SOZAN SULAIMAN

INTELLIGENT SYSTEM FOR IDEUTIFICATION HEART DISEASES

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
SOZAN SULAIMAN MAGHDID

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Computer Engineering

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Sozan Sulaiman Maghdid: INTELLIGENT SYSTEM FOR IDENTIFICATION HEART DISEASES

Approval of Director of Graduate School of Applied Sciences

Prof. Dr. Nadire ÇAVUŞ

We certify this thesis is satisfactory for the award of the degree of Masters of Science in Computer Engineering

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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Date:

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To my parents…

ABSTRACT

Nowadays, artificial intelligence systems become actively used for the identification of different diseases using their medical data. Most of existing traditional medical systems are based on the knowledge of experts-doctors. In this thesis, the application of soft computing elements is considered to automate the process of diagnosing diseases, in particularly diagnosing of a heart attack. The research work will offer probable help to the medical practitioners and healthcare sector in making instantaneous resolution during the diagnosis of the diseases. The intelligent system will predict heart attacks from the patient dataset utilizing algorithms and help doctors in making diagnose of these illnesses. In this study, three techniques such as a neural network (back propagation), Fuzzy Inference System (FIS) and Adaptative Neuro-Fuzzy System (ANFIS) are considered for the design of the prediction system. The systems are designed using data sets. The data sets contain 1319 samples that includes 8 input attributes and one output. The output refers presence of a heart attack in the patient. For comparative analysis, the simulation results of the ANFIS model is compared with the simulation results of the neural network-based prediction model. The ANFIS model has shown better performance and outperformed NN based model. The obtained simulation results demonstrate the efficiency of using ANFIS model in the identification of heart attacks.

Keywords: Artificial neural network; adaptive neuro-fuzzy inference system; fuzzy inference System (FIS); neural network (back propagation); heart attack

ÖZET

Günümüzde yapay zeka sistemleri, tıbbi verilerini kullanarak farklı hastalıkların tanımlanmasında aktif olarak kullanılmaktadır. Mevcut geleneksel tıbbi sistemlerin çoğu uzman doktorların bilgisine dayanmaktadır. Bu tez çalışmasında, yumuşak bilgi işlem elemanlarının uygulanmasının, özellikle kalp krizinin teşhisinde hastalıkların teşhisi sürecini otomatikleştirdiği düşünülmektedir. Araştırma çalışması, tıp pratisyenlerine ve sağlık sektörüne hastalıkların teşhisi sırasında ani bir çözüm bulmada muhtemel yardım sağlayacaktır. Akıllı sistem, algoritmalar kullanarak hasta veri setinden kalp krizi geçirir ve doktorlara bu hastalıkları teşhis etmede yardımcı olur. Bu çalışmada, tahmin sisteminin tasarımı için sinir ağı (geri yayılım), Bulanık Çıkarım Sistemi (FIS) ve Uyarlanabilir Nöro-Bulanık Sistem (ANFIS) gibi üç teknik ele alınmıştır. Sistemler veri kümeleri kullanılarak tasarlanmıştır Veri setleri, 8 giriş niteliği ve bir çıkış içeren 1319 örnek içerir. Çıktı, hastadaki kalp krizinin varlığını ifade eder. Karşılaştırmalı analiz için, ANFIS modelinin simülasyon sonuçları, sinir ağı temelli tahmin modelinin simülasyon sonuçları ile karşılaştırılmıştır. ANFIS modeli daha iyi performans ve daha iyi performans gösteren NN tabanlı model göstermiştir. Elde edilen simülasyon sonuçları, kalp krizlerinin belirlenmesinde ANFIS modelinin kullanılmasının verimliliğini göstermektedir.

Anahtar Kelimeler: Yapay sinir ağı; uyarlanabilir nöro-bulanık çıkarım sistemi; bulanık çıkarım sistemi (FIS); sinir ağı (geri yayılım); kalp krizi

TABLE OF CONTENTS

CHAPTER 4: DATASET

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

WHO	World Health Organization
CVD	Cardio Vascular Disease
CHF	Congestive Heart Failure
CCF	Congestive Cardiac Failure
ECG	Electro Cardio Graph
ANN	Artificial Neural Network
AED	Automatic Electric Defibrillator
NN	Neural Network
WAC	Weighted Associative Classifier
PSO	Particle Swarm Optimization
CKE	Creatine Kinase Enzymes
LSE	Least-Squares Estimator
FIS	Fuzzy Inference System
ANFIS	Adaptive Neuro-fuzzy Inference System

CHAPTER 1

INTRODUCTION

1.1 Overview

Present time, data has been scattered as Statistics, Reports, and Forms and so forth. It as a vast benefit which allows the creation of result in real time situations. Despite that, a lot of research has been conducted in various areas, health care has a wide extension to utilize officially accessible information and determine results which will be available to the world.

Cardiovascular illnesses consist of Heart and blood vessel sicknesses that comprise of many problems, lot of which are linked to an operation termed atherosclerosis. When a material termed plaque accumulates in the walls of the arteries and evolves that case is termed Atherosclerosis. This accumulates and tightens the arteries making them harder for blood to flow out of the arteries. The term Myocardial Infarction or stroke is when the blood becomes clot which can also cause a heart attack (American Heart Association, 2011).

Heart attack diseases are the major reason of death at an average level worldwide. In 2015, 17.7 million deaths which are caused from cardiovascular disease are estimated to be approximately 31% worldwide, according to the World Health Organization. According to this report, 82% of them are in low and middle-income countries, 17 million are under 70 years of age which are prone to non-communicable diseases, 6.7 million due to stroke and 7.4 million were due to coronary heart disease (WHO, 2015).

To examine the mischance of heart attack, specific factors that are related with lifestyle need to be treated. Thus, patients should conduct important tests such as cholesterol, electrocardiograms, chest pain, blood pressure, maximum heart rate and high level of sugar can quickly revel and foretell appropriate situation for counseling. Some estimation with existing test results of patients and factors make medical practitioners' work extra difficult to be analyzed. As such, when considering big number of factors, which make some

complex measures very hard to execute (Anooj, 2012); (Hedeshi and Abadeh, 2014). The presence or absence of a patient with a particular illness depends on the doctor's guess, experience and competence in announcing the decision and comparing the previous decision with the rich data hidden in the database. This action has a very hard mission with regards to big numbers of factor that is to be considered.

When a heart attack happens, we have to quicken medical attention to prevent heart damage and to maintain the life of a patient with a heart attack. These days, the utilization of computer technology for medicine is very high (Ali and Mehdi, 2010). In order to realize our goals in this complex phase, active hybrid fuzzy expert systems that the doctor may need and that can prophecy the probability of a patient getting a heart illness problem and being able to assist in embodying the illness. The purpose of classification is to look for a pattern to predict the category of objects whose classification is unknown and depicts them in distinguishing data categories or concepts.

Complex and uncertain medical tasks such as disease diagnosis where the utilizing of intelligent systems such as genetic algorithm, neural network, fuzzy logic, and neuron-fuzzy system has helped the doctor to embody these illnesses (Zaptron, 1999).

Neural networks and ambiguous systems both have specific characteristics of classical techniques, especially when the previously obscure information or knowledge is involved, over the past few decades has established their reputation as alternative methods of intelligent information processing systems. However, their applicability in individual styles is exposed to some weaknesses. Therefore, it was proposed to establish a system by combining human-like interpretation of fuzzy systems with the learning and interdependence of neural networks where it consists of clusters of neural networks with ambiguous systems, where both models complement each other where Neuro-fuzzy hybridization produces a hybrid intelligent system that combines these two techniques (Mehdi, et al., 2009).

The concept of this thesis is to style an architecture contain of fuzzy system and neural network to represent knowing in an interpretable way and the learning capacity of to

optimize its parameters (Vipul, 2009). This work is different with the utilize of fuzzy logic, neural network (back propagation) and Neuro-fuzzy (ANFIS) algorithms in an integrative manner to predict heart attacks with high amount of accuracy where This thesis aims at developing a dynamic, intelligent and accurate system for diagnosis heart attack and we utilize these algorithms to determine which model gives the elevate proportion of correct foretelling for the diagnose between these algorithms (Vipul, 2009).

1.2 Problem Statement

Most medical heart systems are traditional systems which are not dynamical, intelligent and their results are manually produced. Therefore, their results are not reliable and accurate. Complex and uncertain medical tasks such as disease diagnosis, which utilizes intelligent systems such as genetic algorithm, neural network, fuzzy logic, and neuron-fuzzy system has helped doctors to embody these illnesses (Zaptron, 1999). Neural networks and ambiguous systems both have specific characteristics of classical techniques, especially when the previously obscure information or knowledge is involved, over the past few decades has established their reputation as alternative methods of intelligent information processing systems. However, their applicability in individual styles is exposed to some weaknesses. Therefore, it was proposed to establish a system by combining human-like interpretation of fuzzy systems with the learning and interdependence of neural networks where it consists of clusters of neural networks with ambiguous systems, where both models complement each other where Neuro-fuzzy hybridization produces a hybrid intelligent system that combines these two techniques (Mehdi, et al., 2009).The concept of this thesis is to style an architecture which contains fuzzy system and neural network to represent knowledge in an interpretable way and the learning capacity to optimize its parameters(Vipul, 2009).This work is different with the utilizing of fuzzy logic, neural network (back propagation) and Neuro-fuzzy (ANFIS) algorithms in an integrative manner to predict heart attacks with high amount of accuracy where this thesis aims at developing a dynamic, intelligent and accurate system for diagnosis heart attack and we utilize these algorithms to determine which model gives the elevated proportion of correct foretelling for the diagnose between these algorithms (Vipul, 2009).

1.3 Objectives of the Study

The objectives of this study are to:

i. This thesis aims at developing a dynamic, intelligent and accurate system for diagnosis of heart attack.

ii. The objective of the research is to foretell probable heart attacks from the patient dataset utilizing algorithms and choose which style gives the elevate proportion of correct foretelling for the diagnose.

iii. The goal of the foretelling methodology is to styling a model that can infer characteristic of foreteller class from combination of other data.

iv. This work in this thesis will offer probable aid to medical practitioners and healthcare sector in in making instantaneous resolution during the diagnosis of this disease.

1.4 Significance of the Study

In the realm of diagnosis heart attack diseases, up-to-date inspection of the published articles suggested that**:**

1. In this thesis we use new datasets.

2. This will be the first study that employs at offering probable aid to medical practitioners and healthcare sector in making instantaneous resolution during the diagnosis of this disease.

3. This will be the first study that employs at developing a new dynamical system intelligent and accurate for diagnosis heart attack.

4. This will be the first study to utilize different empirical and AI models for the prediction of diagnosing heart attack.

5. This will be the first study that employs at contacting a practical background of neuro-fuzzy system of diagnosing heart attack.

6. This will be the first study that employs at contacting theory study of neuro-fuzzy system of diagnosing heart attack.

7. This will be the first study that employs at producing new software package for neuron fuzzy system of diagnosing heart attack.

8. This will be the first study that employs at producing report for evaluations.

1.5 Thesis Layout

This thesis has been laid out into the following chapters:

1. Chapter One describes the scope and goal of the thesis. Brief explanation of the considered problem is given.

2. Chapter Two introduces some related works to this study. A detailed explanation of each reviewed research papers that uses algorithms and models for the diagnosis of heart attack diseases are presented.

3. Chapter Three presents the methodologies used in this thesis. The description of Neural networks, Fuzzy system and ANFIS are given.

4. Chapter Four gives explanations of utilized dataset. The effect of input parameters concerning the health of people is given.

5. Chapter Five gives the experimental results obtained from the thesis.

6. Chapter Six presents conclusions with some recommendation for future works.

CHAPTER 2

LITERATURE REVIEW

This chapter introduces some related work to this study. Detailed explanations of the reviewed research works, used algorithms and models for the diagnosis of heart attack diseases are presented.

2.1 Literature Review

Over the last ten years, literatures about the utilization of intelligent methods in the medical field had a major number of related works. Many approaches and algorithms have been utilized to predict heart attacks.

Adeli and Neshat (2010), has utilized in their work a fuzzy expert system for the diagnosis of heart disease. The authors have utilized several variables via chest pain, blood pressure, cholesterol, resting blood sugar, resting maximum heart rate, sex, electrocardiography (ECG), exercise, old peak (St depression induced by exercise relative to rest), thallium scan and age as inputs. The status of patients either healthy or sick has been utilized as output. Four types of sickness have been used as output. These are Sick s1, Sick s2, Sick s3, and Sick s4.

Rajeswari et al. (2011), have suggested a Decision support system for authoritative heart disease risk prediction of Indian patients using machine learning technique. They have utilized genetic algorithm to decide high effect pattern and their optimal value. They have utilized theoretical approaches to execute the machine learning algorithm.

Kaya et al. (2011), have utilized a fuzzy rule-based classifier for diagnosis of congenital heart disease which determines structural and functional disease of heart. They have utilized weighted vote method and single winner method. The result has shown that the weighted vote method in general has increased the classification accuracy of congenital heart disease.

Florence et al. (2014), in their work they focused on utilizing different algorithms for prophesy combinations of several target attributes. They have presented an intelligent and effective heart attack prediction methods using data mining. They enhanced and expanded.

For predicting heart attack significantly 15 attributes are listed. Besides the 15 listed in medical literature and incorporate other data mining techniques, e.g., Time Series, Clustering and Association Rules.

Hai et al. (2008), in their work suggested neural based learning classifier system for classifying data mining tasks. They performed experiments on 13 different datasets from the University of California, Irvine warehouse and one artificial dataset. They proved that neural based learning classifier system conducts equivalently to supervise learning classifier system on five datasets, significantly good execution on six datasets and significantly poor execution on three datasets.

Patil and Kumaraswamy (2009), in their work suggested an intelligent and effective heart attack prediction system utilizing data mining and artificial neural network. They also suggested extracting significant patterns for heart disease prediction. They utilized K-means clustering to extract the data appropriate to heart attack from the depot. They utilized MAFIA algorithm to extract the recurrent patterns.

Niti et al. (2007), in their work suggested a resolution prop system for heart disease diagnosis utilizing neural network. They trained their system with 78 patient records and the errors synthetic by humans are avert in this system.

Anbarasi et al. (2010), in their work suggested an enhanced foretelling of heart disease with advantage subset selection utilizing genetic algorithm. They prophesied more minutely the presence of heart disease with reduced number of attributes. They utilized Naïve Bayes, Clustering, and Decision Tree methods to prophesy the diagnosis of patients with the same fineness as they got before the lowering of attributes. They concluded that the decision tree method outperforms the other two methods.

Peter and Somasundaram (2012), utilized data mining and pattern recognition to predict ways in cardiovascular diagnostics. The testing was carried out utilizing Naïve Bayes, Decision Tree, K-NN and Neural Network classification algorithms, where the results show that Naïve Bayes technology exceeded other technologies.

Shukla et al. (2013), suggested a layered neuron-fuzzy approach to prophesy for happening of coronary heart disease by MATLAB tool. The execution of the neuron-fuzzy integrated approach produced an error average so low and a high action competence in result analysis for coronary heart disease happenings.

Jabbar et al. (2011), suggested a new method for correlations rule mining based on clustering transactional data set and series number for heart disease prophecies. The execution of the suggested method executed was in C programming language and reduced main memory Requirements by considering a small group at same time to be seeing evolution and efficient.

Sundar et al. (2012), depict the prototype utilizing weighted associative classifier (WAC) and gullible qualities to prophesy the prospect of patients drawing heart attacks. There is a notable rise in the number of people hurting from heart illness. As a result, there is a rising in the unavailability of medical practitioners and also errors or inexactness in the diagnosis of the illness due to the rise in the growth of people over the years.

Aditya et al. (2017) suggested a system which can be utilized to hurry up the operation as well as to raise the thoroughness and certainly for diagnosing the illness at the shortest time which results in better execution than the conventional diagnostic styles.

Ebenezer et al. (2015), they suggested a system which given 85% rigor they utilized artificial neural network with 1 hidden layer for diagnosis of heart illness.

Muthukaruppan and Er (2012); Sikchi et al. (2012); Kumar (2013); Sikchi et al. (2013) they reported that the medical practitioners make utilize of computerized technologies to aid in diagnosis and give propositions as medical diagnosis is full of uncertainty.

Opeyemi and Justice (2012), According to their work the best and most efficient techniques for transaction with uncertainty are by incorporating fuzzy logic and neural network. Fuzzy logic, which was conceived by Zadeh is a form of many valued logic in which a truth value of variables may be any real number between 0 and 1. In fuzzy logic,

everything allows or is pliable to be a matter of degree, imprecise, linguistic and perception based. Fuzzy logic provides a foundation for the development of new tools for dealing with knowledge representation and natural languages. Its aim is at formalization of reasoning modes which are approximate rather than exact. Fuzzy logic has four principal facets of logical, set theoretic, relational and epistemic. There are diverse types of studies based on ANFIS methodologies.

Palaniappan and Awang (2008); Patil and Kumaraswamy (2009); Abdullah et al. (2011); Zhu et al., (2012); Kar and Ghosh (2014); Mayilvaganan and Rajeswari (2014); Yang et al., (2014); Sagir and Sathasivam (2017). They designed two different ANFIS based classification models for heart disease prediction and observed that the classifiers learnt how to classify the dataset. Their performances were evaluated based on training, testing and accuracy of classification and has so many features. They utilized grid partition technique, and they confirmed that their proposed models were better than other models in the literature as they have the potential for classifying and predicting heart diseases.

Shinde et al. (2016), they reached that Genetic Algorithm had task pivotal turn while active on prognostication of heart illness and one should look at that Genetic Algorithm necessarily to get extra applicable results. An analysis of dataset concerning with heart illness indicative that people in age collection of 40-60 years should be aware of heart illness signs since this age collection carries hazards of heart disease more. Males have higher hazards of heart illness than female gender.

Feshki and Shijani (2016), suggested PSO system (Particle Swarm Optimization) and feed forward neural network. In the first stage, this system partitions the orders set into two sets of sick and healthy people. In the second stage, 8192 partial groups of gross lineaments were extracted at an obvious cost. In the third stage, the PSO algorithm is applied for all the subsets to discover the better subset with the time, thoroughness, low cost and highest accessibility. The subset 8 contains characteristics of exercise tests (slope, old peak, and exang), treetops (blood pressure), FBS, cholesterol, age and sex by PSO algorithm. The rigor was amended by 2.38% and 9.94% rigor.

Shanthi (2017), has suggested a methodology to analyze the life style parameters of individual with an adaptive neuron fuzzy inference system that acts as a resolution prop system for the physician to prophesy the hazard of heart illness and helping the patient to define their scale of hazard from heart illness with the possibility of avoiding the aggravation of the illness by changing the life style with medications, sound diet and exercise.

Comparing to the works discussed above, this work is different with the utilize of fuzzy logic, neural network (back propagation) and neuron-fuzzy(ANFIS) algorithm in an integrative manner to predict heart attacks with high amount of accuracy where This thesis aims at developing a dynamic ,intelligent and accurate system for diagnosis heart attack and we utilize these algorithms to determine which model gives the highest percentage of correct predictions for the diagnoses between these algorithms.

CHAPTER 3

MATERIALS AND METHOD

This chapter presents the structure of fuzzy logic, neural network and Neuron-fuzzy (ANFIS) are presented in this thesis. The functions of their main blocks are described. The design algorithms of each model used for diagnosis of heart attack are presented. The use of Fuzzy system, Neuron network and ANFIS represents the main functions because they predict heart attacks with a high accuracy. The designs of algorithms for each model used for diagnosis of heart attack are also presented.

3.1 Heart Disease

Heart disease depicts a scope of cases that influence your heart. Sicknesses under the umbrella in close cardiovascular sickness, for example, coronary sickness. Heart beat troubles (arrhythmias); and heart defects you're born by (heart defects at birth), amongst others. The expression "heart disease" is frequently utilized reciprocally with the expression "cardiovascular disease" Cardiovascular ailment by and large alludes to conditions that include tight or closed blood vessels that can front a heart failure, chest pain (angina) or stroke. Other heart conditions, for example, those that influence your heart's muscle, valves or beat, additionally are viewed as types of coronary sickness. Heart action is crucial in human life if capacity of heart isn't fine it will impact different parts of body. Working of heart and brain are interdependent, when heart and brain stops functional in minute's death happen. If blood flow is not suitable then heart and brain pain. When blood stopped in brain, it is called as brain stroke and when blood stopped in heart, it is called as heart attack. So, the heart is significant in human body. Lately, heart diseases being one of the diffuse diseases which human are being experienced from. Reference to statistics, it is one of the most significant reason of deaths at the world (CDC’s report). The World Health Organization (WHO) has recorded 12 million. They cast their fate because of Heart disease every year consistently and furthermore saw that Heart disease kills one individual every 34 seconds (Soni, et al., 2011). So, there is a need to resolve ready Data related with heart disease chronic and regulate out in such a style, to the point that some information's and

models will be determined out of it to help human. Heart attack sicknesses remain the major source of death around the world, including Kurdistan Regional Government Iraq and bearable discovery as soon as will be ban the attack (Sen, et al., 2013). Medicinal specialists produce information with an abundance of concealed data present, and it's not being utilized viably for forecasts (Sen, et al., 2013). People having experienced symptoms that were not taken into considerations they dying. There is a need for medical practitioners to foretell heart disease before they happen in their patients (Ishtake and Sanap, 2013). Cardio Vascular Disease (CVD) incorporated coronary heart, cerebrovascular (Stroke), hypertensive heart, congenital heart, peripheral artery, rheumatic heart, inflammatory heart disease (Chaurasia, 2013).

