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DSSBD: FUZZY RULE BASED DECISION SUPPORT SYSTEM FOR BLOOD DISEASES DIAGNOSIS

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Abstract: Advancement in the field of artificial intelligence have led to the emergence of expert systems for medical applications. Moreover, in the last few decades' computational tools have been designed to improve the experiences and abilities of physicians for making decisions about their patients. This research work is an account of decision support system that we called as an DSSBD (Decision Support System for Diagnosing Blood Diseases). This proposed system is having capability of acting similar to an expert (doctors) in their specialized field. This work enables a patient to find out the diseases by putting symptoms values only, when no other help is possible. The Fuzzy rules are framed by MATLAB fuzzy logic toolbox to use in inference engine[1]. The knowledge acquisition for DSSBD was performed by consulting with the domain experts(physicians)of Arora Hospital, Kartarpur(Punjab-India).Inference rules are framed accordingly. DSSBD is developed and tested using sample record of patients.

Key Words: Expert System, Medical application, Fuzzy logic, Inference system, Fuzzification, defuzzification.

1. INTRODUCTION

The activities related to research and developments have been used, that could make decisions based on the thinking of human and its concepts: Expert Systems (ES). Expert systems are peculiarly designed to replace a human expert or to practiced when human expertise scarce [1]. ES get high scores when we are having shortage of human experts and requirement of those experts is at many locations. It acts as a decision supporter in medicine and health care. It is having capability of a smart patient record system. Diagnosis in a medical field is a method of identification of illness based on few signs and symptoms that occurs. DSSBD aim to supply for tools to assist **Hematologis**t, guide trainee students and encourage medical experts in their diagnoses. Due to non-availability of the expert in remote areas, most of the patient suffers from some danger diseases. Sometime patient's life in danger and may lead to death because of the improper diagnosis and treatment of the diseases. This expert system will very helpful for diagnosing the diseases at early stages and can save the patient's life. Expert systems are not developed using the conventional procedural code rather they are represented primarily as IF-THEN rules [8]. Expert systems are the first absolutely successful class of AI software.

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DSSBD is used to make task of physician easy and simple. DSSBD diagnose the diseases on the basis of sign and symptoms provided by the patient and further recommend the corresponding specialist for the treatment. The advantage of DSSBD is that it simplifies work of the doctors and also assists the patients in emergency by providing initial medicines for minor diseases.

Research has shown that while diagnosing a disease, based on constrained findings provided in the consultation, medical experts instantly make a few disease hypotheses, after which further specialized examination and testing is done to verify or invalidate these hypotheses. Due to the specific and particular importance of all the medical data, knowledgebase environment construction for aiding the medical diagnosis system for diagnosing human diseases is a complex task. Another reason for the complexity of task is the interpretations provided by different doctors to the patients. Diagnosing diseases at early stage can help to overcome and treat them properly. Accurate identification of the treatment depends on the method being used in diagnosing the diseases. An expert system can significantly assist in identifying those diseases and illustrating methods of treatment to be applied taking into consideration the user capability for dealing and interacting with expert system easily. Most of the expert systems take an input as symptoms and confirm the diseases and also provide the treatments to the patient. It is so difficult task to provide the medicines on the basis of some symptoms. The confirmation of some diseases are depend on the tests, before conducting the test we cannot provide the treatment to the patient or we can say we cannot give the medicine for the disease. For example, if the patient has symptoms like cough, sputum then we cannot say that the patient is suffering from pulmonary TB disease. Then the tests of patient conducted and disease is confirmed. So, this expert will remove the limitations of these types of expert systems. It finds the disease on the basis of some symptoms and suggests the corresponding specialist for their treatments.

2 LOGICAL PROGRAMMING FOR MEDICAL DIAGNOSIS

We can diagnose the results by observing patient's sign and symptoms. If we examine the procedure which is followed by the physicians to identifying the disease, that is the simpler method. Some symptoms are occurring at a high range or other are occur at low or moderate range. Fuzzy rules are designed with the same key idea [2].

Example:

Diagnosis-A - (symptom-A is *HIGH* **&**symptom-C is *LOW***&** symptom-D is *MODERATE*)

Diagnosis B - (symptom-B is *LOW***&** symptom-C is *HIGH*).

