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Medical diagnosis System Development with The Help of Shape Recognition

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acknowledgment

We thank in the first place God all powerful for having honored us by the light of the understanding to have given us the courage and the determination to carry out this work.

At the end of this modest work, and as a preamble to this written report, we would like to express our sincere thanks and by the same testimony of our gratitude to the promoter Mr.BENSELAMA for agreeing to supervise our project, as well as for the precious help that he provided us.

We also want to thank him very much for his patience as well as his understanding, and his precious advices which greatly helped us in carrying out this study,

We also extend a big thank you to the members of the jury for agreeing to judge our work and honor our presentation with their presence.

Ultimately, we would like to thank anyone who directly or indirectly participated in the success of this work to which we have devoted so much while also putting all our heart into it.

Dedication

I dedicate this modest work

To our dear parents who always encouraged us

To all our brothers and sisters and all the family.

To all our dear friends

To all our colleagues at the university

To all professors of the electronic department

Abstract

This project lays within the field of medical technologies , therefore , our work consists in finding the best features to extract from a certain biological signals . and we will use those features with a classifier based on an artificial neural network to classify those signals . the results will be used in another algorithm to determine the recognition rate .

Keywords:

Cardiovascular system, Arterial pressure , Neural network , Classification

الملخص

يندرج هذا المشروع ضمن مجال التقنيات الطبية ، لذلك فإن عملنا يتمثل في إيجاد أفضل الميزات لاستخراجها من إشارات بيولوجية معينة.وسنستخدم هذه الميزات مع مصنف الذي يعتمد على شبكة عصبية اصطناعية (ANN) لتصنيف تلك الإشارات

و سيتم استخدام النتائج في خوارزمية أخرى لتحديد معدل التعرف

الكلمات الدالة

نظام القلب والأوعية الدموية ، ضغط الشرايين ، الشبكة العصبية ، التصنيف

Résumé

Ce projet s'inscrit dans le domaine des technologies médicales, notre travail est donc de trouver les meilleures caractéristiques à extraire de certains signaux biologiques. Nous utiliserons ces caractéristiques avec un classificateur qui s'appuie sur un réseau neuronal artificiel (ANN) pour classer ces signaux.

les résultats seront utilisés dans un autre algorithme pour déterminer le taux de reconnaissance.

***Mots clés**:*

Système cardiovasculaire, Pression artérielle, les Réseau de neurones , Classification

Figures table

Introduction

No matter what's your health issues, people can use many types of procedures to solve them depending on your needs, your current conditions and the capacity of your body which leads us to think more about other diseases that you might already have. such as diabetes high blood pressure etc ….

Our Graduation project will in fact **study and specify** some problems that people might have with **arterial pressure** in their **cardiovascular system.**

In This thesis we are going to try by applying the knowledge acquired during our course, to **develop certain simulation programmes** for the **collection and acquisition** of the data, that we obtained from the British heart foundation, in collaboration with the engineering and physical sciences research council divides into two parts **physiological data and non-physiological data** .

The next step would be to put **these two parts in use**, which means in other words that we are going to exploit the information gained from them by applying **a shape recognition techniques that involve three essential blocks (data acquisition , feature extraction , classification)** .

as you can imagine after creating our own data base from the first two datasets, we will extract two types of vectors, each one contain certain features that separates the two datasets. that allows the formation of two matrixes that represent each dataset.

Last but not least this work will mainly focus on the variants of the extraction of the features of the arterial pressure signals with a view to applying them to a classifier based on neural networks. we will use each matrix in the **forming and learning** of our **ANN (artificial neural network).**

being able to recognize the two types of data is our main goal. the artificial neural network will help us test and evaluate the results of every data and define its type.

this manuscript is organized as follows:

In the first chapter, we will cover generalities about the cardiovascular system that includes the cardiovascular structure and functions and the cardiovascular diseases and finally the arterial (blood) pressure and how to measure it and store it.

The second chapter will be about neural network different methods and techniques . their architectures as well as their learning rules with a view to applying it as a classifier. which allows us to pick the best of them to achieve our goal with a good recognition rate.

The fourth chapter will be devoted to the implementation of our system, it will be illustrated by the flowcharts explaining each of its stages. We will then present all the experiments with the necessary interpretations.

We will end this essay with a conclusion which summarizes the results obtained during our work.

Chapter I :
Cardiovascular medicine

I) introduction :

Blood pressure assessment is an integral part of clinical practice. Routinely, a patient's blood pressure is obtained at every physical examination, including outpatient visits, at least daily when patients are hospitalized, before most medical procedures. Blood pressure measurements are obtained for a wide variety of reasons, including screening for hypertension , estimating cardiovascular risk

so in this part of this manuscript we are going to talk about the cardiovascular system in general . its functions and the common diseases that follow it . and how is it related to blood pressure .

II) Cardiovascular system :

II-1) Definition :

The cardiovascular system, also called the circulatory system called , is an organ system with a main function of pumping blood throughout the body. The purpose of the heart is to act as the pump, pushing blood into the blood vessels. The blood is carried by The blood vessels to all the different parts of the body, before it is returned back to the heart to start the cycle again. the Blood carries oxygen from the lungs throughout the body. It is also responsible for transporting waste products such as carbon dioxide, which are then eliminated by other bodily systems [1].

Without a properly functioning cardiovascular system , our cells would be unable to function properly. So it supply nourishment and help in fighting diseases, stabilize temperature and pH, and maintain homeostasis.

II-2) Cardiovascular structure :

The essential components of the human cardiovascular system are the

- Heart
- Blood
- Blood vessels.

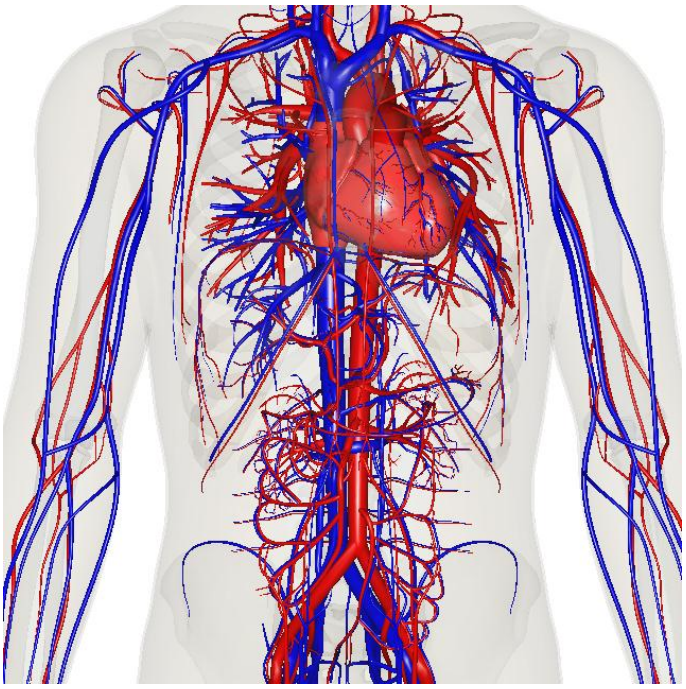

Figure I-1 : Depiction of the heart, major veins and arteries

II-2-1) Heart :

The heart pushes blood in order for it to circulate throughout the body. The heart is a very strong muscle that is able to contract and relax rhythmically throughout a person's lifetime .Because the heart is a large, it a constantly active muscle, it must also have its own constant supply of oxygen, allowing it to continue pumping. and that's called Coronary circulation .

2-1-1) heart structure :

The human heart has four chambers, each separated by a valve (Figure I-2). The four chambers include the right atrium, right ventricle, left atrium, and left ventricle the relaxation and contraction of these chambers that allows the heart to pump blood The valves that separate the four chambers prevent blood from flowing backwards, as a result it only allowing the flow of blood in one direction [2].

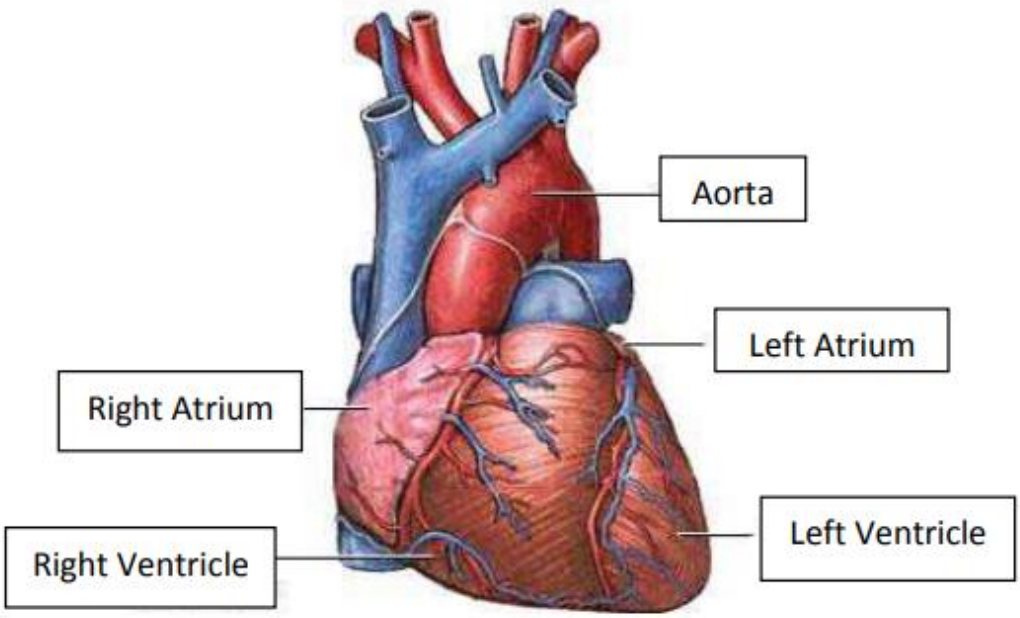

Figure I-2: The heart with the four chambers and aorta

2-1-2) blood flow within the heart *:*

The heart is made up of large muscles that cause the contraction and relaxation to pump oxygenated blood to the body and deoxygenated blood to the lungs. So When these muscles take turns contracting, blood is passed through the valves separating the chambers, from one chamber into another. The right atrium (RA) is the upper chamber of the right side of the heart. The blood that returns to the right atrium is deoxygenated and passed into the right ventricle to be pumped through the pulmonary artery to the lungs for re-oxygenation and removal of carbon dioxide. The left atrium (LA) receives newly oxygenated blood from the lungs as well as the pulmonary vein which is passed into the strong left ventricle to be pumped through the aorta . The aorta splits into the other blood vessels of the body and distributes the oxygenated blood [3].

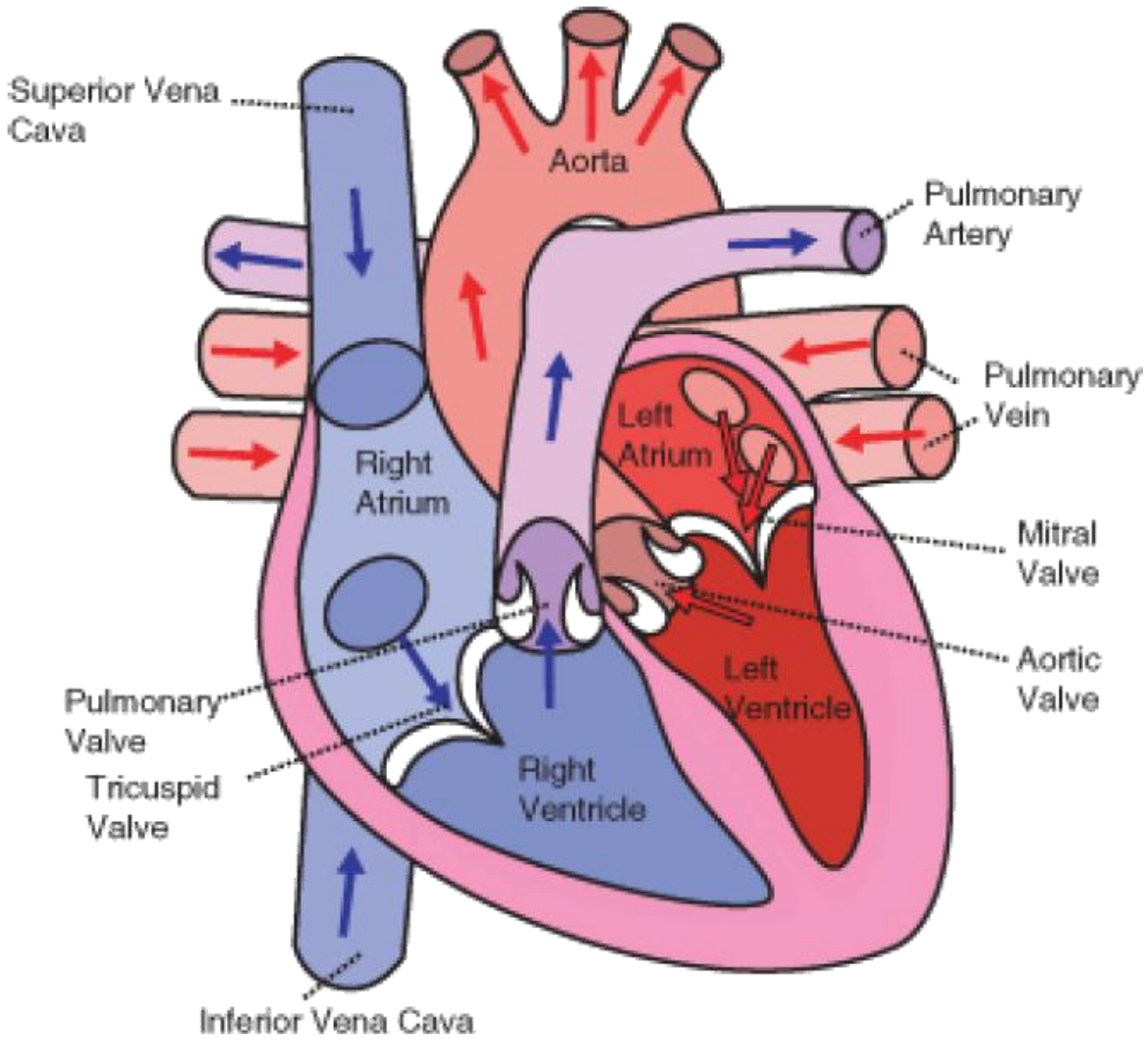

Figure I-3: The Direction Of Blood Flow Through The human Heart

2-1-3) The Cardiac Cycle :

The cardiac cycle is the sequence of events that occurs when the heart beats. A single cycle of cardiac activity can be divided into two basic phases :

- Systole

- Diastole

a) Systole :

the Systole represents the time during which the left and right ventricles contract and eject blood into the aorta and pulmonary artery respectively . during this phase the aortic and

pulmonic valves open and The atrioventricular valves closes to permit ejection into the aorta and pulmonary artery . therefore no blood is entering the ventricles . nonetheless , the blood continues to enter the atria though the vena cavae and pulmonary veins. As shown in (Figure I-3) [4 (62/242)].

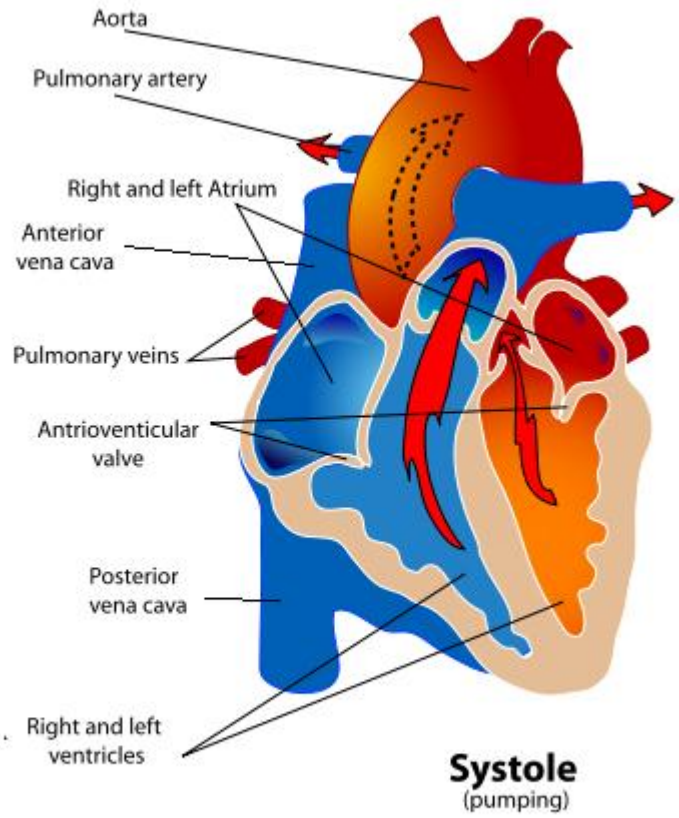

Figure I-4 : circulation of blood inside the heart during systole

b) Diastole :

For the case of the Diastole. it represents the period of time when the ventricles are relaxed . Throughout most of this period, blood is passively flowing from the left atrium and right atrium into the left ventricle and right ventricle .The blood flows through atrioventricular valves that separate the atria from the ventricles. The right atrium receives venous blood from the body through the superior (anterior) vena cava (SVC) and inferior (posterior) vena cava (IVC) .The left atrium acquires the oxygenated blood from lungs through four pulmonary veins that enter the left atrium . At the end of diastole, both atria

contract, which propels an additional amount of blood into the ventricles (Figure I-4) [4(64/242)]

no new blood is pumped into the blood vessels, and as a result the pressure in the blood vessels is lower than it is during systole.

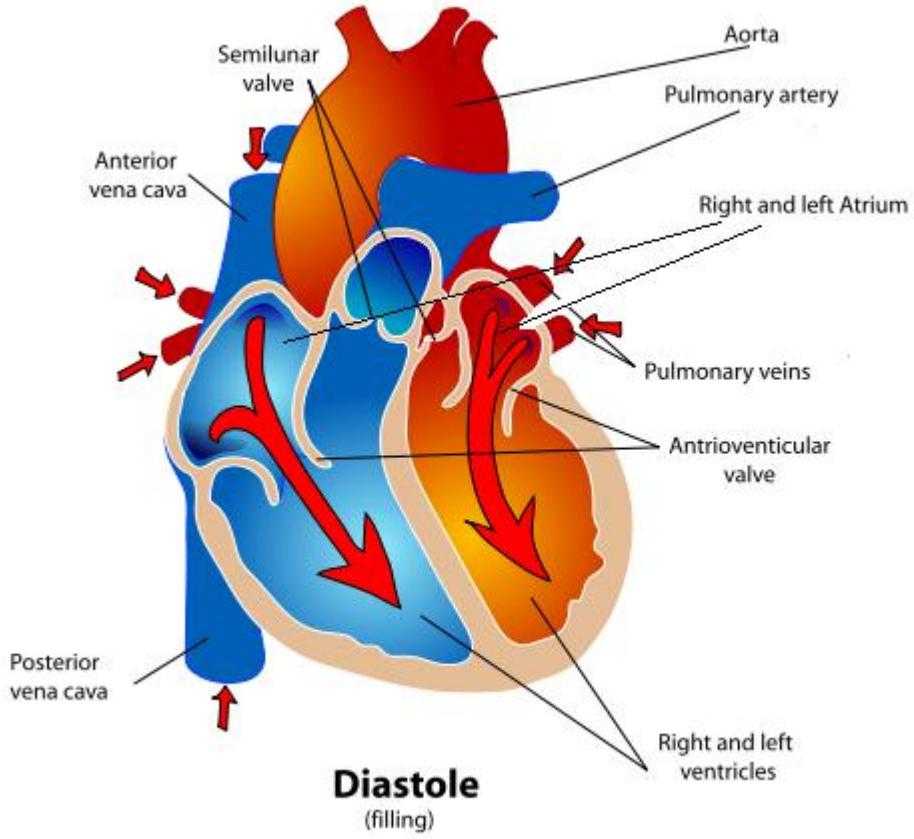

Figure I-5 : blood flow within the heart during diastole

II-2-2) Blood :

the Blood is a liquid that delivers necessary substances, including nutrients and oxygen, to all different parts and cells of the body Blood also carries waste products away from the cells to other areas where they can be processed. there is around 5 liters of blood in the body of an average adult .

