Research on standard quality evaluation method based on fuzzy neural network

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ABSTRACT

In view of the characteristics of standard quality evaluation index diversification, multi-dimension and the result susceptible to subjective factors, a standard quality evaluation model based on T-S model of fuzzy neural network is established by introducing fuzzy system theory. This model combines the advantages of fuzzy system and neural network, such as good fuzzy knowledge expression ability and adaptive ability. It has the advantages of optimal result approximation, short training time and fast convergence speed. This model was used to evaluate the quality of 7 standards in the field of petroleum engineering. The results show that the fuzzy neural network method could solve the fuzzy data processing problem in standard quality evaluation, and the reliability of the evaluation model could also meet the requirements of standard quality evaluation.

Keywords: Standard quality, evaluation, fuzzy neural network

1. INTRODUCTION

Standards play an important role in promoting industrial technological progress, standardizing work order and improving product quality[1]. As an important basis for quality evaluation, standards have become one of the important factors affecting national development and international competition. But how to define and evaluate standard quality, the academia has not given a clear and recognized conclusion. At present, the evaluation of standards mainly depends on the experience of experts. Mathematical evaluation methods include score weighting method, statistical analysis method, Delphi method, etc. However, when there are more factors to be evaluated and more sub-factors are mixed among different factors, it will be difficult to objectively judge the merits and demerits of various methods. In this case, it will be very difficult to judge the standard quality only by experience[2-4]. Although now a lot of standard assessment also began to use analytic hierarchy process and fuzzy mathematics method to analyse the decision, but is still in the process of using these methods use experience estimate method to give the weight of each index[5-7], which to some extent, still rely on subjective experience judgment of evaluators, and the objective factors should be considered to consider comprehensive enough, And comprehensive evaluation of fuzzy neural network method, it is aimed at the difficulty of decision-making in both quantitative and qualitative evaluation indicators for the specific and accurate and avoid the depends on the subjective to the weight of each index is given and the objective factors should be considered to consider comprehensive enough or not enough accurate judgment error problems put forward a kind of method.

2. STANDARD QUALITY EVALUATION INDEX SYSTEM

2.1. Establishment of the index system framework

Standard is a kind of normative document with its own series of inherent characteristics. Through analysis and comparison of different types of standards, the intrinsic characteristics of standard could be summed up as "normative", "applicability", "advanced", "harmony" and "applied" five aspects, therefore, the connotation of the quality standards, from five aspects described above, according to the established standards of quality evaluation index system framework (shown in Figure 1).

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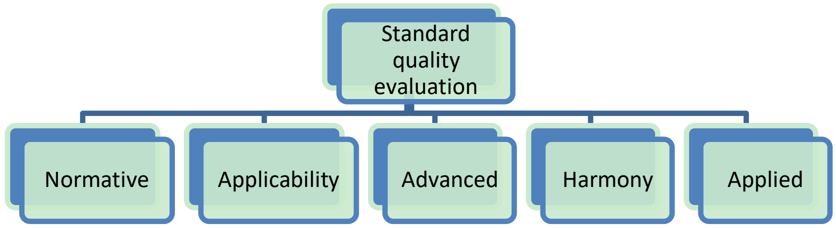


Figure 1. Standard quality evaluation index system framework.

2.2. Determination of the evaluation indicators

Standard quality evaluation system can be divided into three levels: target layer, criterion layer and element layer, which is mainly based on the overall index system framework, the problem is decomposed into different components. These factors will be aggregated and combined according to different levels, which can reflect the common characteristics and basic elements of standard quality. The specific evaluation indicators are specified as shown in Table 1.

Table 1. Standard quality evaluation index system.