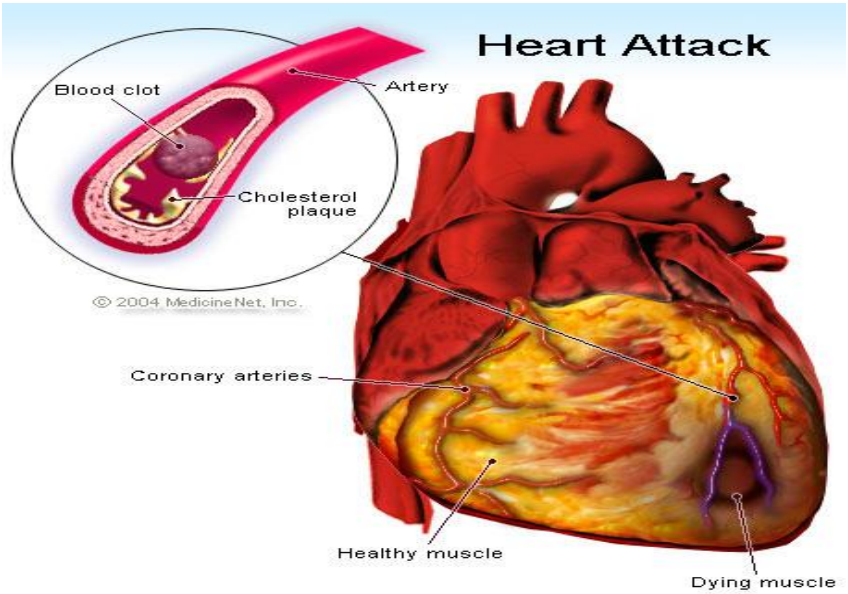

Figure 3.1: Heart Attack

3.1.1 Heart Attack

Heart attack often occurs when a blood clot prevents blood course in the coronary artery - the blood vessel that connects blood to the heart muscle (Figue 3.1). Blocking blood run to the heart may hurt the of the heart muscle, or even ruin it completely Long ago, heart attacks often ended in death. Now, the common of people with heart attacks they stay of

live, thanks to the improved wakefulness of symptom of heart attacks and the development and improvement of treatment. The generally daily life, the food we eat the pace of physical doings we exercise and the way we face stress and stress - all play a significant function in improving from a heart attack. In addition, a healthy daily life can help to ban a first heart attack, or a heart attack, by decrease peril factors that help tight the coronary arteries, which are answerable for supplying the heart with blood.

3.1.1.1 Symptoms of Heart Attack

Common heart attack symptoms include:

1. Pressure, feeling of congestion or pressure in the center of the chest, lasts for more than a few minutes.
2. Pain does not spread to the chest, shoulder, arm, back, or even to teeth and jaw.
3. Chest pains for periods are increasing.
4. Continuous pain in the upper abdomen.
5. Shortness of breath.
6. Sweating.
7. Feeling of impending death.
8. Ghoshe (fainting).
9. Nausea and vomiting.

Heart attacks in women can be dissimilar, or the symptoms of heart attack may be milder than men's heart attack symptoms. In addition to the symptoms of heart attack mention above, the symptoms of heart attack in women also ensure:

- Pain or heartburn in the upper part of the abdomen.
- Wet or sticky skin (viscous).
- Dizziness.
- Unusual or unjustified fatigue.

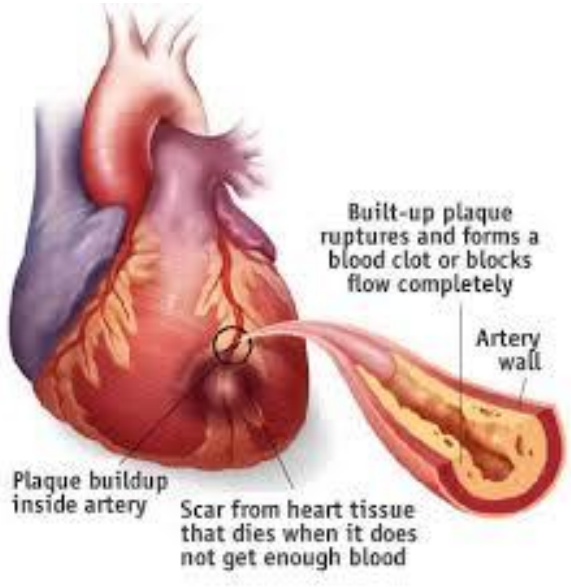

Figure 3.2: Symptoms of Heart Attack

Heart attack symptoms are not the similar for all people with a heart attack (Figure 3.2). If the symptoms of the heart attack itself, do not be the similar grade of risks in all those who have a heart attack. Too many heart attacks are not as dramatic as those shown on TV. Some people still have a heart attack with no having any heart attack symptoms at all. However, the more marks and symptoms show, the greater the perils of a heart attack. A heart attack can happen anytime, anywhere - at work, during play, during rest or during movement. There are surprising heart attacks, but many who have a heart attack have caution marks before the seizure happens hours, days or weeks. The first mark of an impending heart attack may be frequent pain in the chest (angina pectoris), the power of the unit rises when physical effort is made while the immortality eases to rest. Angina pectoris happens an outcome of interim and insufficient blood influx to the heart, a condition also known as "cardiac insufficiency" (Myocardial ischemia).

3.1.1.2 Causes and Risk Factors of Heart Attack:

The medical expression that indicate to a heart attack is myocardial infarction (ie, myocardial infarction - cardio means heart infracts - means tissue death because to

hypoxia). Such any other muscle in the body, the heart (muscle) needs a fixed, continued supply of blood. Without blood, the heart cells are damaged in a way that leads to pain or stress. If the blood feeding is not regenerate, the heart cells may die. In this state scar tissue can be formed, rather than active heart tissue. The irregular or inadequate blood influx to the heart, which can cause heart arrhythmias, can be fatal. The cause of a Heart attack is a blockage in one or more of the arteries that feeding the heart with oxygen-rich blood. These arteries are called coronary arteries, which surrounding the heart like the crown. Over time, coronary arteries become tight, because to the cumulating of a stratum of cholesterol on their indoor walls. The cumulating of this stratum - the so-called thorough "plaques" - within the arteries through the body is recognized as "atherosclerosis". In the case of myocardial infarction, the plaque can be shredding, this may lead to blood clotting at the place of the ripping. If the clot is comparatively large, it may block the blood flux in the artery. The condition, in which the coronary arteries are constricted by atherosclerosis, is called arteriosclerosis (or arteriosclerosis) (Figure 3.3).

Atherosclerosis is a master why of heart attack. Unfamiliar heart attacks cause cramp or spasm in the coronary artery, leading to a breakdown of blood flux to a part of the heart muscle. Toxins, like cocaine, can why such a lethal cramp. Other factors, called risk factors for coronary arteries, raise the risk of heart attack. These factors contribute to the undesirable construction of the layers (atherosclerosis) that lead to narrowing of the arteries all over the body the body, inclusive the arteries connected to the heart (Sudhakar and Manimekalai, 2014). Thrombosis risk factors in the coronary artery include:

1. Tobacco smoking.
2. Hypertension - Over time, hypertension can cause damage to the arteries that supply the heart with blood, because it speeds up atherosclerosis.
3. Hypercholesterolemia or triglyceride in the blood.
4. Physical inactivity.
5. Obesity - Very obese people (overweight) have a particularly high proportion of body fat (30% of body mass or more).
6. Diabetes.
7. Tension.

8. Alcohol - When consumed moderately, alcohol helps to raise the level of good cholesterol (HDL), which protects against heart attacks.
9. Family history of heart attack.
10. Homocysteine, protein C and fibrinogen - people with high levels of Homocysteine, protein C and fibrinogen are more likely to have alkaline diseases.

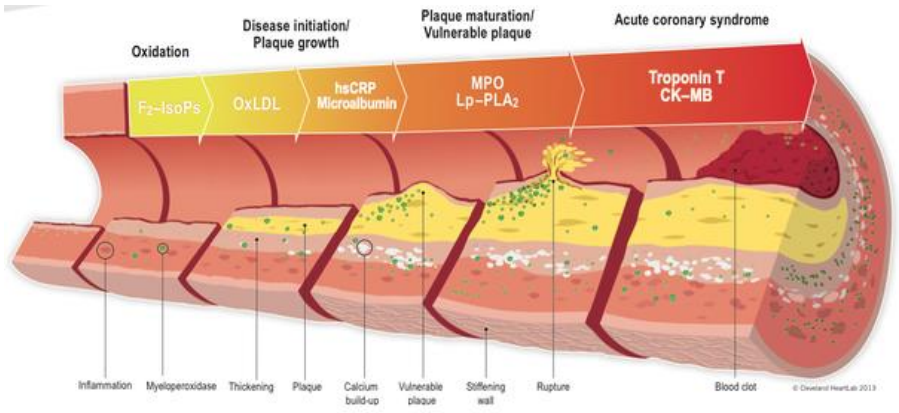

Figure 3.3: Causes and risk factors of heart attack

3.1.1.3 Complications of Heart Attack

Such harms can lead up to the problems which it appears where Complications of a heart attack are commonly related to harm to the heart through a heart attack. There are many following problems:

- Arrhythmia: Of the heart muscle is harmed as a result of a heart attack, a short circuit can be formed and can lead to heart arrhythmia, some of that may be the lead to death.
- Congestive cardiac failure (CCF) or Congestive heart failure (CHF): Damage to the heart tissue might be great to the point that the surviving part of the heart muscle can't flow blood from the heart as healthy and Normal. Accordingly, the quantity of

blood arriving the tissues and different organs in the body is not as much as should be expected, which may cause shortness of breath, exhaustion, and swelling of the lower legs and feet. Heart failure might be an interim issue that automatically heals after the heart heals - inside a couple of days or weeks - from its stun caused by the seizure. In any case, heart failure may be a chronic ailment caused by perpetual harm to the heart through a heart attack.

- Rupture of the heart muscle: in some parts that weakened by the heart attack, the heart muscle lacerate may a hole in the heart. This a laceration predominantly leads to swift death.
- Harm to heart valves: the harms may be exacerbated by leakage problems that pose a serious risk to life. If one or more heart valves are damaged during myocardial infarction.

3.1.1.4 Diagnosis of Heart Attack

Ideally, your doctor should research for hazard factors that may lead to a heart attack through a routine physical examination.

If a person has a heart attack or if he is suspected of having a heart attack, the tests and diagnosis should be conducted as in an emergency. The medical staff asks the patient to describe the symptoms he has observed, his blood pressure is measured, in addition to the pulse and temperature. It is then linked to the (Monitor) heart and is immediately initiated into the tests, by which it is determined whether it is already having a heart attack. The medical staff listens to heart rate and air movement in the lungs via a (stethoscope), asking questions about the patient's medical history and history of heart disease in his family. Medical examinations conducted by medical staff help determine whether signs and symptoms, such as chest pain or other symptoms, indicate a heart attack or other problems.

- ❖ These tests include:

1. Cardiac Electrocardiogram (ECG - Electrocardiogram).
2. Blood tests.
3. Other tests: If a person has been or is currently undergoing a heart attack, doctors will take immediate steps to address the situation. The following tests may be necessary:

- Chest x - ray - Chest x - ray allows the doctor to examine the size and shape of the heart and blood vessels.
- Nuclear scan - This test helps detect and locate blood flow problems to the heart.
- Echocardiogram (Echocardiogram) - This test uses sound waves to produce a layout of the heart.
- Catheterization - This test shows whether the coronary arteries are narrow or blocked.

In the first days or weeks after a heart attack, stress tests may be required. These tests examine how the cardiovascular system responds to physical exertion.

3.1.1.5 Treatment of Heart Attack

When a heart attack happening, the following steps should be taken promptly and without retard:

1. Instantaneous contact for urgent medical help: Even when you doubt heart attack, you must act without decision or retard.
2. Nitroglycerin: If your doctor has prescribed nitroglycerin (Glyceryl trinitrate, which is a drug for widening coronary artery), you should take it as instructed, while waiting for the ambulance crew. The heart attack, in its first minutes, caused a ventricular fibrillation, which means that the heart's tremors are vain and futile and Ventricular fibrillation, which is not immediately treated, leads to sudden death. The use of an automatic defibrillator (AED) that restores the heart to its normal rhythms by electric shock can be an appropriate and successful emergency treatment even before the patient has a heart attack.
3. Medicines: In every minute after the heart attack, the number of tissues that do not get the normal and regular oxygen is increased and increased, resulting in damage or total damage and death. The main way to stop tissue damage is to quickly fix the blood circulation, so that blood returns to the various cells, tissues, and organs of the body. Medications for heart attack include:
    - Aspirin.

- Thrombolytic: These drugs, called thrombolytic condition, aid dissolve and analyze blood clot (Blood clot) that block blood flow to the heart.
- Clopidogrel (which is described as Super Aspirin).
- Other anticoagulants.
- Analgesics.
- Beta Blockers.
- Drugs to lower cholesterol level.

4. Surgery and other measures: In addition to drug therapy, one of the following may be needed to treat heart attack:
    - Coronary angioplasty - a surgical procedure designed to eliminate the narrowing (narrowing of the coronary arteries) either by balloon angioplasty or by the stent.
    - Coronary artery bypasses graft/surgery.

5. Recovery and healing: The purpose of emergency treatments for heart attacks is to replenish the blood flow and save the heart tissue from damage and destruction. The purpose of post-heart attack therapies is to accelerate and enhance and heart healing and prevent another heart attack happened.

3.1.1.6 Prevention of Heart Attack

It is never too late to take measures to prevent a heart attack. This can be done, too, even after a heart attack. Drug therapy has become a very important and important part of reducing the risk of a heart attack, on the one hand, and helping and supporting the heart that has harmed in order to return to better performance. The habits and lifestyle also play a crucial role in preventing and recovering from heart attacks.

1. Pharmaceutical: Doctors generally recommend medication for people who have had a heart attack or who are at high risk for a heart attack. Medications that help improve heart performance, or that reduce the risk of a heart attack, include:
    - Blood thinners that prevent clotting (coagulation).
    - Beta-blocker: These drugs reduce heart rate and blood pressure, reduce the burden on the heart and help to prevent subsequent heart attacks. Many

patients have to take these drugs throughout their lives, after having a heart attack.

- Beta-blocker: These drugs reduce heart rate and blood pressure, reduce the burden on the heart and help to prevent subsequent heart attacks. Many patients have to take these drugs throughout their lives, after having a heart attack.
- Angiotensin Converting Enzyme Inhibitor (ACEI) inhibitors.
- Cholesterol-lowering drugs.

2. Lifestyle: Lifestyle has a decisive effect on the heart. Therefore, taking the following steps would help not only in the prevention of heart attacks but also in recovery and healing from heart attacks:
    - Stop smoking.
    - Check for Cholesterol.
    - Regular medical examinations.
    - Follow up and maintain a healthy level of blood pressure.
    - Exercise regularly.
    - Maintain a healthy weight.
    - Confronting and overcoming stress and psychological tensions.
    - Moderate consumption of alcohol.

3.2 Research Algorithms and Concepts

There is an increase in solicitude for intelligent systems throughout the last years and are being utilized to different problems in various fields especially medicine. In this work, we utilize three algorithms for diagnosing a heart attack and compared between them and determine the best for diagnosing a heart attack. Where substantial concepts, architecture theory, and algorithm for Neural Network, Fuzzy logic and Neuron-Fuzzy are described in this chapter. The dataset is to diagnose the existence or inexistence of heart attack given the result of various medical tests carried out on the patients. This dataset contains 1319 cases, (females 449 —, males —870, mean age: between 14 to 103 years). The dataset contains 9 traits which will be utilized in the study.

Table 3.1: Attributes Names and Description

Attribute	Description
Age	Age of the patient
Gender	Gender of the patient
Heart rate	Maximum heart rate achieved
Systolic blood pressure	Resting systolic blood pressure (in mm Hg on admission to the hospital)
Diastolic blood pressure	Resting diastolic blood pressure (in mm Hg on admission to the hospital)
Blood sugar	(Blood sugar > 120 mg/dl)
CK-MB	Enzyme CK-MB (male upto-6.22 female upto-4.88
Troponin	Enzyme Tropnin (0.0-0.014)

.

3.2.1 Data Normalization and Performance Evaluation

To ensure equal attention is given to all inputs and output, and to eliminate their dimensions, the data used in this study were scaled between 0 and 1.

There are two main advantages of data normalization before the application of AI models. The first is the avoidance of using attributes in bigger numeric ranges that overshadow those in smaller numeric ranges. The second is to avoid numerical difficulties in the calculation. Therefore, the data used in this study were normalized as the following:

$$E_n = \frac{E_i - E_{min}}{E_{max} - E_{min}} i = 1, 2, \dots, n$$

Where E_n, E_i,E_{min},E_{max} represent the normalized values, actual values, minimum values, and maximum values, respectively.

3.2.2 Neural Network (NN):

A neural network is a system developed for information processing generally, it was developed based on the human brain where it is an exemplification of the human brain, which is capable of processing information, where it has a similar way with the characteristics of biological neural systems artificially sophisticated which attempts to spur the operation of learning. Traditionally the neural term pointed to a Nervous system which has biological neuron in it which transfers necessary information. Also pointed to as Artificial Neural Network (ANN) is a computational paradigm where its functions and methods are based on the structure of the brain. Generally, they are complex, nonlinear, and being able to work in parallel, distributed, and local processing and adaptation. NN consists of large/huge processors which are parallel operated, each having its own minor/smaller sphere of knowledge and data which are accessible in its local memory. ANN is designed to resemble brain systems such as the construction of architectural structures, learning techniques, and operating techniques where ANN is used to solve a wide variety of tasks, especially in the field of climate and weather which widely adopted by scientists because of it has of accuracy and it has the ability to develop complex nonlinear models. It is essentially defined as, "Free parameter of NN in process of learning are acclimatized through stimulation process by the environment in which the network is firmed. The types of learning can be specified such that way in which the parameters are changes takes place." Neural network follows up graph topology in which neurons are nodes of the diagram and weights are rims of the diagram. It consists of so many layers that should be limit in order to decrease the time of problem-solving. In this thesis, the neural network is utilized since it has the possibility of backing medical decision backing systems. In big data sets, it has cost-efficient and elastic non-linear modeling since the optimization is easy. In addition, it is precise in predictive conclusion.

Another important factor is that these models can make knowing dissemination easier by providing the caption, for example, utilizing rule extraction or sensitivity analysis (Wu, et al., 2002) this is executing out through a number of successive happens:

1. The neural network is catalyzed by an environment.
2. The neural networks undergo changes in its free parameters as a result of this Emulation.
3. The neural network reacts in a new way to the environment because of the changes that have happened in its interior structure.

ANN has diverse models, like Multi-layer perceptron (MLP), RFB and so forth that are various in terms of architecture and coaching network which will be debated in the following sub-sections.

3.2.2.1 Neuron Modeling

There are neurons that are interconnected to one another In the human brain. These neurons act as a tool that can perform processing of information of human senses. A biological neuron consists of a cell body (Haykin, 2009).

