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Fuzzy Expert System Design For Diagnosis Of Liver Disorder

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ABSTRACT:

Diseases must be treated healthy and on time. If they are not treated lying on time, they can escort to many health problems with these problems might become the reason of death. These problems are becoming inferior due to the scarcity of specialists, health facilities and practitioners. In an attempt to address such problems, studies ended attempts toward design and develop expert systems which can present advice for physicians and patients to make easy the diagnosis along with recommend treatment of patients. This review paper represents a comprehensive study of medical expert systems used for diagnosis of Liver Disorder. It provides a concise overview of medical diagnostic expert systems along with present analysis of already existing studies In Diagnosis Of Liver Disorder.

General Terms

Fuzzification,Defuzzification,Membership Functions.

***Keywords:* Diagnosis, Symptoms, Patient, Facts, Rules.**

Introduction

Liver Disorder is a serious disease which replaces healthy liver tissue with scar tissue. The scar tissue blocks the flow of blood in the liver and slows down the vital functions of liver.Alcoholism affects the normal functioning of the liver by blocking the metabolism of fat, proteins and carbohydrates.Chronic hepatitis A,B,C and D can cause inflation of the liver and Thus damage the liver. Fatty liver associated with diabetes and obesity can affect the normal functioning of the liver which may cause Liver Disorder.Diseasessuch as hemochromatosis in which excessive absorption and disposition of iron takes place in liver can cause Liver Disorder.Certain inherited diseases such as Alpha-1 antitrypsin deficiency, Glycogen storage diseases, Wilson disease and cystic fibrosis can cause Liver Disorder.

Expert System

An expert system is a computer program that simulates the judgment and behavior of a human who has expert knowledge and experience in a particular field.Expert systems are used to advice non experts in situations where a human expert is not available.Expert system is made up of three main components.**User Interface:** User interface allows a user toquery the expert systems and to receive advice. User friendly interfaces are popular in expert systems.**Knowledge Base:** Knowledge base is created from information provided by the domain expert and is a collection of facts and rules.**Inference Engine:** Inference Engine examines the knowledge base for information that matches the user query using various search strategies.Expert System are used in wide variety of fields such as medical diagnosis, financial advice, discover locations to drill for water/oil, to diagnose car engine problem etc.

Rule Base Conflict Resolution

In expert system during inference process appropriate rules from the rule base are selected and triggered. This collection of triggered rules is called conflict set. Out of all the rules in the conflict set, the inference engine selects one rule as per the pre defined criteria. This process is called conflict resolution. Following are the popular conflict resolution strategies

- **Refractoriness:** Under this strategy rule to fire twice on the same data is not allowed to fire.
- **Regency:** Under this strategy data which arrived most recently in the working memory is considered and rule that uses this data is found.
- **Specificity:** Use the rule from the conflict set with most conditions attached. However some simple conflict resolution strategies are also used in the expert systems such as
- Assign priority to each rule and select the rule with the highest priority.
- If choice is to be made between the rules, choose the rule that comes first in the rule base.
- Random selection of rules could be effective alternative for conflict resolution.
- Define the search space and apply special purpose algorithms on it.

What is Fuzzy Expert System?

An expert system which uses a set of fuzzy membership functions and rules, in place of Boolean logic, to reason about data is called fuzzy expert system. The rules in a fuzzy expert system are of the type.

If A is long and B is short then C = medium.

Where A and B are input and C is an output variable, long is a membership function defined on A, short is a membership function defined on B and medium is a membership function defined on C. The antecedent describes to what degree the rule applies and the conclusion assigns a membership function to the output variable.

One or more than one conclusion per rule are allowed in the fuzzy expert system. Knowledge base or rule base in a fuzzy expert system stores set of rules.

The general inference process of the fuzzy expert system is as follows.

- **Fuzzification:** In this sub process crisp sets are transformed to a fuzzy set. The actual values are applied to the membership functions defined on the input variables to determine the degree of truth for each rule premise.
- **Inference engine and rule base:** Upon completion of the fuzzification of the inputs, the corresponding inputs fuzzy sets are passed to the inference engine for processing. The inference engine processes current inputs using the rules derived from the rule base.
- **Defuzzifiction:** The fuzzy inference engine output will always be fuzzy set obtained by the composition of the fuzzy sets output by each of the rules. In this sub process the fuzzy output set is converted to a crisp number.

