Research on Multidimensional Evaluation Model and Algorithm of Effectiveness of New Power System Technical Standard System Based on Association Rules and Big Data

Qiyu Lu[1], Xingde Huang[1], Haoyi Tian[1], Yong Li[2*], Xiaoqian Liu[2]

*ly_xbd@163.com

1.State Grid Shanghai Municipal Electric Power Company, Shanghai 200122, China

2.Shanghai Jiulong Enterprise Management Consulting Co., Ltd., Shanghai 200052, China

Abstract. The current conventional evaluation method of the effectiveness of the technical standard system of power system is mainly through the extraction of key factors of technical standards, so as to construct an evaluation model. Due to the lack of mining processing of technical standard data, it leads to poor evaluation effect. In this regard, a new multidimensional evaluation model and algorithm for the effectiveness of the technical standard system of power system based on association rules and big data are proposed. By extracting the frequent item set, the technical standard data of power system is mined. And the three-level indexes are extracted from multiple dimensions to build the validity multidimensional evaluation model, and the evaluation of validity is realized by calculating the comprehensive evaluation score. In the experiments, the evaluation performance of the proposed evaluation model is verified. The final results can prove that when the proposed method is used to evaluate the effectiveness of the technical standard system of the power system, the model has a low misjudgment rate and has a more desirable evaluation performance.

Keywords: association rules; power systems; technical standards; validity evaluation; frequent item sets

1. Introduction

In view of the demanding nature of power system construction technology, it is usually necessary to measure the level of construction technology from different perspectives when establishing the technical standard system, such as the pre-planning stage[1-2], the mid-term implementation stage and the post-maintenance stage[3] . By dividing the construction technology cycle of the power system with time as the dividing node and establishing different technical standard systems according to different construction cycles, the technical level of the power system can be orderly measured. In summary, the technical standard system of electric power system is usually selected from a number of aspects for comprehensive consideration and thus different standards. Therefore, when evaluating technical standards, the entire system should not be evaluated directly[4] . Rather, based on the analysis of the construction idea of the system, the evaluation of the effectiveness of different characteristics of the system, and

ICIDC 2023, June 02-04, Nanchang, People's Republic of China

DOI 10.4108/eai.2-6-2023.2334621

finally the summary of the evaluation results of different standards, so as to obtain the evaluation results of the effectiveness of the entire system of technical standards. To achieve the above theory, this paper proposes a kind of evaluation of the effectiveness of technical standard system combining association rules and big data technology. The technical standard system is refined by analyzing the technical characteristics of power system construction, and the evaluation is carried out for different technical standards on this technology.

2. Data mining of power system technical standards based on association rules and big data

In order to evaluate the effectiveness of the new power system technical standard system in multiple dimensions, this paper first combines association rules and big data technology to mine the data related to technical standards of power system[5] . By mining the frequent item set, a data mining model of power system technical standards is constructed, and the specific implementation process is as follows.

Firstly, assume that the set of items consisting of the technical standard dataset D of the power system is, and then the support degree of the two random item sets is calculated as shown below.

$$Support(X \Rightarrow Y) = \frac{|X \cup Y|}{|D|} \tag{1}$$

Where, $Support(X \Rightarrow Y)$ represents the support of the contained itemset, $|X \cup Y|$ represents the number of transactions containing $X \cup Y$ in the power system technical standard dataset, and represents the total number of transactions in the power system standard dataset. The support of the two random vector sets is solved by the above formula and compared with the set threshold. If the solved value satisfies the set threshold condition, the set can be considered as a frequent item set[6] . Then, in order to ensure the mining effect of the technical standard data of power system, it is also necessary to pre-process the original data. In this regard, since the data of power system technical standard system is mainly divided into online historical data and offline historical data, in order to improve the comprehensiveness of the technical standard system, it is necessary to integrate the online historical data and offline historical data in the power system technical standard database first. After obtaining the integrated power system standard data, this paper combines the conventional mathematical modeling algorithms to extract the features of the power technical standard system data, for which the Gini coefficient is introduced to measure the sample purity of the data nodes, and the specific calculation formula is shown below.

$$Gini = 1 - \sum p^2(j) \tag{2}$$

Where, $Gini$ represents the purity of node n in the power system standard system, and $p(j)$ represents the number of samples of node n in the power system technical standard system under category j.

