Research Article Impact Factor: 0.621 ISSN: 2319-507X
MS Ali, IJPRET, 2014; Volume 2 (9): 122-132 IJPRET

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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# FUZZY EXPERT SYSTEM FOR THE DIAGNOSIS OF HEPATIC TUBERCULOSIS

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**Accepted Date: 27/02/2014 ; Published Date: 01/05/2014**

**Abstract:** Hepatic tuberculosis is a clinical form of tuberculosis infection. Hepatic tuberculosis is defined as Mycobacterium infections in the liver. The definite diagnosis of the hepatic tuberculosis is difficult due to nonspecific symptoms and signs and involves determination of histopathology. Once confirmed, the disease is usually associated with good prognosis. This paper aims at developing fuzzy expert system for the diagnosis hepatic tuberculosis based on the pathological investigations. The investigation of hepatic tuberculosis involves uncertainty and imprecision, hence fuzzy logic is the most suitable tool for the development of this expert system. The developed expert system has five input variables and one output variable. Input variables are AFB, ALP, GGT,MASS and TEMP. The output variable RISK refers to the risk of hepatic tuberculosis in patient. The system is designed in the MATLAB software and uses MAMDANI method for the interface mechanism. The fuzzification method used is MAX-MIN and CENTROID method is used for defuzzification. The obtained results are within the limits set by the domain expert. The designed system can be viewed as an alternative to the existing methods to diagnose hepatic tuberculosis.

**Keywords:** Fuzzy Logic, Pathological Investigation, Hepatic Tuberculosis, Expert System

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**Access Online On:**

www.ijpret.com

**How to Cite This Article:**

MS Ali, IJPRET, 2014; Volume 2 (9): 122-132

*PAPER-QR CODE*

## INTRODUCTION

Liver is the largest organ in the human body. Liver helps to digest food, store energy and removes toxins. There are many kinds of liver diseases. Cases of liver diseases are continuously increasing due to various reasons such as consumption of alcohol, Pollution, excessive intake of drugs and contamination of food and water.[3, 8, 10]

Hepatic tuberculosis is one of the serious disease of the liver and may involve liver damage. The symptoms of hepatic tuberculosis include fever, Hepatomegaly, night sweats, weight loss, malaise, anorexia and abdominal pain.[1, 6]

Laboratory parameters and imaging methods in the local form of hepatic tuberculosis are frequently abnormal. Definitive diagnosis can be very difficult and mostly relies in the histological and bacteriological investigations. Hepatic tuberculosis is very rare but is very serious and requires early diagnosis and treatment.

In this research fuzzy expert system for the diagnosis of hepatic tuberculosis is designed as it can prove to be more fast, accurate and reliable as compared to the traditional diagnosis method. This paper is organized as follows.

- Design of the system is presented in Section 2
- Input variables are presented in section 2.1
- Output variable is presented in section 2.2
- Fuzzy rule base is presented in section 2.3
- Fuzzification and defuzzification is presented in section 2.4
- Result and discussions in section 3.
- Conclusion in section 4.

## 2. Design of the System

### 2.1 Input Varaibles

#### a) ALP

ALP stands for “Alkaline phosphatase” , Alkaline phosphatase test (ALP) is used to detect liver disease. Raised ALP levels means liver has been damaged due to hepatitis , Blocked bile ducts, liver cancer or due to liver tuberculosis.[2, 5]

This input variables has three fuzzy sets “Low”, ”Normal” and “High”. Membership functions of them are trapezoidal and triangular. Fuzzy ranges of Alkaline Phosphatase are shown in Table 1 and membership functions for fuzzy sets are shown in figure 1. The fuzzification of this variable is done by the following membership functions.

