Customer satisfaction assessment index system for commercial vehicles based on fuzzy comprehensive assessment

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ABSTRACT

With the rapid growth of social productive forces, changes in market supply and demand structure and increasing market competition, the standard for judging products has gradually changed from the previous product performance to the customer's satisfaction with products. According to the investigation and analysis of customer satisfaction, it can help automobile enterprises to allocate resources reasonably, grasp consumers' purchase intention, tap potential consumers and improve sales quantity and quality. In this paper, an algorithm for evaluating the customer satisfaction of commercial vehicles based on fuzzy comprehensive assessment and artificial neural network (ANN) is proposed. Firstly, the assessment system of customer satisfaction is qualitatively described by linguistic variables, and experts score according to the importance of each assessment factor, and then the quantitative assessment results are counted, and then the membership degree theory of fuzzy mathematics is applied to evaluate and identify the customer satisfaction of commercial vehicles. The results show that the error of the proposed commercial vehicle customer satisfaction assessment algorithm is small, and the accuracy is excellent, which can reach more than 96%. This proves that ANN and fuzzy comprehensive assessment have a good effect on evaluating customer satisfaction of automobile enterprises.

Key words: Automobile enterprises; Satisfaction; Artificial neural network; Fuzzy comprehensive assessment

1. INTRODUCTION

In the environment of accelerating economic globalization, the social and economic growth of all countries in the world has encountered unprecedented challenges, but also brought great opportunities to the growth of all countries in the world [1]. With the rapid growth of China's automobile industry, automobile production and sales have hit record highs. Among the automobile sales enterprises, the automobile 4S sales enterprise, which integrates vehicle sales, spare parts supply, after-sales service and information feedback, is the most common form of automobile sales in China at present [2]. Customer satisfaction refers to the degree of customer satisfaction and is a quantitative statistical index of customer satisfaction. Improving customer satisfaction can increase the number of customers and reduce the cost of developing new customers, which has long-term significance for enterprises [3]. With the increasingly fierce competition in the automobile market, automobile dealers and manufacturers pay more and more attention to consumer satisfaction. As a new economic quality index, customer satisfaction can be widely used in the assessment of product quality and service quality, and can also be used in the assessment of enterprise performance [4]. Therefore, customer satisfaction is a comprehensive index to measure the quality of products or services, and it is also a beneficial index to measure the business performance of enterprises.

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Seventh International Conference on Mechatronics and Intelligent Robotics (ICMIR 2023), edited by Srikanta Patnaik, Tao Shen, Proc. of SPIE Vol. 12779, 127791M · © 2023 SPIE · 0277-786X · Published under a Creative Commons Attribution CC-BY 3.0 License · doi: 10.1117/12.2688722

Customer satisfaction can directly reflect the product quality and service quality of 4S stores. Therefore, according to the investigation and analysis of customer satisfaction, it can help automobile enterprises to allocate resources reasonably, grasp consumers' purchase intention, tap potential consumers and improve sales quantity and quality [5]. When the various services of automobile enterprises are in place, buyers' satisfaction will be higher and higher, so they can gather by means of progressive consumption and introduction consumption, and dispose of other customer resources from competitors, resulting in a certain degree of customer loyalty [6]. It is of great significance to carry out customer satisfaction research to improve the quality of national or regional economic operation, improve the product quality and operating performance of enterprises, purify the market environment and standardize the market order, increase market share and improve the quality of life of the people [7]. Customer satisfaction measurement is an important means to implement customer satisfaction management in large supermarkets. Through customer satisfaction assessment, on the one hand, we can understand the present situation of enterprise service, on the other hand, we can grasp the main factors affecting customer satisfaction and the areas that need improvement [8]. In this paper, an assessment algorithm of commercial vehicle customer satisfaction based on fuzzy comprehensive assessment and ANN is proposed. Firstly, the assessment system of customer satisfaction is qualitatively described by linguistic variables, and experts score according to the importance of each assessment factor, and then the quantitative assessment results are counted, and then the membership degree theory of fuzzy mathematics is applied to evaluate and identify the customer satisfaction of commercial vehicles.

