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Fuzzy Logic Based Diagnosis for Liver Disease using CBC (Complete Blood Counts)

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ABSTRACT

In this paper we present a fuzzy expert system for the diagnosis of liver disease using complete blood counts. The developed system consists of four inputs variables (leukocytes, haematocrit, haemoglobin and blood platelets) and three output variable (infection fight, anemia and thrombocytopenia). The system uses mamdani inference engine and is developed using MATLAB software. The developed liver disease diagnosis system is faster, cheaper, and reliable and it can prove to be very useful in comparison with other traditional diagnostic system.

Keywords: anaemia, haematocrit, leukocytes, liver and thrombocytopenia.

1. INTRODUCTION

Liver is one of the largest organs of or body and is very important because of its functions like food processing, metabolizing nutrients, detoxification center and making bile. Liver disease can be due to long term consumption of alcohol or infective viruses like Hepatitis virus A,B and C. The liver disease may be of short duration called acute liver disease or long term called chronic liver disease. This long term liver disease leads to scarring of liver and this disorder is known as cirrhosis. Liver disease is of two main types' namely alcoholic liver disease and non-alcoholic fatty liver disease. The symptoms of liver disease may vary based on the type of liver disease. Some of the common symptoms are loss of appetite, fatigue, general malaise, nausea, vomiting and weight loss.

For the diagnosis of liver disease three main types of test are performed namely laboratory tests, radiological studies and biopsies. Under laboratory examination, blood tests like complete blood count (CBC) test and Ascitic fluid test is performed. Ultrasonogram, CT scan, magnetic resonance imaging (MRI), ERCP (Endoscopic retrograde cholangiopancreatography) is performed under radiology studies.

In this paper complete blood count is used for the diagnosis of liver disease. In CBC the total blood counts of White blood cells, red blood cells and platelets are tested. These values are given as inputs to the fuzzy exert system for the diagnosis of liver disease.

2. RELATED WORK

M. S. Ali, Prof. S. L. Satarkar (2013) presented a fuzzy expert system for the pathological investigation of jaundice. This consists of eight inputs and one output variable. Rajamani.R, Rathika.M (2015) proposed a system for the analysis of liver cancer using Adaptive Neuro Fuzzy Inference System (ANFIS). Anu Sebastian and Surekha Mariam Varghese (2016) developed fuzzy logic for child-pugh classification of patients with cirrhosis of liver. Somdatta Patra and GourSundarMitra Thakur (2013) proposed Neuro-fuzzy model for adult asthma disease diagnosis. Sonu Malu, B. L. Pal and Shiv Kumar (2015) developed an expert system for the detection of anemia. Katebi, Mohebeh Sadat, et al. (2014) used fuzzy logic for the prevention and diagnosis of blood disease. M.Neshat, M.Yaghobi, M.B. Naghibi, A. Esmaclzadeh (2008) designed a fuzzy expert system for the diagnosis of liver disorders. M.A. Kadhim, M.A. Alam, Harleen Kaur (2011) designed amd implemented a fuzzy system for the diagnosis of back pain disease. Ali. Adeli, Mehdi Neshat (2010) proposed a fuzzy expert system for the diagnosis of heart disease. Bayadaa Bhnam (2010) designed a fuzzy expert system for the liver and pancreas disease.

3.1 System Design

The first step in designing the fuzzy expert system for liver diagnosis is the determination of input and output variables. Liver diagnosis system shown in figure1 consists of four input variables namely leukocytes, haematocrit, haemoglobin and blood platelets and three output variables namely infection fight, anemia and thrombocytopenia. In the second step the membership functions of all the variables are designed.

