Rule-based Expert systems

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Introduction

- Knowledge is pratical or theoretical understanding of a subject or domain.Thus who possess knowledge are called experts.

- The human mental process is internal, it is too complex to be represented as an algorithm. However, most experts are capable of expressing their knowledge in the form of rules for problem solving.

- Rules are the popular paradigm for representing knowledge. A **rule based expert system** is one whose knowledge base contains the domain knowledge coded in the form of rules.

Main Components

A typical rule-based system has four basic components

1.A list of rules or **rule base**, which is a specific type of knowledge base.

2.An inference engine or semantic reasoner

-which infers information or takes action based on the interaction of input and the rule base

-executes a production system program by performing the following match-resolve-act cycle

Match: (1st phase)

-the left-hand sides of all productions are matched against the contents of working memory

-a conflict set is obtained consisting of instantiations of all satisfied productions

-An instantiation of a production is an ordered list of working memory elements that satisfies the left-hand side of the production.

Conflict-Resolution:(2nd phase)

-one of the production instantiations in the conflict set is chosen for execution and if no productions are satisfied, the interpreter halts.

Act: (3rd phase)

-the actions of the production selected in the conflict-resolution phase are executed

-this may change the contents of working memory

3.Temporary working memory.

4.A user interface through which input and output signals are received and sent.

Formation of Rules

For any linguistic variable, there are three general forms in which the canonical rules can be formed. They are:

1. Assignment statements

These statements are those in which the variable is assignment with the value. Example :

y = low ,

Sky colour = blue ,

Climate = hot

a = 5

p = q + r

Temperature = high

2.Conditional Statements

In this statements, some specific conditions are mentioned, if the conditions are satisfied then it enters the following statements, called as restrictions.

Example:

If x = y Then both are equal,

If Mark > 50 Then pass,

If Speed > 1, 500 Then stop.

These statements can be said as fuzzy conditional statements, such as If condition C! Then restriction F!

..Formation Of Rules

3.Unconditional statements

Some of the unconditional statements are:
Go to F/o
Push the value
Stop

The control may be transferred without any appropriate conditions. The unconditional restrictions in the fuzzy form can be:

R1 : Output is B1
AND
R2 : Output is B2
AND
. . . , etc.

where B1 and B2 are Fuzzy consequents.
Both conditional and unconditional statements place restrictions on the consequent of the rule-based process because of certain conditions.

Decomposition of rules

There are various methods for decomposition of rules. They are:

1. Multiple conjunction antecedents

2. Multiple disjunctive antecedents

3. Conditional statements with ELSE

4. Nested IF–THEN rules

Aggregation of fuzzy rules

- The process of obtaining the overall conclusion from the individually mentioned consequents contributed by each rule in the fuzzy rule this is known as aggregation of rule.

(1) Conjunctive system of rules
The rules that are connected by “AND” connectives satisfy the connective system of rules. In this case, the aggregated output may be found by the fuzzy intersection of all individual rule consequents.

(2) Disjunctive system of rules
The rules that are connected by “OR” connectives satisfies the disjunctive system of rules. In this case, the aggregated output may be found by the fuzzy union of all individual rule consequents

Properties of set of rules

The properties for the sets of rules are
– Completeness,
– Consistency,
– Continuity, and
– Interaction.

(a) Completeness
A set of IF–THEN rules is complete if any combination of input values result in an appropriate output value.

(b) Consistency
A set of IF–THEN rules is inconsistent if there are two rules with the same rules-antecedent but different rule-consequents.

(c) Continuity
A set of IF–THEN rules is continuous if it does not have neighbouring rules with output fuzzy sets that have empty intersection.

(d) Interaction
In the interaction property, suppose that is a rule, “IF x is A THEN y is B,” this meaning is represented by a fuzzy relation R2, then the composition of A and R does not deliver B

Fuzzy Inference Systems

Fuzzy Inference Systems(FIS)

- Known as fuzzy rule-based systems, fuzzy model, fuzzy expert system, and fuzzy associative memory.

