

# FUZZY-BASED EXPERT SYSTEM FOR THE DIAGNOSIS OF HEART DISEASES

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## ABSTRACT

The use of computer technology for medical diagnosis has highly increased. The utilization of manmade brainpower, neural systems and fuzzy logic innovation in analysis and treatment of diseases has also expanded. In this work, a fuzzy based application that can detect coronary issues and suggest a qualified cardiologist for the patient was developed. The system was developed using eight parameters namely; chest pain, blood pressure, cholesterol level, electrocardiography, highest heart rate, Years as a smoker, thallium output and exercise. The application was developed using the Virginia Therapeutic Centre and Cleveland Facility Establishment database all in the United States of America. The application has 8 input fields which includes the entire variable mentioned above and one yield field which is the presence of heart disease or not. The yield field alludes to the presence of coronary illness in the patient. This system utilizes Mamdani and Seguno induction technique. The application is developed with SQL database and JavaScript programming language.

## General Terms

Heart Disease, Coronary Disease, Fuzzy logic, Expert system.

## Keywords

Suguno inference system, heart disease, expert system, fuzzy logic

## 1. INTRODUCTION

The use of computerized learning in the analysis and treatment of sickness has exceptionally expanded as of late. Because of the perplexity and many-sided quality of these fields, the utilization of expert software, for example, fuzzy logic has been developed. Cardiovascular sicknesses (CVDs) are the number one reason for death in Africa, a bigger number of individuals kick the bucket every year due to CVDs than from any other disease especially adults. An

expected 17.7 million individuals passed on from CVDs in 2015, of these passing, an expected 7.4 million were because of coronary illness and 6.7 million were because of stroke [1]. More than seventy-five percent of CVDs deaths occur in low salary nations.

The misfortune of the ordinary strategies for the recognition and determination of heart related ailments require the advancement and improvement of computer applications which will help medical experts in conveying effective restorative diagnosis to patients at moderate costs regardless of their area. Because of the quality of Fuzzy Logic (FL) in the arrangement of precise resolutions to genuine issues and the progression in Web innovation, there is an expanding need to consolidate Fuzzy Logic idea into medical finding for an effective improvement of Web based master framework that will have a human-like reasoning capacity.

Cardiovascular illness is the kind of affliction that affects the human pump (heart) or veins. Cardiovascular framework, known as circulatory framework in human, complete the consolidated obligations of the heart, blood and veins to transport oxygen and supplements to organs all through the body framework and divert undesirable substances generally viewed as waste items, among its crucial capacities. The typical duties of the heart are the pumping of blood and causing it all through different organs and parts of the body. At the point when the heart's yield cannot meet the ordinary work, a condition known as heart failure happens and when the heart comes up short, other imperative organs, for example, the Kidney, Lungs, and Liver are additionally affected. Heart failure and the subsequent complex issues are the real reason for death for both male and female in most developing nations. It is likewise exceptionally evaluated to be top five reasons for death in nations

like Nigeria. The treatment of heart illness is very fundamental and includes extensive measure of therapeutic subtle elements which are mined, cleaned and put away.

No organ of the body contends with or even come close to the heart. The heart, as indicated by researcher, is the organ that pumps blood around the body, giving oxygen and supplements to the tissues and evacuating carbon dioxide and other waste products from the body; this unmistakably implies that when the heart flops in its capacity, every other organ and parts of the body, including cells we cannot see with our conventional eyes fails. There is however an issue: the aptitudes and labor to care for the heart is not equitably conveyed.

A few nations have enough cardiologists and other prepared faculty to give cardiovascular care to their nationals while others do not have. Nigeria is among the nations that do not have enough cardiologists to tend to patients with cardiovascular issues. The use of Artificial Intelligence (AI) computerized reasoning is to influence machines to perform capacities that would require insight if done by people. [2].