Blood is mainly composed of solid blood cells and the rest is being made up of other dissolved substances like (clotting proteins, sugars, hormones, and minerals), which are suspended in the liquid plasma.

There are four main components of blood :

- red blood cells

- white blood cells

- Platelets

- plasma

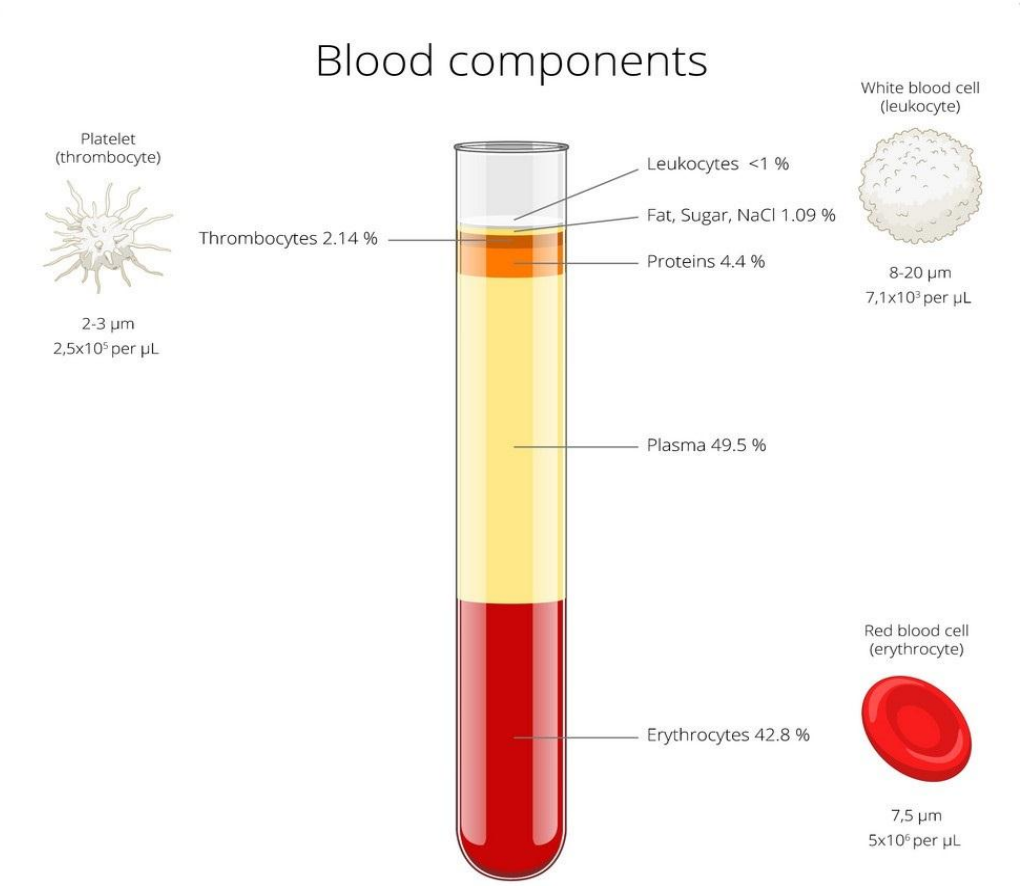

Figure I-6: Blood components

2-3-1) Blood function :

Blood is an essential fluid in our bodies and performs many important functions. Some of these functions includes :

- the red blood cells that transport oxygen and carbon dioxide within the blood stream by protein called hemoglobin

- delivering nutrients from food to cells around the body

- Defense against diseases and detection of foreign material by white blood cells

- Clotting and prevention of blood loss by platelets and clotting protein

- Helping regulate and maintain body temperature

2-3-2) blood circulation paths :

The blood circulatory system is divided into two paths : The systemic circulation and The pulmonary circulation [5,6].

a) The systemic circulation :

the first system (The systemic circulation) provides organs, tissues and cells with blood so that they get oxygen and other vital substances . the left ventricle pumps oxygen-rich blood into the aorta (main artery) . The blood moves from the main artery to larger and smaller arteries and into the capillary network. and after blood drops off oxygen, nutrients and other important substances and picks up carbon dioxide and waste products. it will be collected in veins and travels to the right atrium and into the right ventricle.

b) The pulmonary circulation :

it is the portion of the circulatory system. The right ventricle sends low-oxygen blood into the pulmonary artery, which branches off into smaller and smaller arteries and capillaries. The capillaries shapes a fine network around the pulmonary vesicles. and it is where carbon dioxide is released from the blood into the air inside the pulmonary vesicles . and also where fresh oxygen enters the bloodstream .and finally travels through the pulmonary veins into the left ventricle where it waits the next heart beat.

II-2-3) Blood vessels :

The blood vessels are the components of the circulatory system that transport blood throughout the human body to every tissues and cells.

There are 3 major types of blood vessels :

- Arteries

- Capillaries

- Veins

a) Arteries :

The arteries are the blood vessels that deliver oxygen-rich blood from the heart to the tissues of the body. The walls of these vessels are elastic in nature, which allows them to

enlarge and contract as the heart powerfully pumps blood through them. Each artery is a muscular tube lined by smooth tissue and has three layers [7] (Figure I-7) :

- the inner layer called the intima (in latin) and its lined by a smooth tissue called endothelium

- media , is the middle layer is a layer of muscle that lets arteries handle the high pressures from the heart

- adventitia . is the last one is a connective tissue anchoring arteries to nearby tissues

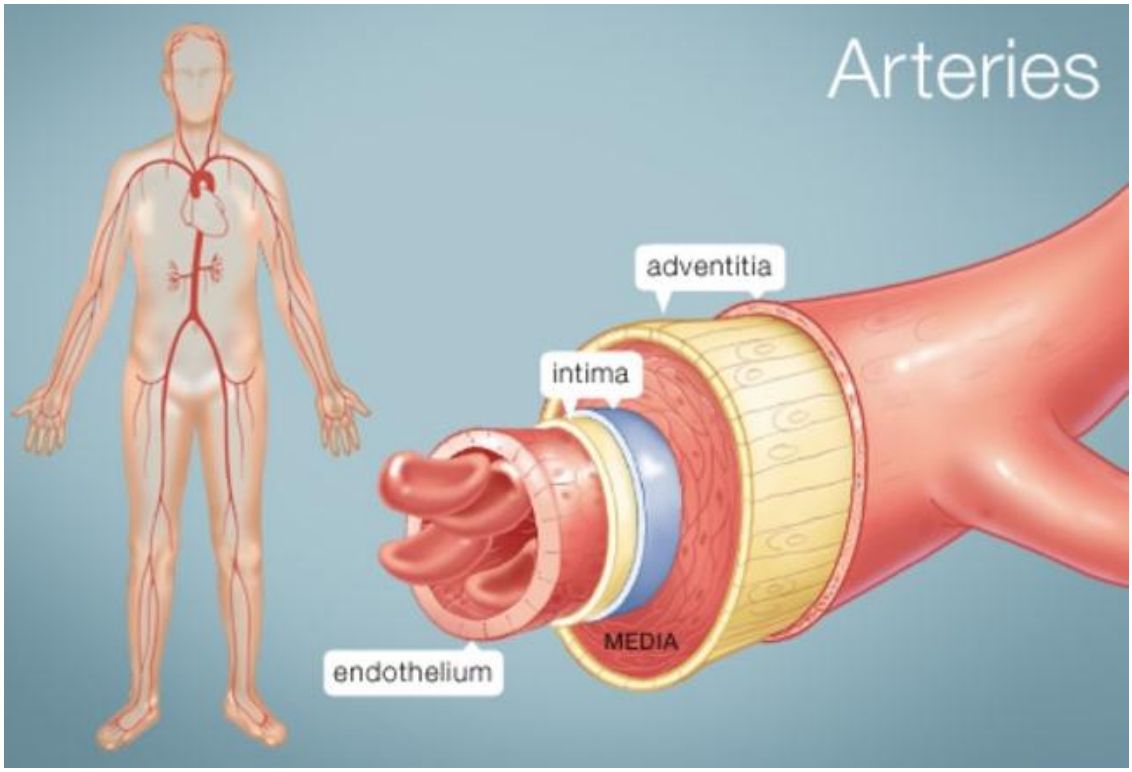

Figure I-7: the three layers of arteries

b) Capillaries :

The size of vessels decreases as they move further and further away from the heart, until they become the smallest vessels to the point where they are only one cell thick. and they are called capillaries .they connect the arteries and the veins. These vessels are thin enough to allow the products carried within the blood stream to be exchanged with the surrounding tissues [8].

c) Veins :

numerous capillaries come together and form larger vessels . these larger vessels are the veins. which gathers the blood from the capillaries and return it to the heart. they all carry low oxygen (poor in oxygen) blood back to the heart [8-1].

III) Cardiovascular Diseases :

III-1) Overview :

after the explanation and the understanding of the normal functions of the cardiovascular system . now we are going to cover some of the important diseases that happen as a result of issues that affect the cardiovascular system. the Cardiovascular diseases are conditions that affect the structures or function of your heart . and that occurs due to Disturbances to any part of the Cardiovascular system , including conditions discussed in the previous chapter . such as heart chamber or valve defects and arrhythmias like atrial fibrillation, all of this can lead to developing a sever disease .

from a long list of cardiovascular diseases we mention the most common ones worldwide and includes :

- Coronary heart disease
- Peripheral vascular disease
- Congenital heart defect
- Aorta disease
- Deep vein thrombosis and pulmonary embolism
- Cerebrovascular disease
- Rheumatic heart disease
- Pericardial disease

III-2) Coronary heart disease (CHD) :

Coronary Heart Disease is also called Coronary Artery Disease CAD , Coronary Microvascular Disease, Coronary Syndrome X.

Heart disease is a catch-all phrase for a variety of conditions and Coronary heart disease is a type of heart disease that develops when the arteries of the heart cannot deliver

enough oxygen-rich blood to the heart. and thats due to the coronary arteries when become too narrow . this condition is developed by the buildup of plaque , it is a a waxy substance, inside the lining of larger coronary arteries , which is developed when cholesterol builds up on the artery walls . These plaques cause the arteries to narrow and many of of them could partly or complitly blook the blood flow in the large arteries of the heart [9,10].

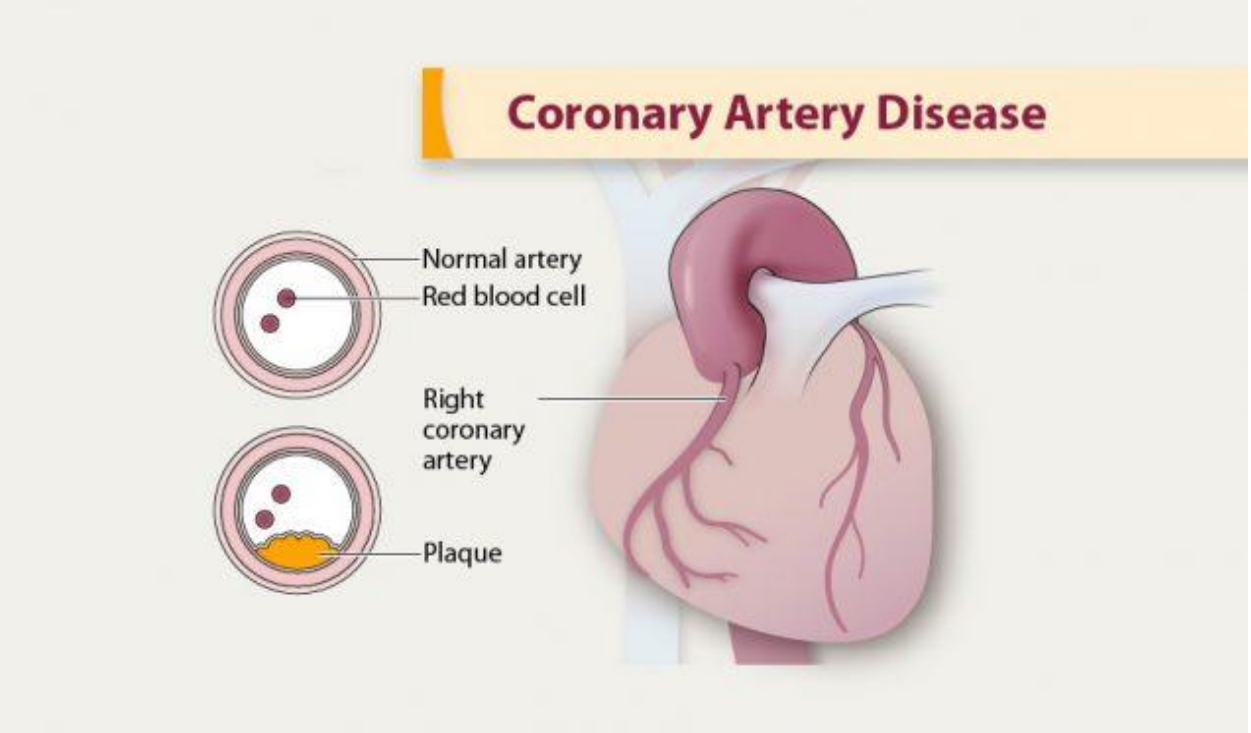

Figure I-8 : the plaque development in the wall of the arteries that supply blood to the heart

the Symptoms of coronary heart disease may be different from person to another even if they have the same type of coronary heart disease . The leading symptoms of Coronary heart disease are :

- heart attack

- angina (chest pain)

- heart failure

III-2-1) Heart attack :

the muscles of the heart requires a constant supply of oxygen-rich blood. our coronary arteries give the heart this critical blood supply . A heartattack is the death of a segment of heart muscle caused by a loss of blood supply . when those arteries become narrow

due to blood clot or plaques build up in the arteries . blood can't flow as well as it should so the heart can't get the oxygen it needs .

The classic signs and symptoms of a heart attack include crushing pressure in your chest and pain in your shoulder or arm, sometimes with shortness of breath and sweating [11].

III-2-2) Angina (chest pain) :

the chest pain caused by reduced blood flow to the heart muscles called Angina . It is a symptom of an underlying heart problem and It is not usually fatal or life threatening, but it's a warning sign that you could be at risk of a heart attack or stroke. This usually happens because one or more of the coronary arteries is narrowed or blocked [12].

we find many types of angina, including microvascular angina, Prinzmetal's angina, stable angina, unstable angina and variant angina .

III-2-3) Heart failure :

This term can be scary. It does not mean your heart has "failed," or stopped working. but it means that your heart doesn't pump as strongly as it should. which it will lead to the body to hold in salt and water, which will give the person swelling and shortness of breath.

III-3) Peripheral vascular disease (PVD) :

Peripheral artery disease is one of the most prevalent conditions, it is a manifestation of systemic atherosclerosis that causes blood circulation disorder in the blood vessels which carry oxygen-rich blood outside of the heart and brain . As a result of the atherosclerotic process, patients with Peripheral artery disease develop narrowing or block, or spasm of these arteries. and they experiance pain and fatigue offten in legs especially during exercise , it can also affect the vessels that supply blood and oxygen to their arms stomach and intestines and kidneys. Peripheral artery disease can lead to organ damage and loss of fingers, toes, or limbs, if left untreated [13].

III-4) Congenital heart defect (CHD) :

it is known as a congenital heart anomaly and congenital heart disease. It is present at birth and it is a defect can involve the walls of the heart, the valves of the heart , and the arteries and veins near the heart . Congenital heart imperfection are the most common type of birth defect . there are many types of defects which leads to different signs and symtoms . they could effect blood flow through the heart or within the heart or make it go in the wrong direction or to the wrong place, or be blocked completely [14].

take a condition called patent ductus arteriosus (PDA) from many types. it is a communication between the pulmonary artery and the aortic arch distal to the left

subclavian artery. Patent ductus arteriosus is the failure of the fetal ductus arteriosus to close after birth.

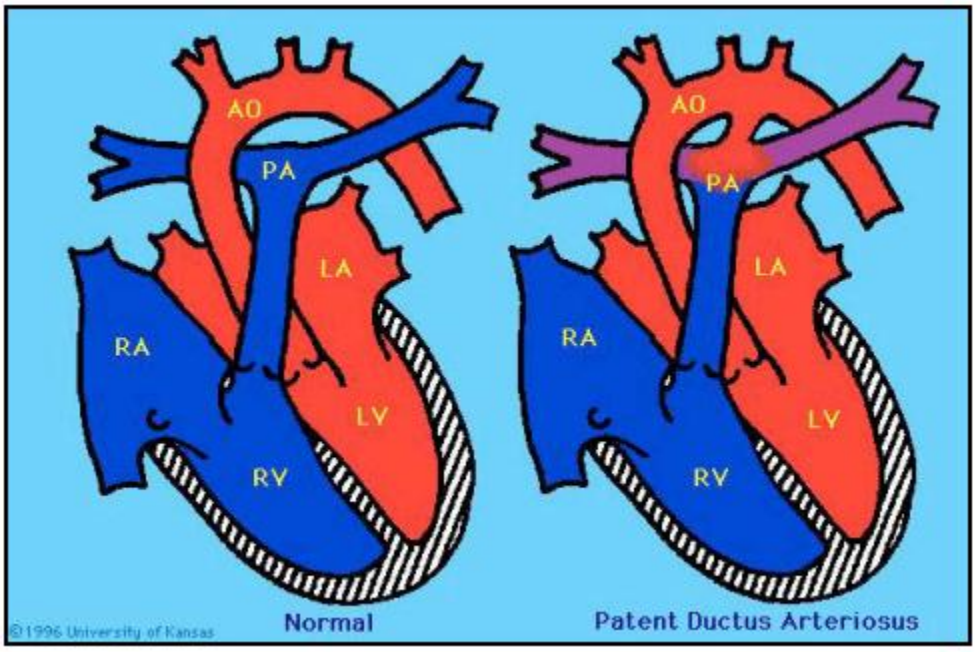

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Figure I-9 : patent ductus arteriosus PDA

III-5) Aortic Disease :

the biggest (largest) artery in the body is The aorta. after a disease has been encountered the aorta can split (dissection) or dilate (aneurysm) and in either case, the rupture may have fatal results. numerous diseases and conditions can cause damage to the aorta and put patients at great risk [15].

