ATLANTIS PRESS
Advances in Intelligent Systems Research, volume 133
2nd International Conference on Artificial Intelligence and Industrial Engineering (AIIE2016)

The Classification Model of Customer Groups Based on Grader

Tao Xi[1,*] and Lijing Wang[2]
[1]Tianjin Polytechnic University, Machinery Institute, Tianjin, China
[2]Tianjin Chengjian University, Control and Mechanical Engineering Institute, Tianjin, China
[*]Corresponding author

***Abstract*—The customer demands were divided into dominant and implicit requirements. Classified by professional ability and social background of customer groups, classified indexes of customer groups were established to accurately obtain implicit requirements. In general, natural language expression of customers was vague and not unified. Then triangular fuzzy sets were used to realize fuzzy semantic quantization of customers. Based on self-organizing feature mapping of SOM neural network, the classification model of customers was built. 104 purchase information of customers was collected. 70 purchase information was randomly selected as the training samples. The remaining 34 purchase information was as the testing samples. Then they were respectively inputted to the classification model of SOM neural network to verify its good applicability.**

Keywords- grader; classification model of customers; fuzzy; SOM neural network

I. INTRODUCTION

Grader is mainly used to level off land, ditch, loosen and compact for highway, airport, and farmland, etc. Whether customer demands are accurately expressed, they are divided into dominant and implicit requirements [1]. If they can be consciously and clearly expressed by customer, they are called dominant requirements. They are the most direct expression of customer actual demands. The enterprises should focus on grasping and comprehending the dominant requirements. Although customers don't directly present and clearly describe implicit requirements, they not only connect with dominant requirements, but also are related with life background and characteristics of customers. In intelligent manufacturing, as important implicit requirement factors, the accuracy of customer group classification directly affects the acquisition of customer needs and the accuracy of the subsequent customization design. Customers are regarded as the driving force and final evaluators of the intelligent manufacturing. How to accurately obtain implicit requirements of customers has become one of the important issues for the intelligent manufacturing.

Dai Ruo-yi established the generalized requirements modeling method for mass customization [2]. It can effectively promote the coupling of product model and process model. But it doesn't refer to the digging of implicit requirements and the mapping process from requirement to resource. Reference [3] regarded the digging of implicit requirements as the digging of the perceptual cognition. The fuzzy cognitive map and immune genetic algorithm were used to identify, obtain and analyze for implicit requirements. Reference [4] proposed the acquiring information method based on ontology for ambiguity, professional limitation, natural language, etc.

This paper is based on grader customer demands of some engineering machinery company as an example. First of all, classified indexes of customer groups are established. Secondly, triangular fuzzy sets are used to quantify the fuzzy semantic information of customer groups. Then, based on SOM neural network, the classification model of customer groups is established.

II. CLASSIFIED INDEXES OF CUSTOMER GROUPS

Customer group characteristics are viewed as an important means and implicit requirement factors that enterprises cognize customers. Professional abilities that the customer purchases products are classified to identify the confidence degree of requirements and whether the customer needs demand guide. By group classification with social background, customers can be divided into different grades and set different standards of product satisfaction. Then it will proceed customer identification and the mapping of product customization to improve the success rate of product customization.

Relevant indexes of customer's social background characteristics can be judged according to customer group's geographical, social and psychological information and the possible relationship between products. Relevant indicators of professional purchasing characteristics can be analyzed according to the similarity of professional knowledge, attitude, proficiency, customer learning ability and so on. Based on grader, relevant indexes of customer purchasing ability are working time, the number of purchase and the understanding degree for products. Relevant indexes of customer's social background characteristics are funds, residence and enterprise scale. Customer groups are classified as basic, expected and excited customer demands.

(1) Basic customer demands

Customers put forward basic demands for enterprise's product (or service). For customers, these demands are properties or functions that products (or services) must possess. But when performance and services of some products exceed customer expectation, customers will not show more favorable impression.

(2) Expected customer demands

It means that satisfaction degree of customers is in ratio with demand degree. When products (or services) that companies provide are beyond the customer expectation, satisfaction degree of customer is better and vice versa. In market research, the hottest topic is expected demands for customer.

(3) Excited customer demands

It refers to the specific demands that customers put forward. When these demands are met, the customer is showing very high satisfaction. It needs enterprises to provide some unexpected product attributes, or services that bring surprise for customers in order to improve customer loyalty.

Classified indexes of grader customer groups are shown in table I.

This paper takes grader customer demands of some engineering machinery company as example. 104 customer demands that purchase grader are collected. They are sorted in random. Then the sorted table of customer groups is established. It is shown in table II.