2. ASSESSMENT MODEL OF COMMERCIAL VEHICLE CUSTOMER SATISFACTION

2.1 Influencing factors of customer satisfaction

Customer's satisfaction with the car depends on many factors, including objective hard factors and subjective personal feeling factors. In the eyes of different users, the satisfaction of the same car is different. Even if the satisfaction with the car is the same, the feelings of service, attitude and after-sales maintenance in the car sales process are different, which leads to different overall satisfaction [9]. How to build a comprehensive, scientific and reasonable index system is an important factor to judge the final result of satisfaction. The definition of customer satisfaction is an important method to measure the degree to which an enterprise's products or services reach their goals, and it is also a way to evaluate the qualification of enterprises in the face of market economy environment. Competition makes enterprises in all industries pay more attention to customer attitude in production, sales and service, and take customer requirements as the core utilization, so as to better and better meet customer needs.

The establishment of satisfaction index system is a systematic and complicated work, which should not only consider the quality of automobile hardware, but also consider the subjective feelings of customers before and after buying a car. There are many factors that affect automobile satisfaction, including some indicators of automobile products themselves and the satisfaction of service quality in the sales process and later maintenance [10]. For consumers, automobile consumption has the characteristics of large one-time expenditure and long service life. Therefore, when purchasing a car, consumers should not only pay attention to the performance of a certain aspect of the car, but also consider the overall performance of the car. The car appearance, car acceleration performance, car driving performance, car operating performance, car safety and economy should all be considered as factors. Taking customer satisfaction as an effective assessment method can not only get the influencing reasons of customer satisfaction in production and sales links faster and better, but also evaluate the performance of producers and service providers, become the benchmark of level comparison and evaluate the effects of different improvement measures.

Whether the automobile satisfaction index system is established properly or not directly affects the credibility of the assessment results, so the determination of indicators should be the core of assessment. The first level indicators in customer satisfaction assessment indicators are often invisible variables, which can not be directly evaluated. Therefore, in order to quantify the final result, it is necessary to expand the invisible indicators step by step until a series of indicators can be directly measured are formed. The quantitative value of customer satisfaction is to objectively evaluate the quality of services and products provided from the perspective of consumers, and can also be regarded as a measure of the ability of a production and sales enterprise. With the help of reasonable assessment of customer satisfaction, we can comprehensively assess the specific service quality in the field of automobile manufacturing and sales service, and analyze and find out the existing defects and deficiencies in the commodity trading and circulation process of the sales department.

2.2 Customer satisfaction assessment algorithm

Through long-term sales, automobile maintenance service and even questionnaire survey, automobile 4S service enterprises obtain customer information, including customer service history, customer driving habits and methods, customer income and demographic data, etc., and comprehensively establish a customer resource base from numerous information resources. The assessment of customer satisfaction is essentially a process of transforming qualitative information that cannot be accurately expressed into quantitative and accurate digital analysis, that is, a process of quantitatively reflecting customer attitudes and opinions with numbers [11]. According to the principles of systematicness, measurability, representativeness, distinctiveness and utility, the assessment factor set of supermarket customer satisfaction is established. The assessment index reflects the influencing factors of customer satisfaction in large supermarkets from different aspects, and the assessment factor set consists of the same level indicators of the assessment index system. Customers' attitudes and opinions can't be directly measured, but some attitude measurement techniques can be used to quantify them, which can objectively and conveniently express those perceptual factors that are difficult to express. The ANN model for fuzzy comprehensive assessment of customer satisfaction of automobile enterprises is shown in Figure 1.

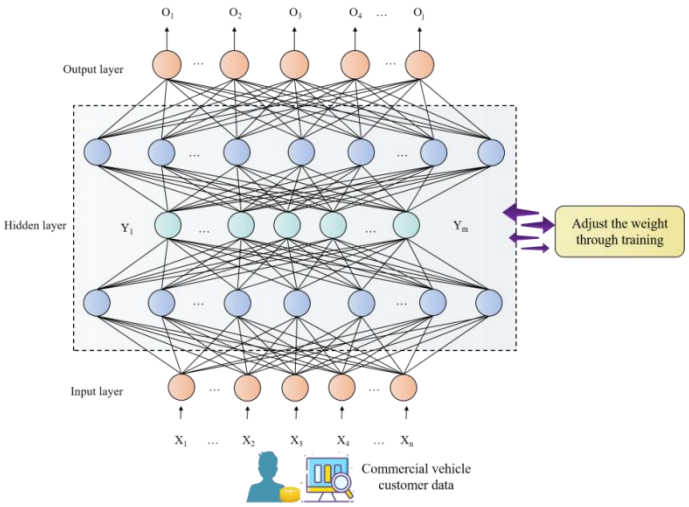

Figure 1. ANN model for customer satisfaction assessment of automobile enterprises