Aortic disorders include: Abdominal aortic aneurysms ,Thoracic aneurysms and Thoracic abdominal aneurysms.

III-6) Deep vein thrombosis (DVT) and pulmonary embolism (PE) :

Pulmonary embolism is a blockage in one of the pulmonary arteries in the lungs by a substance that has moved from elsewhere in the body through the bloodstream (embolism). In the most common cases is caused by blood clots that travel to the lungs from deep veins in the legs or, rarely, from veins in other parts of the body its called a deep vein thrombosis (DVT). Because the clots block blood flow to the lungs, undiagnosed or untreated pulmonary embolism can be life-threatening. However, prompt treatment greatly reduces the risk of death [16].

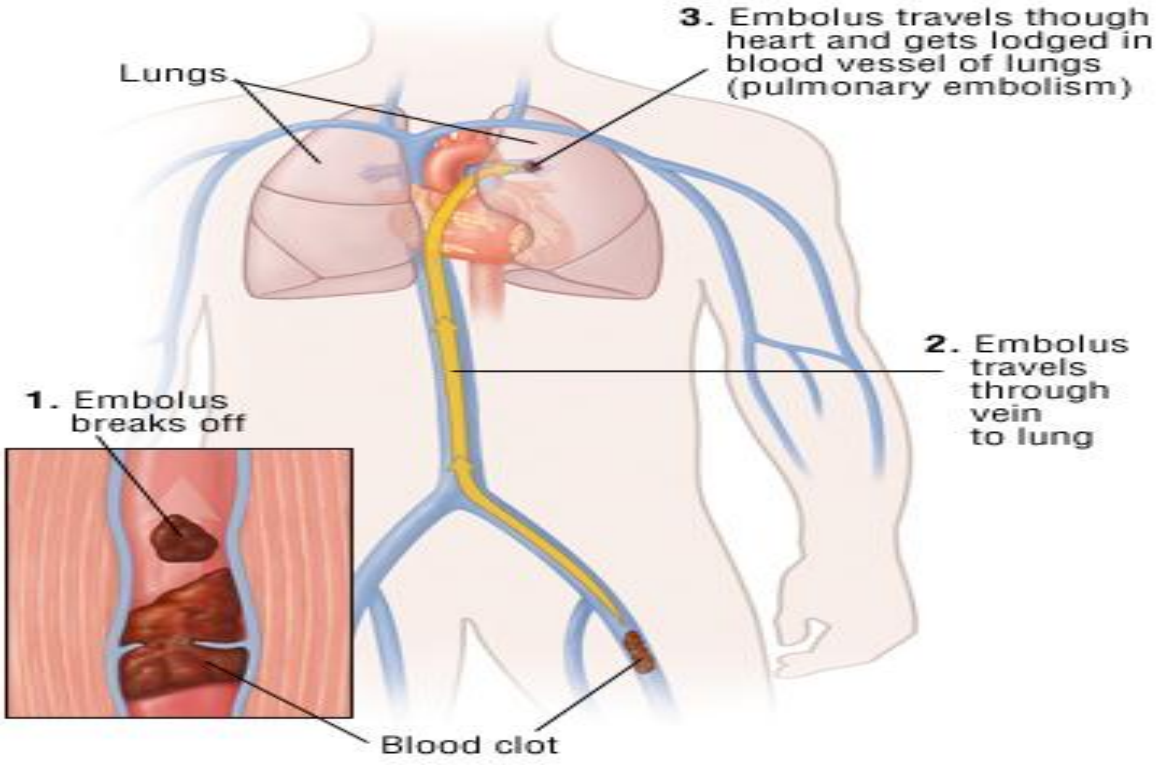


Figure I-10 : Pulmonary embolism

III-7) Rheumatic heart disease :

the condition called Rheumatic heart disease is when the heart valves have been permanently damaged by rheumatic fever. and it is a condition characterized by widespread inflammation affecting a number of organs in the body, including the heart. The heart valve damage may start shortly after untreated or under-treated infection of the throat caused by the bacterium Group A streptococcus . The immune system response is to target both the bacteria and some of the body's own tissues that contain similar molecules to those in the bacteria .in the case of the heart tissues it develops Rheumatic heart disease results from persisting inflammation of the heart after sever or recurrent episodes of rheumatic fever [17].

III-8) Pericardial disease :

in the case of The pericardium desease .it represents a relatively avascular fibrous sac that surrounds the heart. It is based of two layers: the visceral and parietal pericardium .

the single layer of The visceral pericardium is composed of mesothelial cells that are adherent to the cardiac epicardium.

The fibrous structure of the parietal pericardium is a <2 mm thick and is composed primarily of collagen and a lesser amount of elastin.

Between the two layers of the serous pericardium lies the pericardial cavity which normally contains up to 50 mL of pericardial fluid (Figure I-10)

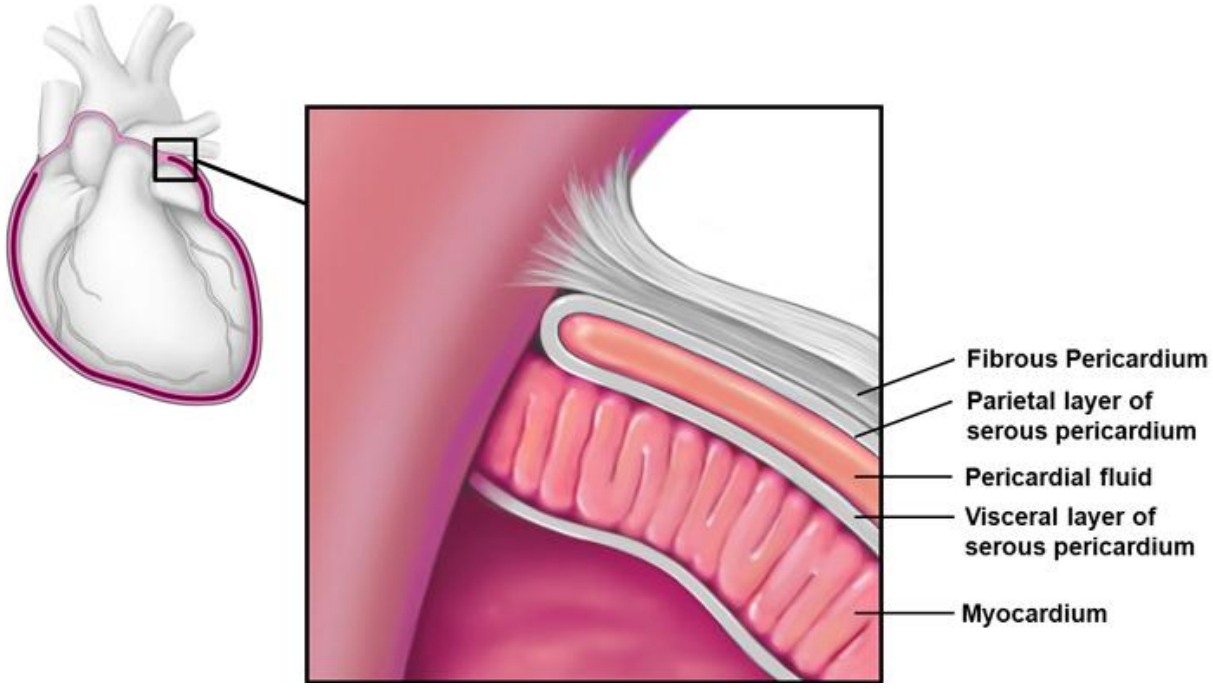


Figure I-11: The pericardium structure

While the pericardium is not critical for life it serves important functions including maintenance of cardiac position within the chest and as a barrier to infection and inflammation.

Acute inflammation of the pericardium with or without an associated pericardial effusion can occur as an isolated clinical problem or as a manifestation of systemic diseases . Although as many as 90% of isolated cases of acute pericarditis are idiopathic or viral[18].

IV) Blood pressure :

by definition Blood pressure is the pressure of blood in the arteries. it is equal to the volume of blood ejected with each contraction of the heart (cardiac output) by the resistance of the peripheral arteries which is opposed to the flow of blood in the arteries. this pressure is also the force of blood pushing against these arteries.

Blood pressure is often measured in centimeters of mercury (cmHg) or even in millimeters of mercury (mmHg).

Blood pressure is usually expressed by two measures: Systolic blood pressure (SBP) and diastolic blood pressure (DBP) [19].

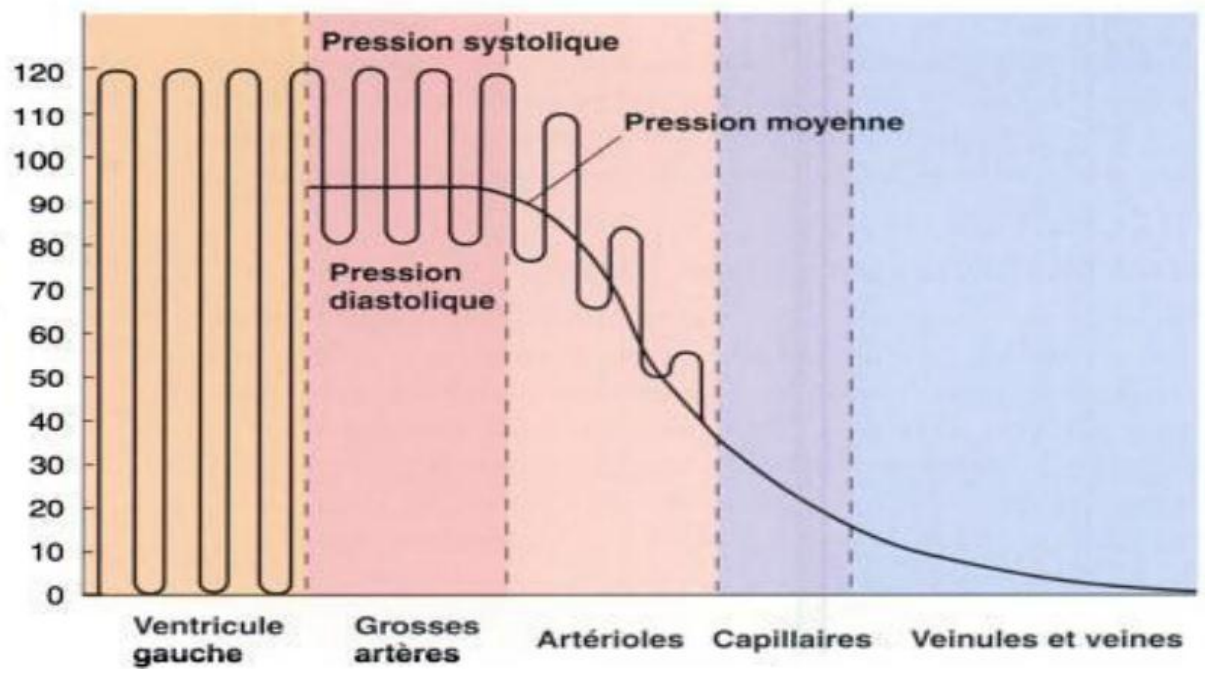


Figure I-12: systolic and diastolic blood pressure in cardiovascular system

IV-1) Blood pressure types :

including the last two main blood pressure measures . there are two more that relate to systolic and diastolic blood pressure called.

Mean Arterial Pressure (MAP) and Pulse Pressure (PP)

IV-1-1) Systolic blood pressure (SBP) :

depends on the ejection rate of the left ventricle, that is to say the volume of blood from the heart, the flexibility of the arterial walls, and peripheral reflection waves.

Indeed, if the cardiac output increases, the SBP increases without major modification of the DBP. An increase in peripheral resistance leads to an increase in SBP, but also to a more marked increase in DBP.

The decrease in arterial compliance increases the PAS by two mechanisms:

the decrease in the damping capacity of the systolic wave by the more rigid arterial walls, and the earlier arrival of peripheral reflection waves which are added to the incident wave generated by the left ventricle.

The modifications of the characteristics of the reflected waves vary the SBP at a particular level of the central arteries.

IV-1-2) Diastolic blood pressure (DBP) :

It is a function of the resistances on the peripheral arterioles. Mainly the Hemodynamic factors that determine DBP they are essentially peripheral arteriolar resistances. which to the blood flow in the small arteries. and the duration of the diastole and the rigidity of the large arterial trunks, the role of which is however minor compared to that of arteriolar resistances. This is an important detail because this pressure reflects the way in which the arteries of the heart, coronary arteries, are irrigated.

IV-1-3) Mean Arterial Pressure (MAP) :

the mean arterial pressure is defined as the average pressure in a patient's arteries during one cardiac cycle. is a theoretical pressure, equivalent to that which would ensure an identical blood flow in the organism throughout the cardiac cycles.

for the determination of the mean arterial pressure, we double the diastolic blood pressure and add the sum to the systolic blood pressure. Then divide by 3.

it goes by the formula :

$$MAP=(SBP+2*DBP)/3$$

IV-1-4) Pulse Pressure (PP) :

Pulsed or differential pressure has been the subject of numerous studies in recent years.it is a predictor of cardiovascular risk, independently of the other parameters concerning blood pressure and above all predictive of myocardial infarction and, to a lesser extent, cerebrovascular accidents (strokes).

the reduction of the viscoelastic properties of the walls of large arterial trunks causes a change in shape of the pressure curve with an increase in the SBP and a decrease in DBP.

The determinants of pulsed pressure, calculated by systolic and diastolic pressures. The main determinant is the viscoelastic properties of the artery wall with large and medium calibers and those influencing the waves incident and reflected blood pressure.

IV-2) Blood pressure regulations :

IV-2-1) Short-term regulation (nervous regulation) :

Short-term control of blood pressure depends on reflex phenomena that detect and respond to changes in seconds. The different, motor portion of this reflex involves vegetative nerves (sympathetic or parasympathetic) regulated by centers of the spinal bulb. these vegetative nerves are :

- Baroreceptors:

they are know as the mechanoreceptors located in the carotid sinus and in the aortic arch. They are in charge of sensing the pressure changes by responding to change in the tension of the arterial wall. The mechanism of the baroreflex is a fast response to changes in blood pressure.

- Voloreceptors :

Voloreceptors allow pressure regulation by knowing the volume, and variations in flow in the blood vessels, veins and left atrium of the heart, as well as in the pulmonary circulation. Voloreceptors detect the deformation of the wall with which they act.

- Chemoreceptors :

the location of the Peripheral chemoreceptors is in the carotid and aortic bodies. They are sensitive to changes in tissue concentrations of O2, CO2 and O2 pH. If the blood pressure is very low, the tissue concentration of O2 can fall even when the arterial concentration of O2 is normal simply because the blood flow becomes insufficient to cover the metabolic needs of the chemoreceptor cells. then the activation of the receptors happens, which stimulates the sympathetic vasoconstrictor nerves to try to restore blood pressure.

- The central ischemic response :

there is a reflex encountered When the arterial pressure is less than the intracranial pressure, this reflex is called the “CNS ischemic response” is initiated by the hypothalamus in the brain. The activation of the sympathetic nervous system is by the hypothalamus, causing peripheral vasoconstriction and an increase in cardiac output .

IV-2-2) Medium-term regulation of blood pressure (hormonal regulation) :

Several hormones are involved in regulating blood pressure. They can act relatively quickly (a few minutes) or exercise their full action only in a few hours or a few days.

- Catecholamines :

they are organic compounds synthesized from tyrosine and playing the role of hormone or neurotransmitter. The most common catecholamines are adrenaline and norepinephrine. They are synthesized by the cells of the adrenal medulla. These

hormones work within minutes and cause vasoconstriction and an increase in heart rate and contractility [20].

- Angiotensin aldosterone renin system :

also known as The Renin-Angiotensin-Aldosterone System (RAAS) and it is a hormone system within the body that is essential for the regulation of blood pressure and fluid balance. This system is mostly comprised of the three hormones renin, angiotensin II and aldosterone. essentially it is regulated by the rate of renal blood flow.

IV-2-3) Long-term regulation of blood pressure (regulation of blood volume) :

Little is known about the mechanism that keeps the average blood pressure constant for weeks to years in the human body. one of the elements of control is the long-term regulation of blood volume which helps to keep venous return and cardiac output at a constant level. several renal mechanisms are involved, many of which are under hormonal control.

- Aldosterone: Aldosterone is a steroid hormone. Its major role is to adjust salt and water in the body. this increases blood volume and therefore blood pressure.

- ADH is also called arginine vasopressin. It is a chemical messenger (hormone) made by the hypothalamus in the brain and stored in the posterior pituitary gland. It commands your kidneys how much water to conserve. the ADH continually regulates and balances the amount of water in the blood.

IV-3) Measuring methods :

The study determined whether the systolic and diastolic blood pressures measured simultaneously by direct and indirect methods to provide similar readings for blood pressure response .

IV-3-1) Indirect method :

this type of measurements are often Non-surgical , especially during Pre-hospital, in the operating room but also in intensive care . However, the principles of non-invasive BP measurement and their clinical implications are sometimes overlooked [21]. some of its methods are :

a) Finger cuff method :

This method was first developed by Penaz and works on the principle of the “unloaded arterial wall.” Arterial pulsation in a finger is detected by a photo-plethysmograph under a pressure cuff. the plethysmograph's return is used to drive a servo-loop, which rapidly

changes the cuff pressure to keep the output constant, so that the artery is held in a partially opened state. This technique gives an accurate estimate of the changes of systolic and diastolic pressure when compared to brachial artery pressures. the following about 8hours of continuous monitoring on a single finger, the finger cuff should be re-applied to another finger. for comfort, two finger cuffs may be connected simultaneously to alternate the measurement between two fingers. it permits uninterrupted continuous monitoring up to 72 hours.

b) the auscultatory method :

at first the cuff is inflated to a level higher than the systolic pressure. as a result the artery is completely compressed, there is no blood flow, and no sounds are heard. The cuff pressure is slowly decreased. At the level 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.

even though the auscultatory method using mercury sphygmomanometer is regarded as the 'gold standard' for office blood pressure measurement, widespread implementation of the ban in use of mercury sphygmomanometers continues decreasing the role of this technique .The situation is made worse by the fact that existing aneroid manometers, which use this technique are less accurate and often need frequent calibration.

c) the oscillometric method :

the cuff is inflated over a couple of locations the upper arm or wrist. fuzzy logic is used by the recent techniques to decide how much the cuff should be inflated to reach a pressure about 20 mm Hg above systolic pressure for any individual. the Oscillatory gadgets produces a digital readout and work on the principle that blood flowing through an artery between systolic and diastolic pressures causes vibrations in the arterial wall which can be detected and transduced into electrical signals.

D) Ultrasound method :

The new technique uses ultrasound transmitter and receiver placed over the brachial artery under a sphygmomanometer cuff to make patient-friendly blood pressure measurements at many points in the body. when the cuff is flattened, the movement of the arterial wall at systolic pressure causes a Doppler phase shift in the reflected ultrasound, and diastolic pressure is recorded as a level at which diminution of arterial motion occurs.

IV-3-2) Direct method :

the representation of The direct method is simply the criterion standard and consists of using an intra-arterial catheter to obtain a measurement. which is used more commonly in the intensive care or operative settings. This technique, nonetheless, is not practical due to its invasiveness and its inability to be applied to large groups of asymptomatic

individuals for hypertension screening. since it is most accurate technique it is used to store data for future studies [22].