The target layer	**The criterion layer**	**The element layer**
Standard quality evaluation	Normative	Whether the text is written and formatted in accordance with relevant requirements
	Applicability	Whether the setting of subjective and objective indicators in the standard is reasonable and balanced
		Whether the measurement method of technical indicators is scientific and reasonable
		Whether it is feasible in practical application
		What is the proportion of general technology and new technology adopted in the standard
		Technology realization cost and production benefit balance
	Advanced	Whether it conforms to the status of the domestic basic technology
		The status of the advancement of the technology against the international standard
	Harmony	Compliance with laws and regulations
		Compliance with standard system
	Appiled	Standard application
		The situation in which a standard is referenced

The target layer is the general goal of decision-making, that is, standard quality evaluation; The criterion layer refers to the factors to be considered and the criterion of decision making, that is, the standard standardization, the standard applicability, the standard advancement, the standard coordination, the standard application; The element layer is used to represent the refined elements that reflect the indicators of each criterion layer, which can be further refined into more intuitive and specific indicators.

Based on the above ideas, the following factors that affect standard quality are considered.

(1) Standard standardization mainly inspects whether the standard text is written and formatted in accordance with relevant provisions, such as whether the logical structure of the standard is reasonable, whether the standard provisions are rigorous, accurate, clear and unambiguous, so as to facilitate users to master and use them accurately.

(2) The applicability of the standard mainly inspects the technical content and technical and economic indicators of the standard, for example, whether the setting of subjective and objective indicators in the standard is reasonable and balanced, whether the measurement method of technical indicators is scientific and reasonable, whether it is feasible in practical application, and what is the proportion of general technology and new technology adopted in the standard. Technology realization cost and production benefit balance (input-output ratio) and other aspects of evaluation.

(3) The progressiveness of the standard mainly inspects the state of the key technology in the standard, how innovative it is compared with the domestic production level, whether it conforms to the status of the domestic basic technology, as well as the status of the advancement of the technology against the international standard.

(4) coordination mainly inspects standard content is beneficial to the implementation of the relevant national policies, comply with the provisions of the laws and regulations, and closely associated with the higher standard and other standards, such as standardized object methods are on the same standards, safety standards, product standards, such as whether to coordinate with each other, content without cross, repeat; In the standard system of this field, the standard and related standard are interrelated and can be used together.

(5) The application of the standard mainly examines the application and citation of the standard in practice, such as whether the standard is incorporated into the management system of the unit, how relevant personnel grasp the standard, and how the standard is referenced by policies, regulations or other standards.

3. FUZZY NEURAL NETWORK MODEL

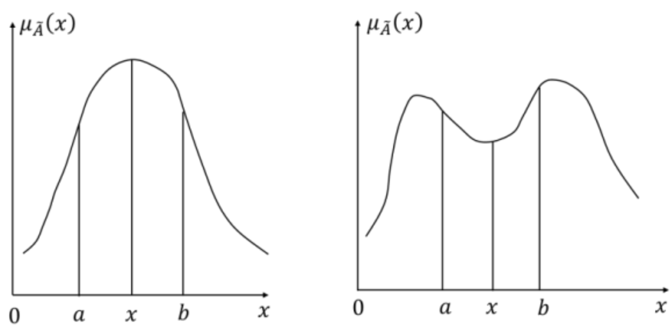
3.1. Establishment of membership function

The fuzzy set is described by membership function[8], which essentially reflects the gradual evolution of things. Therefore, the fuzzy set representing the membership function must be the convex fuzzy set as shown in Figure 2, which follows the following principles:

Setting $\tilde{A}$ to be a fuzzy subset of the vertices of real number R, its membership function is $\mu_{\tilde{A}}(x)$. If to any real number $a < x < b$, there is:

$$\mu_{\tilde{A}}(x) \geq min\big(\mu_{\tilde{A}}(a), \mu_{\tilde{A}}(b)\big) \tag{1}$$

Then $\tilde{A}$ is called fuzzy set. From the definition of convex fuzzy sets, it is not difficult to see that convex fuzzy sets are essentially membership functions with single-peak characteristics, and the membership function of variables is usually symmetric and balanced[9].



(a) Convex fuzzy sets (b) Non-convex fuzzy sets

Figure 2. Morphology of membership function fuzzy set.