Negnevitsky characterizes a fuzzy set as a set with fuzzy limits [3]

## 2. REVIEW OF RELATED WORKS

Fuzzy Logic was started in 1965, [4]. Many authors investigated on this area and applied various techniques. Rahim F, [5] teamed up in building up a framework equipped for being connected in liquid administration in anesthesia. They construct their research and work in light of the commence that the field of anesthesia was loaded with vagueness as with other territory including medicinal choice. They noted exceptionally well that the restorative division was loaded with opposing realities. In Anesthesia the perspective they concentrated on, the Anesthetists utilizes dependable guidelines while overseeing patients. He tilted the medication and liquids admission, or ventilation, to screen physiological condition of the patient. It is difficult to characterize effectively the qualities, for example, high temperature, low arterial weight (MAPr), high intravenous liquid rate (IFRa), and others. The field of anesthesia is profound the same number of reasons add to its profundity, for example, detection and diagnosis, picture preparing, and way physiological reasoning and anesthesia control. They along these lines presumed that fuzzy logic appears to be suited to be use in anesthesia because of the way it so normally speaks to

the subjective human ideas utilized in quite a bit of medicinal basic leadership.

Sanjeev[6]utilized input factors to build up a fuzzy based master framework.

This fuzzy master framework that includes the identification and analysis was executed and yield demonstrates that this framework improved the situation than non-master urologist and around 74 % as a well as the master did. The outlined application goals were to accomplish the accompanying outcomes: Recognition of heart ailments utilizing fuzzy logic, the framework additionally characterizes the careful steps as indicated by the danger of the patient, Framework have (6.0) six sources of info and (2.0) two yields. Each information and yield have fuzzy factors, each fuzzy Variable is related with participation work, the principles quality is computed in light of the enrollment capacity of the fuzzy variable.

The reason of this dataset is to determine the nearness or nonappearance of heart sickness with the consequences of different therapeutic determination and tests completed on a patient. This framework utilizes 6 traits for information and 2 properties for result. Info fields (traits) are chest pain, blood pressure, cholesterol, glucose, most extreme heart-rate, old pinnacle. The outcome field demonstrates the nearness of heart sickness in the patient. It is number an incentive from 0.0 (no nearness) to 1.0; high esteem implies high coronary illness chance. In this exploration, they used cholesterol. About the blood, they utilized systolic pulse. In this dataset, the fields are partitioned into a few bits and each bit has a whole number esteem. For instance, in this dataset, chest throb has (4.0) four bits (low, very low, ordinary, high and high), resting glucose has 2 areas (extremely low, low, typical high and high).

1. Chest ache: In Chest ache there are (5.0) five different functions. The (5.0) five various types are very low, lo, moderate, high and very high. The range of chest pain is 0-1.

2. Blood Pressure: In Blood Pressure there are (5.0) five different functions. The five different types are very low, lo, moderate, high and very high. The range of Blood Pressure id given by 60.0-200.0.

3. Cholesterol: Cholesterol has big effect on the output and can change it easily. For this input field. In cholesterol there are (5.0) five different functions. The (5.0) five different types are very low, low, moderate, high and very high. The range is 100.0-400.0.

4. Blood Sugar: Blood sugar field is a very vital factors in this system that changes the result. In Blood Sugar there are (5.0) five different functions. The (5.0) five different types are very low, low, medium, high and very high. Thus, the range is 50.0-250.0.

5. Maximum Heartrate: In Maximum Heartrate there are (5.0) five different functions. The (5.0) five different types are very low, low, medium, high and very high. The range is 70.0- 150.0.

6. Old Peak: This input data means induced depression relative to rest. Old peak field has (5.0) five fuzzy sets (Very Lo, Lo, Medium, high and very high (risk)). These fuzzy sets have been shown in Table 5 with their ranges. The five different types are very low, low, medium, high and very high. The is 0.0 – 1.0

The "objective" field alludes to the nearness of heart ailment in the patient. It is an incentive from 0.0 (no sickness) to 1.0.

[7] utilized a fuzzy master framework for the identification and finding of heart issue. The creators have utilized numerous factors, for example, chest issue, blood stream weight, cholesterol, resting glucose, resting ideal heart-rate, sexual orientation, electrocardiography (ECG), physical exercise, old pinnacle, thallium output and age-review as information sources. The status of the wiped-out patients as solid or wiped out has been chosen as yield. Four (4.0) sorts of disease has been utilized as yield. These are ailment L1, sickness L2, ailment L3, disease L4.

