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Optoelectronic Data Processing for Investment Prediction in Distribution Networks Using Grey Model Optimization

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Abstract. With the rapid development of the economy, the scale of power grid construction has increased, but at the same time, it is also facing problems such as obsolete power grid equipment and line damage, so it is very important for the sustainable development of power grid enterprises to carry out reasonable technical transformation of the power grid and ensure the reliable operation of the power grid system. However, in the power grid technical transformation investment decision-making, mainly rely on the power grid company professional and technical personnel from the past historical experience, select a few theoretically and power grid technical transformation investment related indicators, through a simple regression analysis to obtain the technical transformation investment prediction value, such a decision-making method is difficult to meet the actual demand, so in-depth analysis of the main influencing factors of investment capacity, to adopt an accurate and reasonable investment forecast model, is the key to the current power grid technical transformation investment forecast. Therefore, this paper proposes a technology for predicting the investment of power grid technical transformation project based on Markov optimization gray model parameters, added optoelectronic data processing for distribution network investment forecasting, and verifies that the prediction accuracy of the proposed algorithm is improved by 5.21% compared with the traditional gray GM(1,N) prediction model, which is significantly improved.

Keywords: Investment in power grid technological transformation, gray model, Markov model, parameter optimization

1. Introduction

Technological transformation project refers to the use of mature and applicable advanced technologies, equipment, processes, materials, etc. at home and abroad, to improve production performance, increase stability, safety, reliability, and economics. Auxiliary facilities, etc. are perfected, matched or updated as a whole [1]. Technological transformation is the most effective and direct way for power grid enterprises to update and transform equipment. It plays an important role in optimizing the grid structure, improving the safety and reliability of grid operation, extending the service life of equipment, and reducing the level of equipment energy consumption[2]. At present, my country's economy has shifted from a stage of high-speed growth to a stage of high-quality development. There are still general expectations of society for lowering electricity prices. The development of power grids that rely on high-speed growth of electricity to support large-scale investment will be unsustainable. Especially with the continuous advancement of my country's power reform system, the profit model based on transmission and distribution services requires grid companies to make more precise control of operating costs [3].

Technological transformation investment is an important part of company investment [4]. With the passage of time, the scale of investment in technological transformation of power grid companies has gradually increased, and in contrast, the growth rate of power generation has gradually slowed down, and the growth of corporate operating efficiency is facing many difficulties. Therefore, under the new situation, power grid companies must change their business philosophy, strengthen the accuracy of investment forecasts for power grid technological transformation projects, and improve project investment benefits while meeting the needs of power grid

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development. Based on this, this article first focuses on the characteristics of the numerous indicator data of power grid companies, and based on the gray correlation analysis method, rationally screens the relevant indicators; then builds a technical transformation investment prediction model based on the gray GM(1,1) theory, and aims at The parameters of the model were optimized; finally, the effectiveness of the model was verified through empirical analysis. This technological transformation investment forecasting model can provide scientific and powerful decision support for the technological transformation investment of power grid enterprises.

2. Screening of Technical Renovation Investment Forecast Indicators Based on Slope Correlation Analysis

2.1 The Basic Idea of the Method

The slope correlation degree is also defined according to the difference in the relative rate of change between the two data series curves. The slope correlation is based on discrete data series. The greater the correlation, the more similar the slopes of the two data series in the corresponding time period. The smaller the correlation, the greater the difference in the slopes of the two data series in the corresponding time period. The slope correlation algorithm is calculated as follows: Record the original data sequence as, and record the characteristic behavior of the system as sequence $X_i = (x_i(1), x_i(2), ..., x_i(n)), (i = 1,2,...,m)$ .The calculation formula of slope correlation degree is:

$$r_{0,i} = \frac{1}{n-1}\sum_{k=1}^{n-1}\zeta(k) \tag{1}$$

Among them, the calculation formula of $\zeta(k)$:

$$\zeta(k) = \frac{1}{1+\left|\frac{\Delta x_0(k)}{x_0(k)} - \frac{\Delta x_i(k)}{x_i(k)}\right|} \tag{2}$$

Among them : $\Delta x_i(k) = x_i(k+1) - x_i(k), i = 0,1,2,...,m, k = 1,2,...,n-1$.

