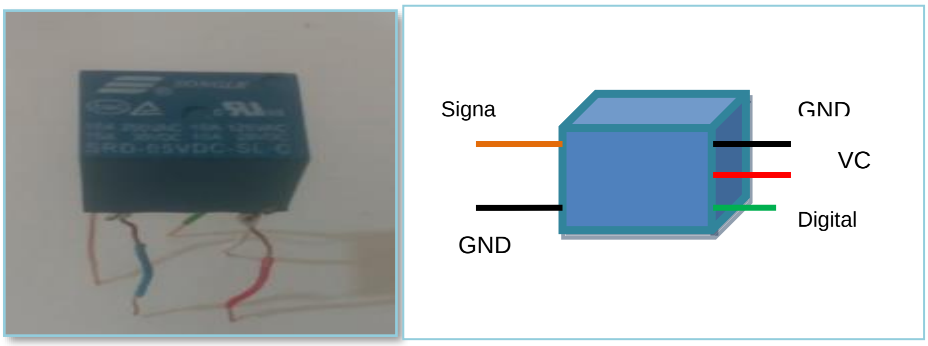


Figure (28): The relay module

Pin Configuration:

1. VCC: 5V DC
2. COM: 5V DC
3. IN1: high/low output
4. IN2: high/low output
5. GND: ground.

e. **Microphone HXJ-17:** measure the sound levels of blood in the arteries, there is a Vcc pin, a ground pin, an analog out pin and a digital out pin.

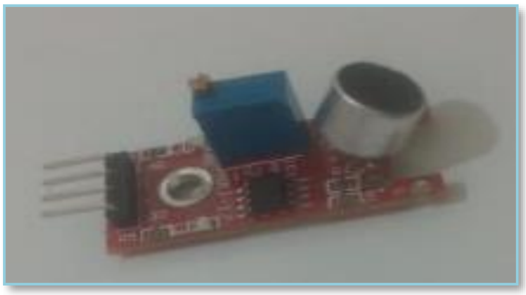


Figure (29): sounds sensor.

f. **Amplifier AD620:**

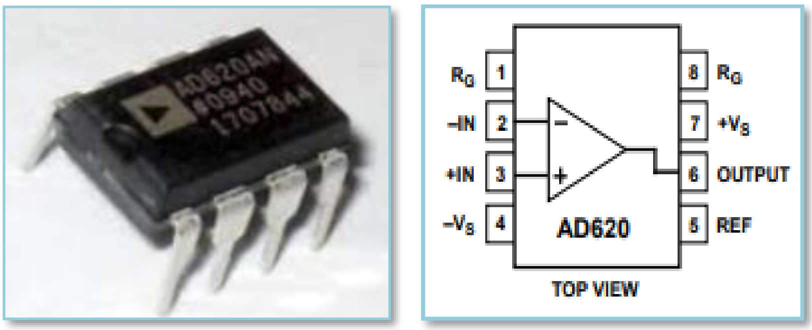


Figure (30) **[35]**: AD620 amplifier

g. **Pressure sensor Mpx 2200 GP:** We used the MPX2200 pressure sensor. This sensor produces an output voltage proportional to the pressure difference applied to the input. The armband tube is connected to the sensor tube.

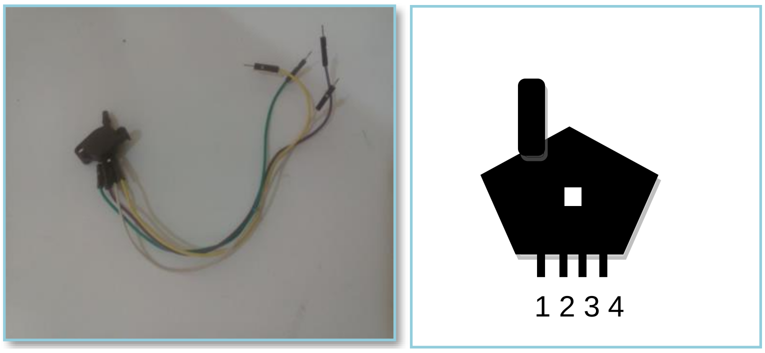


Figure (31): Pressure sensor

Pin configuration:

Pin (1): GND

Pin (2): Vout+

Pin (3): Vs

Pin (4): Vout-

6.3 Diagram of circuit:

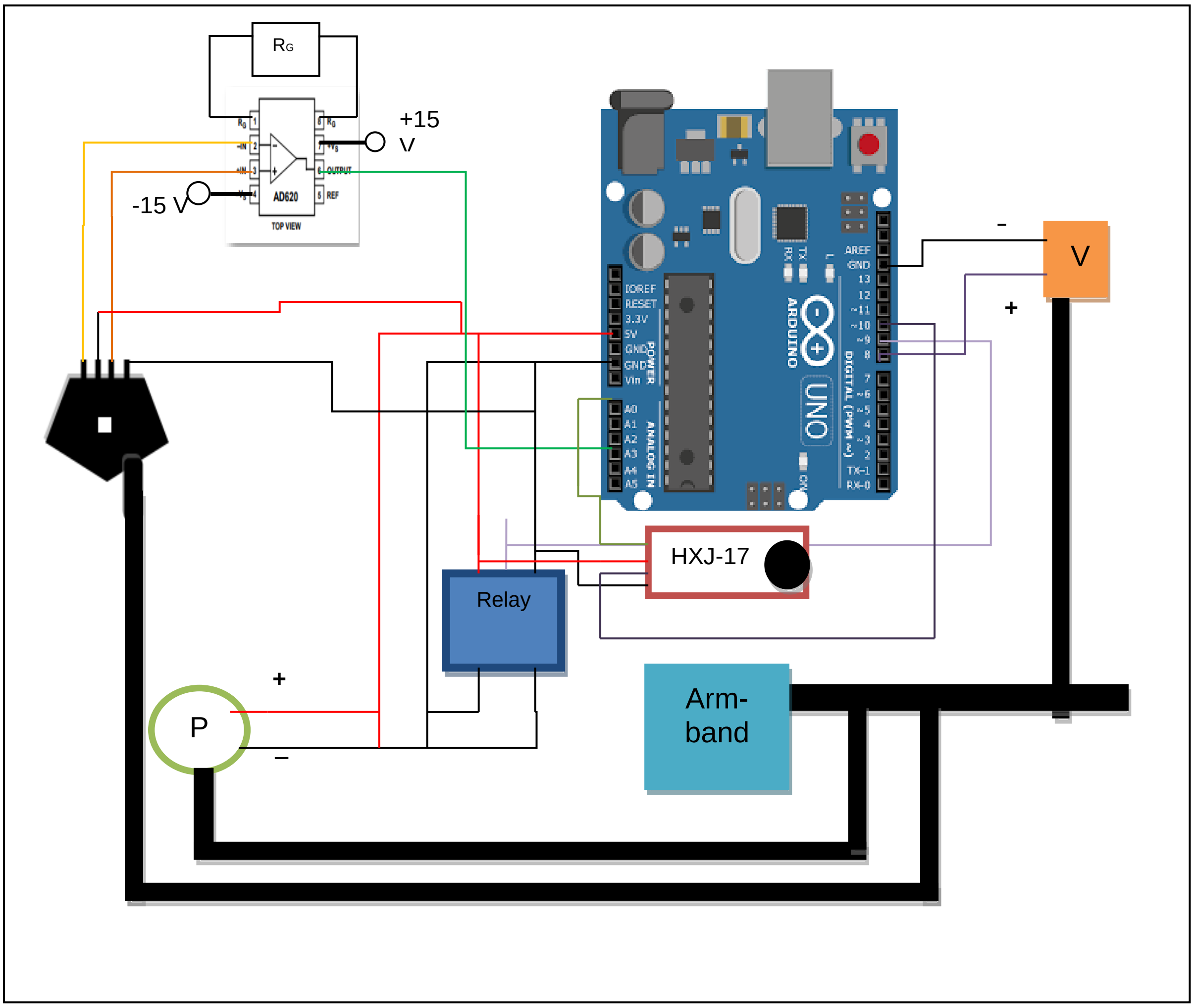


Figure (32): the blood pressure monitor circuit

7 Tracker System:

A tracking system allows the observation of people or objects in motion or at rest and to provide an ordered sequence of location data in a timely manner for further processing.

Figure (33): Google Maps

7.1 Global Positioning System (GPS):

Satellite geolocation system developed by the US military, is a network of 24 satellites currently in operation, it's available to civilians. This system allows the determination of the geographical coordinates of any point located on the surface of the earth. Its accuracy can reach 1 meter.GPS operation is based on the calculation principle by triangulation between satellites and receivers, each GPS satellite broadcasts a message that includes the satellite's current position, orbit, and exact time. A GPS receiver combines the broadcasts from multiple satellites to calculate its exact position. [36, 37, 38]

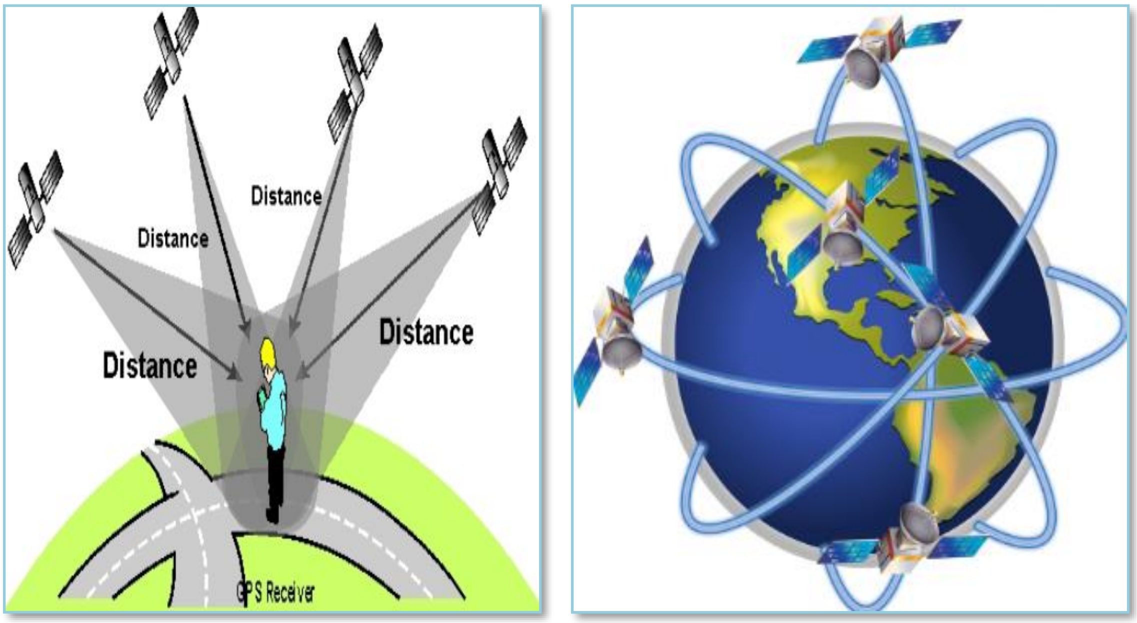


Figure (34): Tracking systems GPS/GPS satellites. [38]

7.2 Global System for Mobile Communications (GSM):

GSM, Global System for Mobile communication is a digital mobile network that is widely used by mobile phone users in Europe and other parts of the world. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies: TDMA, GSM and code-division multiple access (CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 megahertz (MHz) or 1,800 MHz frequency band.
The GSM standard has given birth to wireless services like General Packet Radio Service (GPRS). Its end users were the first to take advantage of an inexpensive implementation of SMS (short message system), which is more popularly known as texting.
Being a cellular network, GSM makes use of cells to provide wireless communication to subscribers who are in the vicinity of these cells. The four main cells that make up a GSM network are called macro, micro, pico and femto. Outdoor coverage is typically provided by macro and micro cells, while indoor coverage is usually provided by the pico and femto cells.

GSM phones may be identified by the presence of a Subscriber Identity Module (SIM). This tiny object, which is about as wide as a finger, is a removable smart card that contains a user’s subscription information, as well as some contact entries. This SIM card allows a user to switch from one GSM phone to another. In some countries, especially those in Asia, GSM phones are locked to a specific carrier. However, if a user manages to unlock a phone, he can insert any SIM from any carrier into the same phone. [39]

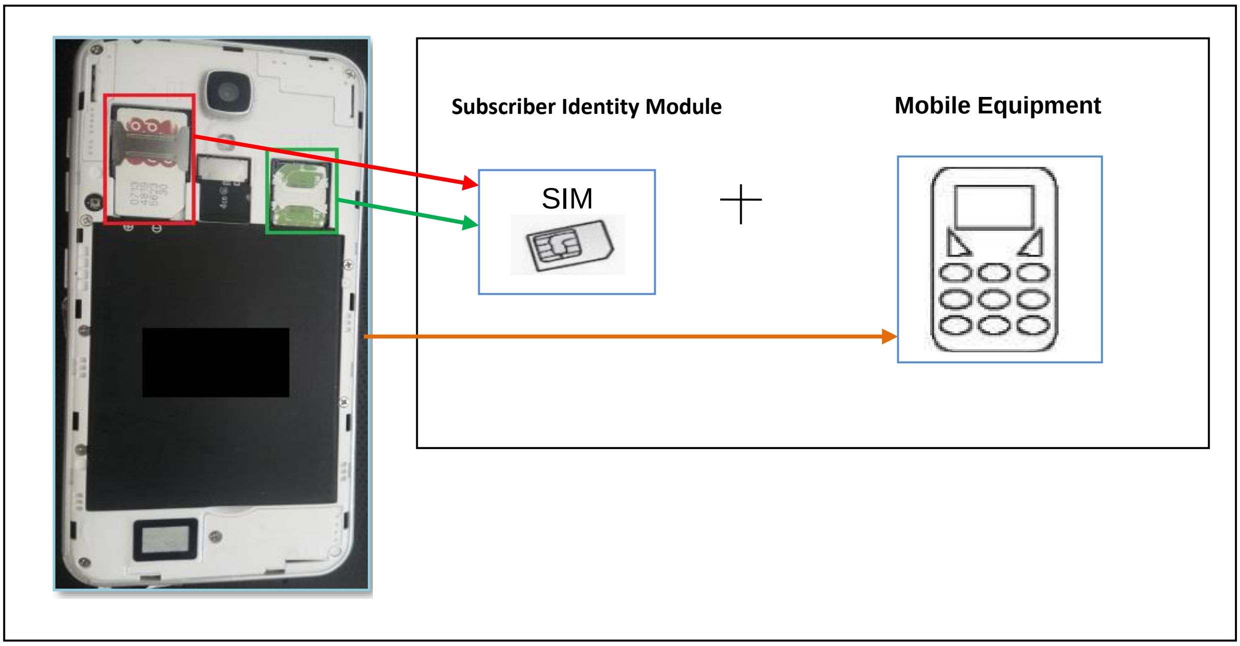


Figure (35): Mobile Station (MS).

7.2.2 Composition of the network:

The GSM network has four separate parts that work together: the mobile device, the base station subsystem (BSS), the network switching subsystem (NSS) and the operation and support subsystem (OSS).

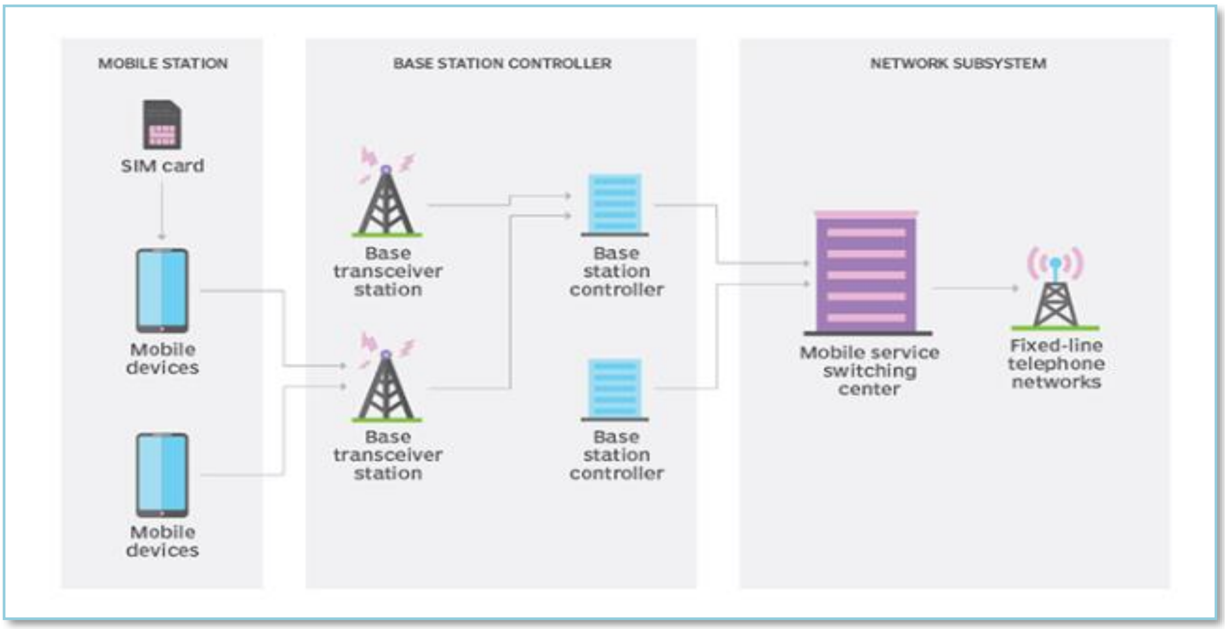


Figure (36): Diagram of the GSM network organization [39]

The BSS handles traffic between the cell phone and the NSS. It consists of two main components:

- The base transceiver station (BTS) contains the equipment that communicates with the mobile phones, largely the radio transmitter receivers and antennas.
- The base station controller (BSC) communicates with and controls a group of base transceiver stations.