$$\mu Low(x)=\begin{cases}0 & x<30\\ \frac{30-x}{10} & 20\le x\le 30\\ 1 & x\le 20\end{cases} \qquad \mu High(x)=\begin{cases}0 & x<70\\ \frac{x-70}{15} & 70\le x\le 85\\ 1 & x>85\end{cases}$$

$$\mu Normal(x)=\begin{cases}0 & x\le 25\\ \frac{x-25}{30} & 25< x\le 55\\ 1 & x=55\\ \frac{85-x}{30} & 55<x<85\\ 0 & x\ge 85\end{cases}$$

| Input Field | Range | Fuzzy set |
|---|---|---|
| ALP | < 25 | Low |
| | 25-85 | Normal |
| | >=85 | High |

**Table 1:** Fuzzy set ranges of Alkaline Phosphatase.

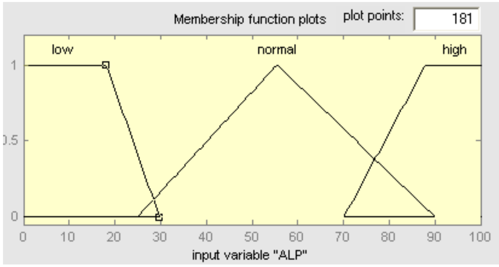



**Figure 1:** MF of Alkaline Phosphatase.

**b) GGT**

Stands for Gamma-glutamyltransferese. Gamma-glutamyltransferese is an enzyme which is found in the liver. GGT is predominantly used as a diagnostic marker for liver disease. Elevated serum GGT means presence of diseases of liver, biliary system or pancreas.[11]

This input variables has three fuzzy sets "low" ,"Normal" and "high". Membership functions of them are trapezoidal and triangular. Fuzzy ranges of GGT are shown in Table 2 and membership functions for fuzzy sets are shown in figure 2. The fuzzification of this variable is done by the following membership functions.

$$\mu Low(x)=\begin{cases}0 & x>10\\ \frac{10-x}{6} & 4\le x\le 10\\ 1 & x\le 10\end{cases} \qquad \mu High(x)=\begin{cases}0 & x<50\\ \frac{x-50}{10} & 50<x\le 60\\ 1 & x>60\end{cases}$$

$$\mu Normal(x) = \begin{cases} 0 & x \le 4 \\ \frac{x-4}{24} & 4 < x \le 28 \\ 1 & x = 28 \\ \frac{60-x}{32} & 28 < x < 60 \\ 0 & x \ge 60 \end{cases}$$

| Input Field | Range | Fuzzy set |
|---|---|---|
| GGT | < 4 | Low |
| | 4-60 | Normal |
| | >=60 | High |

**Table 2:** Fuzzy set ranges of GGT.

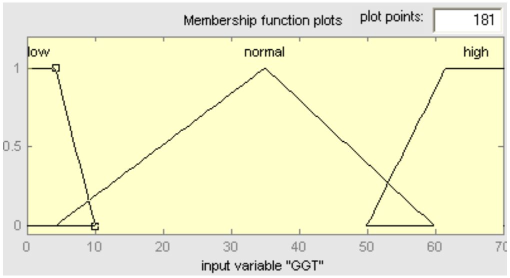



**Figure 2:** Membership functions of GGT.

**c) MASS**

An abnormal mass that is located in the liver. The possible causes of the presence of mass in the liver could be hepatocellular carcinoma, liver abscess, cyst, hepatic tuberculosis or hydated disease [9]. This input variable has only two values “0” and “1” and one fuzzy set (true). If the mass is detected in the liver value “1” will be entered else value” 0 “will be entered. The membership function of this variable is shown in the figure 3.