[8] settled on utilization of a Choice Emotionally supportive network for the identification and conclusion of Inborn issue from the accessible information based and database. They have utilized back propagation neural system which contains one information layer, one yield layer and at least one shrouded layers. As the name propose the information layer gets signals from the outside focuses or hubs and transmits these signs to different layers without executing any calculation at that layer. The yield layer gets the signs from an info layer through an association joins, performs calculations at that layer and delivers yield of the system. A regulated delta learning standard prepared. The dataset utilized as a part of this exploration and study are the signs, indications and the aftereffects of physical check and assessment of a patient. The proposed framework has accomplished a productivity and exactness of 90%.

[9]Utilized a fuzzy logic-based classifier for the identification of inborn heart which characterizes auxiliary and utilitarian misnomer of heart. They have utilized weighted vote strategy and single champ technique. The outcome demonstrates that the weighted vote technique has expanded the order exactness of inherent heart illness. In this examination, fuzzy logic manage based classifier is utilized for the finding of inborn coronary illness. Intrinsic heart ailments are characterized as basic or utilitarian coronary illness. Restorative informational indexes were acquired from Pediatric Cardiology Office at Saluki College, from years 2000 to 2003. Right off the bat, fuzzy set were produced by utilizing medicinal information. At that point the weights of fuzzy set were figured. Two diverse thinking techniques as "weighted vote strategy" and "singles victor strategy" were utilized as a part of this investigation. The after effects of fluffy classifiers were looked at.

[10] has utilized a Fuzzy Petri-net based framework rather than fuzzy base master framework and has carefully analysed the framework through fluffy run-based thinking calculation. They have utilized 11.0 qualities for input and 1.0 trait as result or yield for finding of the heart issue. They have demonstrated that their yield and result was effective, precise and fantastic by utilizing their proposed petri net based fluffy framework.

[11]have proposed a neuro fluffy master framework that finds an answer for analysing the ailment utilizing a portion of the developmental registering strategies like hereditary calculation, fluffy administer based learning and neural networks. They additionally utilized a mind fluffy master framework and application that brings an answer for recognize and analyse the sickness utilizing a portion of the transformative figuring systems, methodology and procedures like hereditary calculation, fluffy manage based learning and neural systems. Their planned cerebrum fluffy techniques allude to the get together and mix of manufactured neural-arrange and fluffy rationale-based framework in which the 13.0 traits have been utilized taken from UCI Machine learning database. The yield and result have spurred the therapeutic experts to achieve a decision about the conviction that there is the nearness of coronary illness of the nonattendance of coronary illness in a person.

Different creators have utilized a few neural system techniques, methodology and models like back spread neural system, multilayer perceptron neural system and so forth. Their work, research and exertion were to

analyse and identify the nearness of coronary illness utilizing fluffy base master framework, however they have not demonstrated how much effectiveness and precision they have accomplished in their outcome. Medical Fuzzy-Expert System for Diagnosis of Cardiac Diseases [12]. This diary and the distributor contributed time on building up a numerical philosophy for foreseeing heart sicknesses. The design of their discoveries is shown in fig 2.3.

The displaying of their fluffy master framework for the most part contains the accompanying strategies:

- (1) Determination of applicable intake\input and yield parameters
- (2) Picking of fitting enrolment capacities, vague parameters and administrators, considering and thinking components and
- (3) Choosing the correct or particular sort of fluffy deduction application\system
- (4) Plan of if-then lead or manage base

## 2.1 ANALYSIS OF EXISTING DESIGN

The current framework for diagnosing coronary illness utilizing fuzzy logic was proposed by [13]. In this outline, fuzzy logic master framework was utilized as a part of the analysis. The framework was planned in light of information gotten from Universal Lab database in India. The framework involved 6 input fields and two yield field. The fields utilized for input are chest-torment, cholesterol, most extreme heart-rate, pulse, blood sugar and old peak. The outcome or yield field means the nearness of coronary illness in the patient and precautions are set up in like manner. It is numerical whole number esteemed from 0.0 (no nearness) to 1.0 distinguish nearness (values 0.0 to 1.0). The Mamdani inference procedure was utilized as a part of this examination. They also utilized low thickness lipo-protein (LDL), cholesterol and Systolic pulse. In this dataset, fields were divided into areas and each part had an esteem. A brisk separate of the information sources utilized is:

1. Chest-torment: In Chest-torment there are (5.0) five distinct capacities. The (5.0) five distinct composes are very low, low, direct, high and very high. The scope of chest-torment is 0-1.2.

