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Complications of Diabetes with Cardiovascular Diseases Diagnostic Using Fuzzy Set Theory

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Abstract - ***Aim:*** *To design fuzzy set theory for diagnosing the complications of cardiovascular diseases with diabetes.*
Method: *In the current era, artificial intelligence is used in the field of medicine, treatment, diagnosis, and also patients risk assessment and prediction of diseases. This research paper has to patient's diagnosing the complications of cardiovascular diseases with diabetes mellitus. The fuzzy set theory is based on the Lab data base of hospital. From the hospital, 100 diabetic patients' medical records are taken for the case study. Author has design a system consists of 8 input parameters and 2 output parameters. The system input is blood sugar, heart rate, chest pain, blood pressure, cholesterol, ST depression, physical activity, smoking; and system output is complications of cardiovascular diseases and precautions accordingly. The membership function of the system valued from 0 to 1. Author has used the Mamdani inference method and fuzzy rules.*

Result: *The fuzzy set theory is an expert system for the cardiologist and diabetologist for diagnosing complications of cardiovascular diseases with diabetes. The output of this system is given the complications of cardiovascular diseases such as low risk, to high risk and second one is precautions of diabetic patients. A patient with type 2 diabetes is suffered from the cardiovascular diseases and highest risk. This system gives 93% accuracy.*

***Key Words*:** Cholesterol, Diabetes Mellitus, Fuzzy Set Theory, Fuzzy Rules, ST Depression

1. INTRODUCTION

Diabetes mellitus is one of the most common diseases in current era. A diabetes mellitus is a long-lasting illness. It requires constant health care and to decrease risk of long term critical complications[1]. Also giving training to the patient's for self-care to prevent critical complications. In this disease diabetology gives treatment to the patients for controlling blood glucose level and for preventing many symptoms and complications through insulin dosage, diet and exercises. There are various types of diabetes such as type1, type2, Prediabetes, gestational diabetes, diabetes jenuvile, and diabetes insipidus. When the diabetic patients suffering from long term he/she has a type2 diabetes and he/she has also a risks of cardiovascular diseases. Diabetic patients have some complications such as cardiac disorder, blurred vision, neuro- disorder, arthritis, kidney failure, etc. Type 1 is generally seen in children and young age peoples. Type 2 is seen in adult and long term diabetic patients are suffering. In type 2 diabetes, patients have risks of cardiac arrest, stroke, and ischemic heart failure.

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1.1 Cardiovascular Complications

Current era's, cardiovascular and diabetes both are most common diseases and major cause of death in India and in world. When the diabetic patients suffering from long term he/she has a type2 diabetes and he/she has also a risks of cardiovascular diseases. Type 2 diabetes is related with cardiovascular morbidity and death. The diabetic patients with type 2 have risks such as myocarditis, ischemia, and infarction, infiltrative or myopathic processes. Metabolic factors such as hypoglycemia, hyperventilation are also complications of diabetes mellitus with cardiac disorder. In Indian populations, cholesterol, hypertension, smoking and physical inactivity.

In Chennai, recent survey in newsletter that most young age peoples are suffering from diabetes and cardiac disorders because of their life styles and physical inactivity in their daily life. In Gujarat, on 'world diabetes day', newspaper surveys that young and children people have type1 diabetes and type2 diabetes diagnosed. In Ahmedabad, 20% of diabetic patients are suffering from cardiovascular diseases. A mostly cardiovascular disease is seen in men.

Cardiovascular diseases is mostly occurs due to stress, smoking, obesity. In men, work load and stress in their life is highest for this reason cardiovascular diseases and stroke is

occurs. In this fast life, at the age of 35 cardiovascular diseases, stroke and arrest is happens.

In 2019, World Health Organization surveys that 17.9million people have suffer from cardiovascular diseases from that 31% people deaths because of the strokes, attacks and diabetes. Author has do retrospective study in Ahmedabad city. 100peoples are suffering from diabetes from that 43people have cardiovascular diseases. In 2019, prevalence of Diabetes with cardiovascular diseases in Ahmedabad city is 30%, it's a geographical statistical analysis.