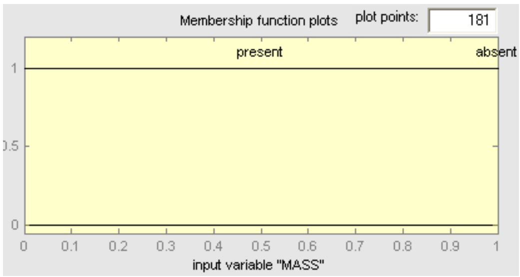



**Figure 3:** Membership functions of MASS.

**d) AFB**

This test is done to detect bacteria called acid – fast bacilli in fluid or tissue samples. This test is the most significant in the diagnosis of Tuberculosis.[12, 14]

This input variables has four fuzzy sets "Negative", "Scanty", "Grade1" and "Grade2". Membership functions of them are trapezoidal and triangular. Fuzzy ranges of AFB are shown in Table 3 and membership functions for fuzzy sets are shown in figure 4. The fuzzification of this variable is done by the following membership functions.

$$\mu Negative(x)=\begin{cases}0 & x>5\\ \frac{5-x}{4} & 1\le x\le 5\\ 1 & x<1\end{cases}$$

$$\mu Scanty(x)=\begin{cases}0 & x\le 1\\ \frac{x-1}{4} & 1<x\le 5\\ 1 & x=5\\ \frac{10-x}{5} & 5<x<10\\ 0 & x\ge 10\end{cases}$$

$$\mu Grade1(x)=\begin{cases}0 & x\le 9\\ \frac{x-9}{36} & 9<x\le 45\\ 1 & x=45\\ \frac{90-x}{45} & 45<x<90\\ 0 & x\ge 99\end{cases} \quad \mu Grade2(x)=\begin{cases}0 & x<90\\ \frac{x-90}{10} & 90\le x\le 100\\ 1 & x>100\end{cases}$$

| Input Field | Range | Fuzzy set |
|---|---|---|
| AFB | < 1 AFB/100hpf | Negative |
| | 1-9AFB/100hpf | Scanty |
| | 9-99AFB/100hpf | Grade1 |
| | >= 100AFB/100hpf | Grade2 |

**Table 3:** Fuzzy sets range of AFB.

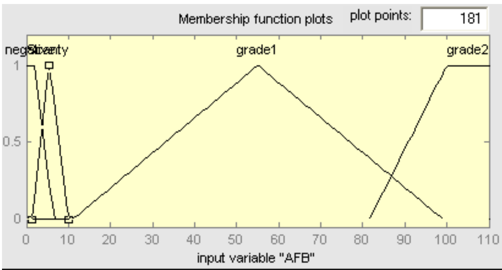



**Figure 4:** Membership functions of AFB.

**e) TEMP**

Stands for temperature. Rise in body temperature is one of the main symptom of hepatic tuberculosis and can prove useful in the diagnosis of the hepatic tuberculosis [4]. This input variable has four fuzzy sets" Low", "Moderate", "High" and "Very High". Membership functions of them are triangular. Fuzzy sets range of TEMP are identified in table 5 and membership functions for fuzzy sets are identified in Figure 5.

$$\mu Low(x)=\begin{cases}0 & x\le 10\\ \frac{x-10}{10} & 10\le x\le 20\\ 1 & x=20\\ \frac{30-x}{10} & 20<x\le 30\\ 0 & x\le 30\end{cases}$$

$$\mu Modrate(x)=\begin{cases}0 & x\le 30\\ \frac{x-30}{15} & 30<x\le 45\\ 1 & x=45\\ \frac{60-x}{15} & 45\le x\le 60\\ 0 & x\ge 60\end{cases}$$

$$\mu High(x)=\begin{cases}0 & x\le 60\\ \frac{x-60}{10} & 60<x\le 70\\ 1 & x=70\\ \frac{80-x}{10} & 70\le x\le 80\\ 0 & x\ge 80\end{cases}$$

$$\mu VeryHigh(x)=\begin{cases}0 & x\le 0\\ \frac{x-80}{10} & 80\le x\le 90\\ 1 & x=90\\ \frac{100-x}{10} & 90\le x\le 100\\ 0 & x\ge 100\end{cases}$$

| Input Field | Range | Fuzzy set |
|---|---|---|
| TEMP | 10 - 30 | Low |
| | 30 - 60 | Moderate |
| | 60 - 80 | High |
| | 80 - 100 | Very High |