V) CONCLUSION :

the stored data that have been collected by using the direct method of blood pressure measurements . we are going to make a program that uses this data for diagnostics .

for the classification of blood pressure signals into physiological or non-physiological signals. we have chosen the shape recognition techniques, this will be detailed in the following chapter

Chapter II :
Shape recognition and classification of the acquired data

I) Introduction :

After we have seen the signals that we must classify, we move in this chapter to the tools that we have chosen, specifically the techniques of shape recognition.

there are a lot of algorithms that can work with the obtained data. and many of methods that can be used to analyze and process it . which is relies on the user choices (algorithms and methods) that can lead him exactly to what should be achieved .

in this segment of the manuscript we are going to explain some of this algorithms and methods that can be used to accomplish the desired purpose.

II) The form recognition and classification chain :

Pattern recognition is used to designate a set of techniques and methods aimed at identifying patterns and classifying input data into objects or classes based on key features depending on the category assigned to this pattern. It is considered to be a branch of artificial intelligence that makes extensive use of machine learning techniques. this chain consists with three main steps during the process :

- data acquisition (collection)

- Key features extraction or (descriptors extraction)

- And finally choosing the right classifier

We will see in what follows the development of each block of our shape recognition chain from acquisition to classifier

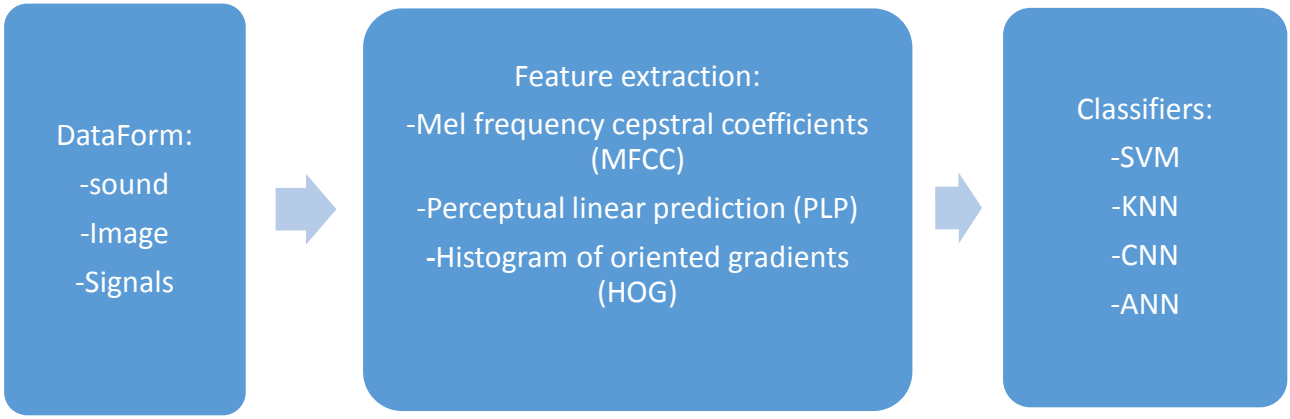


Figure II-0: From recognition chain

II-1) Data acquisition :

II-1-1) Collected data origin :

the data is collected by using the direct (invasive) method to measure the signals . and it is the criterion standard and consists of using an intra-arterial catheter to obtain a measurement. the Commonly used anatomical sites for arterial catheter placement are the radial, brachial, and femoral arteries. but the Catheter insertion in the radial artery is most commonly used because it is technically easy and rarely associated with major complications . there have been a few parameters considered while measuring the signals [23], and that includes :

-the diameter and stiffness of elastic and muscular arteries,

-the peripheral vascular resistance,

-the heart rate and stroke volume.

II-1-2) Data source :

the data source we are going to diagnose later on is from a virtual database . which encloses more than 3000 cases which could be encountered in a clinical study.

this database is basically consists of virtual healthy adults subjects by using a validated one-dimensional numerical model of the arterial hemodynamics. The arterial and cardiac parameters are varied within physiological healthy ranges . in each simulation of these hemodynamic signals (pressure, flow and distension waveforms) stored are available at all arterial locations . focusing on the particular application of central and peripheral biological pulse wave velocities [24].

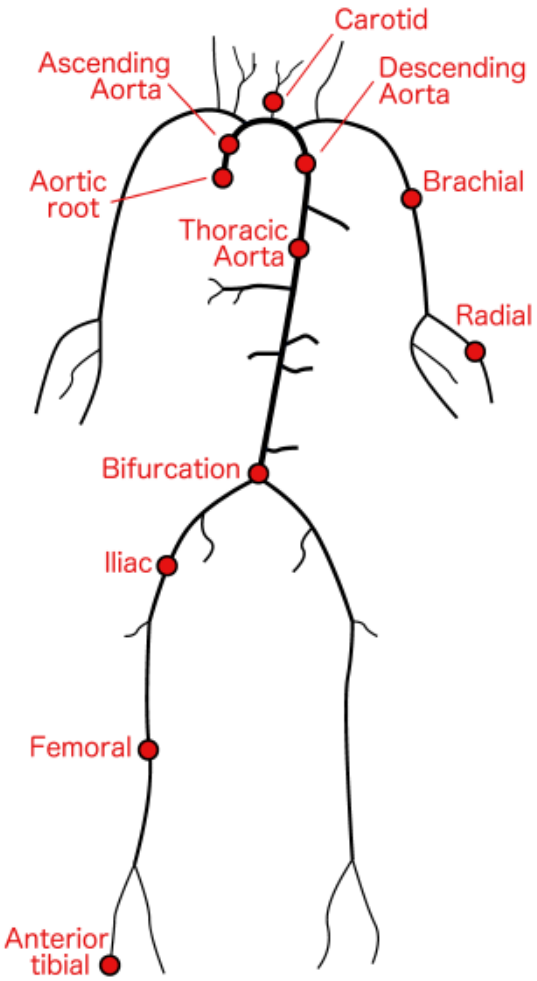


Figure II-1 : highlight of the 11 locations where hemodynamic data is available

The Signals was analyzed using customized Matlab software and it was saved in Matlab formatted binary files (.mat) .

II-2) Features extraction :

presenting characteristic vectors remains the most common and convenient means of data representation for classification. Features extraction is an algorithm in machine learning for classification or recognition. and in large data sets we have a large number of variables that require a lot of computing resources to process. Feature extraction is the name for methods that select and /or combine variables into features in a dataset by creating new features from the existing ones (and then discarding the original measures). The new reduced set of features should then be able to summarize most of the information contained in the original set of measure. In this way, a summarized version of the original features can be created from a combination of the original set [25].

this operation is also useful when you need to reduce the number of resources needed for processing without losing important or relevant information. the data and the machine's efforts reduction in building variable features facilitate the speed of learning and generalization steps in the machine learning process.

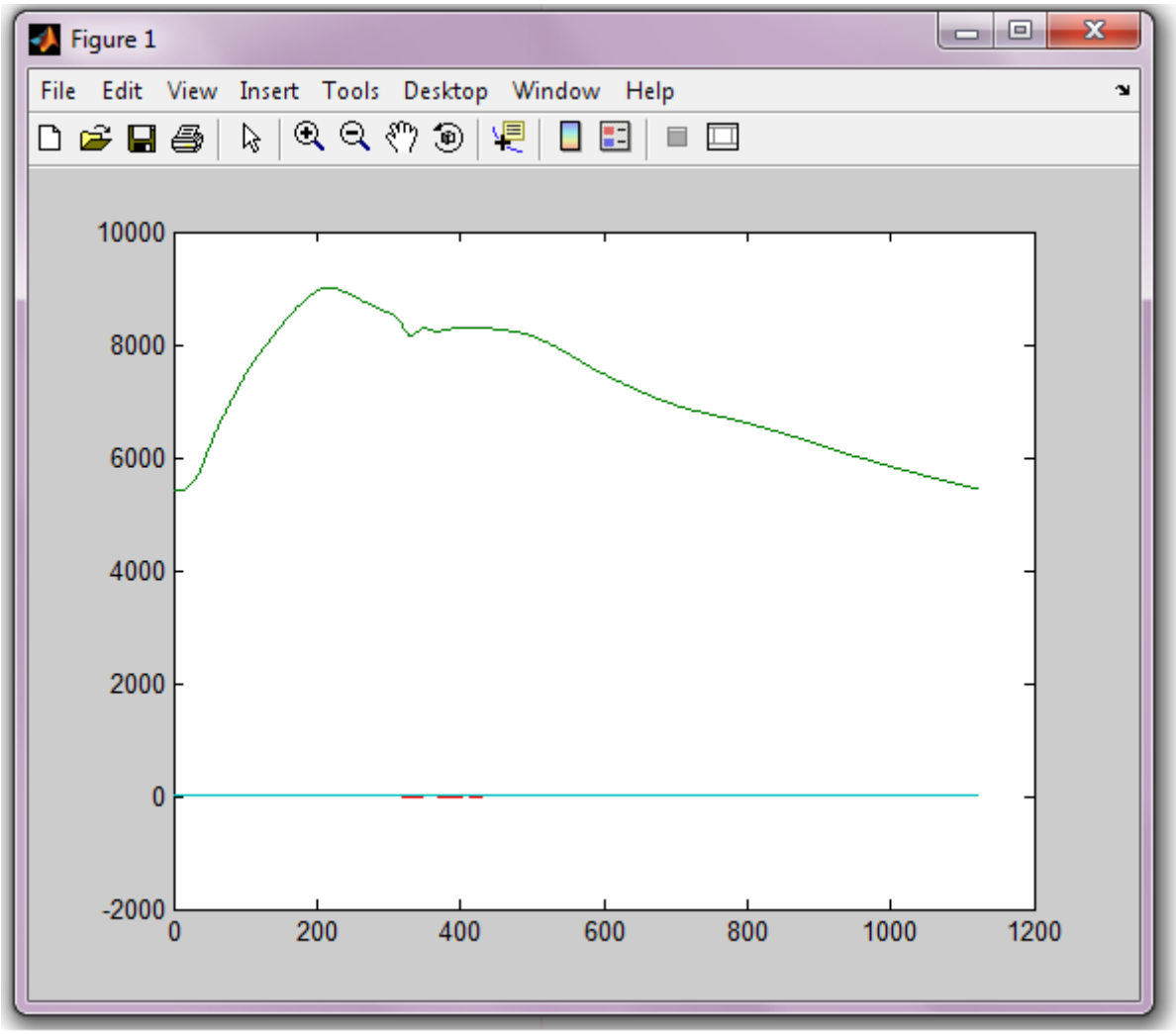


Figure II-2 : example of graphical curve to extract features from

analyzing and extracting features from the data plotted into the graphical representation (curve) simplify the process to distinct a graphical curve from other curves and that makes the classifying them faster and flawless.

In addition to these feature , feature extraction methods may also be categorized by the theoretical type of information they are designed to extract. inside this study, various theoretical feature types were explored.

#	Abbreviation	Theoretical group	Full name	References
1	HOMAV1	Amplitude	First Higher-Order Mean Absolute Value	Phinyomark et al., 2014
2	HOMAV1n	Amplitude	Normalized 1st Higher-Order Mean Absolute Value	Phinyomark et al., 2014
3	HOMAV2	Amplitude	Second Higher-Order Mean Absolute Value	Phinyomark et al., 2014
4	HOMAV2n	Amplitude	Normalized 2nd Higher-Order Mean Absolute Value	Phinyomark et al., 2014
5	MAV	Amplitude	Mean Absolute Value	Phinyomark et al., 2012
6	P2P	Amplitude	Peak to Peak Amplitude	Walter et al., 2014
7	PK	Amplitude	Peak Amplitude	Walter et al., 2014
8	RMS	Amplitude	Root Mean Square	Phinyomark et al., 2012
9	TMNP	Amplitude	Mean Relative Time of the Peaks	Phinyomark and Scheme, 2018
10	TMNV	Amplitude	Mean Relative Time of the Valleys	Phinyomark and Scheme, 2018
11	IQR	Variability	Interquartile Range	Walter et al., 2014
12	R	Variability	Range	Walter et al., 2014
13	SD	Variability	Standard Deviation	Walter et al., 2014
14	VAR	Variability	Variance	Phinyomark et al., 2012
15	IDS	Stationarity	Interal Degree of Stationarity	Cao and Slobounov, 2011
16	MD	Stationarity	Median	Walter et al., 2014
17	MIDS	Stationarity	Modified Integral Degree of Stationarity	Cao and Slobounov, 2011
18	MMNDS	Stationarity	Modified Mean Degree of Stationarity	Cao and Slobounov, 2011
19	SDMN	Stationarity	Standard Deviation of Mean Vector	Walter et al., 2014
20	SDSD	Stationarity	Standard Deviation of Standard Deviation Vector	Walter et al., 2014
21	ApEn	Entropy	Approximate Entropy	Ferenets et al., 2006
22	FuzzyEn	Entropy	Fuzzy Entropy	Al-sharhan et al., 2001
23	SampEn	Entropy	Sample Entropy	Richman and Moorman, 2000
24	ShannonEn	Entropy	Shannon Entropy	Ferenets et al., 2006
25	SpectralEn	Entropy	Spectral Entropy	Ferenets et al., 2006
26	LDF	Linearity	Lag Dependence Function	Walter et al., 2014
27	PLDF	Linearity	Population Lag Dependence Function	Walter et al., 2014
28	CC	Similarity	Correlation Coefficient	Kennedy, 2007
29	MDCOH	Similarity	Median Coherence	Dukic et al., 2017
30	MI	Similarity	Mutual Information	Chen et al., 2003
31	MICOH	Similarity	Modified Integral of Coherence	Dukic et al., 2017
32	MNCOH	Similarity	Mean Coherence	Dukic et al., 2017
33	MMNCOH	Similarity	Modified Mean Coherence	Dukic et al., 2017
34	BW	Frequency	Bandwidth	Walter et al., 2014
35	CF	Frequency	Center Frequency	Walter et al., 2014
36	MDF	Frequency	Median Frequency	Phinyomark et al., 2012
37	MNF	Frequency	Mean Frequency	Phinyomark et al., 2012
38	MOF	Frequency	Mode Frequency	Walter et al., 2014
39	ZC	Frequency	Zero Crossings	Phinyomark et al., 2012
40	MNRR	Variability	Mean Resting Rate	Shaffer and Ginsberg, 2017
41	RMSSD	Variability	Root Mean Square Successive Interval Differences	Shaffer and Ginsberg, 2017
42	slopeRR	Variability	Slope Resting Rate	Shaffer and Ginsberg, 2017

Feature abbreviations are included along with theoretical feature types and an accompanying article with mathematical definition.

Figure II-3: List of different features and their theoretical groups

for example we can extract several features from the list above simply by just observing the curve without going through a complicated process . for example we can extract :

- the maximum value (peak amplitude)

- the period

- the minimum value

- the mean value

- Root mean squared value

- the ascending time of the first peak

- the descending time

a) Peak amplitude (max value) and minimum value :

These values are the largest and smallest values that a signal takes on over some interval defined .The detection of peaks in signals is an important step in many signal processing applications. in our case it is The problem with most of the peak detection algorithms available is that the more generally applicable the algorithm .

In MATLAB we can determine these values by using the min and max commands :

Maximum = max(A) returns the maximum elements of an array.

Minimum = min(A)) returns the minimum elements of an array.

- If A is a vector, then max(A) returns the maximum/minimum of A.

- If A is a matrix, then max(A) is a row vector containing the maximum/minimum value of each column.

b) The period :

A signal is considered a periodic signal if it completes a pattern within a measurable time frame called a period . the period is defined as the amount of time (expressed in seconds) required to complete one full cycle.

A continuous-time signal y(t) is said to be periodic with period T , where T is some positive real number, if :

$y(t + T) = y(t)$ then y(t) is periodic with period T

Similarly, a discrete-time signal y[n] is said to be periodic with period N, where N is some positive integer, if

$y[n + N] = y[n]$, then y[n] is periodic with period N

The commaned used to find it is :

T = mean(diff(t(Y)));

c) The mean value :

the mean value in blood pressure is defined as the average pressure in a patient's arteries during one cardiac cycle. It is simply considered as a better indicator of perfusion to vital organs than systolic blood pressure (SBP) . the detection of this value is around which the signal is “centered” over some interval by :

$$M(s(t)) = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} s(t)dt$$

And for matlab is by ;

MeanV= M(s(t))

c) Root mean squared value:

it is also called the average power. the simple explanation of the RootMeanSquared value (or RMS value) of a signal over some interval is simply the square root of mean squared value. since the squared value of a signal is considered to be the immediate power of the signal. the RMS of one period of the function is equal to the rms over all time of a periodic function .

It is calculated by the formula :

$$RMS(s(t)) = \sqrt{\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} s^2(t)dt}$$

And in matlab by the command :

RMS(s) = sqrt(mean(s.ˆ2))

d) The ascending and the descending time of the first peak :

the ascending time to the first peak is different from a signal to another . its is the time spent to reach highest (maximum) point in a signal curve.

In matlab we can find it by the command :

pks = findpeaks(data)

it returns a vector with the local maxima (peaks) of the input signal vector.

For the the descending time of the peak , it is the time to get from the highest point of the signal to the lowest before rising again.

The command ‘’[pks,locs,widths,~] = findpeaks(data) ‘’ is used to find peaks to isolate the largest peak in the signal

II-3) Learning types in machine learning :

Classification is an assignment that demand the use of machine learning algorithms that learn how to assign a class label to examples from the problem domain. and we can count numerous different types of classification tasks that we may encounter in machine learning and specialized approaches to modeling that may be used for each [26].

Given that the focus of the field of machine learning is “learning" there are three types of leaning techniques for Learning Problems :

- unsupervised learning

- supervised leaning

- Reinforcement Learning

II-3-1) Unsupervised learning :

Unsupervised learning represents a class of problems that involves using a model to describe or extract relationships in data. it is much more complex since the system will have to detect similarities in the data it receives and organize them according to the latter (previous). This way of working has an undeniable advantage in that the categorization is a human resource intensive process. Its elimination, or at least its reduction, removes a barrier to the implementation of the technology.

unsupervised learning works upon only the input data without outputs or target variables. As such, unsupervised learning does not have a teacher or instructor correcting the model, and the algorithm must learn to make sense of the data without this guide. as in the case of supervised learning [27].

There are many types of unsupervised learning. although there are two main problems that are often encountered called

Density Estimation and Clustering

a) Density Estimation :

density estimation is a non-parametric technique and it is the relationship between observations and their probability. it makes use of statistical models to find an underlying probability distribution that gives rise to the observed variables.

the most famous method for density estimation is called the kernel density estimator (KDE). it is a mathematic process of finding an estimate probability density function of a random variable. The attempts to infer characteristics of a population, based on a finite data set [28].

b) Clustering :

The most common unsupervised learning task is clustering .it is the process of grouping similar entities together by finding hidden patterns in unlabeled input data in the form of Clusters . The aim of this unsupervised machine learning technique is to discover identical in the data point and group similar data points together.

assembling identical entities together help profile the attributes of different groups and it will give us insight into underlying patterns of different groups. There are many applications of grouping unlabeled data, for example grouping documents together which belong to the similar topics.