There are various techniques used for defuzzifaction. Two of the most common techniques are Centroid and Maximum methods.

In Centroid method, variable value of the center of gravity of the membership function for the fuzzy value is considered to compute the crisp value of the output variable. In Maximum method, maximum truth value of the variable is chosen as the crisp value for the output Variable.

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Fuzzy Rules

Conditional statement in the form if *A* is *X* then *B* is *Y*, where *A* and *B* are linguistic variables and *X* and *Y* are its linguistic values can be define as a fuzzy rule.

Fuzzy rules can be defined using linguistic values such as low, high and very high, hence rules can be merged to minimize its numbers. Fuzzy rules can have single or multiple antecedents for example.

If speed is high

THEN risk is more

has single antecedent.

If speed is high

AND road is bad

AND light is dark

THEN risk is high

Have multiple antecedents.

The consequent of a fuzzy rule can have single or multiple parts for example

If	X	is	A
And	Y	is	B
Then	Z	is	C.

In multiple consequent, all parts of the consequent are affected equally by the antecedent. A fuzzy system contains several rules. The output of each rule will be a fuzzy set, a fuzzy expert system aggregates all output sets into a single output fuzzy set, defuzzifies the output fuzzy set into a single number representing the expert system output.

Fuzzy Inference

A process of mapping from a given input to an output, using the theory of fuzzy sets is fuzzy inference. Mamdani method is one of the most popularly used fuzzy inference technique. To compute the output of fuzzy inference system from the given inputs using Mamdani method one must go through following steps.

- Fuzzy rules determination.
- Input fuzzification using the input membership functions,
- Combining the fuzzified inputs according to the fuzzy rules to establish a rule strength,
- Combining the rule strength and the output membership function to find the consequence of the rule.
- Combining the consequences to get an output distribution, and
- Defuzzifing the output distribution.

Fuzzy Membership Functions

A Membership function for a fuzzy set A on the universe of discourse X is defined as

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$\mu_A(X) \rightarrow [0, 1]$

Here each element of X is mapped between 0 and 1. The value 0 means that x is not member of the fuzzy set and the value 1 means x is fully member of the fuzzy set. The values between 0 and 1 represent fuzzy members which partially belongs to the fuzzy set. Membership functions graphically represent fuzzy set. X axis represents the universe of discourse and Y axis represents the degree of membership.There are a number of ways membership function can be represented such as

Triangular membership function (trimf)

Trapezoidal membership function (trapf)

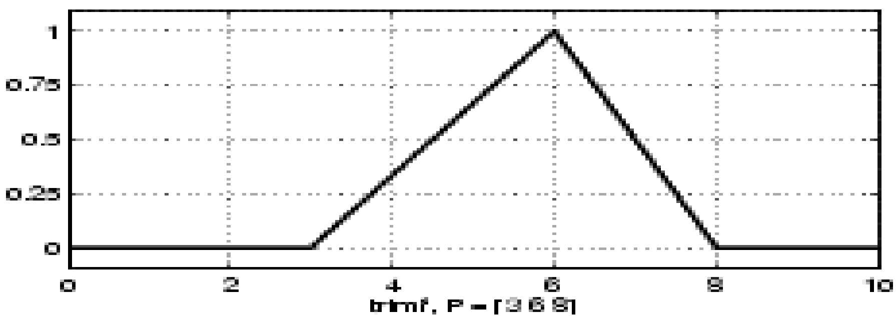
Gaussian function (gaussmf)

Triangular Membership Function

A triangular membership function is specified by three parameters {a, b, c} where a is the lower limit, c is the upper limit and b is the value between a and b, such that a < b < c.

Triangular membership function can be represented mathematically by the following mathematical model

$$\mu_A(X) = \begin{cases} 0 & x \le a \\ \dfrac{x-a}{b-a} & a < x \le b \\ 1 & x = b \\ \dfrac{c-x}{c-b} & b < x < c \\ 0 & x \ge c \end{cases}$$



trimf

Figure Triangular Membership Function

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Trapezoidal function

Trapezoidal function is specified by four parameters {*a*, *b*, *c*, *d*} where $a < b < c < d$ *in* which *a* is the lower limit, *b* is lower support limit, *c* is upper support limit and *d* is an upper limit.