**Table 5:** Fuzzy sets range of TEMP.

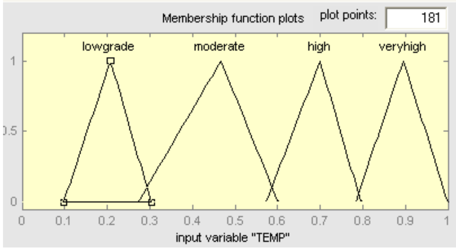



**Figure 5:** Membership functions for TEMP

### 2.2 Output variable

The aim of the system is to diagnose the hepatic tuberculosis. The output variables "Risk " is a value from 1 to 4 , representing No risk, Low risk and High risk. The output has three fuzzy sets No risk, Low risk and High risk. The fuzzy sets range of output variable is shown in the Table 6. The membership functions of these fuzzy sets are triangular and are shown in Figure 6.

| Output variable | Range | Fuzzy set |
|---|---|---|
| Risk status | 0 - 2 | No risk |
| | 1 - 3 | Low risk |
| | 2 - 4 | High risk |

**Table 6:** Range of Output variable Risk status.

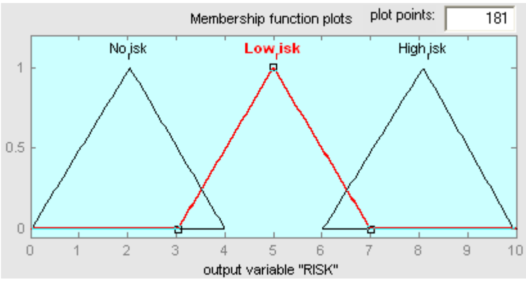



**Figure 6:** The membership functions of "Risk"

### 2.3 Fuzzy Rule Base

The Rule base for this system is determined with the help of the pathologist of GMC, Akola. The rule base consists of 24 well-defined rules that determine the risk of hepatic Tuberculosis. The rule base is shown in the Table 7.

| Rule | AFB | GGT | MASS | ALP | TEMP | RISK |
|---|---|---|---|---|---|---|
| 1 | Negative | N | A | N | Low | No Risk |
| 2 | Negative | N | A | N | M | No Risk |
| 3 | Negative | N | A | N | High | No Risk |
| 4 | Negative | N | A | N | Very High | No Risk |
| 5 | Negative | H | P | H | Low | NO Risk |
| 6 | Negative | H | P | H | M | NO Risk |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | Negative | H | P | H | High | NO Risk |
| 8 | Negative | H | P | H | Very High | NO Risk |
| 9 | Scanty | N | P | N | Low | Low Risk |
| 10 | Scanty | N | P | N | M | Low Risk |
| 11 | Scanty | N | P | N | H | Low Risk |
| 12 | Scanty | N | P | N | Very High | Low Risk |
| 13 | Scanty | H | P | H | Low | Low Risk |
| 14 | Scanty | H | P | H | M | Low Risk |
| 15 | Scanty | H | P | H | H | Low Risk |
| 16 | Scanty | H | P | H | Very High | Low Risk |
| 17 | Grade1 | H | P | H | Low | High Risk |
| 18 | Grade1 | H | P | H | M | High Risk |
| 19 | Grade1 | H | P | H | H | High Risk |
| 20 | Grade1 | H | P | H | Very High | High Risk |
| 21 | Grade2 | H | P | H | Low | High Risk |
| 22 | Grade2 | H | P | H | M | High Risk |
| 23 | Grade2 | High | Present | High | High | High Risk |
| 24 | Grade2 | High | Present | High | Very High | High Risk |

N-Normal, H-High, M-Moderate, P-Present, A-Absent

Table 7: Fuzzy Rule Base of the System

**2.4: Fuzzification and Defuzzifaction.**

The system is designed using MATLAB and uses Mamdani model for Interface mechanism. This system contains only "AND" operator hence the method is minimum. Implication method is minimum. Aggregation method between the rules is maximum to combine the output fuzzy set, so fuzzification method here is MAX-MIN and defuzzifaction method is CENTROID.