III. Quantitative Processing of Fuzzy Semantic Information

Because of the customer profession, habits and themselves' preference, different customers will choose different natural language to express their ideas in extraction of actual customer demands. These natural languages usually are fuzzy and not unity. Based on the related expert experience, fuzzy sets are used to effectively convert fuzzy language variables of different granularity into triangular fuzzy number with unified goal. Then binary defuzzification is used to realize quantitative processing of fuzzy semantic information.

Professor L.A.Zadeh defined fuzzy language variables as a five element group $(X,\ U,\ S_{(x)},\ G,\ M)$ [5]. where X is the fuzzy language variable name. U is universe. $S\ (x)$ is the set of x that is called language variable granularity. G is the rules of grammar that make standards of x. M is the semantic rules to define algorithm of each language variable. Fuzzy is used to approximately convert the language into fuzzy membership degree. For $S_{(x)} \rightarrow \mu_{A(x)}$, $\mu_A(x)$ is the membership degree of $A \in x$. It will realize quantitative processing of fuzzy semantic information [6]. The membership function $\mu_A(x)$ of triangular fuzzy number A is as following.

$$\mu_A(x) = \begin{cases} \frac{1}{m-x}x - \frac{l}{m-l} & x \in [l,m] \\ \frac{1}{m-u}x - \frac{u}{m-u} & x \in [m,u] \\ 0 & x \in (-\infty,l] \cup [u,+\infty) \end{cases} \tag{1}$$

where l and u are the lower bound and upper bound value of fuzzy number A, respectively. m is the mid value, when the membership degree of A is 1. $l \le m \le u$.

When $x = m$, it means that x belongs to fuzzy number A. When $x \in (-\infty,l] \cup [u,+\infty)$, it means that x doesn't belong to fuzzy number A. The distribution function diagram is shown in figure I.

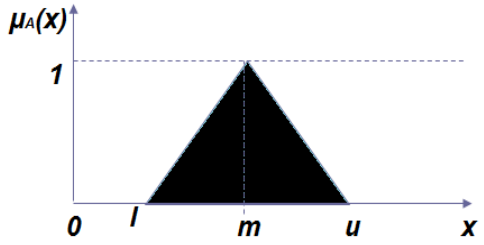

FIGURE I. THE DISTRIBUTION FUNCTION OF TRIANGULAR FUZZY NUMBER

Customer demands of triangular fuzzy need remove fuzziness for the subsequent custom mapping. Usually, the expectation method is used to remove fuzziness. The defuzzy value $\widetilde{\mu_A}(S_T)$ of $\mu_A(S_T)$ is as following.

$$\widetilde{\mu_A}(S_T) = \frac{u+2m+l}{4} \tag{2}$$

According to equation (2), 104 customer group samples of table II are done the semantic fuzzy quantization. The quantization results are shown in table III.

IV. The Classification Model of Customer groups Based on SOM

Classification of customer groups is mainly based on specified behavior and the division of clusters. The division of clusters can not only reflect the characteristic index of segment customers, but also get comprehensive view for customers. Clustering algorithm of data mining is often used to form clusters such as neural network. Neural network can implement learning and adaptivity of uncertain systems under unsupervised learning [7]. The Self-Organizing Mapping (SOM) neural network is the neural model of self-organizing function and unsupervised learning [8]. At present, it has been widely applied in identification of clustering system. SOM neural network is a kind of lateral inhibition phenomena to simulate biological nervous system [9]. When a nerve cell is exciting, it will inhibit other nerve cells around them and form competition between nerve cells. Then the winner will be exciting and the loser will be eliminated. The network structures are usually formed by input layer and mapping layer. Each neuron can realize two-way link between two layers. The characteristics of SOM neural network are suit for the studying of complex and changeable characters of customer groups.

SOM neural network has the self-organizing mapping algorithm. It can automatically seek the similarity neurons constructed by input data, inhibit near neurons and keep similar neurons together so as to selectively respond to input data [10]. The learning steps are as following.

Step 1 Network initialization

Initial weight is randomly set between input and mapping layer. The smaller connection weight is given from m input to output neurons. The j sets of neighboring neurons are selected

from output neurons. Assembly area $S_j(t)$ is steadily reduced.

Step 2 Input vector

Input vector $\mathbf{X}=(x_1,x_2,x_3,\cdots,x_m)^T$ is assigned to the input layer.

Step 3 Calculate the distance of input vector and weight vector sum of the mapping layer

The distance is calculated between the *j*th neuron and the input vector in mapping layer. The distance is calculated between weight of each neuron and input vector in mapping layer. The Euclidean distance is used.

$$d_j=\|\mathbf{X}-\mathbf{W}_j\|=\sqrt{\sum_{i=1}^{m}(x_i(t)-w_{ij}(t))^2} \tag{3}$$

where W_j is the initial weight between the input layer and *jth* mapping layer. w_{ij} is the weight between neurons of the *ith* neuron of input layer and *jth* neuron of mapping layer.