3.2. T-S fuzzy neural network

T-S fuzzy system could update by itself and modify the fuzzy membership function continuously[10]. Supposing that for the input value $x = [x_1, x_2, \cdots x_k]$, according to fuzzy rules each input variable membership degree of x_j is firstly calculated:

$$\mu A_j^i = exp\left(-\left(x_j - c_j^i\right)^2 / b_j^i\right) j = 1,2,\cdots,k;\ i = 1,2,\cdots,n \tag{2}$$

where, A_j^i is the fuzzy set of the fuzzy system, c_j^i and b_j^i are respectively the center and width of the membership function, k is the input parameter, and n is the number of fuzzy subsets.

Fuzzy calculation was carried out for each membership degree, and the fuzzy operator was adopted as the multiplication operator:

$$\omega^i = \mu A_j^1(x_1) * \mu A_j^2(x_2) * \cdots * \mu A_j^k(x_k) i = 1,2,\cdots,n \tag{3}$$

The output value y_i of the fuzzy model is calculated according to the results of fuzzy calculation:

$$y_i = \sum_{i=1}^{n} \omega^i \left(p_0^i + p_1^i x_1 + \cdots + p_k^i x_k\right) / \sum_{i=1}^{n} \omega^i \tag{4}$$

T-S fuzzy neural network contains input layer, fuzzy layer, fuzzy rule calculation layer and output layer. The input layer connected to x_i which means the input vector, and the dimension of nodes number and the input vector is the same. The fuzzy membership value μ is calculated by equation (2), which is mainly obtained by fuzzifying the input value. The ω is calculated by equation (3) and the y_i is calculated by equation (4) to calculate the output of fuzzy neural network.

4. EXAMPLE

4.1. Sample data collation

For the petroleum engineering field, 7 professional industry standards of natural gas, storage and transportation, geology, pipe, LNG, drilling, and oilfield chemicals are selected as evaluation samples. The 12 secondary indicators of the standard quality evaluation index system were scored by questionnaire method. The research objects included technical personnel and standardized management personnel in related fields. The average value of the scoring results was taken as the input value of sample data S_1-S_7. In addition, 8 experts were invited to assign weights and score the 12 second-level indicators of each standard. The fuzzy comprehensive evaluation method was used to obtain the evaluation results, which were used as the target value S_0 of the sample data. The final sample data of the standard quality evaluation were shown in Table 2.

Table 2. The standard quality evaluation data samples.

The target layer	The training sample					The testing sample		
	S_0	S_1	S_2	S_3	S_4	S_5	S_6	S_7
C_{11}	0.957	0.679	0.695	0.709	0.751	0.814	0.717	0.569
C_{12}	0.485	0.758	0.317	0.755	0.255	0.244	0.286	0.469
C_{21}	0.800	0.743	0.750	0.276	0.506	0.729	0.757	0.512
C_{22}	0.419	0.392	0.344	0.680	0.699	0.350	0.754	0.337
C_{23}	0.422	0.656	0.439	0.655	0.891	0.597	0.380	0.622
C_{24}	0.716	0.712	0.382	0.626	0.459	0.251	0.568	0.794
C_{31}	0.792	0.706	0.766	0.519	0.547	0.616	0.759	0.311
C_{32}	0.860	0.318	0.795	0.498	0.339	0.473	0.654	0.529
C_{41}	0.656	0.277	0.387	0.597	0.649	0.352	0.531	0.766
C_{42}	0.836	0.462	0.490	0.340	0.258	0.831	0.779	0.602
C_{51}	0.849	0.571	0.446	0.585	0.841	0.585	0.493	0.263
C_{52}	0.934	0.824	0.646	0.224	0.254	0.550	0.430	0.654

4.2. Model building

The standard quality evaluation algorithm flow based on T-S fuzzy neural network is shown in Figure 3. Based on the data in Table 2, five input and output sample data (target value S_0 and evaluation value S_1-S_4 of the first four standards) are used for learning and training of neural network, and then three sample data (evaluation value S_5-S_7 of the last three standards) are used for testing. If the test results meet the requirements, a learned model will be obtained. Fuzzy neural network according to the training sample dimension of input, output, determine the input node number is 12, output node number is 1, and then through the network training error objective function in the process of the convergence condition of the adjustment, to determine the number of membership functions of 15, so build network structure for the 12-15-1, random initialization fuzzy membership function center c, Width b and coefficients P_0-P_6. MATLAB software was used for network training, network training 2000 times.