The NSS portion of the GSM network architecture, also called the core network, tracks the location of callers to enable the delivery of cellular services. Mobile carriers own the NSS. The NSS has a variety of parts, including mobile switching center (MSC) and home location register (HLN). These components perform various functions, such as call routing, SMS (short message service), authentication and storing caller account information via SIM cards.

The Operation and support subsystem (OMC), the centralized operation of the various units in the system and functions needed to maintain the subsystem; it's the dynamic monitoring and controlling of the network. Their functions are configuration management, fault report and alarm handling, performance supervision and or management. Storage of system software and data

7.2.2 Security in GSM:

Security in the GSM system is provided by IMSI encryption, the SIM card provided with a PIN code consisting of 4 to 8 digits to validate the ownership of the SIM card also by the use of the algorithm for authentication, encryption and key generation.

7.3 Conception:

7.3.1 GPS antenna:

HitCar SMA, male Plug GPS Active Antenna Aerial Connector Cable for Dash DVD Head Unit Stereo (Right Angle Plug).

It help the GPS to get stronger signal and picks up the position rapidly it's very easy to install: this antenna has a magnetic base which can adhere to any metal surface the most important that it's ready to plug in and use.

Figure (37): GPS Antenna.

7.3.2 The GPRS/GSM Shield:

The GSM cell phone network used to receive data from a remote location. The shield allows the achievement of this via any of these three methods: Short Message Service (SMS), audio or GPRS Service. In our study we will use the first method (SMS).

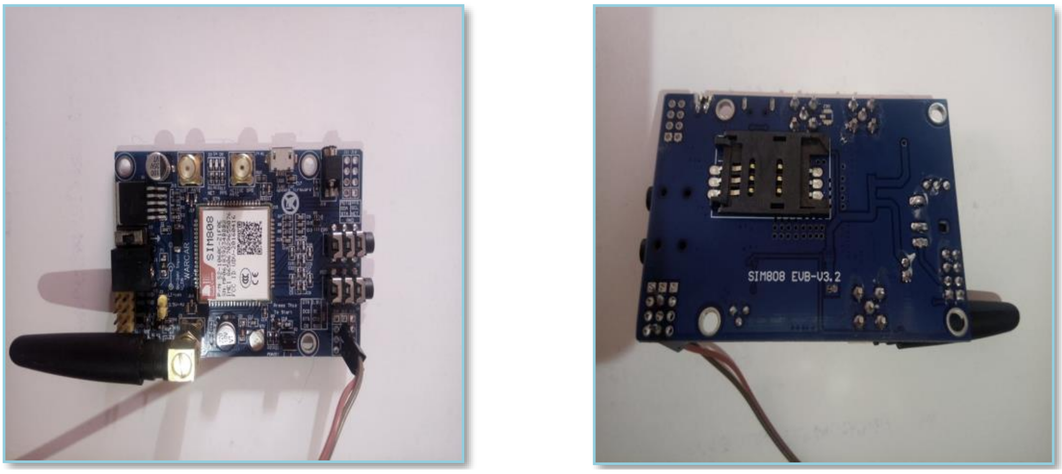


Figure (38): GSM/GPRS Shield.

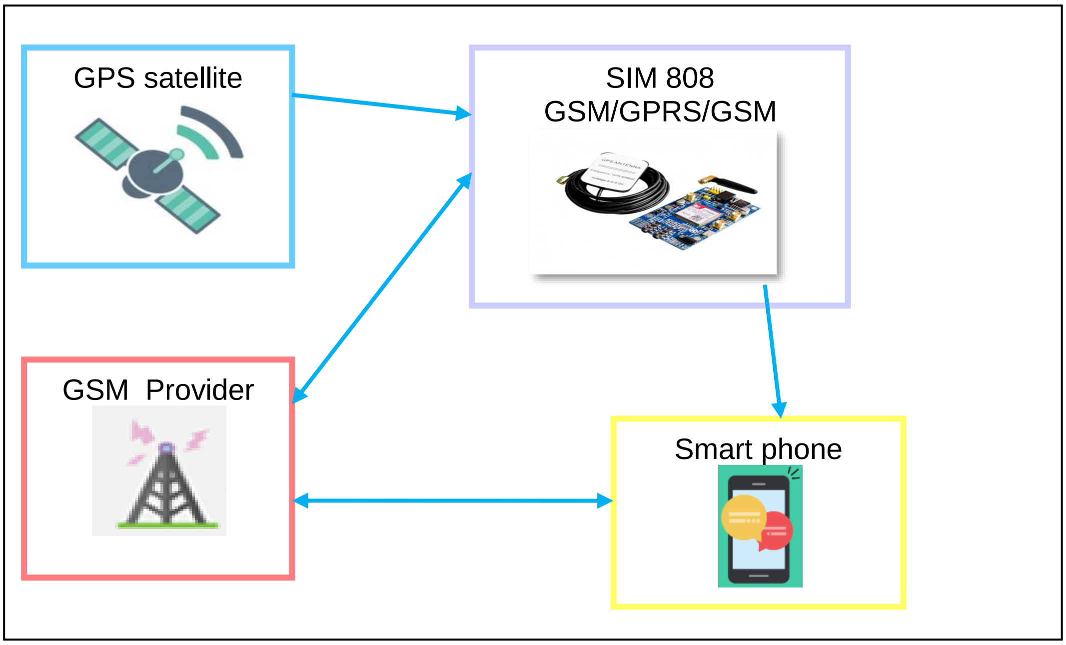


Figure (39): The System Architecture

SIM 808 module will start on. Then, with the GPS antenna, the position will be detected after about six seconds. The coordinates are then sent to the phone number of the assistant in our case as a receiver via a GSM provider server. The recipient will then receive an SMS with a message that would attach the link to the coordinates (latitude, longitude) of the user's location (sender). The receiver on a Smartphone can then click on the link and get the position via Google Maps which will get the information from the GPS database service. [40]

7.4 Implementation:

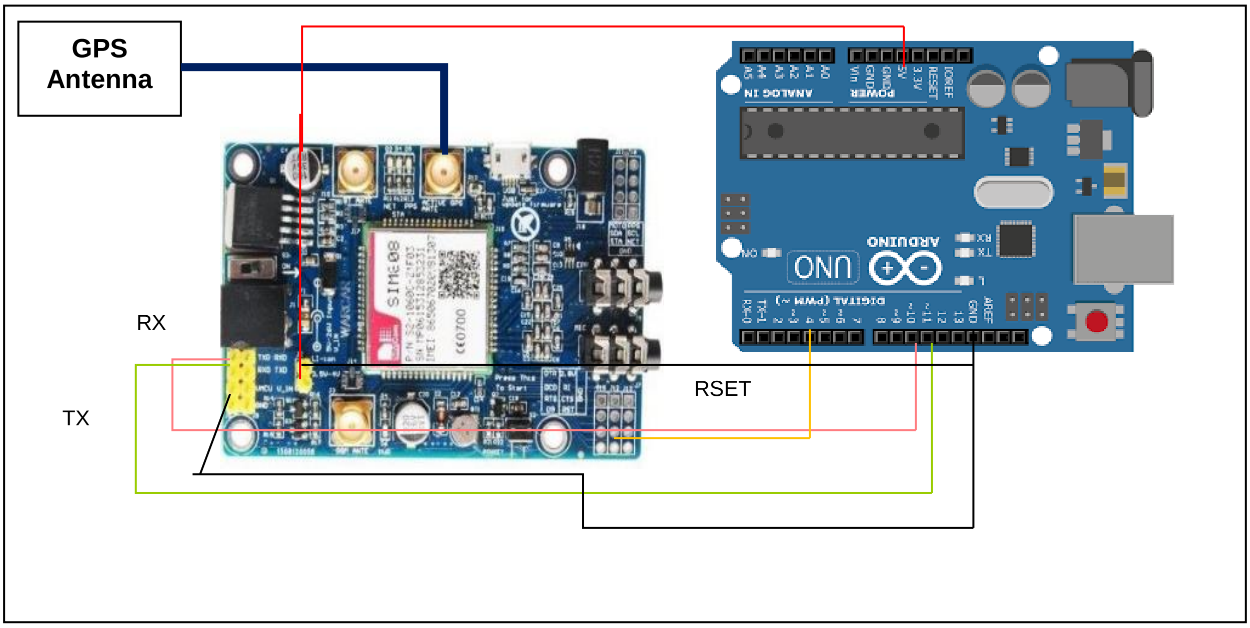


Figure (40): The Arduino UNO AND THE SIM808 module

8 The final device:

As mentioned earlier, the goal of this project is to create a non-invasive device that can measure the four physiological parameters and send the obtained values to an Android application via Bluetooth.

We have seen the implementation of each device and we will now implement the final device. The process is shown on the diagram below:

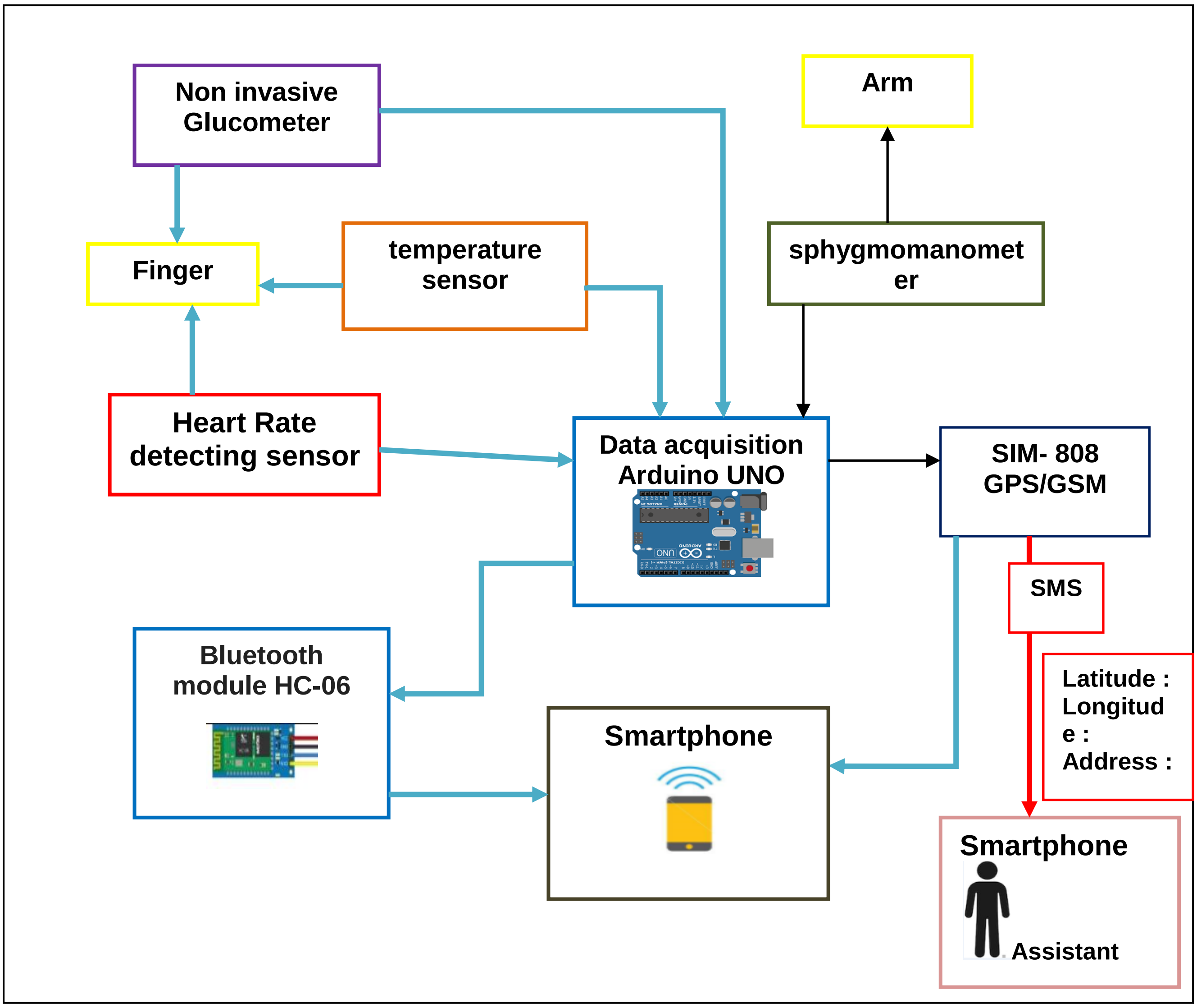


Figure (41): The Non invasive device architecture

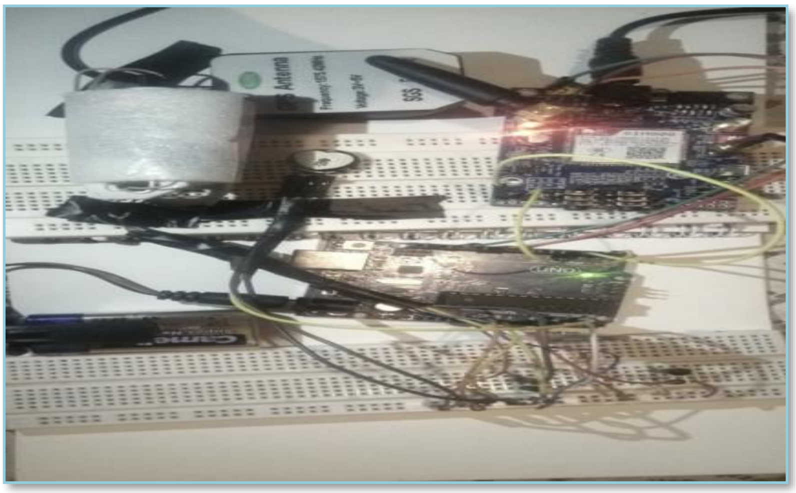
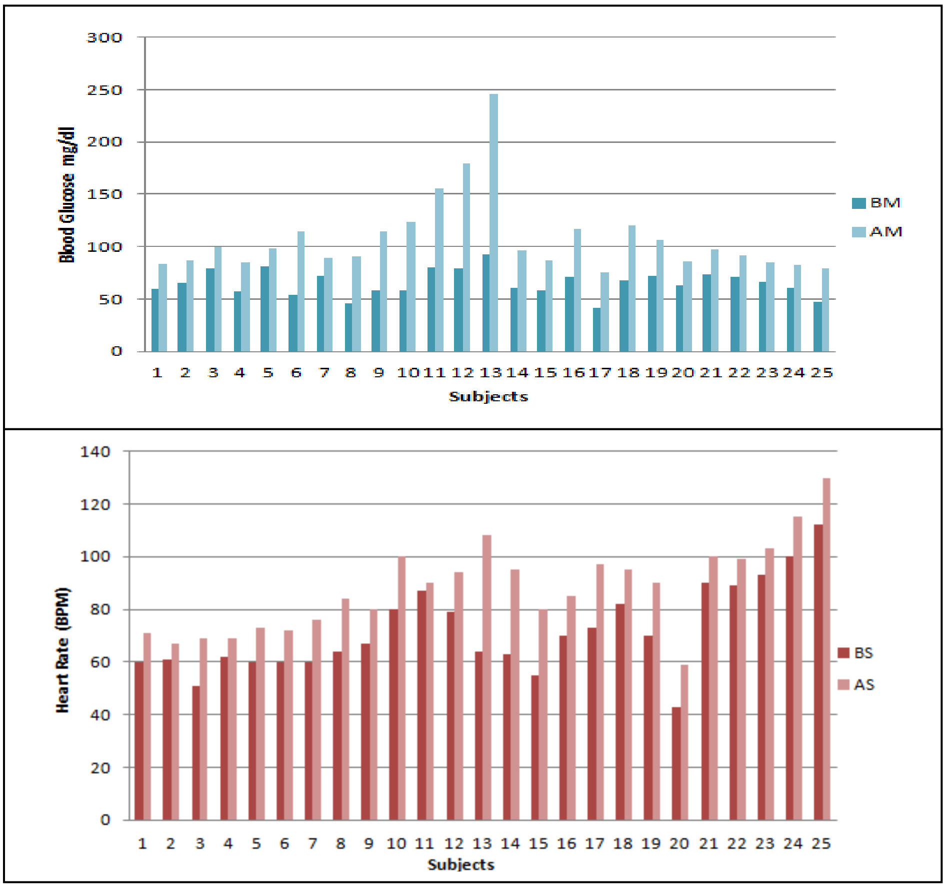


Figure (42): the finale device.