**3 Results and Discussion**

Fuzzy expert system for the diagnosis of hepatic tuberculosis has been developed. The developed system is used to evaluate the study of twenty patients. It is found that the results obtained are in the predefined limits set by the domain expert. Table 8 and figure 8 show the tested value and figure 10,11,12 and 13 shows surface viewer of some fields.

| AFB | GGT | MASS | ALP | TEMP | RISK |
|---|---|---|---|---|---|
| 5 | 60.3 | 1 | 91.8 | 0.213 | 3.95 |

**TABLE 8:** Tested Values

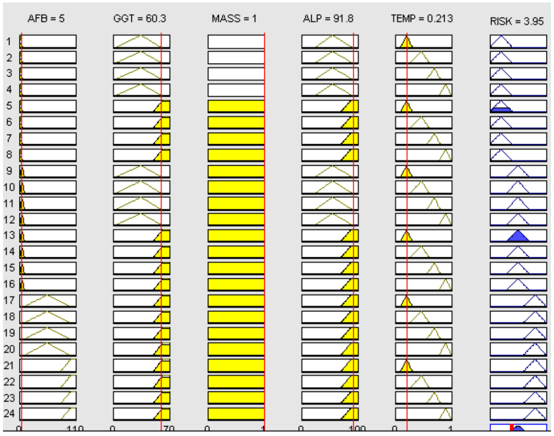
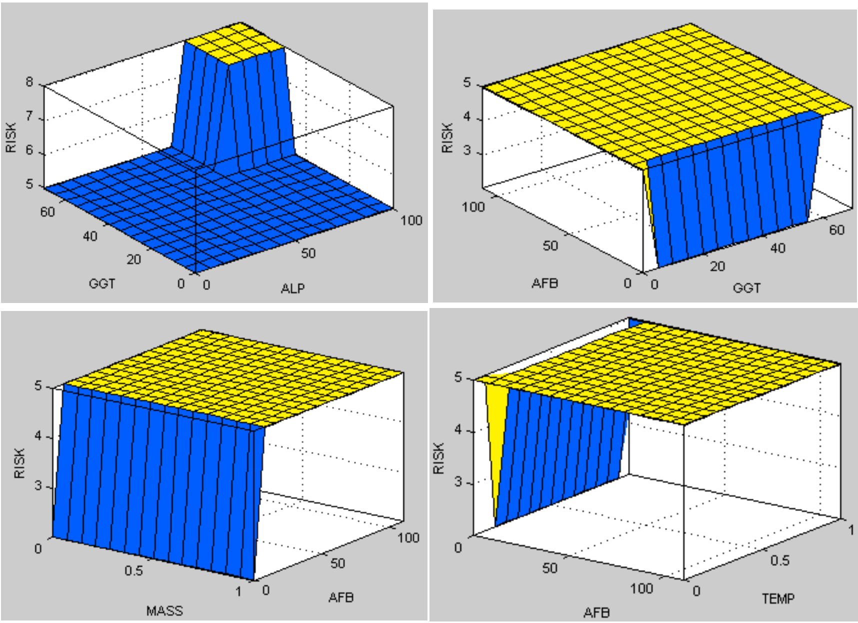



**Figure 8:** Result of the tested values.




## 4. Conclusion and Future work:

This paper describes design of fuzzy expert system for the diagnosis of the hepatic tuberculosis which can be used by the specialized doctors for further treatment.

The system design is based on membership functions, input variables, output variable and rule base. The use of fuzzy logic in the design of the system enhances the reasoning in dealing with the uncertain data and is efficient as compared to the traditional system. Combination of fuzzy and expert system increases the performance of the system. In future with proper modifications this system can be applied for the diagnosis other types of diseases.

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