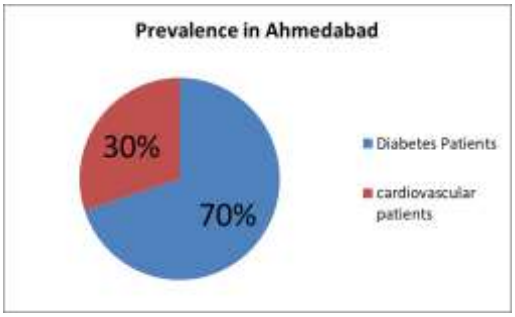


Chart -1: Prevalence in diabetes with cardiovascular diseases in Ahmedabad city.

Cardiac morbidity is up to 4% in diabetic patients. Also the diabetic patients have 18% hypertension. Cholesterol in diabetes with cardiac disorder is 5%. Obesity is 20% in diabetic patients and who have cardiovascular diseases suffered from that. Chest pain is 20% in men. Stroke is 10% seen in men.

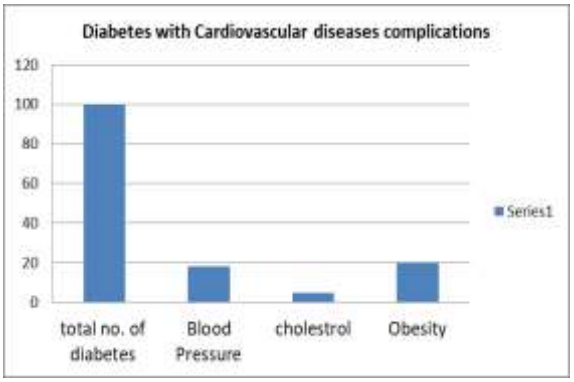


Chart -2: Diabetes with cardiovascular diseases complications.

1.2 Data Set

Fuzzy set theory is used for diagnosis purposed has been investigated results. This fuzzy set theory gives result healthier than non-experienced endocrinologist and 90% as well as the experienced endocrinologist did. The fuzzy set theory designs steps are as follows:

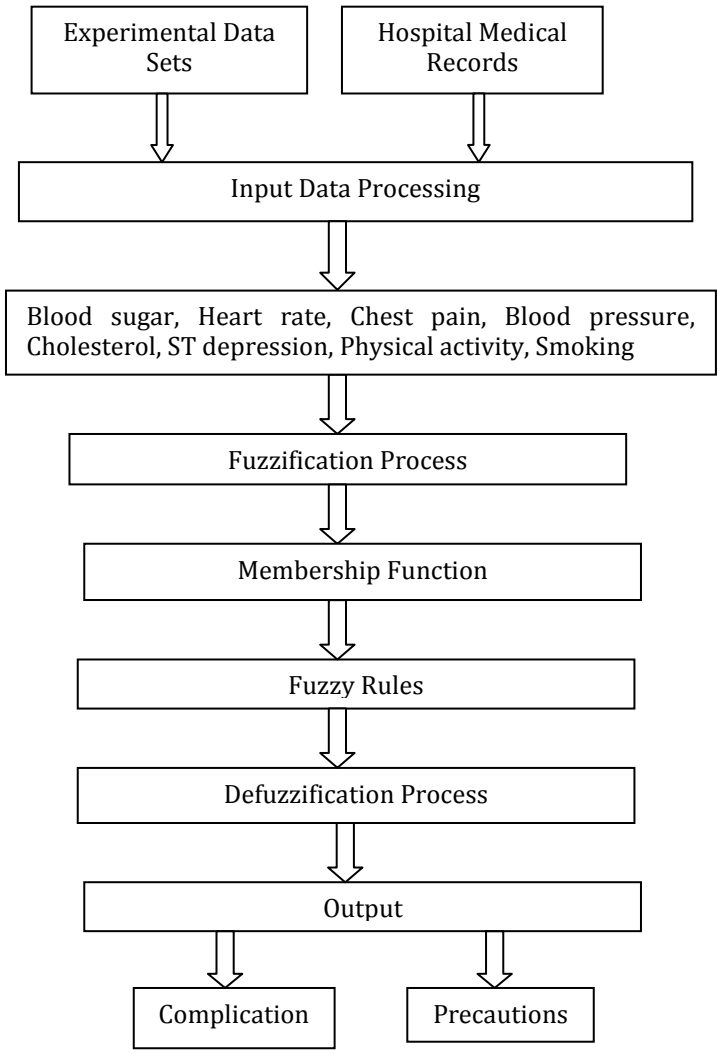


Fig -1: Design flow chart of fuzzy set theory.