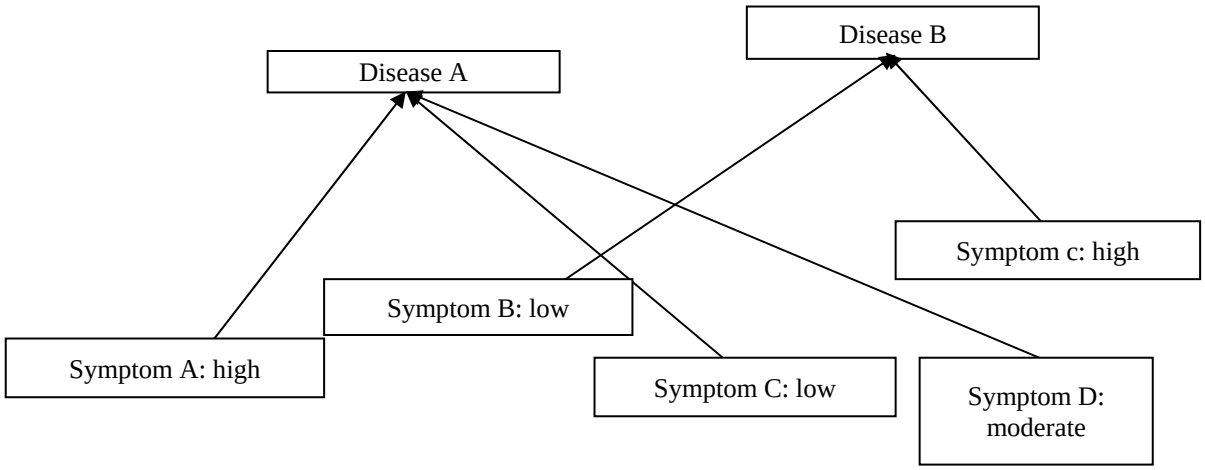

Figure 1 Rule Designing Pattern for Disease Diagnosis

Fuzzy logic is a kind of logic which has become very essential in our everyday lives to control vague concepts. Unlike binary logic, fuzzy is a multi- valued logic. For medical field applications, fuzzy logic has a wide scope. It is used in predicting the disorder of eye, liver functioning, kidney, nerve system, Ear Nose Throat(ENT), blood etc.

2.1 Identifying the parameters

The most essential aspect to take into the account is to identify the parameters for the particular disease. The symptoms play a crucial role for causing a disease. In this research work, different diseases are highlighted with some expectancy that are related with symptoms of each specialist.

2.2 Choosing membership function

Selection of membership function determines the efficiency and effectiveness of the system. These membership functions are applied to all the input and output variables to represent fuzzy sets. There are different ways for selecting the membership functions. Based on intuition method the membership values are chosen in this research work [5]. There are several other factors also such as range of the parameters, type of parameters, the conjunction, disjunction and aggregation that must be taken into consideration apart from number of membership functions being used. Triangular membership function is used to represent the attribute of each output fuzzy variable and input fuzzy variable is represented through the trapezoidal membership function.

