# Fuzzy Expert System Design for Diagnosis of liver disorders

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## Abstract

*In spite of all the standardization methods in medical diagnosis, a correct diagnosis is still considered to be an art .much of this situation is for, that medical diagnosis needs proficiency as well as experience in dealing with uncertainty. Although, in our mechanized age, boundaries of medical science have extremely expanded, you can not overcome this uncertainty easily. Offering a powerful framework to construct the model of existing systems causes fuzzy theory to change to a valuable factor towards medical diagnosis improvement. In this research, a fuzzy system has been designed for learning, analysis and diagnosis of liver disorders. Required data has been chosen from trusty data base (UCI) that has 345 records and 6 fields as the entrance parameters and rate of liver disorder risks is used as the system resulting. This system in comparison with other traditional diagnostic systems is faster, cheaper, and also more liable and more accurate. One can uses this system as a specialist assistant or for training medicine students. Also, on time diagnosis of disease and appointing the rate of liver disorders improvement has been experienced and its Verification 91%.*

## 1. Introduction

Medical diagnosis is the art of determining a person's pathological status from an available set of findings. Why is it an art? Because it is a problem complicated by many and manifold factors, and its solution involves literally all of a human's abilities including intuition and the subconscious. If it is an art, is it at all susceptible to information processing? Although it appears to be among the most demanding problems ever to be approached by the information processing community, there is strong evidence that it is. It does, however, require an integration of results from most of the many sub disciplines of information processing and, especially, AI. [1]

The functioning of the human body is characterized by the complex and highly interactive interplay of its organs and the psyche. The goal of this concerted effort is homeostasis, the equilibrium of all physiological quantities. While the actual level at which the balance is maintained varies - within physiological bounds - from individual to individual, deviations from it are indicative of some kind of perturbation, be it of internal or of external cause. The identification of these perturbations is the goal of medical diagnosis. With the diagnostic means available today it is often impossible to look inside a sick patient and determine the primary cause that led to the (series of) effects and reactions the patient complains about. More often than not, diagnosis is therefore based on indirect evidence, the presence of symptoms, and the knowledge of the medical mechanisms that relate presumed causes to observed effects. The problems of diagnosis do not only arise from the incompleteness of this knowledge, but also and most immediately from the theoretical and practical limitations associated with the reversal of the chain of implications that lead from an initial cause to its observable effects.[2]

But research on data base (BUPA) liver disorders to table1. [3][4][5][6][7][8][9][10]

## 2. Outline of system structure

This system is compound of an expert and a fuzzy system and they are known as hybrid systems (fuzzy expert). This system consists of expert individual, knowledge engineer and fuzzy System. Fuzzy system itself consists of four/4 parts (fuzzy rule base, fuzzy inference engine, Fuzzification, and defuzzification).

Fuzzy systems are used especially in medicine and could have helped specialists so much and they are applied as an assistant for improvement of medical diagnosis.

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**table1: research on liver disorders**

| Author | year | Method | accuracy |
|---|---|---|---|
| Pham et al | 2000 | Rules-4 | 55.90 |
| Cheung | 2001 | C4.5(5*CV) | 65.59 |
| Cheung | 2001 | Naïve Bayes | 63.39 |
| Cheung | 2001 | BNND(5*CV) | 61.83 |
| Cheung | 2001 | BNNF(5*CV) | 61.42 |
| Van Gestel | 2002 | Svm with GP | 69.70 |
| Lee and Man | 2001 | SSVM | 70.33 |
| Lee and Man | 2001 | RSVM | 74.86 |
| Yalcin and Yild | 2003 | MLP(3*CV) | 73.05 |
| Yalcin and Yild | 2003 | PNN(3*CV) | 42.03 |
| Yalcin and Yild | 2003 | GRNN(3*CV) | 65.55 |
| Yalcin and Yild | 2003 | RBF(3*CV) | 58.55 |
| Polat | 2005 | AIRS | 81 |
| Polat | 2007 | FW-AIRS | 83.38 |

Different expert systems have been designed for disease, such as liver disorders diagnosis, blood disease diagnosis, analysis treatment, training anesthetic management etc.