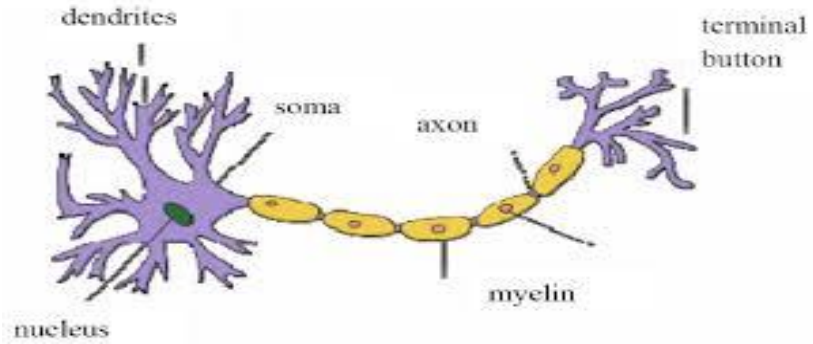

Figure 3.4: Schematic diagrams of biological neurons

They are covered by the cell membrane (Figure 3.4). Each dendrite is branches which are play a role in receiving the information into the cells of the body through the axon. The axon that can carry the signal from the cell body toward the neuron—the next neuron which is a long single fiber. The space of synapses is applicable for shipping and receiving all information processes from the senses where the meeting point between neurons with the next neuron found in a small space between dendrites and axons is known as a synapse. All electrical signals into the synapses are counted and calculated. Any information entered will be encoded in the form of electrical signals. If the electrical signals cannot be separated from the predetermined threshold, then the synapses will be retarded a lag of

synapses causes hindering of the relationship between the two neurons because the number of electrical signals regardless of the limits or thresholds specified in the synapse, the synapses react to a new electrical signal input to be used by the next neuron. A model neuron that has the characteristics of the transmission and receipt of information process (McCulloch and Pitt ,1943). In line with the biological neuron model, this is a simplified model of neurons termed a Threshold which that is similar to the process that occurs in biological neurons. A collection of input connections fetches activation than other neurons where Processing units collect the input then you do apply a non-linear activation (transmit function/threshold function) and an output line transmits the results into other neurons. This neuron modeling was becoming a reference in the development of ANN model at the current state. A neuron plays a role in determining the function and operation of the network. The mathematical models of neurons, which are usually utilized in the ANN model is shown in (Figure 3.5). Neuron modeling based on Figure (3.5), can be exemplified by the following mathematical neutralization:

$$u_{(k)} = \sum_{i=1}^{n} wk_i x_i \text{ and } y_{(K)} = \varphi(u_{(K)}) + b_{(K)}$$

Where $u_{(k)}$ is the output of the collector function neuron model, xi is data or input signal on path synapse i, and wki is weighted in the path of synapse i to k neuron. The output of the neuron is symbolized by $y_{(K)}$, where it is dependent on the activation

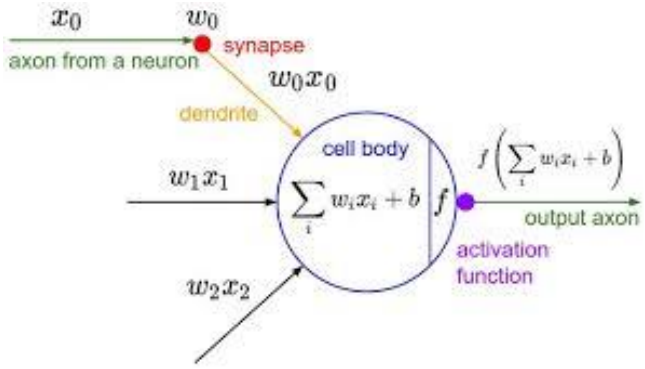

Figure 3.5: Basic Neural-network Model

The bias $b_{(k)}$ and function$\varphi(.)$ there are many kinds of activation functions that were utilized in modeling neurons, some of them are a bipolar sigmoid function, sigmoid function, linear function, fixed and limiter function (Dorofki, et al., 2012) ;(Duch and Jankowski, 1999).

3.2.2.2 Neural Network Architecture

Neurons can be arranged in diverse methods where the weights (connection between neurons) can form diverse styles which are termed neural network architecture where Connections between neurons with other neurons will form a layer pattern in ANN, Normally, ANN architecture consists of three different layers. The first layer is called the input layer there are diverse kinds of architectures, this layer acts as a receiver of data or input from the external stimuli. Coming data is then sent to the following layer. In this layer, there are no obligated rules for determining the number of neurons; the number of neurons can be more than one. It depends on the number of entries to be utilized in the network. The following layer is a hidden layer which includes neurons that can extradite data or electrical signal than the former layer of the input layer. The hidden layer can contain one or more neurons where Data or electrical signal that goes into these layers is processed using the functions available such as arithmetic, mathematics, etc. Output layer plays a role in determining the authenticity of data that are analyzed based on the existent limits in the activation function where Data processing results of the hidden layer are then routed to the output layer. The output of this layer can be utilized as a determinant of the result. ANN architecture is divided into two types. (Figure 3.6) shows the classify of both the ANN architectures. Based on the pattern of connections between neurons in the ANN, such as feedback neural network and feed forward neural network (Haykin, 2009); (Jain, et al.,1996); (Tang, et al. 2007). The feed-forward neural network is an ANN that does not have a feedback link on architecture. Feed-forward architecture can contain single or multilayer of weights. In single layer feed-forward link, there are one linked weights while in multilayer feed-forward net, more than one linked layers of weights can be there Feed-forward architecture can contain single or multi-layer of weights. In single layer feed-forward net, there is one linked weights while in multi-layer feed-forward net, more than one linked layers of weights can be there. Data or coming signals are allowed only to move in one direction only. This means that the output of each layer will not give any impact to the former layer. In architecture, it can be developed using a single layer or multiple layers. Usually, the multilayer component consists of three layers, namely a layer of input, output, and hidden. In a multilayer, the rising the ability of computing power is done by hidden layer component which plays a role in this rise. The kinds of ANNs that are utilizing feed-

forward neural networks are a radial basis function, One-layer perceptron, and multilayer perceptron. Second architecture is a feedback neural network or repetitive. It has a layout similar to the architecture of feed-forward neural networks, the data or electrical signals that are allowed to propagate forward and feedback can be an input to the neurons before. Where in an architectural design, there are additional feedbacks slow or feedback on the previous layer. Some examples of the kinds of ANNs utilizing feedback neural network are Hopfield networks, Elman network, and Jordan network. This network is utilized for dynamic applications such as adaptive control.

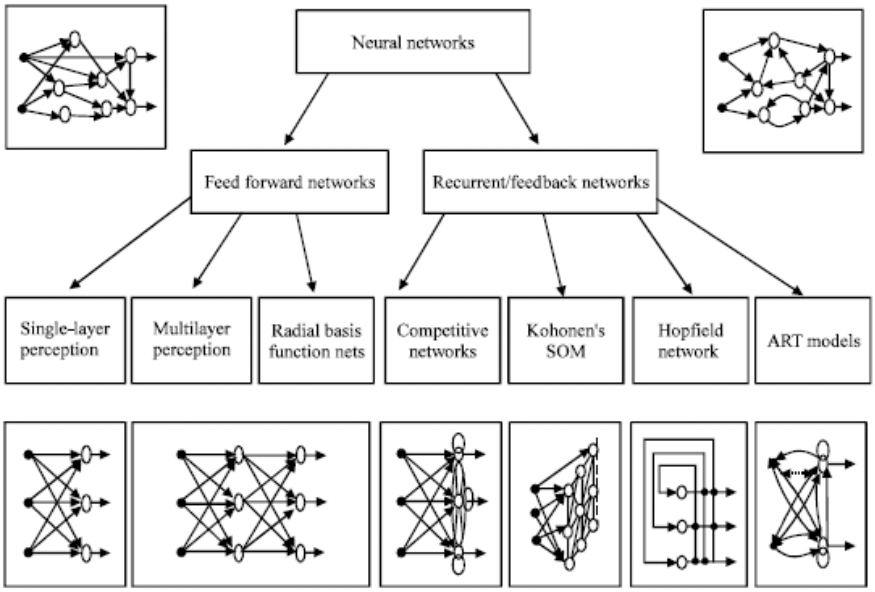

Figure 3.6: Neural Network Architecture

3.2.2.3 Multilayered Feed Forward Neural Network

The algorithm of multilayered feed forward neural network reads the dataset. The table above shows different parameters which depend on. After reading the dataset the algorithm executes normalization/discretization process for the above data values. This algorithm then limits the gross number of layers L and limits a gross number of neurons Ni in each layer. This algorithm will generate the neural network after limitation the gross number of layers L and the gross number of neurons operated in each layer. In the axioms of the network are assigned the random weight values. On the input layer of the network are

assigned the Input values. In the hidden layer, the values of each neuron are calculated by using this formula.

$$val = \sum_{i=1}^{n}(w_{ij} * l_{ij}) \quad (1)$$

With the help of neutralization (1), the value of each neuron in the network is calculated till the output layer is reached after that with the help of neutralization (2) the limiter function is utilized to the output value (Figure 3.7).

$$f(x) = \frac{1}{1} + e^{-x} \quad (2)$$

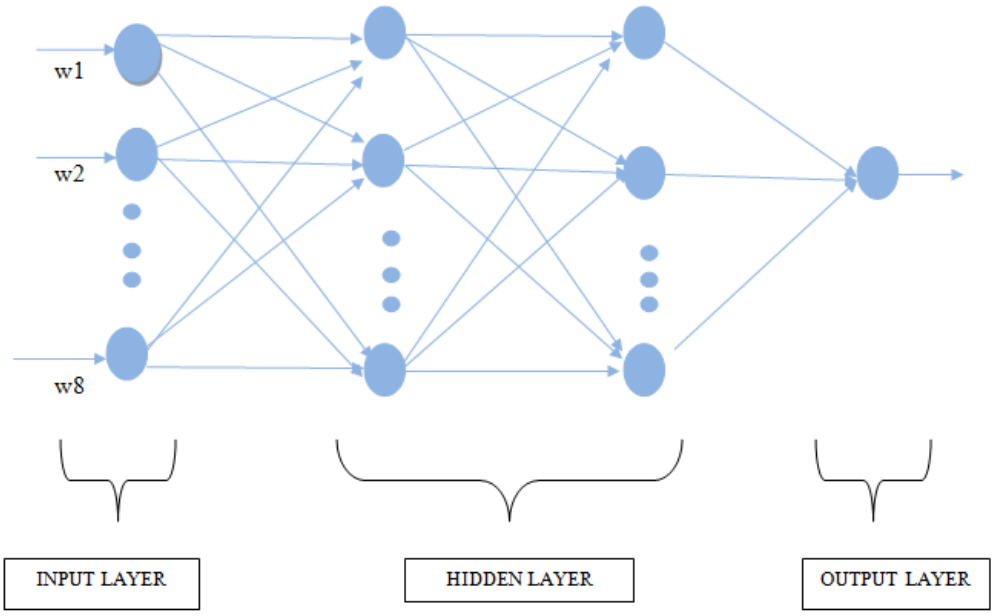

Figure 3.7: Neural Network (8 input neurons, 2 hidden layers and1 output neurons)

3.2.2.4 Back Propagation Neural Network

The method of gradient descent used to look for the minimum of an error function of the Back-propagation algorithm**.** The gross of weights is considered to be a solution to the learning problem that minimizes the error function**.** By utilizing the equation (3) after that the output value to minimize the error function of the multilayered feed forward neural

network algorithm is then calculated utilizing a back-propagation neural network algorithm.

$$\Delta = (T - 0) * (1 - 0) * 0 \quad (3)$$

During propagating backward, according to error gradient descent function. The back-propagation algorithm makes sure to change the weight values of the neurons till the input layer is reached by using the equation (4), the weight values are recalculated by it.

$$\sum_{new}^{1} = W * \Delta * input \quad (4)$$

3.2.3 Fuzzy logic

One of the prediction algorithms used in this project is a fuzzy logic. Fuzzy logic (FL) is a multi-valued logic that has been utilized to disband numerous intricate defies such as medical diagnostics (Zadeh,1965); (Zadeh, 1973). Where in FL instead of fixed and accurate values, the values are approximated. In the mid - the 1960s Professor Lotfi A. Zadeh first Suggested the expression “fuzzy logic” and “fuzzy sets”. The classic logic is called fuzzy logic according to Zadeh. Where the information is either true or false and it is based on Boolean logic. In classical logic, the membership represented by 0 if it does not belong to the set and 1 if it is in the set, i.e. {0, 1} furthermore, in fuzzy logic, this set is protracted to the interval of [0, 1].Fuzzy logic is a way to calculate the analysis based on their accuracy, which is done to utilizing Boolean logic of 0s and 1s.Where Based on mysterious, inaccurate, uncertain, noisy, or missing input information where the idea of fuzzy logic serves a process that can achieve a distinct conclusion. Fuzzy logic resembles to control problems almost exactly the approach a person would make decisions but only quicker. To solve control problems that fuzzy logic basically depends on are a simple rule: IF <statement 1> then <statement 2> or in other words, IF <premise> THEN <consequent> instead of count on structure a mathematical paradigm for the system can be expressed the variation between fuzzy sets and traditional by a build up a membership function. Take into account a limited set X = $\{x_1 x_2, x_3 \ldots . x_n\}$(Rojas, 1996). The subset A of X depending on the one item x1 can be described by the n-dimensional membership

vector U(A) = (1, 0, 0,...,0), where 1 at the i-th position point to a fact that xi belongs to A. The set B consists of the elements x_1 and x_n is described by the vector U (B) = (1, 0, 0, 1).

Any other crisp subset of X can be represented in the same way by an n-dimensional binary vector. If we remove the restriction to crisp values then we can describe the fuzzy set C with the following vector description: U(C) = (0.6, 0, 0, 0) (Rojas, 1996). It is remarkable that we cannot define a set as such since in crisp set theory we have an element that either belongs to a subset or it does not, Notwithstanding, in the theory of fuzzy sets. We can define and generalize such a set .By a real number in the interval [0, 1], this is expressed as the degree of membership that is uttered in this case, 0.6.an explanation which is correlated to the sense that we attribute to such statements as "person x is an expert." is called The degree of membership, The process to transform the membership of a person to the set of expertise goes gradually from 0 to 1 and which is done by Fuzzy logic and theory of fuzzy sets (Rojas, 1996).The basic rules of the fuzzy inference system are fuzzy if-then to be expounded below. Fuzzy Logic and Fuzzy Set Theory are Fuzzy Systems Which consists of the system. In a logical way where fuzzy logic coordinates, knowledge data. Fuzzy systems can handle linguistic data and numerical simultaneously. For modeling of conditions which are inherently imprecisely defined by providing opportunities by fuzzy systems. With the help of fuzzy systems, many real-world problems have been modeled, replicated and simulated that. Robot vision, Navigation system, and Information retrieval systems are one of the applications of Fuzzy Systems (Rashid, 2012). At first, the fuzzy logic algorithm separates the data into two as a training set and test set (Jameer and Kanmani, 2016).

About 70% of the data has been assigned to the training set and 30% is assigned to the test set. In the training set to build a rule set these datasets have been utilizing. Their data sets utilized in the test set to assess the quality where they're utilized for predictive relationships. The sets that have members of the self-same scope of the relationship are called Fuzzy sets. The membership functions are limited by Fuzzy logic maps to predicates into fuzzy sets. It is the operation of converting the fuzzy values into fragile sets and represents graphically the connotation of fuzzy logic on the form of models by utilized MATLAB which is a collection of tools. The output for the given conditions to interpret

and analyze it by helps this software (Vanisree and Singaraju, 2011). The engine utilized to evaluate fuzzy datasets is Rules. These rules can be creating in fuzzy logic.

3.2.3.1 Fuzzy inference system Architecture

The structure of Fuzzy inference system consists of the following:

1. Inputs Vector: are crisp values such as X = [x_1, x2…x_n] T in the fuzzification blocks which are transformed into fuzzy sets.

2. Output Vector: in this part where transform an output fuzzy set back to a crisp value such as Y = [y_1, y_2,…y_n] T, which comes out from the defuzzification block.

3. Fuzzification: an operation of converting crisp values into grades of membership for fuzzy sets for linguistic expressions, "small", "near", "far".

4. Fuzzy Rule base: a set of suggestions are including linguistic variables; the rules are explained in the following shape:

If (A is X) AND (B is Y) THEN (C is Z) Where A, B, and C are linguistic variables (e.g. `small', `far', ``near") and x, y, and z symbolize variables (e.g. size, distance). Fuzzy if-then Rules are one of the fuzzy rule bases. Fuzzy conditional statements or Fuzzy if-then rules are terms of the shape IF A THEN B, where naming of fuzzy sets are A and B distinguished by suitable membership functions. distinguished by suitable membership functions. Fuzzy if-then rules are predominately utilized to control the inaccurate ways of thought inasmuch due to their abbreviated formula and that plays a fundamental turn in the human capacity to determine resolution in a milieu of impreciseness and doubt. An epitome that depicts an unpretentious truth is if the volume is small, then the pressure is high where linguistic variables are volume and pressure, small and high are labels or linguistic values that are distinguished by membership functions. The second format of the fuzzy if-then base, that suggested by Sugeno and Takagi has fuzzy sets embroiled but just in the premise portion. we can characterize the resistant force on a moving object through utilizing Sugeno's and Takagi, the fuzzy if-then base as follows: force = IC *velocity If the velocity is high, were again in the premise part

a linguistic label is high which distinguished by a suitable membership function. Yet, the next portion is described by a non-fuzzy neutralization of, the velocity and input variable. Both kinds of fuzzy if-then bases have been utilized extensively in each controlling and

modeling. By the utilize of membership functions and linguistic labels, a fuzzy if-then base can readily catch the soul of a “base of the basic” utilized by people and as a local characterization of the system under consideration where every fuzzy if-then base can be viewed and due to the Eligible on the premise portions (Figure 3.8).

5. Membership function: Equips a gauge of the grade of the resemblance of elements in the world of discourse U to the fuzzy set.

6. Fuzzy Inference: Compiles the truths gained through the rule base with Fuzzification and leading the Fuzzy thinking operation.

7. Defuzzification: analysis the outcomes to the genuine world.

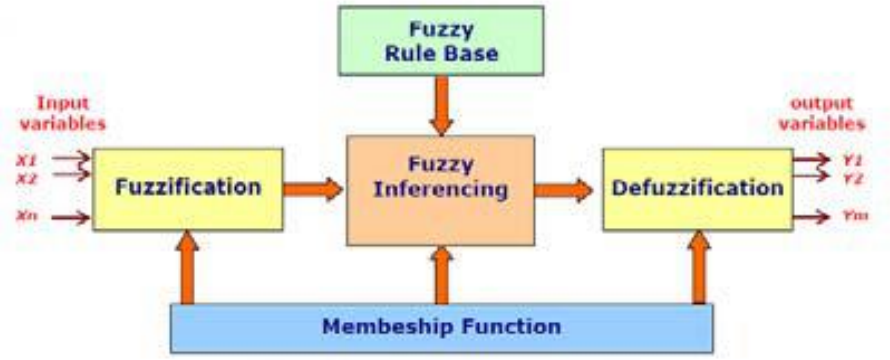

Figure 3.8: Fuzzy Logic

3.2.4 Adaptive Neuron-Fuzzy Interference System (ANFIS)

A combination of two soft-computing methods of ANN and fuzzy logic is called Modify network-based fuzzy inference (ANFIS) (Jang, 1993). Fuzzy logic has the capability to alteration the insights into the process of precise quantitative analysis and qualitative aspects of human knowledge. However, fuzzy logic takes quite a long time to modify the membership functions (MFs) and also it doesn't have a defined style that can be utilized as an evidence in the human thought and operation of conversion into rule-based fuzzy inference system (FIS) (Jang, 1993). In contrast ANN, it has a higher ability in the learning operation to adapt to its circumference. Thus, the ANN can be utilized to reduce the rate of errors in the determination of rules in fuzzy logic and automatically adjust the MFs. This

section will depict in specifics of the architecture of ANFIS, network flexibility, FISs, and hybrid learning algorithm.

3.2.4.1 Fuzzy Inference System

There are three main components and that are namely basic rules that A FIS was built mainly on. Where it depends on the chosen of fuzzy logic basics “If-Then;” as a reasoning fuzzy inference technique from basic rules to get the output and function of the fuzzy set membership; (Figure 3.9) Shows the detailed structure of the FIS. When using the fuzzification process the input that contains the actual value is converted into fuzzy values, during its membership function. FIS will work when doing this operation, the fuzzy value domain is between 0 and 1. The knowledge base is consisting of the databases and basic rules, in dec ision-making, both of them are key elements. Usually, information on fuzzy

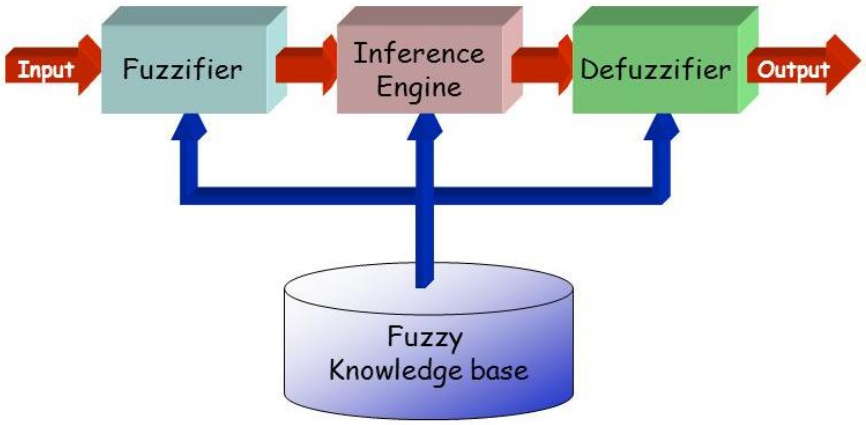

Figure 3.9: Fuzzy inference system

sets parameter with a function that has been defined for each existent linguistic changing is the contents of the database. Limitation of the number of linguistic values to be utilized for

each linguistic variable, defining a universe is the development database typically that consisting of it, as well as construct a membership function Based on the rules, it contains a conditional statement "If-Then and" fuzzy logic operators. The basic rules can be structure either automatic generation or from a human, where the input-output data utilizing numerically in the searching rules. Takagi–Sugeno, Mamdani, and Tsukamoto are several types of FIS. In the application of ANFIS method, utilized A FIS of Takagi–Sugeno model was found to be widely (Chenget, et al., 2005).

3.2.4.2 Adaptive Network

One example of a feed forward neural network with multiple layers is an adaptive network (see Figure 3.10).These networks often use a supervised learning algorithm in the learning process, the adaptive network has that consists of a number of adaptive nodes interconnected directly without any weight value between them this is in relation to its architectural characteristics, where there are different functions and tasks for each node in this network, parameters and the incoming signals that the output depends on its that are available in the node. It can reduce the occurrence of errors at the output of the adaptive network and A learning rule that was used can affect the parameters in the node (Jang, 1993). Gradient descent or back-propagation and the chain rule these learning algorithms that had been proposed by Werbos in 1970 it is normally using these learning algorithms in learning the basic adaptive network, (Jang, 1993).In an adaptive network till day, gradient descent or back-propagation is still used as a learning algorithm; however, the capacity and accuracy of adaptive networks in making decisions further can reduce because there are still found weaknesses in the back-propagation algorithm. Tend to always stick in local minima and the slow convergence rates are master problems on the back-propagation algorithm. The hybrid learning algorithm, an alternative learning algorithm, which has avoided the occurrence of trapped in local minima and has a better ability to accelerate convergence (Jang, 1993).

