Design and Implementation of Fuzzy Expert System for Back pain Diagnosis

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***Abstract*—Decision support through information technology become a part of our everyday lives. In this paper we produce a Fuzzy Expert System (FES) to diagnosis of back pain disease based on the clinical observation symptoms using fuzzy rules. The clinical observation symptoms which processed by fuzzy expert system may be used fuzzy concepts to describe that symptoms such as (little, medium, high). To deal with fuzzy concepts in clinical observation symptoms we should be used fuzzy rules to hold this concepts.**

The parameters used as input for this fuzzy expert system were Body Mass Index (BMI), age, and gender of patient as well as the clinical observation symptoms. The proposed expert system can help to diagnosis of back pain disease and produce medical advice to the patient. The system implemented and tested using clinical data that is correspond to 20 patients with different back pain diseases. The proposed system implemented using Visual Prolog programming language ver. 7.1.

Keywords: Fuzzy expert system, fuzzy logic, fuzzy rules, back pain diagnosis

I. 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 [1]. Nowadays the methods of Artificial Intelligence (A.I.) have largely been used in the medical applications. In the medicine area, many expert systems were designed to diagnose and treatment the disease. Hence, a rule-based fuzzy expert system that simulates an expert-doctors behavior for diagnosis of the disease is developed. Fuzzy logic is a true extension of conventional logic, and fuzzy logic controllers are a true extension of linear control models. Hence anything that was built using conventional design techniques can be built with fuzzy logic, and vice-versa [2].

Expert system is one of the most common application of A.I., it is a computer program that simulates the judgment and behavior of a human or an organization that has expert knowledge and experience in a particular field. Typically, such a system contains a knowledge base containing accumulated experience and a set of rules for applying the knowledge base to each particular situation that is described to the program[3]. A fuzzy expert system is a collection of membership functions and rules that are used to reason about data. Unlike conventional expert systems, which are mainly symbolic reasoning engines, fuzzy expert systems are oriented toward numerical processing. The part of the rule between the "if" and "then" is the rule's _premise_ or _antecedent_ . This is a fuzzy logic expression that describes to what degree the rule is applicable [2]. There are two general types of fuzzy expert system: fuzzy control and fuzzy reasoning. Although both make use fuzzy sets, they differ qualitatively in methodology. It accepts numbers as input, then translates the input numbers into linguistic terms such as Slow, Medium, and Fast (fuzzification). Rules then map the input linguistic terms onto similar linguistic terms describing the output. Finally, the output linguistic terms are translated into an output number (defuzzification). The syntax of the rules is convenient for control purposes, but much too restrictive for fuzzy reasoning; fuzzification and defuzzification are automatic and inescapable [4].

The advent of computers and information technology in the recent past has brought a drastic change in the fuzzy medical expert system. Information gathered from the domain experts must be transferred to knowledge and must be used at the right time [5] .These Knowledge can be incorporated in the form of fuzzy expert system in the diagnosis of back pain disease in specific.

In this study, we present a Fuzzy Expert System (FES) to diagnosis of back pain diseases depend on medical observation symptoms which represented as fuzzy rules or linguistic rules, the fuzzy rule is a rules which take the condition part linguistic values. There are other parameters can effect on back pain diseases such as patient's history, Body Mass Index (BMI), age, and gender of patient. The input age, BMI and symptoms for the patient converted it to lingustic values using fuzzification process, the lingustic values and corresponding membership function have been determined by the aid of the experts.

II. RELATED WORKS

Most of researchers develop many methods to diagnosis medical diseases based on clinical symptoms such as neural networks, rule-based systems, expert systems, and fuzzy expert systems.

In [2], a fuzzy expert system is designed for diagnosis of hypertension risk for patients aged between 20's, 30's and 40's years and is divided into male and female gender. The input data is collected from a total of 10 people which consists of male and female with different working background.

In [1], A fuzzy expert 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.

