Designing of Fuzzy rule base for Vision Defects

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Abstract:
Knowledge based system providing a new dimension to the medical advancement. Fuzzy set theory and fuzzy logic are a highly suitable and applicable basis for developing knowledge-based systems in medical field. The analysis which can be performed by knowledge based system is providing optimal result with minimum human intervention. A fuzzy expert system can be implemented in almost every medical proficient system for diagnosis the syndromes of any disease. Many of the systems has been developed and implemented. This research paper is providing the novel framework for vision defects using fuzzy rule base.

Keywords : disease, symptoms, significance, rule.

1. Introduction

In past few years, the computational intelligence has been used to solve many difficult problems by developing intelligent systems. And fuzzy logic has proved to be a powerful tool for decision-making systems, such as expert systems and pattern classification systems. Fuzzy set theory has already been used in many medical expert systems.

In traditional rule-based approach, knowledge is encoded in the form of antecedent-consequent structure. When new data is encountered, it is matched to the antecedents clauses of each rule, and those rules where antecedent match a data exactly are fired, establishing the consequent clauses. This process continues until desired conclusion is reached, of no new rule can be fired.

In the last decade, fuzzy logic has proved to be a wonderful tool for intelligent systems in many fields. Some examples of using fuzzy logic to develop fuzzy intelligent systems are fuzzy systems in their microprocessors, fuzzy control of the subway system, fuzzy washing machines, fuzzy cameras and camcorders that map image data to lens settings, and fuzzy voice commands: “up”, “land”, “hover” to control an unmanned helicopter.

This research paper would be discussing the Fuzzy rule base for vision defects. Section 4 would be the database implementation of the rule base for designing the expert system for vision defects. Section 5 would be the discussion on the proposed design. Some conclusions are given in section 6.

2. Fuzzy set theory & Fuzzy logic

Fuzzy Set Theory was formalized by Professor Lofti Zadeh at the University of California in 1965 [4]. What Zadeh proposed is very much a paradigm shift that first gained acceptance in the Far East and its successful application has ensured its adoption around the world. A paradigm is a set of rules and regulations which defines boundaries and tells us what to do to be successful in solving problems within these boundaries. For example the use of transistors instead of vacuum tubes is a paradigm shift - likewise the development of Fuzzy Set Theory from conventional bivalent set theory is a paradigm shift.

Problems in the real world turn out to be quite complex, due to uncertainty in the parameters that define the problem and due to uncertainty in the situations in which that particular problem occurs. Probability theory is an age old theory, which excellently handles this uncertainty. But this probability theory can be applied only to situations whose occurrence of events is greatly determined by random process [3].

Fuzzy Set Theory exhibits immense potential for effective solving of the uncertainty in the problem. Fuzzy Set Theory is an excellent mathematical tool to handle uncertainty occurred due to vagueness.

Fuzzy set theory hold all the possible operation on the fuzzy sets which are the part of set theory in mathematics. Fuzzy logic is a multi valued logic
derived from crisp logic. Unlike crisp logic which gives answer with a fixed value like 0 or 1 true or false, Fuzzy logic provides answer within a specified range, i.e. answer between 0 and 1, value between true and false, represent the degree of truthiness or falseness in a given statement. It will address the word “approximate” rather than to be “precise”. In real world situation we often face problem with vague information. This vague information’s are easily understandable by human beings but are hard to interpret computationally. For example weather forecasting, decision making with uncertain conditions, diagnosing problem, speech recognition, image processing etc.[1,2,7]

Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth- truth values between "completely true" and "completely false". As its name suggests, it is the logic underlying modes of reasoning which are approximate rather than exact. The importance of fuzzy logic derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature.

3. Fuzzy Rule Base for Vision Defect

In this section the fuzzy knowledge base and the Fuzzy set theory for that knowledge base has been discussed. We have considered the fixed number of rules; one of the rules is as follow:

**RULE [Macular Degeneration]**


Then [Suffering from the disease Maculer Degeneration] = "Yes" and [Suffering from the disease Visual Acuity] = "Yes" and [Vision defects] = "Yes"

The above rule can be represented in general with the help of fuzzy set theory, [6] which has been explained as under with the help of three equations (1-3):

Consider the set of symptoms S, set of disease D, set of Significance value SV

Where $S=\{s_1, s_2, \ldots, s_n\}$

$D=\{d_1, d_2, \ldots, d_n\}$

$SV=\{v_1, v_2, \ldots, v_n\}$

For designing the fuzzy rule base, let consider one example:

If $s_1$ is $v_1$, $s_2$ is $v_2$, $s_3$ is $v_3$, ..., $s_n$ is $v_n$ then disease is $d_1$.

All the rules can be framed as shown in the example, by considering different significance value for the symptoms.

We can compute the degree to which the conditions are applicable:

$$\mu_{condition} = \mu v_1(s_1) \land \mu v_2(s_2) \land \ldots \land \mu v_n(s_n)$$

$\Rightarrow$ Equation(1)

Then for each possible disease, we can compute the degree to which the rule holds:

$$\mu_{rule} = \mu_{condition} \land \mu D(Disease)$$

$\Rightarrow$ Equation(2)

Now, there are possibilities of several rules that is part of set of rules $(r_1, r_2, \ldots, r_n)$ for the diseases which can be represented in the general equation that is Equation (3) as below:

$$\mu (Disease) = \mu r_1(Disease) \lor \mu r_2(Disease) \lor \ldots \lor \mu r_n(Disease)$$

$\Rightarrow$ Equation(3)

In Equation 1, the AND operations has been performed between the values of the symptoms which are the condition for finding the defects which apply that the membership condition should hold TRUE for all the values.