9 Experimental studies of the results:

9.1 Study of precision:

The study of the accuracy of our device was based on the tests of 25 subjects, 20 subjects are in good health and the others are sick, in different cases (before and after a meal 'BM/AM', before and after a sports activity 'BS/AS') and the output voltages are measured and recorded. Figures (43) show the experimental results of the device.



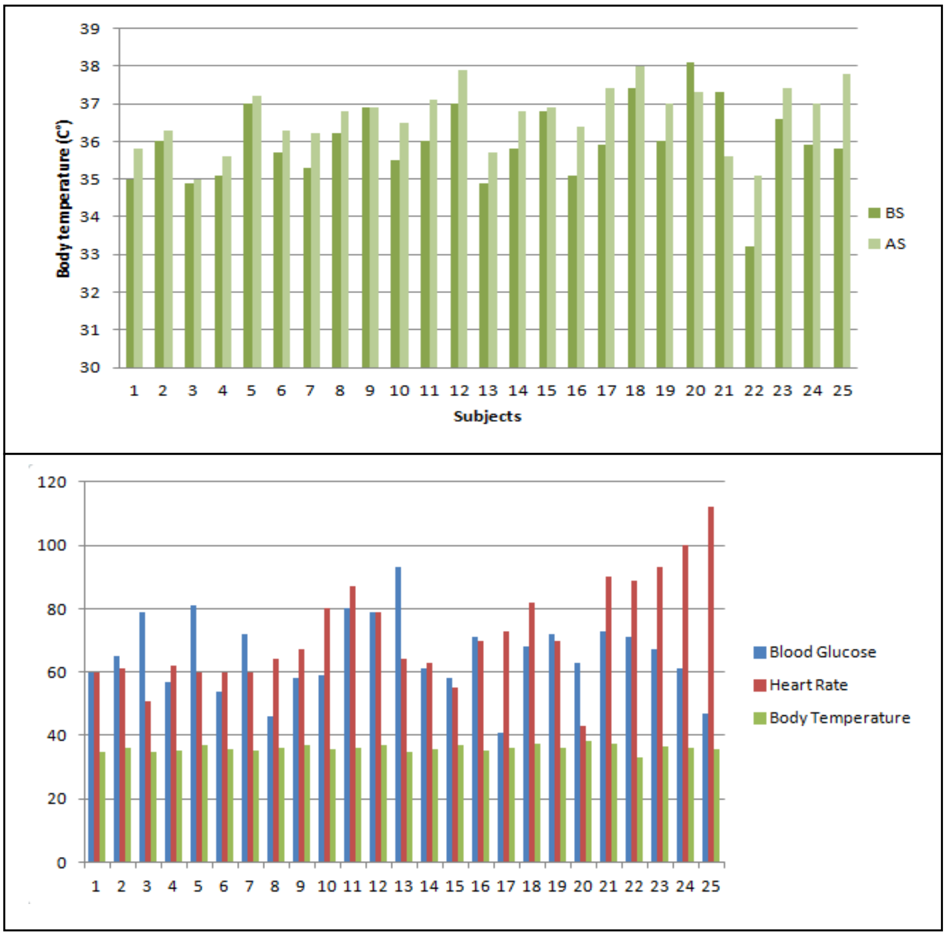


Figure (43): Experimental results of the device

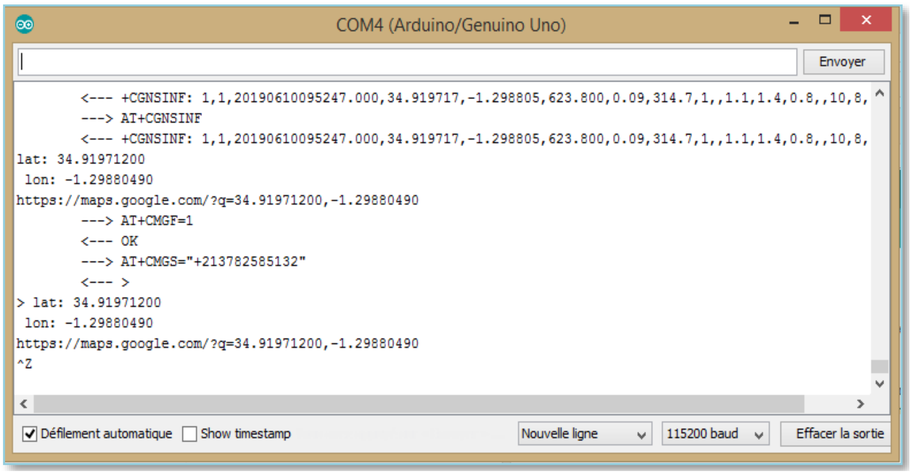


Figure (44): the serial monitor of the message

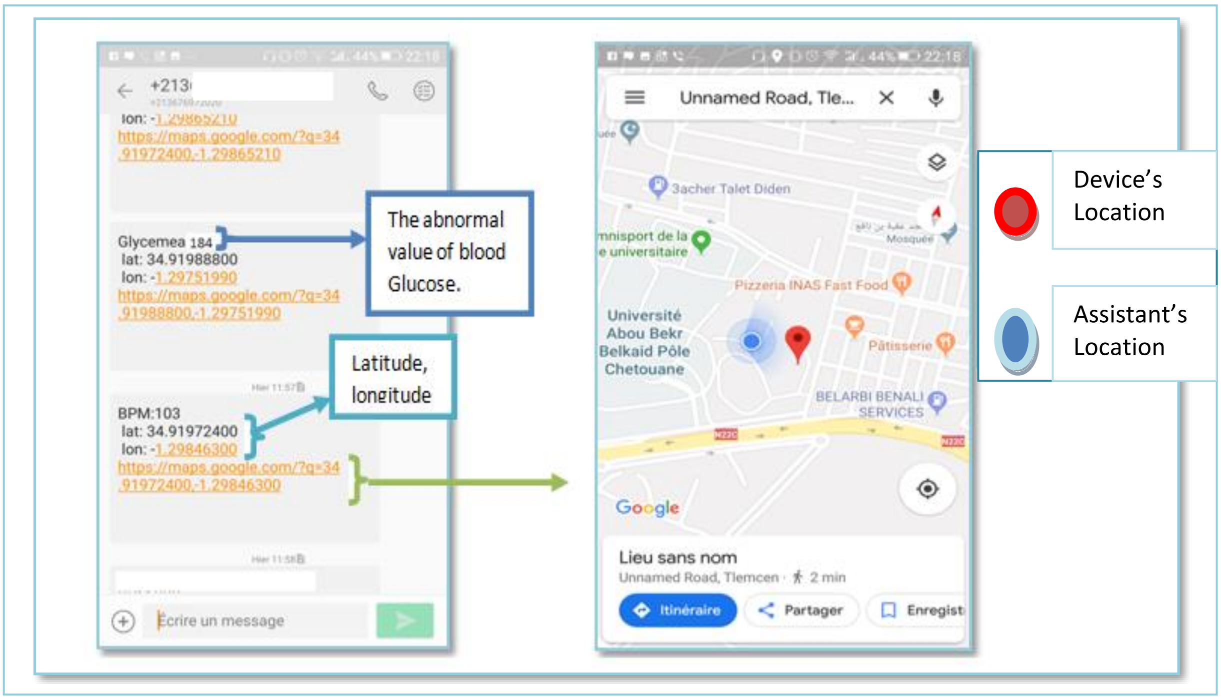


Figure (45): the message on the Smartphone

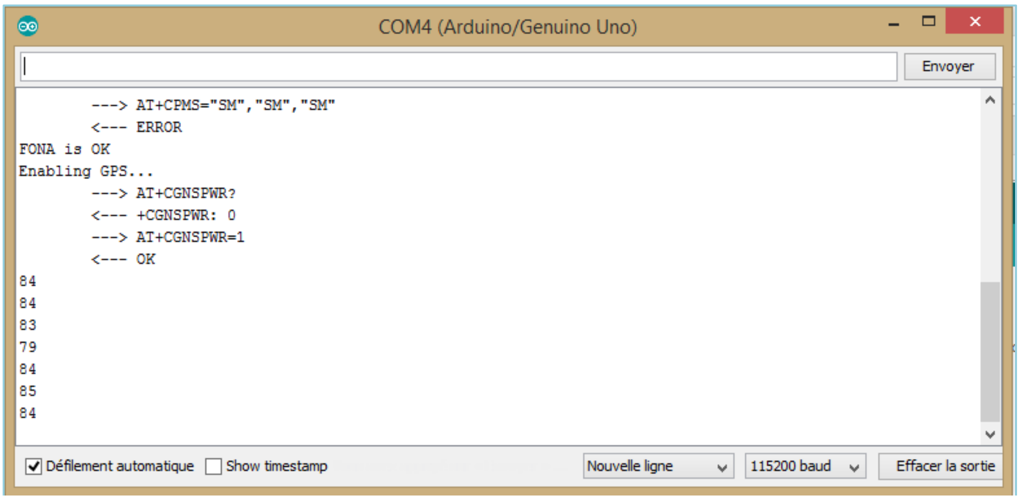


Figure (46): Normal Values on the Serial Monitor

OBSERVATION:

The measured output voltages increased for the 25 subjects after the meal and after the sporting activity.

Subjects 10,11,12,13 and 25 have the highest output voltage among the 25 subjects tested for blood glucose level, body temperature, heart rate and even blood pressure as they are the 5 sick subjects of this experiment.

Other subjects, with the exception of the five sick subjects, showed a normal increase in the output voltage after the meal and after the sporting activity.

Alert messages are sent to my number, indicating that subjects 10, 11, 12, 13, and 25 have abnormal values. The following figures fig (44, 45) shows the sent message containing the latitude, longitude, address even the link of Google Maps that shows the location of the device and the user, the abnormal values of each subject appear at the beginning of the messages.
If the values are normal, no message will be sent to the number, as shown in Figure (46).

9.2 Stabilization time

The device is tested on a healthy subject to determine the stabilization time of the device initially, the measured output voltage increases sharply and after 15seconds the output voltage stabilizes. A maximum voltage value and no further increase do occur. This time, Spam explicitly describes the response and stabilization time of blood glucose, blood pressure, body temperature and heart rate required by the device.

9.3 Detected anomalies:

It should be noted, however, that the margin of error exists in the following cases: the thickness of the human tissue that determines the "path length", so that a longer path length would reduce the transmittance.
For the glucometer, the measured blood glucose can vary with the temperature because the voltage of the photo detector depends on the temperature. For the thermometer, the ambient temperature can also affect the operation of the temperature sensor.

10 Conclusions:

In this chapter, we tried to make the non-invasive device from inexpensive and easy to find components on the Algerian market.
We also harness the GPS / GSM technology for our device, which has given amazing results, in order to remotely monitor the health of the users and to immediately intervene on its location in case of danger.
Despite the lack of subjects, means and place of work, satisfaction results were obtained.

CHAPTER III

Creation and development of an Android Application integrated with Machine Learning.

1 Introduction

This chapter is divided into two parts:
The first one is sacrificed for the application that I come to develop, the project design, its analysis and all the features related to the Android application. And how this Android Application will help in the self and tele-monitoring.
In the second part, we will talk about machine learning and how we used the classifier model based on decision tree to make a decision.

2 Definition of MIT app inventor:

It is a mobile operating system developed by Google, based on the Linux kernel. Launched in June 2007, the system was designed only for Smartphone and tablets, and then diversified into connected objects and computers. In 2015, Android is the most used mobile operating system in the world.

Figure (1): Android Operating System (OS)

2.1 Android App Inventor:

App inventor is one of the easiest, funniest and most powerful Android application development tools. It is a visual and intuitive programming environment, written in JAVA, KAWA, and SCHEME. It’s available in different languages.

App Inventor is an open source web application provided by Google and now managed by the Massachusetts Institute of Technology (MIT).

2.2 The features of app inventor:

App Inventor is primarily used to create and develop phone applications, but it can also be used as an electronic "Prototype" napkin.

It offers even more features that improve your productivity when creating Android apps, such as:

- High-tech apps: the app inventor can create an application that detects the orientation of the phone, make phone calls and send SMS...
- Location-aware apps: the app inventor has access to the GPS sensor.
- Web-enable apps: communication with web.
- And the most important thing that App Inventor can do it, the classification of data like a machine learning without machine learning.

In this study, we use it to create a decision tree to classify the measurement values.

3 Application design:

3.1 Creation of a new project:

In the menu select new project, and choose a name for the application.

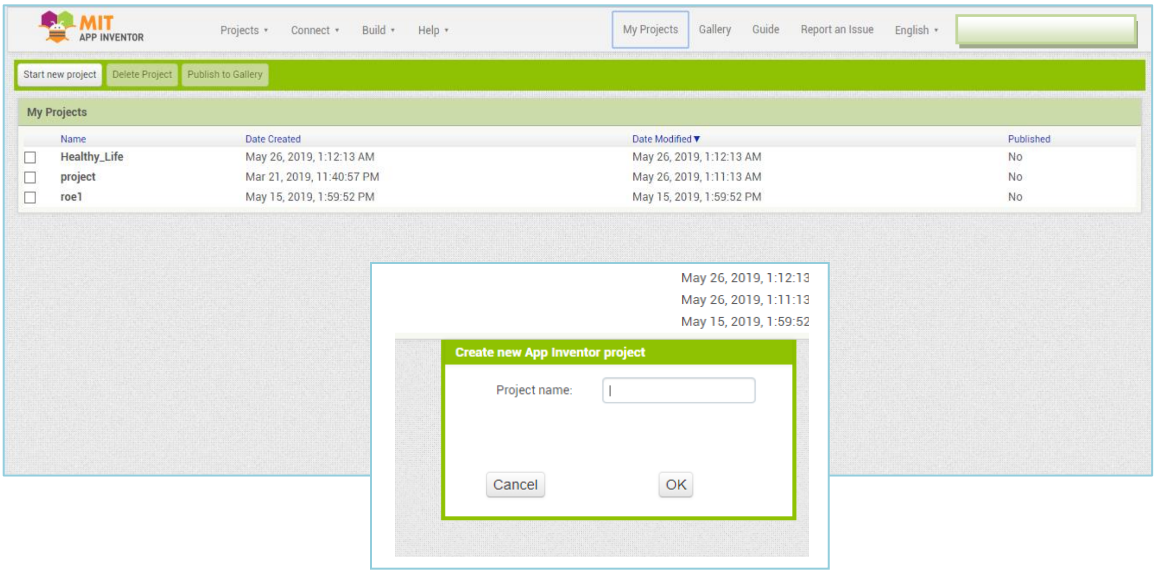


Figure (2): Project creation

3.2 project structure:

I - Designer: In the editor, there are different elements for the application, just drag them to the screen.