2. Pulse: In Circulatory strain there are (5.0) five distinct capacities. The five distinct composes are very low, low, medium, high and very high. The scope of Pulse is given by 60.0-200.0.

3. Cholesterol: Cholesterol importantly affects the yield and can transform it effortlessly. For this information field, the creator utilized the estimation of low thickness lipo-protein (LDL) cholesterol. In cholesterol there are (5.0) five distinct capacities. The five distinct writes are very low, low, medium, high and very high. The scope of cholesterol is 100.0-400.0.

4. Glucose: Glucose zone is a standout amongst the most essential and vital factors in this application\system that affects the outcome. In Glucose there are (5.0) five distinct capacities. The five distinct composes are extremely - lo, low, medium, high and exceptionally \_high. In this way the scope of Glucose is 50.0-250.0.

5. Greatest Heart-Rate: In Most Extreme Heart-Rate there are (5.0) five unique capacities. The (5.0) five distinct composes are very low, low, medium, high and very high. The scope of Greatest Heart-rate is 70.0-150.0.

6. Old peak field has (5.0) five fuzzy sets. The (5.0) five different types are very low, low, medium, high and very high. The range for old pinnacle is given by 0-1. The yield field was separated into two. These are the yield and safety measure field.

1. Result: Can likewise be known as the outcome or "objective" field indicates to the nearness of coronary illness

in the patient. It is number an incentive from 0.0 (no nearness) to 1. As the system is on the expansion the danger of coronary disease increases. In this application\system, we have considered an alternateresult\output variable, which partitions to (5.0) five fuzzy sets Solid, Low Risk, Moderate Risk, Hazard, and High-risk

2. Precautions: The yield variable is precautionary measures; this application\system gives the safeguards relying upon the hazard and consequence of the patient. The scope of safety measure is set from 0-1.

