Creation of an Expert System to Estimate the Product Sale
Based on Fuzzy Logic

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Abstract: Expert systems in different domains like estimation and prediction of diverse business contexts have become highly significant. In the present study, fuzzy logic was used to design and implement an expert system which estimates the probability of buying product through parameters like buyer’s age, income level and product’s quality and price. 108 fuzzy rules were used to create data. The system presents the user the exact quantity of output variable the amount of which is defined through the two methods of converting fuzzy quantity to exact one.

Keywords: Expert System, Fuzzy Logic, Fuzzy CLIPS Software

1. Introduction

1.1. General Logic of Expert System

Expert systems are computer programs which emulate the way of thinking of an expert [1]. Therefore, an expert system is a computer system which emulates the decision-making capability of expert individuals. Figure 1 shows the fundamental conception of a knowledge-based expert system [2].
The user informs the system about fact or events and receives experience and expertise in exchange. On internal structure, one could say that an expert system is composed of two main parts. The first part is a knowledge base which utilized the both kind of knowledge based on facts and one based on uncertain knowledge. Factual or certain knowledge is a type of knowledge which can be exchanged in different domains because its truthfulness is absolute and verified. On the other hand, uncertain knowledge is based on individual conceptions. Such a base includes a knowledge based on which, the second part of inference engine concludes. These results constitute the reply of an expert system to user’s questions.

1.2. General Fuzzy Concept

Fuzziness and Ambiguity happens when the limit and boundary if a piece of information is not apparent. There is no unique qualitative value which defines the concept of youth. For some people, being in 20 year means youth while for some others it is 30 year. In fact, the concept of youth has no clear and apparent limitation. In fuzzy logic, the membership of an element in a set might be partial which is against binary membership in which membership is regarded as absolute so that an element can’t be simultaneously a member of a set and a disparate element away from it. In fuzzy logic, an element is a member of a set to a degree of possibility. Degree of membership of an element in a set is defined by a membership function which can be in a range of [0-1]. “One” denotes an absolute and confirmed membership while “zero” shows lack of an element’s membership in a fuzzy set [3]. As an example, the fuzzy term of “young” can be defined as a fuzzy set as in table 1.
<table>
<thead>
<tr>
<th>Age</th>
<th>Degree of Membership</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>1.0</td>
</tr>
<tr>
<td>30</td>
<td>0.8</td>
</tr>
<tr>
<td>35</td>
<td>0.6</td>
</tr>
<tr>
<td>40</td>
<td>0.4</td>
</tr>
<tr>
<td>45</td>
<td>0.2</td>
</tr>
<tr>
<td>50</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Table 1: Fuzzy Term of “Young”

Base on the above table, one can define the fuzzy term of “young” as a term which includes fuzzy terms of “young”, “middle-age” and “old”.

In the present study, fuzzy logic was used to design and implement an expert system which estimates the probability of buying product through parameters like buyer’s age, income level and product’s quality and price. It is supposed that all intended products are electronic and digital products (like smart phones, Laptop, Tablet, etc.) so as to contribute to precision of written rules in addition to preventing the expansion of a rule to different product types. This is because of the fact that a product might be extremely popular with an age range while not so prevalent in another one. So, digital products were chosen due to their relative popularity and preventing excessive complications. As an example of applied rules in the present study, one could say that if a young man possesses a high level of income, it is highly probable that he/she will buy products with average price and high quality. As observed in the above rule, the used words are often fuzzy and ambiguous which necessitates application of fuzzy rule in the present research methodology.

2. Implementation of an Expert System

In order to implement an expert system, different applications like Prolog, DEX, Doctus, Jess and CLIPS were developed [4]. The general logic of such applications is the same and it is based on search for an answer among organized information. Therefore, Fuzzy CLIPS software was used to implement an expert system.

Fuzzy CLIPS software is a developed version of previous version of CLIPS software which identifies fuzzy rules and realities. In general, uncertain concepts in this system is categorized in two forms of fuzzy and uncertainty. Fuzziness means that a part of information is not precise and exact. In such software, these types of information are shown within the concept of fuzzy theory [5, 6].

In order to define a fuzzy variable like age in addition to its fuzzy values in a Fuzzy CLIPS, we act in the following manner. Each of these fuzzy values is defined as a fuzzy set.
(deftemplate Age
    0 120 years
    (young 25 1 (50 0))
    (old 50 0 (65 1))
)

In this example, the numbers of 0-120 define the permissible values for the fuzzy variable of age. The rightmost number within parenthesis defines the degree of membership of leftmost number shown in parenthesis. Based on the above definition, it can be observed that a fuzzy variable called “age” with authorized values of 0 to 120 plus to fuzzy sets have been defined for the two concepts of “young” and “old”. In order to register the facts in knowledge base, the following order is used in Fuzzy CLIPS.

(assert Fact)

The word “fact” denotes a reality which is going to be registered in knowledge base. Fuzzy rules are defined in the following manner:

(defrule Rule-Name
    (Antecedent)
    =>
    (Consequent)
)

In the above definition “Rule-Name” is the name of Fuzzy rule while “Antecedent” and “Consequent” show the preceding and following elements of Fuzzy rule. It is possible to define Certainty Factor for facts and fuzzy rules. Certainty factor has a range of 0 to 1 for which 1 denotes total absoluteness the decrease of which shows decline in absoluteness. As an example, the following rule shows that if an animal is a bird, in 95 percent of conditions, the animal can fly.