4.3. Result analysis

The reliability of fuzzy neural network is very important, which is related to the input value and the number of hidden layer neurons and other factors. The random value obtained after 20 operations is shown in Figure 4. It can be clearly seen from Figure 4 that standard S_3 has the highest score, with the highest score of 19 times and program reliability of 95%. Therefore, the quality evaluation result of this standard is the best. S_6 had the lowest score of 7 times and program reliability of 35%, so it had the worst evaluation result. The reliability and comparative analysis of each calculation can be obtained according to the occurrence times of the highest score in the calculation results of each standard fuzzy neural network, as shown in Table 3. The calculation results show that the reliability of the fuzzy neural network model can meet the requirements of standard quality evaluation.

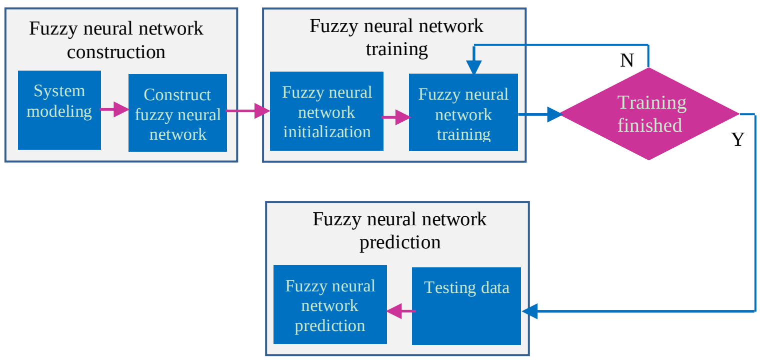


Figure 3. Evaluation algorithm flow of fuzzy neural network.

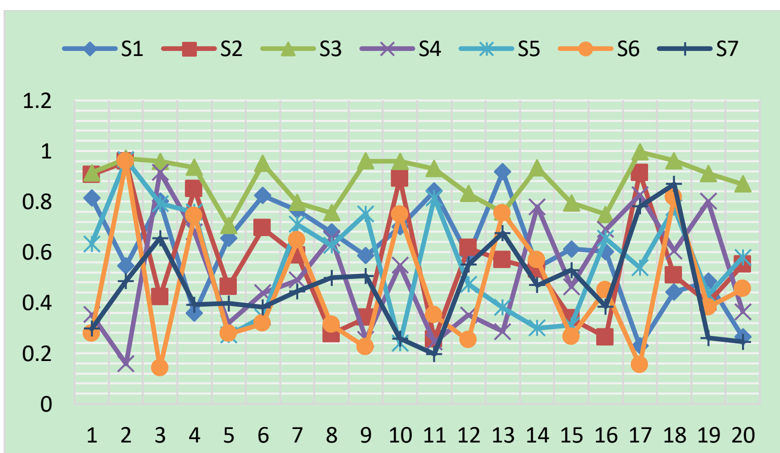


Figure 4. The score curves.

Table 3. Reliability of fuzzy neural network.

Standard number	Number of calculations	Number of occurrences in the series	Reliability (%)
S1	20	17	85
S2	20	18	90
S3	20	19	95
S4	20	18	90
S5	20	17	85
S6	20	7	35
S7	20	16	80

5. CONCLUSION

As an important link in the whole life cycle management of standardization, standard quality assessment plays an important role in strengthening the management of standard formulation and revision, perfecting the construction of standard system, and promoting the information feedback and effect assessment of standard implementation. Based on the experience of traditional evaluation methods and the advantages and characteristics of fuzzy neural network in decision making, this paper puts forward a new method and idea of standard quality evaluation in petrochemical industry.

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