In [6], the authors produce a Knowledge based diagnosis of abdomen pain using fuzzy Prolog rules the main objective of the system is to assist doctors, assistants and social workers in their decision making process and create awareness in the area especially where trained manpower is in scarce. To impart the fuzziness of the domain, modified Prolog rule format is used, which is illustrated in a case of appendicitis.

In [7], A fuzzy expert system for diagnosing, and learning purpose of the prostate diseases is described. HIROFILOS is a fuzzy expert system for diagnosis and treatment of prostate diseases according to symptoms that are realized in one patient and usually recorded through his clinical examination as well as specific test results.

In [8], an expert system for diet recommendation in this study they proposed a case-based approach for diet recommendation. Based on this approach, we are going to construct an expert system which is intended to be employed in a health record management system. Their approach is based on ripple down rules (RDR), however, a special representation is also needed for patient attributes and rule actions.

In [9], enhanced fuzzy rule based diagnostic model for lung cancer using priority values which design a fuzzy rule based medical model to detect and diagnose lung cancer. The disease is determined by using a rule base, populated by rules made for different types of lung cancer. The algorithm uses the output of the rule base (i.e. the disease name) and the symptoms entered by the user; it also uses the priority and severity values to determine the stage of cancer the patient is in.

III. STRUCTURE OF THE SYSTEM

After selecting the domain that we want to build expert system, knowledge acquisition is started which involves the acquisition of knowledge from human experts, books, or documents. The knowledge may be specific to the problem domain or to the problem solving procedures, it may be general knowledge, or it may be metaknowledge (by *metaknowledge*, we mean information about how experts use their knowledge to solve problems and about problem-solving procedures in general). We formally verified that knowledge acquisition is the bottleneck in ES development today [10]. Acquired knowledge is organized to will be ready for use, in an activity called knowledge representation. This activity involves preparing and encoding of knowledge in the knowledge base. The proposed system used production system method to represent acquired knowledge which are sets of:

IF antecedents THEN consequent

The model of proposed system is given in figure (1) which represent the components of the system. The **Knowledge Base (K.B)** contains the problem solving knowledge (information about back pain diseases). the knowledge of the expert in the decision-making can be represented in various forms. The knowledge of expert can be easily represented into rule-based format as a set of conditional rules. Rules may be chained according to the knowledge it represents[6].

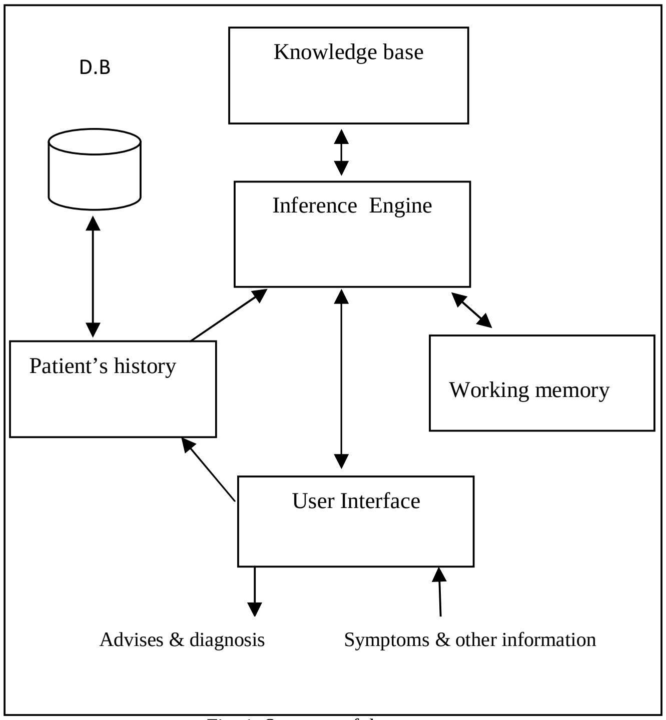

Fig. 1. Structure of the system

The knowledge here represented as a set of fuzzy rules which is extracted from human experts (doctors) and back pain diseases documents, the fuzzy rules example can be represented in Prolog format as:
diagnosis("slipped disc",3):-
(age(young);age(middle);age(old)),(bmi(medium) ;bmi(high)), back_pain(very high), leg_pain(high), leg_narcotize (little), foot_senseless(medium).