Trapezoidal function can be represented mathematically by the following mathematical model.

$$\mu_A(X) = \begin{cases} 0 & x < a \\ \dfrac{x-a}{b-a} & a \le x \le b \\ 1 & b \le x \le c \\ \dfrac{d-x}{d-c} & c \le x \le d \\ 0 & x > d \end{cases}$$

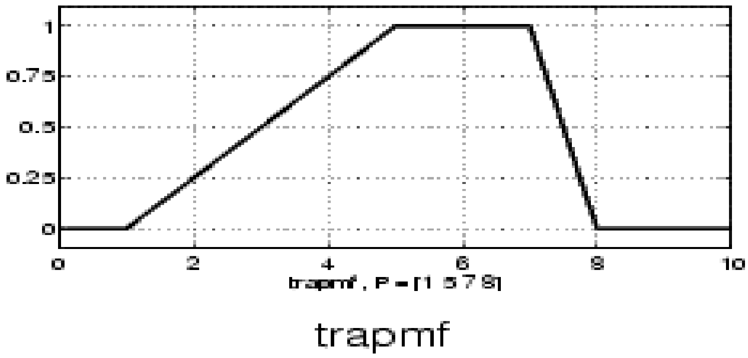

Figure Trapezoidal function

PROPOSED ALGORITHM

The proposed expert system assist physician in the diagnosis of the disease the patient might have, in a fuzzy way. Based on the patient complaints, the signs and symptons are input into the system, according to the selection the fuzzy expert system diagnosis disease based on its knowledge. The algorithm for the proposed system is adapted from [1].

Step1: Input signs and symptoms of patient complaint into the system. Where s= number of symptoms and signs.
Step2: Search the knowledgebase for the disease p whether it matches the signs and symptoms identified.
Step3 : Get the associated degree intensity(weighting factor) di =1,2 and 3 where 1= mild,2= moderate,3=severe
Step4: Apply fuzzy rules.

Step5: Map fuzzy inputs into their respective weighting factors to determine their degree of membership.
Step6: Determine the rule base evaluating (non-minimum values).
Step7: Determine the firing strength of the rules R.
Step8: Calculate the degree of truth R, of each rules by evaluating the nonzero minimum value.
Step9: Compute the intensity of the disease.
Step10: Output fuzzy diagnosis.

Fuzzy Expert System Design For Diagnosis

of Liver Disorders.

In this section we show fuzzy expert system designing for the pathological investigations and diagnosis of Jaundice is designed. Flow chart for the system is as follows.In this section we show the fuzzy expert system designing, membership functions, fuzzy rule base, fuzzification and defuzzification. The first step of fuzzy expert system is determination of input and output variables. There are Eleven Input variables SBT, BILI_D, BILI_ID, AST, ALT, ALP, RC,HB,Bononcini Score (AST/ALT Ratio, INR,PLT) and one output variable Risk Status.

Fuzzy Rule Base:

The rule base is determined with the help of the domain expert. The rule base consists of 89 well defined rules that determine the causes of liver Disorders by evaluating the input variables. The rule base is as follows:

1. If (SBT is Normal) then (No Liver Disorder Risk).
2. If (SBT is High) and (Bili_D is High) and (Bili_ID is Normal) and (AST is Normal) and (ALT is Normal)and(ALP is Normal)then (Possibility of DJS).
3. If (SBT is High) and (Bili_D is High) and (Bili_ID is Normal) and (AST is High) and (ALT is High)and(ALP is Normal)then (Possibility of HI).
4. If (SBT is High) and (Bili_D is Normal) and (Bili_ID is High) and (HB is Low) and (RC is Low) then (Possibility of HA).
5. If (SBT is High) and (Bili_D is Normal) and (Bili_ID is High) and (HB is Normal) and (RC is Normal) then (Possibility of GS-CNS).
6. If (SBT is High) and (Bili_D is High) and (Bili_ID is Normal) and (AST is Normal) and (ALT is Normal)and(ALP is High)and (INR is Score0) and (AST/ALT ratio is Score0) and (PLT is Score0) then (Liver Disorder is Low Risk).
7. If (SBT is High) and (Bili_D is High) and (Bili_ID is Normal) and (AST is Normal) and (ALT is Normal)and(ALP is High)and (INR is Score0) and (AST/ALT ratio is Score0) and (PLT is Score1) then (Liver Disorder is Low Risk).And So On….