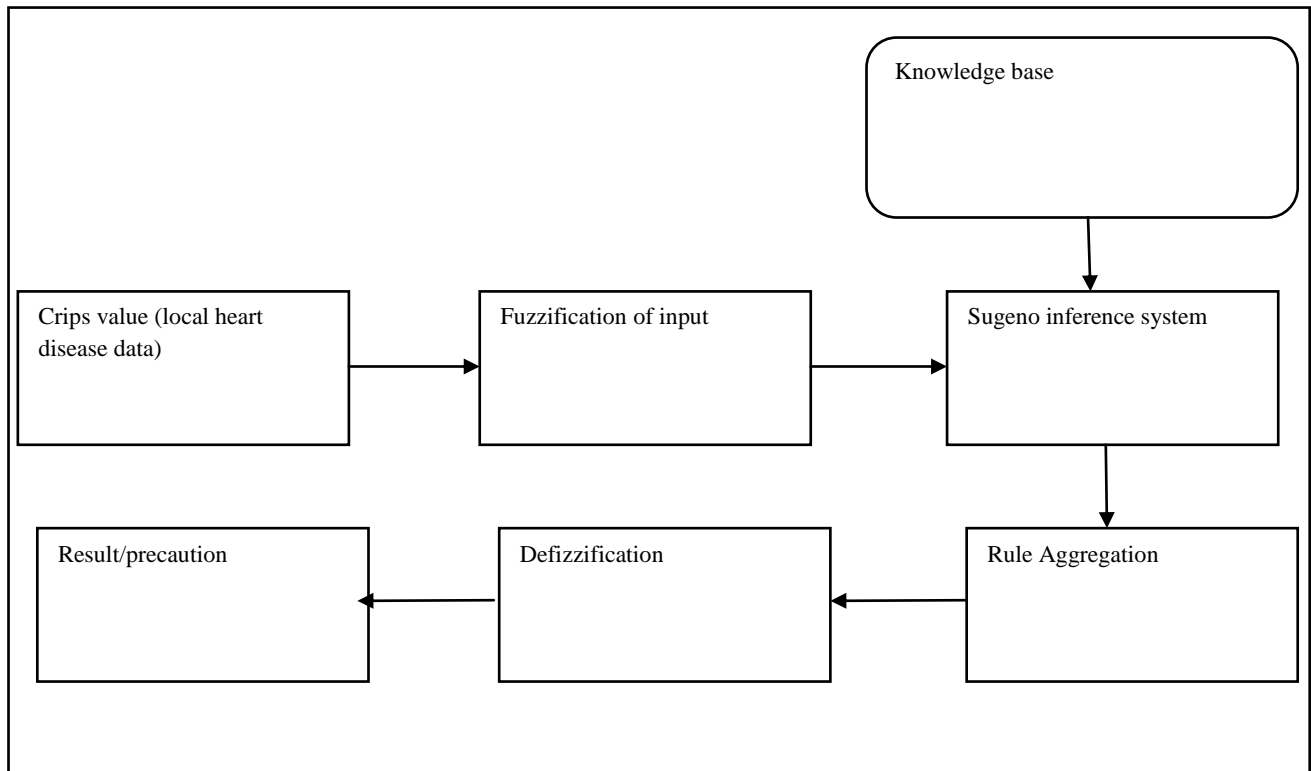


Fig 1. The existing system

Sanjeev existing system (2013)

### 3. Analysis of Proposed System

The proposed system for this research will utilize the use of Fuzzy logic for the diagnosis of heart disease combining both the Sugeno and the Mandani inference system. The Sugeno and the Mandani inference system will be used on this research and the dataset used is from the Cleveland database [15]. 8 input variables will be taken as input and 1 variable has been used as an output. The input attributes are Chest-Pain (which will be divided into types of Chest-Pain), Blood Pressure that will be measured in (Trestbps), Serum Cholesterol that will be measured in mg, Number of years spent as a Smoke, Blood-sugar, The highest heart-rate, Blood-rate. The output will be the heart condition or the disease status of the patient. The first input field which is the Chest-Pain will comprise four types, and will be denoted by a positive integer.

The value 1 indicate typical, the value 2 indicate atypical, the value 3 indicate non-angina and the value 4 indicates asymptomatic angina. The second and the third input fields are blood pressure and serum cholesterol respectively. The fourth input field is the number of years spent as a smoker and it is denoted as a positive numeric value. The fifth input variable field

indicated the blood-sugar. When the blood-sugar is higher than or equal to 120mg, the level of blood-sugar is 1.0 otherwise 0. The sixth and seventh fields are Heart-rate and blood-rate respectively. The eight input is the hereditary factor.

The output field refers to the disease status of the heart of the patient. It is a number between 0 and 1. Where 0 show the diameter of the arteries is less than 50% of original diameter

and 1 indicates the diameter of arteries is more than 50% of its original

diameter. The output field refers to the disease status of the heart of the patient. It is a number between 0 and 1. Where 0 show the diameter of the arteries is less than 50% of original diameter and 1 indicates the diameter of arteries is more than 50% of its original diameter. When the input variables are passed through the Mandeni inference system and the result observed not to be accurate enough, it is further passed through the Sugeno inference system. But if the result is observed to be accurate, it skips the Sugeno inference system and goes straight to the defuzzification engine.