The fuzzy rule consists of two parts, head of rule (consequent) and body of rule (antecedents). The head of rule here consist of two arguments, disease name and region number (1-5) as well as to predicate name (diagnosis). The body of rule consists of all symptoms and their severity which stored in K.B. The other component of K.B is treatment of the diseases which represented as facts for medical advices which may be name of drugs, surgery operation, or take some rest, for example for these facts can be represented in Prolog format as:
treatment("slipped disc", "take some drugs like Tilcotil20mg ،Arcoxia 90 mg , if the situation continue do surgery operation").

The treatment facts consist of two arguments the first one represent disease name and the other represent the appropriate medical advice for that disease. The **Inference Engine (I.E)** makes use of fuzzy logic to map the given input in this case the symptoms to an output the possible disease a patient can have. Based on this we can make decision and the treatment for a particular patient [9] also it makes use of membership function, If-then rules and logical operators for making these decisions.

The inference engine contain the strategies of reasoning process, its carries out the reasoning process by links the contains of the knowledge base with the symptoms which input by users through user interface to capture appropriate decision, the **working memory** contains all the temporary results during the reasoning process, the backward chaining strategy is used in inference engine of proposed system. I.E performs fuzzification on the inputs and determine the degree to which the input belongs to the fuzzy set.

The user can interact with fuzzy expert system through **User Interface (U.I)**, the U.I must be friendly of user and hide the other complex components of fuzzy expert system, the questions and answers method used in building of user interface for the system. When the user input his preliminary information (ID, name, age, gender, weight, height for the patient), the proposed system check all this data in database if any, then retrieves the patient's history otherwise called registration procedure to stored it in database, that mean the **database** contain all data about registered patients and their diseases, the **patient's history** is very important for decision making because of most diseases may be overlapping with each other (especially back pain diseases with other diseases) the structure of database can be illustrated by table I:

Table I
Structure of database for proposed system

ID	Name of patient	gender	Birth date	BMI Kg/ m^2	Disease
1	Tom	m	1978	20.3	Rupture and contraction
2	Sarah	f	1967	19.5	Spinal injury
.	…	…	…	…	…
.	…	…	…	…	…
20	John	m	1980	22.1	Slipped disc

IV. CALCULATING MEMBERSHIP FUNCTION

A membership function defines how each point in the input space is mapped to a degree of membership between 0 and 1 [5]. In our system we calculate the membership function for age and BMI input variables. For each of them we can calculate the membership function, we use three linguistic variables young, middle, and old for age input value as in figure(2) and table II, and we use three linguistic variables low, medium, and high for BMI value as in figure(3) and table III.

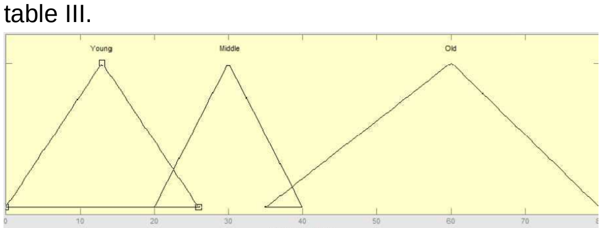

Fig. 2. Linguistic variables and membership function of 'Age'

table II
Classification of age input variable

Input variable	Range	Fuzzy Sets
Age	<25 22-40 38>	Young Middle Old

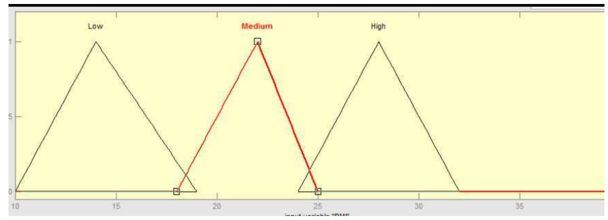

Fig. 3.Linguistic variables and membership function of 'BMI'

table III
Classification of BMI input variable

Input variable	Range	Fuzzy Sets
BMI	<18 19-25 24>	Low Medium High

Also we can calculate the membership function for the input symptoms based on the severity experienced by the patient we scale the range [0-100], for each symptom can calculate the member function, we use four linguistic variables little, medium, high, and very high for symptom input value as in figure (4) and table IV.