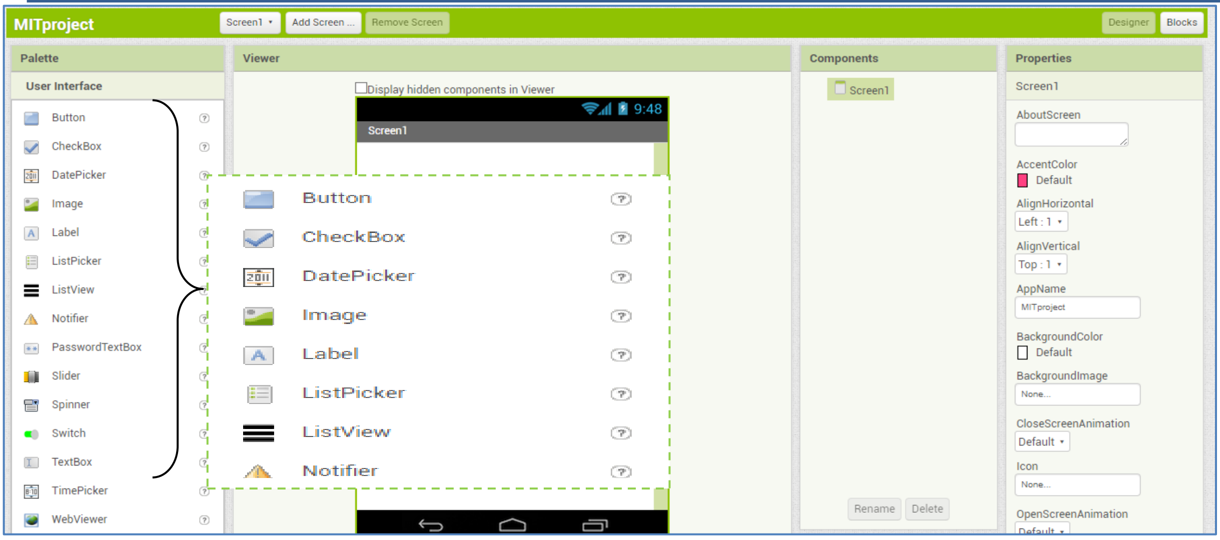


Figure (3): the different elements constituting the interface (Designer)

II – Blocks: this area is used for coding the application

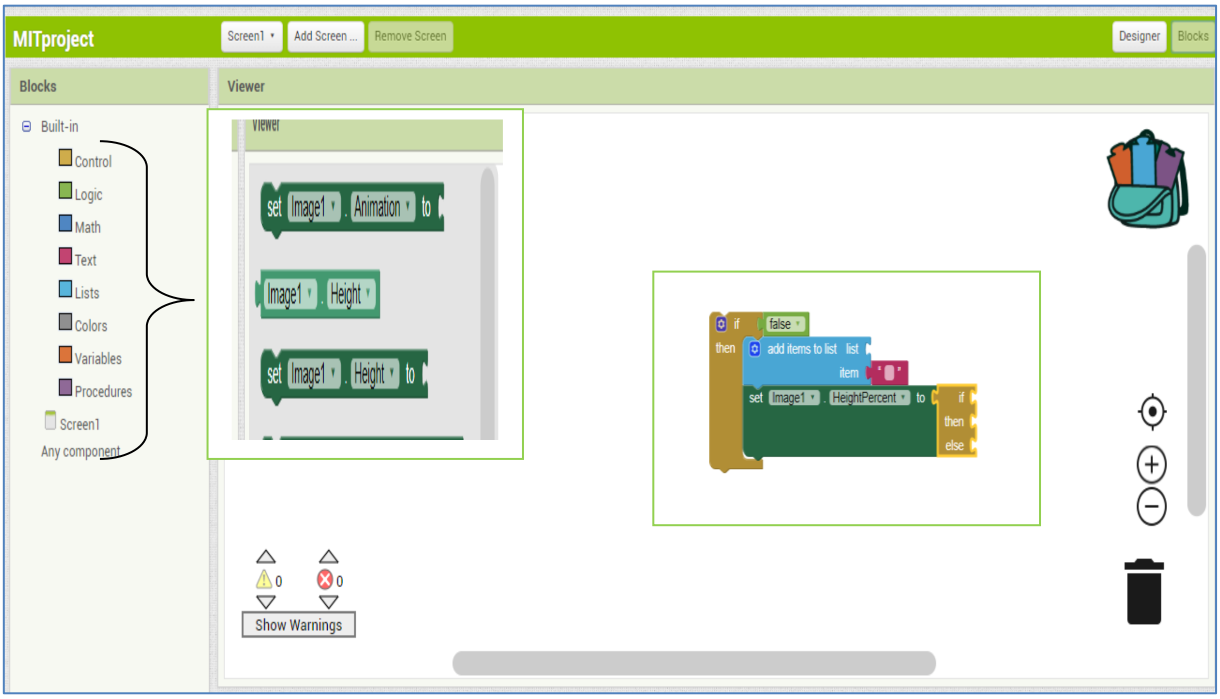


Figure (4): Coding area

3.3 Connection of the App:

To connect the phone to App Inventor, it must be connected to the same Wi-Fi network or connected to the computer with a USB cable to test the application. The Android emulator can be used also or simply create an application file and send it to the phone.

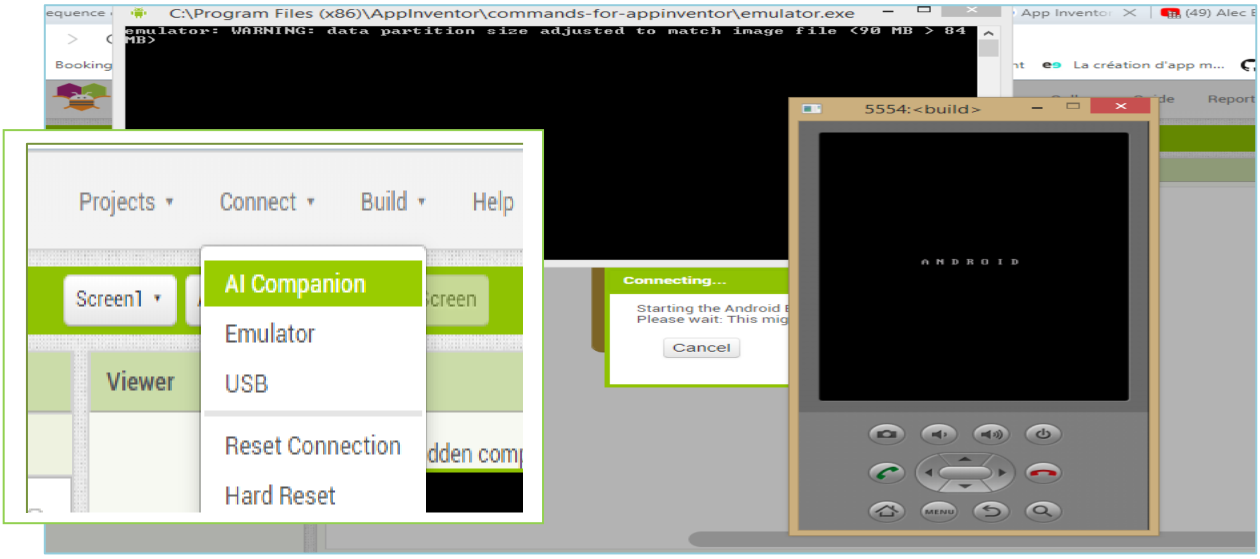


Figure (5): The emulator of App Inventor

4 "Healthy Life" Application:

The application consists in ensuring a continuous surveillance of sick or non-sick people by providing them with an interface that is easy to handle.

The application is adaptable according to the users we have taken into account the naive people in the technology, the visually impaired people and even the people who can't challenge the colours.

For the creation of the application, we followed the rules of ergonomics which aims to improve communication and interaction between humans and an interface "App". Based on knowledge from cognitive psychology and physiology, we seek a correspondence between the human characteristics and the characteristics of an interface. For this application we choose a white background, writing with a dark gray, we tried to avoid uppercase letters.

- The number of colours was limited: Two main colours applicable: pink, blue, three significant colours: orange, red and green.
- We did not multiply the images or the animations: any Christmas tree effect.
- Direct manipulation limited: click and keyboard input.

Users: presumed, ignorant and lazy or just because these users are in serious condition, so we took all that into account when designing "Healthy Life".

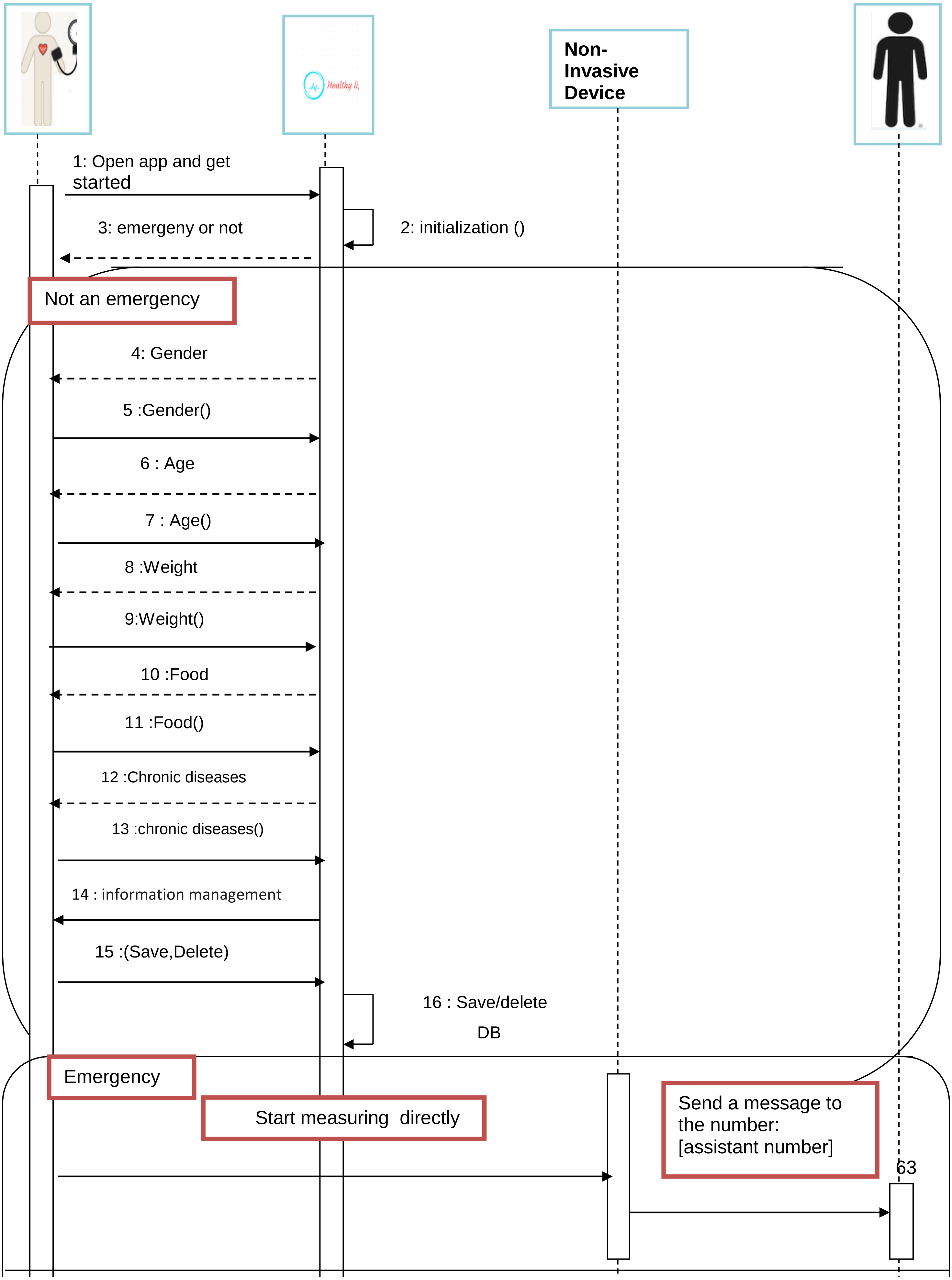
4.1 description of the application:

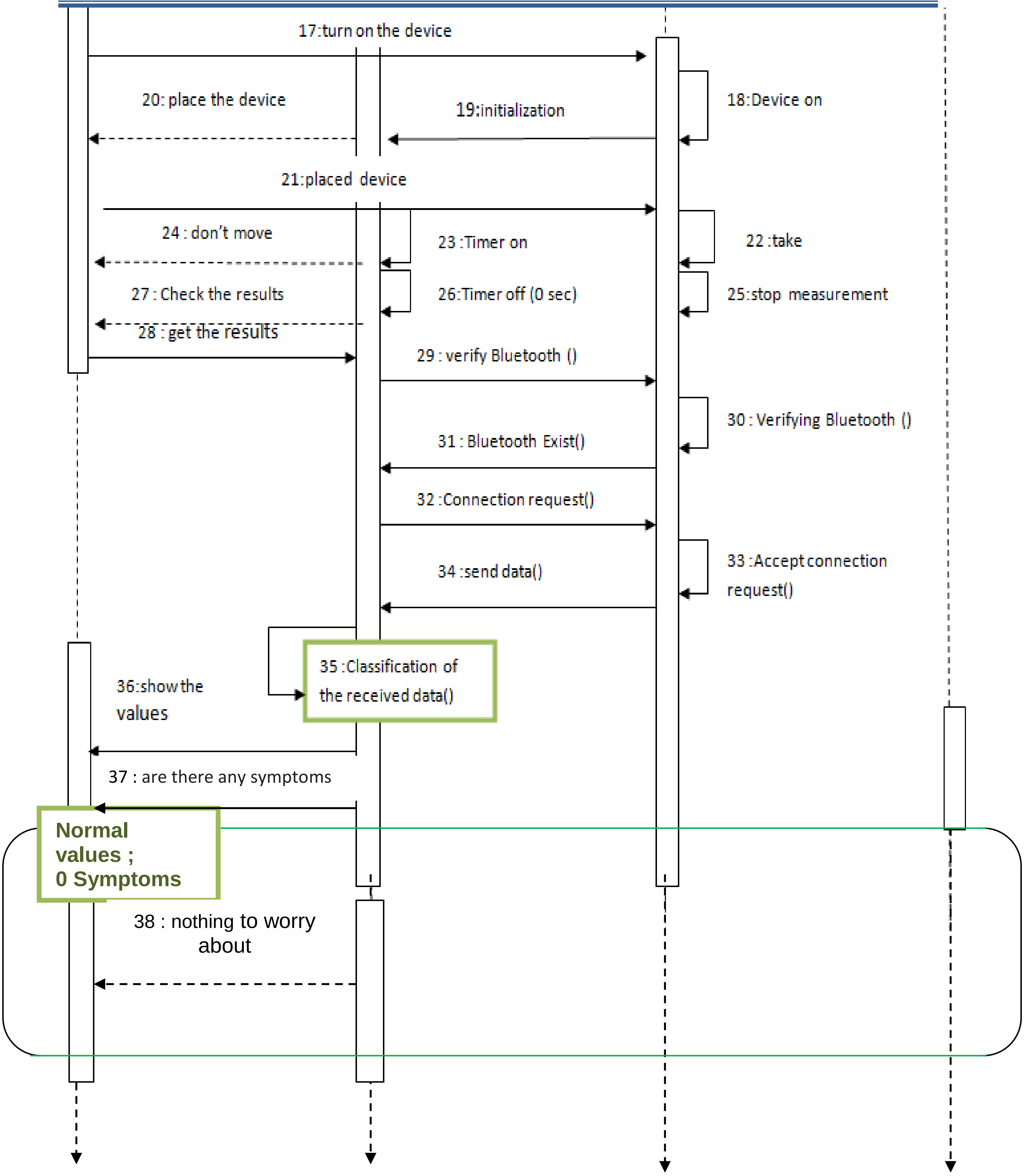
The app once connected to the non-invasive device designed receives Bluetooth blood glucose, systolic and diastolic blood pressure, body temperature and the heart rate. These values will be ranked according to a decision tree and the results will be displayed according to the state of the person.
The application is connected to an internal database, in the fourth interface of the application, an information sheet appears to be filled then the user is directed to the interface of the measurement and finally to the interface of the result.