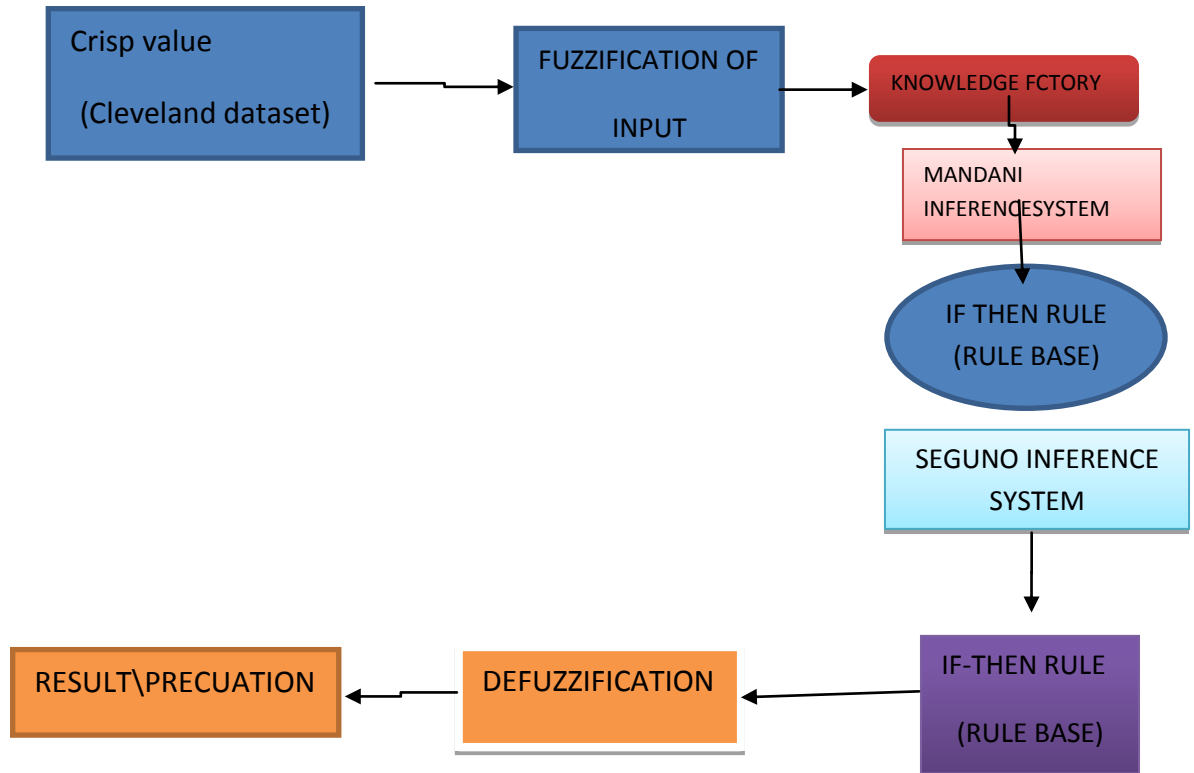


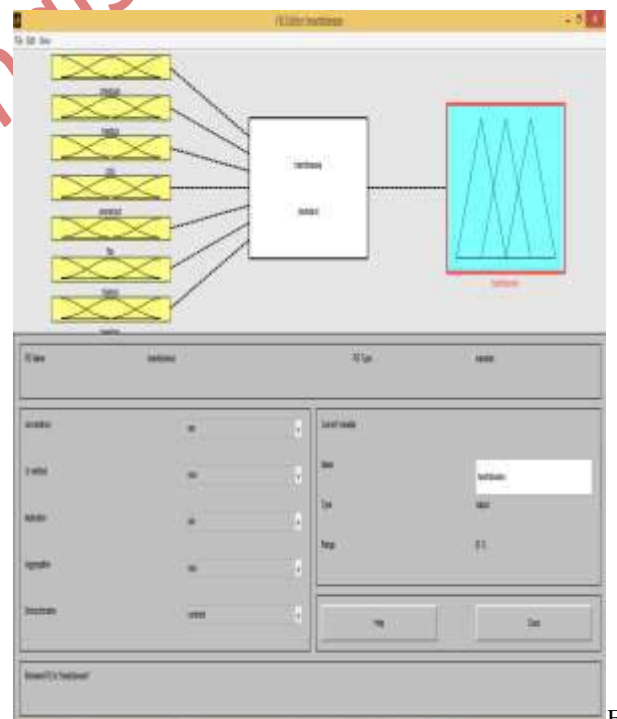
fig 2. Proposed system

#### 4. METHODOLOGY

The methodology adopted in this research is the object-oriented methodology. This technique or approach empowers the improvement of programming frameworks by demonstrating objects in reality. It includes breaking down the framework into measured units and coupling same as far as individual segment questions that can be amassed together to shape the real application. This approach receives the utilization of all-inclusive displaying dialect (UML) for the demonstrating of the product plan. Some UML approaches embraced in the advancement of this system utilize case chart, Class graph, Grouping outline, Substance Relationship Outline and so on.