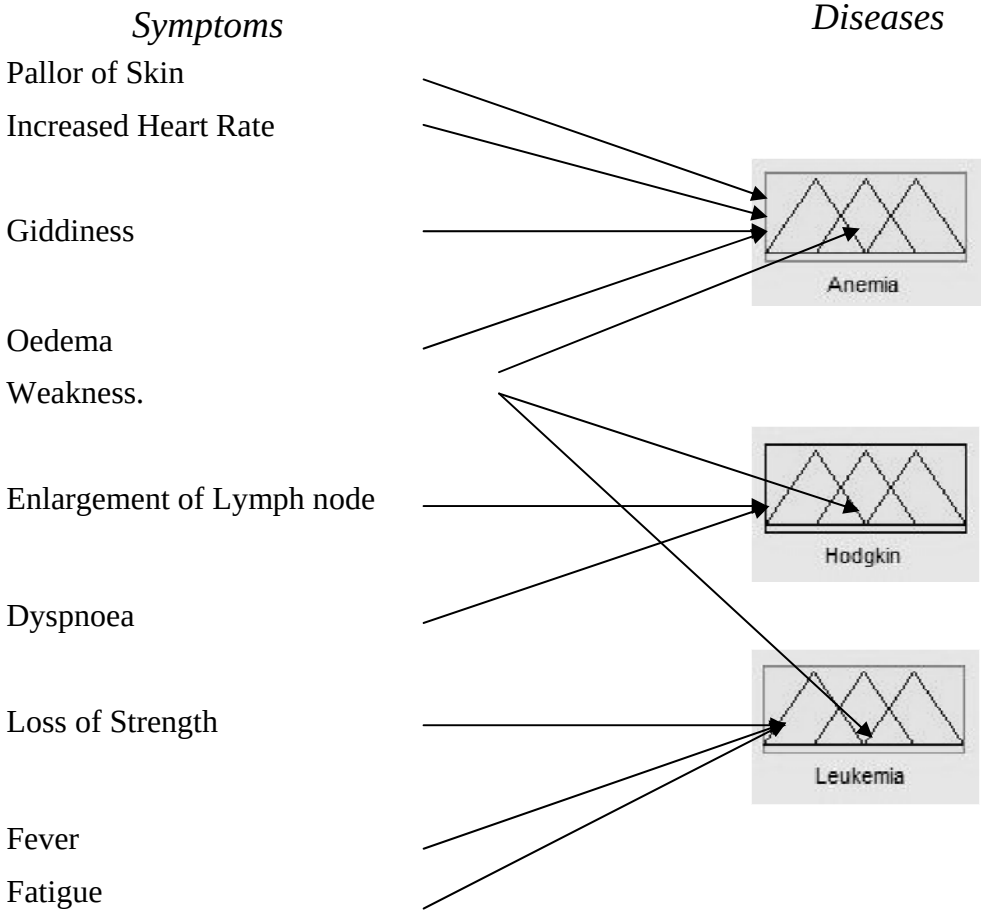

Figure 2 Blood diseases with common symptoms

Rules are designed after collecting pre-requisites to diagnose the disease. This expert system is built to play the role of a **Hematologist.** Details of the diseases diagnosed by hematologist when blood is infected are given below:

Hematologist: the human blood includes the blood cells that are red cells, white cells, platelets cells. Red cells are the responsible for the transport of oxygen and carbon dioxide. White cells are responsible for the phayotosis of bacteria. The platelet cells are responsible for the cellular immunity. The diseases related to the blood are:

- **Anemia:** it is the one the common disease of blood. It occurs due to the loss of the red cells in the blood. And increased the destruction of the blood cells. The sign and symptom are pallor of skin, weakness, increased heart rate, giddiness.
- **Leukemia:** it is a fatal disease of blood forming tissue. It occurs due to absence white cell in the blood. The vital sign and symptom of this disease are fever, pallor of skin, fatigue, loss of strength.
- **Hodgkin's Diseases:** it is a maligner disorder of the blood. It produces the painless enlargement of the lymph node. The vital sign and symptom of this disease is enlargement of lymph node and weakness.

3. DESIGN ALGORITHM OF FUZZY LOGIC

Here is the designing of a powerful solution for hematologists to diagnose various blood diseases. [10]