After completing the parameter setting and data preprocessing, enter the training stage. At this stage, the model is trained according to the previously set parameters. If the training is successful, the model can be generated according to the needs of users for assessment [12]. Generally speaking, the scores of various assessment factors of the appraisee are the average of the scores of all the appraisers. This method is simple and intuitive, and can well reflect the actual situation of the appraisee when there are a large number of appraisers. The disadvantage of this method is that it can't effectively eliminate abnormal data, that is, it can't objectively evaluate the evaluated data. The assessment model of customer satisfaction is based on the theory of consumer psychology and consumer behavior, and is established by repeated verification and improvement with a large number of statistical data. Determine the assessment items of customer satisfaction, that is, analyze and determine the main decisive factors affecting customer satisfaction according to each organization's own situation, and then evaluate these factors.

Generally speaking, the degree of influence of factors on the evaluated is different. In order to reflect the importance of assessment factors, it is necessary to give different weights to each assessment factor subjectively from the actual needs. Suppose that the customer satisfaction document of the automobile enterprise is expressed as:

$$D = \{M, N\} \tag{1}$$

Where M stands for short-term satisfaction and N stands for long-term satisfaction. Due to the variety of satisfaction, M and N are expressed as:

$$M = \{S_1, S_2, \ldots, S_n\} \tag{2}$$

$$N = \{L_1, L_2, \ldots, L_n\} \tag{3}$$

Customer satisfaction is expressed as:

$$U = \{S_1, S_2, \ldots, S_n, L_1, L_2, \ldots, L_n\} \tag{4}$$

For each S_i, L_j, category attribute variables E_i, E_j and weight attribute variables F_i, F_j are introduced, so S_i, L_j are expressed as:

$$S_i = \langle S_i, F_i, E_i \rangle, i = 1,2,\ldots,m \tag{5}$$

$$L_i = \langle L_j, F_j, E_j \rangle, i = 1,2,\ldots,n \tag{6}$$

Customer satisfaction documents can be expressed in the form of a two-dimensional table:

$$D = \begin{Bmatrix} S_1 & S_2 & \ldots S_m & L_1 & L_2 & L_n \\ F_1 & F_2 & \ldots F_m & F_{m+1} & L_{m+2} & L_{m+n} \\ E_1 & E_2 & \ldots E_m & E_{m+1} & E_{m+2} & E_{m+n} \end{Bmatrix} \tag{7}$$

S_m and L_m are some attribute values of short-term satisfaction and long-term satisfaction respectively; E_{m+n} stands for the product category corresponding to customer satisfaction; F_{m+n} represents the satisfaction weight of attribute value vocabulary.

Taking customer satisfaction index as an important service quality assessment method can exert influence on enterprise management strategy in the near future and in the long term. Therefore, in the whole manufacturing and sales service process, ensure that the quality of products or services meets the requirements of customers, so that customers can follow the enterprise and brand more, and manufacturers can get more benefits.

3. RESULT ANALYSIS AND DISCUSSION

The service satisfaction index system of automobile 4S enterprises should comprehensively, completely and systematically reflect all the factors of automobile 4S enterprises' service, and realize the whole life cycle consideration, from the first contact with products or services to the later maintenance and coordination of products or services. In order to verify the effectiveness of the algorithm, simulation should be carried out based on Matlab software. The abnormal value removal processing of commercial vehicle customer satisfaction data is shown in Figure 2.