There are many algorithms developed to implement this technique but the Most clustering algorithms are based on two popular techniques known as hierarchical and partitional clustering [29].

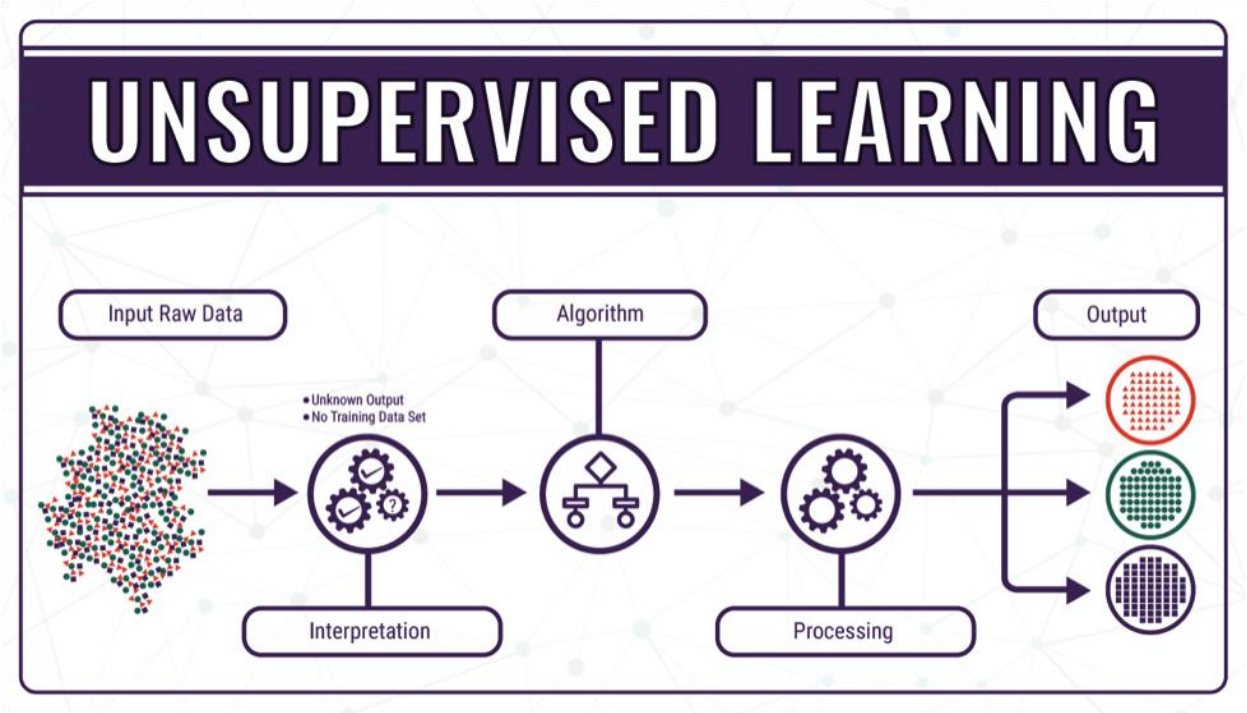


Figure II-4 : an Overview of how unsupervised learning operates

II-3-2) Supervised learning :

the supervised learning uses a set examples each example is a pair consisting of an input object (typically a vector) and a desired output value (also called the supervisory signal). In supervised learning the trainee (typically, a computer program) is learning provided with two sets of data, a training set and a test set. The goal for the trainee is to “learn” from a set of labeled examples in the training set so that it can identify unlabeled examples in the test set with the highest possible accuracy.

the learning algorithm inspects the training data and produces an inferred function that known as a classifier (if the output is discrete) or a regression function (if the output is continuous). The deduced function should predict the correct output value for any valid input object . that way it can identify the elements in the test set and classifies them.

the training set contain an n ordered pairs (x1, y1), (x2, y2), ...,(xn, yn), where each xi is some measurement or set of measurements of a single example data point, yi is the label for that data point.

The try out data in supervised learning is another set of m measurements without labels: (xn+1, xn+2, ..., xn+m). As described above, the aim is to make educated guesses about the labels for the test set by drawing inferences from the training set [30].

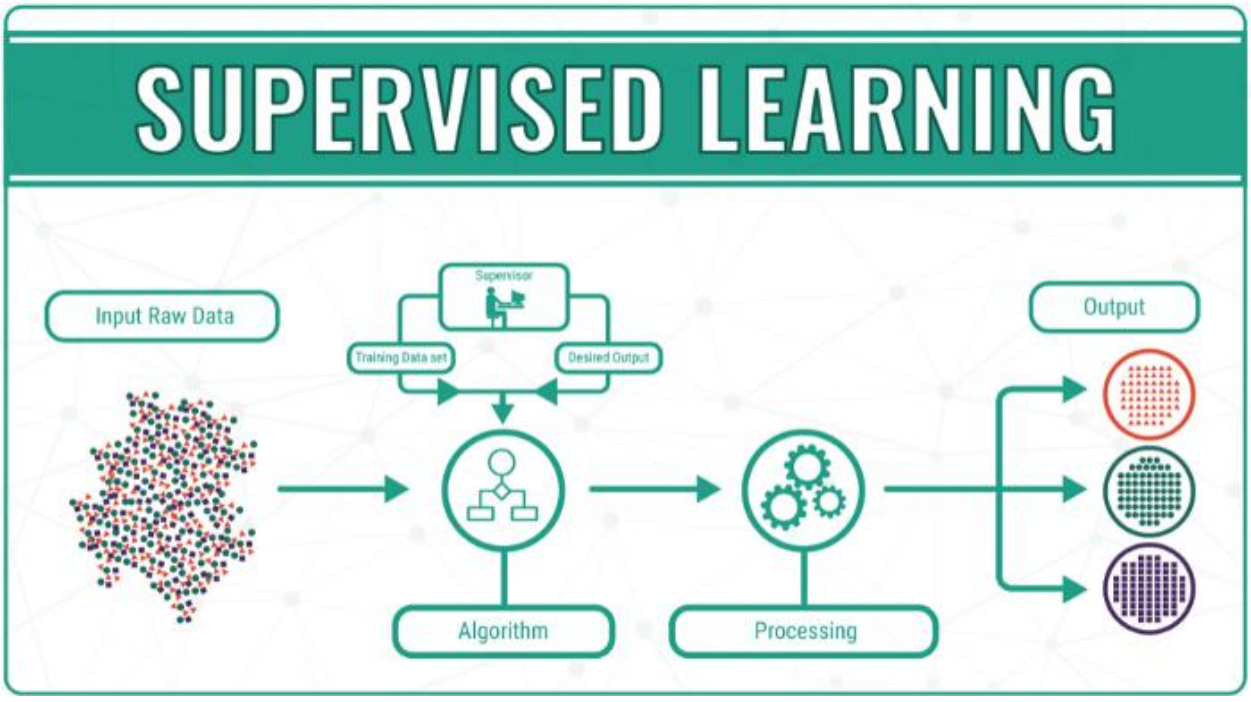


Figure II-5 : over view of supervise learning steps

there are two types of learning algorithms in supervised learning and that includes discriminative algorithm and generative algorithm [31].

- discriminative algorithm :

it also referred to as conditional models, are a class of models used in statistical classification, especially in supervised machine learning. the discriminative modelling studies the P(y|x) i.e, it predicts probability of y(target) when given x(training samples).

- generative algorithm :

unlike the discriminative algorithm. in the case of Generative Model the learning of the joint probability distribution p(x,y). It foretell the conditional probability with the help of Bayes Theorem. the training algorithms used in Generative Model are often simpler and more computationally efficient than discriminative training algorithms.

In final we can say that both of them is predicting the conditional probability). But Both models learn different probabilities [31].

supervised learning is applicable on a lot of different fields like (Bioinformatics Cheminformatics ,,Database marketing ,Handwriting recognition Information retrieval Optical character recognition and more …)

II-3-2) Reinforcement Learning :

Reinforcement learning purpose involve learning what to do—how to map situations to actions— to maximize a numerical prize signal. basically they are closed-loop problems because the learning system's actions influence its later inputs.

besides , the learner is not told which actions to take, as in many forms of machine learning. but instead must discover which actions submit the most reward by trying them out. in most difficult cases actions may not only affect the immediate reward but also the next situation and, all subsequent rewards along with that . that leave us to acknowledge the fact that the three most important distinguishing features of reinforcement learning problems are :

- being closed-loop in an essential way

- not having straight instructions as to what actions to take

- the consequences of actions, including reward signals

reinforcement learning the primary idea is to apprehend the majority of important aspects of the real problem facing a learning agent interacting with its environment to achieve a goal. The agent also must have a goal or goals relating to the state of the environment. the three aspects (sensation, action, and goal) must be included in their simplest possible forms without trivializing any of them.

Reinforcement learning unlike what machine learning researchers call unsupervised learning. They think of reinforcement learning as a kind of unsupervised learning because

it does not rely on examples of correct behavior. reinforcement learning is trying to maximize a reward signal instead of trying to find hidden structure in the case of unsupervised learning [32].

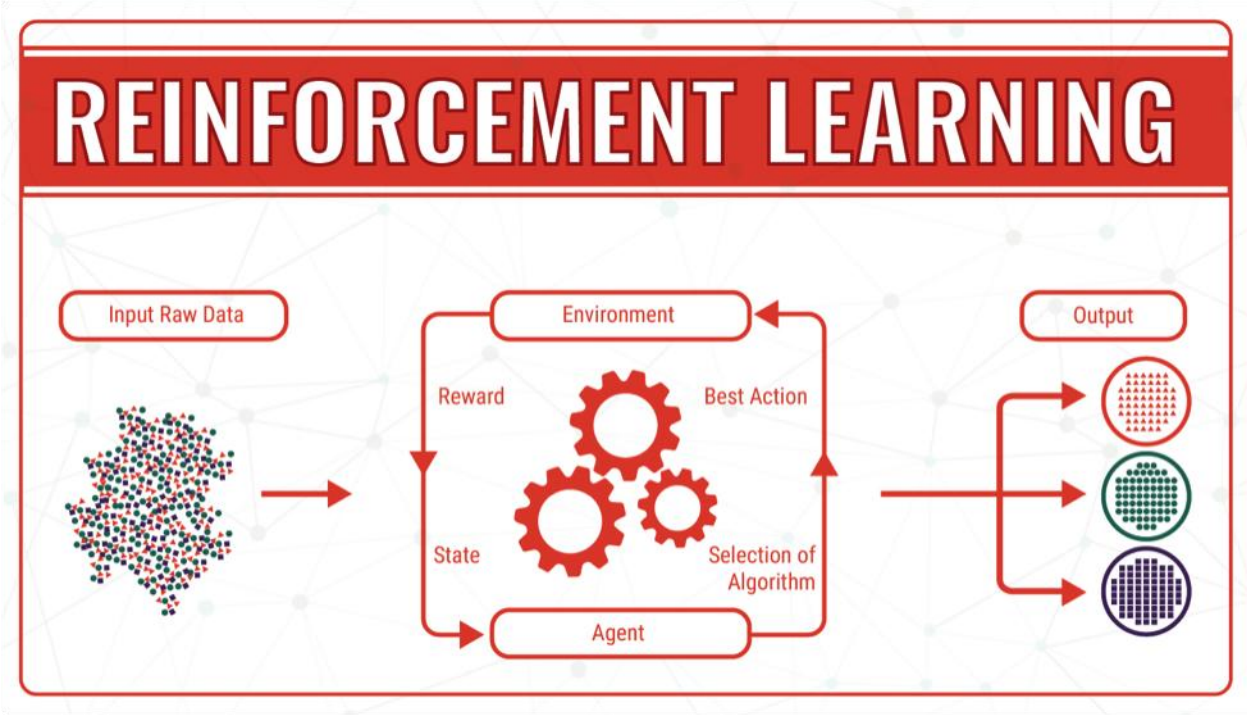


Figure II-6 : reinforcement learning general process

II-4) Classifier choice :

classification is a supervised learning approach in which the computer program learns from the input datasets consisting of hundreds of thousands of instances .and then uses this learning to classify new observations as mentioned previously. This data set may simply be two or multiple classes .

Here we have few types of classification algorithms (classifiers) :

- Support Vector Machines SVM

- Nearest Neighbor KNN.

- Neural Networks ANN

This classifiers are chosen by the dataset nature (biological signal , sound , image, documents ..) [33].

II-4-1) Support Vector Machines (SVM) :

The Support Vector Machine (SVM) are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis .it is a widely used classifier in bioinformatics because of its high accuracy, ability to deal with high-dimensional data such as gene expression, and flexibility in modeling diverse sources of data.

the SVM technique belongs to the general category of kernel methods. which is an algorithm that depends on the data only through dot-products. which can be replaced by a kernel function which computes a dot product in some possibly high-dimensional feature space. the First advantage is the ability to generate nonlinear decision boundaries using methods designed for linear classifiers. the second one is the use of kernel functions allows the user to apply a classifier to data that have no obvious fixed-dimensional vector space representation. The main example of such data in bioinformatics are sequence, either DNA or protein, and protein structure.

many SVM algorithms use different types of kernel functions. These functions can be different types. we can find linear, nonlinear, polynomial, radial basis function (RBF), and sigmoid.

There are two types of margin in SVM that works with these kernel functions (Hard Margin SVM and Soft margin SVM) .Hard margin SVM can work only when data is entirely linearly separable without any errors (noise or outliers). In case there was errors either the margin is smaller or hard margin SVM fails. however the soft margin SVM was proposed to solve this problem by introducing slack variables [34].

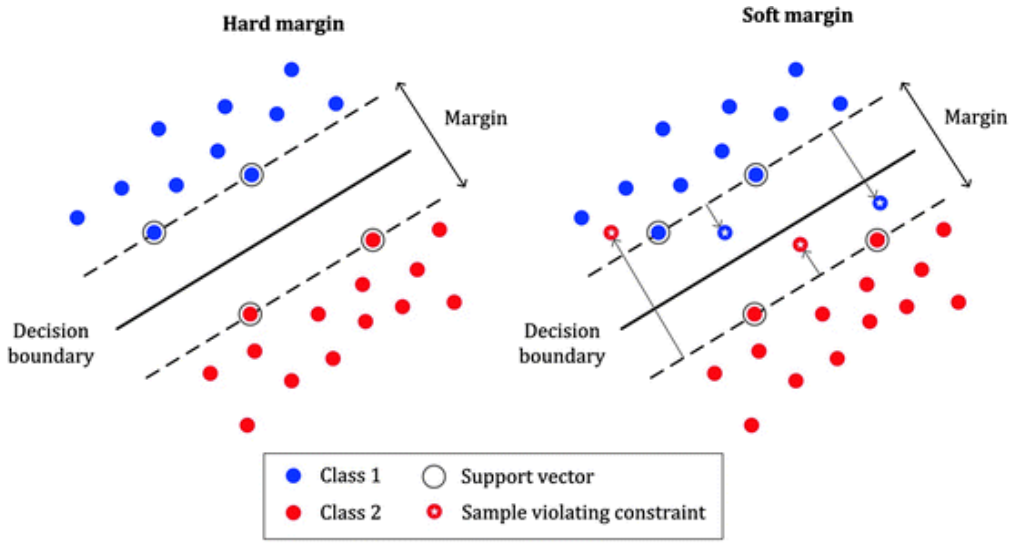


Figure II-7: Soft and hard Margin SVM

II-4-2) Nearest Neighbor KNN :

The kNN (k-nearest neighbors) is one of the most widely used non-parametric classification methods and its algorithms are among the simplest of all machine learning algorithms. The goal is to memorize the training set and then to predict the label of any new instance on the basis of the labels of its closest neighbors in the training set. but it is still bounded due to memory consumption related to the size of the dataset, which makes them impractical to apply to large volumes of data.

a variety of this method have been proposed, such as condensed KNN which divides the training dataset into clusters to be classified, other variations reduce the input dataset in order to apply the algorithm [35].

in numerous cases k-nearest neighbors (kNN) is a simple and effective classification method. However, it presents two major problems when it comes to implementation: first it is a lazy learning method and second it depends on the selection of the value of k . Other boundaries appears in this method corresponding to the high memory consumption which limits its application .

there is a family of methods known as instance based methods which the The kNN algorithm belongs to .

this family is based on the principle that observations (instances) within a dataset are usually placed close to other observations that have similar attributes. this method selects the nearest observations from the dataset in such a way to reduce the distance.

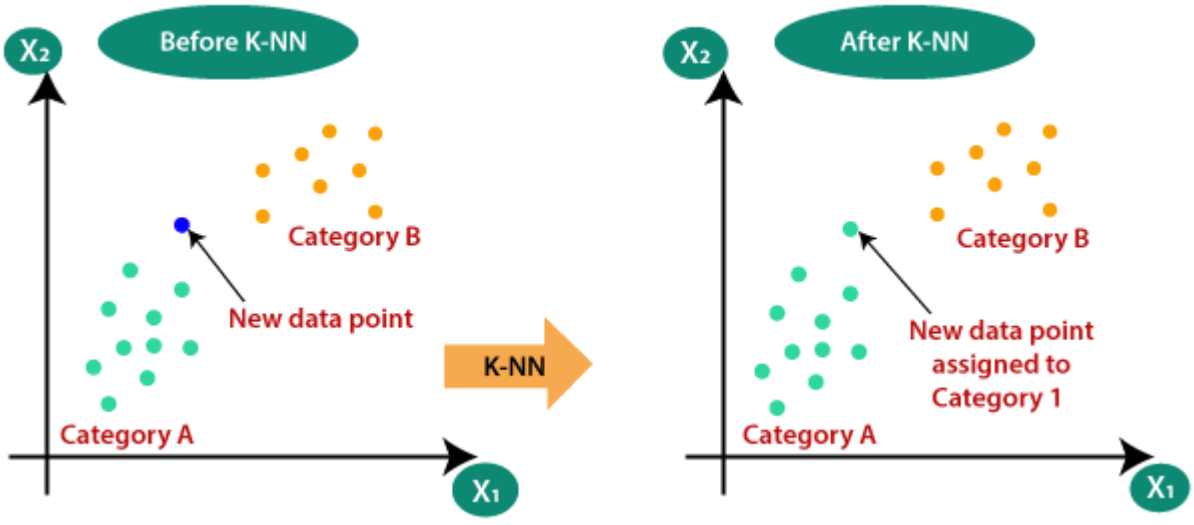


Figure II-8: class assignment of new data using kNN

There are two types of kNN algorithms :

- Structure less NN

- Structure based NN

to work with categorical data . the kNN algorithm, of the type structure less NN is used to defines the basic scheme of the kNN classification method on a dataset with m observations .

due to the nature of Categorical data . it can be compressed in order to decrease the memory requirements at the time of executing the classification. This technique suggests a previous phase of compression of the data to then apply the algorithm on the compressed data. This allows us to maintain the whole dataset in memory which leads to a considerable reduction of the amount of memory required [35].