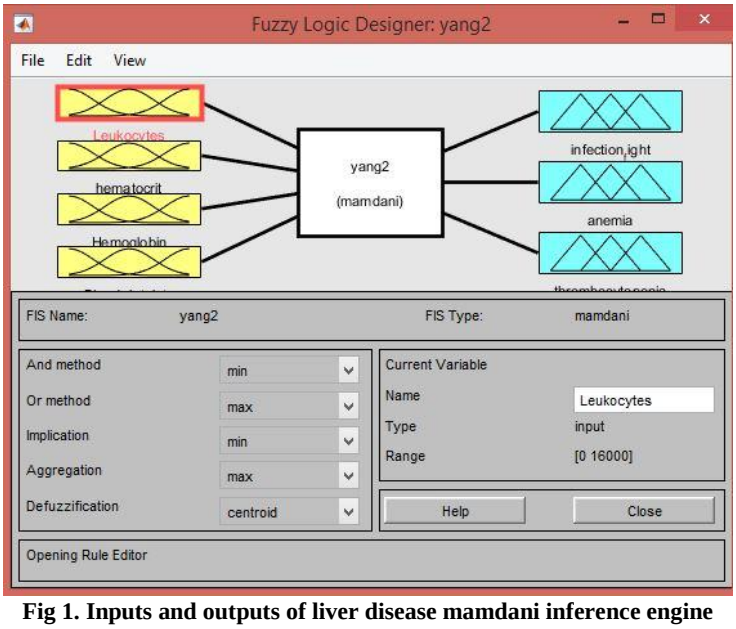

Fig 1. Inputs and outputs of liver disease mamdani inference engine

3.1.1 Input Variables

A. Leukocytes

Leukocytes are also known as white blood cells which belong to the immune system. These leukocytes prevent us from communicable diseases. This input variable has five fuzzy sets very low, low, medium, high and very high. Membership function of these fuzzy sets is triangular. Fuzzy set range of leukocytes is shown in table 1and the membership functions for the fuzzy sets are given in fig 2.

Table 1. Fuzzy set range of leukocytes

Input Field	Range value	Fuzzy set
Leukocytes	0-4000	Very low
	0-8000	Low
	4000-12000	Medium
	8000-16000	High
	12000-16000	Very high

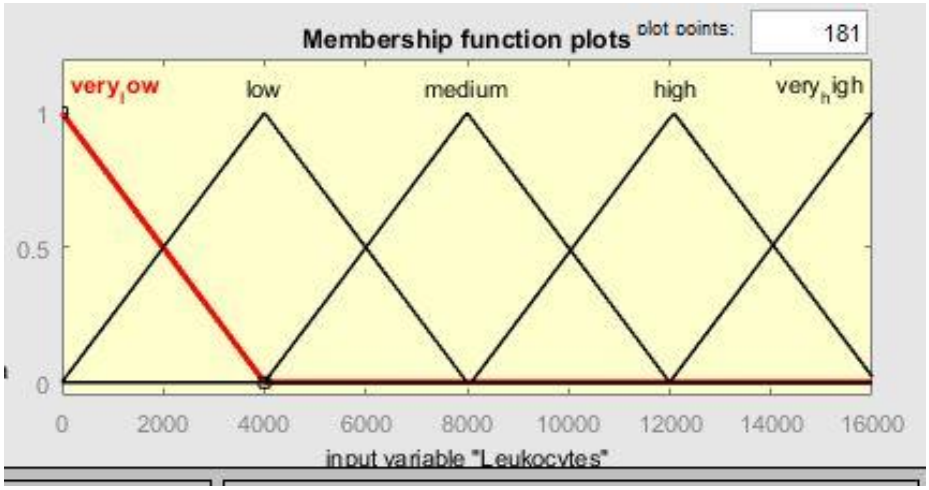

Fig 2. Membership functions of input variable –leukocytes

B. Hematocrit

Hematocrit indicates the percentage of red blood cells in our body. Very low percentage of red blood cells causes anemia. This input variable has seven fuzzy sets very low, low, below medium, medium, above medium, high and very high. Membership function of these fuzzy sets is triangular. Fuzzy set range of haematocrit is shown in table 2 and the membership functions for the fuzzy sets are given in fig 3.

Table 2. Fuzzy set range of haematocrit

Input Field	Range value	Fuzzy set
Hematocrit	30-35	Very low
	30-40	Low
	35-45	Below medium
	40-50	Medium
	45-55	Above medium
	50-60	High
	55-60	Very high

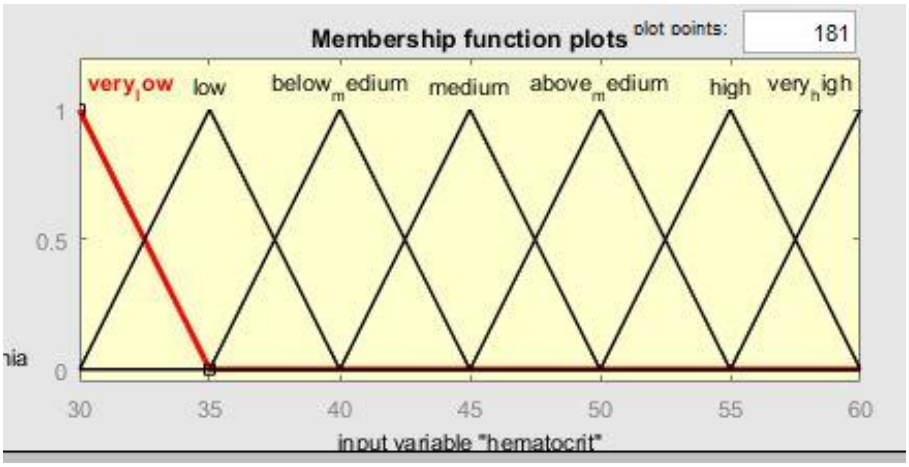

Fig 3. Membership functions of input variable –hematocrit

C. Hemoglobin

Hemoglobin is a protein in red blood cells which carries oxygen and carbon dioxide from and to the lungs. This input variable has six fuzzy sets very low, low, below medium, medium, above medium and high. Membership function of these fuzzy sets is triangular. Fuzzy set range of hemoglobin is shown in table 3and the membership functions for the fuzzy sets are given in fig 4.