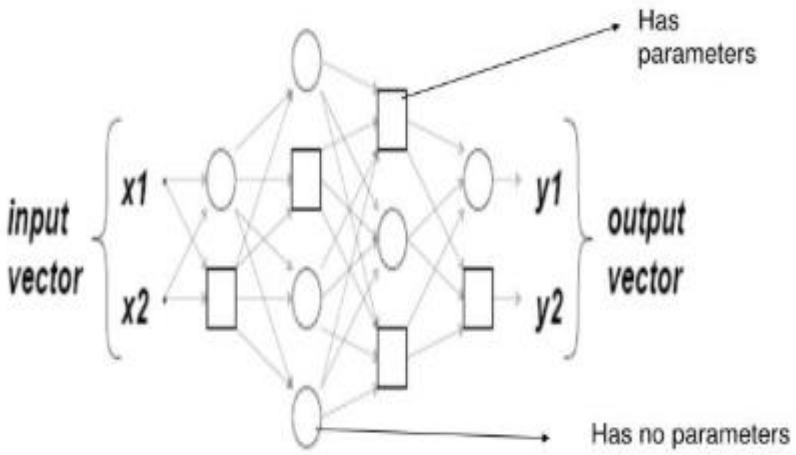

Figure 3.10: Adaptive Network

3.2.4.3 ANFIS Architecture

An adaptive network that utilizes supervised learning on learning algorithm is called ANFIS architecture, which similar to the model of Takagi–Sugeno fuzzy inference system because has similar a function. Figure (3.11a, b) shows the scheme fuzzy reasoning mechanism for Takagi–Sugeno model and ANFIS architecture. For clearness, assume that there are two inputs x and y, and one output f. Two rules were utilized in the method of "If-Then" for Takagi–Sugeno model, as follows:

Rule 1=If x is A1 and y is B1 Then f1 = p1x+q1x+r1
Rule 2=If x is A2 and y is B2 Then f2 = p2x+q2x+r2

Where x and y are the inputs $A_i$and B_i are the fuzzy sets,f_i are the outputs within the fuzzy region specified by the fuzzy rule,$p_i q_i$ and r_i are the design parameters that are determined during the training process. Indicating to Figure 3.11, ANFIS architecture has five layers. The first and fourth layers include an adaptive node, while the other layers include a fixed node. A concise characterization of every layer is as follows:

Layer 1: Each function parameter conforms to a node in this layer. A grade of membership value is the output from all nodes that is assumed by the input of the membership functions.

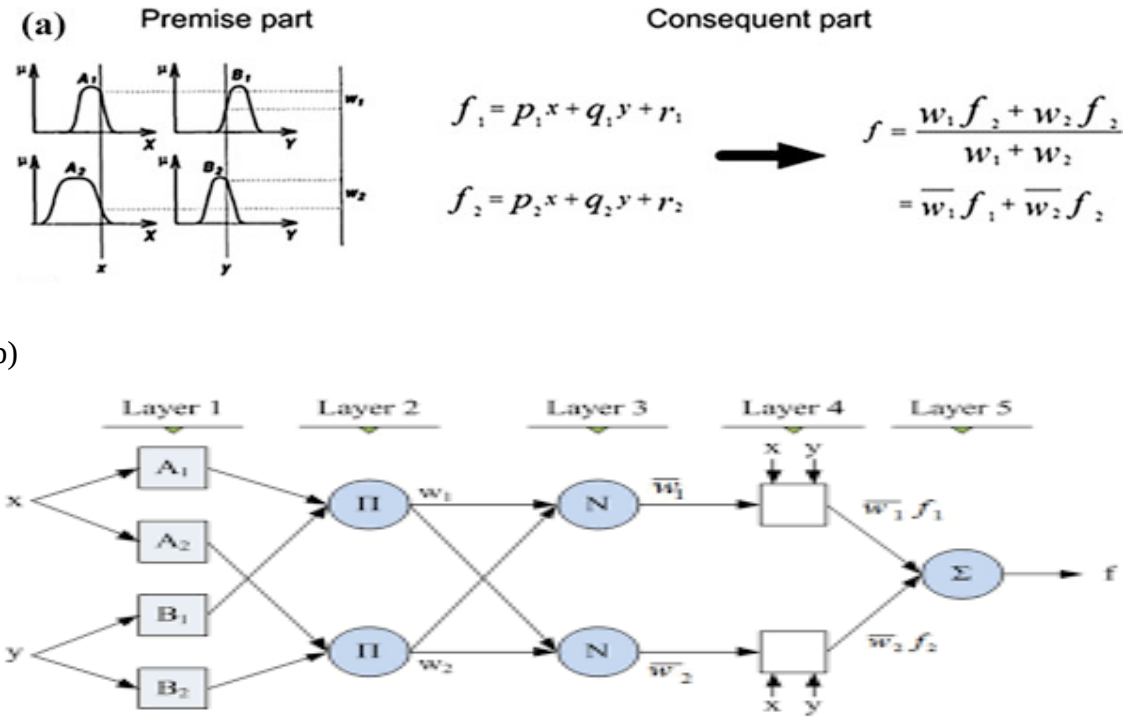

Figure 3.11: ANFIS Architecture

For epitome, there are different kinds of membership function such as a generalized bell membership function (Eq. 1), Gaussian membership function (Eq. 2), or other kinds of membership function

$$\mu_{Ai}(\mathrm{x}) = \frac{1}{1+\left|\frac{x-ci}{ai}\right|^{2b}} \tag{1}$$

$$\mu_{Ai}(\mathrm{x}) = exp\left[-\left(\frac{x_{c_i}}{2a_i}\right)^2\right] \tag{2}$$

$$o_i^1 = \mu_{Ai}(\mathrm{x}),\ fori = 1{,}2 \tag{3}$$

$$o_i^1 = \mu_{Bi-2}(\mathrm{y}),\quad fori = 3{,}4 \tag{4}$$

The inputs to node i are x and y, and the fuzzy membership degree of inputs are the output. All nodes utilize Gaussian membership function, In order to calculate the degree of membership of the input.

$$o_i^1 = \mu_{Ai}(\mathrm{x}) = e^{\frac{-1}{2}\left(\frac{x-c_i}{\sigma_i}\right)} \tag{5}$$

A parameter set is {c,σ}. Where the membership function's center is C represents and the membership function's width is σ. Where premise parameters are all those parameters.

Layer 2: The second layer is Rule layer. The input values are the membership functions in this layer, and the firing strength of rule is an output which given by every node multiplies inputs in this layer. The output of this layer given in neutralization

$$o_i^2 = W_i = \mu_{Ai}(x1) \times \mu_{Bi}(x2) \times \mu_{Ci}(x3) \times \mu_{Di}(x4) \times \mu_{Ei}(x5) \times \mu_{Fi}(x6) \times \mu_{Gi}(x7) \times \mu_{Hi}(x8) \quad i = 1,2,3, \dots \dots \dots ,8 \qquad (6)$$

Layer 3: Here in this layer, the ratio of the i-th rules firing strength to the sum of the rule's firing strengths is the i-th node.

$$o_i^3 = \overline{W} = \frac{wi}{w1+w^1} i = 1,2,3, \dots .,8 \qquad (7)$$

Layer 4: The nodes are adaptive nodes in this laye

$$0_i^4 = \overline{w}_i f_i = \overline{w}_i(p_i x_1 + q_i x_2 + r_i x_3 + a_i x_4 + b_i x_5 + c_i x_6 + d_i x_7 + e_i x_8 + t_i) i = 1,2,3, \dots \dots ,8 \qquad (8)$$

Where, in this layer the output of layer 3 is (*w*), and the parameter set *is {pi, qi, ri, ti}* which referred to as consequent parameters.

Layer 5: there is a single constant node in this layer. Calculates the overall output as the collection of the all forthcoming signals in this layer, given in neutralization:

$$o_i^5 = y = \sum_1 \overline{w_i} f_i = \frac{\sum_i w_i f_i}{w_i f_i} \; i = 1,2,3, \dots ,8 \qquad (9)$$

3.2.4.4 Hybrid-learning Algorithm

The forward pass and backward pass are two passes for the hybrid algorithm. The values of premise algorithm are fixed in the forward pass of the hybrid algorithm. As a linear combination of the consequent parameters can be the expressed the overall output. Output can be given as:

$$f = \frac{w_1}{w_1 + w_2} + \frac{w_2}{w_1 + w_2} f_2 = \overline{w_1}(p_1 x + q_1 y + r_1) + \overline{w_2}(p_2 x + q_2 y + r_2)$$

$$= (\bar{w}1x)p1 + (\bar{w}1y)q1 + (\bar{w}1)r1 + (\bar{w}2x)p2 + (\bar{w}2y)q2 + (\bar{w}2)r2 \quad (10)$$

$$y = f(i, s) \quad (11)$$

The vector of input variables is i , the set of parameters is S. the elements of S can be identified by the least-squares method If there is a function H such that the composite function H◦f is linear in some of the elements of S (Malhotra and Malhotra,2001).If S is the parameter set can be split into two groups S1and S2, where a set of premise parameters is S1 and set of consequent parameters is S2 we have

$$S = S_1 \oplus S_2 \quad (12)$$

(The direct sum represented by $\oplus$) where that the linear in the elements of S2 is H◦f, after applying H to Eq. (11), we have

$$H°O = H°f(i, s) \quad (13)$$

H◦f is linear in the elements of S2. The matrix equation is obtained after substituting training data in (13).

$$A\theta = Y \quad (14)$$

Here an unknown parameter vector is θ and elements θ are parameters in S2. Let S2=M and M×1 parameter vector is dimensions of t, p×M matrix is A and p×1 output vector is y.

This is the best solution for θ, which minimizes$\|A\theta - Y\|^2$ is the least-squares estimator (LSE) $\theta*$ and the standard linear least-squares problem (Malhotra and Malhotra,2001).

$$\theta^* = (A^T A)^{-1} A^T y \quad (15)$$

CHAPTER 4

DATASET

4.1 Data preparation

In this thesis we described dataset that we got from the (Surgical Specialty Hospital-Cardiac Centre "Directorate of Health-Erbil" Kurdistan Regional Government Iraq, 2018). This dataset is used to diagnose the existence or nonexistence of heart attack obtained from various medical tests carried out on the patients. This dataset contains 1319 cases, 8 input fields and one output field which indicate the presence of heart attack of the patient. We utilized 8 attributes for input and one attribute for output. Input fields are age, sex, heart rate, systolic BP, diastolic BP, blood sugar, CK-MB and test-Troponin, and output field refers to the presence of heart attack which has 2 classes (0 and1): 0 refers to the nonexistence of heart attack and 1 refers to the existence of heart attack. We utilized MATLAB framework for the dataset to be utilized in order and the data were normalized between 0 and 1. The detailed information about variables is presented in (Table 4.1).

Table 4.1: Information about the input variables

Description	**Number of MF IN (FIS)**	**Number of MF IN (AFIS)**	**Max**	**Min**	**Variable Name**
Age in years	3	2	103	14	Age
Sex	2	2	1	0	Sex
maximum heart rate	3	2	1111	20	Heart Rate
systolic BP	3	2	223	42	SBP
diastolic BP	3	2	154	38	DBP
blood sugar	3	2	541	35	FBS
CK-MB	2	2	300	0.321	CK-MB
test-troponin	2	2	10.3	0.001	test-troponin

The input variables are:

4.1.1 Age

The input field is containing numerical numbers of age where the maximum of age is 103 and the minimum is 14.

4.1.2 Sex

The input field includes two values (0, 1) and sets (Female and male).

4.1.3 Heart Rate

The pulse of the heart muscle is generated by the generation of a pulse stimulator, or the so-called senatorial node / SA node, a node that gives the catalytic signal to the contraction of the heart muscle, resulting in the closure and opening of the heart valves, This closure and opening is the sound of heartbeats that we hear while closing and opening the pumping of blood in the arteries of the body and this is the function of pulse, and can feel pulse in areas where the artery is close to the surface of the skin, such as the hand in the hand at the wrist, To be measured across the left hand being a Near the heart, the artery in the neck area, and the artery in the leg below the kneel (Ake,2007).

Pulse rate is inversely related to the average age of the human, meaning that the older the person, the lower the pulse rate. Thus, the pulse is at its highest rate at the fetus and then the child, gradually decreasing to its lowest age. The pulse rate is specific for each age and at the longest stage in human life, which is the youth stage between the ages of eighteen and fifty. The normal pulse rate ranges between 60 beats per minute - 100 beats per minute. However, if a person is in an abnormal position, such as being an athlete in a long-distance race, the acceleration is not very dangerous for very little time if he is relieved to feel stressed. However, if there is an acceleration or slowdown for non-immediate periods, this means that he suffers from a heart health problem the third case is the presence of acceleration and deceleration in the same minute during which the pulse rate is measured. In this case, the pulse should be measured for more than two minutes to be confirmed. This means that there are disturbances in the pulse rate. Also, healthy should be followed up and knowledge, and through the pulse rate can also know the blood flow rate, and whether there is imbalance in blood circulation.

4.1.3.1 How to Measure Heart Rate

There are many ways to measure heart rate, most notably:

- Method 1: Place the fingers of the index finger and the middle of the other hand (or someone else's wrist) under the thumb, feel the place of the rings and then start after the chimes for fifteen seconds, then multiply the result by 4 to get the number of beats per minute.
- Method 2: Place the fingers of the index finger and middle on the end of the neck from the top to the left or right of the trachea, and the location of the chimes, then start after the chimes for ten seconds, and then multiply the result by 6 to obtain the number of beats per minute, Heart rate in resting mode, the best time for it is in the morning after waking up and before taking out of bed.

4.1.3.2 Factors Affecting Heart Rate

There are several factors that affect the heart rate, the first of which is age, as mentioned earlier (Ake, 2007). The most important of these factors are:

- Endocrine: Certain glands, specifically the thyroid and thyroid glands, control the heart's activity and activity through its activity because of its secretion of hormones that affect blood circulation such as thyroxin. These glands also affect the heartbeat when feeling fear and anxiety. The heart stimulates the secretion of the adrenaline hormone, which increases the pulse quickly and suddenly.
- Temperature: When the temperature and humidity rise around the body, the heart pumps the blood a little more to reach the skin faster; the body is faster, so the pulse rate may increase, but usually no more than five to ten strokes per minute.
- Age: Heartbeat affected by human age, the pulse varies from child too young to old age, each of which fits his pulse with the size of his arteries, and heart, and with the extent of the circulation.
- Body Position: The body tries to maintain its pulse rate in its different positions in general, but it may change for a few seconds and increase when standing or moving but quickly returns to its normal state.

- Emotions: Exposure to rapidly changing moods, such as anger, joy, or sadness, increases heart rate significantly.
- Body size: The body size usually does not change the pulse, but if the obesity is severe may see the pulse is higher than the average person in normal weight, but usually does not raise the pulse rate of 100 beats per minute.
- Use of drugs: Drugs that act to prevent adrenaline (beta blockers) tend to slow down the pulse, while a lot of thyroid drugs work to raise the pulse rate.
- Fitness Level: The more a person is a mathematician, the lower his heart rate is when resting from other people, sometimes up to 40 beats per minute.

4.1.3.3 Maintain Normal Pulse Rate

Some things may help to prevent changes or disturbances in the heart rate, including:

- Getting enough rest to avoid fatigue. Fatigue may cause increased risk of arrhythmia Heart rhythm and pulse rate.
- Avoid or reduce caffeine by avoiding coffee, tea, soft drinks, etc., for the possibility of caffeine in raising the heart rate.
- Keep away from alcohol and tobacco, because it contains substances that cause the increase of heart rate, and irregular pulse.
- Relaxation exercises and deep breathing where stress and stress affect the heart rate.

The input field is containing numerical numbers of heart rate where the maximum of heart rate is 1111 and the minimum is 20.

4.1.4 Blood Pressure

When the heart beats, it pumps the blood through the arteries to the rest of the body, and this force that pumps the heart blood on the walls of blood vessels formed pressure which it called Systolic Blood Pressure, which forms the numerator in blood pressure readings, where Blood pressure is described in two numbers, number in the numerator and number in the denominator, while the diastolic blood pressure represents the blood pressure on

blood vessel walls during the heartbeat between each pulse(American Heart Association, 2017). Blood pressure is important for delivering oxygen and food to all parts of the body, its importance is not limited to this only; it is also important for the transfer of white blood cells for immunity, hormones such as insulin, and many other tasks.

4.1.4.1 Blood Pressure Measurement

When measuring blood pressure, the person should sit on a chair his back and advise not to place a man on the other, with the need to touch the feet of the ground, and the arm must be supported so that it is almost at the level parallel to the heart (Lip, et al., 2000). It should be noted that the presence of blood pressure readings above the normal limit requires the monitoring of blood pressure readings by person and recorded for a review of the doctor in this regard (American Heart Association, 2017). Although most attention is given to reading systolic blood pressure as a major cause of cardiovascular disease for people over the age of 50 years, however, reading diastolic blood pressure may be used alone to diagnose high blood pressure. The risk of death due to ischemic heart disease or stroke is doubled for every 10 mmHg increase in diastolic blood pressure readings, and for every 20 mmHg increase in a systolic blood pressure reading in people Aged between 40 and 89 years.

4.1.4.2 Blood Pressure Readings

Blood pressure readings are divided into five stages according to the American Heart Association (American Heart Association, 2015). The following is a clarification of each stage:

1. Normal Blood Pressure: Blood pressure is considered within normal limits if blood pressure is less than 120 mg / 80 mm Hg and above 90/60 mm Hg. If the blood pressure reading is 90/60 mm Hg or below, the person has low hypotension. the causes of hypotension are following:
    - Heart problems.
    - Drought.
    - Pregnancy.
    - Blood loss.

- Squeamishness.
- Severe infection or septicemia.
- Endocrine problems.
- Malnutrition.
- Take some medications.

2. Hypertension: At this stage, diastolic blood pressure ranges from 120-129 mm Hg with diastolic blood pressure below 80 mm Hg. In such cases, the risk of high blood pressure increases unless appropriate measures are taken to prevent the development of the condition.

    ❖ The first stage of high blood pressure: Also called pre-high blood pressure and at this stage, systolic blood pressure permanently between 130-139 mm Hg, or the diastolic pressure between 80-89 mm Hg, and usually advised doctors at this stage to make changes in the Lifestyle, drugs may be prescribed to treat blood pressure at this stage.

    ❖ The second stage of hypertension: At this stage, blood pressure is equal to 140/90 mm Hg or higher, and at this stage, doctors prescribe more than one treatment, in addition to the changes that should be made in lifestyle.

    ❖ Hypertensive crisis: This condition requires medical intervention. When the blood pressure reading exceeds 180/120 mmHg, the person must wait for five minutes and re-check the blood pressure again. If the case remains the same, you should contact the doctor. Directly, but if Hypertensive crisis accompanied the emergence of any symptoms that indicate damage to a member of the body, they must contact the emergency immediately without waiting for 5 minutes to re-examination, and these symptoms include:

- Symptoms of a stroke, such as a paralysis or loss of control of facial or limb muscles.
- Pain in chest.
- Breathing difficulty.
- A backache.
- Difficult to speak.
- Change in vision.

- Numbness or weakness.
- Headaches.
- Rotor.
- The appearance of blood in the urine.

4.1.4.3 Preventing and Controlling High Blood Pressure

Healthy people should take measures to change their lifestyle in order to avoid high blood pressure and heart disease, and also for people with high blood pressure; success in controlling blood pressure by changing lifestyle may avoid, Delay or reduce the need to take medicines (Lip, et al., 2000). The following are the most important measures:

- Loss of excess weight and attention to the waist circumference; where the risk is greater if the waist circumference of the male more than 102 cm and the female if more than 89 cm.
- Exercising for at least half an hour for most days of the week may help reduce blood pressure by 4-9 mm Hg.
- Eat healthy food, i.e. vegetables, fruits, whole grains, and avoid foods high in cholesterol and saturated fat, and eating healthy food may reduce blood pressure by 14 mm Hg.
- Reduce eating sodium to less than 2,300 mg per day, reducing blood pressure by 2-8 mm Hg.
- Stop smoking and drink alcohol.
- Avoid stress.
- Monitor blood pressure at home regularly, and check with your doctor regularly.
- The caffeine effect in blood pressure may vary depending on the person's consumption. Caffeine has the ability to raise blood pressure by 10 mm Hg in people who rarely take caffeine, while it has little effect on people who are used to it. To know the role of caffeine in raising blood pressure, the person is advised to drink a drink containing caffeine and then measuring blood pressure within half an hour, if found a rise of 5-10 mm Hg, it means that the body is affected by caffeine.

This input field is divided into two sets of systolic pressure and diastolic pressure as it contains numerical numbers where the maximum of systolic pressure is 223and the minimum is 42; the maximum of diastolic pressure is 38 and the minimum is 154.

