Asset Quality Evaluation of Power Grid Enterprise based on LSSVM and PSO

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Abstract

As an asset dense enterprise, the level of quality for power grid enterprise assets related to the success or failure of the enterprise's future development and operations. In this paper, based on analyzing the characteristics of power grid enterprise assets, we constructed the asset quality evaluation index system. Then, the hybrid model combined with least squares support vector machine (LSSVM) and particle swarm optimization (PSO) is proposed to evaluate its quality level, which can provide some reference for improving asset quality management level of power grid enterprise.

Keywords

Power Grid Enterprise, Asset Quality, LSSVM, PSO.

1. Introduction

Because of the historical development of Chinese power grid enterprises and the complexity of the power grid assets, the evaluation of power grid assets is still limited to the safety and reliability. Ignoring economic evaluation of power grid assets, will not only seriously restrict economic benefit of power grid enterprises, but also limit regional economic development. Therefore, it is necessary to research the existing assets of power grid enterprises to build a s reasonable index system and evaluate the security, reliability and economic level of power grid enterprises. Building a comprehensive evaluation model of power grid assets quality, is not only beneficial to promote the competitiveness of the enterprise, but also can improve asset utilization rate and revitalize the bad assets. In addition, it is of great significance to analyze the feasibility of investment projects in the process of new construction, alteration or expansion. At present, some scholars have evaluated the power grid enterprise asset management, but the existing index system can’t fully reflect the quality of power grid enterprises [1-6]. Therefore, this paper present an index system that can fully reflect the quality level of power grid enterprise assets. Then, build a hybrid model to evaluate the quality level.

2. Index System Construction

This paper is to evaluate the assets quality of power grid enterprise and give a scientific and reasonable results of assets quality management. The object of the evaluation is the assets of the power transmission and distribution owned by power grid enterprises. According to the different application fields and the evaluation methods of the index system, there are a variety of index system construction principles. On the basis of the characteristics of grid assets quality evaluation,

Three main principles are put forward in this paper: (1) the principle of comprehensiveness. As for reflecting the overall characteristics, the index system is complete and sufficient. The index system must reflect all the aspects, stages and levels of the evaluated problems. (2) The principle of operability. This principle shows that the index system need to be easier to measure and calculate. The purpose of comprehensive evaluation is to practice. (3) The principle of refining. The principle shows that the redundancy and correlation of the index system need to be smaller, and some aspects of the index have not been repeatedly considered.

Considering the characteristics of power grid assets, this paper selects an index system that reflects the quality level of the enterprise’s assets, as shown in Figure 1.

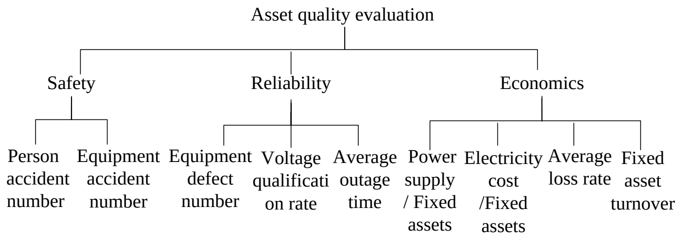

Fig. 1 The index system of asset quality evaluation

3. Evaluation Model Construction

3.1 Data Preprocessing.

Pretreatment of index is also called the standardization of attribute values. The essence of data preprocessing is to give the actual value of the attribute value of a certain index when the decision maker evaluates the program. In order to achieve the comparability of different types of indexes, the harmonization, dimensionles and normalization of index types are needed.

3.2 Index Weights Determination.

The weight of the index system can be determined by the subjective weighting method and the objective weighting method. The objective weighting method mainly relies on a large amount of index data, and the subjective weighting method depends on the expert's knowledge, experience and preference. In this paper, we use the analytic hierarchy process to determine the index weight. Analytic Hierarchy Process (AHP) can be divided into the following five steps: First, to clarify the problem and establish hierarchical structure model of program evaluation; Second, to compare and construct comparison and judgement matrix; Thirdly, to single order hierarchy and consistency test; Fourth, the overall rank hierarchy and consistency test; Fifth, according to the analysis of the calculation results, consider the corresponding decision. The values of the elements in the judgment matrix are shown in Table 1.

Table 1 1-9 scale method

Scale	Meaning
1	compare factors A_i and factors A_j, they have the same importance
3	factors A_i is slightly important than factors A_j
5	factors A_i is obvious important than factors A_j
7	factors A_i is mightiness important than factors A_j
9	factors A_i is extremely important than factors A_j
2,4,6,8	the mid-value of these two adjacent judgment value

3.3 Model Building.

The hybrid model combined with LSSVM and PSO is given below:

(1) LSSVM model

For a given set of samples, (x_i, y_i), $i = 1, 2, \cdots, l$, $x_i \in R^n$, $y_i \in R$, using nonlinear mapping $\phi(\cdot)$, which mapping the sample set from the input space to the feature space. Then, the linear regression is performed in the high dimensional feature space.

