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A Study on a Multi-Attribute Decision Making Process Using a Fuzzy Neural Network

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Abstract

In multi-attribute decision making, human beings influenced with various factors often change their decisions. This paper presents a new approach to express the changes in the decision makings when they got new information. The new approach uses the fuzzy neural network (FNN) which has been proposed by the authors. The FNN identifies the weights to the attributes with the back propagation learning. Through experiments, it is shown that the changes of subjects' decisions can be described by the changes of their weights to the attributes.

1. Introduction

The processes of multi-attribute decision makings are complex, and many researches on the decision makings have been reported[1]~[4]. The authors have also proposed a new multi-attribute decision making model based on fuzzy inferences and have proposed a fuzzy neural network (FNN) [5]~[8]. The new model divides input space into fuzzy sub-spaces, and the consequence in each sub-space has a weighted sum of the evaluated values for the attributes. The FNN identifies the weights through the back propagation learning. The feature of the new model is that the weights to the attributes can vary in every fuzzy sub-space.

In decision making, human beings are influenced with various factors, and often change their decisions. This paper presents a new approach to describe these changes with the FNN. Experiments are done to obtain data of subjects' processes of multi-attribute decision makings. The FNN identifies the changes of the subjects' weights to the at tributes. It is shown that the changes of human decisions can be described by the changes of their weights to the attributes.

2. Process of Decision Making

2.1. Decision Making Model with a Fuzzy Neural Network

The authors have proposed a multi-attribute decision making model based on fuzzy inference whose consequences are described with weighted sums of the input values [5]~[8]. This model divides input space into fuzzy sub-spaces, and the input-output relationships are identified with a weighted sum of the inputs in each sub-space. In this model, inputs are the evaluated values for the attributes of the objects, and outputs are the total evaluated values. The weights in the consequences mean the degrees of attention to the attributes. This model allows varying degree of attention to the same attributes in every sub-space. Suppose that you want to buy a car, if the candidates satisfy your budget, your choice will depend not on the price but on the other attributes of the cars. On the contrary, if you choose one beyond your budget, the price will influence your choice much more. It is easy for our model with different weights in each sub-space to describe these cases.

We have also proposed a fuzzy neural network (FNN) which was specially designed to realize following fuzzy inferences of this model given by

R^i : If x_1 is A_{i1} and x_2 is A_{i2}

then $y_i = a_{i1}x_1 + a_{i2}x_2 \quad (i=1,2,\cdots,n)$ (1)

$$y^* = \frac{\sum_{i=1}^{n} \mu_i y_i^*}{\sum_{i=1}^{n} \mu_i}, \quad \mu_i = A_{i1}(x_1)\, A_{i2}(x_2) \qquad (2)$$

where R^i is i-th fuzzy rule, A_{i1}, A_{i2} are fuzzy variables, y_i is inferred value of R^i, a_{i1}, a_{i2} are the weights for inputs x_1 and x_2, n is the number of fuzzy rules, y^* is the inferred value of the network, μ_i is the truth value in premise.

Fig. 1 shows the configuration of FNN when the attributes of the objects are two (x_1, x_2) and the membership functions in premises are two for each attributes. The units with a symbol f have sigmoid functions. Those with Σ and Π are sums and products of their inputs, respectively.

The units without any symbol just deliver their inputs to succeeding layers. The connection weights wc and wg are the parameters of the shape of membership functions. wa between (D) and (E) layers correspond to the weights in the consequences. These connection weights are modified through learning using the modified back propagation algorithm [9][10]. After the learning of the result of human decision making, we can easily find which inputs influence the output more from the identified weights.

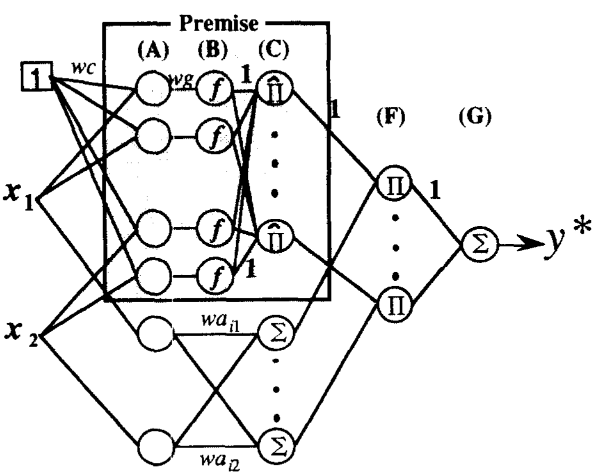


Fig. 1 Fuzzy Neural Network

2.2. Change of Evaluation

In multi-attribute decision makings, human beings put the evaluated values on the attributes of each object. They decide the total evaluated value for the object by aggregating each evaluated value on the attribute. Humans' evaluations change in their decision making processes. Especially if some new information about the objects such as advice, suggestions, etc., are given, the evaluations are greatly influenced by the information. The more important the information are, the greater the change of evaluations becomes.