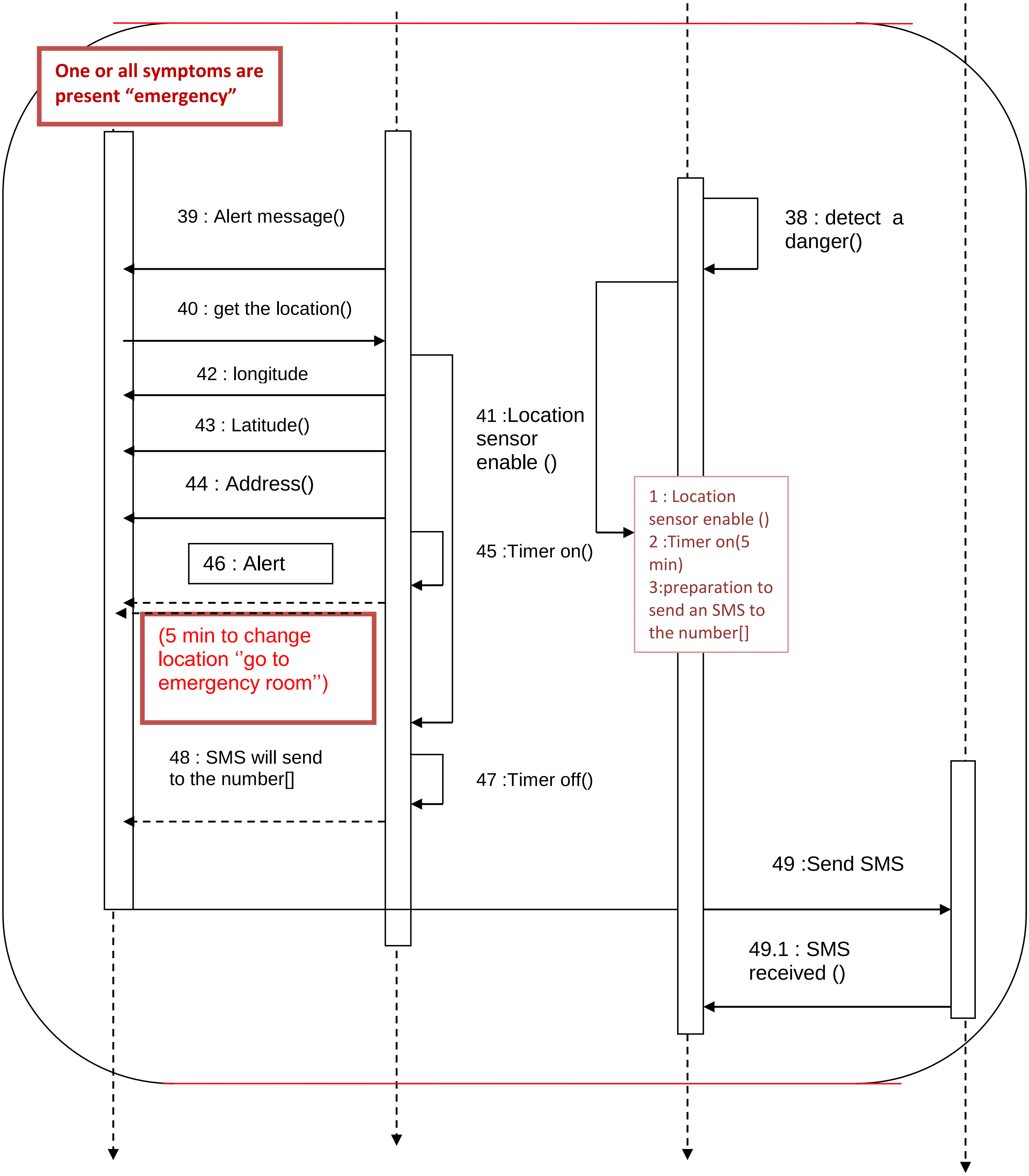
4.1.1 UML Sequence Diagram:

For this project we used UML Sequence Diagrams that are interaction diagrams that show how operations are carried out. They capture the interaction between objects (Actors) in the context of collaboration. Sequence Diagrams are time focus and they show the order of the interaction visually by using the vertical axis of the diagram to represent time what messages are sent and when.

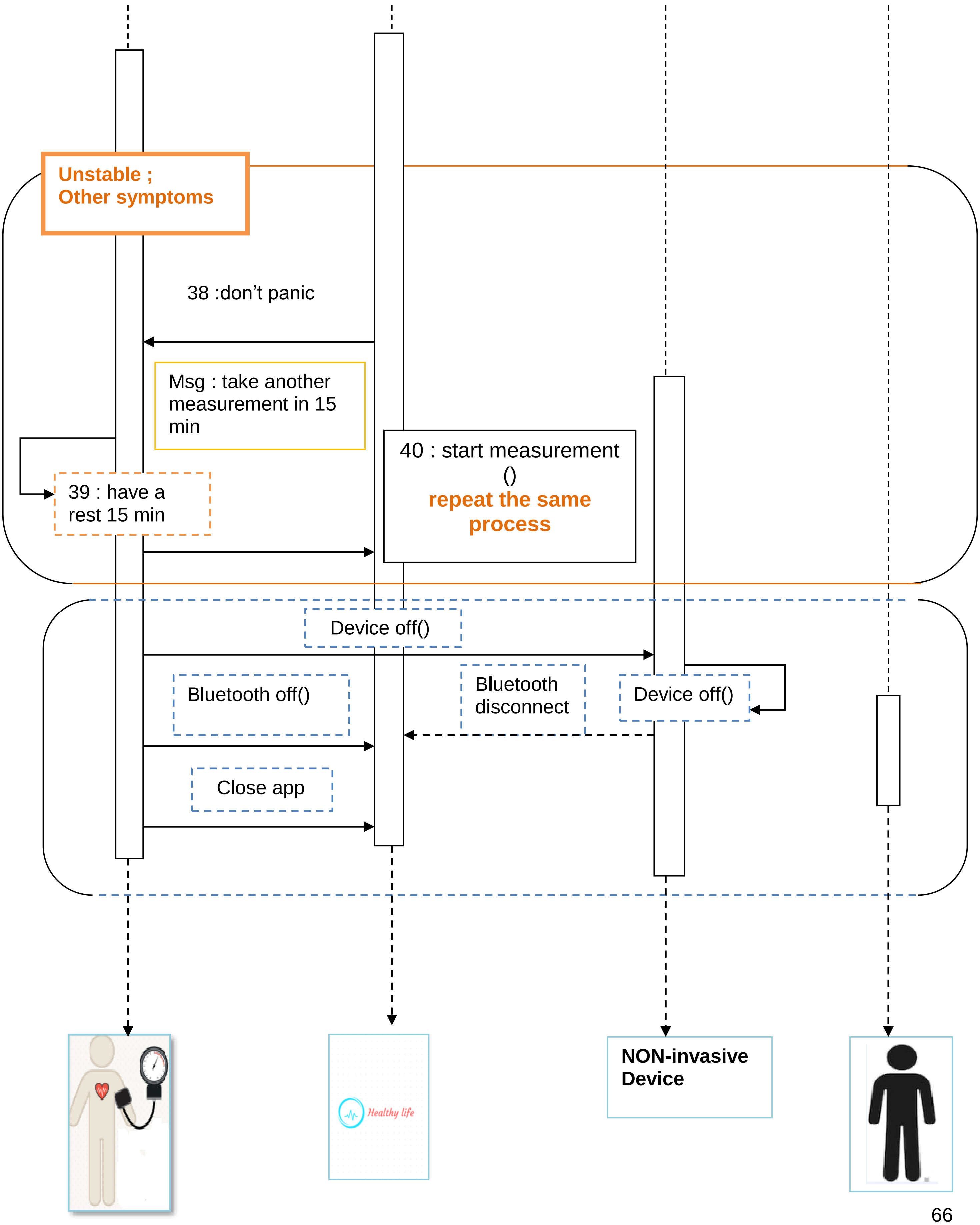
In interactions between different actors of the system (User - App - Non-invasive device - Assistant), actors produce messages that affect the computer system and usually wait for a response from it. The System Sequence Diagram isolates these messages and graphs them.


Healthy li
Non-Invasive Device
1: Open app and get started
2: initialization ()
3: emergeny or not
Not an emergency
4: Gender
5 :Gender()
6 : Age
7 : Age()
8 :Weight
9:Weight()
10 :Food
11 :Food()
12 :Chronic diseases
13 :chronic diseases()
14 : information management
15 :(Save,Delete)
16 : Save/delete DB
Emergency
Start measuring directly
Send a message to the number: [assistant number]


17:turn on the device
18:Device on
19:initialization
20: place the device
21:placed device
22 :take
23 :Timer on
24 : don't move
25:stop measurement
26:Timer off (0 sec)
27 : Check the results
28 : get the results
29 : verify Bluetooth ()
30 : Verifying Bluetooth ()
31 : Bluetooth Exist()
32 :Connection request()
33 :Accept connection request()
34 :send data()
35 :Classification of the received data()
36:show the values
37 : are there any symptoms
Normal values ; 0 Symptoms
38 : nothing to worry about



One or all symptoms are present "emergency"
39 : Alert message()
38 : detect a danger()
40 : get the location()
42 : longitude
41 :Location sensor enable ()
43 : Latitude()
44 : Address()
1 : Location sensor enable ()
2 :Timer on(5 min)
3:preparation to send an SMS to the number[]
46 : Alert
45 :Timer on()
(5 min to change location ''go to emergency room'')
48 : SMS will send to the number[]
47 :Timer off()
49 :Send SMS
49.1 : SMS received ()


Unstable ;
Other symptoms
38 :don't panic
Msg : take another measurement in 15 min
39 : have a rest 15 min
40 : start measurement ()
repeat the same process
Device off()
Bluetooth off()
Bluetooth disconnect
Device off()
Close app
Healthy life
NON-invasive Device

4.1.2 Running the application "Healthy Life":

Presentation of the interfaces of the Health Life application:

Before accessing the main interface, a home page appears and prompts the user to activate the Bluetooth of his Smartphone. Then define the nature of the measurement if it is a normal daily measure or it is an emergency measure.

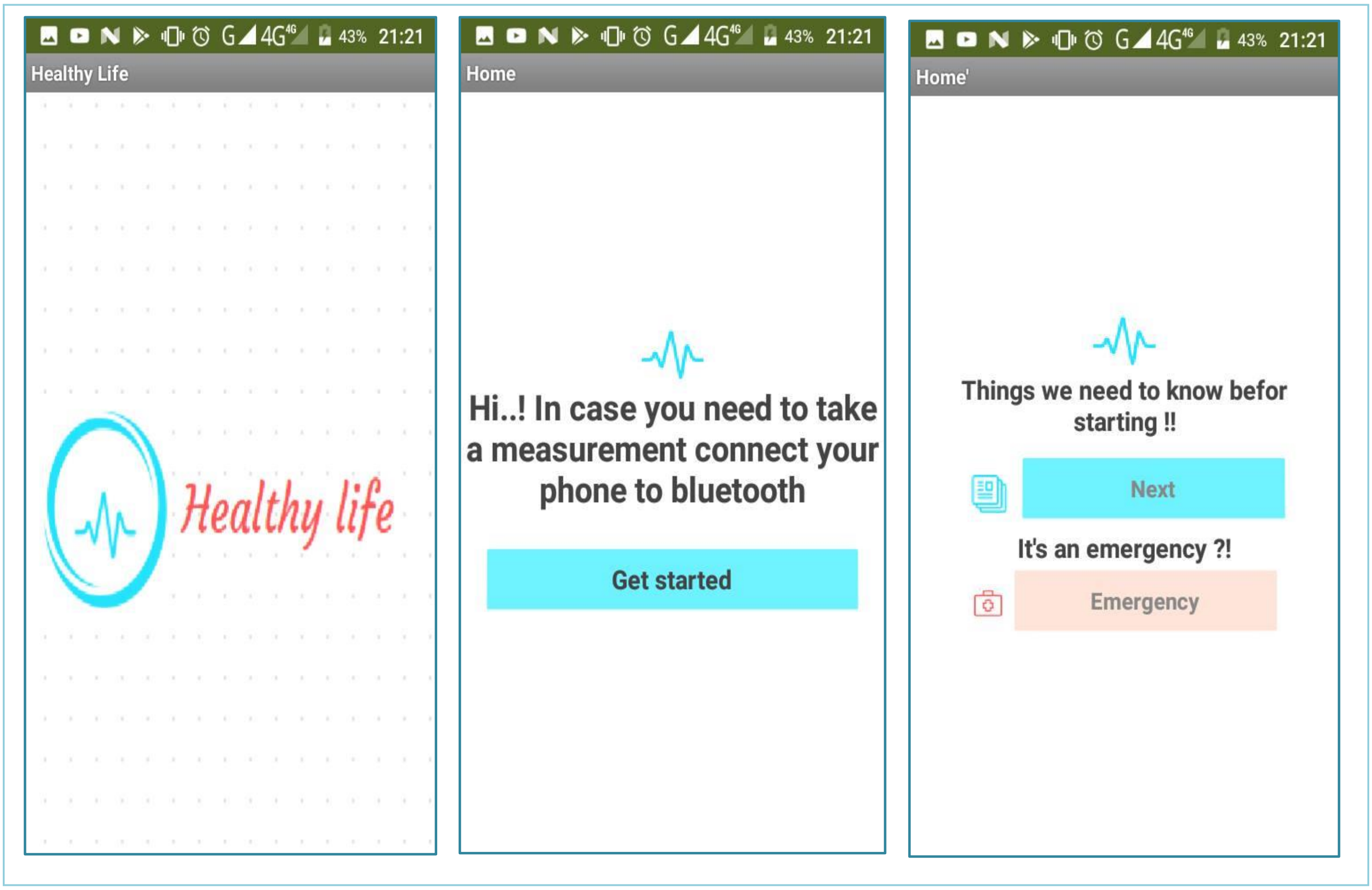
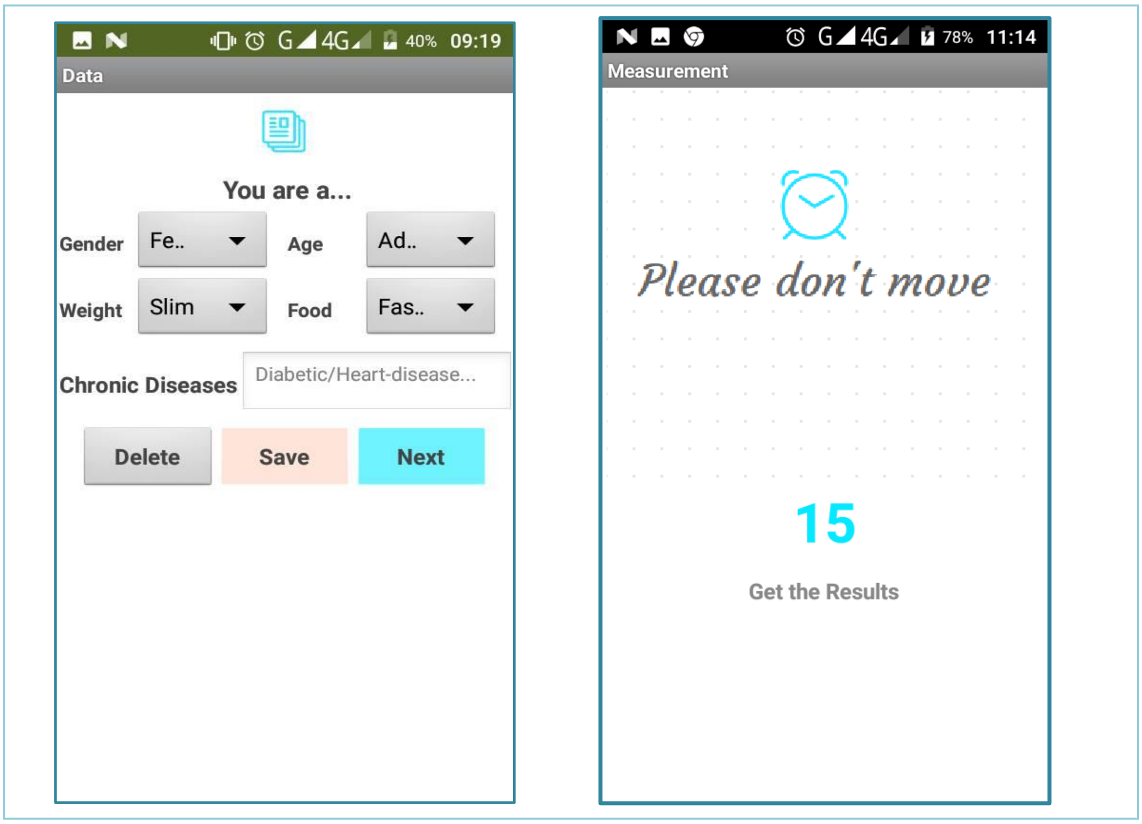


Figure (6): The homepage of the application

In the following interface, the user gives the necessary information (age-weight- if he eats something before this measurement and whether or not he has a chronic disease) to facilitate the classification task.
After that, the user must place the device and not move for15 seconds (the maximum time of the measurement), as the fig (7) shows.



Figure(7): patient information

Receiving measurements via Bluetooth connection with the source of the non-invasive device designed.