4.1.5 Blood Sugar

When eating the food Glucose increases in the blood or is known as blood sugar the high glucose in the blood stimulates pancreatic cells known as beta cells. These cells respond to insulin secretion. (Insulin), which in turn stimulates the body's various cells to allow glucose to enter into it to be used in energy production. If the amount of glucose in the blood exceeds the need of the cells of the body, these excess amounts are stored in the liver with the help of insulin to be used at the need, and the transcendent happens for the natural ratios of glucose in the blood when it is not the secretion of the hormone insulin in sufficient quantity, or when the body's cells become resistant to the effect of insulin secreted (Robert, 2016); (Elkeles, 2000).

4.1.5.1 Natural blood Sugar

Natural Blood Sugar The level of natural sugar in the blood is determined by performing a number of different tests, which are as follows:

1. Diabetic Hemoglobin Test: The gyrated hemoglobin test is known as the hemoglobin test (A1C). This test is based on glucose linked to the hemoglobin protein responsible for oxygen transport in red blood cells over the past three months. Glucose increases with hemoglobin whenever blood glucose is increased, the test results are explained as follows:
    - Normal level: If the result is less than 5.7%.
    - Pre-diabetes: Prediabetes when the result ranges between 5.7% and 6.4%.
    - Diabetes: When the result is 6.5% or more.
2. Random Blood Glucose Test: Random Blood Sugar Test can be performed at any time of the day regardless of the time of the last meal. Blood sugar is normal when this test is less than 200 mg / dL. If the result is 200 Mg / dL or more, this may indicate a person's diabetes.

3. Fasting Blood Sugar Test: Fasting Blood Sugar Test measures the blood sugar level in the morning after fasting the night. The results of the test are explained as follows:
    - Normal level: If the result is less than 100 mg / dL.
    - Diabetic predisposition: If the result is between 100 to 125 mg / dL.
    - Diabetes: If the result is 126 mg / dL or more, it should be noted that the diagnosis of the patient with diabetes after the re-test on two separate times and achieve these results.
4. Oral Glucose Tolerance Test: The person is required to fast a full night before oral glucose tolerance test, then the blood sugar is checked, the person is asked to drink a solution containing sugar. The blood sugar level is then checked Over a period of two hours periodically and then interpret the test results as follows:
    - Normal level: If the result is less than 140 mg / dL.
    - Diabetic predisposition: if the result is between 140 to 199 mg / dL.
    - Diabetes: If the result is 200 mg / dL or more.

4.1.5.2 Low Blood Sugar

Hypoglycemia occurs when blood sugar is less than 70 mg / dL. Low blood sugar is not a disease in itself, but a sign of another health problem. Low blood sugar is often associated with a treatment of disease may be a side effect of the drugs used in the treatment of diabetes, but it may be associated with other health conditions such as fever, and because blood sugar is the main source of energy production in the body, You should treat low blood sugar immediately by eating foods or drinks rich in sugar, or use drugs, and as must determine the cause of which has led to a decline in the level of sugar to prevent it from happening again. There are some symptoms that may appear on the patient when low blood sugar level, including the following:

- Feeling tired and tired.
- Pale skin. Feeling anxious and irritable.
- Flicker.
- Sweating.
- Feeling hungry.

- Feeling numb or numb around the mouth.
- Confusion, loss of consciousness, insensitive, and sight-seeing disorders
- Severe hypoglycemia.

The input field is containing numeric numbers of blood sugar where the maximum of blood sugar is 541 and the minimum is 35.

4.1.6 Creatine Kinase (CK)

Enzymes are proteins that help in the rapid chemical reactions within the living cell without consumption or a change has occurred in it such as Creatine Kinase Enzymes (Chang, et al.,2015).

4.1.6.1 What is the Heart Enzyme?

Severe chest pain, blood pressure and other chronic conditions that cannot be mitigated except if the presence of the enzyme heart can reduce the degree of complications of heart disease, but what is the enzyme heart?

Heart enzymes are defined as proteins that are excreted in the bloodstream directly without the presence of a medium in large amounts of the internal tissue of the heart muscle, which is exposed to the gangrene as a result of infarction in the internal muscle of the heart and relates to the extent of secretion of different proteins in the body according to molecular weights, Center of myocardial cell and blood flow position and lymphocyte (American Heart Association, 2015). The importance of such enzymes is that it diagnoses the condition of cardiac infarction resulting from non-death in a part of the heart muscle, especially for the patient suffering from pain in the chest area, so control the extent of increase or decrease in the enzymes of the heart in several days. This process is due to the high level of serum keratinize phosphokinase after the so-called infarction for four to eight hours, but not until it returns to its normal concentration after 48-72 hours of occurrence, and the enzyme creative is not limited to the role only on the muscle The heart, but it is excreted in other muscles of the body in large quantities when any damage to those

muscles, for example: in the case of convulsions or chronic muscle diseases such as cruciferous or in the case of intramuscular injection, not to mention that there are other secondary causes lead to high levels The serum keratinize phosphokinase, which is In cases of hypothyroidism, Or in cases of stroke, and at the high level of this enzyme, requires the examination of a molecule of this hormone, which is secreted especially from the heart muscle, and in the case as found that the enzyme is at a high level, it is an indication of the presence of a muscle injury in the heart, but this may indicate an inflammation of the heart muscle and may require a heart operation so that the heart systems are restored to their normal position using electric shock.

4.1.6.2 Types of CK

1. CK-MB Creatine kinase of the heart muscle medical analysis of this type of enzyme is needed for the purpose of detecting heart disease and stroke to provide the necessary health care based on a reading in the blood, where the heart's enzymes reach the blood. A sample of the suspect's blood is taken by drawing a blood sample from one of the venous blood vessels in the arm, with a sample of approximately every 4 hours, where the blood reaches its peak within 24 hours, and returns to normal after forty-eight hours of heart attacks which we have relied upon in our research work (Lynn, et al., 1999); (Ana and Grasiely, 2012).
2. CK-BB Creatine kinase in the brain is a very accurate test and is an indicator of the brain's exposure to any injury, which secretes it when exposed to such conditions.
3. CK-MM Creatine kinase in the muscles, in very rare circumstances, is needed to detect the condition of the muscles of the body, in case of severe stress, or very strong convulsions, to determine the condition of those muscles.

4.1.6.3 Characteristics of the CK Enzyme

- The CK is existed in the cytoplasm for cells, for the brain, heart, body muscles, liver, nervous system, kidney, intestines, diaphragm, and thyroid gland, where the activity of this enzyme depends on the activity of the muscles and thyroid gland .Where the increase of this enzyme about its normal rate leads to the occurrence of

clots in the heart, where the detection of its percentage in the blood an indication of the presence of such heart disorders.

- The CK enzyme increases the speed of the reactions, especially when exerting a high physical effort. It transfers the phosphate groups necessary to contract the muscles during exercise and releases the energy necessary to complete the effort. It is an important indicator of the level of athletic effort, especially in the operations of Sugar burning anaerobic in the muscles.

4.1.6.4 What is CK Analysis?

Is a medical analysis that calculates the number of protein factors that help to complete the body's interactions in the muscles of the body, including the heart muscle, which belonging to Creatine Kinase Enzymes (CKE) and has other common names such as Phosphorylase Creatine.CK analysis is based on its type and where it's in the body.

4.1.6.5 Read the Results of CK Analysis

The results of the analysis are based on international units per milliliter of blood. CK-MB is considered within normal limits is between (0.0 up to 6.22) if the person man and (0.0 up to 4.88) if the person woman, If the concentrations are high, especially the analyzes performed every four hours, they are an indicator of heart injury, which requires further tests to determine the problem of the heart, if the concentrations above the normal range, and below the high levels, and this reading is indicative of musculoskeletal disorders.
The input field is containing numerical numbers of CK-MB where the maximum of CK-BM is 300 and the minimum is 0.321.

4.1.7 Troponin

Troponin; is one of the most important enzymes in the heart and is a family of proteins found in the skeletal muscle fibers and the heart muscle, causing muscle contraction. Troponin test detects the level of protein in the blood to help detect heart injury. Typically, Troponin is found in very small amounts in the blood. When there is damage to myocardial cells, Troponin is released into the blood. The greater the damage, the greater the

concentration in the blood. In the first place, Troponin tests are used to help determine whether an individual has a heart attack or not (Lynn, et al., 1999).

4.1.7.1 Types of Troponin

- Troponin C binds to calcium ions to produce a conformational change in TnI.
- Troponin T binds to Tropomyosin, interlocking them to form a troponin-Tropomyosin complex.
- Troponin I bind to actions in thin my filaments to hold the Troponin-Tropomyosin complex in place.

4.1.7.2 Troponin Analysis

When a person has a heart attack, the levels of Troponin in the blood can rise within 3 or 4 hours after infection, and may remain elevated for 10 to 14 days. A sample of Troponin is examined by taking a blood sample from one of the veins in the arm. Troponin tests are used primarily to help diagnose a heart attack, and to exclude other cases with similar signs and symptoms. Troponin tests sometimes use heart enzymes to evaluate people with heart injuries due to causes other than the heart attack or to distinguish signs and symptoms such as chest pain which may be caused by other causes. A test can also be performed to evaluate people with angina if their signs and symptoms worsen. Troponin test is the best in detecting heart attacks from other cardiac biomarkers. A test called high-sensitivity Troponin reveals is the same protein as the standard test at much lower levels. Because this version of the test is more sensitive, it is useful in early detection of heart injury and acute coronary syndrome. The proportion of natural Troponin in the blood should be less than 0.015 ng/ml for all ages, males, and females (Lynn, et al., 1999). The input field is containing numeric numbers of Troponin where the maximum of Troponin is 10.3 and the minimum is 0.001.

CHAPTER 5

EXPERIMENTS AND RESULTS

The data set that includes the symptoms of 1319 patients are utilized in this study. The data set is split into two parts- the training and testing sets. Using identical inputs and output variables, the design of the models has been carried out. Eight input features are age, sex, heart rate, systolic BP, diastolic BP, blood sugar, CK-MB and test-Troponin. We have utilized three models Back Propagation Neural Network, the fuzzy inference system, and ANFIS. Each model has only one output to predict the heart attack of the Patient. Each model utilized the same domain of data sets. Matlab toolbox is utilized to design the models including Back Propagation Neural Network, the fuzzy inference system, and ANFIS. As follows the simulations of models are expounded: -

5.1 Back Propagation Neural Network

In the test, we have utilized1060 training styles to train the Back Propagation Neural Network, 259 testing and validation Patients are utilized to see the performance of the model and the best validation performance with 100neuron200 epoch is 0.081708 . As shown in (Figure 5.1).

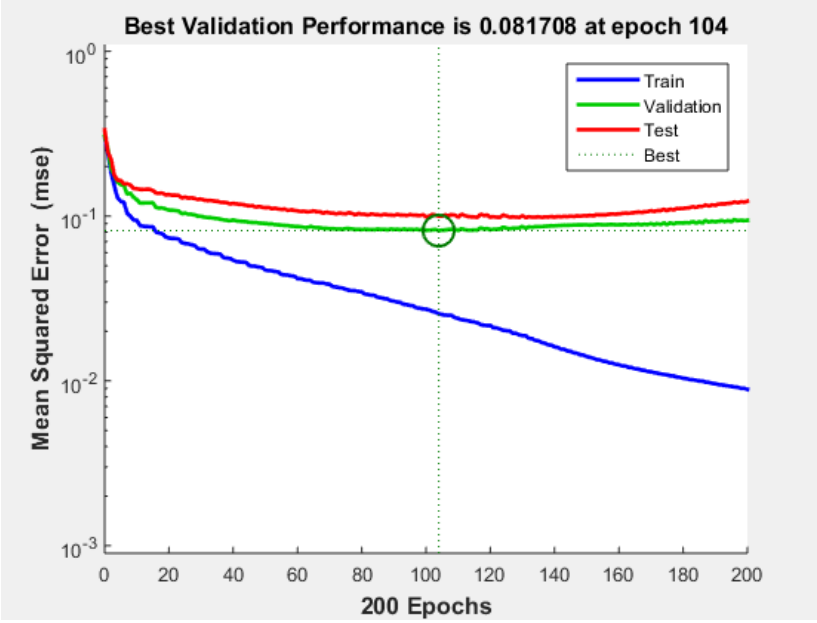

Figure 5.1: The best validation performance

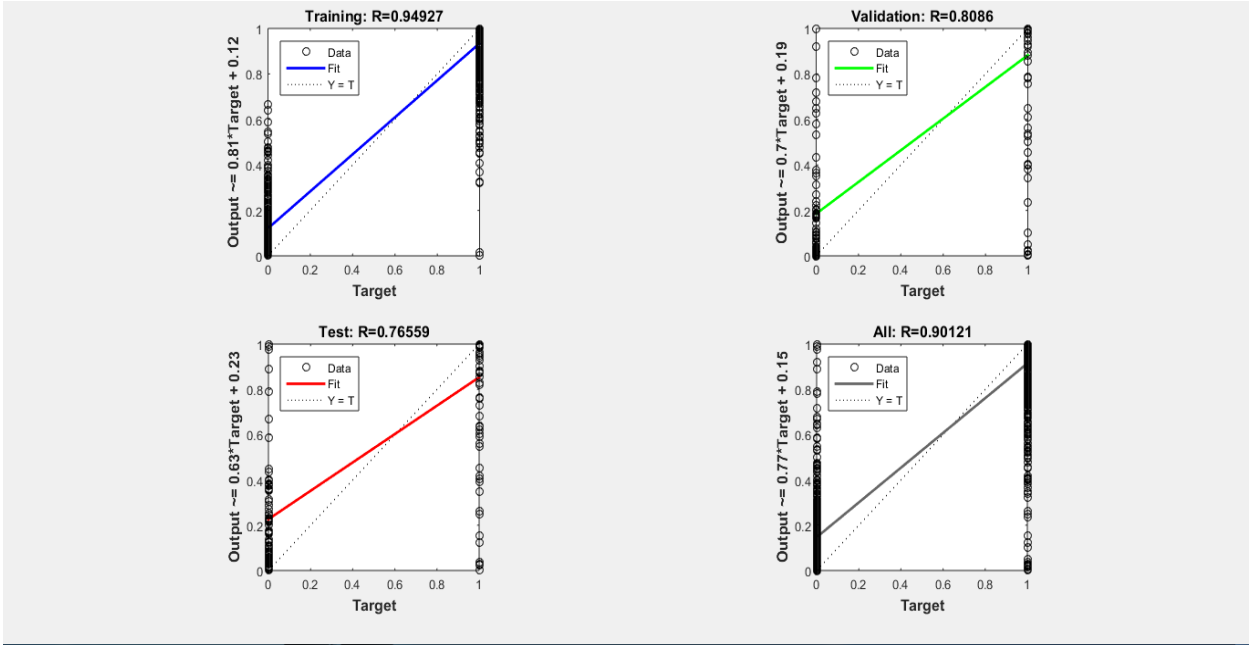

Figure 5.2: Back propagation training, testing, validation accuracy using NNTOOL

Figure 5.2 and table 5.1 highlights the training, testing and validation accuracy; the accuracy of training is 0.94927 and it's fair enough but not perfect. The testing accuracy was 0.76559. The validation accuracy is 0.8086.

Table 5.1: Training, testing and validation by BP for 1319 patients

Patients	**neurons**	**epoch**	**Inputs**	**output**	**Function**	**Training**	**testing**	**validation**
1319	100	200	age, sex, heard rate,SBP ,DBP,BS ,CK-MB and Troponin.	Heart attack	Trainlm	0. 94927	0.76559	0.8086

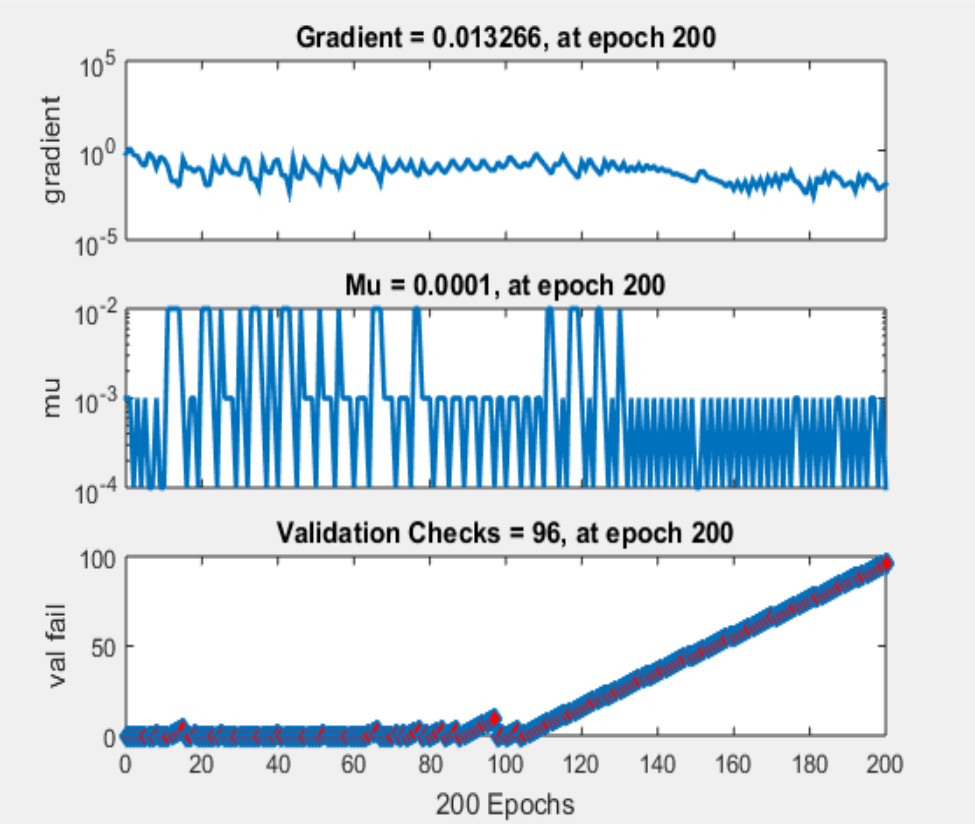

Figure 5.3: Back propagation Gradient, Mu, Validation checks state

Figure 5.3 the Gradient at 200 epochs which is 0.013266, Mu is 0.0001 and validation checks is 96.

5.2 Fuzzy Inference System

In the test, we have utilized 1060 training styles to train the fuzzy inference system model, 259testing and validation Patients are utilized to see the performance of the model The Mamdani technique is utilized for this model as shown in (Figure 5.4).