Our aim in this paper is to represent these changes of evaluations with the changes of the degrees of attentions to the attributes. For example, when you know some more discount is possible, then both the evaluation for the price and the total evaluation become better. This can be described by the change of degree of attention to the price. The degree of attention to the price gets bigger, so the influence of the price to the total evaluation is larger. As a result, the total evaluation is higher than before.

The degrees of attentions before and after some information are given can be identified by the FNN. It is easy to know from the identified weights by the FNN how the degrees of attentions change.

3. Numerical Example

3.1. Experiments

We did experiments using the data of second handed motorcycles to see how the degrees of attentions to the attributes change. The data were obtained from a monthly magazine. Table 1 shows examples of the data. We asked students of our laboratory to do the following experiments:

Table 1 Data of second handed motorcycles

Name(col.)	Price(k Yen)	Mileage (km)	External
AX-1 (Blue)	255	600	almost new
RGV250Γ (BL)	298	8,297	very good
RZ250R (W/R)	235	6,600	good
FZR250 (BL)	238	11,942	so so
. . .	. . .	. . .	. . .

(1) Total evaluation

We asked the subjects to classify the data into 5 classes under the criterion : " How much do you want to buy the motorcycle ?".

We asked the subjects to evaluate the motorcycles three times. First, we showed the subjects three attributes, "*Name of the motorcycle*", "*Price*" and "*Mileage*", and asked to classify the motorcycles. After finishing this evaluation, we added one more attribute "*External Appearance*", and asked the subjects to evaluate the motorcycles again. Finally, we replaced the attribute *"External Appearance"* with a new attribute *"Location of the Shop"*.

(2) Evaluation of attributes

(a) Price and Mileage : We asked the subjects to evaluate each data of "Price" and "Mileage". Fig.2 shows examples of the obtained results from a subject.

(b) Name : The subjects were asked to put the motorcycles in the order of favorite names. This is to evaluate the style of the motorcycle not the name itself. The order was slightly adjusted with their colors.

(c) External appearance and Location of the shop : Evaluated values were given to every motorcycles.

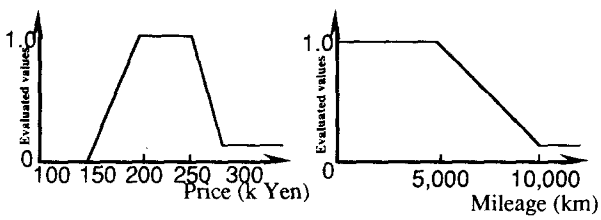


Fig 2. Evaluated values for "Price" and "Mileage"

3.2. Change of Evaluation Identified by the FNN

This paper shows the typical results of one subject. The subject was required to evaluate 33 motorcycles three times under the different conditions described above. Identified input-output relationships by the FNN are shown in Fig.3, Fig.4 and Fig.5. In these figures the evaluated values for the "Name" of the motorcycle are fixed at 0.5. The axes on the horizontal surface are the evaluated values for "Price" and "Mileage". The vertical axis is the total evaluated value inferred by the FNN after the learning. Identified weights by the FNN are also shown in the figures.

Fig.3 is the result of evaluation with three attributes, "Name", "Price" and "Mileage". Identified weights in this figure are those in the sub-space where both the evaluation of "Price" and "Mileage" are GOOD (indicated with ■) and those in "Price" is GOOD and "Mileage" is BAD (▨). Fig.4 shows the result after the information of the "External Appearance" are given to the subject. Fig.4 (a) is the case where the evaluation of "External Appearance" is BAD. The case where that is GOOD is shown in Fig.4 (b). Other parameters in Fig.4 are the same as those of Fig.3. Comparing Figs. 3 and 4, we can conclude that the information of "External Appearance" influences a little bit to the total evaluation. From Fig.4 (a), we can see that the total evaluation gets a little worse than Fig.3. On the other hand, from Fig.4 (b) where "External Appearance" is GOOD, the total evaluation becomes better. From the difference of the identified weights between Figs. 3 and 4, the weights to "Name" are especially influenced by "External Appearance". These weights become smaller or bigger by the information that "External Appearance" is BAD or GOOD, respectively. As a result, the total evaluated values change with the information of "External Appearance".