In the works that have done, always, liver disorders have been divided into two parts of people with healthy liver and unhealthy people and no report based on patient calibration has been seen, however, always each person has a grade of health and a grade of illness. In this research for calibration of disease risk intensity measure, the tool (FIS) in (MATLAB) software is used and in FIG.1 you can see the outline of system model:

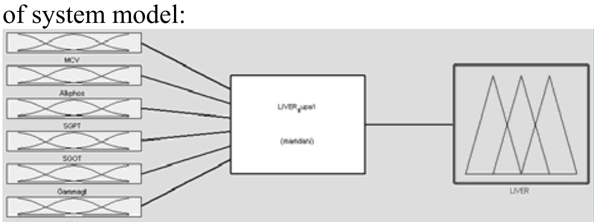


**Fig 1: outline model of liver disorders fuzzy expert system**

## 2.1. Expert individual

Using of expert individual knowledge is the basis of designing expert systems, (Liver specialist) that is experienced and skilled in an especial field and in a word is an expert. Therefore an expert individual has special knowledge that is unknown or unavailable for others. Expert individual solve problems that are unsolved for others or he/she offers most efficient solution for that case (diagnosis of liver disorders). In this research discussed with a consultant (post graduated degree in liver disorders) and his experiences is applied for collecting the fuzzy rules bank and for making the relationship between the disease fields and disease diagnosis. Also, we were given a helping hand in system accurate function.

## 3 Data

All the data used in this project, have the goal of enhancing the ability of liver disorders diagnosis according to their qualities, collected by Richard s.forsyth and presented to the site UCI in 1995. Samples in this collection are 345 and each sample consists of 7 qualities that you will see below: In this bank the first 5 fields related to changeable Substances of blood test of a male, the 6th field is the measure of alcohol drinking and the 7th field is using for determining the healthy or ill individual.

Attribute information:

1. Mcv means corpuscular volume Alkphos
2. Alkaline phosphates
3. Sgpt alamine aminotransferase
4. Sgot aspartate aminotransferase
5. Gammagt gamma-glut amyl Tran peptidase
6. Drinks number of half-pint equivalents of alcoholic beverages Drunk per day
7. Selector field used to split data into two sets

Data are continuous and there is no Missing or destroyed data.

## 4. Fuzzification

Fuzzifier has defined as an assumption of a point $X^* \in U \subset R^n$ to a fuzzy subset $A'$ in U. The most important scale in a fuzzifier is that this fact should be considered which entry in $X^*$ is certain.

It means that fuzzy subset of $A'$ must have much amount of dependency, also if the entry of fuzzy system destroyed by noise, fuzzifier must be able to reduce or stop the noise effect and finally fuzzifier must play a part on simplifying the calculations related to fuzzy inference engine. Most complicated of calculations of fuzzy inference engine is related to calculate on $\underset{x \in u}{SUP}$. Designing and using of triangular or trapezoidal fuzzifier simplifies preparation of inference engine and in according to the nature of data (liver disease), these fuzzifiers are used preferably.

According to the normal amounts of disease fields in table.2 membership functions of fields_classification seen below has done by an expert. [11]

MCV (S, M, B)
GAM, SGOT, SGPT, ALP (L, M, H)
DRINK (L, M, H)
L_D (L, N, H)

**table.2: amounts normal range of liver disorders**

| fields | Domain normal |
|---|---|
| MCV | 80-96fl |
| Alkphos | 20-130IU/L |
| Sgpt | 4-36 IU/L |
| Sgot | 8-33 IU/L |
| Gammgt | 5-40 IU/L |
| Drink | 0.2-1 L |

Membership functions of diseases fields have been created by a specialist. For example membership function (MCV), is shown in fig.3.