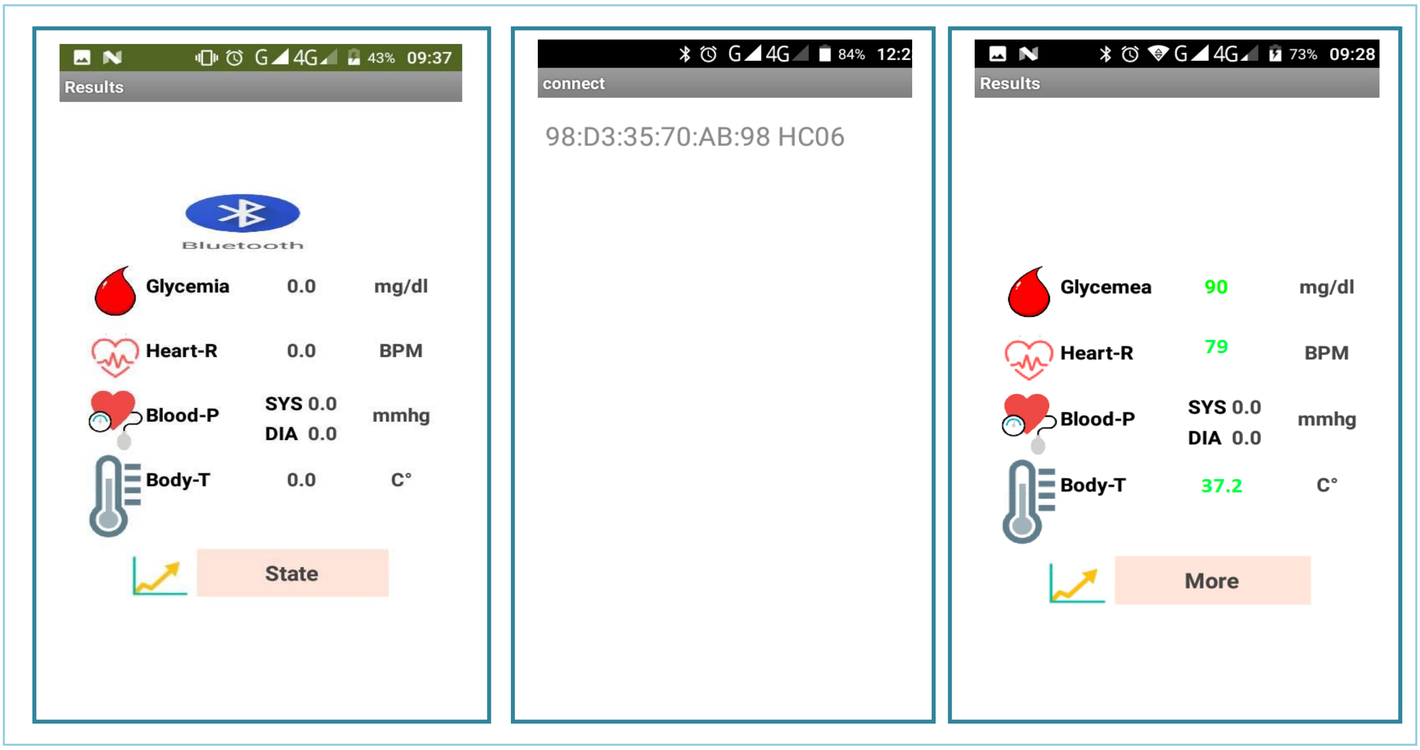


Figure (8): measurement recovery via Bluetooth

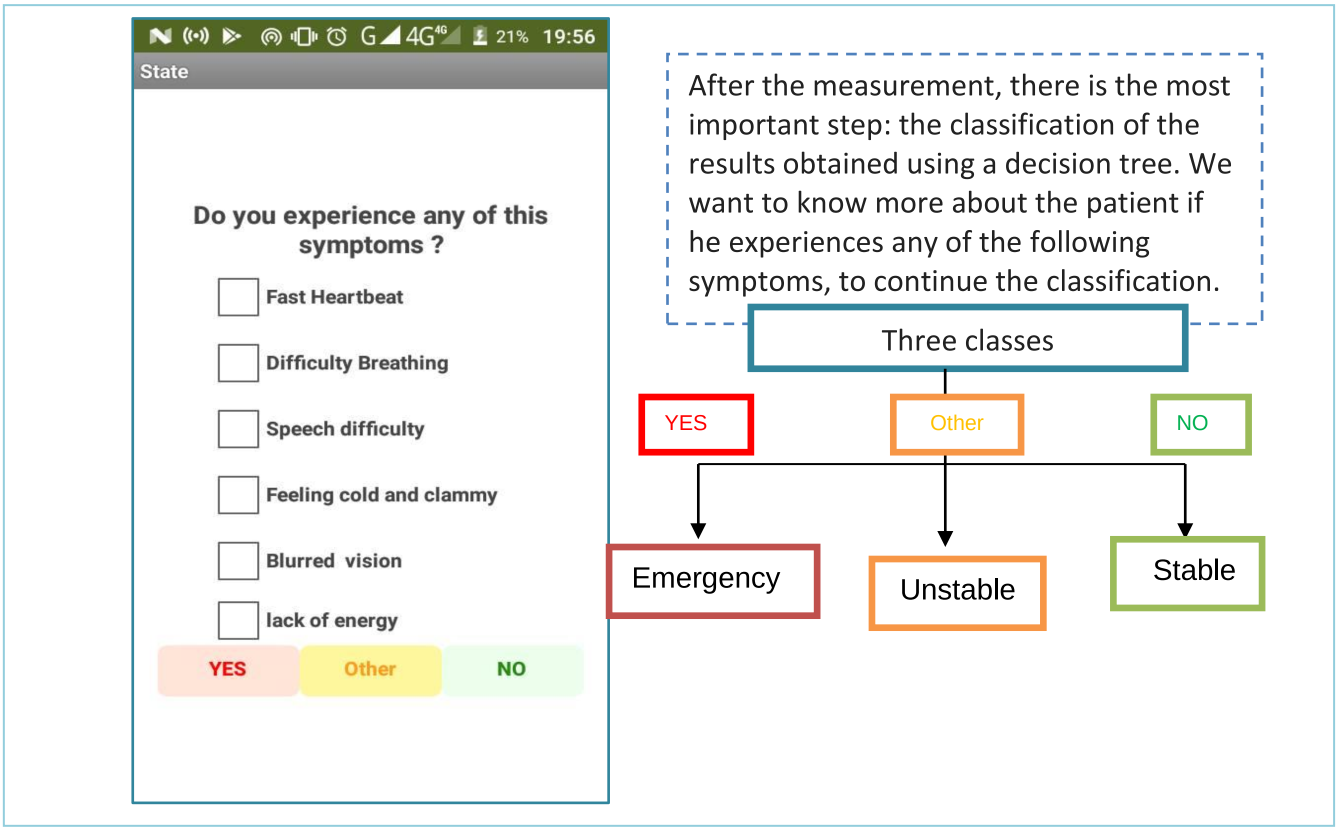


Figure (9): The symptoms's interface.

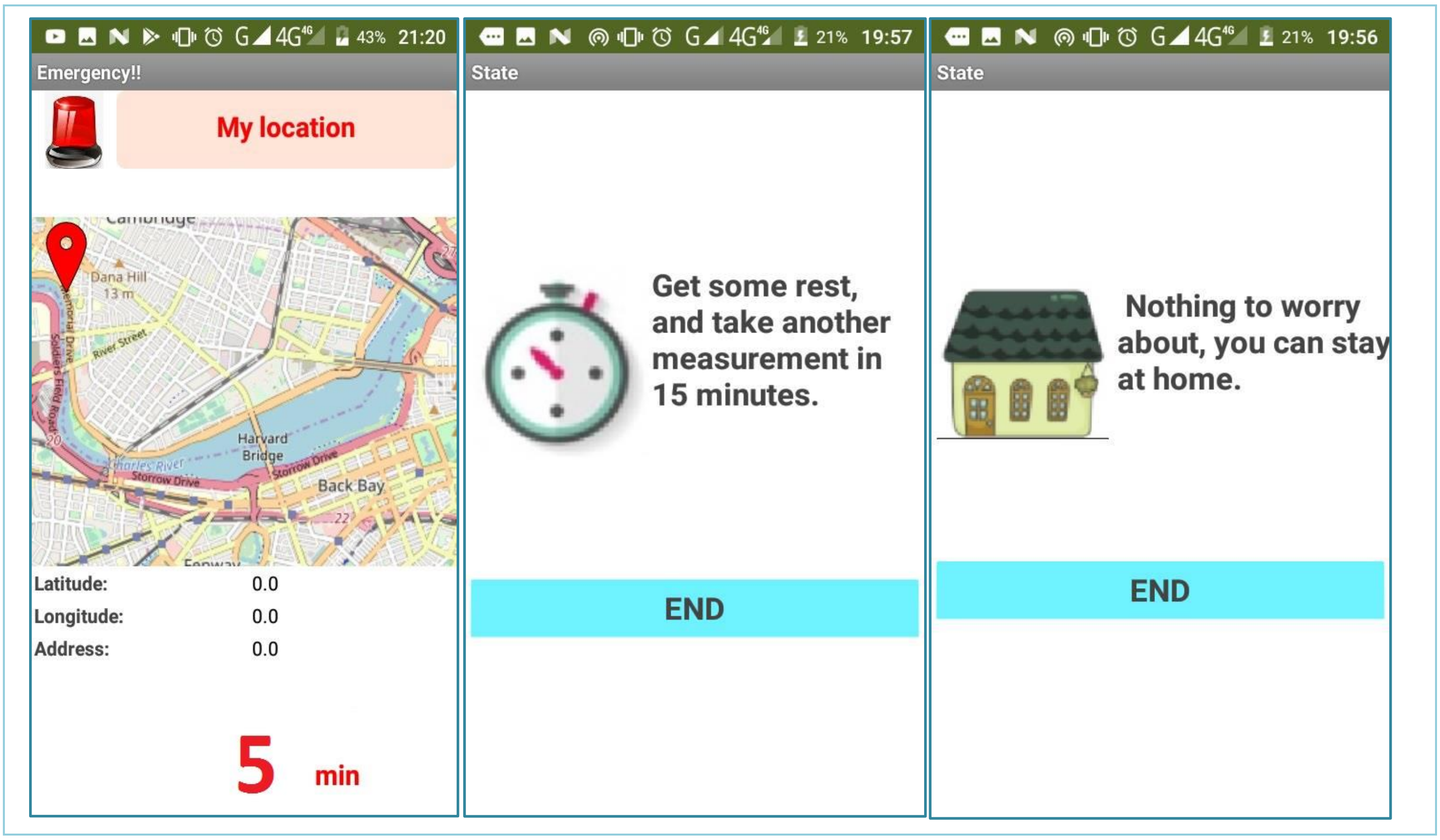


Figure (10): the three classes, depending on the patient's condition

The figure (10) shows the instructions dedicated to the patient according to his condition
And if he (Patient) is in danger the location sensor activate to track him and a timer of 5 minutes start to give him time to change his location and go to the nearest emergency room. And when time is out then a message will send to his assistant with patient's location (Latitude, Longitude and his address and the abnormal value).

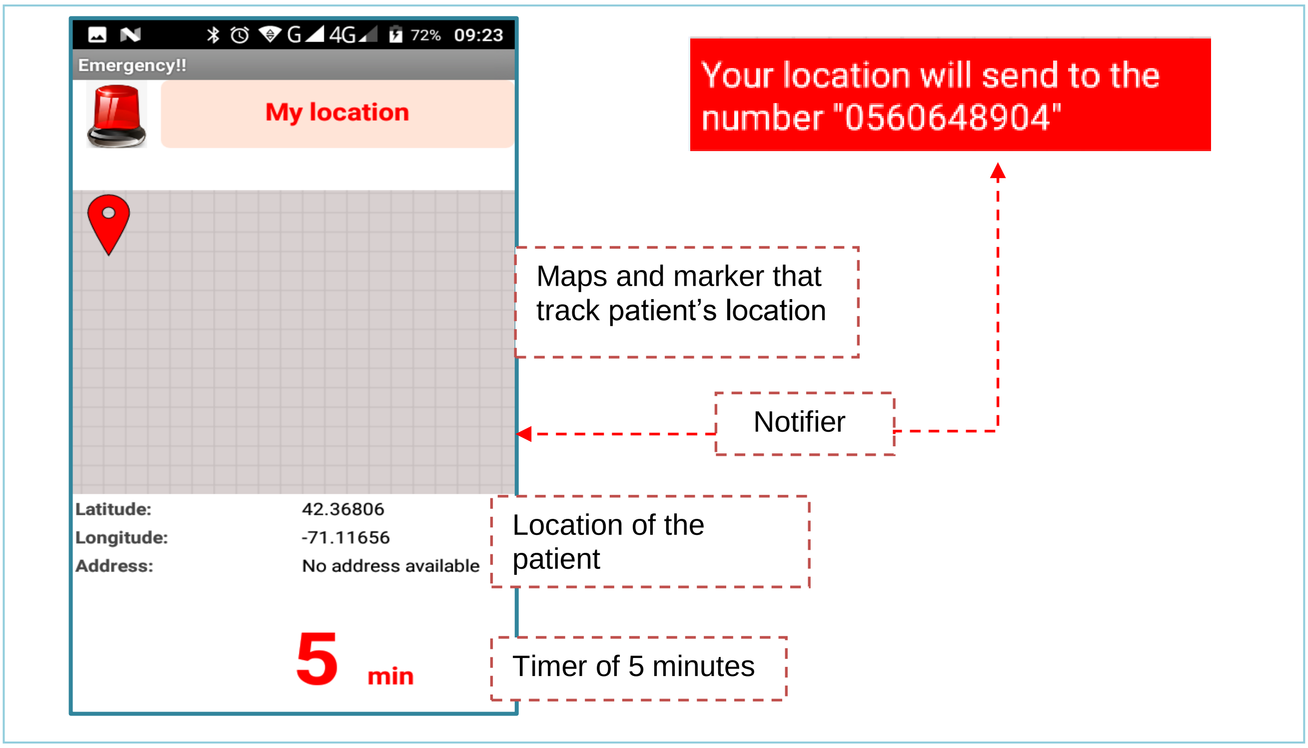


Figure (11): the timer and sending the message

5 Classifications:

5.1 Machine learning:

Machine learning, the field of study of artificial intelligence, concerns the design, the analysis, the development and the implementation of methods allowing a machine (in a broad sense) to evolve through a systematic process and thus accomplish tasks difficult or impossible to accomplish. Fill by more conventional algorithmic means. [41]

5.2 Decision Trees:

It's a data structure used as a template for classification. Recursive method based on division to rule to create pure subgroups (a subgroup is pure when all elements of the subgroup belong to the same class).