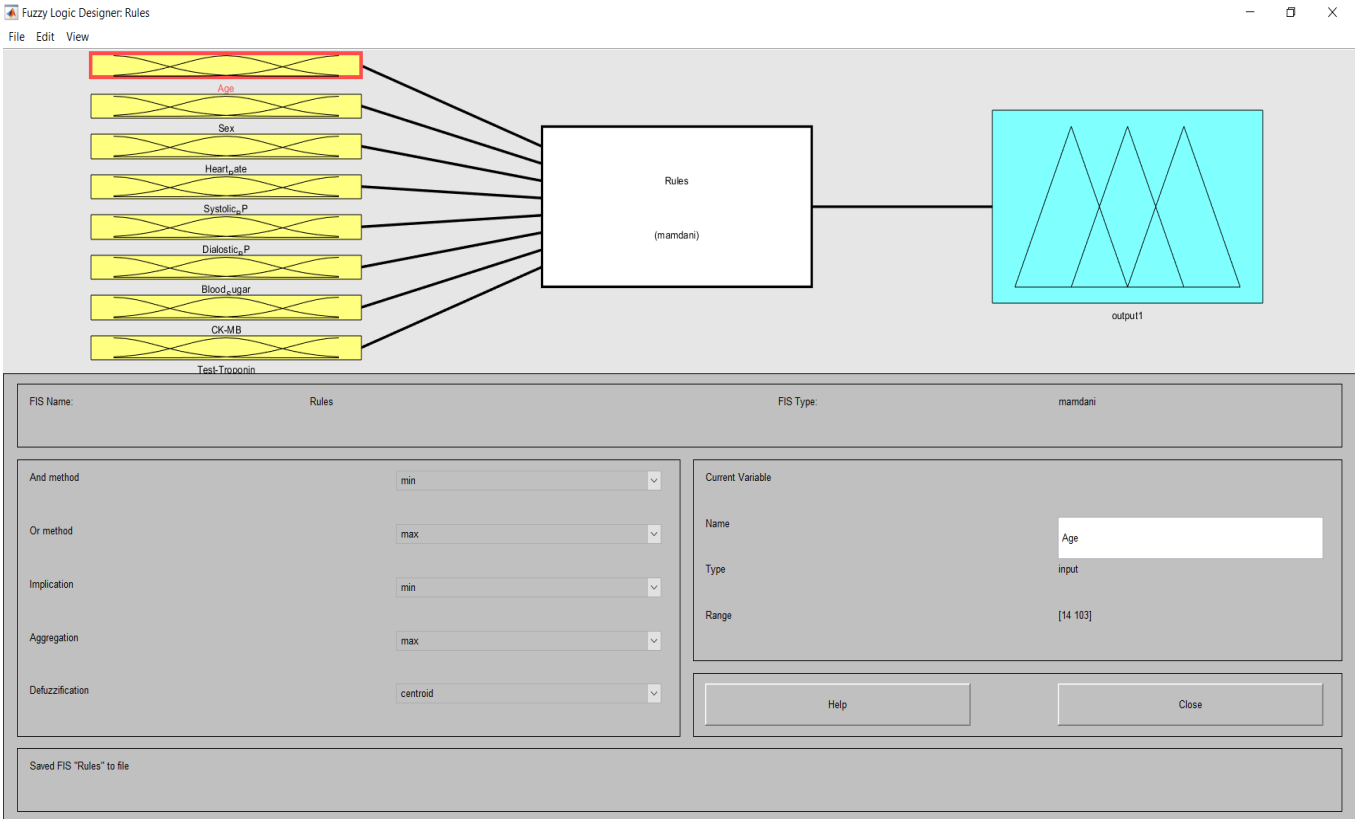

Figure 5.4: The Mamdani technique is used for fuzzy inference system.

we have specified the range of input variables from the data sets the range is set as follows: the age was in between 14- 103, the sex was in between 0- 1, the heart rate was in between 1111-20, the systolic blood pressure was in between 42-223, the diastolic blood pressure was in between 38-154, the blood sugar was in between 35-541,the CK-MB was in between 0.321-300, the Troponin was in between 0.001-10.3 and one output which was the diagnosis heart attack in between 0 -1 (see Figure 5.5, 5.6, 5.7, 5.8,5.9,5.10,5.11,5.12,5.13)