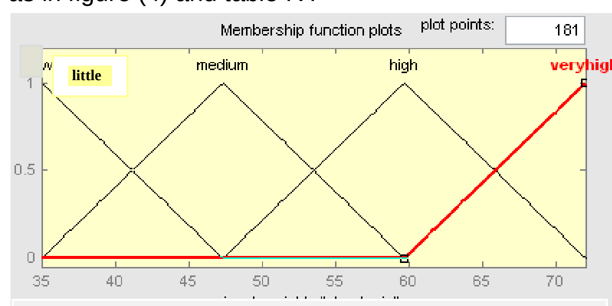

Fig. 4. Linguistic variables and membership function of 'symptom'

Table IV
Classification of symptom input variable

Input variable	Range	Fuzzy Sets
Any symptom	<20 18-60 58-80 78>	Little Medium High Very high

V.HOW THE SYSTEM WORKS

In general the following algorithm represent the main steps of proposed system:

Algorithm

1) Take input from user (patient) as $(a_1,a_2,a_3\ldots a_7)$ which represent (ID, name, age, gender, weight, height, and region pain number for the patient) respectively, and calculate $BMI=a_5/(a_6)^2$
2) Select N number of symptoms and choose their severity and assign some membership values to linguistic variables, $symptom_i$=little| medium| high| very high, where i=1 to N .
3) IF the patient is new THEN register all his data in database ELSE retrieval his data from database.
4) Matching the $symptom_i$ and their severity (input in step 2) against the antecedents part of fuzzy rules in knowledge base to make decision as disease name.

The rules that used by experts can be developed using decision tree by maintaining the decision sequence this is illustrated in figure (5) that describe the structure of decision making for the slipped disc disease, the backbone of human being can be divided into five regions as shown in figure (6).