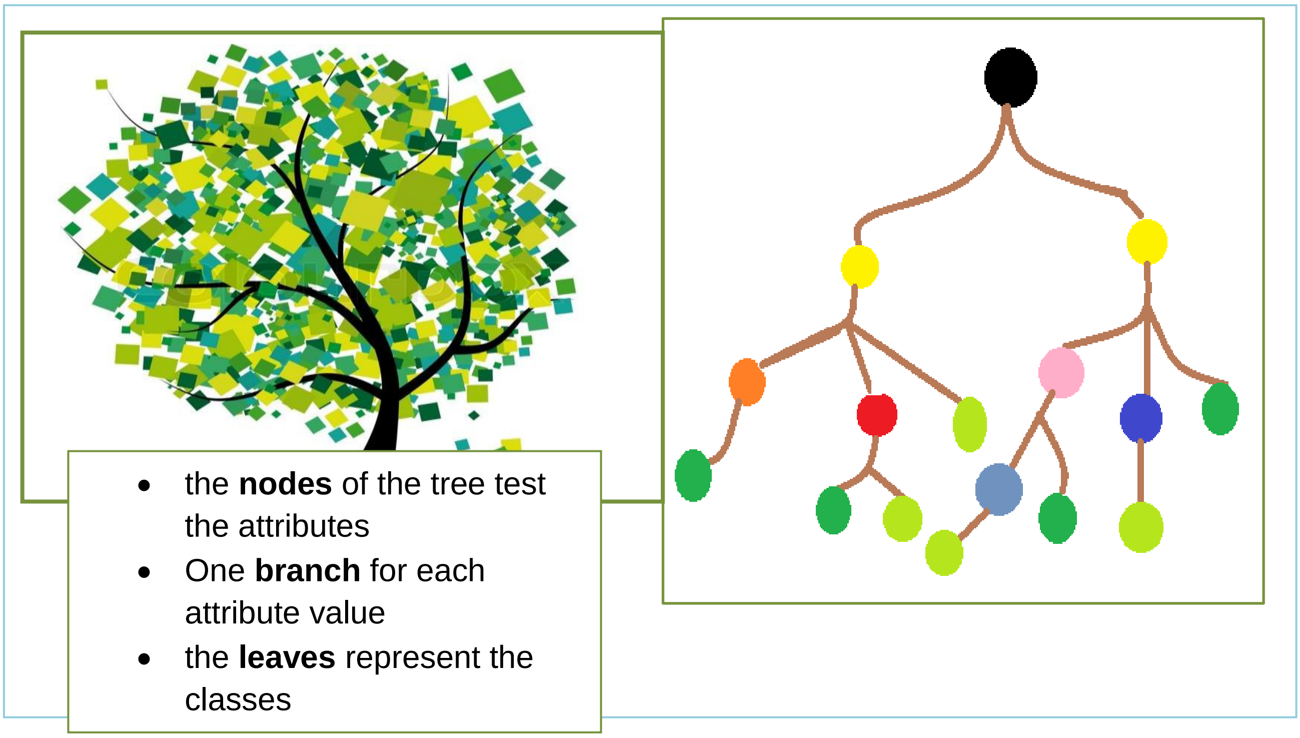
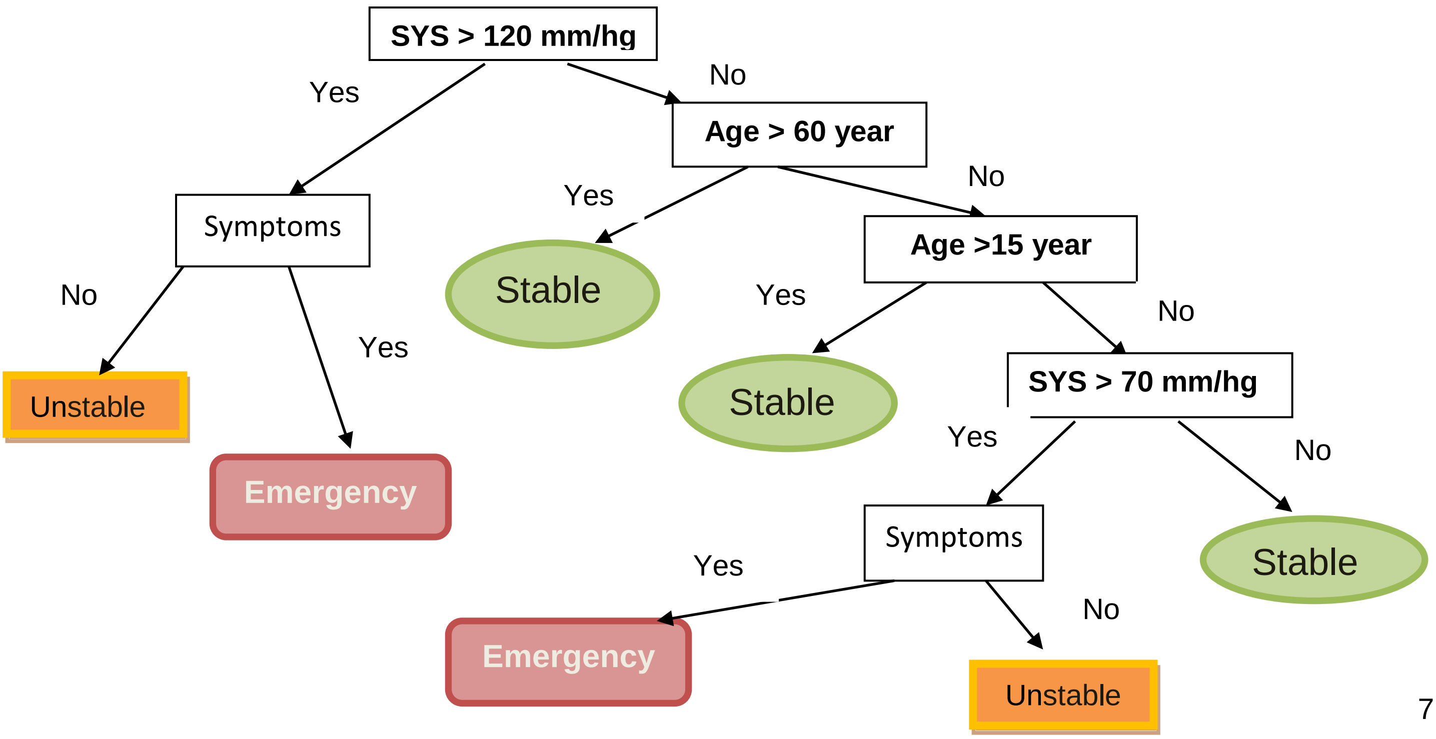


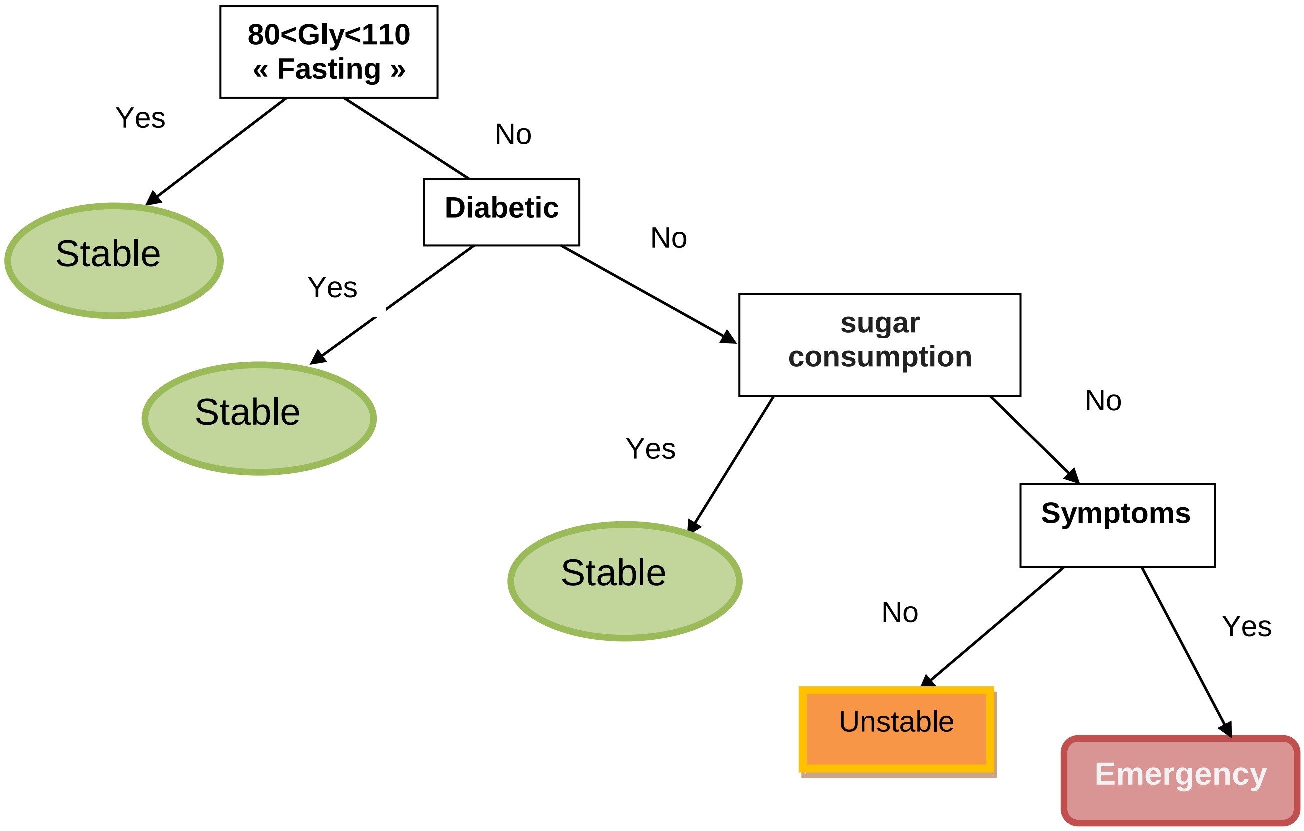
Figure (12): Decision Tree.

In this study, we prefer to use the decision tree to make decision because it is a very powerful machine-learning class model that can achieve high precision in many tasks while being highly interpretable. What makes decision trees special in Machine Learning is really the clarity of the representation of their information. The "knowledge" acquired by a decision tree through training is directly formulated in a hierarchical structure. This structure contains and displays knowledge so that it can be easily understood even by non-specialists.

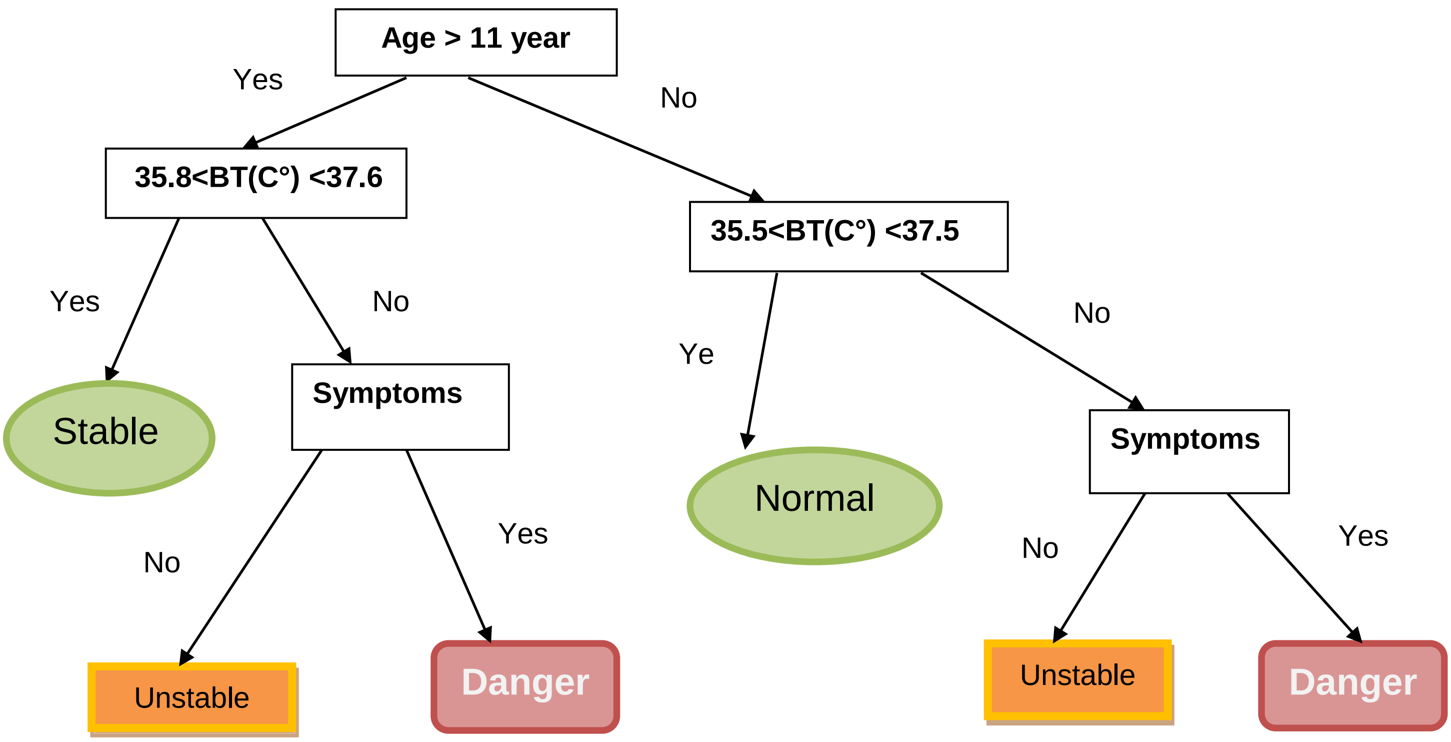
5.2.1 Decision tree for blood pressure:



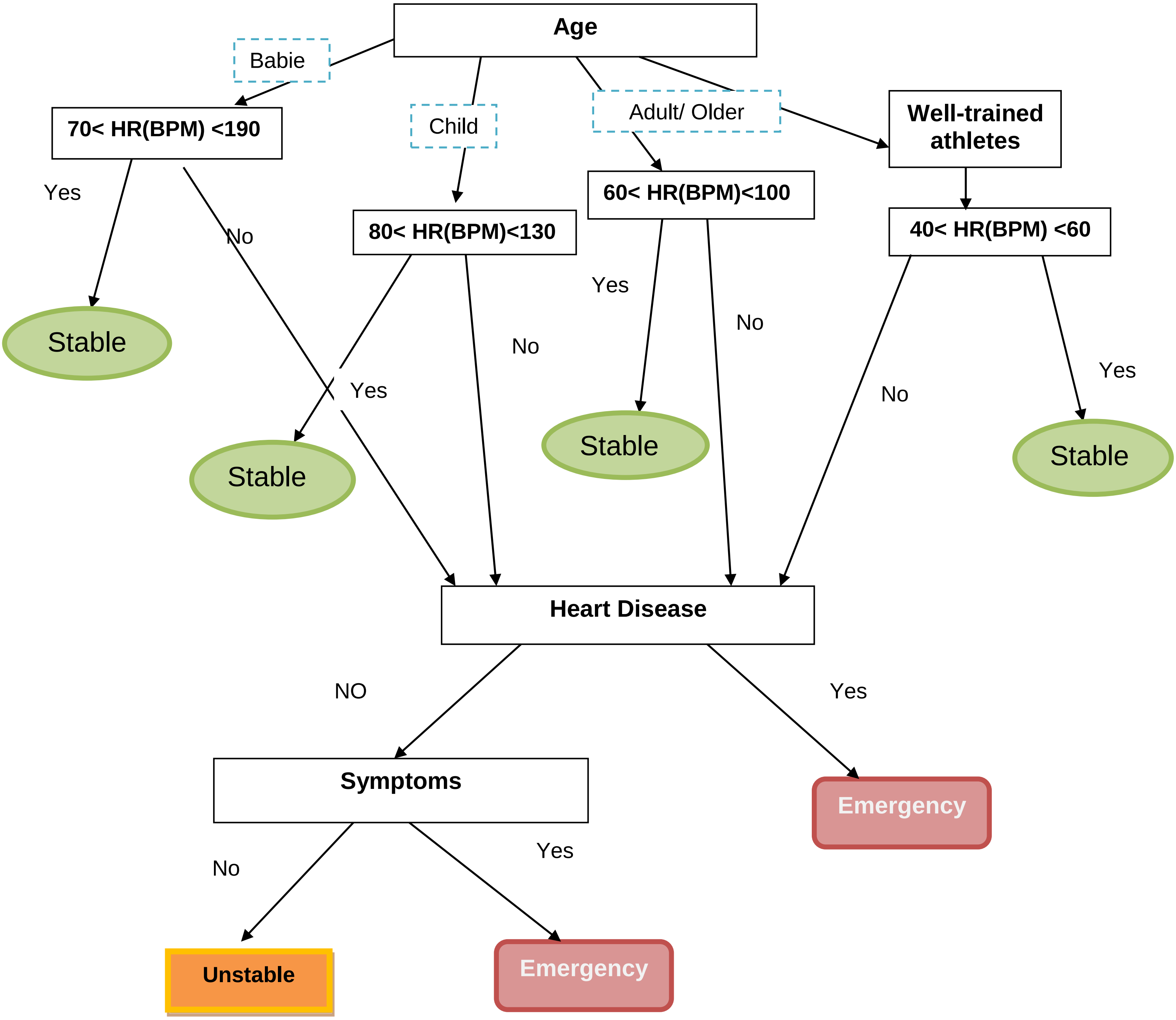
5.2.2 Decision tree for Blood glucose:



5.2.3 Decision tree for body Temperature:



5.2.4 Decision tree for Heart Rate:



5.3 Database Collection:

To create the decision trees mentioned above, used as classifiers in our project, we needed a databases validated by an expert (a doctor).

Now, let's talk a bit about our databases, their descriptions, how and when they are collected and their validation.

The first database was collected is: the blood glucose database:

The non-invasive glucometer implemented as part of this project was used in this collection, this database includes 60 subjects of different age, sex and health status. It was collected in a separate period of 4 days. In different regions (Tlemcen, Blida and Tipaza). In April (spring). The database contains 7 attributes (sex, Age, Weight, Fasting, Smoking, Diabetic, and the Blood glucose value) and 2 classes. The table below shows more details about attribute values and classes.