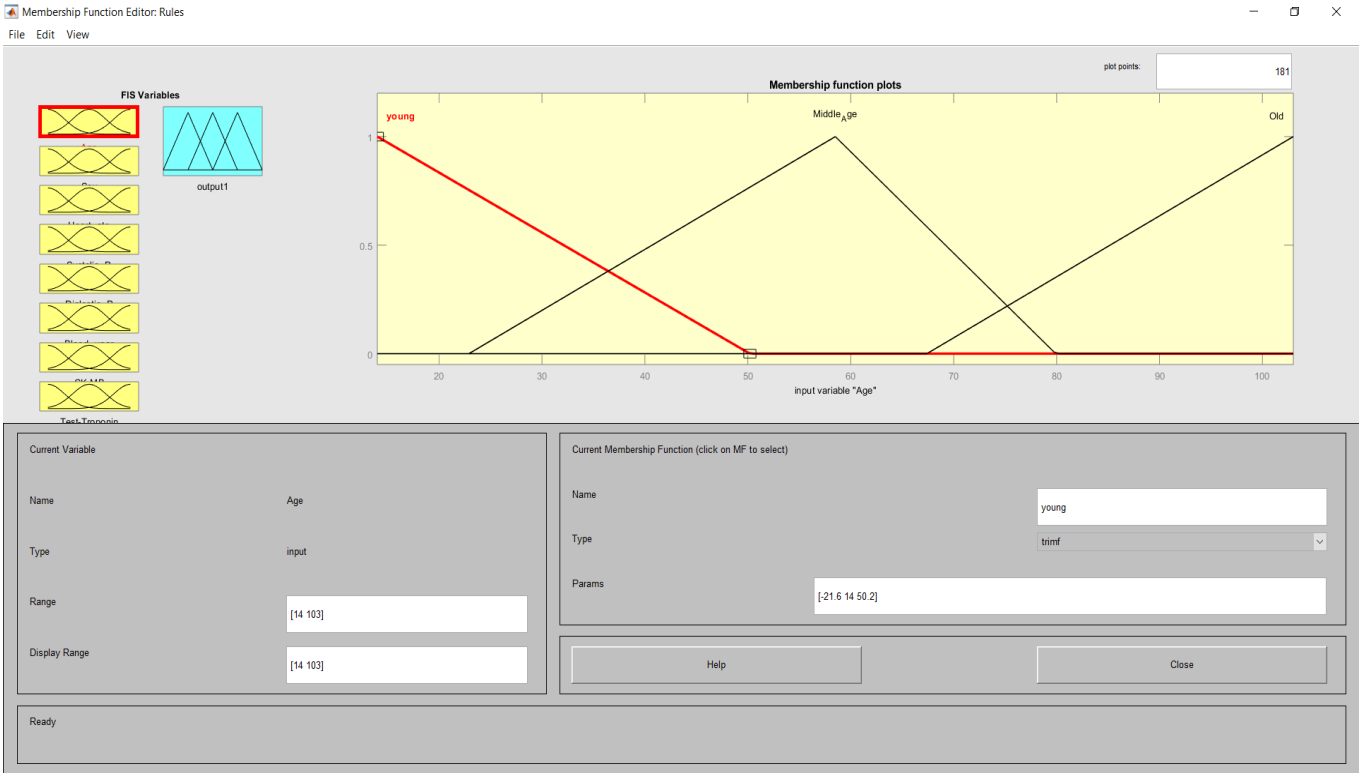

Figure 5.5: The membership function for the age variable

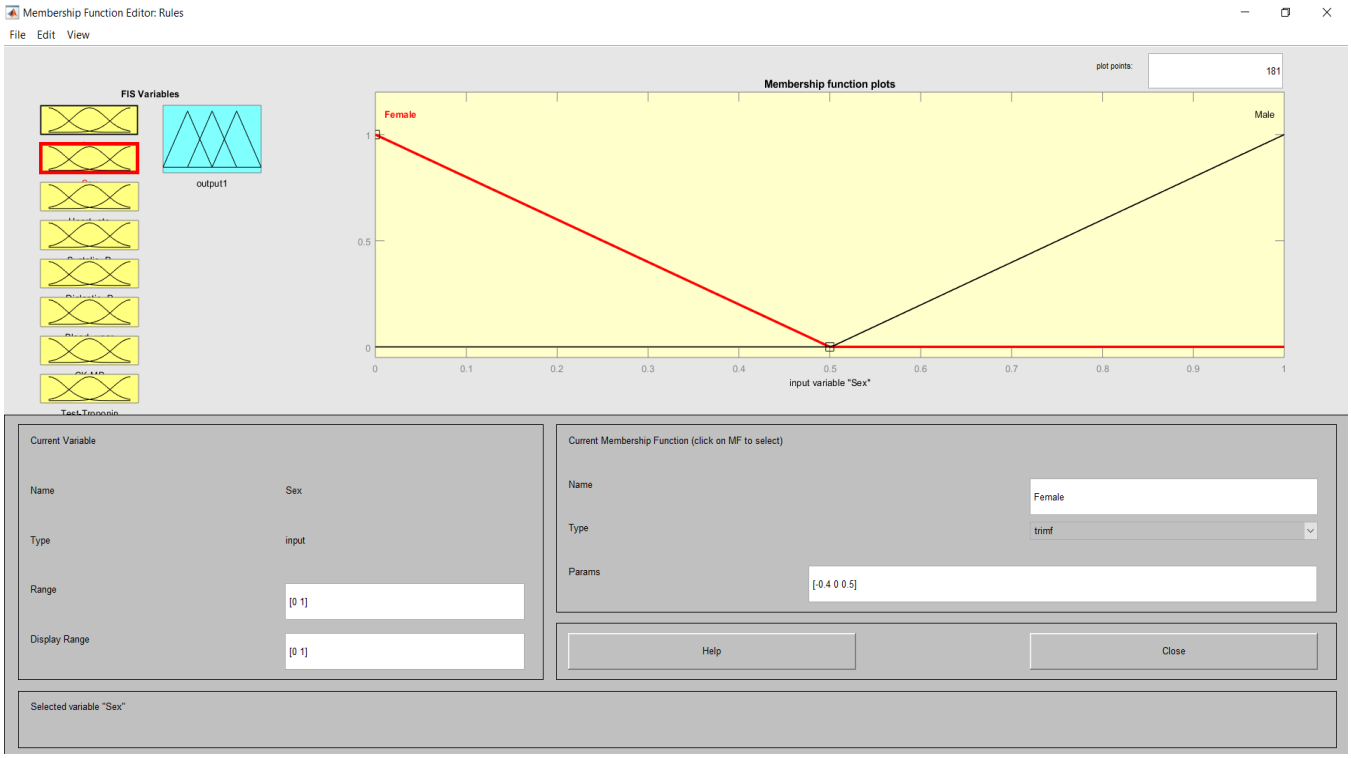

Figure 5.6: The membership function for the sex variable

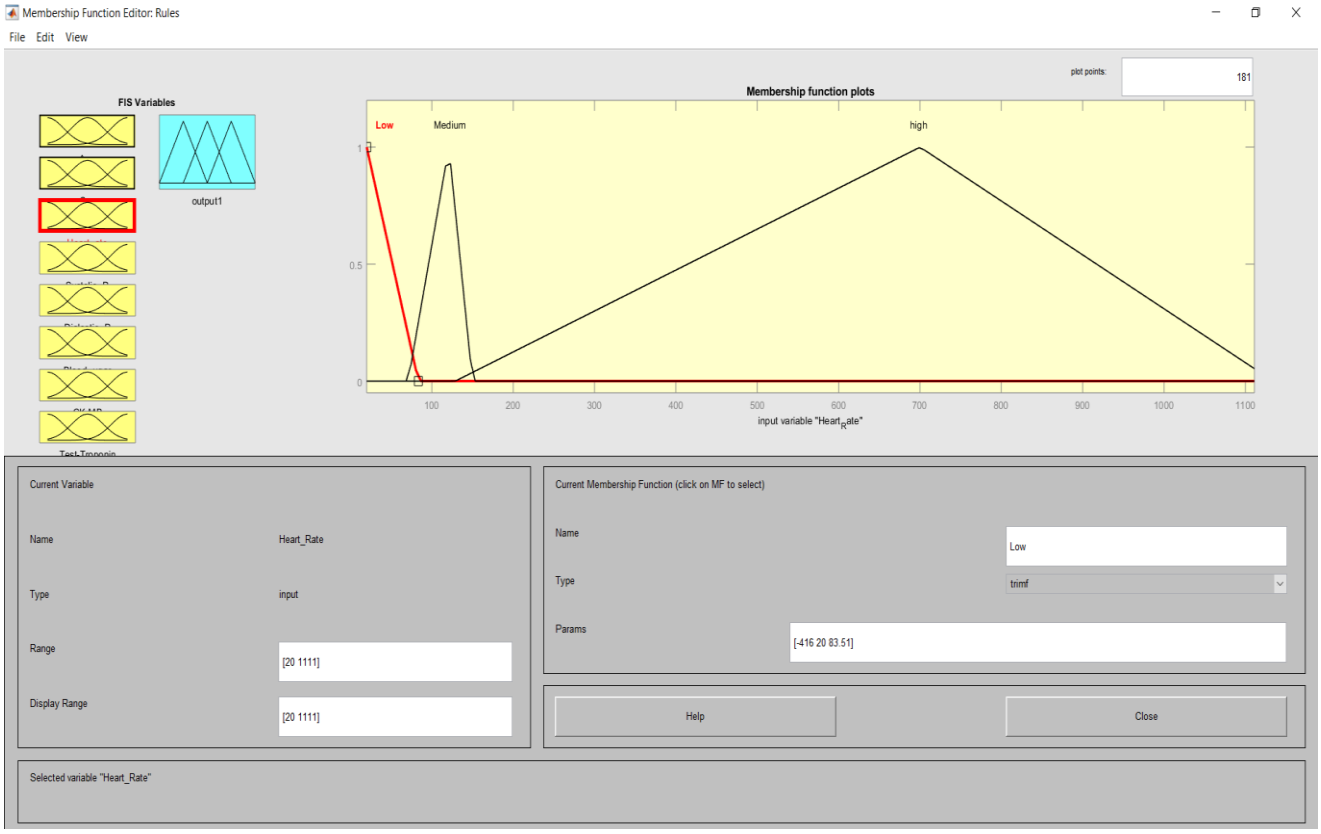

Figure 5.7: The membership function for the heart rate variable

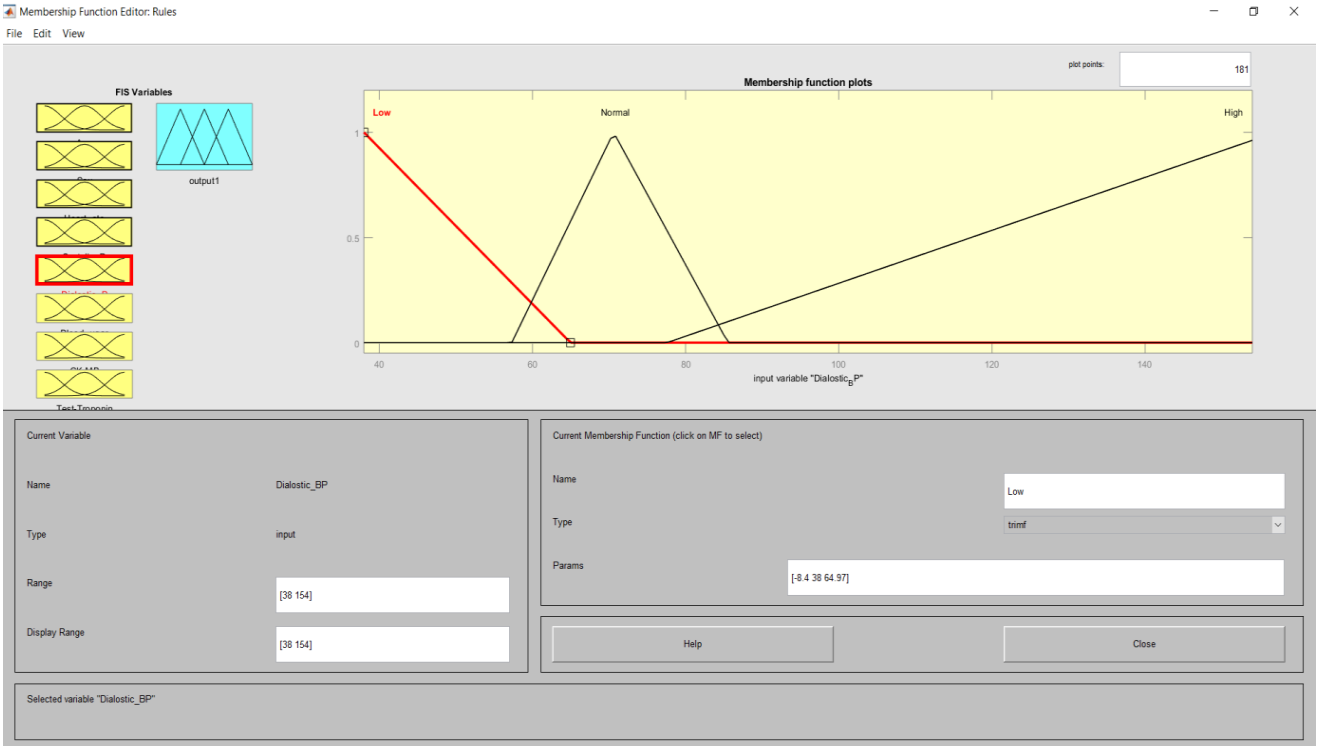

Figure 5.8: The membership function for the systolic BP variable

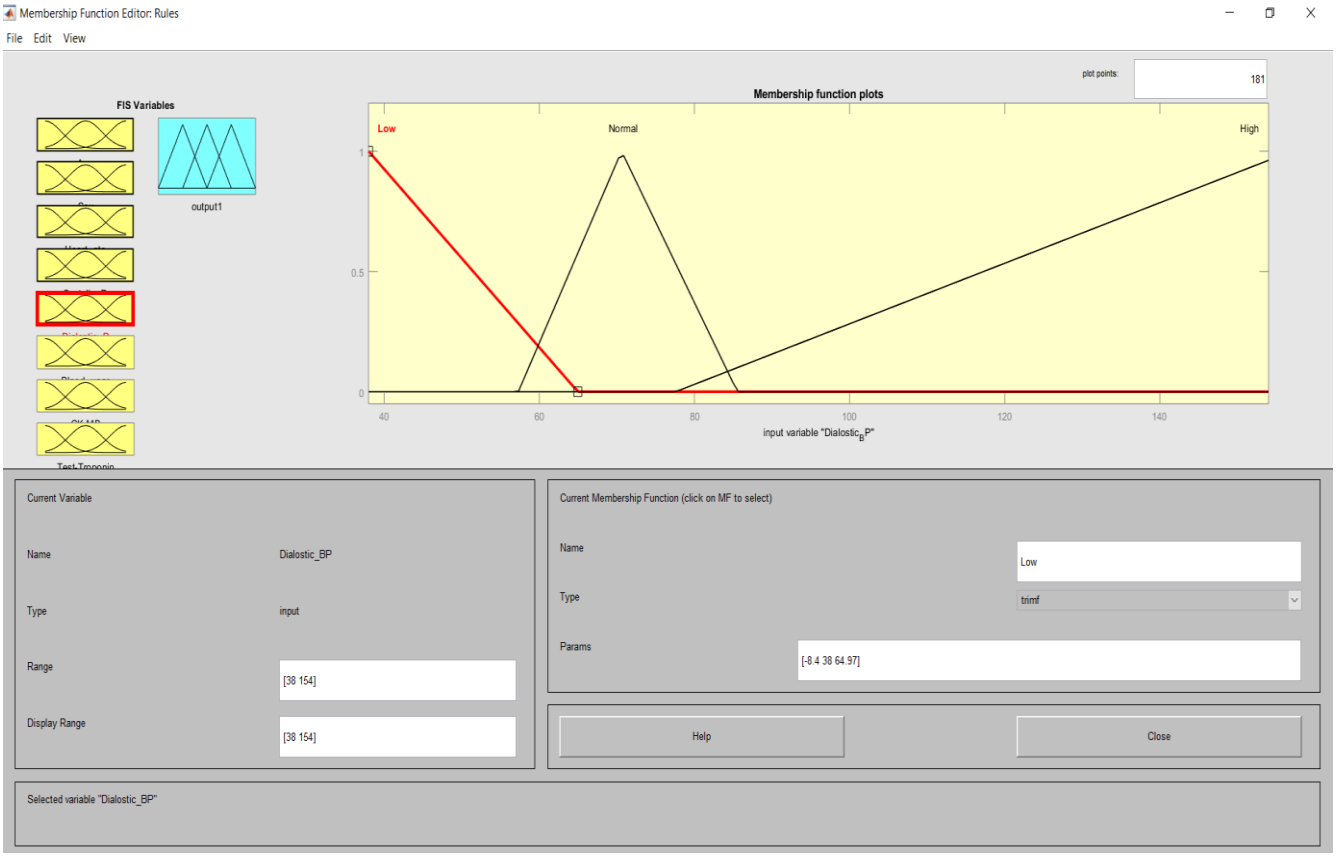

Figure 5.9: The membership function for the diastolic BP variable

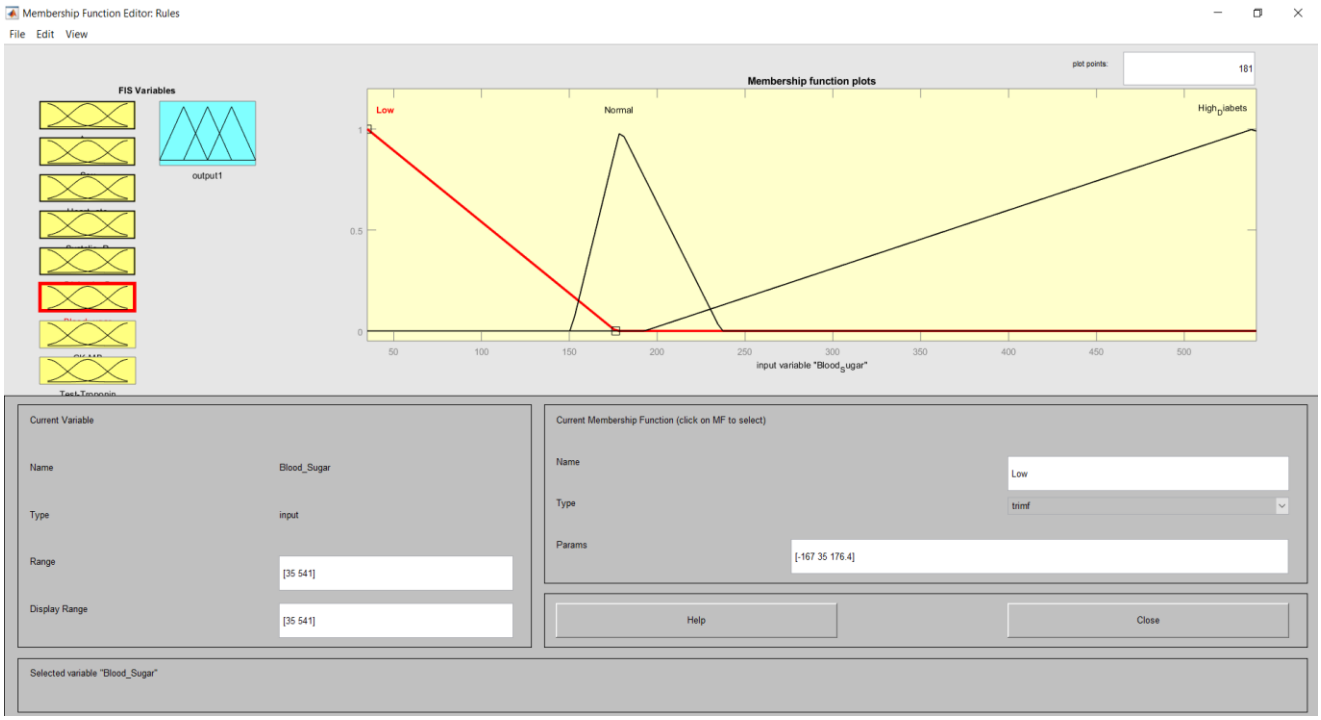

Figure 5.10: The membership function for the blood sugar variable

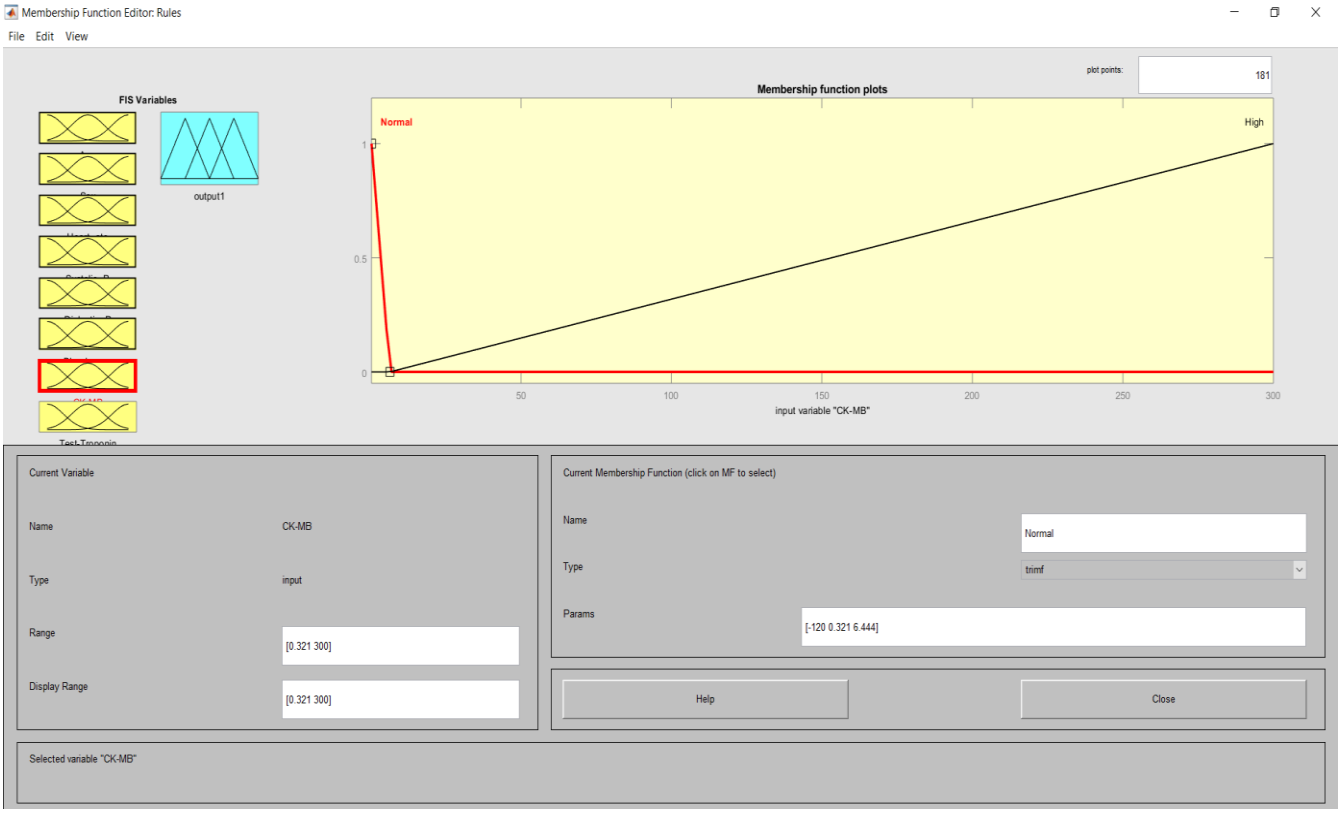

Figure 5.11: The membership function for the CK-MB variable

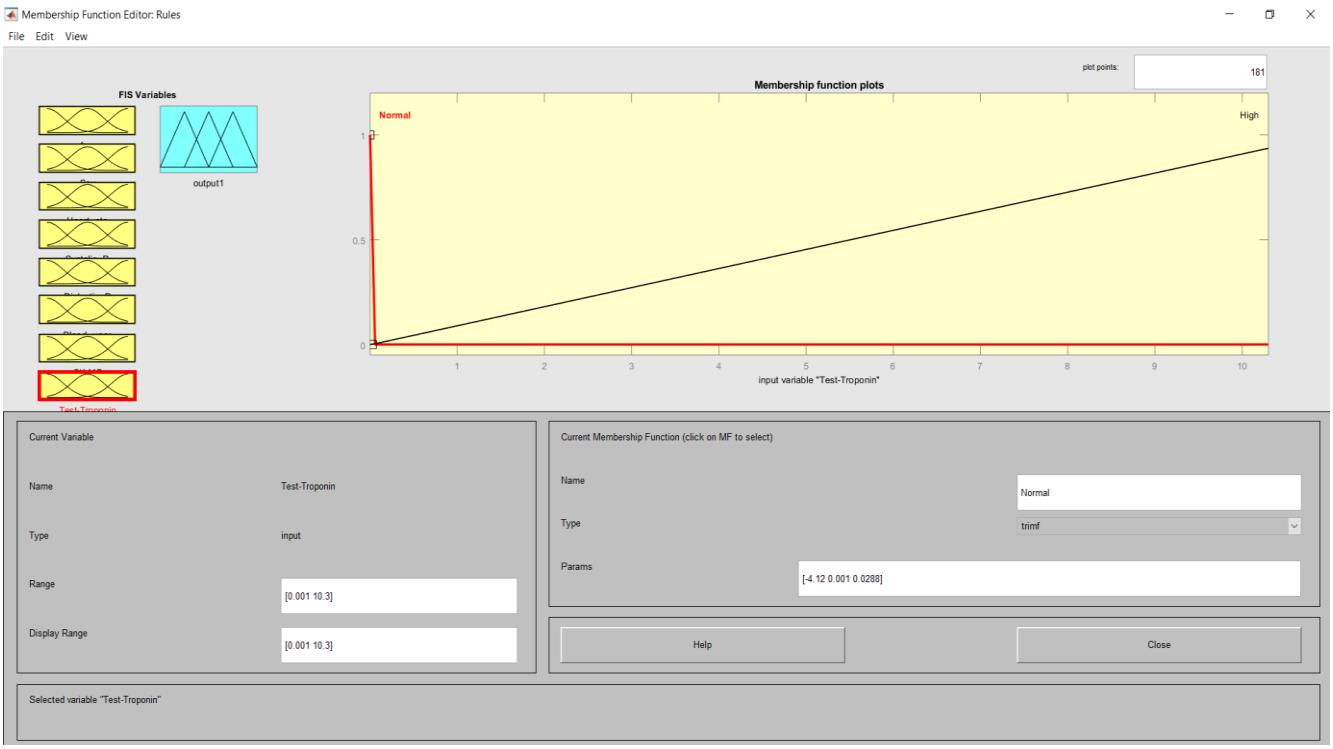

Figure 5.12: The membership function for the Troponin variable

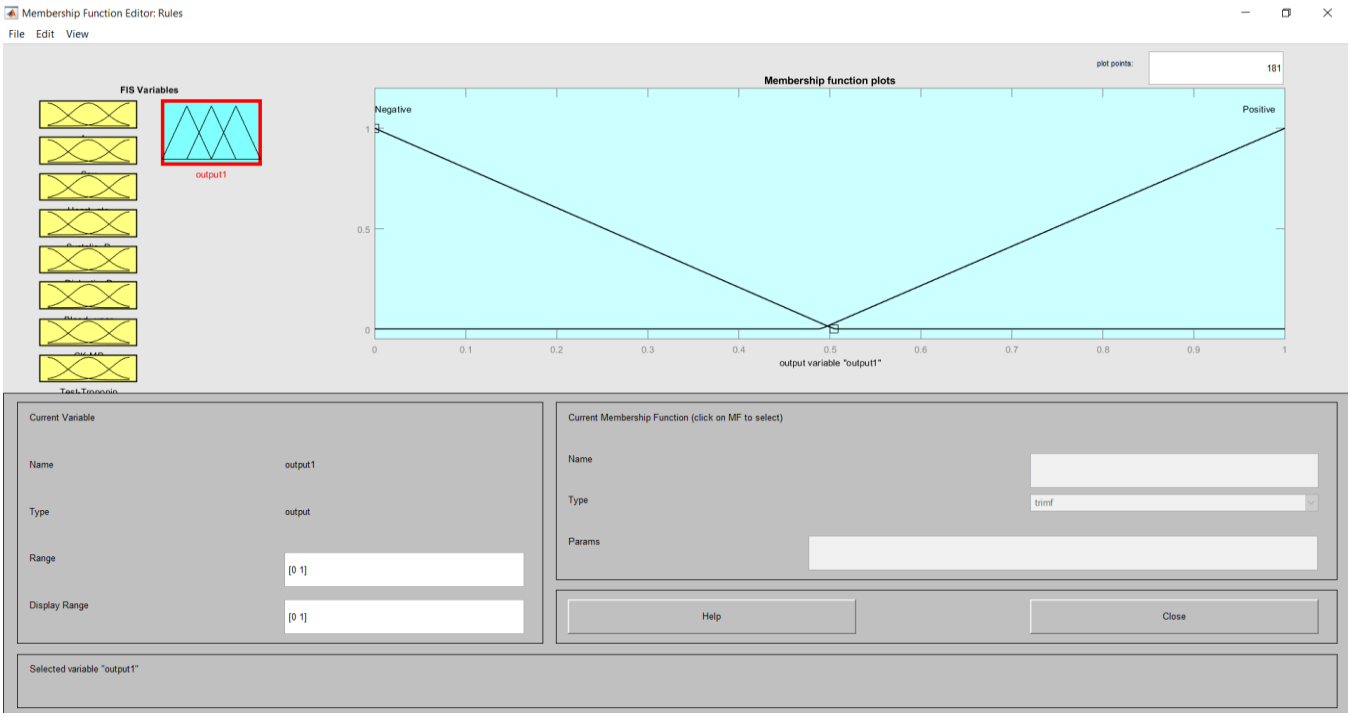

Figure 5.13: The membership function for diagnosis heart attack output

Beneath a perfect conception to our data set, and the domain of the different input variables and the output variable, we come up with some rules. The rules were as follows:

1. If (age is young) and (sex is female) and (heart rate is low) and (systolic is low) and (diastolic is high) and (blood sugar is low) and (CK-MB is normal) and (Troponin is high) then (output is positive).
2. If (age is old) and (sex is female) and (heart rate is normal) and (systolic is high) and (diastolic is low) and (blood sugar is low) and (CK-MB is high) and (Troponin is normal) then (output is positive).
3. If (age is old) and (sex is female) and (heart rate is low) and (systolic is low) and (diastolic is high) and (blood sugar is low) and (CK-MB is normal) and (Troponin is high) then (output is positive).
4. If (age is middle age) and (sex is female) and (heart rate is low) and (systolic is low) and (diastolic is high) and (blood sugar is low) and (CK-MB is normal) and (Troponin is high) then (output is positive).
5. If (age is young) and (sex is male) and (heart rate is low) and (systolic is low) and (diastolic is high) and (blood sugar is low) and (CK-MB is normal) and (Troponin is high) then (output is positive).

6. If (age is middle age) and (sex is male) and (heart rate is low) and (systolic is low) and (diastolic is high) and (blood sugar is low) and (CK-MB is normal) and (Troponin is high) then (output is positive).
7. If (age is old) and (sex is male) and (heart rate is low) and (systolic is low) and (diastolic is high) and (blood sugar is low) and (CK-MB is normal) and (Troponin is high) then (output is positive).
8. If (age is old) and (sex is male) and (heart rate is normal) and (systolic is high) and (diastolic is low) and (blood sugar is low) and (CK-MB is high) and (Troponin is normal) then (output is positive).

The results are shown in (Figure 5.14) and (Figure 5.15).

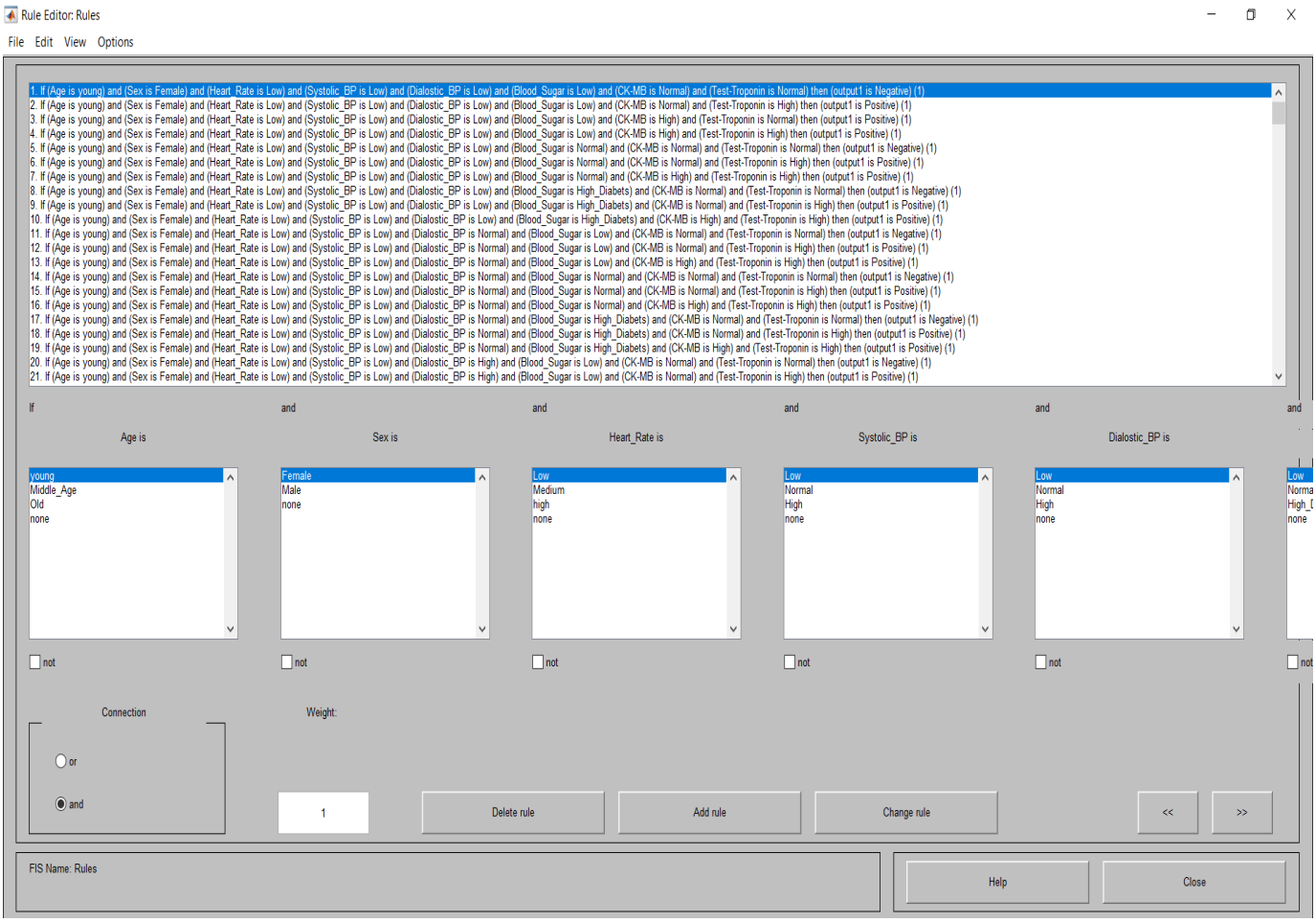

Figure 5.14: The rules in fuzzy logic

Figure 5.15: The eight variables input

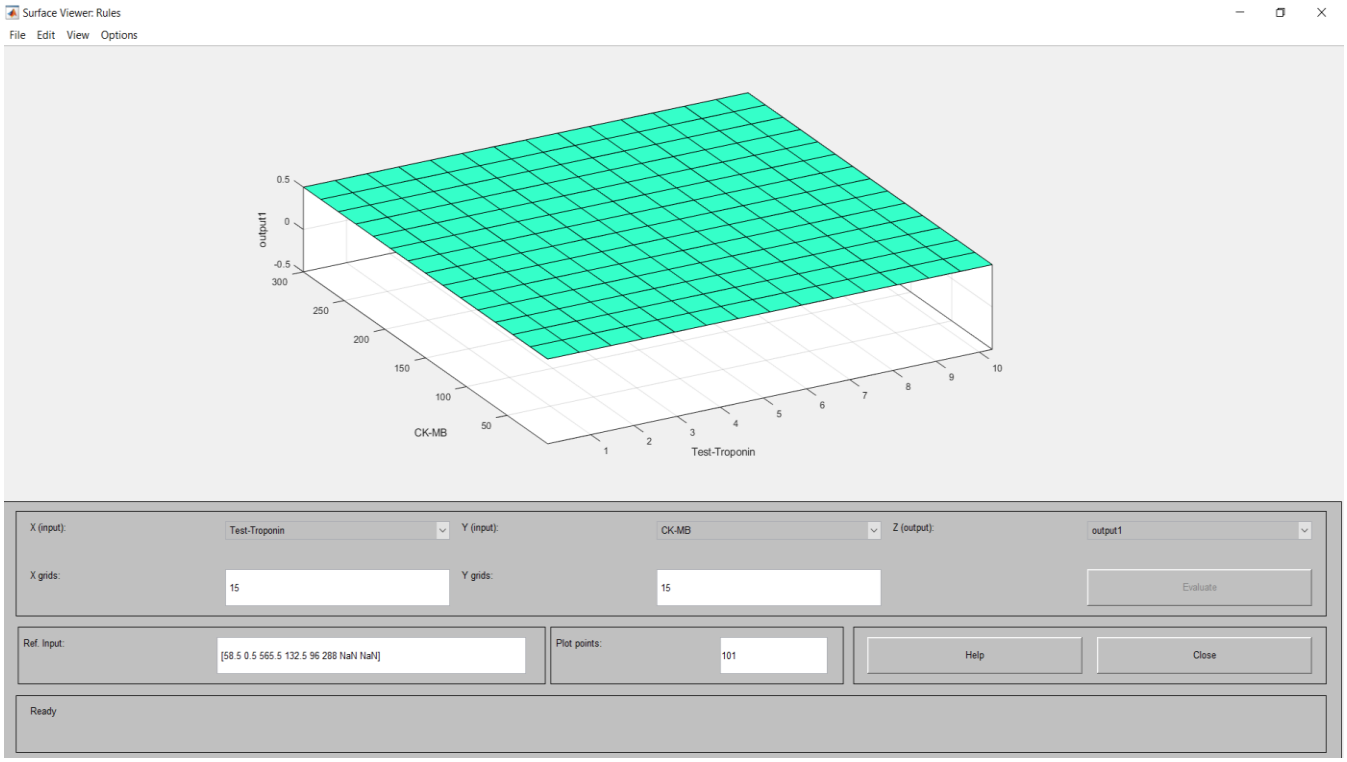

Figure 5.16: The surface of the model in fuzzy logic

5.3 Adaptive Neuron-Fuzzy Interference System (ANFIS)

In the trial, the Sungo technique is utilized as shown in (Figure 5.17).

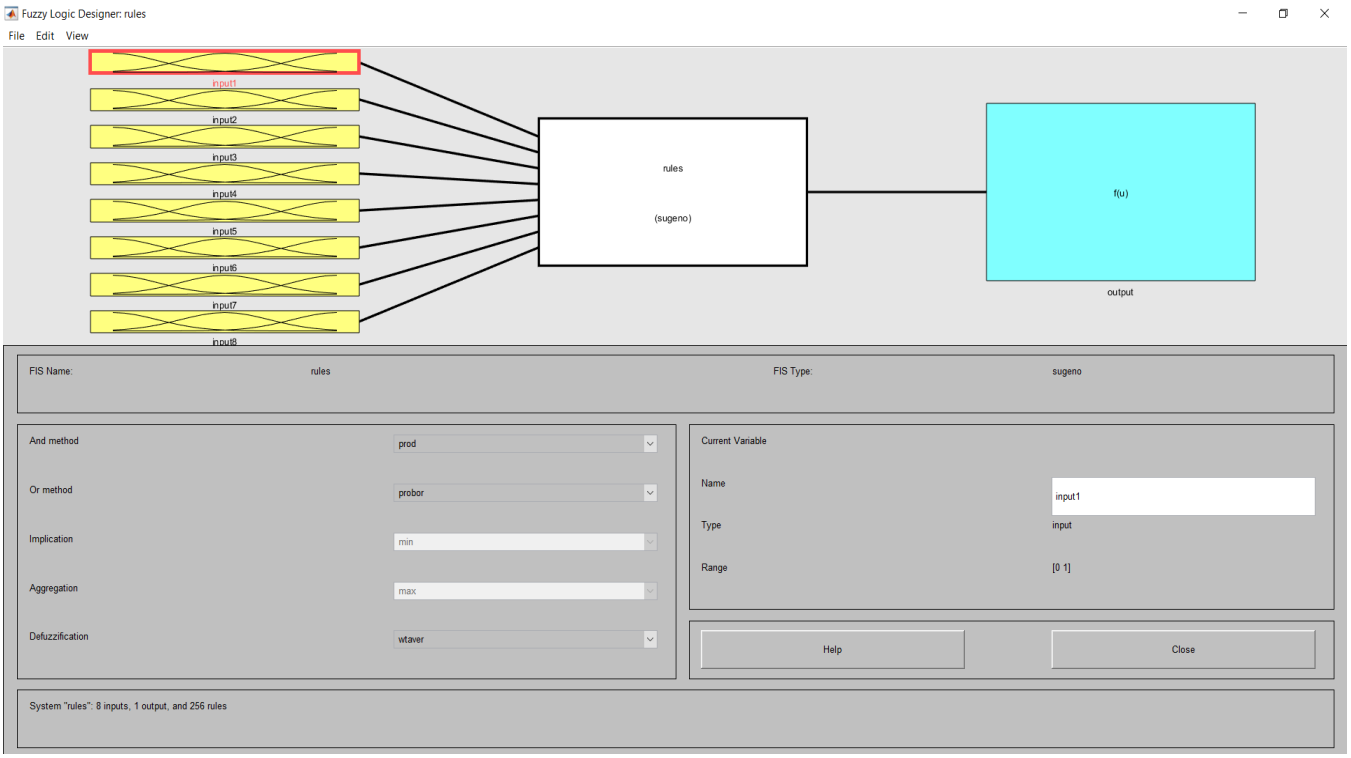

Figure 5.17: The Sungo technique is used for fuzzy inference system.