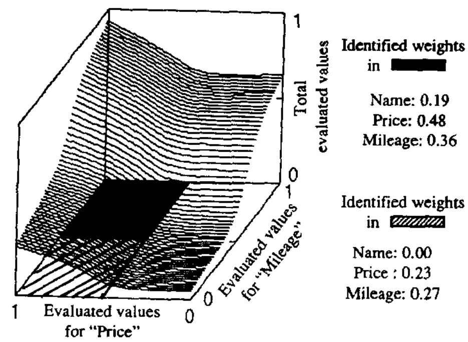
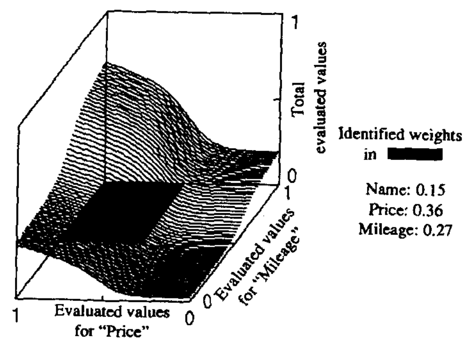
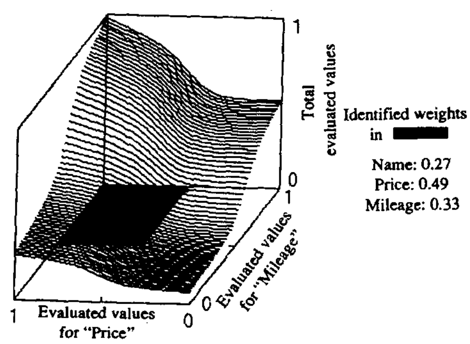


Fig.3 Identified input-output relationship by the FNN



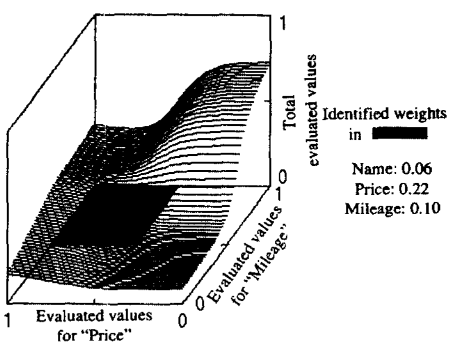
(a) "External Appearance" is BAD



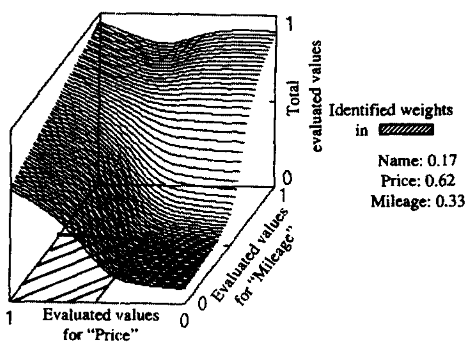
(b) "External Appearance" is GOOD

Fig.4 Identified input-output relationship by the FNN

Fig.5 shows the case where the information of "Location of the Shop" are added in place of "External Appearance". The total evaluation seems to be greatly influenced by the information of "Location of the Shop". The subject hesitated to buy a motorcycle when the shop is far from his house. This can be seen in Fig.5 (a). Fig.5 (a) shows the case where the evaluations for "Location of the Shop" are BAD, which means the shop is far. It is obvious that the total evaluated values are greatly degraded in the sub-space where both the evaluations for " Price " and " Mileage " are GOOD (■). All the weights for the attributes are also degraded. Fig.5 (b) shows the case where "Location" is GOOD. It is typical in the sub-space where "Price" is GOOD and "Mileage" is BAD. In this sub-space (▨), the total evaluated values become higher than Fig.3, and the weights to the "Price" is also getting much larger from 0.23 to 0.62.



(a) "Location of the Shop" is BAD



(b) "Location of the Shop" is GOOD

Fig.5 Identified input-output relationship by the FNN

4. Conclusions

This paper proposed a new approach to describe the changes of human decision makings. They can be represented by the changes of the weights to the attributes. The changes of the weights are easy to grasp with the identified weights by the FNN. Through the experimental results, the changes of the total evaluations of motorcycles were explained with the changes of the weights to the attributes of the motorcycles.

5. References

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