Attributes	**Age**	**Sex**	**Weight**	**Fasting**	**Smoking**	**diabetic**	**Glucose**
attribute values	Year	F:female M:male	Kg	1:Fasting 0:Not	1:smoker 0:Not	1:diabetic 0:Not	(mg/dl)

Classes	
	N : a normal subject
	NN: abnormal subjects

Table (1) descriptions of the blood glucose database.

We did a treatment of the missing values and therefore for the unstable values of the glucometer, the treatment was the suppression of these individuals downright.

The figure below is a screenshot to our database:

Subjects	age	sex	Weight	Fasting	Smoking	Diabetic	Glucose(mg/	Classes
1	24	F	56	0	0	0	166	N
2	22	F	59	1	0	0	41	NN
3	23	F	57	0	0	0	145	N
4	22	F	55	0	0	0	140	N
5	23	F	56	0	0	0	116	N
6	22	F	88	1	0	0	100	N
7	25	F	58	1	0	0	64	NN
8	24	F	54	0	1	0	116	N
9	24	F	47	0	0	0	117	N
10	23	F	53	0	0	0	140	N
11	24	F	89	0	0	0	141	N
12	24	F	80	0	1	0	129	N
13	24	F	50	1	0	0	101	N
14	56	F	65	0	0	0	116	N
15	46	M	62	1	0	0	100	N
16	18	F	89	1	0	0	70	NN
17	52	M	90	1	0	0	98	N
18	60	F	75	1	0	1	167	NN

Figure (13): Blood glucose database.

The second one is the heart rate database: it was performed using the heart rate sensor.

It was a bit difficult to collect this base, because of lack of material and then we really wanted to collect as many people as possible with different heart rate (normal, higher and even lower)

So this database includes just 38 subjects. We collected this database during one week, in the

middle of April, the individuals were in relaxation when the values was taken.
6attributes and 2 classes are details in the table (2):

Attributes	Age	Sex	Heart diseases	athletes	Heart rate
attribute values	Year	F:female M:male	1:Yes 0:No	1:Yes 0:No	BPM

Classes	
	N : a normal subject
	NN: abnormal subject

Table (2) description of the Heart rate database.
A screenshot for our database is shown in the figure below:

Subjects	Age	Sex	Athletes	Heart diseas	Heart rate	Classes
1	19	F	1	0	39	N
2	46	F	0	0	72	N
3	40	F	0	0	70	N
4	63	M	0	0	99	N
5	24	M	0	0	69	N
6	27	M	1	0	67	N
7	23	M	1	0	91	N
8	24	M	0	0	70	N
9	18	M	1	0	53	N
10	25	F	1	0	41	N
11	30	F	1	0	62	N
12	16	F	0	1	57	N
13	11	M	0	0	117	NN
14	76	M	0	1	140	NN
15	25	F	1	0	54	N

Figure (14): Heart rate database

The third database which represents the body temperature normal and abnormal values: collected in one day on May, contain 4 attributes and 2 classes and 60 individuals, like it's shown in the next table:

Attributes	Age	Sex	Weight	B-T value
attribute values	Year	F:female M:male	Kg	°C

Classes	
	N : a normal subject
	NN: abnormal subject

Table (3) description of the Body temperature database.

The figure (15) is a screenshots from the database:

Subjects	Age	Sex	Weight	B-T value	Classes
1	19	F	41	35,2	NN
2	26	F	59	36	N
3	40	F	57	35,9	N
4	63	M	55	36	N
5	24	M	56	38	NN
6	29	M	88	35,9	N
7	23	F	58	36,1	N
8	24	M	54	36,2	N
9	20	F	47	36,3	N
10	25	F	54	35,9	N
11	30	F	89	36,1	N
12	16	F	61	36,1	N

Figure (15): Body temperature database

The fourth database and the last one is the blood pressure database, which includes 50 individuals, 2 parameters and 2 classes, it was collected in May, in Tlemcen, in a period of 3 days.
This database underwent some treatment,

Attributes	Age	Systolic
attribute values	Year	mmgh

Classes	**N : a normal subject**
	NN: abnormal subject

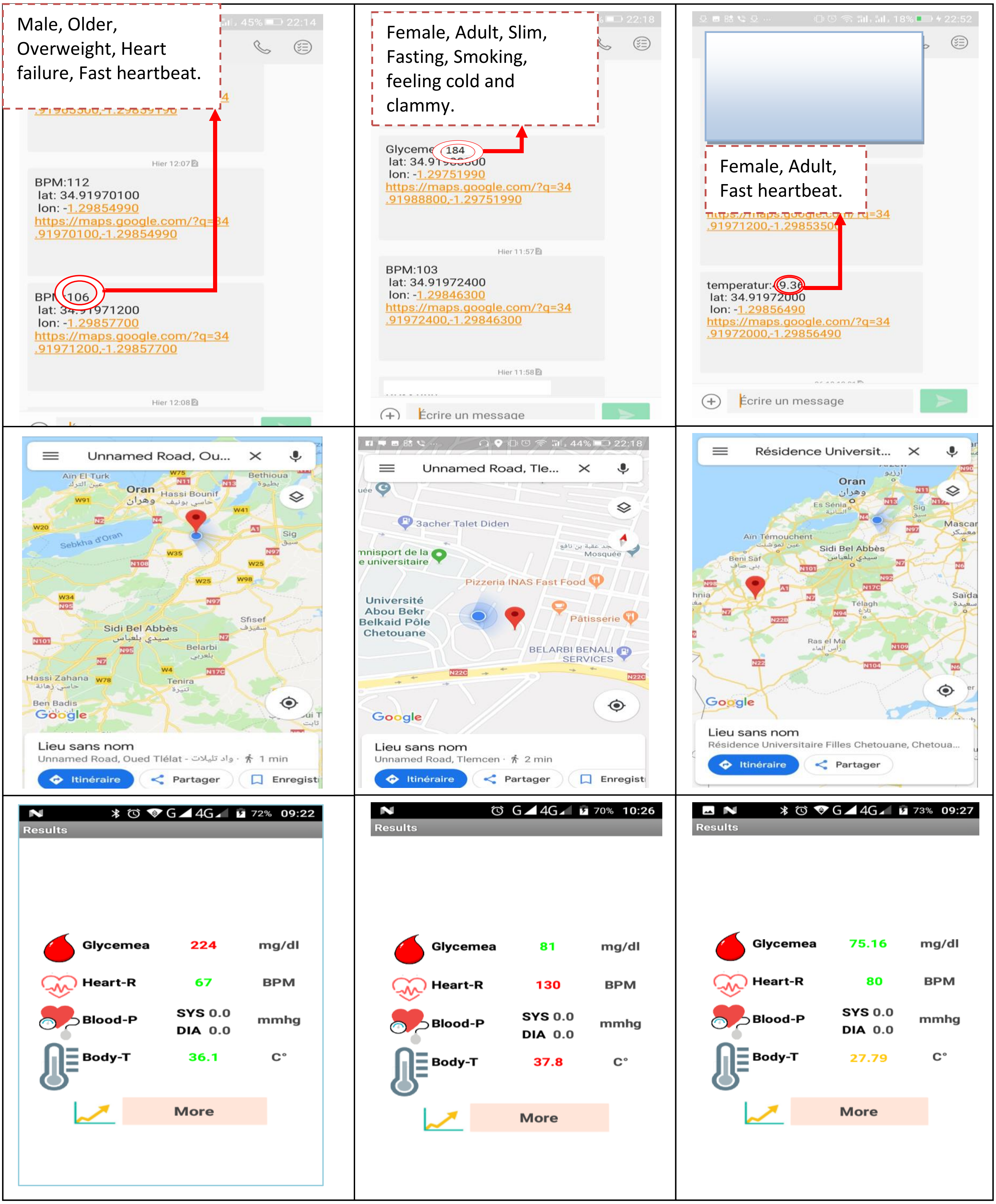
Table (4) description of the blood pressure database.

Subjects	sex	Systolic	Classes
1	F	136	NN
2	F	114	N
3	F	110	N
4	F	112	N
5	F	70	NN
6		77	NN
7	F	100	N
8	F	108	N
9	M	106	N
10	F	104	N
11	M	114	N
12	F	63	NN
13	F	121	NN

Figure (16): blood pressure database

6 Experiments performed:

As we said in the 2nd chapter, we tried our device on 25 people, 5 of whom are sick. The same thing for the Android application (Healthy Life), we will show some results in the following figures (17).



Figure(17): some experiments

7 Conclusions:

Self-monitoring is recognized as an indispensable tool to achieve a balance in physiological parameters, in people who are ill or not.
Tele-monitoring proves the evolution of technology today; it combines several forms of organization of medical practice in the context of: patient having in common to be realized at a distance. This can be an important vehicle for improving the quality and effectiveness of care and can also save lives.

Also the Android application "Healthy Life", easy to handle, that I have just developed will undoubtedly be a great contribution to the success of self monitoring and even tele-monitoring, which should allow proper care of people and this fact appears as a necessary tool to obtain a good control for the vital signs (glycaemia, heart Rate and body temperature).
In this study, we tried to use machine learning to help people, giving them more information about their health stats

Finally we can ensure that the device (module 808) fixes the coordinates of the geolocation of both the person doing the measurement and his assistant with good accuracy (a few meters), we can visualize this accuracy in the experiment carried out In this study.

GENERAL CONCLUSION

GENERAL CONCLUSION

In the end I can say that,

In this project, I carried out a non-invasive device using 3 sensors that detect the level of blood glucose, the heart rate and body temperature. I added a geolocation detection (GPS) and communication (GSM) module, which are all connected via a Bluetooth with a smart Android application. The system (device /ANDROID app) that I created aims to remote and autonomous monitoring, which can help all categories of people, at all ages.

Despite all the difficulties I meet with during my work, nevertheless I tried to combine the three specialties of biomedical engineering (biomedical electronics, biomedical informatics and telemedicine) in my project in order to obtain the best results.

It is true that the results obtained were satisfactory and that the performances of the device work perfectly, as well as for the application (Healthy Life) that classifies the data and the values according to the decision trees that I created, but I'm a little disappointed, unfortunately because of the lack of time and of course the unforeseen events, that I could not finish the sphygmomanometer that I made it, after its electrical failure, and to protect the other components, I decided to not do it again.

Of course, this work can always be developed; on the side of the device itself, on the side of classification, it can perform the decision tree more by adding other nodes and conditions, without forgetting the network part for the improvement of self-and tele-monitoring. In addition, experience gained during this study can also be used for the future development of the non-invasive device and the Android application.

During the system test experience, I noticed people's satisfaction and even they gave me a lot of ideas and suggestions to add. I'm sure this system (device /ANDROID app) can save a lot of lives.

Finally I remain very optimistic about obtaining in the near future a non-invasive device that meets the expectations of people.

ANNEX

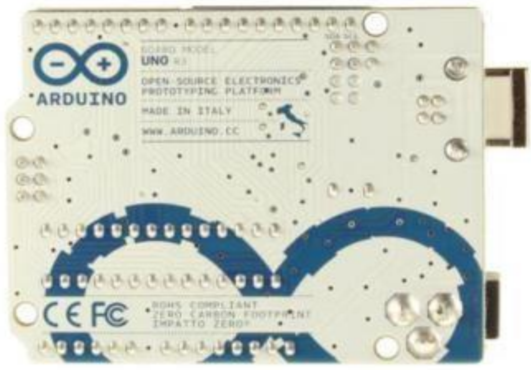
ANNEX 1

Arduino Uno

Arduino Uno R3 Front

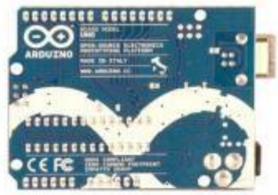
Arduino Uno R2 Front

Arduino Uno SMD



Arduino Uno R3 Back

Arduino Uno Front



Arduino Uno Back

Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Summary

- Microcontroller ATmega328
- Operating Voltage 5V
- Input Voltage (recommended) 7-12V
- Input Voltage (limits) 6-20V
- Digital I/O Pins 14 (of which 6 provide PWM output)
- Analog Input Pins 6
- DC Current per I/O Pin 40 mA
- DC Current for 3.3V Pin 50 mA
- Flash Memory 32 KB (ATmega328) of which 0.5 KB used by bootloader
- SRAM 2 KB (ATmega328)
- EEPROM 1 KB (ATmega328)
- Clock Speed 16 MHz

Power

VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

• 5V. This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the

VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator and can damage your board. We don't advise it.

• 3V3. A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

• GND. Ground pins.

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode (), digital Write (), and digital Read () functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

• Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

• External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details. • PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write () function.

• SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

• LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference () function. Additionally, some pins have specialized functionality:

• TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

There are a couple of other pins on the board:

• AREF. Reference voltage for the analog inputs. Used with analog Reference ().

• Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board. See also the mapping between Arduino pins and ATmega328 ports. The mapping for the Atmega8, 168, and 328 Is identical.

USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mils (0.16"), not an even multiple of the 100-mil spacing of the other pins.

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ABSTRACT:

According to studies conducted on the Algerian population, researchers found that 14% of sick and healthy person are dead in 2016 because they never arrived or were late for the emergency room, when they had been exposed to a crisis: Increased blood glucose or high blood pressure, which is also a significant risk factor or/and a heart attack.
As part of this project, we created a medical device that measures blood pressure, blood glucose, body temperature and heart rate in seconds without pain or tingling. The results will then be sent to a smart Android app (Healthy Life), which will classify them and give the user information about his health.
We also used the geolocation (GPS) and communication (GSM) technologies to perform the Tele-monitoring. Our goal is to minimize the percentage of deaths in the population.

Key words: Self-monitoring, Tele-monitoring, Glucometer, Sphygmomanometer, Thermometer, Heart Rate Monitor, Bluetooth, GPS, Cellular Network, GSM, Android application, Classification, Smart phone.

RESUME

Selon des études menées sur la population algérienne, des chercheurs ont découvert que 14% des personnes malades et en bonne santé étaient décédées en 2016 parce qu'elles n'étaient jamais arrivées aux urgences ou étaient en retard, lorsqu'elles avaient été exposées à une crise: soit d'évaluation de taux de glucose, une hypertension, qui est également un facteur de risque et / ou une crise cardiaque.
Dans le cadre de ce projet, nous avons créé un dispositif médical qui mesure la pression artérielle, la glycémie, la température corporelle et la fréquence cardiaque en quelques secondes, sans douleur ni picotement. Les résultats seront ensuite transmettre à une application Androïde (Healthy Life), qui les classera et donnera à l'utilisateur des informations sur sa santé.
Nous avons également utilisé les technologies de géolocalisation (GPS) et de communication (GSM) pour effectuer la télésurveillance. Notre objectif est de minimiser le pourcentage de décès dans la population.

Mots clés : Auto-surveillance, télésurveillance, Glucomètre, Tensiomètre, Thermomètre, Le moniteur Cardiaque, Bluetooth, GPS, Réseau Cellulaire, GSM, Androïde application, Classification, Smart phone.

ملخص

وفقًا للدراسات التي أجريت على السكان الجزائريين ، وجد الباحثون أن 14٪ من السكان المرضى و الأصحاء قد ماتوا في عام 2016 بسبب عدم وصولهم أو تأخرهم إلى غرفة الطوارئ عندما تعرضوا لأزمة: زيادة نسبة الجلوكوز في الدم أو ارتفاع ضغط الدم ، وهو أيضا عامل خطر كبير و/او أزمة قلبية
كجزء من هذا المشروع، أنشأنا جهازًا طبيًا يقيس ضغط الدم والجلوكوز في الدم ودرجة حرارة الجسم ومعدل ضربات القلب في ثوانٍ دون ألم أو وخز. بعد ذلك، سيتم إرسال النتائج إلى تطبيق الاندرويد الذكي ، والذي سيقوم بتصنيفها وإعطاء المستخدم معلومات حول صحته.
كما استخدمنا تقنيات تحديد الموقع الجغرافي والاتصالات لإجراء مراقبة عن بُعد. هدفنا هو تقليل نسبة الوفيات بين السكان

الكلمات المفتاحية: المراقبة الذاتية ، المراقبة عن بعد ، مقياس السكر ، مقياس ضغط الدم ، ميزان الحرارة ، رصد معدل ضربات القلب، بلوتوث، تحديد الموقع الجغرافي ، الشبكة الخلوية ، الاتصالات ، تطبيق أندرويد ، التصنيف ،الهواتف الذكية