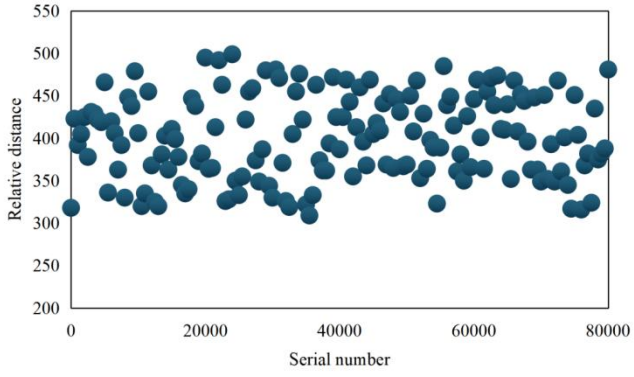

Figure 2. Processing of removing outliers from robot perception data

Using these data to train the designed ANN, we can get better network weights. Then, substituting the obtained network weights into ANN can become the basic model of customer satisfaction assessment of commercial vehicles.

The learning rate determines the change of weights produced in each cycle training. Excessive learning rate may cause system instability; If the learning rate is too small, it will increase the training time and make the convergence speed slow, but it can ensure that the error value does not jump out of the trough of the error surface and eventually tends to the minimum error value. Therefore, in general, we tend to choose a smaller learning rate to ensure the stability of neural network learning. Compare the ANN output data with the real commercial vehicle customer satisfaction data, as shown in Table 1 and Figure 3.

Table 1. Learning results of machine learning

Sample set	Neural network assessment	Expert appraisal
40	0.83	0.842
80	0.789	0.801
120	0.8	0.812
160	0.754	0.766
200	0.848	0.86
240	0.815	0.807
280	0.812	0.826

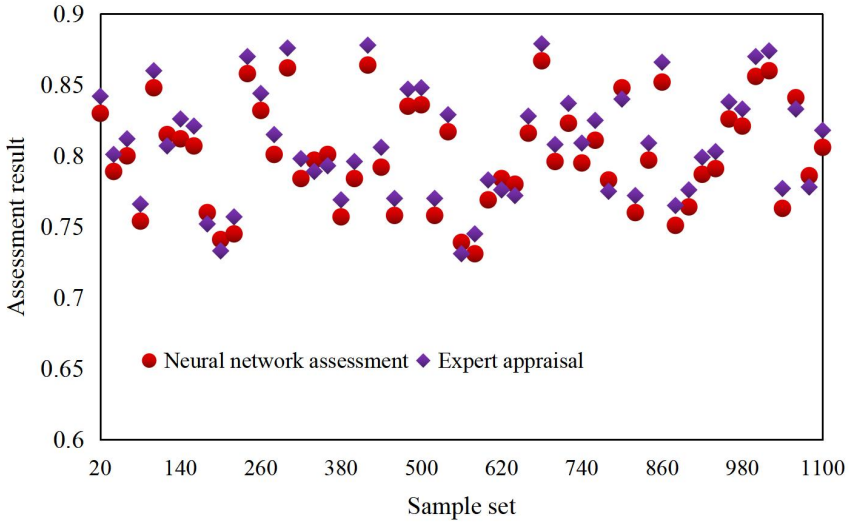

Figure 3. Learning results of machine learning

The result of ANN learning is convergent, which can approximate the original data well, and has the basis for forecasting customer satisfaction data. When the maximum number of iterations is exceeded, the training still cannot meet the training accuracy requirements, that is, the mean square error of the sample is less than the cut-off error, and the training is considered to have failed. Generally speaking, there is a positive relationship between the maximum number of iterations and the sample size, and there is a negative relationship between the maximum number of iterations and the cut-off error.

In the design process of an ANN, it is usually necessary to train at different learning rates for many times, and observe the decline rate of the sum of squares of errors after each training to judge the choice of learning rate. If the decline rate of the sum of squares of errors is fast, it means that the learning rate is appropriate; if the sum of squares of errors

oscillates, it means that the learning rate is too high. The algorithm experiments are carried out under different transaction sets, and the error of the customer satisfaction assessment algorithm is shown in Figure 4. The comparison result of the accuracy of the algorithm is shown in Figure 5.