The fuzzy set theory designed system based on the K D Hospital, Ahmedabad. Author's aim is to diagnose the presence of cardiovascular diseases with diabetes gives results of various examinations carried out on a patient. The fuzzy set theory has design a system consists of 8 input parameters and 2 output parameters. The system input is blood sugar, heart rate, chest pain, blood pressure, cholesterol, ST depression, physical activity, smoking; and system output is complications and precautions of cardiovascular diseases accordingly.

The membership function values from 0 (low) to 1 (high) increasing value sets according to diseases risk. Author has decided to use LDL cholesterol and systolic blood pressure, physical activity such as sitting more times to less time. The fuzzy set theory, sets the membership function values very low, low, normal, high, very high in every input and output parameters.

2. Input Data Processing

2.1 Blood Sugar

Most important parameter, results can be changed by this. Blood sugar test is simplest test. The range of random blood sugar is 50 to 300. Membership functions are very low [50 55 60 65], low [60 65 70 75], normal [70 90 120 140], high [130 150 200 240] , and very high [230 250 280 300].

2.2 Heart Rate

The normal heart rate of a person is 70 to 72beats/minute. The range of heart rate in this system is 60 to 150beats/minute. Membership functions are very low [60 62 64 66], low [65 67 69 71], medium [70 80 90 100], high [98 100 110 120], and very high [115 125 140 150].

2.3 Chest Pain

It is a symptom of cardiovascular diseases. Membership function range is up to 0 to 1. Membership functions values are very low [0 0.1 0.2 0.3], low [0.2 0.3 0.4 0.5], moderate [0.4 0.5 0.6 0.7], high [0.6 0.7 0.8 0.9], and very high [0.8 0.9 1 1.1].

2.4 Blood Pressure

The blood pressure is firstly measured when symptoms of heart diseases. Blood pressure informs about the patient's resting heart condition[2]. Normal range of blood pressure is 120/80mmHg. Here author has taken systolic blood pressure for measuring the cardiovascular diseases risk. Membership functions range is 60 to 200mmHg. Membership functions values are very low [60 65 70 75], low [70 80 100 120], normal [110 121 128 130], high [128 135 145 150], and very high [148 160 190 200].

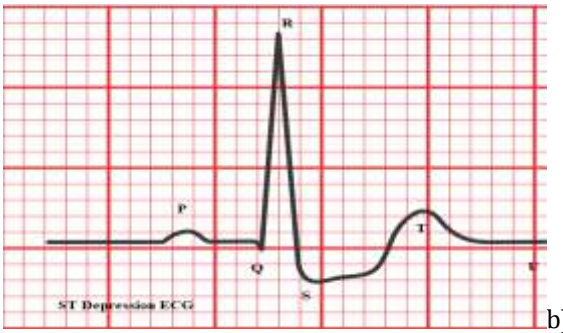
2.5 Cholesterol

Doctors and medical practitioner measuring the cholesterol test for measuring lipid profile. Generally doctors' measures cholesterol test at the age of 35years in men and 45years in women has lipid disorders. The cholesterol includes total cholesterol, low density lipoprotein cholesterol (LDL, bad), and high density lipoprotein cholesterol (HDL, good), and triglycerides (fats). From that low density lipoprotein cholesterol, bad cholesterol is taken as input parameters. Membership range is 50 to 400. Membership function values are very low [50 60 80 100], low [90 120 180 200], medium [190 210 240 260], high [250 270 300 310], very high [300 320 380 400].

2.6 ST Depression

The ST segment is flat, isoelectric section of the ECG between the ends of the S wave and the beginning of the T wave. The ST segment represents the interval between ventricular depolarization and repolarization. The most important cause of ST segment abnormality is myocardial ischemia or infarction.

a)



b)

Fig -2: a) Normal ECG b) ST Depression (https://www.seekpng.com/ima/u2q8y3q8a9u2o0i1/).

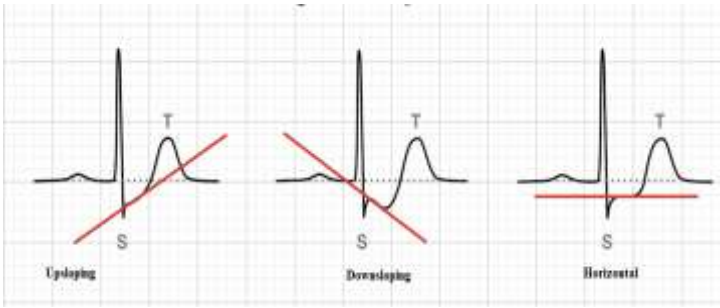


Fig -3: ST depression slopes for ECG reading[3]

The range of membership function is 0 to 1. Membership functions values are very low [0 0.05 0.1 0.15 0.2], low [0.18 0.24 0.3 0.35], medium [0.32 0.4 0.45 0.5], high [0.48 0.55 0.6 0.7], and very high [0.65 0.75 0.85 1].