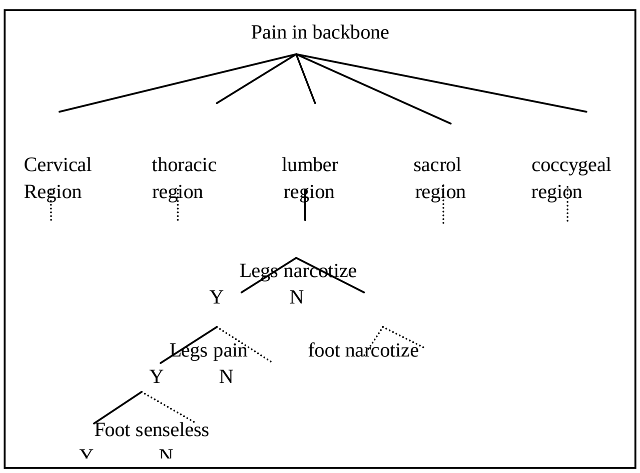

Fig. 5. decision tree for slipped disc disease

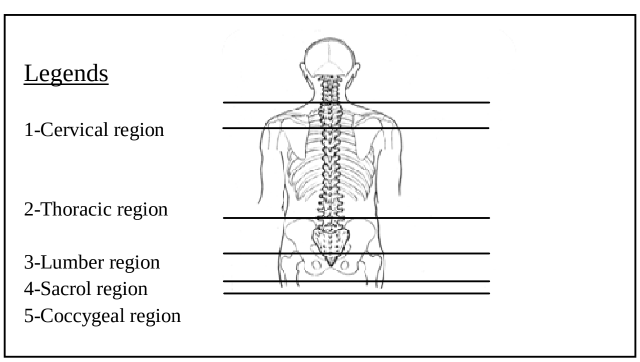

Fig. 6. regions of backbone human being

VI.IMPLEMENTATION OF CLINICAL DATA

The tests of the proposed system were performed using real clinical data that correspond to 20 patients, 13 males and 7 females taken from Max hospital, New Delhi, India during the year 2010, The accuracy of the system diagnosis is evaluated by comparing with the diagnosis of specialist (doctor), the system accuracy diagnosed is 90% of cases which tested it. Patients distributed according to age groups is illustrated in figure(7), and figure (8) show the distribution of patients according to gender and age group.

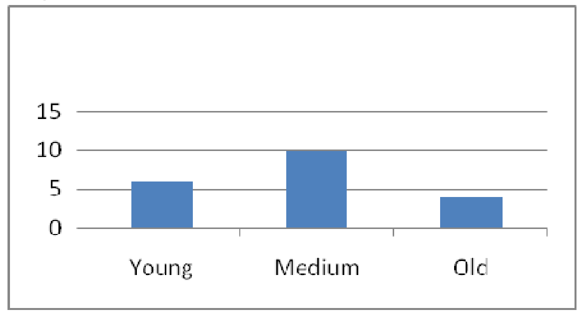

Fig. 7. distribution of patients according to age

To evaluate the working of the proposed system, we will produce real case for the proposed system to show the steps of system carry out to produce the

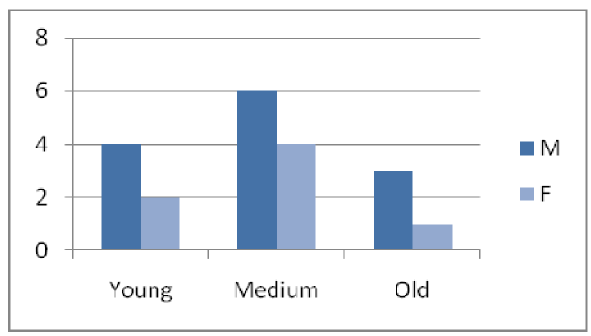

Fig.8.distribution of patients according to age and gender group

diagnosis and advices for that case, the figures (9), (10), and (11) illustrated that steps.