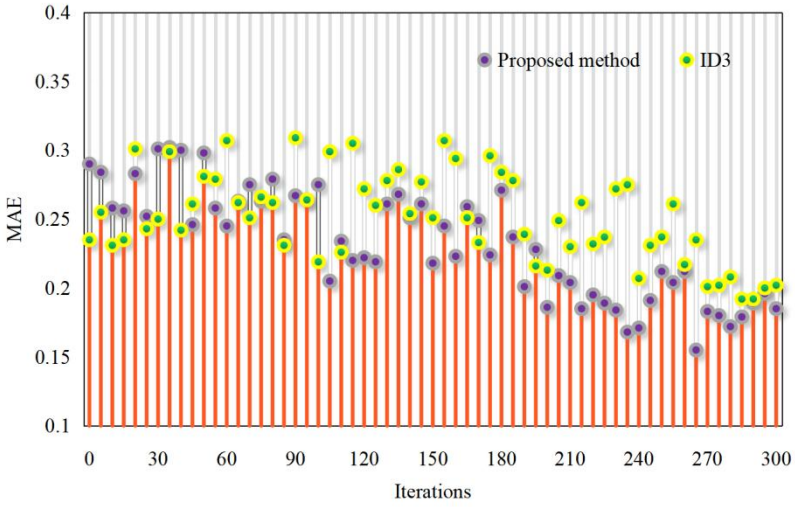

Figure 4. Error comparison of different algorithms

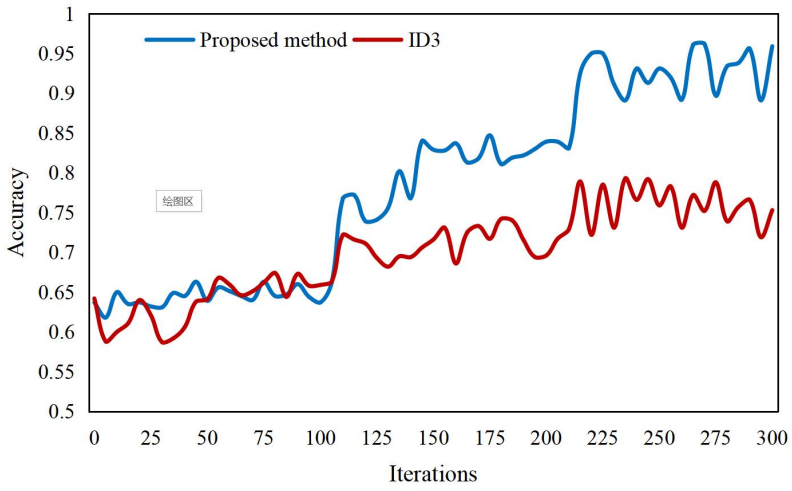

Figure 5. Comparison of accuracy of different algorithms

Experiments show that the error of the proposed assessment algorithm of commercial vehicle customer satisfaction is small, and the accuracy is excellent, which can reach more than 96%. Based on the error and accuracy of different algorithms, it can be seen that the performance of the commercial vehicle customer satisfaction assessment algorithm in this paper is relatively superior. It can fully serve the innovation of marketing mode of automobile 4S enterprises and improve the competitiveness of automobile 4S enterprises in the automobile industry.

4. CONCLUSION

As a new economic quality index, customer satisfaction can be widely used in the assessment of product quality and service quality, and can also be used in the assessment of enterprise performance. Therefore, customer satisfaction is a

comprehensive index to measure the quality of products or services, and it is also a beneficial index to measure the business performance of enterprises. In this paper, an assessment algorithm of commercial vehicle customer satisfaction based on fuzzy comprehensive assessment and ANN is proposed. The assessment system of customer satisfaction is qualitatively described by linguistic variables, and the experts score according to the importance of each assessment factor, and the quantitative assessment results are counted. This method can not only accurately describe the customer's subjective satisfaction with each assessment grade, but also describe the customer's uncertain satisfaction, and solve the qualitative problems with fuzziness and uncertainty by quantitative methods, thus reflecting the customer's subjective assessment more accurately. Based on the error and accuracy of different algorithms, it can be seen that the performance of the commercial vehicle customer satisfaction assessment algorithm in this paper is relatively superior. It can fully serve the innovation of marketing mode of automobile 4S enterprises and improve the competitiveness of automobile 4S enterprises in the automobile industry. Customer satisfaction covers all aspects of customers' perception of enterprises. The assessment index system established in this paper will inevitably miss some assessment indexes that affect customer satisfaction, and the assessment index system can be further studied and expanded.

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