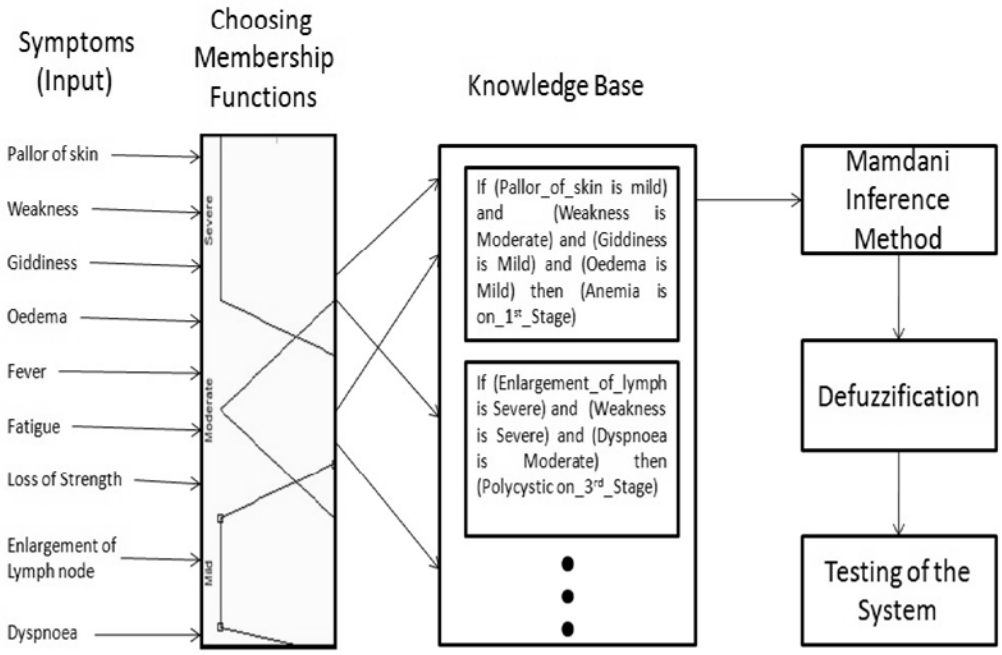

Figure 3 Design Algorithm for the system

3.1 FIS of DSSBD

If we focalize blood, three severe diseases can be diagnosed. These are Anemia, Leukemia and Hodgkin's disease. There are260 rules in the Fuzzy Inference System(FIS) for Anemia.

Table1
Fuzzy input variables and ranges of their membership functions

S. No.	*Input Variable*	*Membership Function Range-[0 10]*			
		Nill	*Mild*	*Moderate*	*Severe*
1	Pallor of skin	[0 0 0 0.5]	[0.5 1 3 4]	[3 5 7]	[6 7 9 10]
2	Weakness	[0 0 0 0.5]	[0.5 1 3 4]	[3 5 7]	[6 7 9 10]
3	Increased heart rate	[0 0 0 0.5]	[0.5 1 3 4]	[3 5 7]	[6 7 9 10]
4	Giddiness	[0 0 0 0.5]	[0.5 1 3 4]	[3 5 7]	[6 7 9 10]
5	Oedema	[0 0 0 0.5]	[0.5 1 3 4]	[3 5 7]	[6 7 9 10]
6	Fever	[0 0 0 0.5]	[0.5 1 3 4]	[3 5 7]	[6 7 9 10]
7	Fatigue	[0 0 0 0.5]	[0.5 1 3 4]	[3 5 7]	[6 7 9 10]
8	Loss of Strength	[0 0 0 0.5]	[0.5 1 3 4]	[3 5 7]	[6 7 9 10]
9	Enlargement of Lymph node	[0 0 0 0.5]	[0.5 1 3 4]	[3 5 7]	[6 7 9 10]
10	Dyspnoea	[0 0 0 0.5]	[0.5 1 3 4]	[3 5 7]	[6 7 9 10]

Table 2
Fuzzy output variables and ranges of their membership functions

S.. No.	*Output Variable*	*Membership Function Range-[0 10]*			
		Not positive	*1st stage*	*2nd stage*	*3rd stage*
1	Anemia	[0 0 0.5]	[0.5 2.5 4]	[3 5.3 7]	[6 8.5 10]
2	Hodgkin's disease	[0 0 0.5]	[0.5 2.5 4]	[3 5.3 7]	[6 8.5 10]
3	Leukemia	[0 0 0.5]	[0.5 2.5 4]	[3 5.3 7]	[6 8.5 10]

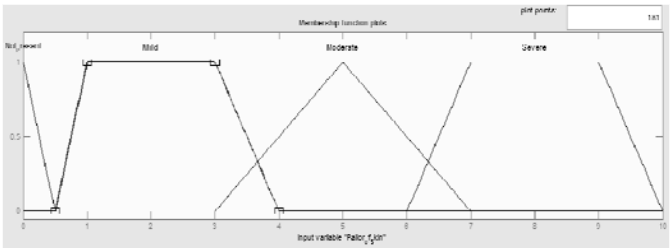

Figure 4a Membership functions for Inputs.

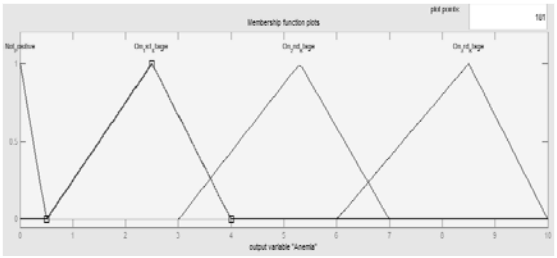

Figure 4b Membership functions for Outputs.

Each input variable for blood diseases can be categorized into Mild, Moderate and Severe [4].The ranges for each variable are defined from 0-10. The variable value ranges from 0.5 to 4 for Mild symptoms. For Moderate symptoms the variable value ranges from 4 to 7, similarly for severe symptoms the variable value ranges from 7 to 10. The value of variable will be from 0 – 0.5 if the symptom is not present. Each Input variable is a union of the triangular and trapezoidal membership function.The Mild and Severe fuzzy linguistic variablesare depicted through trapezoidal membership functions whereas the Moderatelinguistic variable is depicted through the triangular membership function [6].

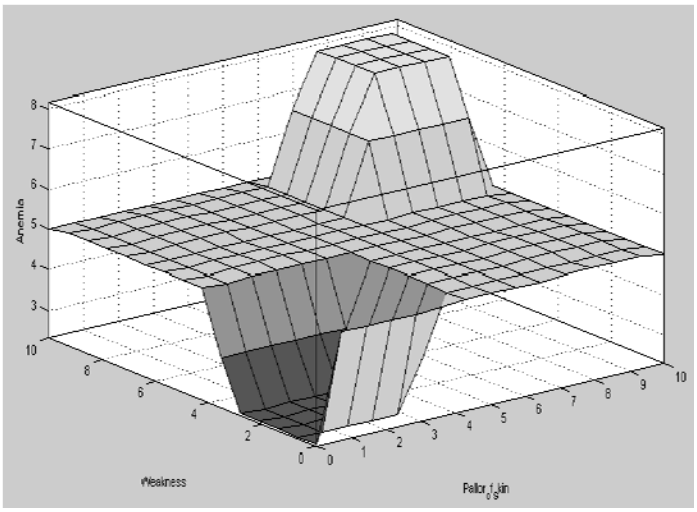

Figure 5 DSSBD-Surface View

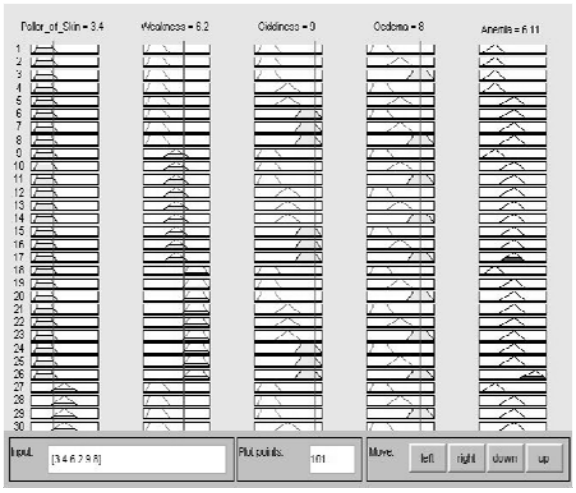

Figure 6 Rule Viewer

In the rule viewer, put the value of the each symptom of Anemia ranging from 0-10, it will give the corresponding output (Disease). The same fuzzy inference has been created for Hodgkin's disease and Leukemia.

4. DIAGNOSTIC POWER OF DSSBD

Table 3 shows the data of some patients and the diseases corresponding to the symptoms of these patients as diagnosed by the Expert (Doctor). Table 4 shows the output produced by the system for the same data of patients. The diagnosis of disease done by expert (doctor) and the system are compared and it is found that out of data of 5 patients, 4 are matched whereas 1gave a false positive result. Table 5 shows the ranking of some symptoms of patients to test the accuracy of result using LOM, MOM, BISECTOR, SOM, CENTROID defuzzification method.

Table 3
Sample data of patients for testing the fuzzy inference system for disorders related to Blood.