3. Multi-dimensional evaluation system construction for the effectiveness of the technical standard system of power system

In this paper, the construction solutions requirements of the general power system construction technology are analyzed as an example . When repairing and constructing a certain power supply equipment of the power system, four aspects are generally involved, which are equipment repair, equipment construction, equipment commissioning and equipment acceptance. Equipment maintenance work needs to ensure that the performance of the repaired electrical equipment can be restored to its original level, while equipment construction work needs to ensure that the completed construction work can be put into normal use and will not cause operational problems. Equipment commissioning work not only needs to debug the specific performance of the equipment, but also to predict the operating cycle of electrical equipment, so as to grasp the total length of use of electrical equipment. Equipment acceptance work needs to test the different indicators of electrical equipment functions, so as to ensure that the completed electrical equipment can meet the requirements of use, to ensure that the electrical project can be carried out effectively . Therefore, through the analysis of the above four aspects, it can be clear that the main construction objects of the technical labeling system of the power system are equipment operation and maintenance as well as project acceptance content. Based on the above detailed analysis of the technical standard system of electric power system, this paper selects multi-dimensional evaluation three-level indicators from four aspects: planning and construction, construction acceptance, operation and maintenance, and automation and intelligence, and the evaluation system thus constructed is shown in Table 1.

Table 1 Evaluation system of the effectiveness of the technical labeling system of the power system

Secondary indicators	Tertiary Indicators
Planning and construction level	Distribution Plan Integrity
	Quality of distribution system
	Distribution system safety
Construction acceptance quality	Quality of power distribution construction engineering
	Quality of distribution system debugging
	Acceptance results of distribution system
Operation and maintenance	Degree of distribution system modeling
	Distribution System Simulation Results
	Operation situation of distribution system
Automation and intelligence level	Automation level of power distribution process
	Automation level of power distribution detection system
	Automation level of intelligent maintenance system for power distribution

According to the effectiveness assessment system of power system technical standard system constructed above, the judgment matrix constructed in this paper is expressed as follows.

$$A=\begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix} \tag{3}$$

Where, a_{mn} represents the three-level indicators in the effectiveness assessment system of the technical standard system, and m and n represent the number of elements in each row and column of the matrix, respectively. The product of the vectors of indicators in each row of the above matrix can be calculated as shown in the following formula.

$$M_i=\prod_{i=1}^{n} a_{ij} \tag{4}$$

Based on the matrix vector product calculated above, the weights of each validity assessment index in the judgment matrix can be calculated, and the specific calculation formula is shown below.

$$w_i=\sqrt[n]{M_i} \tag{5}$$

Where, w_i represents the weight value of the evaluation indexes of the effectiveness of the technical standards of power system. Through the above steps, the construction of the assessment system can be completed. Through the analysis of the construction technology requirements of the power system, the main construction characteristics of the technical standard system are obtained, and different evaluation indicators are selected according to the construction direction of the technical standard system, which are used to evaluate the effectiveness of the technical standard system.

4. Multi-dimensional evaluation model construction

After constructing the evaluation system of the effectiveness of the technical standard system of power system, the weights of each evaluation index in the evaluation system are calculated, and then the order of the weights is obtained. After calculating the weights of the subsets of evaluation indicators in a single layer, a consistency test is performed on the single layer of the evaluation system, and the final indicator weights are output after the test results meet the criteria. The effectiveness multidimensional evaluation model designed in this paper achieves the evaluation of the technical standard system of power system by calculating the evaluation results of different standards separately and calculating the final total technical standard evaluation score. The evaluation results of different standards under the technical standard system are calculated by the formula shown below.

$$S=\sum_{i=1}^{N} Q_i W_i \tag{6}$$

Where, S represents the final evaluation score of the technical standard system of power system, Q_i represents the characteristic value of the ith index in the standard system, and W_i represents the characteristic weight value of the index.

Through the above steps, the evaluation scores of different standards under the technical standard system of power system can be found, and the total evaluation scores of the system can be obtained by weighting and summing the evaluation scores of different standards. By combining the contents of this section with the above-mentioned data mining of the standard system and the construction of the effectiveness evaluation system, the new multidimensional evaluation model and algorithm design of the effectiveness of the technical standard system of power system based on association rules and big data is completed.

5. Experiment and analysis

5.1 Experimental preparation

In order to prove that the multidimensional evaluation model and algorithm of the effectiveness of the new power system technical standard system based on association rules and big data proposed in this paper is better than the conventional multidimensional evaluation model of the effectiveness of the new power system technical standard system in terms of practical evaluation effect, after the design of the theoretical part is completed, an experimental session is constructed to test the practical evaluation effect of the method in this paper. In order to ensure the experimental effect, two conventional multidimensional evaluation models of the effectiveness of the new power system technical standard system are selected for comparison, namely, the multidimensional evaluation model of the effectiveness of the new power system technical standard system based on cross-evaluation method and the multidimensional evaluation model of the effectiveness of the new power system technical standard system based on deep learning.