II-4-3) Artificial Neural Network (ANN) :

An artificial neural network is not a surprise that it is a model of computation inspired by the structure of neural networks we find in the brain. and it can be utilized for machine learning and AI (artificial intelligence) . The ANN is to some expanse modelled on the structure of the biological brain , In simpler models of the brain, it consists of a large number of basic computing devices (neurons) that are connected to each other in a complex communication network, whose special arrangement and linking can be used to solve computer-based application problems The neural network is a research subject of Neuro informatics and part of the artificial intelligence. Neural networks must be trained before they can solve problems for it to be able to carry out highly complex computations.

the Learning of neural networks was proposed in the mid-20th century. It submits an functional learning paradigm and has recently been shown to achieve cutting edge performance on several learning tasks [33].

the commonly used for classification algorithm in data science are Artificial neural networks . They allow you to input new data and find out which label fits best. This have unlimited potential for labeling anything, like customer types or music genres. in scientific fields the classifiers are often used to diagnose the health of equipment, for example identifying it as normal, suspect, or faulty.

4-3-1) Artificial Neural Networks construction :

for problems simplification , the structure and operation of a neural network can be described as follows: First, the abstract model of a neural network consists of neurons,

also called units or nodes. They can harvest information from outside or from other neurons and pass it on to other neurons or output it as a final result. essentially, distinction can be made between input neurons, hidden neurons and output neurons. The neurons that are located in the input collects information in the form of patterns or signals from the outside world. The neurons that are located between the input and output neurons which is the hidden layer maps the internal information patterns. The output neurons transmit information and signals to the outside world as a result. many neurons are connected to each other by what called edges. consequently, the output of one neuron can become the input of the next neuron. relying on the strength and meaning of the connection, the edge has a certain weighting. The stronger the weighting, the greater the influence a neuron can exert on the connection to another neuron [36].

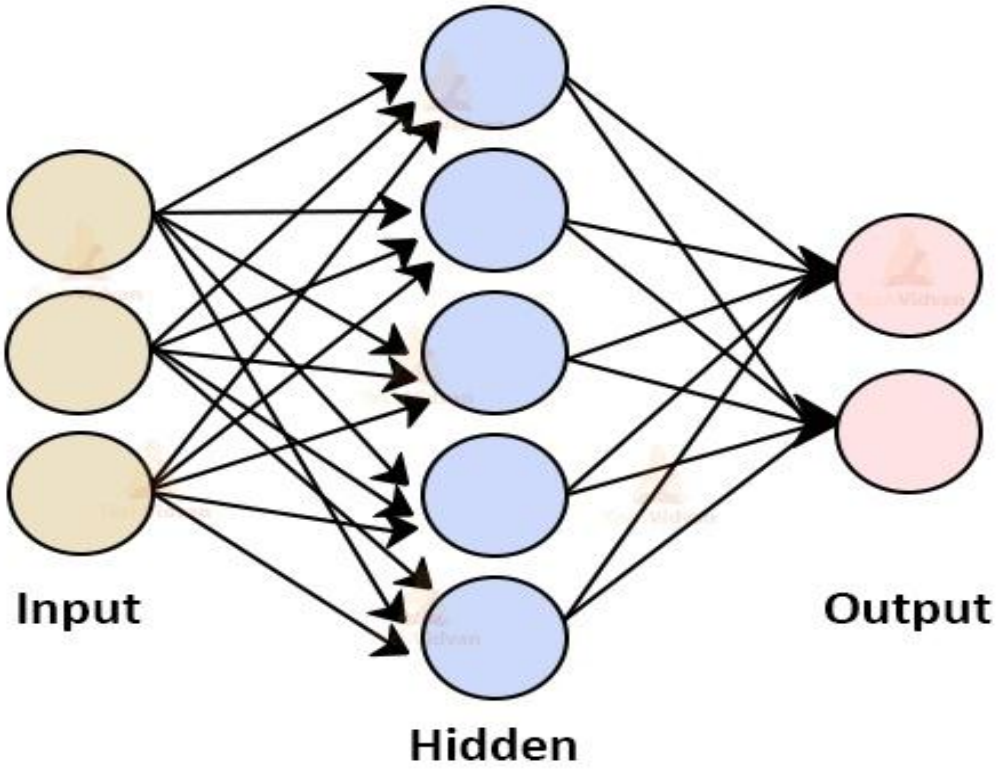
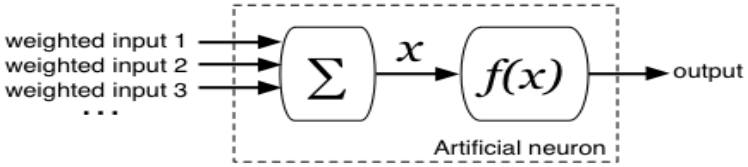


Figure II-9 : Artificial neural network structure

4-3-2) Neuron assignment:

All the neurons are identical in structure, and contain a sum unit and a function unit. The inputs to the neuron are summed to give a single value, x. This is then input to the function, and the output of the neuron is the output of the function, f(x).



There are many functions which can be used in neurons, including the Radial Basis Function or a simple linear function, but the most common is the sigmoid or logistic function, calculated by:

$$f(x)=1/(1+e^{-x})$$

every time it gives a value between 0 and 1, so the output of a neuron can only ever be in the range 0 to 1. And From this information, the result of each output neuron can be calculated . for example

Activation function	Equation	Example	1D Graph
Unit step (Heaviside)	$\phi(z) = \begin{cases} 0, & z < 0, \\ 0.5, & z = 0, \\ 1, & z > 0, \end{cases}$	Perceptron variant	
Sign (Signum)	$\phi(z) = \begin{cases} -1, & z < 0, \\ 0, & z = 0, \\ 1, & z > 0, \end{cases}$	Perceptron variant	
Linear	$\phi(z) = z$	Adaline, linear regression	
Piece-wise linear	$\phi(z) = \begin{cases} 1, & z \geq \frac{1}{2}, \\ z + \frac{1}{2}, & -\frac{1}{2} < z < \frac{1}{2}, \\ 0, & z \leq -\frac{1}{2}, \end{cases}$	Support vector machine	
Logistic (sigmoid)	$\phi(z) = \frac{1}{1 + e^{-z}}$	Logistic regression, Multi-layer NN	
Hyperbolic tangent	$\phi(z) = \frac{e^{z} - e^{-z}}{e^{z} + e^{-z}}$	Multi-layer Neural Networks	
Rectifier, ReLU (Rectified Linear Unit)	$\phi(z) = max(0, z)$	Multi-layer Neural Networks	
Rectifier, softplus	$\phi(z) = \ln(1 + e^{z})$	Multi-layer Neural Networks	

Figure II-10 : types of Activation fonctions

4-3-3) ANN architectures :

there are a variety of different structures Neural networks can have. which description would go beyond the scope of this definition. In principle, a distinction is possible in in feedback networks, feedforward networks and recurrent networks.

a) Feedforward networks :

first the name (feedforward) to a neural network architecture is given when the input signals are fed into the input layer, then, after being processed, they are forwarded to the next layer, just as shown in the following (figure II-10). MLP and radial basis functions are also good examples of feed-forward networks.

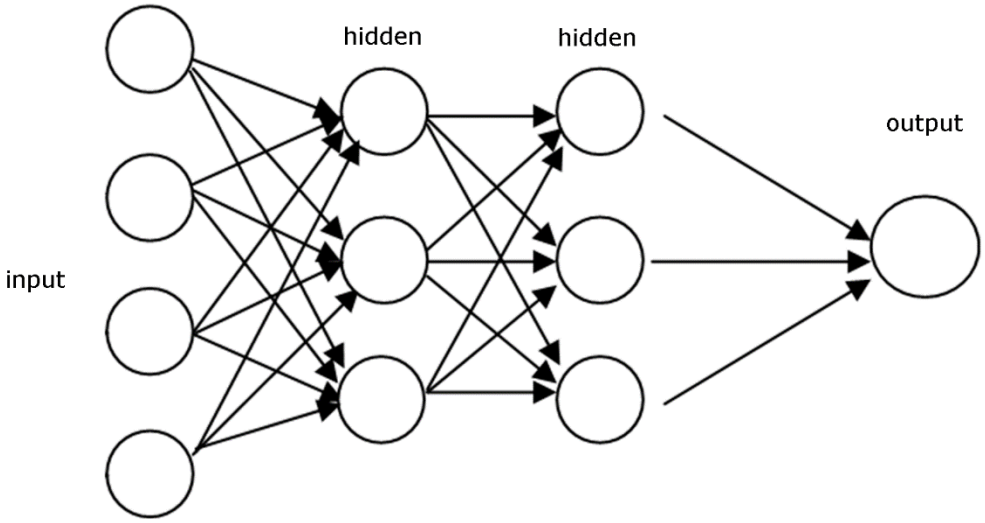


Figure II-11: feedforward network

- MLP :

the MLP stands for Multi-layer Perceptron classifier which in the name itself connects to a Neural Network and it is a class of feedforward artificial neural network (ANN). It is composed of more than one perceptron. They contain an input layer to receive the signal and an output layer that makes a decision or prediction about the input and in between those two a number of hidden layers that are the engine of the MLP. an MLP with one hidden layer are capable of approximating any continuous function.

to supervised learning problems a Multilayer perceptrons are often applied . they use a set of input-output pairs and learn to model the correlation (or dependencies) between those inputs and outputs [37].

- Radial basis function :

Radial basis function networks are a frequently used type of artificial neural network for function approximation problems. they are distinguished from other neural networks due to their universal approximation and faster learning speed. the simplest form is a three-layer feedforward neural network. The first layer represents the inputs of the network the second is a hidden layer consisting of a number of RBF non-linear activation units and the last one corresponds to the final output of the network. Activation functions in RBFNs are conventionally implemented as Gaussian functions [38].

b) recurrent networks :

A variant of the Recurrent Neural Networks with Long Shortterm Memory (LSTM) are enjoying renewed interest as a result of successful applications in a wide range of machine learning problems that involve sequential data.

The main reason to add recurrence in a network is the production of a dynamic behavior, especially when the network addresses problems involving time series or pattern recognition, which requires an internal memory to reinforce the learning process. but still, such networks are very difficult to train and in the end failing to learn.

in the situation of the neural network has some kind of internal recurrence, which means that the signals are fed back to a neuron or layer that has already received and processed that signal, the network is of the type feedback.(Figure II-12)

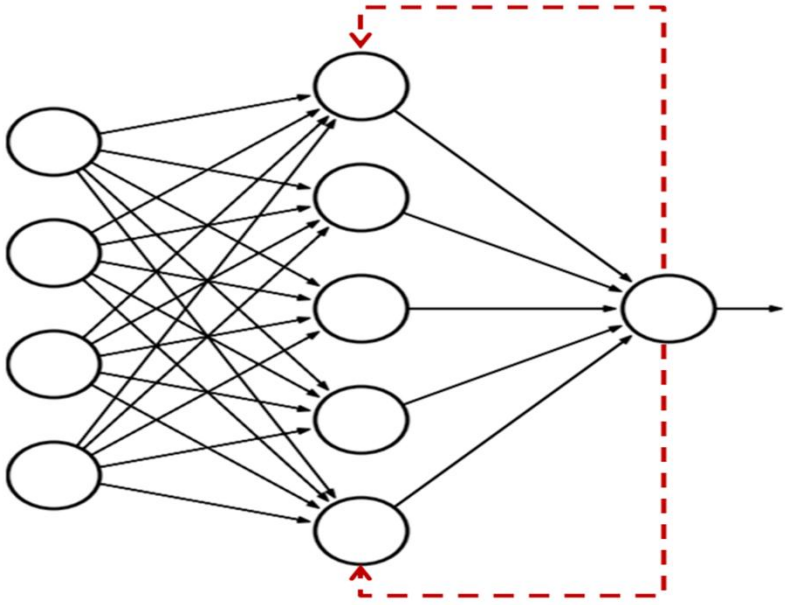


Figure II-12*:* recurrent (feedback) networks

The simplest instantiation of a deep recurrent network arranges hidden state vectors h in a two dimensional grid, where T = 1 . . . T is time and L = 1 . . . L is the depth. The bottom row of vectors at depth zero holds the input vectors xt and each vector in the top row is used to predict an output vector yt. All intermediate vectors h are computed with a recurrence formula . Through these hidden vectors, each output yt at time step t becomes a function of all input vectors up to t, {x1, . . . , xt}. The precise mathematical form of the recurrence varies from model to model [39].

4-3-3) ANN training :

after the neural network has been structured for a particular application, that network is ready to be trained.

the network tell the differentiate between classes if all the neurons are identical is by in the weights assigned to neuron inputs. A characteristic can have a large or small weight, varying the contribution it makes to the sum in any neuron. actually a feature can have a large weight feeding into one neuron and an almost zero weight feeding into another, which means it has a strong influence on the first and practically none on the second.

the sigmoid function means that the neuron's output switches from zero to one when its x value crosses a threshold. it is capable of happening in various ways, such as if one highly weighted input has a high value, or if a collection of medium weighted inputs have high values. the network Training is the process of finding the best values of weights to maximize the accuracy of classification. The weights are updated using :

$$w_i(t+1) = w_i(t) + \Delta w_i(t)$$

$$with \quad \Delta w_i(t) = \eta(-\frac{\partial E}{\partial w_i})$$

$$where \quad \frac{\partial E}{\partial w_i} = -2(t_p - f_p)\frac{\partial f}{\partial u_p}x_{i.p} = -2(t_p - f_p).f_p(1-f_p).x_{i.p}$$

$$\boxed{w_i(t+1) = w_i(t) + 2\eta(t_p - f_p).f_p(1-f_p).x_{i.p}}$$

the designer's creativity control the rules of training. There is numerous algorithms utilized to insert the adaptive feedback required to adjust the weights during training. The technique is backward-error propagation more commonly known as back-propagation is the most repeated technique .

backward propagation of errors or the Backpropagation is an algorithm for supervised learning of artificial neural networks using gradient descent.

A training iteration, is when the network has been shown every sample of training data one time. Training continues over multiple iterations, until the weights reach a steady state value, or a maximum number of iterations is reached [40].

4-3-4) ANN Applications :

The ANNs are quite flexible for adaption to different type of problems and can be custom-designed to almost any type of data representations, they have a broad field of applications compared to other classifiers . such as :

- first Classification, which is the aim is to predict the class of an input vector

- then Pattern matching, which aims is to produce a pattern best associated with a given input vector

- Pattern completion, it is to complete the missing parts of a given input vector

- Optimization, the aim is to find the optimal values of parameters in an optimization problem

- an appropriate action is suggested based on given an input

vectors for Control purpose

-the Function approximation/times series modeling, the goal is to learn the functional relationships between input and desired output vectors;

- and the Data mining is for discovering hidden patterns from data

(knowledge discovery)

it can also be used for clustering, experimental design, mapping [41].

III) Conclusion :

we have chosen the ANN as a classification algorithm (classifier) due its flexibility and adaption with any type of data , and we are going to use it as a last block in our recognition chain to classify the obtained data mentioned before .

Chapter III :
The simulation experiences

I) Introduction :

The aim in this part of the manuscript is to find and extract the best features from the signals of the arterial pressure, that can help us to achieve the highest recognition rate.

first we will introduce the software and the algorithm used to extract those feature . then finally we will talk about the best classifier that can use the extracted features for the signals classification.

After that we will inject the testing results into another algorithm that will determine the recognition rate. Which tells us how successful our network's training was .

In addition we will also make an interface to wrap up our work.

II) The used materials :

in this part there is two types of materials used in our journey. there is the hardware and the software

II-1) hardware:

for the hardware we used laptop with a dual-core intel chip pentium(R) with clock speed of 2.20GHz and powered with 4GB of random memory (RAM)

II-2) software :

for the software part we Programmed under the R2015a version of MATLAB (version 8.5.0.197613) and it is a a fourth-generation programming language and numerical analysis environment. the Uses of MATLAB involve creating user interfaces (UI) and matrix calculations and running algorithms and data visualization and more . this numerical computing environment allows developers to interface with programs developed in different languages, which makes it possible to harness the unique strengths of each language for various purposes.

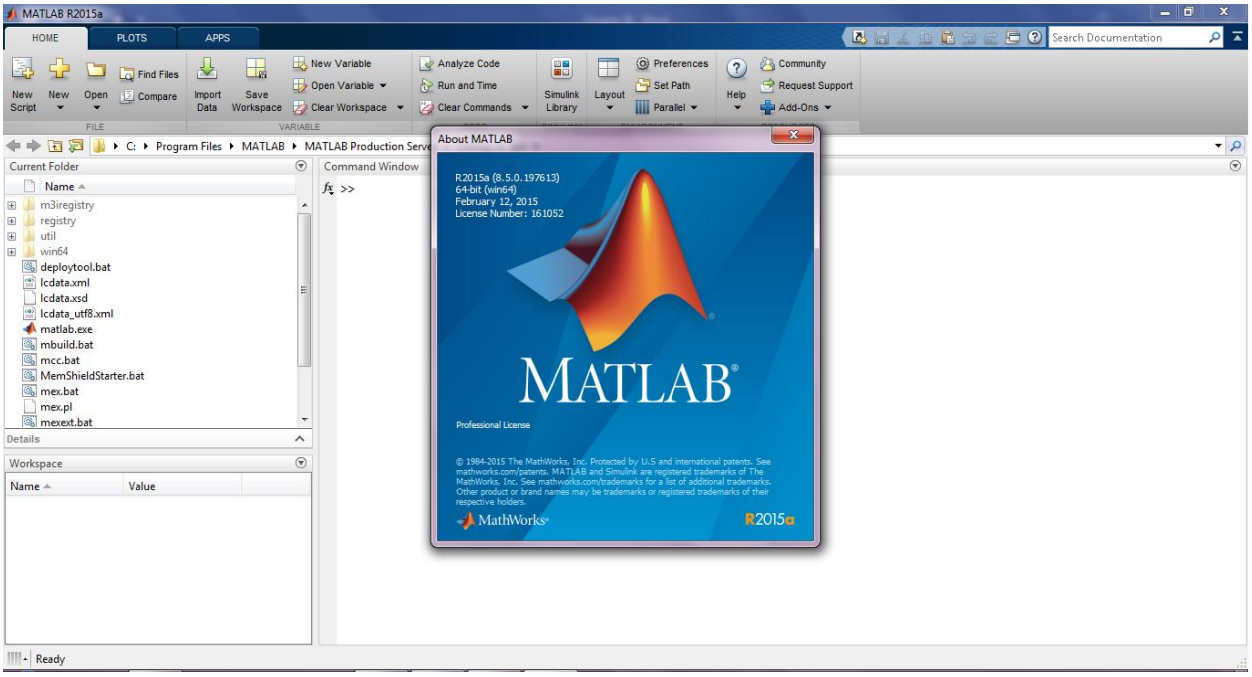


Figure III-1: the interface of MATLAB and version used

MATLAB offers groups of applications that are compiled or saved in toolboxes, so it has proven to be the most suitable software for our applications due to the advantages it offers us in terms of processing and extraction. signal. Parameters required by our study or by the ease with which they generate neural network (ANN) applications for classification.