Sign and *Symptoms*										*Diseases*		
Pallor of skin	*Weakness*	*Increased heart rate*	*Giddiness*	*Oedema*	*Fever*	*Fatigue*	*Loss of Strength*	*Enlargement of Lymph node*	*Dyspnoea*	*Anemia*	*Hodgins*	*Leukemia*
Mild	svere	Mild	Mild	Mild	notexist	notexist	notexist	notexist	notexist	2nd		
Notexist	svere	Notexist	Svere	Notexist	notexist	notexist	notexist	notexist	notexist	2nd		
Notexist	notexist	Notexist	Notexist	Notexist	svere	svere	mild	notexist	notexist			2nd
Notexist	notexist	Notexist	Notexist	Notexist	svere	svere	svere	moderate	moderate		2nd	
Svere	svere	Moderate	Svere	Notexist	notexist	notexist	notexist	Notexist	notexist			2nd
Notexist	notexist	Notexist	Svere	Svere	svere	notexist	notexist	Notexist	notexist	3rd		
mild	moderae	Mild	Severe	Moderate	Notexist	notexist	notexist	Notexist	notexist	2nd		
mild	moderae	Mild	Severe	Severe	Severe	notexist	notexist	Notexist	notexist	3rd		

Table 4
Sample data of patients for testing the fuzzy inference system for disorders related to Blood.

Sign and Symptoms										*Disease Diagnosis by System*			*Disease Diagnosis by Expert*			
Pallor of skin	*Weakness*	*Increased heart rate*	*Giddiness*	*Oedema*	*Fever*	*Fatigue*	*Loss of Strength*	*Enlargement of Lymph node*	*Dyspnoea*	*Anemia*	*Hodgins*	*Leukemia*	*Anemia*	*Hodgins*	*Leukemia*	*Results*
2	9	3	2	4	0	0	0	0	0	5.06	0.13	0.13	2nd			TRUE
0	7	0	7.5	0	0	0	0	0	0	5.1	0.13	0.13	2nd			TRUE
0	0	0	0	0	7	7	3	0	0	0.13	0.13	5			2nd	TRUE
0	0	0	0	0	7	9	7.5	4	5	0.13	2	8		2nd		FALSE POSITIVE
3	4	2	8	6	0	0	0	0	0	5.06	0.16	0.13	2nd			TRUE

Table 5 shows the testing of the FIS for Anemia by using different defuzzification methods LOM, SOM, CENTROID, MOM, BISECTOR to produce the output for same set of inputs and providing corresponding ranks to them. Similarly the FIS for Hodgkin's disease and Leukemia are also tested**.** Since all the inputs got almost same ranks in all the five defuzzification methods, this shows the accuracy of the system.

Table 5

Deffuzified values obtained by applying different defuzzification methods and their corresponding ranks

Sign and Symptoms for anemia				*Deffuzified results and ranks*									
Pallor of skin	*Weakness*	*Giddiness*	*Oedema*	*Centroid*	*Rank*	*Bisector*	*Rank*	*LOM*	*Rank*	*SOM*	*Rank*	*MOM*	*Rank*
1	1.4	2	2.1	2.33	9	2.4	6	2.5	9	2.5	8	2.5	7
1.4	1.8	2.4	2.5	2.33	9	2.4	6	2.5	9	2.5	8	2.5	7
2	2.4	3	3.1	2.33	9	2.4	6	2.6	8	2.3	9	2.45	6
2.7	3.1	3.7	3.8	3.87	8	4	5	6.4	4	3.9	7	5.15	5
4.5	4	5	4.2	5.07	6	5.1	4	6.1	6	4.2	5	5.15	5

Table 5 contd…

5	4.5	5.5	4.7	5.09	5	5.1	4	5.7	7	4.8	4	5.25	4
5.8	5.3	6.3	5.5	5.05	7	5.1	4	6.4	4	3.9	7	5.15	5
6.7	5.9	6.9	6.1	5.66	4	5.4	3	6.2	5	4.1	6	5.15	5
7.6	8	7.1	7.3	8.17	1	8.2	1	8.5	3	8.5	1	8.5	1
8.1	8.5	7.6	7.8	8.17	1	8.2	1	8.5	3	8.5	1	8.5	1
8.7	9.1	8.2	8.4	8.16	2	8.2	1	8.6	2	8.3	2	8.45	2
9.1	9.5	8.6	8.8	8.11	3	8.1	2	9.2	1	7.3	3	8.25	3

