FUZZY EXPERT SYTEM FOR DIAGNOSIS OF SICKLE CELL ANEMIA

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ABSTRACT

The logical thinking of medical practitioners plays an important role in diagnostic decisions. The diagnostic decisions depend upon experience, proficiency and sensitivity of the medical practitioner. As the complications of system increases, it is not easy to follow an exacting path of diagnosis without any mistake and Medical diagnosis is a complex human process that is difficult to represent in an algorithmic model. Fuzzy logic has already proved to be a wonderful tool for building intelligent decision making systems in medical field for diagnosis process that can properly handle the ambiguity, vagueness and complexity. In this paper we will use Fuzzy set theory and fuzzy logic which are highly appropriate and applicable for developing a fuzzy expert system for diagnosis of sickle cell anemia.

Key word- fuzzy logic, fuzzy expert system, medical diagnosis, sickle cell anemia, fuzzy inference system.

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I. INTRODUCTION

Sickle cell anemia is one type of anemia. Anemia is a condition in which your blood has a lower than normal number of red blood cells. This condition also can occur if your red blood cells don't contain enough hemoglobin. Sickle cell anemia is the most common form of sickle cell disease (SCD). SCD is a serious disorder in which the body makes sickle-shaped red blood cells. “Sickle-shaped” means that the red blood cells are shaped like a crescent. Normal red blood cells are disc-shaped and look like doughnuts without holes in the center. They move easily through your blood vessels. Red blood cells contain an iron-rich protein called hemoglobin. This protein carries oxygen from the lungs to the rest of the body. Sickle cells contain abnormal hemoglobin called sickle hemoglobin or hemoglobin S. Sickle hemoglobin causes the cells to develop a sickle, or crescent, shape. Sickle cells are stiff and sticky. They tend to block blood flow in the blood vessels of the limbs and organs. Blocked blood flow can cause pain and organ damage. It can also raise the risk for infection.Fig.1 show normal and abnormal sickle shape red blood cell.

Red blood cells are made in the spongy marrow inside the larger bones of the body. Bone marrow is always making new red blood cells to replace old ones. Normal red blood cells live about 120 days in the bloodstream and then die. They carry oxygen and remove carbon dioxide (a waste product) from your body. In sickle cell anemia, the abnormal sickle cells usually die after only about 10 to 20 days. The bone marrow can't make new red blood cells fast enough to replace the dying ones. Sickle cell anemia is an inherited, lifelong disease. People who have the disease are born with it. They inherit two genes for sickle hemoglobin—one from each parent. People who inherit a sickle hemoglobin gene from one parent and a normal gene from the other parent have a condition called sickle cell trait.

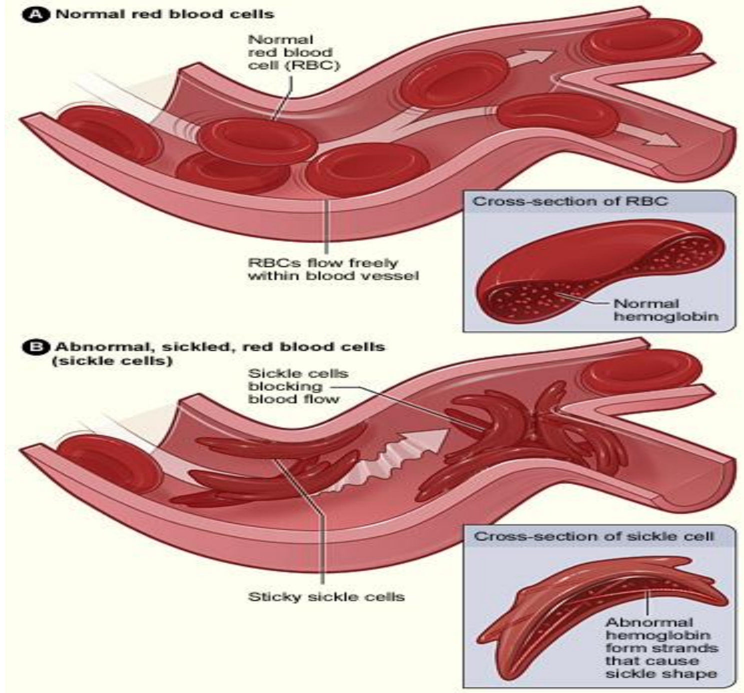

Figure 1(A) shows normal red blood cells flowing freely in a blood vessel. Figure1 (B)shows abnormal, sickled red blood cells blocking blood flow in a blood vessel.