Test Results: Fuzzy expert system for the risk identification of Liver Disorder has been developed. The development system is used to evaluate the study of patients. It is found that the results obtained are in the predefined limits set by the domain expert.

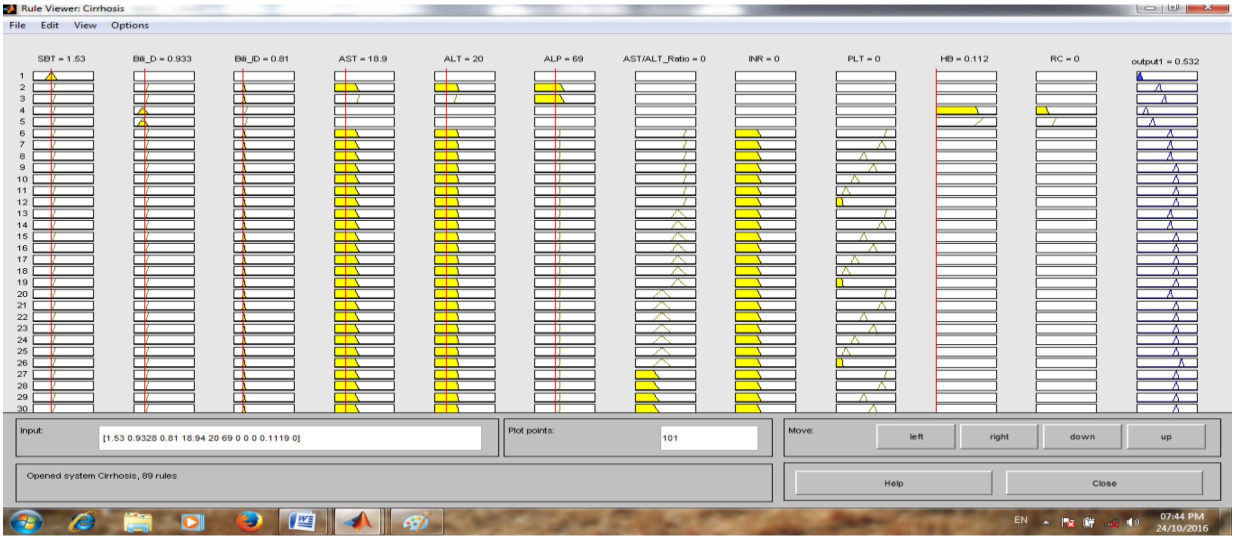

Figure:- Calculation of the value of Liver Disorder represents the diagnosis of patient affected by "No Liver Disorder Risk" depending on the following laboratory test values.

(SBT = 1.53, Bili_D = 0.933, Bill_ID = 0.81, AST = 18.9, ALT = 20, ALP =69,

AST/ALT =0, INR=0, PLT=0, HB =0.112, RC = 0).