##### 4.1 Result

Using mat-lab, we build the fuzzy system by specifying the attributes and output and also selecting the fuzzy inference method that is either the seguno or the Mandani method On the left of the Mat-lab Fuzzy inference editor we have the input fields that will be fuzzified



g 3 Mat-lab Fuzzy inference editor

From here we apply membership functions to each input variables starting with the first input variable to the last input variable and also select Gaussian as the membership function to apply

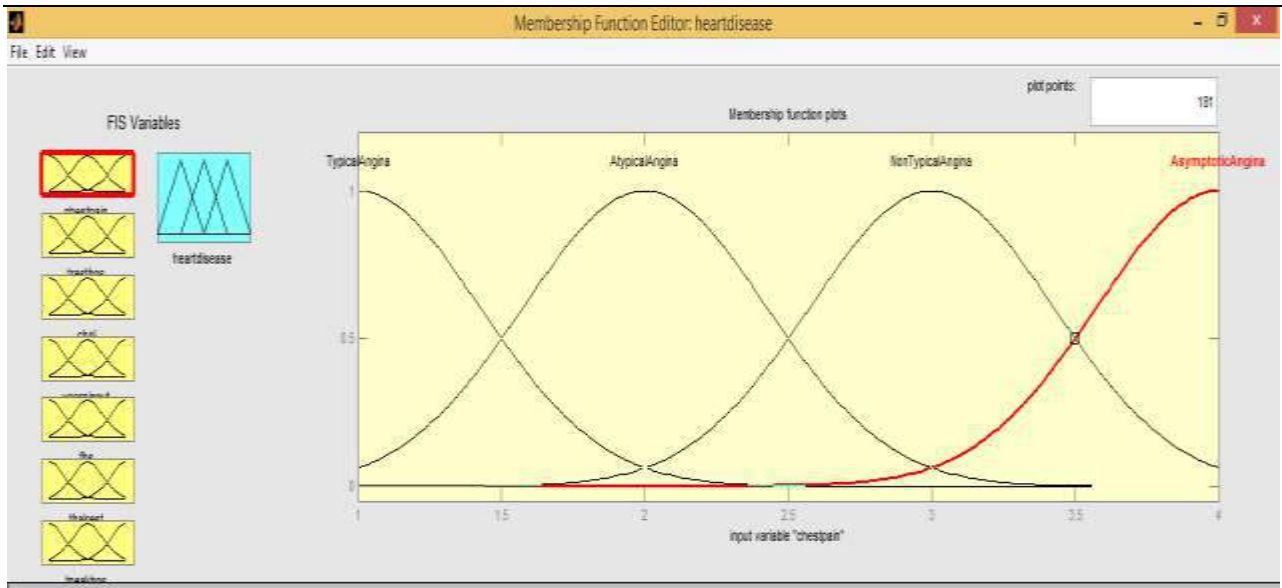


Figure 4 Adding membership function to the input variable.

From here we can extrapolate or generate the rules to be used by the inference system. This is shown in figure 5.

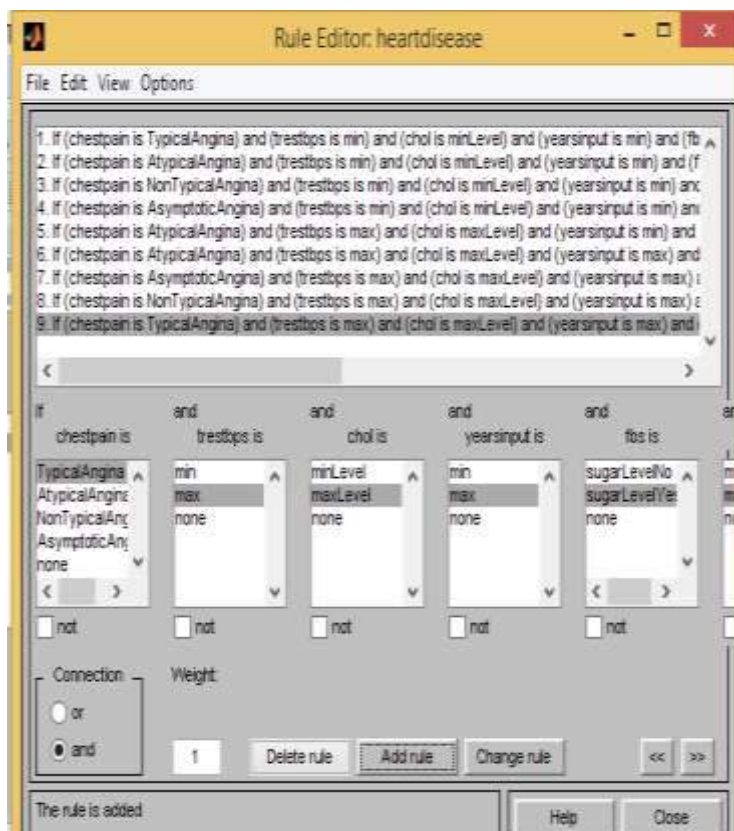


Figure 5. Fuzzy Rules Generation.