In order to improve the reliability of the experimental results, the technical standard data of a power system was used as the base test data for this experiment. By using the expert evaluation method, the validity of this technical standard was evaluated, and the results of this evaluation were used as the comparison criteria for this experiment. According to the evaluation results of the expert evaluation method, this experiment divided the original data set into three levels, and the validity of its technical standard system decreases in order, and the specific test sample data is shown in the following table.

Table 2 Experimental test sample set data

Evaluation Level	Number of training samples	Number of test samples
Good	100	80
Moderate	100	50
Poor	100	40

The effectiveness of the above-mentioned technical standards for power systems is evaluated by using three evaluation methods, and the results of expert evaluation are used as a comparison, so as to compare the evaluation effects of different methods.

5.2 Analysis of test results

The comparison standard selected for this experiment is the evaluation accuracy of different evaluation models for the power system standard system, and the specific measurement index is the evaluation error rate, and the specific experimental results are shown as Figure 1.

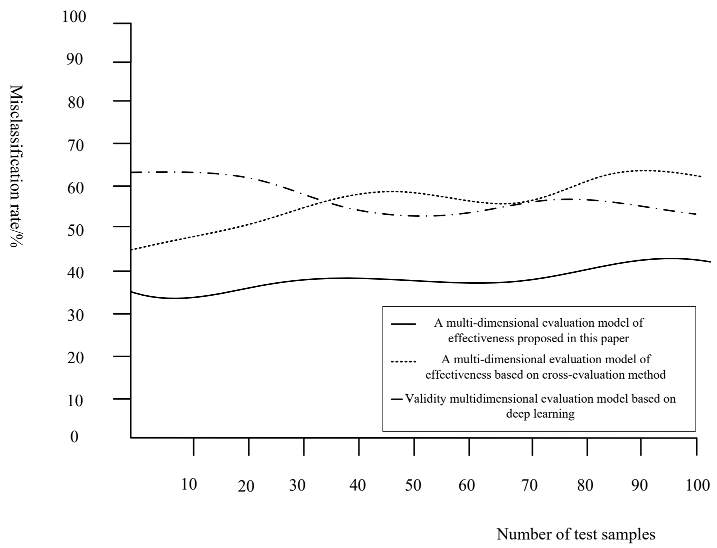

Figure 2 Comparison results of false positive rate

The above experimental results show that with the increasing number of test samples, there are differences in the accuracy of different assessment methods for assessing the validity of technical standard systems. The numerical comparison shows that the misjudgment rate of the two conventional validity assessment methods is high, with an average misjudgment rate of about 65%, and the assessment misjudgment rate fluctuates with the change in the number of test samples. In contrast, the misjudgment rate of the multidimensional evaluation model of the effectiveness of the new power system technical standard system based on association rules and big data proposed in this paper is significantly lower than that of the two conventional evaluation methods. It can be proved that the evaluation performance of the evaluation model proposed in this paper is better than the conventional evaluation model.

6. Conclusion

In this paper, a new multidimensional evaluation model is proposed by combining association rule algorithm to address the problem of low evaluation accuracy of the conventional multidimensional evaluation model of the effectiveness of the technical standard system of power system. By combining association rules and big data technology, the data related to the standard system of power system is mined and the evaluation system is constructed with the effectiveness of the standard system as the evaluation target.

Acknowledgements: The paper is funded by "Key Technological Project of SGCC (1400-202257472A-2-0-ZN)".

References

[1] Li J, Sun Y, Gong L 2021 Multiattribute Fuzzy Decision Evaluation Approach and Its Application in Enterprise Competitiveness Evaluation. Mathematical Problems in Engineering, 2021(1): 1-11.
[2] Wang J, Cao J, Hu D 2021 Eye Blink Artifact Detection With Novel Optimized Multi-Dimensional Electroencephalogram Features. IEEE transactions on neural systems and rehabilitation engineering: a publication of the IEEE Engineering in Medicine and Biology Society, 29: 1494-1503.
[3] Wu S, Li S, Gong J 2023 Modeling and Quantitative Evaluation Method of Environmental Complexity for Measuring Autonomous Capabilities of Military Unmanned Ground Vehicles. Unmanned Systems, 11(04): 367-382.
[4] Fengjiao X U, Xie X, Guo Q 2021 Magnetotelluric modeling based on a two-dimensional induced-polarization geothermal reservoir model and its response characteristics analysis. Geophysical Prospecting for Petroleum, 60(6): 1026-1035.
[5] Deng Y, Liu D 2022 A multi-dimensional comparison of the effectiveness and efficiency of association measures in collocation extraction. International Journal of Corpus Linguistics, 27(2): 191-219.
[6] Xu M, Wang Y 2023 Mining Model of Association Data Consistency Rules in Heterogeneous Internet of Things. Computer Simulation, 2023(5): 425-428,442.