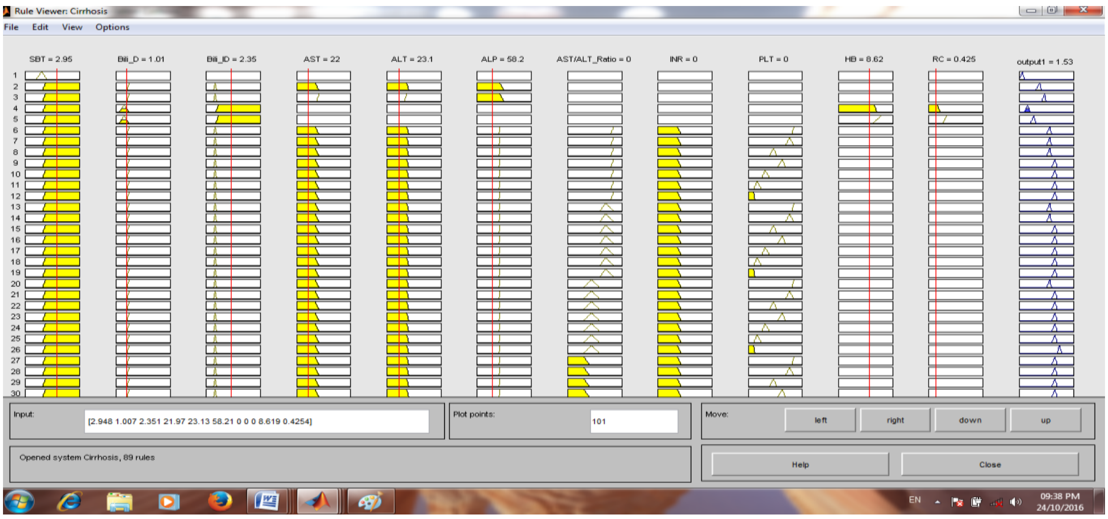

Figure:- Calculation of the value of Liver Disorder represents the diagnosis of patient affected by "Hemolytic Anemia" depending on the following laboratory test values. (SBT = 2.95, Bili_D = 1.01, Bill_ID = 2.35, AST = 22, ALT = 23.1, ALP =58.2, AST/ALT =0, INR=0, PLT=0, HB =8,62, RC = 0.425).

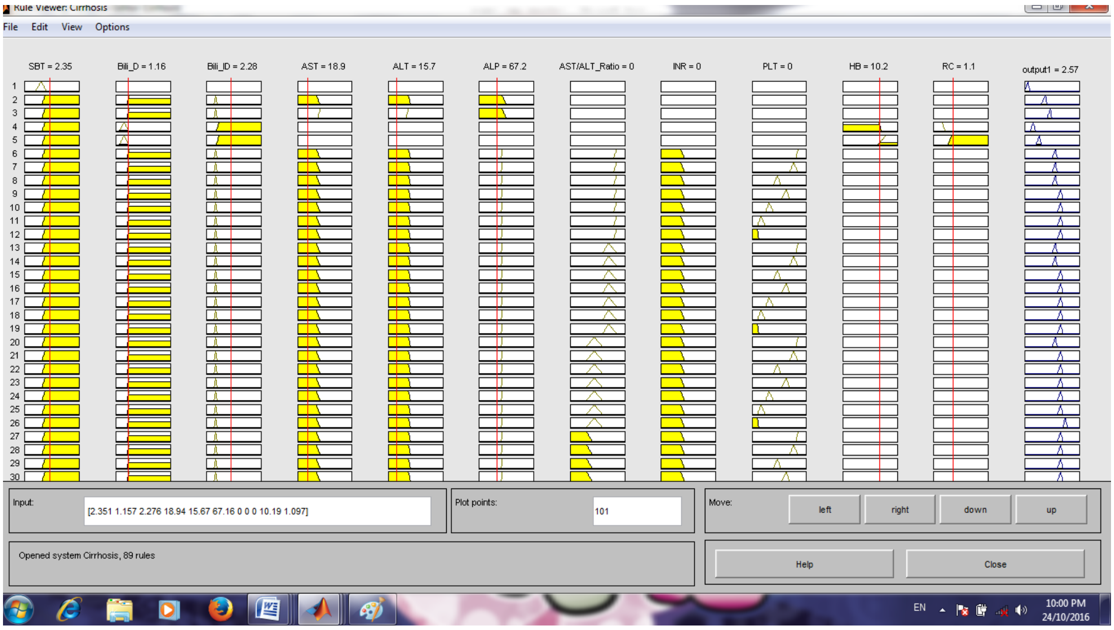

Figure:- Calculation of the value of Liver Disorder represents the diagnosis of patient affected by "Gilberts Syndrome or Crigler Najjar Syndrome" depending On the following laboratory test values (SBT = 2.35, Bili_D = 1.16, Bill_ID = 2.28, AST = 18.9, ALT = 15.7, ALP =67.2, AST/ALT =0, INR=0, PLT=0, HB =10.2, RC = 1.1).

This System Has Accuracy Of About 91.50 %, And Is Different From Earlier Approaches Consider And Executed In This Domain.

Comparison of Existing Studies on Disoder By Using Expert System.

Reference	**Technique Used**	**Disease Diagnosed**	**Inputs to Technique**	**Remarks**
Hossain, M.S, Khalid, M.S, Akter, S, Dey, S [14]	Rule Based Expert System	Influenza Disease	Real patients data are collected by consulting the Influenza specialists of Bangladesh, Disease Symptoms	This system is developed by using rule-based inference method of evidential reasoning and handle different types of uncertainties. Validate the system by using the practical case studies and shows