III) PROCESSING STEPS :

our work consists of Three main steps

- Data collection
- Feature extraction
- Training and Classification

III-1) Data collection :

the used datasets is stored in a virtual database of a of Thousands of Virtual Subjects (A Computational Approach for Assessing Haemodynamics and Cardiovascular Indices and Algorithms)

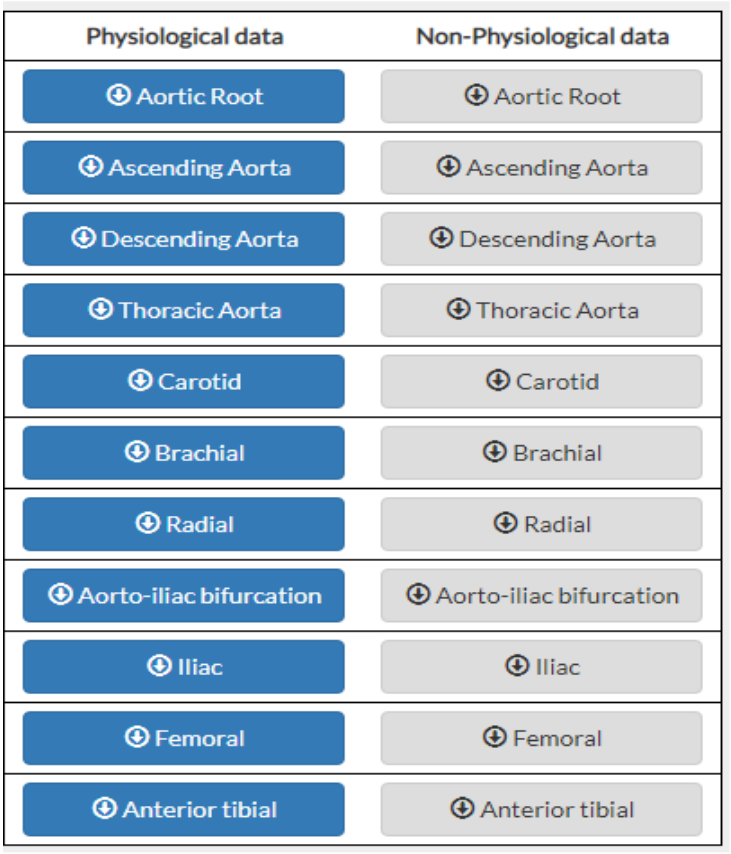


Figure III-2: different arterial pressure sites

This data base is made by three founders :

- British heart foundation
- the EPSRC (engineering and physical sciences research council)
- welcome trust

a) Data types :

the datasets obtained from this virtual data base have two forms :

- physiological

- not-physiological

And they represent a variety of arterial pressure (aortic root , ascending aorta ,descending aorta, carotid...) locations to pick from as shown in (figure III-2) .

we picked the ascending aorta (physiological and not-physiological) to process in our simulation

each ascending aorta dataset have a lot of information stored in a array cell and there is 3325 cells in a mfile form (AORTA_ASC_physio.m and AORTA_ASC_notphysio.m) so we have 6650 cells to process in total

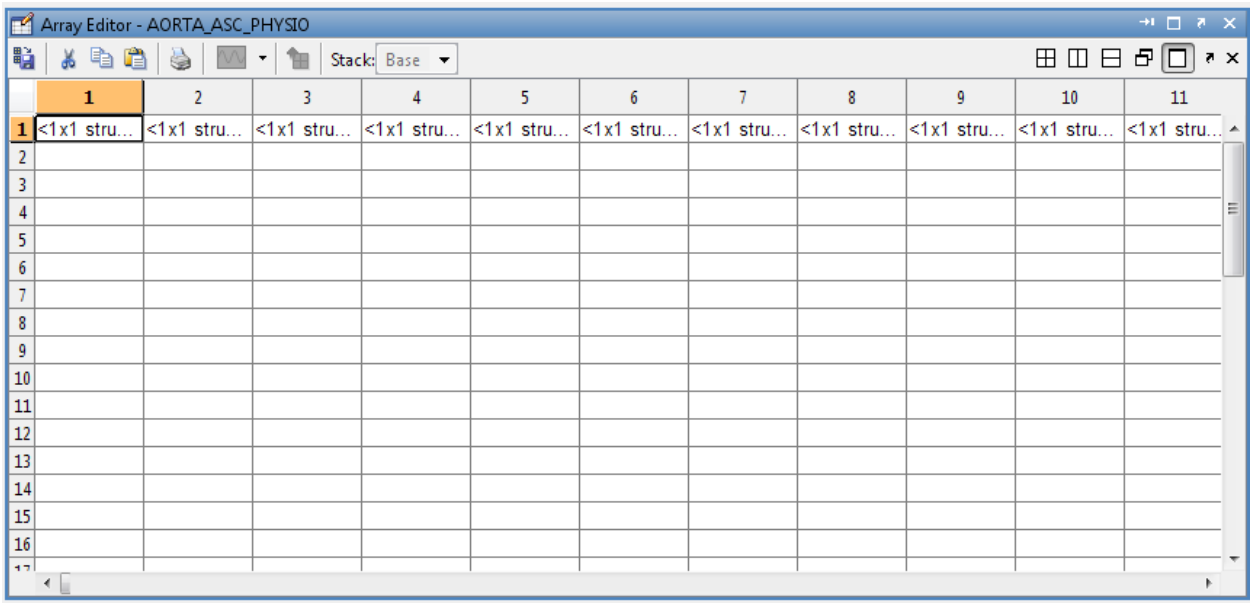


Figure III-3: ascending aorta dataset form

This table consists of 1 line and 3325 columns (1x3325) and each cell contained in the table have its unique informations stored inside and it represents the measurement on a live subject (human trials). and it is represented as the following (figure III-4) .

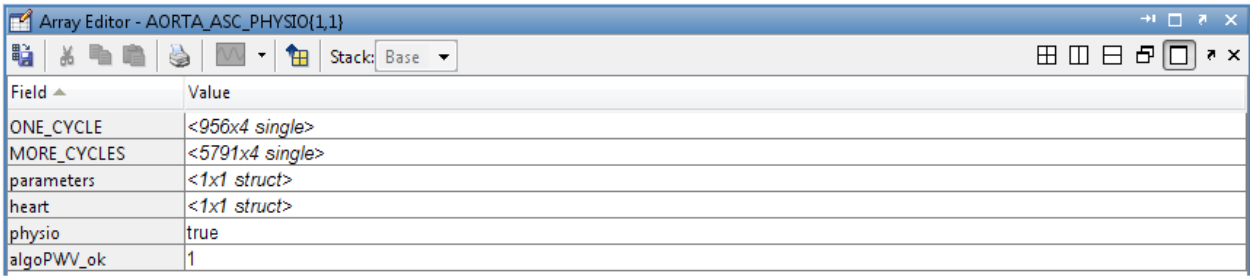


Figure III-4 : representation of the content in each cell of the dataset

b) the obtained signals:

As we can see From the (Figure III-4) we can obtain two kinds of graphical Figures:

- the Figure from “One_Cycle “ represents arterial pressure in the aorta in a single heartbeat

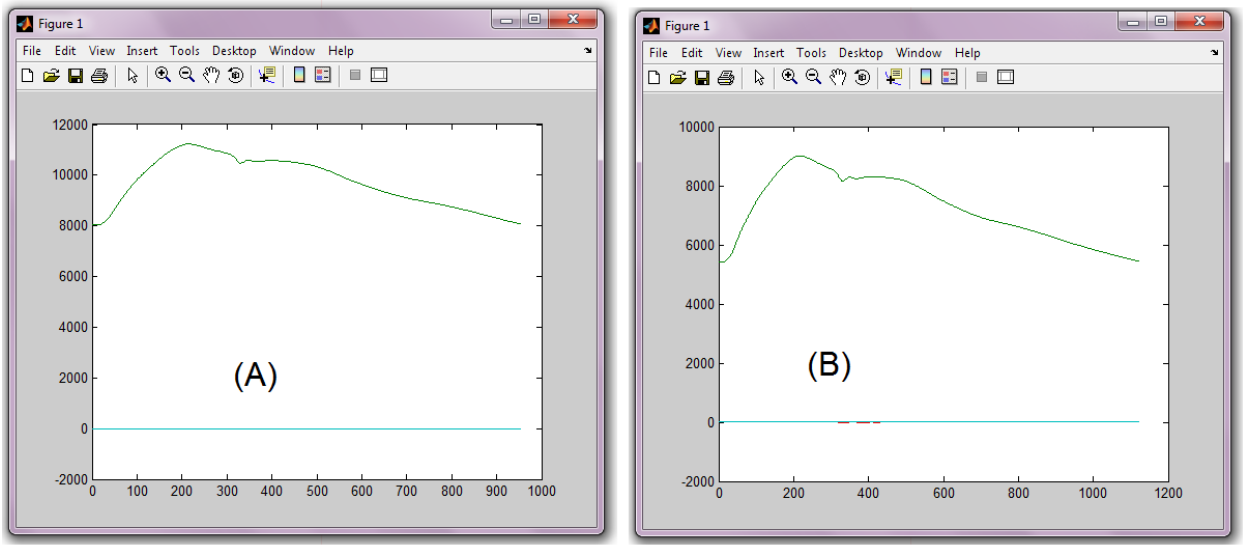


Figure III-5: representation of a Single Heartbeat in the Aorta

(A) : Physiological Data

(B) : Not-Physiological Data

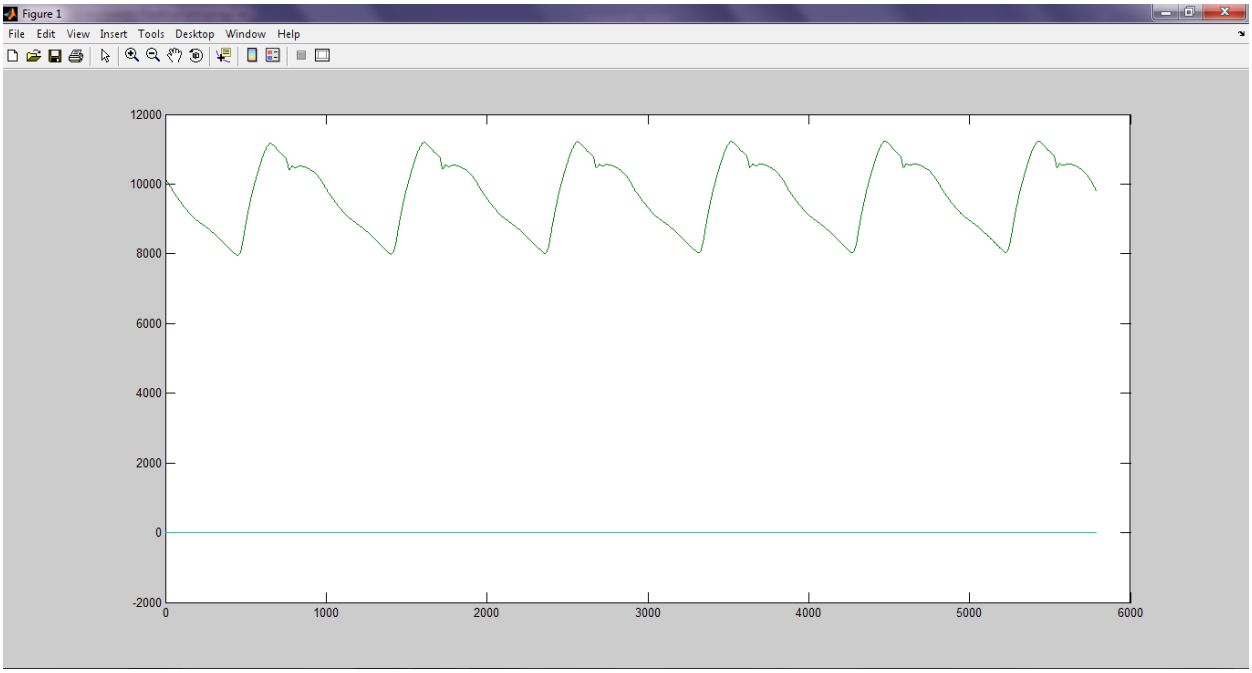


Figure III-6 : representation of heartbeats in the aorta in a 5 seconds duration

This Figure looks like the previous one (figure III-5 (A)) repeated multiple times in a 5 second period (about 6 heartbeats).

And is taken from a single human of 3324 other subjects . so it will be different every time we take the same information to create a graphical Figure from the others .

The same thing is going to be noticed if we try to obtain a figure of 5 seconds heartbeats on the 'Not-Physiological ' Data of the same cell as (figure III-6 (B))

As a result we can use the Single heartbeat in our studies for classification purposes to come up with the wanted results .

III-2) Features Extraction :

In pattern recognition and machine learning, a feature vector is an n dimensional vector of numerical features that represent some object. Many algorithms in machine learning require a numerical representation of objects, since such representations facilitate processing and statistical analysis.

III-2-1) Feature Vector creation :

In this part We need to transform the information in every cell in the dataset to a Vector with four lines called "Feature Vector ". every time we extract a feature it will be placed in one of those lines .

After importing the Dataset to MATLAB we had to develop an Algorithm that could collect all the data we needed stored inside it.

to collect the data in a single cell array we used the command :

```
x1=AORTA_ASC_PHYSIO{1,1}.ONE_CYCLE;
```

This command Has describe 3 parts :

- First it's the ''AORTA_ASC_PHYSIO'' part of the command . and it locates which dataset to collect the information from.

- second part " {1,1}" is related to the first which specifies a single cell contained in the dataset of 3325 cells

- the third part as shown in the (Figure III-4) ".ONE_CYCLE" for example . and it select the tab we use to get the informations .

As shown in the (Figure III-4) both ''one_cycle'' or ''more_cycles'' have four columns

So if we run the command for example of the ‘’one_cylcle’’ we will get :

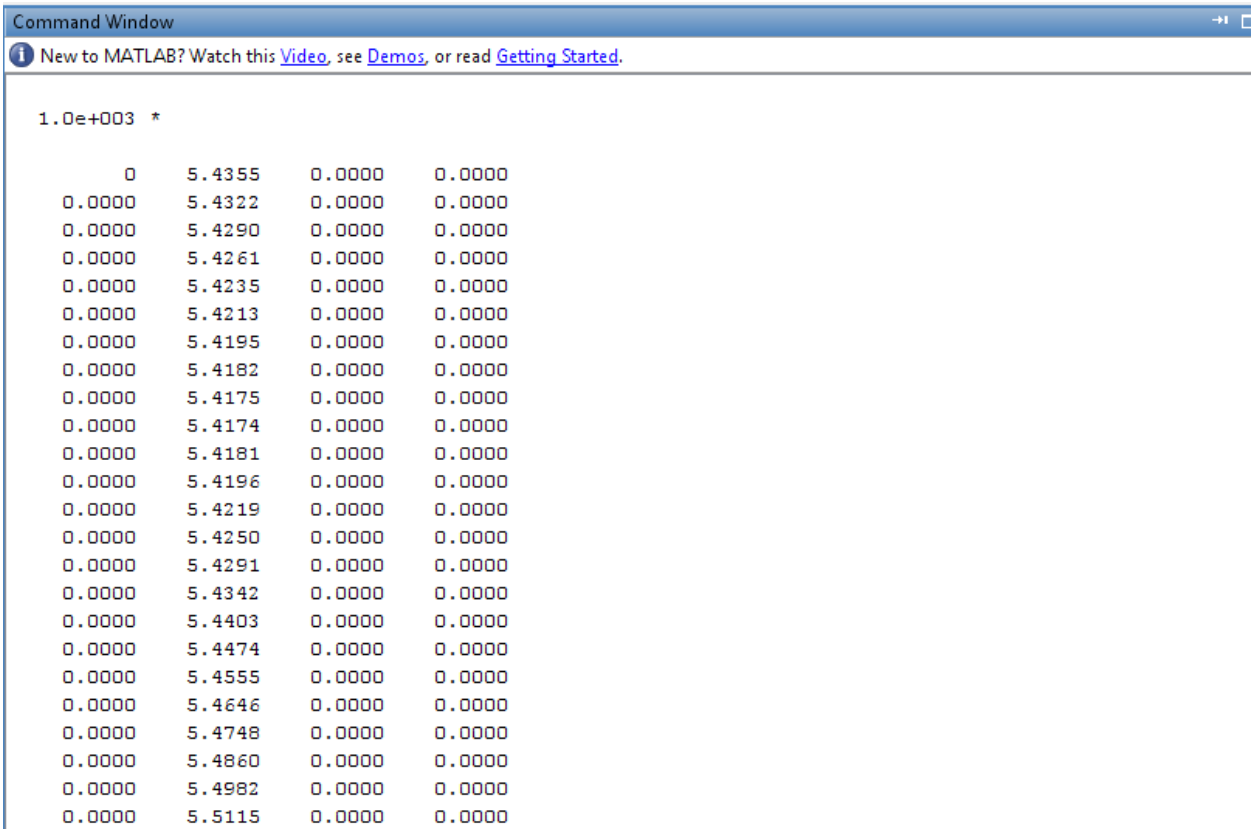


Figure III-7 : the information in a single cell

And After calling a specific cell we can use many commands to extract any wanted feature. in our case we chose 4 commands to extract (the minimum and the maximum Value and the peak factors and the effective value) we used the commands as follows :

- The Minimum and the Maximum Value :

```
x1=AORTA_ASC_PHYSIO{1,1}.ONE_CYCLE
Vm1=max(max(x1))
vmin1=max(min(x1))
```

The First command as we explained before is the data source selection.

Following after that is the maximum command , its usually written (Vm1 = max(x1)).

But as u can see we added another ‘’max()’’ , and u might be wondering why we used it

Well . If we launched the command without adding ‘’the extra max()’’ we will get four values like this :

```
Vm1 =

  1.0e+003 *

    0.0011    9.0110    0.0000    0.0000
```

and that’s due to our data nature (Figure III-7) . so we needed to edit the original maximum value command to get a single value :

```
Vm1 =

  9.0110e+003
```

- the standard deviation :

the third feature we could extract from the data base we have is the effective value. we chose this feature because it can distinguish a signal from different classes

it can be extracted by the following command :

```
V1=max(std(AORTA_ASC_PHYSIO{1,k}.ONE_CYCLE))
```

The function “STD” returns the standard deviation in the case of a vectors . For matrices, it is a row vector containing the standard deviation of each column.
The extra ‘’max’’ function we added at the beginning of the command is for the same reason we explained in the case of minimum and maximum values .

- Crest factor :

Crest factor is a characteristic measurement of a signal. It is the ratio between the amplitude of the signal peak and the RMS(Root mean square) value of the signal. We picked it to be last feature to form out feature vector by using the command :

```
F1=max(V1)/std(V1)
```

- Feature vector :

The final step in this process is to put the features we extracted before to form what we call a feature vector .

For collecting the information in a vector we use command :

```
vp3=[Vm1 ; vmin1 ; V1 ; F1 ]
```

this command will form the vector looking like this :

1.2224e+04
8.1186e+03
1.2774e+03
1.4142

III-2-2) Matrices formation :

The first step in feature extraction is essentially extracting the feature and making a vector out of them . but that was in the case of only one array cell . and we have 3000 cells so that means we need to make a matrix with a size of (4x3000). 4 lines that represents the features and 3000 column that represent the measurement cases.

Making this matrix with the size of (4x3000) manually is almost impossible and it is time consuming because the development of an algorithm that can collect all the manually entered data could take days and in case of a failure u need to repeat it from the start .