According to equation (3), neuron with minimum distance is defined as the winning neuron j^*. All of j^* is collected as *k* set. Any *j* in *k* set meets $d_k=\min_j(d_j)$.

Step 4 Modified weight

The weight of the winning neuron and its adjacent neuron is modified. The equation is as following.

$$\Delta w_{ij}=w_{ij}(t+1)-w_{ij}(t)=\eta(t)(x_i(t)-w_{ij}(t)) \tag{4}$$

where η is constant, $0<\eta<1$ and tends to zero with increasing time.

$$\eta(t)=\frac{1}{t} \quad \text{or} \quad \eta(t)=0.2(1-\frac{t}{10000}) \tag{5}$$

Step 5 Calculate the output $o_k=f(\min_j\|X-W_j\|)$, where $f(*)$ is a function of (0, 1).

Step 6 Judge whether the training is over

If it achieves the given minimum distance, the training is over. Otherwise, it will return to step 2 to circulate.

V. EXAMPLES

A. Establish SOM Neural Network Classification Model

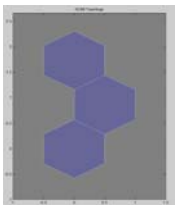

FIGURE II. THE SOM NETWORK TOPOLOGY

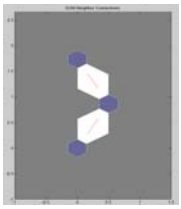

FIGURE III. THE CLASSIFICATION OF THE NEIGHBORING NEURONS

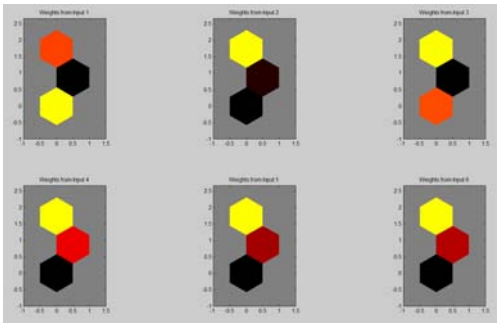

FIGURE IV. THE CLASSIFICATION OF EACH NEURON

70 samples are randomly selected as training samples in 104 samples of table III. The remaining 34 samples are looked as test samples. Then the SOM network topology, the classification of the neighboring neurons and the classification of each neuron are respectively shown in figure II, III and IV.

B. The Classification Model Test

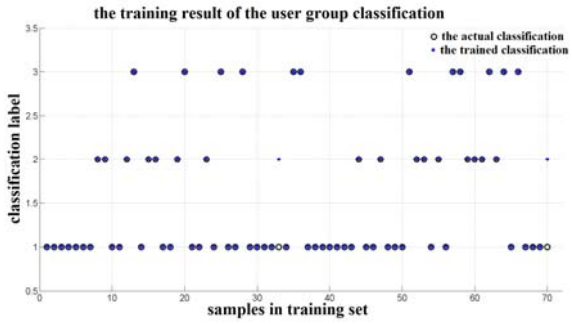

FIGURE V. THE ACTUAL AND PREDICTION CLASSIFICATION FIGURE OF 70 TRAINING SAMPLES

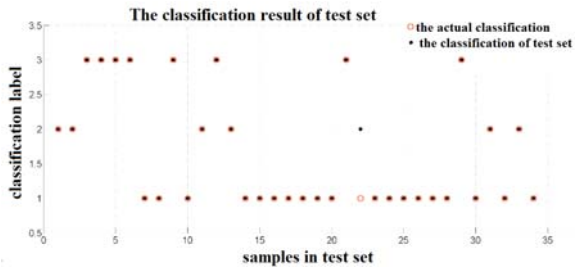

FIGURE VI. THE ACTUAL AND PREDICTION CLASSIFICATION FIGURE OF 34 TEST SAMPLES

The training and predicting results of classification model are respectively tested.

First of all, attribute values of 70 training samples are

inputted to the classification model. The calculated classification codes are compared with actual customer classification code. The result is shown in figure V. Then attribute values of 34 test samples are inputted to the classification model. The calculated classification codes are compared with actual customer classification code. Then the result is shown in figure VI.

The 33th and 70th training sample are wrongly classified in figure V. So the training accuracy of classification model is about 97.14%. The 22th test sample is wrongly classified in figure VI. So the predicting accuracy of the model is about 97.05%. Therefore, the clustering model of customer groups has good applicability based on SOM neural network.

VI. CONCLUSION

In the intelligent manufacturing, customer demands are divided into dominant and implicit requirements. The customer doesn't put forward implicit requirements, but they not only connect with dominant demands, but also are related with life background and characteristics of customers. When customer groups are accurately classified, implicit requirements of customer can be excavated to accurately capture customer demands.

(1) Establish the classified index of customer groups

According to grader characteristics, related indicators are determined for professional purchase ability and social background of customer. Customer groups are classified as basic, expected and excited customer demands.