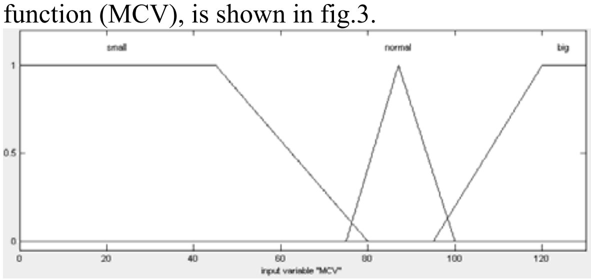


**Fig2. Membership function MCV**

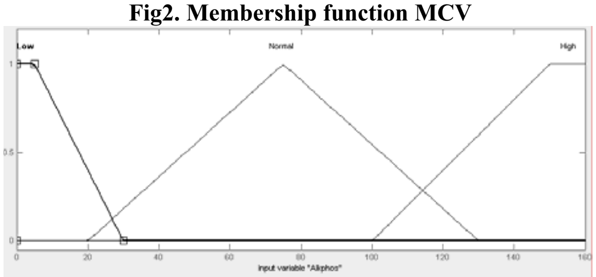


**Fig3. Membership function Alkphos**

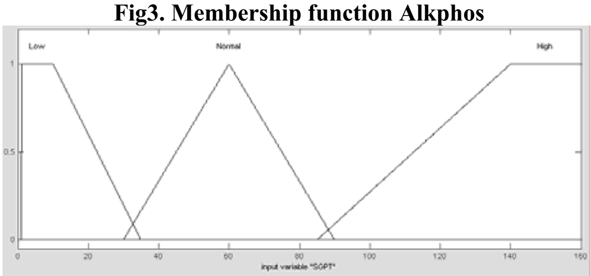


**Fig4. Membership function SGPT**

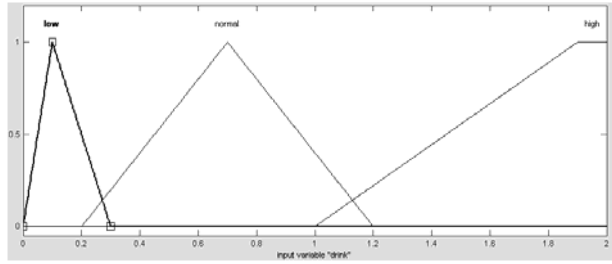


**Fig5. Membership function DRINK**

System output that show the intensity of disease, defined in tow ***low*** and ***high*** range (fig.6)

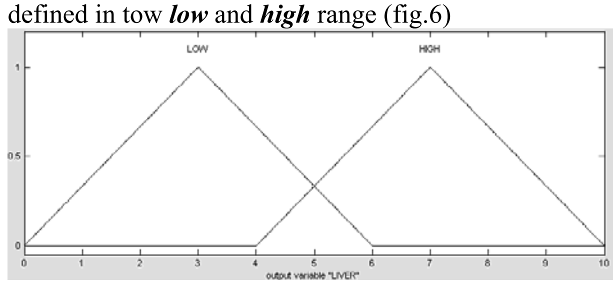


**Fig.6: function of triangular membership of output system**

Fuzzification of applied fields is done by below functions. They have been created by a specialist.

$$MCV(\alpha) = \begin{cases} 0 & \alpha < 20 \\ \alpha & 20 \le \alpha \le 130 \\ 1 & \alpha > 130 \end{cases} \qquad (1$$

$$ALP(\beta) = \begin{cases} 0 & \beta < 10 \\ \beta & 10 \le \beta \le 130 \\ 1 & 130 < \beta \le 500 \\ 0 & \beta > 500 \end{cases} \qquad (2$$

$$SGOT(\lambda) = \begin{cases} 0 & \lambda < 1 \\ \lambda & 1 \le \lambda \le 80 \\ 1 & \lambda > 80 \end{cases} \qquad (3$$

$$L\_D(\delta) = \begin{cases} 0 & \delta < 0 \\ \delta & 0 \le \delta \le 10 \\ 0 & \delta > 10 \end{cases} \qquad (4$$

Phrases of the fields according to the formula of triangular membership functions are defined below.

Variants of liver disorders intensity (L_D) are ***low*** and ***high.*** Variants of (MCV) consist of ***small***, ***medium*** and ***large***. Also variants of (SGOT) are ***low***, ***normal*** and ***high***.

$$\mu_{low}(A)=\begin{cases}0 & \alpha\le 0\\ \frac{\alpha}{3} & 0<\alpha\le 3\\ \frac{6-\alpha}{3} & 3<\alpha<6\\ 0 & \alpha\ge 6\end{cases} \quad (5$$

$$\mu_{High}(A)=\begin{cases}0 & \alpha\le 4\\ \frac{\alpha-4}{3} & 4<\alpha\le 7\\ \frac{10-\alpha}{3} & 7<\alpha<10\\ 0 & \alpha\ge 10\end{cases} \quad (6$$