So we had to figure some easiest method that can get us the matrix we want and without any error that can be encountered . and solve them faster and more efficient if there were any.

We thought that a loop algorithm is good for our case. A loop that can make a matrix with the size we want for our classification process

The loop we come up with looks like this :

```
for k=1:3000
k=k+1

end
```

what this loop does is: it repeat it self 3000 times and it increments by one step. And every time it passes from a cell to another from the dataset it creates a feature vector of every cell and saves them in order.

Finally it will make the matrix of (4x3000) with no errors what so ever.

In the result matrix is in (the Figure III-8)

vp2

4x3001 single

	2988	2989	2990	2991	2992	2993	2994	2995	2996	2997	2998	2999	3000
1	1.7097e+04	1.3988e+04	1.6819e+04	1.7845e+04	1.5140e+04	1.9013e+04	1.6112e+04	1.3203e+04	1.5790e+04	1.3406e+04	1.1011e+04	1.7309e+04	1.4670e+04
2	8.6678e+03	7.1599e+03	5.5997e+03	7.1315e+03	6.1281e+03	8.8779e+03	7.5741e+03	6.2880e+03	8.5619e+03	7.3275e+03	6.1044e+03	1.0514e+04	8.9476e+03
3	2.7028e+03	2.1936e+03	3.5196e+03	3.3936e+03	2.8602e+03	3.2553e+03	2.7487e+03	2.2285e+03	2.2417e+03	1.8899e+03	1.5297e+03	2.1257e+03	1.7954e+03
4	5.4183	5.4192	5.4174	5.4162	5.4165	5.4157	5.4162	5.4171	5.4180	5.4187	5.4187	5.4196	5.4201
5													
6													
7													
8													
9													
10													
11													
12													

Figure III-8 : The Result Matrix

III-2-3) Input organization :

After the matrix is been created there is one more step before starting the learning process for our network .

What we did in this step in particular is we associate every column in the matrix with it class. This way it will help the recognition in the testing procedure .

after loading the matrix we need to split it into two parts

- the first part is for the learning , which represents about 70% of the matrix and we call it “trainmatrix”

- the second one is for testing (testmatrix) and it is what is left in the matrix (30%)

You can declare the size of the secondary matrix from the original matrix by using the following command :

```
SM=OM(A:B,C:D);
```

SM : secondary matrix

OM : original matrix

A and B : is the number of where u want the range to Start (A) and to End (B)

C and D: is the Range of the columns u want in the secondary matrix . Start (C) and to End (D)

Following the “trainmatrix” creation we needed to create its corresponding class . and because we have two classes we can identify them by using a binary code ([1 0] for the first class and [0 1] for the second class) .

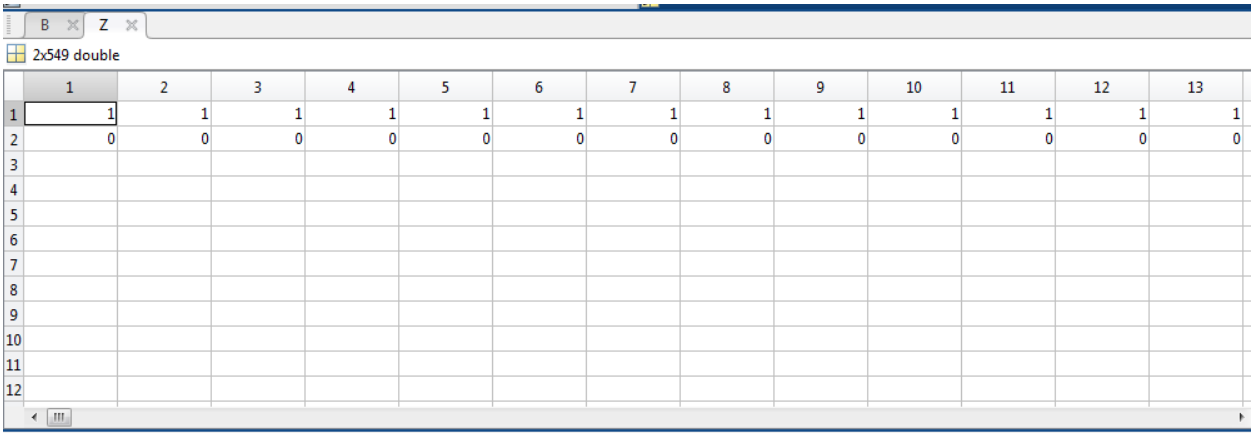
We inserted two lines that represent the class in the “trainmatrix” in both classes . But before doing that its required to have a matrix of the same size as the “trainmatrix” that contain the class:

- `cnt=size(trainmatrix,2)` : this command allows us to copy the size of the “trainmatrix”

- `aa=[1 0]` : the creation of the class binary code

- `classmatrix = repmat(aa,cnt,1)` : this creates a large matrix consisting of an cnt-by-1 tiling of copies of aa

as a result we will have the classmatrix looking like this :



	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													

When its ready we can use one more command to have our trainmatrix associated with its class :

```
trainclassone=[Trainmatrix,Classmatrix]
```

6x2099 single

	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085
1	1.9250e+04	1.5735e+04	1.8312e+04	1.6167e+04	1.3735e+04	14979	11287	1.4987e+04	1.7664e+04	1.2293e+04	1.9300e+04	1.5306e+04	1.3015e+04
2	7.8367e+03	6.5118e+03	6.7680e+03	8.1228e+03	6.9720e+03	5.6581e+03	5.8285e+03	8.5722e+03	10048	7.1052e+03	1.2132e+04	7.1833e+03	6.1910e+03
3	3.6700e+03	2.9660e+03	3.7282e+03	2.5289e+03	2.1255e+03	3.0107e+03	1.7151e+03	2.0228e+03	2.4030e+03	1.6348e+03	2.2781e+03	2.5594e+03	2.1497e+03
4	5.3507	5.3504	5.3457	5.3466	5.3479	5.3474	5.3482	5.3495	5.3506	5.3513	5.3525	5.3534	5.3547
5	1	1	1	1	1	1	1	1	1	1	1	1	1
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7													
8													
9													
10													
11													
12													

6x2099 single

	1535	1536	1537	1538	1539	1540	1541	1542	1543	1544	1545	1546	1547
1	1.3780e+04	1.7769e+04	1.5141e+04	1.2475e+04	1.8770e+04	1.3153e+04	1.9912e+04	2.0972e+04	1.7838e+04	1.4656e+04	2.2236e+04	23689	2.0224e+04
2	5.5503e+03	5.1599e+03	4.5045e+03	3.8559e+03	6.6160e+03	4.8165e+03	8.3354e+03	6.5722e+03	5.6753e+03	4.7875e+03	8.3976e+03	1.0500e+04	5.6662e+03
3	2.5454e+03	3.9088e+03	3.2909e+03	2.6611e+03	3.7903e+03	2.5903e+03	3.6559e+03	4.4886e+03	3.7831e+03	3.0622e+03	4.3665e+03	4.2227e+03	4.5578e+03
4	4.9870	4.9872	4.9884	4.9901	4.9905	4.9921	4.9928	4.9914	4.9919	4.9933	4.9923	4.9917	4.9901
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	1	1	1	1	1	1	1	1	1	1	1	1	1
7													
8													
9													
10													
11													
12													

Figure III-9 : the training set matrices of the two classes

III-3) Training and Classification :

The final steps of our simulation is to teach our network about the classes we have and how to identify them . the two main procedures are :

- learning (teaching)

- classification (testing)

III-3-1) Learning :

When we have our two training matrices ready for use we need to prepare them for the learning procedure . which require them to be a randomized feature victors to used them as an input in the neural network . we split this into three parts :

- randomizing the matrices , create the input and the target , and finally the training

- **randomizing the matrices:**

in this part we need to group the two matrices together . but we need them to be in a randomized order . for example the first two feature vectors are from the first class and the third is from the second class and it goes on randomly like this .

the command used to achieve this are :

```
trainfnl=[trainclass1,trainclass2]

n=size(trainfnl1,1);
```

these two commands group them together in order. and after that it uses the result matrix to determine the size we need later on .

```
index=randperm(n);
```

what this function do is returns a vector containing a random permutation of the

integers 1:N. For example:

randperm(6) might be [2 4 5 6 1 3]. It can result in a numerous combination every time we run this command .

we used the result combination to create the wanted matrix by using a loop that looks like the following code :

```
for cnt1=1:n ;
    tmp(cnt1,:)=trainfnl1(index(cnt1),:);
end;  %for cnt1
 train1=tmp;
```

- n: is the size of the grouped two matrices
- trainfnl1 : is the grouped matrices in order
- index(cnt1): is randomizing the vectors of the grouped matrices
- train1: the randomized matrix that contain both classes

The following figure represents the result matrix

6x4198 single

	63	64	65	66	67	68	69	70	71	72	73	74	75
1	19963	1.1380e+04	1.9240e+04	1.5340e+04	1.6823e+04	1.7079e+04	1.2643e+04	1.6569e+04	1.7610e+04	1.4290e+04	1.1848e+04	1.5187e+04	1.6980e+04
2	231e+03	5.3507e+03	9.9340e+03	9.2218e+03	1.3423e+04	8.2625e+03	7.7080e+03	1.2154e+04	9.3873e+03	8.2078e+03	5.8671e+03	3.1226e+03	9.5728e+03
3	791e+03	1.9064e+03	2.9715e+03	1.9463e+03	1.0689e+03	2.7384e+03	1.5593e+03	1.3902e+03	2.5958e+03	1.9031e+03	1.7941e+03	3.8040e+03	2.1906e+03
4	5.2095	5.1820	5.4460	5.3622	6.3234	4.8112	5.1179	5.3548	5.3950	4.8655	4.6030	4.3721	4.4957
5	0	0	1	1	0	0	0	1	1	0	0	0	0
6	1	1	0	0	1	1	1	0	0	1	1	1	1
7													
8													
9													
10													
11													
12													

Figure III-10: randomized matrix for training input

As we can see It is randomized by the two classes we mentioned before

- **the input and the target creation :**

before the training process begin we need to set a target matrix and a training sample matrix from the matrix we got previously “train1”. due to our network requirements.

and even when we set the training sample every feature vector will have its matching class in the target matrix .

2x4198 single

	1	2	3	4	5	6	7
1	1	1	0	0	1	1	1
2	0	0	1	1	0	0	0
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

4x4198 single

	1	2	3	4	5	6	7
1	18609	1.4393e+04	16283	1.4369e+04	13113	1.3802e+04	1.6306e+04
2	7.7310e+03	6.4814e+03	1.3137e+04	4.5963e+03	7.0188e+03	1.0545e+04	1.1123e+04
3	3.4922e+03	2.4829e+03	1.0161e+03	3.0345e+03	1.8792e+03	1.0553e+03	1.6421e+03
4	5.4286	6.0447	6.1827	4.4317	6.0002	5.3415	5.3484
5							
6							
7							
8							
9							
10							
11							
12							

Figure III-11 : the target and the training sample ready for processing

- **Neural Network training :**

As we explained in the previous chapter an ANN network have a lot of algorithms to use. And in our situation we thought that the Feedforward network is suitable for our cause .

To use the Feedforward network. First we need to define the network for training.

That can be achieved by setting up the input and the target and how many hidden layers we use and their sizes (the containing neurons), and finally the raining function.

We can also configure some settings during the training process to obtain the best results in the testing procedure. Like the Maximum number of epochs to train and the Performance goal.

After we finish the network definition we can start training by using the following command:

```
net = train(net,X,T);
```

net : the defined feedforward netwrok

X: is the trainSimple

T : is the target

After we run this command we can visualize the training performance . and the obtained feedforward network.

The following Figure shows the obtained network

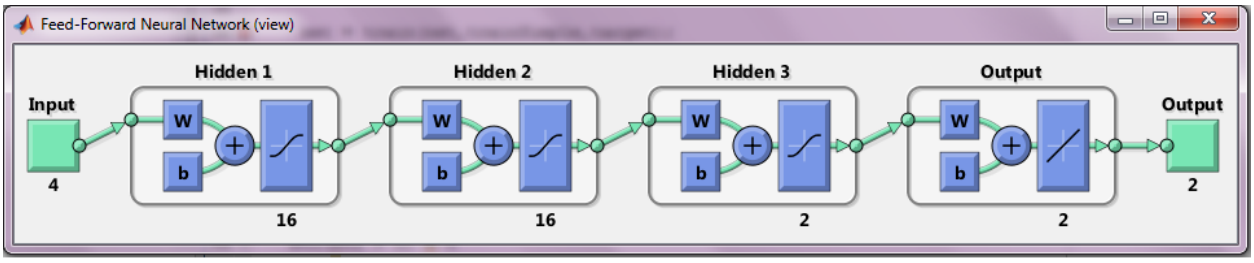


Figure III-12 : FeedForward network layers

Four inputs : represents the four features contained in the feature vectors.

Two outputs : represents the two classes .

we used three hidden layers to get the wanted results in its best .

the next figure shows the training process performance along with its validation

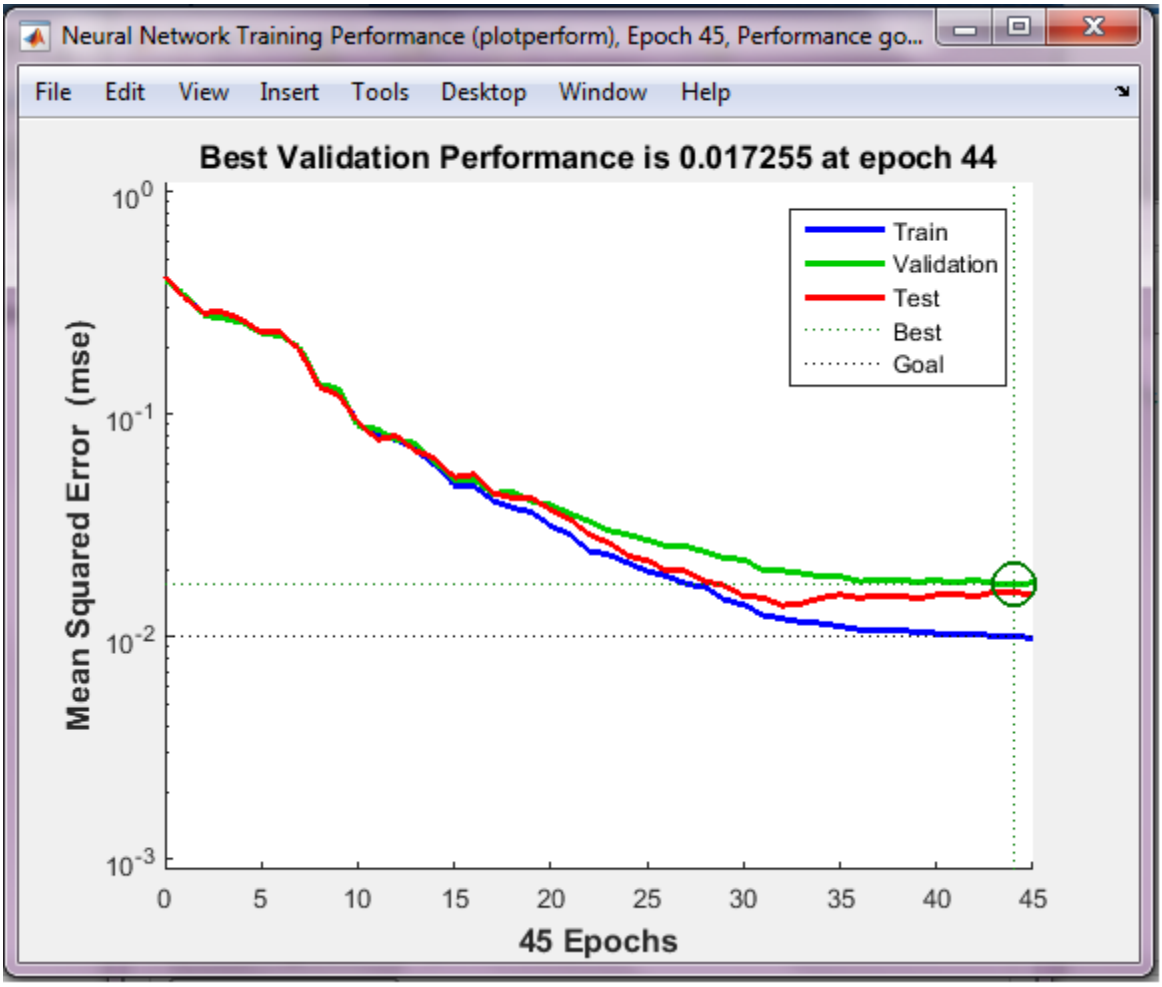


Figure III-13: the training performance of the network

III-3-2) Classification :

Following the training process comes the testing of the network. in this part of our work we need to insert different signals and observe its recognition. and compare it with the original matrix of the same class to determine the recognition rate .

2x901 double

	354	355	356	357	358	359	360	361	362	363	364	365	366
1	0.0038	0.0130	0.0056	0.0128	0.0121	0.0119	0.0012	0.0119	0.0119	0.0119	0.0032	0.0052	0.0119
2	0.9962	0.9870	0.9944	0.9872	0.9879	0.9881	0.9988	0.9881	0.9881	0.9881	0.9968	0.9948	0.9881
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													

2x901 double

	224	225	226	227	228	229	230	231	232	233	234	235	236
1	0.9784	0.9400	0.9912	0.8902	0.9701	1.0008	0.7832	0.9638	0.9828	0.9913	1.0010	0.9424	0.9953
2	0.0216	0.0600	0.0088	0.1098	0.0299	-7.8938e-04	0.2168	0.0362	0.0172	0.0087	-0.0010	0.0576	0.0047
3													
4													
5													
6													
7													
8													
9													
10													
11													

Figure III-14: the testing results for physiological of Not-Physiological signals

This results as you can see are around 1 and 0 . which is the same numbers that define our classes.

To determine the recognition rate of the two classes by our network . we round all the numbers inside the cells in (the Figure III-14) to 1 or 0 and then we can compare it with a classmatrix of the same class.

The result of comparison is a percentage that represents the recognition rate .

	Recognition Rate	**Error Rate**
Physiological	99.67%	0.33%
Not-Physiological	86.57%	13.43%

After completing the whole recognition chain we made a interface that concludes our work. Which contain a buttons for testing different classes and switching between different scripts to try different hidden layers numbers.

IV) Conclusion :

in this chapter we went through all the stages we passed in practical part of our work . and we explained the method that made us achieved the wanted results.
However, from this experience we could conclude that :
- Feedforward is the simplest type of artificial neural network that everyone can use for classification grounds

- the recognition rate of the Physiological signals is higher than Not-Physiological signals

CONCLUSION

after trying to demonstrated the multiple and diverse simulations of the functioning of the human brain in a neural network technology form. it gave us much hope for further improvements .

as a result , our work consisted in putting a means of recognition of arterial pressure signals, These various experiments allowed us to obtain a good the recognition rates and lower the error rate to its minimum,

therefore .We allow ourselves to give some perspectives to which this work can be oriented towards the creation of a system . it will certainly be a great event in the medical field to diagnose any type of biological signals, which is the objective expected in our study.

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