$$y(x) = \omega^T \phi(x) + b \tag{1}$$

According to the principle of structural risk minimization, regression problem can be presented as:

$$\min \frac{1}{2}\|\omega\|^2 + \frac{c}{2}\sum_{i=1}^{l}\xi_i^2 \tag{2}$$

$$y_i = \omega^T \phi(x_i) + b + \xi_i, i = 1, 2, \cdots, l \tag{3}$$

where ω is the weight coefficient of LSSVM, b is the constant deviation, c is the punishment factor, and ξ is the relaxation factor. In order to solve the constrained optimization problem, the Lagrange function is introduced. Then the final LSSVM regression function model can be defined as:

$$y(x)=\sum_{i=1}^{l}\delta_i K(x,x_i)+b \tag{4}$$

As discussed above, the LSSVM model has some drawbacks, such as the selection of model parameters. The main parameters affecting the LSSVM model are given below:

1) Penalty coefficient c. According to the properties of the sample data, the complexity of the model can be decided.

2) Insensitivity coefficient ε. It shows the expectation of the error of the estimation function on the sample data.

3) Kernel function parameter σ. It defines the structure of the high-dimensional characteristic space $\varphi(x)$.

Therefore, PSO is used to optimize the parameters (c, ε, σ) of the LSSVM model in this paper.

(2) PSO

PSO is a kind of evolutionary computation method proposed by Dr. Eberhart and Dr. Kennedy in 1995. Its basic idea is to find the optimal solution by information transfer and information sharing among the individuals in the population.

Suppose the population size is M and each particle is flying in the D-space, the initial velocity is $V_i=[v_{i1},v_{i2},\cdots,v_{id}]$ and the initial position is a random variable $U_i=[u_{i1},u_{i2},\cdots,u_{id}]$, $i=1,2,\cdots,M$, $d=1,2,\cdots,D$. Then each particle will find the optimal solution through two extremes, one is the optimal solution of the particle itself p_{besti}, expressed by $P_i=[p_{i1},p_{i2},\cdots,p_{id}]$, the other is the entire population of the optimal solution g_{best}, expressed by $P_g=[p_{g1},p_{g2},\cdots,p_{gd}]$.

According to the particle fitness value, the following particle update speed and position can be obtained until the termination condition is satisfied:

$$v_{id}^{k+1}=\omega v_{id}^{k}+c_1r_1(p_{id}-u_{id}^{k})+c_2r_2(p_{gd}-u_{id}^{k}) \tag{5}$$

$$u_{id}^{k+1}=u_{id}^{k}+v_{id} \tag{6}$$

where k represents the number of iterations, c_1,c_2 is the acceleration factor, which makes each particle close to the position of p_{besti} and g_{best}. r_1,r_2 is the random number between 0 and 1. w is inertia weight coefficient.

(3) LSSVM-PSO

In this paper, the flow chat of the hybrid model is given in Figure1, and the specific steps are presented as follows:

1) Initialize the size M of the particle swarm, the maximum allowable iteration number L, the inertia weight W, the learning factor D, and the velocity of each particle.

2) Initialize the particle position. Randomly generate a 3-dimensional vector, and generate N initial speeds.

3) If the particle fitness is superior to the individual extremum, then the fitness of the particle swarm is set to the new position.

4) If the particle fitness is better than the global extremum, then the global extreme is set to the new position.

5) Update the velocity and position of the particle.

6) Optimize the optimal position.

7) If the number of iterations meet the maximum value, then the global optimal position is the parameter vector (L, W, D); otherwise, return to step (3).

8) According to the parameters of C, ε and σ, the sample variance is taken as the fitness function of the least squares support vector machine.

9) If the sample variance of the LSSVM model reaches the minimum value, then the corresponding parameters of C, ε and σ is the optimum parameters.

4. Application Example

Taking five city power supply companies (A, B, C, D, E) as an example, then the 110kV power assets is chosen as the evaluation object. The evaluation results of five city power supply companies is shown in Table 2.

Table 2 Evaluation results of asset quality level

Evaluation Companies	Company A	Company B	Company C	Company D	Company E
Safety level	0.024	0.025	0.026	0.027	0.024
Reliability level	0.025	0.026	0.025	0.026	0.026
Economic level	0.038	0.067	0.057	0.077	0.048
Comprehensive level	0.031	0.045	0.038	0.050	0.036

As it can be seen from Table 2, the difference of the comprehensive evaluation results among five companies is obvious. But all of the security value and reliability value of the power supply company is not big, it illustrates that all the companies have a high safe and stable operation level. A company has the highest comprehensive level, mainly due to its new assets, low maintenance and depreciation costs. D company has the lowest comprehensive level, mainly due to the older assets, higher maintenance costs.

5. Conclusion

Analyzing the characteristics of the power grid enterprise assets, this paper proposes the evaluation index system and build a hybrid model to evaluate the power grid enterprise asset quality. The security, reliability and economy of the assets are taken into full consideration, which make the index system more comprehensive. The evaluation results has certain guidance and practical significance for power grid enterprise asset management.

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