The slope relevance focuses on the local similarity of the two data sequences. Its biggest advantage is that the relative size of the relevance sequence remains unchanged before and after the data sequence is transformed, that is, it has order preservation. However, the slope relevance still cannot be characterized Two data series with negative correlation, in addition, the degree of correlation defined in this way also has certain defects. For example, when $x_0(k)$ or $x_i(k)$ is very small, the calculation of the correlation degree will always be close to zero. When it is zero, the correlation degree will not be calculated. For this reason, some scholars have made certain modifications to them, replacing $x_0(k)$ with the average value of X_0 and using X_i Replace $x_i(k)$ with the mean of.

2.2 Index Screening

This paper takes the power grid company of a certain city in my country as an example, combined with the angle slope correlation analysis method, and finally determines the selected technological transformation investment scale forecast analysis indicators as follows:

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Table 1. Results of selection of forecast indicators for technological transformation investment.

Indicator	Unit	Correlation
Cost of unit substation capacity	Yuan/kVA	0.914
Energy used	Billion kWh	0.618
Line reconstruction length	km	0.805
Number of Main Transformer Transformation Units	Yuan/km	0.787
Maximum load	Megawatt	0.681
GDP	100 million yuan	0.483
Unit electricity transmission and distribution cost	Unit electricity transmission and distribution cost	0.491
Line loss rate	%	0.914

3. Construction of Predictive Model for Technological Transformation Investment

3.1 Gray Model

Grey system theory mainly studies systems with part of the information known and part of the information unknown, and has the characteristic of small and uncertain sample size.The main technical solution is system modeling and decision-making. It has been applied in many fields. The gray model is an approximate differential differential equation model with properties such as compatibility of differential differential exponents. The parameters can be adjusted and the structure changes with time. The gray model is different from the traditional model. It requires less data. The prediction model is constructed by studying the cumulative sequence of the original data sequence, and the original value is obtained through inversion. The model building process is as follows:

(1) Suppose sequence $X^0 = (x^{(0)}(1), x^{(0)}(2), ..., x^{(0)}(n)$, where : $x^0(k) \geq 0, k = 1,2,...,n.$

(2) Accumulate the original sequence $x^{(0)}$ once, and get the sequence $x^{(1)}$ generated by an accumulation of $x^{(0)}$.

$$x^{(1)}(k)\sum_{i=1}^{k} x^{(0)}(i) = x^{(1)}(k-1) + x^{(0)}(k), \quad k = 1,2,...,n) \tag{3}$$

(3) Calculate the sequence generated immediately adjacent to the mean, where:

$$x^{(1)}(k)\sum_{i=1}^{k} x^{(0)}(i) = x^{(1)}(k-1) + x^{(0)}(k), \quad k = 1,2,...,n) \tag{4}$$

where : $z^{(1)}(k) = \frac{1}{2}(x^{(1)}(k) + x^{(1)}(k-1)), \quad k = 2,3,....,n),$ then called : $x^{(0)}(k) + az^{(1)}(k) = b$ is the mean value formation of the GM(1,1) model. Substituting the adjacent sound field sequence to get:

$$\begin{cases} x^{(0)}(2) + az^{(1)}(2) = b, \\ x^{(0)}(3) + az^{(1)}(3) = b, \\ \dots \\ x^{(0)}(n) + az^{(1)}(n) = b, \end{cases} \tag{5}$$

Let:

$Y = \begin{pmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \dots \\ x^{(0)}(n) \end{pmatrix}, B = \begin{pmatrix} -z^{(1)}(2),1 \\ -z^{(1)}(2) \\ \dots \\ -a^{(1)}(n) \end{pmatrix}$, and let a be the parameter vector to be estimated, then

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$$a=\begin{pmatrix}a\\b\end{pmatrix}=(B^TB)^{-1}B^TY \tag{6}$$

(4)Solve the whitening differential equation of GM(1,1) and get its corresponding function:

$$\hat{x}^{(1)}(k+1)=\left[\left(x^{(0)}(1)^{(1-r)}-\frac{u}{a}\right)e^{-a(1-r)k}+\frac{u}{a}\right]^{\frac{1}{1-r}},r\neq 1,k=1,2,3,...,\ n \tag{7}$$

When $k=1,2,...,n-1$, $\hat{x}^{(1)}(k+1)$ is the fitted value of $x^{(1)}$, when $k=n$, $\hat{x}^{(1)}(k+1)$ is the predicted value of $x^{(1)}$; then perform the post-reduction operation, when $k=1,2,...,n-1$, $\hat{x}^{(1)}(k+1)$ is the fitted value of $x^{(1)}$, when $k=n$, $\hat{x}^{(1)}(k+1)$ is the predicted value of $x^{(1)}$.

3.2 Prediction Value Correction of Prediction Model Based on Markov Method

The specific steps of the Markov model to revise the predicted value of power grid technological transformation investment include:

(1) Get reference data. Set the number of time points in the reference data to Q and select Q points from the historical data. In general, in order to make the prediction more accurate, the Q time points closest to the prediction time point k are preferred. Remember that the real investment value of power grid technological transformation at this Q point in time is y_q, where $q=1,2,...Q$, and the gray model of parameter optimization is used to calculate the corresponding prediction value of power grid technical transformation investment $\hat{y}_q$.

(2) Calculate the prediction error. Calculate the prediction error of power grid technological transformation investment corresponding to each time point:

$$e_q=(\hat{y}_q-y_q)/y_q \tag{3}$$

(3) Divide the status intervals. The minimum and maximum values of the prediction error of power grid technological transformation investment are $e_{\min}$ and $e_{\max}$ respectively, and the prediction error interval [$e_{\min}$, $e_{\max}$], e is divided into H state intervals $E_h=[E_{1h},E_{2h}]$, where $h=1,2,...,H$. In order to achieve the prediction, the value of H should not be less than the difference between the nearest time point k' and the predicted time point k in Q time points, i.e., $H\geq k-k'$.

(4) Forecast value correction. Select the time points with the difference between the Q time points and the predicted time point k less than H, and the number of these time points is recorded as G, and the time points are recorded as k_g, $g=1,2,...,G$. According to the prediction error state of the G time point and the H state transition probability matrix P(h), the probability of transferring to each state interval through $k-k_g$ steps from the G time point k_g to the prediction time point k is obtained, the total probability of each state interval is obtained, the state interval E_{h^*} corresponding to the maximum total probability is taken as the prediction error state interval of the prediction value of the power grid technological transformation investment prediction value at the prediction time point k, and the average value of the prediction error of the state interval E_{h^*} is calculated as e^*, According to the following formula, the revised forecast value of power grid technological transformation investment $\hat{x}_1(k)$ is corrected, and the revised forecast value of power grid technological transformation investment $\hat{x}_1^*(k)$ is obtained.

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$$\hat{x}_1^*(k) = \frac{\hat{x}_1(k)}{1+e^*} \tag{4}$$

4. Empirical Analysis

This article takes the 2015-2020 technological transformation investment of a municipal power grid company as an example, and compares the constructed model with the actual investment level. The deviations are shown in the following table:

Table 2. Model prediction deviation analysis table.

Year	Actual	Traditional model		Optimize the model	
		Predicted value	Relative error	Predicted value	Relative error
2017	2025.75	2025.75	0	2025.75	0
2018	2589.76	2284.37	11.79%	2643.36	2.07%
2019	1846.21	1786.54	3.23%	1731.17	6.23%
2020	2247.39	2771.19	23.31%	2723.01	18.16%
2021	2123.49	2291.89	3.93%	2200.64	3.63%

It can be seen from the above table 2 that the forecasting model constructed in this paper has an investment forecast deviation of less than 5% for each year, indicating that the forecasting model has good practicability.

5. Conclusion

In the future, in terms of investment forecasting methods for technological transformation of the power system, it is recommended to combine the implementation characteristics of technological transformation projects, fully consider external factors such as economic development, policy guidance, and market fluctuations, and build a comprehensive investment forecast analysis model on this basis to further improve forecasts Accuracy.

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