In Equation 2, rules has been represented, degree of the rule hold gives the decision about the disease, so the operation which performed in equation 2 is also AND implies that both should hold that is condition as well as disease.

In Equation 3, it is deriving that one of the disease rule should hold true, so the OR operation has been performed on the different functions of the rule.

The significance value will be lying in the range of 0 & 1. So the mapping of the disease will be done on which value of the symptoms has been selected. $v_1$ is showing the 1 and $v_n$ is showing the 0 and intermediates values has been considered depending
upon the reason which are neither max or min (neither Yes or No). The decision making is always done on the basis of the significance value of the symptoms. So the discussed rule base is implemented to design the Database for the Vision Defect System which has been discussed in the next section.

4. Data dictionary for Rule base

The database has been created in MYSQL query language. Three relations have been created based on the fuzzy rule base which are- Symptoms relation, Disease relation, Significance relation. The mapping of the relations has to be done. Mapping is required for inferences the decision about the disease out of the Symptoms and the significance value observed by an expert in the patients [3]. Each relation has its attribute as the master relation; then the inferences can be made by creating the relation between these master relations.

Table 1: Data Dictionary of Symptoms table

Symptoms relation is having the attributes {symptom_id, symptom_name, symptoms_desc}

Table 2: Data Dictionary of Disease table

Disease relation is having attribute {disease_id, disease_name disease_desc, disease_image}

Table 3: Data Dictionary of Significance Value table

Significance relation is having the attributes {sig_id, sig_name, value}

Linguistic Variable for Vision Defect | Associated Fuzzy Number
--- | ---
Definite Defected | F0 = (0.0,0.0,0.0)
Defected: | F1 = (0.0,0.0,0.1)
Almost Defected | F2 = (0.0,0.1,0.2)
Probably Defected | F3 = (0.1,0.2,0.3)
Partly Defected | F4 = (0.2,0.3,0.4)
Very low Vision | F5 = (0.3,0.4,0.5)
Low Vision | F6 = (0.4,0.5,0.6)
Partly improved vision | F7 = (0.5,0.6,0.7)
Preferably improved vision | F8 = (0.6,0.7,0.8)
Good vision | F9 = (0.7,0.8,0.9)
Very good vision | F10 = (0.8,0.9,1.0)
Nearly Accurate Vision | F11 = (0.9,1.0,1.0)
Accurate Vision | F12 = (1.0,1.0,1.0)

5. Fuzzy Inference

In section 3 & 4 we have defined Fuzzy rule base for the proposed system. Now we apply fuzzy inference mechanism in order to generate result based on type of the symptoms the patient is suffering from. The rule base consists of IF-THEN statements which are applied by the usage of membership functions which provide the measure of degree of similarity for the given symptom(s) for particular disease. For the current rule base triangular membership function is applied based on linguistic variable specified in Table 4 and membership function is depicted in Fig: 4.
The Membership function is applied along with rule base and fuzzy variables to the inference engine, where decision making process is applied with decision trees and structure to generate result on particular rule based condition. The process of fuzzy inference is explained in Fig 5. For example when RULE [Macular Degeneration] as mentioned above is applied then fuzzy inference engines deduces the output that “According to the symptom specified patient has vision defects and is suffering from disease Macular Degeneration and Visual Acuity”. Hence by applying various rules we can obtain specific identification of the disease based on the specified symptoms of the patients.

6. Discussion

First the patient database has been created then the evaluation of the disease can be done. The registered patient can be diagnosis with the help of the designed system. The main interface of the system will be diagnosis the disease of the patient with the help of rule base reasoning.

In this discussed expert system, more than one disease can be suggested depending upon the symptoms observed by the doctor in the patient. Symptoms, matching will be done in the knowledge base and based on the reasoning defined in the knowledge base the vision defect information will be suggested to the doctor and doctor takes the final decision. This system is very useful to the doctors and the suggestion provided to the doctor which reduces the decision making timing taken by the doctor. This system is in the designing phase. So this paper is restricted to designing of the rule base system [5]. Fuzzy set theory and rule base plays a very important role in designing the human like intelligence and results are more efficient as compared to any other branch of Artificial Intelligence. As now a days most of the systems are intelligent in nature and everyone prefer to use the system which has some or other decision making capability. So this system design is an addition to that list.

7. Conclusion

The discussed Vision Defect diagnosis system is using logical reasoning base entities for decision making which are approximately formulated with the help of fuzzy set theory and rule base. It requires more time to formulate the fuzzy set and rule base for any medical application.

This designing is very useful to finding the vision defect, though only design part has been discussed, further work will be done on implementation of this designing. Though many other diagnosis systems have been designed and discussed but this is the novel diagnosis system which is also considering the image of the disease so that the eye perception of the patient can be considered in the implementation part.

8. References: