DEVELOPMENT OF A RULE-BASED EXPERT SYSTEM WITH FUZZY SETS AND FUZZY LOGIC

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Abstract: We propose in this paper to model of a rule based expert systems using the techniques of Fuzzy sets and Fuzzy logic. In the real world problem solving is the process of finding a solution when the path leading to that solution is uncertain. The Expert Systems need to have the ability to handle vague associations, for example by accepting the degree of correlations as numerical certainty factors. When the data is incomplete or missing, the only solution is to accept the value "unknown" and proceed to an approximate reasoning with this value. Fuzzy logic provides a framework to model uncertainity, the human way of thinking, reasoning and the perception process. In this paper we proposes a fuzzy rule based expert system is simply an expert system that uses a collection of fuzzy membership functions and rules to solve the uncertainty.

Keywords: Expert System, Fuzzy Sets, Fuzzy Logic, Fuzzy Control, Inference Engine, Knowledge base.

1. INTRODUCTION

An expert system is a computer system that emulates the decision-making ability of a human expert, i.e. it acts in all respects as its human counterpart. Rule-based expert systems have emerged from early work in problem solving, mainly because of the importance of domain-specific knowledge.

Expert Systems for Fuzzy Control and for Fuzzy Reasoning There are two general types of fuzzy expert systems: fuzzy control and fuzzy reasoning. Although both make use of fuzzy sets, they differ qualitatively in methodology.

2. EXPERT SYSTEMS

Expert systems are computer programs, designed to make available some of the skills of an expert to nonexperts. Since such programs attempt to emulate the thinking patterns of an expert, it is natural that the first work was done in Artificial Intelligence (AI) circles [1,2].

AI's scientific goal is to understand intelligence by building computer programs that exhibit intelligent behavior. It is concerned with the concepts and methods of symbolic inference, or reasoning, by a computer, and how the knowledge used to make those inferences will be represented inside the machine. AI programs that achieve expert-level competence in solving problems in task areas by bringing to bear a body of knowledge about specific tasks are called knowledge-based or expert systems. . The area of human intellectual endeavor to be captured in an expert system is called the task domain. Task refers to some goal-oriented, problem-solving activity. Domain refers to the area within which the task is being performed.

Typical tasks are diagnosis, planning, scheduling, configuration and design. Expert system have a number of major system components and interface with individuals who interact with the system in various roles. These are illustrated below in fig. 1.

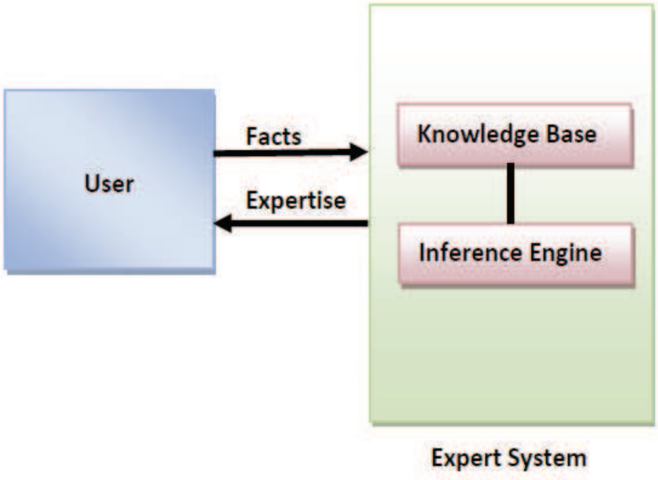

Fig: 1. Basic concept of an Expert System

3. RULE-BASED EXPERT SYSTEM

Rule-based systems require that the expert's knowledge and thinking patterns be explicitly specified. Usually, two persons (or groups) develop a system together. These are the domain expert, who knows how to solve the problem at hand but who is seldom acquainted with computer programming; and the knowledge engineer, who is thoroughly familiar with the computer technology involved and expert systems [3-5].

Represent the knowledge in expert systems may be rule-based, the rule-based approach used IF-THEN type rules and it is the method currently used in constructing expert systems. IF-THEN rules take the following form:

IF there is a *flame* THEN there is a *fire*.

The rule-based expert systems is their ability to learn by creation of new rules.

3.1 Development of a rule-based expert system: As we have mentioned, a substantial body of thought, stemming largely from the work of Artificial Intelligence pioneer Allen Newell, contends that much verbal reasoning can be successfully expressed in production rules, called here simply rules. We subscribe to this line of thought. Rules take the form "IF the data available meet certain specified conditions THEN take these specified actions", in which "actions" should

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be viewed in a very broad context, including drawing conclusions, firm or tentative. A sample simple rule might be "IF the car engine will not turn over when attempting to start THEN check if the battery is discharged". A more complex fuzzy rule might be "IF the pulmonary artery systolic pressure is considerably reduced AND the diastolic pressure is at least normal THEN the pressure reading might be damped".

3.2 Components of a rule-based expert system:The structure of a rule-based expert system is solve the problems is contained in the knolwedge base in the form of rules [6].

- knowledge acquisition facility: a way for the user to directly ener knowledge in the system, without the need for explicit knowledge coding;
- interface engine: decides which rule is satisfied by the supplied facts, prioritise the rules and execute the highest priority rule;
- user interface: it is the communaction of user-expert system;
- agenda: the prioritised list of rules whose patterns are satisfied by facts in the working memory.
- working memory: a database of facts used by the rules globally;

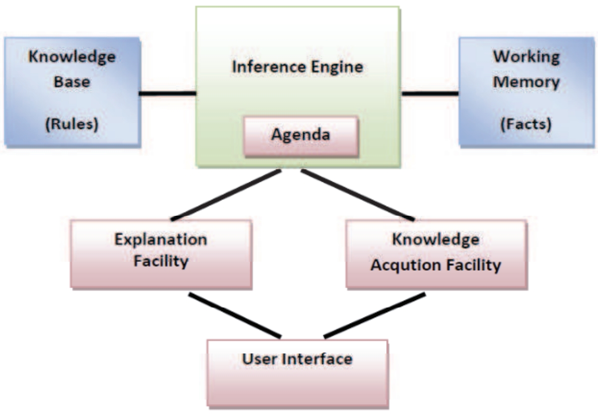

Fig:2. Structure of a rule-based expert system

4. FUZZY SETS AND FUZZY LOGICS

The Fuzzy Set approach was developed by Zadeh (1964), provides a tool for modeling human-centered systems. As a matter of fact, fuzziness seems to pervade most human perception and thinking processes [7,8].

Moreover, according to Zadeh (1973), one of the most important facets of human thinking is the ability to summarize information "into labels of fuzzy sets which bear an approximate relation to the primary data."

4.1 Fuzzy Logic: "Fuzzy logic differs from conventional logical systems in that it aims at roviding a model for approximate rather than precise reasoning." In fuzzy logic what matters is not necessarily the calculation of the absolute (pointwise) truth values of propositions; on the contrary, a fuzzy proposition induces a possibility distribution over a universe of discourse. Truth becomes a relative notion, and "true," is a fuzzy predicate in the same sense as, for instance, "tall."

Fuzzy logic is a logic represented by a fuzzy expression (formula) which satisfies the following:

- Truth values, 0 and 1, and
- variables x_i (Є[0,1], i = 1, 2, …, n) are fuzzy expressions.
- If f is a fuzzy expression, ~f (not f) is also a fuzzy expression.
- If f and g are fuzzy expressions, f □ g and f □ g are also fuzzy expressions.

4.2 Operators in fuzzy expression:

- Negation a'= 1 – a
- Conjunction a □b = min (a, b)
- Disjunction a □ b = max (a, b)
- Implication a → b = min (1, 1+b-a)

5. Fuzzy Rule-based Expert Systems

The world of information is surrounded by uncertainty and imprecision. The human reasoning process can handle inexact, uncertain, and vague concepts in an appropriate manner. Usually, the human thinking, reasoning, and perception process cannot be expressed precisely. These types of experiences can rarely be expressed or measured using statistical or probability theory. Fuzzy logic provides a framework to model uncertainty, the human way of thinking, reasoning, and the perception process. Fuzzy systems were first introduced by Zadeh (1965).[9].

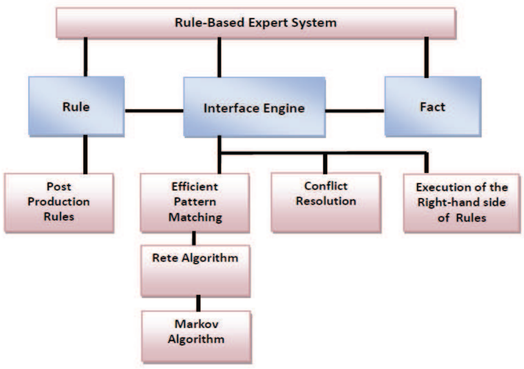

Fig: 3. The foundatation of the rule-based expert system

A fuzzy expert system is simply an expert system that uses a collection of fuzzy membership functions and rules, instead of Boolean logic, to reason about data (Schneider et al., 1996). The rules in a fuzzy expert system are usually of a form similar to the following:

- If A is low and B is high then X = medium

where A and B are input variables, X is an output variable. Here low, high, and medium are fuzzy sets defined on A,B, and X respectively. The antecedent (the rule's premise) describes to what degree the rule applies, while the rule's consequent assigns a membership function to each of one or more output variables.

Let X be a space of objects and x be a generic element of X. A classical set A, $A \subseteq X$, is defined as a collection of elements or objects $x \in X$, such that x can either belong or not belong to the set A. A fuzzy set A in X is defined as a set of ordered pairs.

$$A = \{(x, \mu_A(x)) | x \in X\} \quad (1)$$

Where $\mu_A(x)$ is called the *membership function* (MF) for the fuzzy set A. The MF maps each element of X to a membership grade between zero and one. Obviously (1) is a simple extension of the difinition of a classical set in which the characteristic function is permitted to have any values between zero and one.

The intersection of two fuzzy sets A and B is specified in general by a function

$T : [0,1] \times [0,1] \rightarrow [0,1]$, which aggregates two membership grades as follows:

$$\mu_{A \cap B}(x) = T(\mu_A(x), \mu_B(x)) = \mu_A(x) \# \mu_B(x) \quad (2)$$

where # is a binary operator for the function T.

This class of fuzzy intersection operators are usually referred to as T-norm operators.

Four of the most frequently used T-norm operators are:

Minimum: $T_{min}(a, b) = \min(a, b) = a \wedge b$ (3)

Algebraic product: $T_{ap}(a, b) = ab$ (4)

Bounded product: $T_{bp}(a, b) = 0 \vee (a + b - 1)$ (5)

$$\text{Drastic product: } T_{dp}(a, b) = \begin{cases} a, & \text{if } b = 1 \\ b, & \text{if } a = 1 \\ 0, & \text{if } a, b < 1 \end{cases} \quad (6)$$

Both the intersection and union operators retain some properties of the classical set operation. In particular, they are associative and commutative.

Figure: 5. illustrates the basic architecture of a fuzzy expert system. The main components are a fuzzification interface, a fuzzy rule base (knowledge base), an inference engine (decision-making logic), and a defuzzification interface [10, 11].

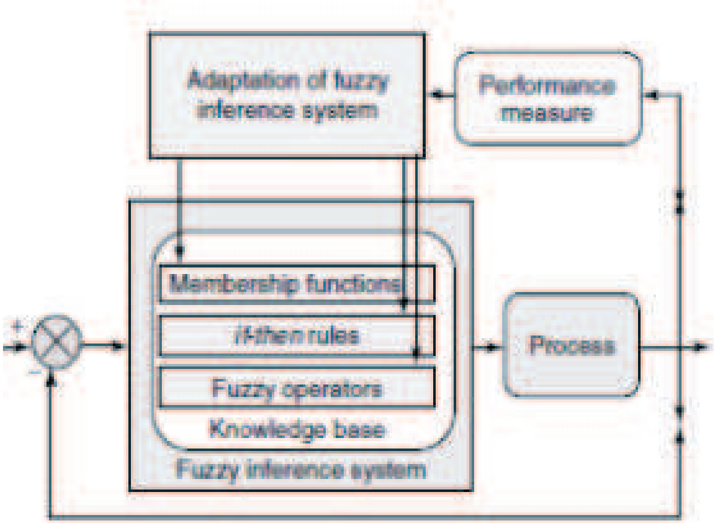

Fig: 4. Architecture of a fuzzy expert system

6. CONCLUSION

In this paper, we have model a rule-based expert systems with fuzzy set theory. We proposes the rules and methods to handel uncertainity and vagus information to solve the problem. It is observed that some theories previously dealing with expert system. We focused a new technique is fuzzy set theory to develop a member ship function (MF) and developed a practically feasible approach. For future work, we believe that the discussed approach will become suitability for develop a rule-based expert system.

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