Sickle cell trait (SCT) is different than sickle cell anemia. People who have sickle cell trait don't have the disease. People with SCT usually do not have any of the symptoms of SCD and live a normal life, but they can pass the sickle cell gene on to their children. When both parents have SCT, they have a 25% chance of having a child with SCD with every pregnancy. When both parents have SCT, they have a 50% chance of having a child with SCT with every pregnancy. Sickle cell anemia has no widely available cure. However, prior or in time treatments to improve the anemia and lower complications can help with the symptoms and complications of the disease in both children and adults. Sickle cell anemia varies from person to person. Some people who have the disease have long-term pain or tiredness. However, with proper care and treatment, many people who have the disease can have improved quality of life and reasonable health much of the time. Because of earlier and in time starts treatments and care, people who have sickle cell anemia are now living into their forties or fifties or longer. In diagnosing of a disease, physicians make decisions about the type of disease based on the symptoms and by studying the history of the patients. The uncertainty about the possibility of this disease may be represented by linguistic variables. The purpose of this paper is to deal with sickle cell anemia under-diagnosing by designing a Fuzzy Expert System (FES). The designed FES gives patients with respiratory symptoms the ability to check their disease for sickle cell anemia, the designed FES based on the status of their symptoms, historical data and their blood test report. In addition, it helps physicians to diagnose sickle cell anemia at initial stage, so for that patients get treatment at earlier stage of the disease.

In this research paper, we developed a fuzzy expert system for the diagnosis of sickle cell anemia. This expert system was design based on medical diagnosis; patient symptoms record blood test report and the expert's knowledge. The objective of this research paper is to provide a decision support platform to researchers, doctors and other healthcare practitioners. This system will assist physician in the serious and complex task of diagnosing and additional provide a system that will assist medical staff especially in rural areas, where there are shortages of doctors and another facilities, in this manner, this expert system helping people to get better treatment in time. This paper is organized as follows: A brief outline and design of the fuzzy expert system is presented in section2.The material and methodology of the fuzzy model for diagnosing sickle cell anemia will be discussed in section 3.process of data collection defined in section 4.input ant output variable and their membership function describe in 5^{th} section. In section 6 testing the proposed fuzzy expert system and last one is conclusion.

II. DESIGN OF FUZZY EXPERT SYSTEM

Fuzzy systems are a part of soft computing that works on the discipline of vagueness and gives results in an interpretable manner. Fuzzy system makes use of fuzzy set theory, fuzzy reasoning and inference mechanism so that such systems can be employed in various applications. The application of fuzzy logic in medical field is started in the early 70s after that the paper published by Zadeh(1965).one of the most important area of application of fuzzy logic as developed by Zadeh is Fuzzy Rule Based System (FRBS) also known as Fuzzy Expert System (FES). We apply fuzzy expert system which is a knowledge based system where fuzzy logic is used as a tool for developing relations between present symptoms and disease [11].

Several researchers have used fuzzy logic in medical diagnosis of different diseases such as diagnosis of heart disease [1], asthma [2], Hypothyroidism [9**]**, HIV [6], cancer [4], [3], malaria [8], tuberculosis [7].

The task of medical diagnosis and managing is complex because of the several variables involved. It is made more so because of a lot of ambiguity and vagueness. Patients cannot make clear exactly how they feel, doctors and nurses cannot tell exactly what they observe, and laboratories results are dotted with some errors caused either the carelessness of technicians or defectiveness of the tool. Expert System (ES) is an intelligent computer program help to systematize, store and obtain appropriate medical knowledge needed by the practitioner in dealing with each complicated case and suggesting suitable diagnosis for decision-making procedure that uses inference procedures for problem solving [5],[10].

Figure 2 shows architecture of fuzzy expert system.

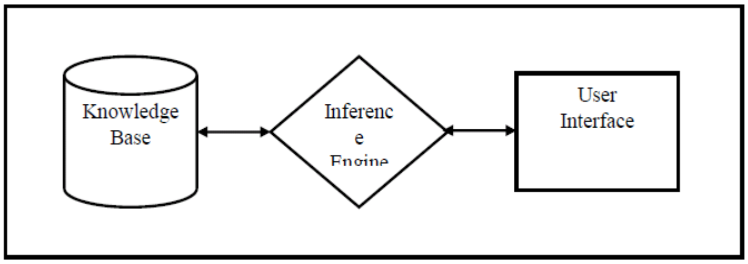

Figure 2 Architecture of fuzzy expert system

III. METHODOLOGY

The fuzzy expert system is a rule based system where fuzzy logic is used as a tool for representing different forms of knowledge about a problem, as well as for modeling the interactions and relationships that exist between its variables. The functions of this system are: first to collect all information (symptoms) that is generally used by experts. Second to find blood test for level of hemoglobin A and hemoglobin S. third, to offer knowledge based expert systems which have been successfully used to model a disease diagnostic system. Where the classical way to represent human knowledge is the use of if- then rules. The proposed system uses the mamdani fuzzy inference system for implementation Fig. 3 shows the flow diagram of the system.

The proposed fuzzy expert system for diagnosis of sickle cell anemia consists of three input, one output and ten rules. Its block diagram is shown in figure 4.The diagnosis is based on three input variable (1) symptoms score (2) hemoglobin A and (3) hemoglobin S, which are nothing but the values of obtain from the blood test report of the patients. System output is diagnosis of the patients which gives the severity of the sickle cell anemia which is divided in to four types. So proposed system have four linguistic variables out of these four, three variables are input variable specifically- symptoms score , hemoglobin A, hemoglobin S and one output variable is called severity of sickle cell anemia. fuzzifier unite convert the input variable into membership function in accordance to fuzzy value defined in database. Inference engine interprets the rules combined in the rule base. Variable into membership function in accordance to fuzzy value defined in database. Inference engine interprets the rules combined in the rule base. The inference engine is performed in three steps – (1) antecedent activation (2) implication (3) Aggregation and last defuzzifire convert fuzzy output into crisp value through the defuzzification process. Figure 3 shows the flow diagram of proposed fuzzy expert system.

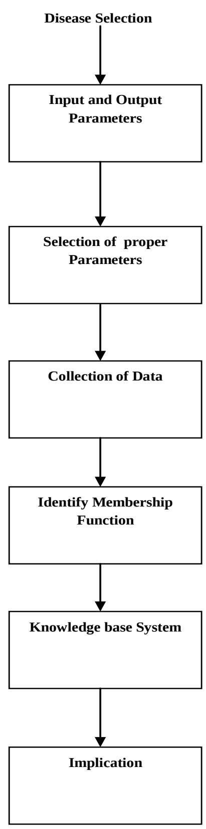

Fig 3 Flow diagram of fuzzy inference system

Figure 4 shows the Block Diagram of proposed fuzzy expert system given below -

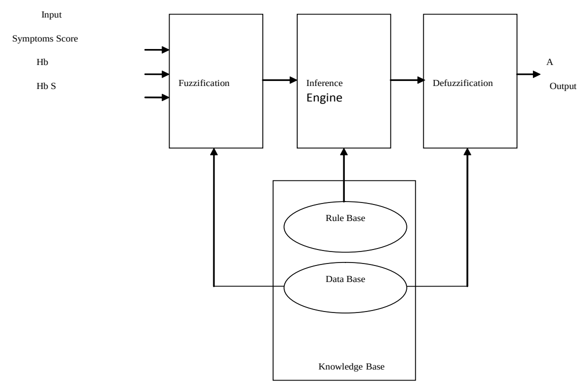

Fig: 4 Block Diagram of FIS

IV. DATA COLLECTION

A form was designed to collect the patient symptoms. This form (Fig 5 -which is given below) shows the severity of symptoms of a particular patient.

Patient No: **Name of the Patient:** ______________________________

Sex: M/F **Age:** ____

Sr. No.	Symptoms	Severity		
1	Fever	Rare	Ocutionaly	Daily
2	Swalling in hands and Feet	Yes/No		
3	Pain in lower back, joints & Chest	Light	Midil	High
4	Nose bleeds	No	Ocutionaly	Daily
5	Fatigue(Shortness of Breath)	Low	Midil	High
6	Jaundice	Yes/No		
7	Vision Problem	Yes/No		
	Total Score			

Blood Test

Test	Value
Hb A	0-20
Hb S	0-30

Fig 5 patients symptoms check form

V. MEMBERSHIP FUNCTIONS FOR INPUT AND OUTPUT VARIABLE

The fuzzy variable symptoms score has been represented using three fuzzy sets to categorize the input given by

Low risk _ the range is between 0-30.

Med risk – the range for this set 25-60.

High risk _ the range is between to 55-100.

The shape of membership function used for this low- risk and high-risk are of trapezoidal type and for med risk is of triangular type shown in Fig.6.

The second input is the levels of hemoglobin A. this value can be obtain fro blood report of patient. A normal and healthy person has Hbl A in between 14-20. If Hbl A is below this level then it is termed as low and Heb A is called medium in between level 10-15. There are three membership functions for Hbl A low, med and normal as shown in the Fig.7.

Third input variable is Hbl S for this type of variable two membership functions are chosen such that in the range 0-0 shows absent and in the range 0-30 it is shows present as shown in Fig.8.

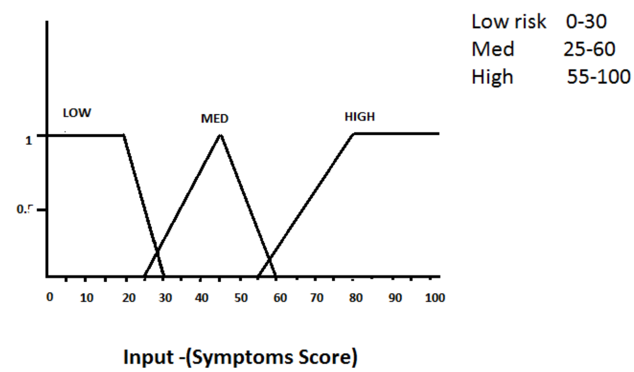

Fig. 6 membership function of symptoms score

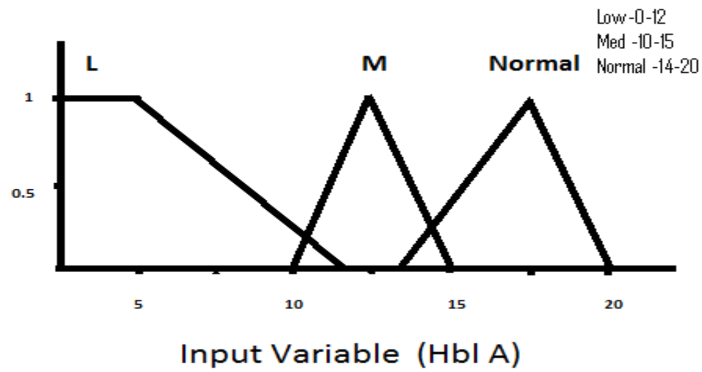

Fig. 7 membership function of hemoglobin A

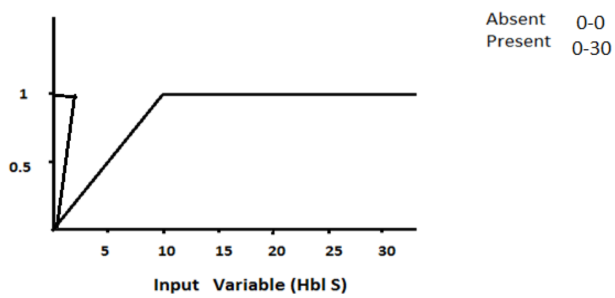

Fig. 8 membership function of hemoglobin S

The third output variable is sickle cell anemia which gives the diagnosis of patient.There are four steges of sickle cell anemia namelly normal , subclinicle, primary and seconary range for these mambership function is 0 to 100.fuzzy set normal and secondary are of trapezodial and another two sets are of triangular shape as in Figure 9.

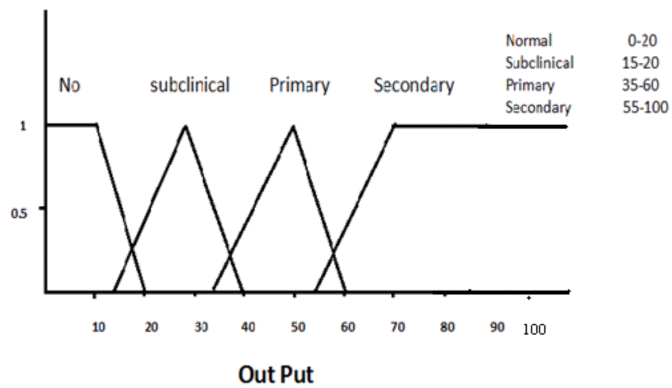

Fig. 9 mambership function of output variable

Every fuzzy rulebase system consiste of rule antecedents (input) and consequents (output). table 1 shows the rule antecedents and consequents for this system.Rule antecedents uses three input parameters symptoms score, Hbl A and Hbl S with their linguistic variables.Rule consequents gives disease diagnosis of sickle cell anemia. Input parameter symptoms score heving three linguistic variable low, medium and high which is depending upon patients symptoms, its severity and his/her family history.second input parameter is hemoglobin A and it has some specific range of values which we can describe in to three variable low,medium and normal.third parameter is hemoglobin S ,we have concidered two linguistic variable present and absent for this parameter.These ranges indicate severity of disease and these ranges play an important role in disease diagnosis. Final output of this system is steges of disease sickle cell anemia.which is divided in four categories –normal, subclinical, primary and secondary.

Table No.: 1 Rule Antceedent & Rule Consequence

Rule No	Antceedent			Consequence Sickle cell
	Symptoms Score	Hb A	Hb S	
1	Low	Normal	Abs	No Sicle cell
2	Low	Low	Abs	No Sicle cell
3	Low	Med	Abs	No Sicle cell
4	Med	Normal	Pres	Primary
5	Med	Low	Pres	Secondary
6	Med	Med	Pres	Secondary
7	Sever	Low	Pres	Secondary
8	Sever	Low	Abs	Primary
9	Sever	Med	Abs	Secondary
10	Sever	Med	Pres	Secondary
11	Med	Med	Abs	Subclinical
12	Low	Med	Pres	Primary
13	Low	Normal	Pres	Primary
14	Sever	Normal	Abs	Subclinical
15	Sever	Normal	Pres	Primary
16	Low	Low	Pres	Secondary
17	Med	Normal	Abs	No Sicle cell
18	Med	Low	Abs	Subclinical

Table 1 Rule Antcedent and consequence

VI. TESTING OF THE FUZZY EXPERT SYSTEM

About 10 patient’s data are collected for results. Table no.2 shows the data about all patients its output obtained from the proposed fuzzy expert system. Table no. 2 shows the data about all patients, its output obtain from the proposed fuzzy expert system. This is crisp value and diagnosis result made by doctor.

Table No: II Diagnosis of Patient done by FIS & Doctors:

Patient No	Age & Sex	Symptoms Score	HblA	HblS	Output of FIS	Doctors Diagnosis
1	60/M	70	15	A	30	Subclinical
2	38/F	85	13	P	60	Primary
3	29/F	20	14	A	15	No Sickle cell
4	15/M	60	10	P	78	Secondary
5	20/F	40	12	A	35	Subclinical
6	13/F	90	10	P	85	Secondary
7	32/M	20	14	A	20	No Sickle cell
8	24/F	50	12	A	30	Subclinical
9	36/M	25	13	P	77	Secondary
10	10/M	30	15	P	55	Primary

Table No: II Diagnosis of Patient done by FIS & Doctors

VII. CONCLUSION

Nowadays Fuzzy Expert System used appreciably in the medical diagnosis for quantitative analysis and qualitative assessment of medical data. Fuzzy Expert System for sickle cell anemia diagnosis is designed with membership function of input and output variable and knowledge base system. Designed FES system has been tested with expert doctor and resultant diagnosis of disease by FIS is all most same as by an expert doctor .this is one of the more efficient, simple and easy to understand method for diagnosis the sickle cell disease. This system is designed in way that a patient can easily use it himself. So the proposed Fuzzy Expert System proves to be an effective and helpful diagnostic tool for the users and patients.

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