A gauss2mf membership function for the eight inputs utilized and a linear function utilized for the output as shown in (Figure 5.18).

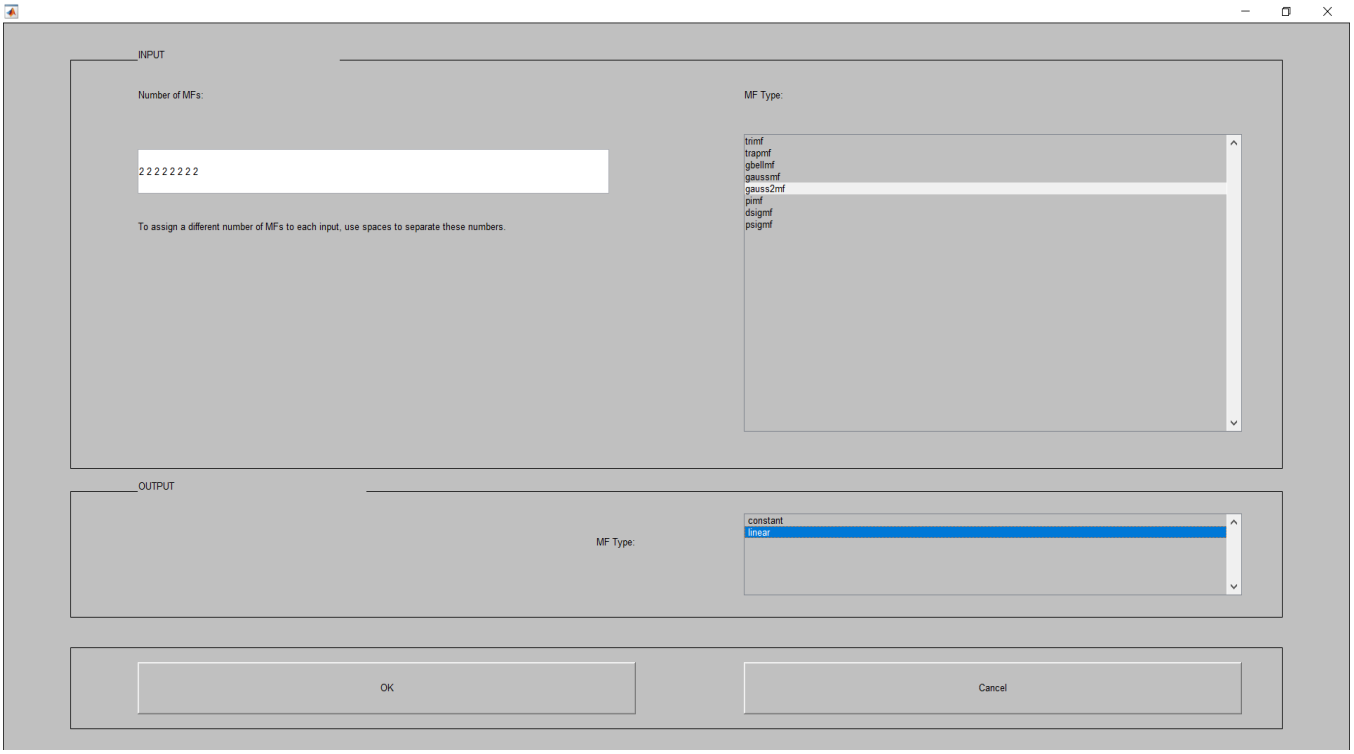

Figure 5.18: How to select the functions for both inputs and output

1060 Patients was the training set and 259 Patients is utilized as a testing set. The ANFIS parameter optimization way options available for FIS training are hybrid. The hybrid is executed. Error toleration is utilized to make a training cessation norm, which is linked to the error size. After the training data error remains within this toleration where the training will stop. If we were not sure how our training error would behave this is best left set to 0. The test set is done, and the results were outstanding compared to the FIS model and the Back Propagation Neural Network, see (Figure 5.19).

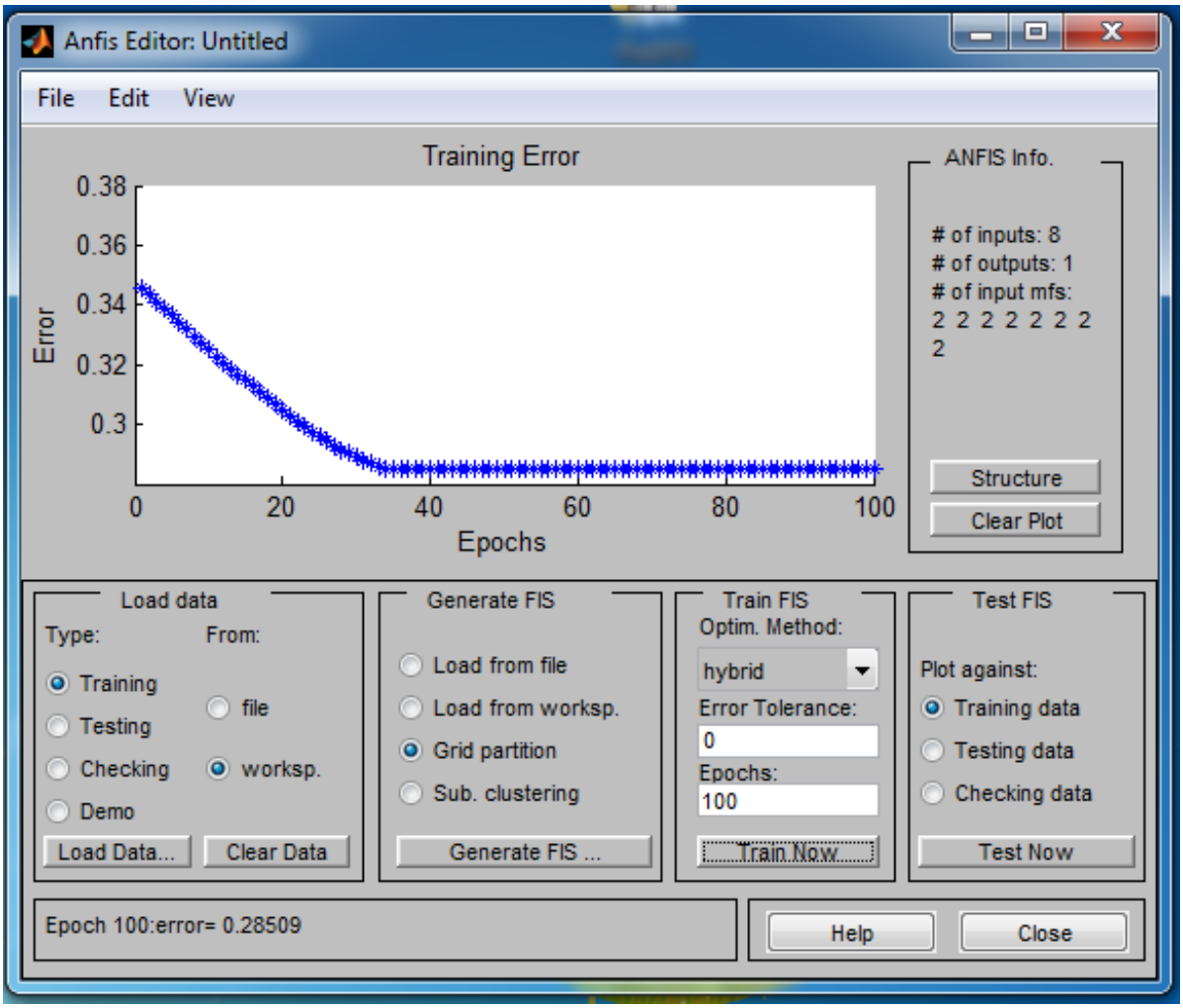

Figure 5.19: The testing session for the ANFIS model.

Table 5. 2: Training, testing and validation by ANFIS for1319 patients

Patients	MF type	neurons	epoch	Inputs	output	Function	Error tolerance	Obtained error
1319	Linear MF	10	100	Age, sex, heard rate, SBP, DBP, BS, CK-MB and Troponin.	Heart attack	gauss2mf	0.00	0.28509

The five layers that were expounded in portion 2 presently for the ANFIS model are drawn as shown in (Figture 5.20).

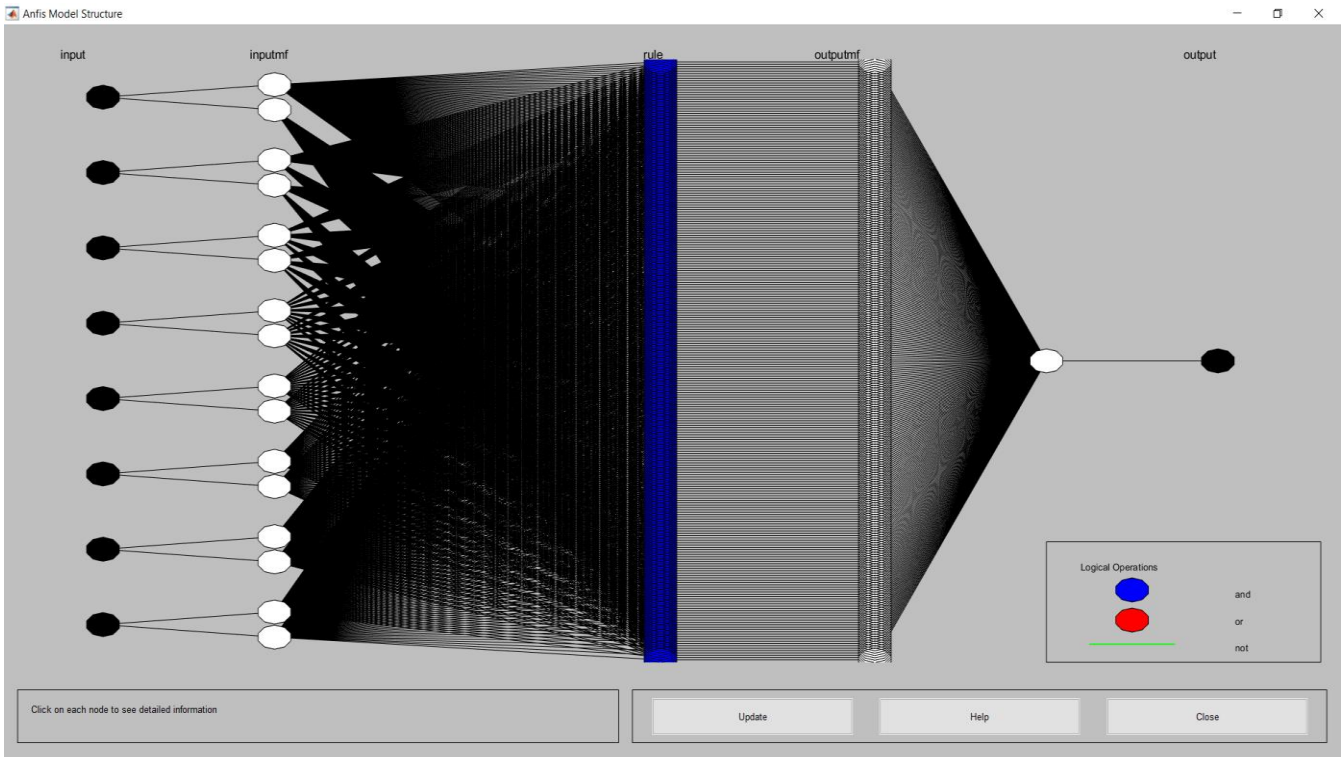

Figure 5.20: The ANFIS model

Figure 5.21 and Figure 5.22 show the results that produced by ANIS.

Figure 5.21: The results of the model ANFIS

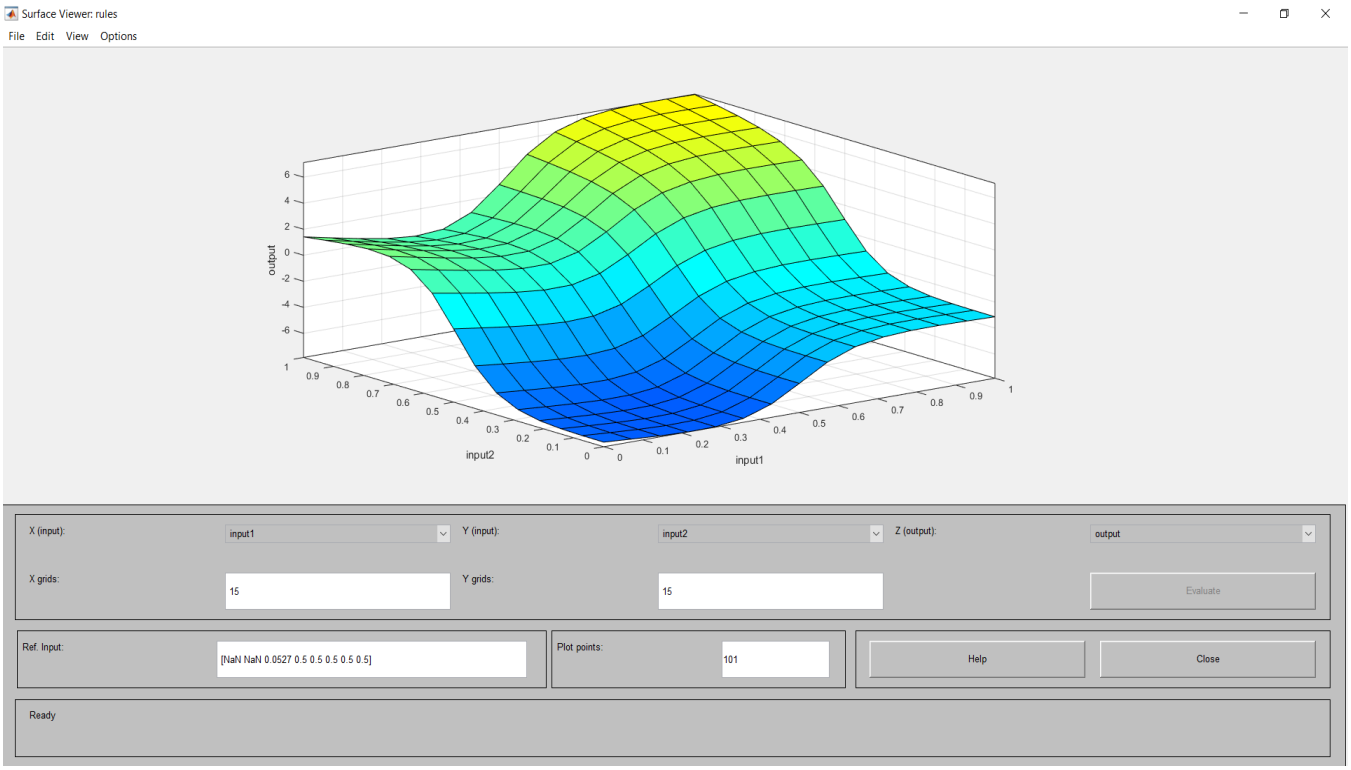

Figure 5.22: The surface view of the model in ANFIS

5.4 Comparison of the three algorithms

We utilized the Root Mean Square Error (RMSE) evaluation method for Comparison of the three algorithms. RMSE is the criterion perversion of the residuum (foretelling errors). Residuum is a gauge of how away from the regression streak data points are; RMSE is a gauge of how prevalence out this residuum is. In other words, he informs you how centered the data is about the streak of the better. Root mean square error is generally utilized in foretelling, regression analysis, and climatology to prove experiential results. The formulation is:

$$\sqrt{\overline{(f-o)^2}}$$

Where:

f = prediction (unknown results or predictable values),

o = observed values (known results).

Table 5.3: Root-mean-square-error (RMSE) after training and testing

Number of patients	Number of neurons	RMSE		Accuracy	
		BPNN	ANFIS	BPNN	ANFIS
1319	16	0.597605	0.28509	74.343866	91.250607

Table 5.3 is Root-mean-square-error (RMSE) after training and testing for BPNN and ANFIS and compare between them where the ANFIS is the best because the error rate is less compared to BPNN which is 0.28509 and BPNN is 0s.597605.

As for the fuzzy logic where the fuzzy logic is a design pattern which can be joined with algorithms to predict based on Fuzzy Rules. For example, ANFIS is using Fuzzy Logic Rules and train Neural Network with it. It also can predict alone by itself one by one.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In this study we used dataset that we got it from the (Surgical Specialty Hospital-Cardiac Centre "Directorate of Health-Erbil" Kurdistan Regional Government Iraq, 2018). This dataset is used to design intelligent system for diagnosing of the heart attack. The data set is obtained in the result of various medical tests carried out on the patients. The dataset contains 1319 cases, 8 input fields and one output field which refers presence of heart attack. We utilized 8 attributes for input and one output for diagnosing heart attack. Input fields are age, sex, heart rate, systolic BP, diastolic BP, blood sugar, CK-MB and test-troponin, and output field refers to the presence of heart attack which has 2 classes (0 and 1): 0 refers to the inexistence of heart attack and 1 refers to the existence of heart attack. We utilized MATLAB circumference normalization and processing of data set.

In this study, three techniques- neural networks (back propagation), fuzzy inference system (FIS) and ANFIS models are utilized to predict the heart attack of the patients. The simulation results of three techniques are compared. Mathlab software was utilized to implement all techniques FIS, ANFIS and neural network (back propagation) for identification of heart attack. The Neural Network (back propagation) has shown good performance.

In this thesis the following was concluded for the model based on FIS (fizzy inference system):

1. A brainy path to simplification.
2. Easy to understood and executed.
3. The fuzzy inference systems have high-fineness specifications which are the ability to utilize linguistic variables to exemplify naturalistic doubts of human knowledge.
4. The produce of relations between the designers of the system with the expert of the domain.
5. Directly analyze results.
6. Because of the naturalistic rules exemplification; unpretentious amplification of the base of knowledge by the adding together of new rules.

However, the fuzzy inference systems have the poor things which are:

1. Their inability to popularize.
2. Hard to discovery suitable rules and proper membership functions due to a fatigued operation which relies on experiment and error.
3. Hard in generating the inference logical rules as their limitation rely on the expert and the knowledge.
4. Difficulty to evolve a paradigm of a fuzzy system.
5. Demand finer setting and simulation prior to the work.

Neural networks are characterized by the following:

1. Learning efficiency.
2. Popularization vigour.
3. The self-organizing: during learning, ANN cans the representation of the information or construct its especially regality.
4. Toleration with errors through frequent Information Coding.

However, the neural networks have the poor things which are:

1. Difficulty in explanation of task.
2. Hard in limit the number of neurons and a number of layers.
3. If training data is available then can use neural networks only.
4. In the learning process usually can't explain the acquired solution.
5. Very long time maybe can take the learning process and there is generally no warranty of successfully.
6. A neural network commonly cannot be started with before knowing if the information is ready, so the network should learn from zero.

Integrating fuzzy systems and neural networks one can be combine their best features and to recapture their Disadvantages. Neural networks Progress its Arithmetical features of learning in the fuzzy systems and draw from them clearness of systems exemplification. The synthesis of fuzzy neural inference system includes the finding of the optimal definitions of the premise and consequent part of fuzzy IF-THEN rules through the training capability of neural networks, evaluating the error response of the system. The use of

neuro-fuzzy system allows to eliminate the disadvantages of neural networks, and fuzzy systems and to produce better model for solution of heart diseases

6.2 Recommendations

In view of the obtained results this study can further be expanded and enhanced for foretelling heart attack. Significant attributes can be added. Besides the features listed in medical literature, it can be suggested to use more AI-based models where we can merge other techniques like Decision Tree, Time Series, Clustering and Association Rules, etc.

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Vol. 6, Issue 2.