Table3. Fuzzy set range of hemoglobin

Input Field	Range value	Fuzzy set
Hemoglobin	5-8	Very low
	5-11	Low
	8-13	Below medium
	11-16	Medium
	13-18	Above medium
	16-18	High

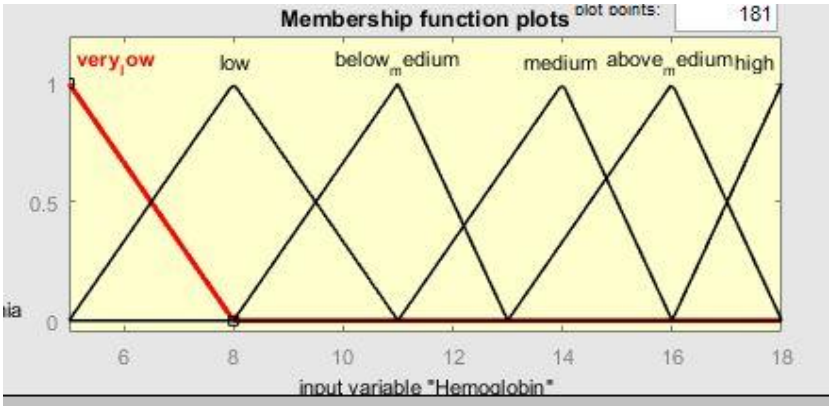

Fig 4. Membership functions of input variable –hemoglobin

D. Blood platelets

Blood platelet is a constituent of blood also called thrombocytes. When any injury happen these blood platelets join together and form clots which stops the blood flow. Thrombocytopenia is caused due to low platelet count. This input variable has five fuzzy sets very low, low, medium, above medium and high. Membership function of these fuzzy sets is triangular. Fuzzy set range of blood platelets is shown in table 4 and the membership functions for the fuzzy sets are given in fig 5.

Table 4. Fuzzy set range of blood platelets

Input Field	Range value	Fuzzy set
Blood platelets	50-150	Very low
	50-250	Low
	150-350	Medium
	250-450	Above medium
	350-450	High

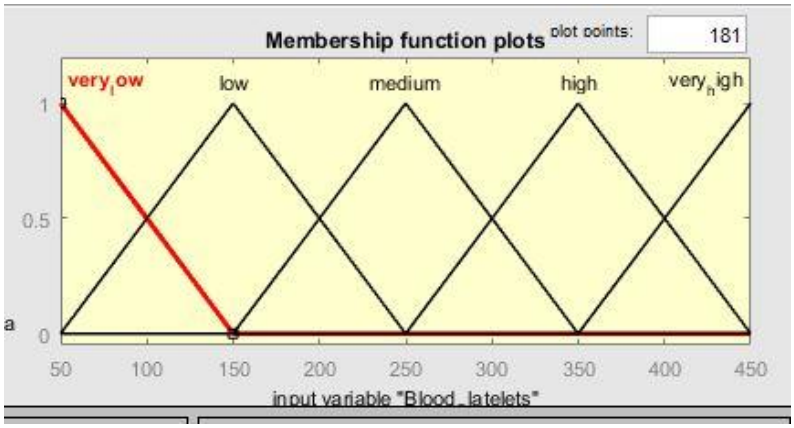

Fig 5. Membership functions of input variable blood platelets

Fuzzification of blood platelets is done by the below function

$$\mu_{verylow} = \begin{cases} \dfrac{x-50}{100-50}, 50 \le x \le 100 \\ 1, \quad x = 100 \\ \dfrac{150-x}{150-100}, 100 \le x \le 150 \end{cases}$$

$$\mu_{low} = \begin{cases} \dfrac{x-50}{150-50}, 50 \le x \le 150 \\ 1, \quad x = 150 \\ \dfrac{250-x}{250-150}, 150 \le x \le 250 \end{cases}$$

$$\mu_{medium} = \begin{cases} \dfrac{x-150}{250-150}, 150 \le x \le 250 \\ 1, \quad x = 250 \\ \dfrac{350-x}{350-250}, 250 \le x \le 350 \end{cases}$$

$$\mu_{abovemedium} = \begin{cases} \dfrac{x-250}{350-250}, 250 \le x \le 350 \\ 1, \quad x = 350 \\ \dfrac{350-x}{350-250}, 350 \le x \le 450 \end{cases}$$

$$\mu_{high} = \begin{cases} \dfrac{x-350}{400-350}, 350 \le x \le 400 \\ 1, \quad x = 400 \\ \dfrac{450-x}{450-400}, 400 \le x \le 450 \end{cases}$$

3.1.2 Output Variables

Infection Fight is one of the output variables and the membership functions for the fuzzy sets are given in fig 6.