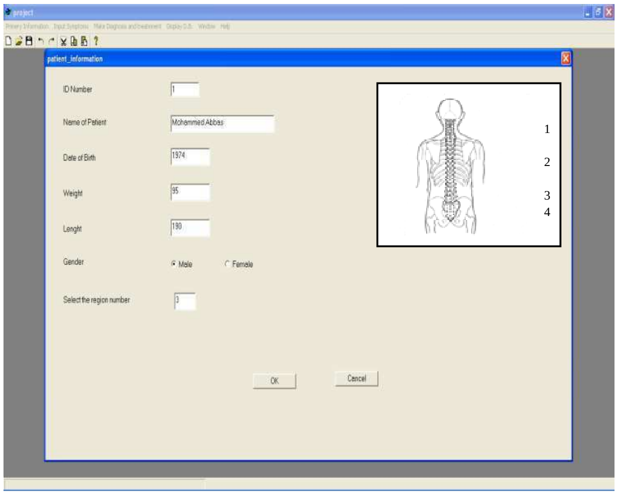

Fig. 9. Primarily information for the patient

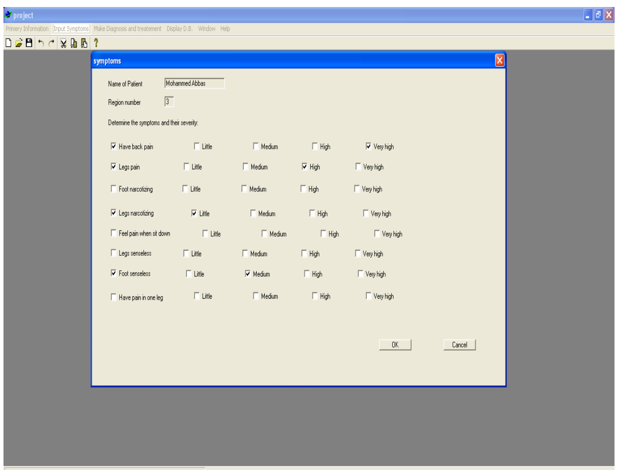

Fig. 10. Detail symptoms for the input patient

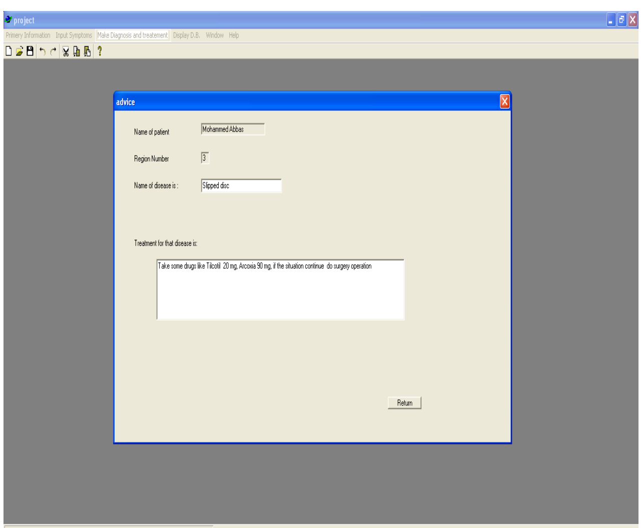

Fig. 11. Make decision and produce advices for the patient

When the proposed system carry out this case study, it will invoked the fuzzy rules concern with region number 3 for backbone regions and neglected the fuzzy rules for other regions, therefore we should be mentioned to region number with the head of fuzzy rules. We can illustrate the sample of knowledge base contains (set of fuzzy rules for different regions to make diagnosis and set of treatment facts to produce advices for that disease using Prolog language format) as in figure (12).

Rule1:diagnosis("rupture and contraction",2):-
((age(young);age(middle); age(old)) , (bmi (medium);bmi(high)), long_back_pain(very high), difficult_breath(high),cough(high).

Rule2:diagnosis("osteoporosis",2):-age(old),(bmi(medium);bmi(high)), back_pain(high),smoke(high),drink(high).

Rule3:diagnosis("slipped disc",3):-((age(young);age(middle);age(old)) , (bmi (medium);bmi(high)), back_pain(very high), leg_pain(high), leg_narcotize (little), foot_senseless(medium).

Rule4:diagnosis("arthritis of vertebae",3):-((age(old);age(middle); age(old)) , (bmi (medium);bmi(high)), back_pain(very high), leg_pain(high), foot_narcotize (little).

Rule5:diagnosis("osteoporosis",4):-age(old),(bmi(medium);bmi(high)), back_pain(high),smoke(high),drink(high).

Fact1:treatment("rupture and contraction"," heating the region and the use of patches with palliative treatments like Voltaren").
Fact2:treatment("osteoporosis,"Bisphosphonates or Calcitonin").
Fact3:treatment("slipped disc ", "take some drugs like Tilcotil20mg ، Arcoxia 90 mg , if the situation continue do surgery operation").
Fact4:treatment("arthritis of vertebrae","Panadol and Nsaids").

Fig. 12. Sample of knowledge base contains

VII. CONCLUSION

This paper discuss the architecture of fuzzy expert system that used fuzzy rules to represent the diseases of backbone for human being, it can be conclude there is no doubt whether fuzzy expert system should be applied for diagnosis of back pain diseases and produce an advice for patient based on the symptoms which represented as fuzzy concepts in antecedents of fuzzy rules. Fuzzy logic systems are a very good tools for handling of ambiguous and imprecise information especially in medical diagnosis. The accuracy of the proposed system diagnosis was evaluated by comparing it to diagnosis indicated by specialist (doctor), the system accuracy diagnosed 90% of cases which tested it

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