(defrule flight-rule
    (declare (CF 0.95))
    (animal type bird)
    =>
    (assert (animal can fly))
)
2.1. Descriptions of Encoding

In the first section, the codes of fuzzy variables of age input, product price and income level and product quality were provided in addition to their defined fuzzy sets. The output fuzzy variable which shows the probability of buying a product is defined in this section. This output variable, after conversion to crisp value is presented to the user. As it can be observed in the following code piece, the fuzzy variable of “age” is defined in four fuzzy series. In the following, the fuzzy variable of “product price” is provided in addition to its 3 fuzzy series. Next, the fuzzy variables of level of income, product quality and probability of buying a product, each with 3, 3 and 5 fuzzy series respectively, are provided.

Fuzzy variables Definition

- Age Fuzzy Variable With 4 Fuzzy Sets
  (deftemplate Age
   10 70 Years
   (very-young (10 1) (15 0))
   (young (10 0) (30 1) (35 0))
   (middle-age (30 0) (45 1) (60 0))
   (old (45 0) (60 1) (70 1))
  )

- Price Fuzzy Variable With 3 Fuzzy Sets
  (deftemplate Price
   100 1500 USD
   (low (100 1) (300 1) (500 0))
   (middle (300 0) (750 1) (1200 0))
   (high (750 0) (1200 1) (1500 1))
  )

- Income-Level Fuzzy Variable With 3 Fuzzy Sets
  (deftemplate Income-Level
   500 3000 USD
   (low (500 1) (1000 1) (1500 0))
   (middle (1000 0) (1750 1) (2500 0))
   (high (1750 0) (2500 1) (3000 1))
  )

- Product-Quality Fuzzy Variable With 3 Fuzzy Sets
  (deftemplate Product-Quality
   0 100 Percent
   (low (0 1) (25 1) (50 0))
   (middle (25 0) (50 1) (75 0))
  )
In the second section, the code of input fuzzy variable is received from user in crisp manner, converted to fuzzy values and registered in knowledge base. After inserting values by the user, these values fire one of fuzzy rules of knowledge base and a value is registered for output fuzzy variable of knowledge base which is converted by provided techniques of Fuzzy CLIPS into a precise value and presented in output. The rules of receiving input from the user are defined in the following manner.

get input

(defrule get-information
  (declare (salience 100))
  =>
  (printout t crlf)
  (printout t crlf)
  (printout t "please enter age in years (between 10 70 years):")
  (bind ?M- (read))
  (assert (Age ((- ?M- 1) 0)((+ ?M- 1) 0)))
  (printout t "please enter price of the product (between 100 1500 USD):")
  (bind ?N- (read))
  (assert (Price ((- ?N- 1) 0)((+ ?N- 1) 0)))
  (printout t "please enter customer's income level (between 500 3000 USD):")
  (bind ?O- (read))
  (assert (Income-Level ((- ?O- 1) 0)((+ ?O- 1) 0)))
  (printout t "please enter product quality level (between 0 100 percent):")
  (bind ?P- (read))
  (assert (Product-Quality ((- ?P- 1) 0)((+ ?P- 1) 0)))

Product-Sales-Probability Fuzzy Variable With 5 Fuzzy Sets
(deftemplate Product-Sales-Probability
  0 100 Percent
  (very-low (0 1) (10 1) (20 0))
  (low (10 0) (30 1) (50 0))
  (middle (30 0) (50 1) (70 0))
  (high (50 0) (70 1) (90 0))
  (very-high (70 0) (90 1) (100 1)))

ds

After providing the rules of receiving input from the user, definition of primary fuzzy rules forms the basis of an expert system. As an example, the following rule shows that if a buyer is young, then product price will be high too along with buyer’s income level and product quality which leads to a high probability of buying a product. Based on defined fuzzy series for their associated variables in the preceding section, one can conclude that in sum, $4^3*3^3=108$ fuzzy rules will exist in our expert system.

(defrule fifty-four
  (Age young)
  (Price high)
  (Income-Level high)
  (Product-Quality high)
=>
  (assert (Product-Sales-Probability very-high)))

In final section, the provided code is converted into a precise value through application of the two techniques in Fuzzy CLIPS which are registered in the last section of FIRE rule of knowledge base. This code is presented as an output to the user. The code of this section is provided in the following.

**Defuzzify the result fuzzy set**

(defrule crisp-result-1 "with moment defuzzification"
  (declare (salience -10))
  ?f <- (Product-Sales-Probability ?)
=>
  (bind ?result (moment-defuzzify ?f))
  (printout t crlf)
  (printout t "using moment based defuzzification" crlf)
  (printout t "Product-Sales-Probability is " ?result "%" crlf))

(defrule crisp-result-2 "with maximum defuzzification"
  (declare (salience -10))
  ?f <- (Product-Sales-Probability ?)
=>
  (bind ?result (maximum-defuzzify ?f))
  (printout t crlf)
  (printout t "using maximum based defuzzification" crlf)
  (printout t "Product-Sales-Probability is " ?result "%" crlf))
3. Conclusion

One of the functions of marketing is estimation of present demand so that marketing managers need to estimate the existing and future demands of market. In a market, parameters like buyer’s age, his/her income level and product quality and price might be influential. By using an expert system, one can estimate the probability of buying a product by customers and then one can have a relatively precise estimation of market sale and customers’ categorization. Application of fuzzy logic can be influential in imprecise estimations.

References