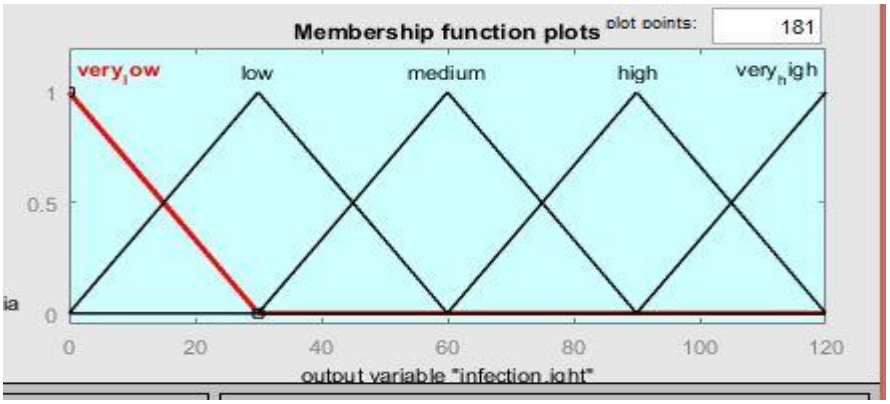

Fig 6. Membership functions of output variable-infection fight

The rule base is determined by an expert in the field of liver disease. Few rules are given below

1. If (Leukocytes is very_low) and (hematocrit is very_low) and (Hemoglobin is very_low) and (Blood_Platelets is very_low) then (infection_fight is very_low)(anemia is very_high) (thrombocytopenia is very_high)
2. If (Leukocytes is high) and (hematocrit is very_low) and (Hemoglobin is low) and (Blood_Platelets is medium) then (infection_fight is high)(anemia is very_high) (thrombocytopenia is medium)
3. If (Leukocytes is very_low) and (hematocrit is medium) and (Hemoglobin is medium) and (Blood_Platelets is very_low) then (infection_fight is very_low)(anemia is medium) (thrombocytopenia is very_high)
4. If (Leukocytes is high) and (hematocrit is high) and (Hemoglobin is high) and (Blood_Platelets is high) then (infection_fight is high) (anemia is very _low) (thrombocytopenia is low)

The result of tested values is given by rule viewer in fig7 and surface viewer in fig 8.

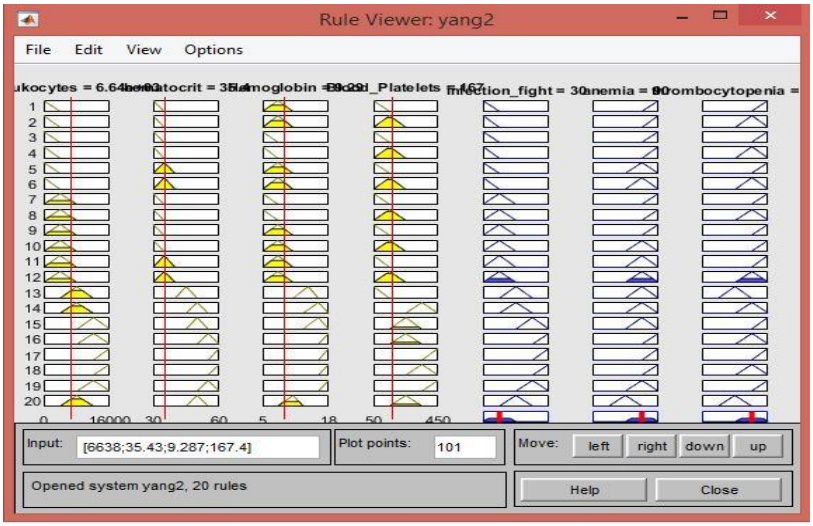

Fig 7. Rule viewer

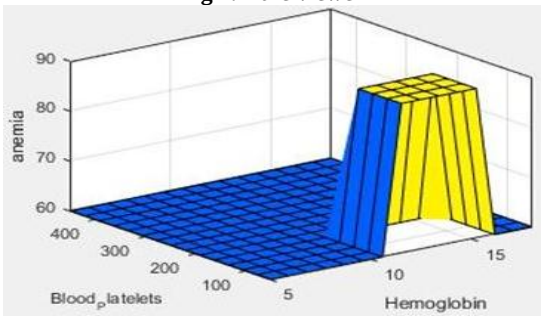

Fig 8. Surface viewer

4. CONCLUSION

The proposed system describes the design of fuzzy logic for the diagnosis of liver disease using complete blood counts as inputs. This system can be used by the physicians for the easy diagnosis of liver disease.

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