2.7 Physical Activity

Doctors are also check the physical activity in their daily routine such as siting, running, walking, and exercises are performing or not. Because in this fast routine life generally men's have works on the laptops or computers for that they have to sits more times. Some peoples are not doing exercises daily. Membership function range is 0 to 1. In these membership function is [0 0.3 1 1.5].

2.8 Smoking

Smoking is dangerous to our life. Some peoples have habits of doing smoking. It creates cardiovascular diseases, infections causes' stroke. It harms to blood vessels supply which quick atheroma. The range of membership function is 0 to 1. Membership function values is [0 0.5 1 1.5].

3. Output Parameter

The output of this system gives the presence of heart diseases in the patients. The output of this system gives the complications of heart diseases in the patients. The membership range is 0 to 1; it shows the risks of heart diseases in patients. Membership functions value are healthy [0 0.05 0.1 0.15 0.2], low risk [0.18 0.24 0.3 0.35], medium risk [0.32 0.4 0.45 0.5], risk [0.48 0.55 0.6 0.7], and high risk [0.65 0.75 0.85 1].

Second output parameter gives the precautions to the patients. From this output parameter, doctors and medical practitioners give the precautions to the patients from the complications of the heart diseases. The membership function range is 0 to 1. Membership function values are normal diet [0 0.05 0.1 0.15 0.2], balanced diet [0.18 0.24 0.3 0.35], olive oil [0.32 0.4 0.45 0.5], exercise [0.48 0.55 0.6 0.7], and other [0.65 0.75 0.85 1].

4. Fuzzy Rules

Fuzzy rules designs for the fuzzy set theory system and trains the system for quality results. This system includes rules are as follows:

1. If blood sugar is very low and heart rate is very low and chest pain is very low and blood pressure is very low and cholesterol is very low and ST depression is very low and physical activity is active and smoking is yes then complication is low risk precaution is normal diet.
2. If blood sugar is very low and heart rate is very low and chest pain is very low and blood pressure is very low and cholesterol is very low and ST depression is very low and physical activity is inactive and smoking is no then complication is low risk precaution is normal diet.
3. if blood sugar is very low and heart rate is very low and chest pain is very low and blood pressure is very low and cholesterol is very low and ST depression is very low and physical active is inactive and smoking is yes then complication is low risk precaution is normal diet.
4. If blood sugar is very low and heart rate is very low and chest pain is very low and blood pressure is very low and cholesterol is very low and ST depression is very low and physical active is inactive and smoking is no then complication is low risk precaution is normal diet.
5. If blood sugar is low and heart rate is low and chest pain is low and blood pressure is low and cholesterol is low and ST depression is low and physical activity is active and smoking is yes then complication is low risk precaution is balanced diet.
6. If blood sugar is low and heart rate is low and chest pain is low and blood pressure is low and cholesterol is low and ST depression is low and physical activity is inactive and smoking is no then complication is low risk precaution is balanced diet.
7. If blood sugar is low and heart rate is low and chest pain is low and blood pressure is low and cholesterol is low and ST depression is low and physical active is inactive and smoking is yes then complication is low risk precaution is balanced diet.
8. If blood sugar is low and heart rate is low and chest pain is low and blood pressure is low and cholesterol is low and ST depression is low and physical active is active and smoking is no then complication is low risk precaution is balanced diet.
9. If blood sugar is medium and heart rate is medium and chest pain is medium and blood pressure is medium and cholesterol is medium and ST depression is medium and physical activity is active and smoking is yes then complication is medium risk and precaution is olive oil.
10. If blood sugar is medium and heart rate is medium and chest pain is medium and blood pressure is medium and cholesterol is medium and ST depression is medium and physical activity is inactive and smoking is no then complication is medium risk and precaution is olive oil.
11. If blood sugar is medium and heart rate is medium and chest pain is medium and blood pressure is medium and cholesterol is medium and ST depression is medium and physical active is inactive and smoking is yes then complication is medium risk precaution is olive oil.
12. If blood sugar is medium and heart rate is medium and chest pain is medium and blood pressure is medium and cholesterol is medium and ST depression is medium and physical active is active and smoking is not then complication is medium risk precaution is olive oil.
13. If blood sugar is high and heart rate is high and chest pain is high and blood pressure I high and cholesterol is high and ST depression is high and physical activity is active and smoking is yes then complication is risk precaution is exercise.
14. If blood sugar is high and heart rate is high and chest pain is high and blood pressure is high and cholesterol is high and ST depression is high and physical activity is inactive and smoking is no then complication is risk precaution is exercise.
15. If blood sugar is high and heart rate is high and chest pain is high and blood pressure is high and cholesterol is high and ST depression is high and physical activity is inactive and smoking is yes then complication is risk precaution is exercise.
16. If blood sugar is high and heart rate is high and chest pain is high and blood pressure is high and cholesterol is high and ST depression is high and physical active is active and smoking is no then complication is risk precaution is exercise.

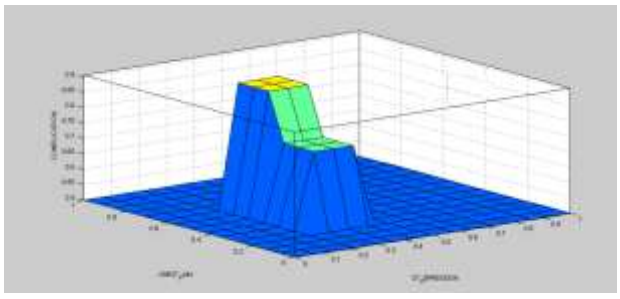
17. If blood sugar is very high and heart rate is very high and chest pain is very high and blood pressure is very high and cholesterol is very high and ST depression is very high and physical activity is active and smoking is yes then complication is high risk precaution is other precaution.
18. If blood sugar is very high and heart rate is very high and chest pain is very high and blood pressure is very high and cholesterol is very high and ST depression is very high and physical activity is inactive and smoking is no then complication is high risk precaution is other precaution.
19. If blood sugar is very high and heart rate is very high and chest pain is very high and blood pressure is very high and cholesterol is very high and ST depression is very high and physical active is inactive and smoking is yes then complication is high risk precaution is other precaution.
20. If blood sugar is very high and heart rate is very high and chest pain is very high and blood pressure ST very high and cholesterol is very high and physical active is active and smoking is no then complication is high risk precaution is other precaution.

5. Defuzzification Process

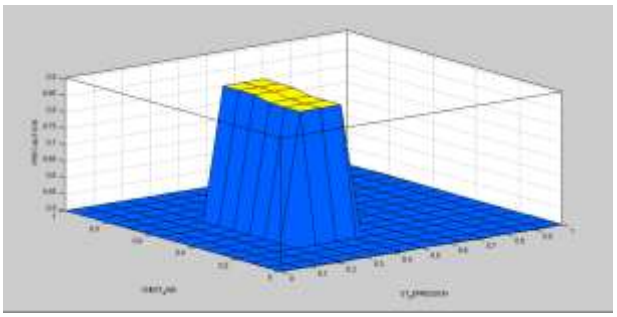
Defuzzification is the process in which fuzzy set is converted in to crisp values for understanding in a human language. It controls and train by the fuzzy rules. It is totally based on the fuzzy rules. It is a conversion of fuzzy output into crisp set. In this system, centroid is used for the defuzzification for output variable reads.

6. Result

In result diabetic patients have a cardiovascular diseases diagnosis. In this system, two output parameters precautions and complications. Complications are depends on the different conditions and result shows risks in the patient's body. Precautions are second result from this system. Precaution is depends on the risks of complication. From the complications doctor or medical practitioner gives the precautions.



a)



b)

Fig -3: a) Complication result of ST Depression and Chest pain. b) Precaution result of ST Depression and chest pain.

7. CONCLUSIONS

In this proposed system, author has made a diagnostic system using the fuzzy set theory for diagnosing complications of diabetes with cardiovascular diseases conditions. Doctors such as diabetologist and cardiologist have easy to operate this system for diagnosing purposes. An advantage of this system is both risk assessment and precautions are given in the output. From the condition of the diabetic patient's doctors directly knows about their complications that low risk to high risk from that doctor easily gives precautions like olive oil, exercises or balanced diet.

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