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				that system results are effective than manual system.
Azian Azamimi Abdullah, Zulkarnay Zakaria, Nur Farahiyah Mohammad [9]	Fuzzy Expert System	Hypertension Disease	Age, Gender, Blood pressure, Body mass index and heart rate	This system is used to diagnosis of hypertension for patient's divided between aged and gender. Experimental results shown that this system is more accurate than other traditional methods.
Komal R. Hole, Vijay S. Gulhane [15]	Rule Based Expert System	Memory Loss Disease	Disease Symptoms	The developed system based on rules and helps patients patients to obtain the advice about the different disorders. The knowledge base collects information from books and doctors about neurology and its disorders.
Neshat, M, Yaghobi, M, Naghibi, M.B, Esmaelzadeh, A [5]	Fuzzy Expert System	Liver Disorders	Data gathered from trusty database, 6 entrance parameters of liver disorders	This fuzzy system can be helpful to a specialist assistant or for training medication students for diagnosis of liver disorders. The system verification on time diagnosis and appointing the rate of liver disorders is 91%.
Noura Ajam [16]	Artificial Neural	Heart Disease	Disease Symptoms	88% accuracy is achieved in diagnosis of heart disease by using

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	network			feed forward back propagation neural network.
Maitri Patel, Atul Patel, Paresh Virparia [11]	Rule Based Expert System	Viral Infection	Disease Symptoms	This system hass most important focus is made on practice of technology by the current inventions is made, to benefit the community in over all wellbeing. Prescriptions to these infections canister are deduced through this system, which are accurate as well as many medical practitioners.
Reference	**Technique Used**	**Disease Diagnosed**	**Inputs to Technique**	**Remarks**
E. Bursuk, M. Ozkan, B. Llerigelen [2]	Knowledge Based System	Cardiological Diseases	Disease Symptoms	This proposed medical expert system will be practical for both patients and physicians for providing decision of disease. Twenty-five patient's information can be used to valuation of the expert system.
S Ali, P Chia, K Ong [3]	Knowledge Based System	Chest Pain	Data obtained from Laboratory examinations, Ultrasound, Chest X-Ray images, Narrative texts describing the	This expert system distributes appropriate clinical strategy and is finalized for pilot trial on the accidents and emergency department of the national university hospital. No experimental results of this expert

CONCLUSION AND FUTURE SCOPE

The proposed system is designed in MATLAB software using FIS toolbox. The system uses Mamdani inference mechanism. Rules representation fulfills the essential criteria of expressiveness, effectiveness, efficiency and explicitness even in dealing with the uncertainty, hence rules representation is used to represent the knowledge in the proposed system.

Inference engine uses forward chaining mechanism to deduct the hypothesis from the knowledge base. The system contains only AND operator hence the method is Minimum. Implication method is Minimum. Aggregation between the rules is Maximum hence the fuzzification method is Max-Min. And the defuzzification method is Centroid.

The tests of the proposed system were performed using real pathological test data that corresponds to 100 patients collected from the two pathological laboratories. The accuracy of the system diagnosis is evaluated by comparing the results obtained by the system with the diagnosis made by the specialists(doctors). For the tested data of 100 patients, the overall accuracy of the proposed system is 94.10 %. From the result it can be concluded that the proposed system improves the accuracy of the diagnosis.

From this research work it has been concluded that there are various approaches and tools for the design of fuzzy expert system for the pathological investigations and diagnosis.

Proposed system considers all the hepatobiliary organs and uses almost all the necessary parameters. The proposed work intends to achieve more general reasoning approach rather than simple deductive approach towards expert system design to simulate expert physicians behavior to make the system more accurate and acceptable dividing it into further goals.

1. Identifying methods and tools for the development of fuzzy expert system for pathological investigations and diagnosis.
2. To provide proper framework for the knowledge representation of the pathological data.
3. To explore fuzzy approach for knowledge representation and medical diagnosis.
4. To design inference engine for the expert system in pathological investigation and diagnosis.

From the results it can be concluded that the proposed system improves the accuracy of the diagnosis and simulates the behavior of the expertise in making diagnosis and hence can be more acceptable. So it takes step towards more complete and accurate diagnosis.

During the current research several areas have been identified that could be further investigated. The major areas of immediate research is modeling of value and temporal data, comparative evaluation of different modeling techniques, research on inference algorithms and development of easy to use, precise and accurate online diagnosis tools.

Future scope:

1. If this fuzzy expert system will be uploaded on the web medical practitioners,can use this system throughout the world especially in the rural area.
2. Same framework of this can be applied to diagnose other diseases with some modification in the knowledge base.

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