(2) Quantify fuzzy semantic information

Different customers will choose a set of different natural language to express their idea. Yet these natural languages usually are fuzzy and no unity. Fuzzy sets are used to effectively convert fuzzy language variables of different granularity into triangular fuzzy number with unified goal, in order to realize quantitative processing of fuzzy semantic information.

(3) Establish the classification model of customer groups based on SOM

SOM has the self-organizing feature mapping algorithm. Based on SOM neural network, it can effectively reflect characteristic indices of segmented customers and get more comprehensive view.

(4) 104 purchase information of customers is collected. 70 purchase information is randomly selected as the training samples. The remaining 34 purchase information is the testing samples. Then they are respectively inputted to the classification model of SOM neural network to verify its good applicability.

ACKNOWLEDGMENT

This work is supported by the Natural Science Foundation of Tianjin (15JCYBJC47900), Science and Technology Correspondent of Tianjin (15JCTPJC59800 and 14JCTPJC00541) and Achievement Transformation of Tianjin Chenjian (KJZH-A2-1625). The authors would like to express their gratitude.

REFERENCES

[1] Luo Yi-jing, "The research of product design method based on implicit demand," Nanjing University of Aeronautics and Astronautics. China, 2009.

[2] DAI Ruo-yi , TAN Jian-rong , LI Tao, "Research on general requirement modeling and enable technology for mass customization," Journal of Computer-Aided Design & Computer Graphics. China, 2003, 15(4) : 467—474.

[3] Li Yu-meng, "Mining the user's implicit demand," Beijing Printing Institute. China, 2015.

[4] XIE Jian-zhou, YANG Yu, ZHANG Xiao-wei, etc, "Generalized customer requirement and it's resolute allocation based On FCM and IGA," Computer Integrated Manufacturing Systems. China, 2015, 21(3) : (634-647).

[5] Wang Lijing, Xi Tao, "The Mapping Model of Design Parameters in Product Customization Driven by Uncertain Users," The Chinese Mechanical Engineering. China, 2013,24(17) : (2346-2351).

[6] KANG I, LEE S, CHOI J, "Using fuzzy cognitive map for the relationship management in airline service," Expert Systems with Applications, 2004, 26(4) : 545—555.

[7] lE Hong-chi, "Increasing the density functional theory calculations homolytic precision of Y - NO system: neural network and support vector machine (SVM) method,"The Northeast Normal University. 2011.

[8] CHEN Bo-cheng, LIANG Bin, ZHOU Yue-bo, LING Xi-quan, "An application of SOM Neural Network in customer classification," Systems Engineering—Theory & Practice. 2004,24(3) : (546-558).

[9] XIA Ling, GU Han-yu, "SOM-based approach for addressing multi-criteria scheduling problems," Computer Integrated Manufacturing Systems. China, 2008, 14(4) : (1132-1142).

[10] WU Yi, ANG Qiong, WU Qing-xiang, SHEN Lian-feng, LIN Xiao, "Networking algorithm based on self-organizing map neural network for VANET," Journal on Communications. China,2011, 32(12) : (113-126).

TABLE I. CLASSIFIED INDEX OF CUSTOMER GROUPS

Classified indexes	**Customer background**	Funds	Residence	Enterprise scale
	Professional purchasing power	Professional time	The number of purchase	The understanding degree for products
Categories of customer groups		Basic demands	Expected demands	Excited demands

TABLE II. SORTED TABLE OF CUSTOMER GROUPS

Number	Customer purchase background characteristics						Categories
	Funds	Residence	Enterprise scale	Professional time	The number of purchase	The understanding degree for products	
1	middle	developed	larger	long	3	high	excited demands
2	high	richer	larger	middle	1	middle	expected demands
	…			…		…	
18	low	developed	smaller	long	1	higher	basic demands
19	lower	poor	middle	long	2	higher	basic demands
	…			…		…	
103	middle	rich	smaller	middle	1	middle	basic demands
104	middle	poorer	middle	short	0	low	expected demands

TABLE III. THE QUANTITATIVE PROCESSING RESULT OF CUSTOMER GROUPS

number	**funds**	**residence**	**enterprise scale**	**professional time**	**the number of purchase**	**the understanding degree for products**	**The number of original classification**	**The fitted classified number**
1	0.5	0.5	0.75	0.95	3	0.95	3	3
2	0.95	0.75	0.75	0.5	1	0.5	2	2
	…			…		…		
18	0.75	0.5	0.75	0.95	4	0.95	1	1
19	0.25	0.25	0.5	0.95	2	0.75	1	1
	…			…		…		
103	0.75	0.75	0.95	0.5	1	0.5	1	1
104	0.25	0.5	0.5	0.5	1	0.25	2	2