From here, we can view the rules using the rule viewer. The figure 6 shows the rules generated. The

Rule Viewer shows in one screen, all parts of the fuzzy inference methods from inputs to outputs. Each row of

plots equals to one rule, and each column of plots corresponds to either an input parameter (yellow, on the left) or an output parameter (blue, on the right).

You can change the system input either by typing a specific value into the Input window or by moving the long yellow index lines that go down each input variable's column of plots.

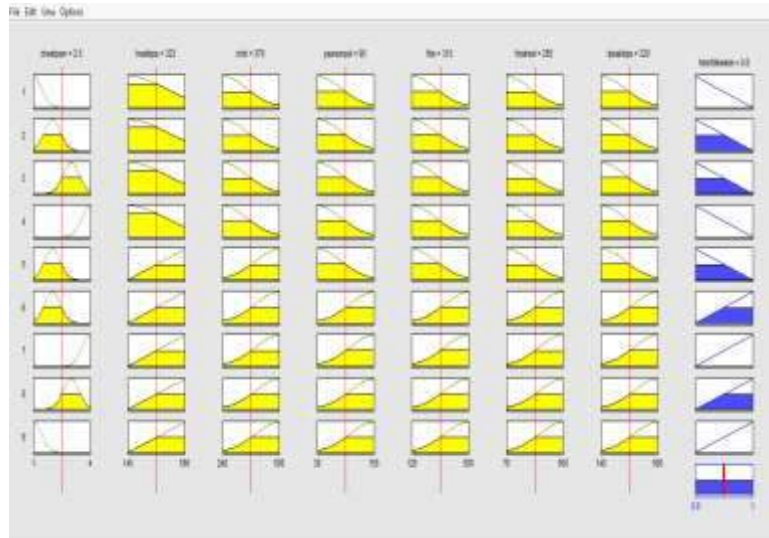


Figure 6. Rule Viewer for Rules.

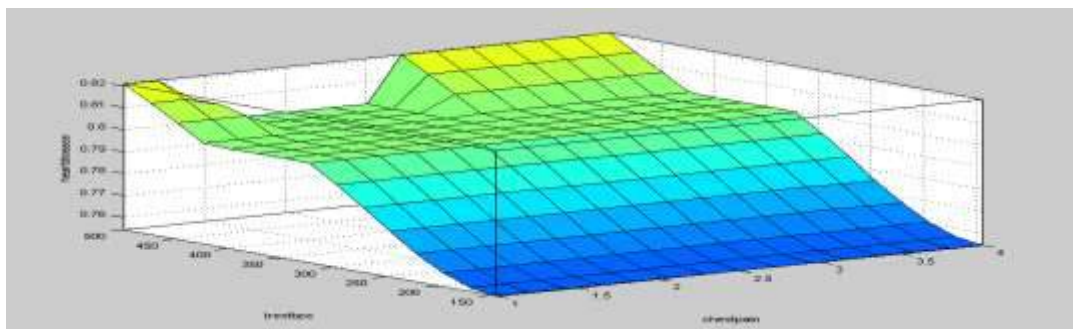


Figure 7. Surface View Generated by Gaussian Membership function.

## 5. CONCLUSION

The problem of diagnosing heart diseases can be solved using expert decision support application or system that utilizes a fuzzy rule base inference system. This application can perform much better than the traditional approach because of the inherent ability of fuzzy logic to deal with imprecision or vagueness. This application has a high degree of effectiveness and accuracy due to the use of the combined Mandeni and Suguno Inference system. This system also recommends qualified Doctor and specialist hospital to patient. This therefore means that fuzzy inference system can be extended or applied to other areas of human endeavour or fields.

## 6. RECOMMENDATION

Heart disease is one of the killer diseases in America and many parts of the world [15] In this work, there are other applications of fuzzy logic which could give a holistic insight to heart disease diagnosis. These areas can be useful in diagnosing heart diseases and they include, use of fuzzy rule base system to find out if the heart disease is due to the person's lifestyle choices etc.

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