For expression of this dependency functions can use above formulas, for example, $\mu_{high(L\_D)}$ with attention to formula 6 is defined like below:

$$\mu_{High}(L\_D)=\{\frac{0}{4}+\frac{.33}{5}+\frac{.66}{6}+\frac{1}{7}+\frac{.33}{8}+\frac{.66}{9}+\frac{0}{10}\}$$

$$\mu_{normal}(MCV)=\{\frac{0}{20}+\frac{.18}{30}+\frac{.36}{40}+\frac{.55}{50}+\frac{.73}{60}+\frac{1}{75}+\frac{.9}{80}+\frac{.73}{90}+\frac{.55}{100}+\frac{.36}{110}+\frac{.18}{120}+\frac{0}{130}\}$$

## 5. Fuzzy rules base

Taking notice of different conditions of diseased people and even situations that have not happened but may do, rules have edited. Totally, there are 78 dependant rules. Each rule is a collection of variants that have been "AND" together and show an especial situation of disease. (table. 3){L=low, M=medium, B=big).

**Table3.fuzzy rule base**

| # | MCV | ALP | SGPT | SGOT | Gammagt | Drink | L_D |
|---|---|---|---|---|---|---|---|
| 1 | M | M | M | M | M | M | L |
| 2 | M | M | M | M | M | L | L |
| ... | | | | | | | |
| 78 | B | H | H | H | H | H | H |

For example rules 1, 2, and 78 are defined in this way:

$1) if\ (MCV = M \ \&\ ALP = M \ \&\ SGPT = M \ \&$
$SGOT = M \ \&\ Gammgt = M \ \&\ Drink = M)$
$then\quad (L\_D = L)$

$2) if\ (MCV = M \ \&\ ALP = M \ \&\ SGPT = M \ \&$
$SGOT = M \ \&\ Gammgt = M \ \&\ Drink = L)$
$then\quad (L\_D = L)$

$78) if\ (MCV = B \ \&\ ALP = H \ \&\ SGPT = H \ \&$
$SGOT = H \ \&\ Gammgt = H \ \&\ Drink = H)$
$then\quad (L\_D = H)$

## 6. Defuzzification

We should diagnose the accurate rate of $\alpha$ rules in this level. Firstly, the minimum amount of each rule is recognized and then the maximum amount between them is chosen. For instance (MCV=87, ALP=105, SGPT=35, SGOT=31, Gammgt=11, drink=1.1) rules 28 & 63 will perform.

$$\alpha_{28}=\min(M,M,M,M,L,M)$$
$$\alpha_{28}=\min(1,0.45,0.063,0.24,0.33,0.2)=0.063$$
$$\alpha_{63}=\min(M,H,H,H,M,H)$$
$$\alpha_{63}=\min(1,0.1,0.25,0.05,0.067,0.11)=0.05$$

Using this momdani equation (max/min), system membership function is: $\max(\alpha_{28},\alpha_{63})=0.063$

Of course, this rate of liver disorders is low. We use center of gravity defuzzifier formula for calculating the certain resulting amount (L_D).

$$D^{*}=\frac{\int D.\mu_{middle}(D)dD}{\int \mu_{middle}(D)dD} \quad (7$$

As it is shown in fig.5 the amount 3, 4 is the result for the rate of liver disorders danger. The specialist diagnosis for these fields is a normal situation while system reports a little of disorders.

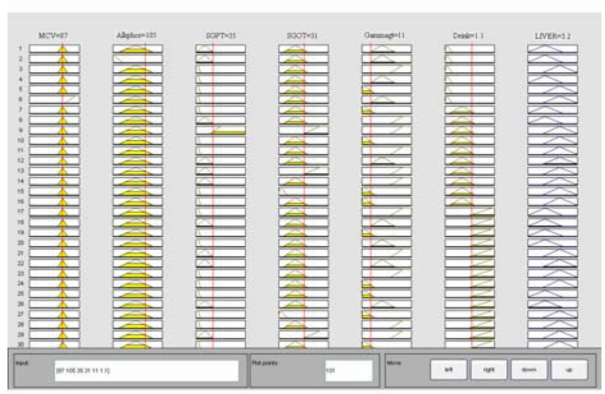

**FIG 7: is the result for the rate of liver disorders danger**

## 7. Conclusion

Fuzzy expert system –designed according to 345 records of liver disorders in the mentioned bank-Was tested, using the new records that were supported by liver specialist. Accuracy of diagnosis is 91% and it is a wonderful improvement. This system appoints the rate of disease intensity. So, it takes steps towards more complete and more accurate diagnosis.

This system can be applied as a liver specialist assistant or applied in learning medicine students. Yearly, thousands people lose their lives because of not accurate diagnosis of liver disorders intensity.

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