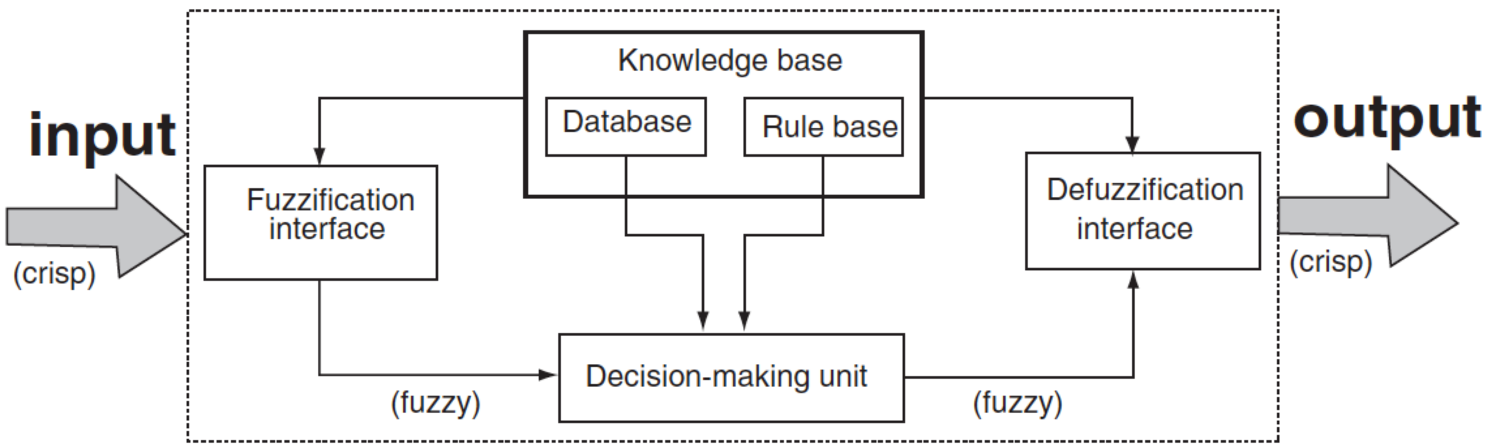
- The FIS formulates suitable rules and based upon the rules the decision is made.

- Mainly based on the concepts of the fuzzy set theory, fuzzy IF–THEN rules, and fuzzy reasoning.

Construction and Working Of FIS

Construction and Working of Inference System
-Consists of a fuzzification interface, a rule base, a database, a decision-making unit, and finally a defuzzification interface.

The function of each block is as follows:
– a rule base containing a number of fuzzy IF–THEN rules;
– a database which defines the membership functions of the fuzzy sets used in the fuzzy rules;
– a decision-making unit which performs the inference operations on the rules;
– a fuzzification interface which transforms the crisp inputs into degrees of match with linguistic values;
– a defuzzification interface which transforms the fuzzy results of the inference into a crisp output.



Working Of FIS

Working of FIS:

Conversion of crisp input to fuzzy by fuzzification
Formation of rule base
(Rule base and database are referred jointly as knowledge base)
Defuzzification-Conversion of fuzzy value to real world values

Exact steps:
1. Compare the input variables with the membership functions on the antecedent part to obtain the membership values of each linguistic label. (this step is often called fuzzification.)
2. Combine (through a specific t-norm operator, usually multiplication or min) the membership values on the premise part to get firing strength (weight) of each rule.
3. Generate the qualified consequents (either fuzzy or crisp) or each rule depending on the firing strength.
4. Aggregate the qualified consequents to produce a crisp output. (This step is called defuzzification.)

Fuzzy Inference methods

Fuzzy Inference Methods

Mamdani Fuzzy Inference Model
-Commonly used
-Introduced by Mamdani and Assilian in 1975
-Uses fuzzy sets as rule consequent

Sugeno or Takagi-Sugeno-Kang method
-Introduced by Sugeno in 1985
-Employs linear functions of input variables as rule consequent

All the existing results on fuzzy systems as universal approximators deal with Mamdani fuzzy sys- tems only and no result is available for TS fuzzy systems with linear rule consequent.

Advantages of rule-based expert system

- Natural knowledge representation – an expert usually explains the problem-solving procedure with "In such-and-such situation, I do so-and-so". represented quite naturally as IF-THEN production rules.

- Uniform structure: production rules have uniform IF-THEN structure. Each rule is an independent piece of knowledge (self-documented)

- Separation of knowledge from its process

The structure provides an effective separation of the knowledge base from the inference engine. This makes it possible to develop different applications using the same expert system shell.

- Dealing with incomplete and uncertain knowledge

Capable of representing and reasoning with incomplete and uncertain knowledge

Disadvantages of rule-based expert systems

- Opaque relations between rules.

  Although individual production rules are relatively simple and self-documented, their logical interactions within large set of rules may be opaque. Rule-based systems make it difficult to observe how individual rules serve the overall strategy.

- Ineffective search strategy

  The inference engine applies an exhaustive search through all the production rules during each cycle with a large set of rules (over 100 rules) can be slow, and thus large rule-based systems can be unsuitable for real-time applications

- Inability to learn

  In general, rule-based expert systems do not have an ability to learn from experience.

  Unlike a human expert, who knows when to “break the rules”, an expert system cannot automatically modify its knowledge base, or adjust existing rules or add new ones.