5. SYSTEM INTERFACE

Designing of graphical user interface (GUI) is the last stage of the development procedure of proposed system. Using the GUI user can interact with the expert system to identify the particular disease he is suffering from. The symptoms are provided to this Expert system as a input and the system provides the output as the diagnosed disease. After the output is obtained from the system, it can recommend the specialist for the treatment of the disease. The medical diagnosis system is developed using the MATLAB R2013a. The whole database including rules is designed using the fuzzy logic. Following are main modules of the system:

5.1 Rule Base

All the vital and important symptoms of patients are kept into this system. Each and every symptom added to the rule base is assigned weights [7]. These symptoms are fuzzified then and rules are designed [9]. Few rules for the FIS of Anemia are shown below :

1. If (Pallor_of_Skin is Mild) and (Weakness is Mild) and (Giddiness is Mild) and (Oedema is Mild) then (Anemia is On_1st_Stage) (1)
2. If (Pallor_of_Skin is Mild) and (Weakness is Mild) and (Giddiness is Mild) and (Oedema is Moderate) then (Anemia is On_1st_Stage) (1)
3. If (Pallor_of_Skin is Mild) and (Weakness is Mild) and (Giddiness is Mild) and (Oedema is Severe) then (Anemia is On_1st_Stage) (1)
4. If (Pallor_of_Skin is Mild) and (Weakness is Mild) and (Giddiness is Moderate) and (Oedema is Mild) then (Anemia is On_1st_Stage) (1)
5. If (Pallor_of_Skin is Mild) and (Weakness is Mild) and (Giddiness is Moderate) and (Oedema is Moderate) then (Anemia is On_2nd_Stage) (1)
6. If (Pallor_of_Skin is Mild) and (Weakness is Mild) and (Giddiness is Severe) and (Oedema is Mild) then (Anemia is On_2nd_Stage) (1)
7. If (Pallor_of_Skin is Mild) and (Weakness is Mild) and (Giddiness is Severe) and (Oedema is Moderate) then (Anemia is On_2nd_Stage) (1)
8. If (Pallor_of_Skin is Mild) and (Weakness is Mild) and (Giddiness is Severe) and (Oedema is Severe) then (Anemia is On_2nd_Stage) (1)
9. If (Pallor_of_Skin is Mild) and (Weakness is Moderate) and (Giddiness is Mild) and (Oedema is Mild) then (Anemia is On_1st_Stage) (1)
10. If (Pallor_of_Skin is Mild) and (Weakness is Moderate) and (Giddiness is Mild) and (Oedema is Moderate) then (Anemia is On_2nd_Stage) (1)
11. If (Pallor_of_Skin is Mild) and (Weakness is Moderate) and (Giddiness is Mild) and (Oedema is Severe) then (Anemia is On_2nd_Stage) (1)
12. If (Pallor_of_Skin is Mild) and (Weakness is Moderate) and (Giddiness is Moderate) and (Oedema is Mild) then (Anemia is On_2nd_Stage) (1)
13. If (Pallor_of_Skin is Mild) and (Weakness is Moderate) and (Giddiness is Moderate) and (Oedema is Moderate) then (Anemia is On_2nd_Stage) (1)
14. If (Pallor_of_Skin is Mild) and (Weakness is Moderate) and (Giddiness is Moderate) and (Oedema is Severe) then (Anemia is On_2nd_Stage) (1)
15. If (Pallor_of_Skin is Mild) and (Weakness is Moderate) and (Giddiness is Severe) and (Oedema is Mild) then (Anemia is On_2nd_Stage) (1)
16. If (Pallor_of_Skin is Mild) and (Weakness is Moderate) and (Giddiness is Severe) and (Oedema is Moderate) then (Anemia is On_2nd_Stage) (1)
17. If (Pallor_of_Skin is Mild) and (Weakness is Moderate) and (Giddiness is Severe) and (Oedema is Severe) then (Anemia is On_2nd_Stage) (1)

5.2 Process Selection Interface

This module facilitates the user to interact with the expert system. The graphical user interface as shown in Figure 6 displays the information of the patients and the crucial sign and symptoms that can appear.

The user can enter the input (Symptoms) in the range of 0 to 10. The value of the Anemia is 6.10859, Hodgkin's disease has the output value 8, and Leukemia has value 5, this means that patient is suffering from the Hodgkin's disease at severe stage.

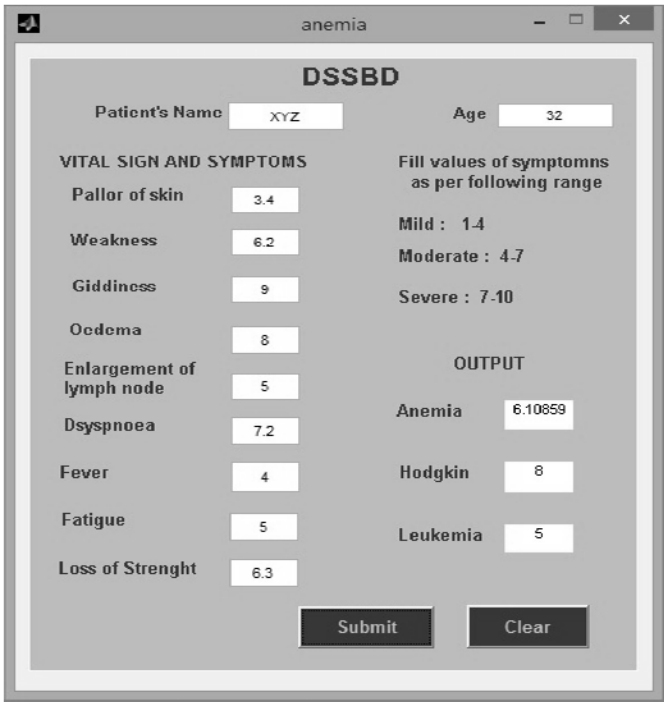

Figure 6 Process Selection Screen

5.3 Inference Engine

This expert system is built using the Mamdani fuzzy inference process. In this interface user will enter the range of the symptom that is present or positive 0.5-4 as mild infection, 5-7 moderate, 8-10 as severe. On the basis of these symptoms it will give you the output i.e disease. After concluding the result it will suggest the corresponding specialist. The patient has to put the vital sign and symptoms from which he suffering. On the basis of those symptoms the system will predict the disease. If the value of the output is less than 1, then the patient has no disease. If the value is between 2 -4, the patient's disease is on 1st stage, if the value is between 4-6, patient's disease on 2nd stage and if value is between 7-10 then the patient has severe problem of that particular disease .

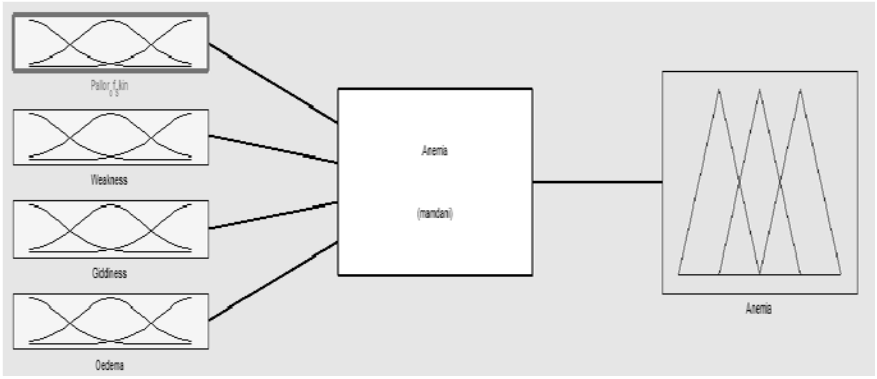

Figure 7 Inference System for Anemia

5. CONCLUSION AND FUTURE SCOPE

This paper presents the fuzzy logic based medical expert system that diagnoses the diseases related to disorder of blood. Doctors and physician can utilize this system to assist them in their daily life.The proposed medical expert system also enablesthe physician and doctors to pursue the similar method to diagnose the diseases and can easily suggest the specialist.

Future scope of this system is that it can be used for early detection of cancer, diagnosing the diseases of child, disorder of the female reproduction system. This system can be implemented using neuro-fuzzy method for diagnosing the chronic diseases.

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