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Application of Grey Model in Power Load Forecasting

Jian-Na ZHAO[1,a], Xiao-Bo HE[2,b,*]

[1,2]Department of Economics and Management, North China Electric Power University

NO.689 Huadian Road, Beishi district, Baoding, 071003, China

[a]zhjnzhf@163.com, [b]hxb8858460@163.com

*Corresponding author

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Abstract. Power load forecasting is the basic work of electric power dispatching and planning of power system, Scientific and reasonable short-term power load forecasting can provide a strong basis for power system dispatching and long-term planning. Using the grey control theory to forecast the electric load, the known information from the annual electricity consumption, the original data were analyzed by the method of generating, strengthening law, establishing the differential equation model, make a scientific and accurate prediction of the demand of electricity. This method needs less complex data, does not take into account the distribution of the rule, the operation is simple and accurate, has provided an effective method for the electric power load forecast.

Introduction

Power load forecasting is one of the important tasks in the management of power system dispatching, electricity, planning and so on. To improve the technical level of load forecasting, to plan for power management, is conducive to the reasonable maintenance plan for power grid operation mode and the units, is conducive to coal saving, saving and reduce the cost of power generation, but also conducive to the reasonable power construction plan is conducive to the improvement of power system economic and social benefits.

The theory of color system was put forward by Professor Deng Julong in 1980s in China. The method of fuzzy control was adopted to solve the mathematical method of incomplete information system. Because of the grey prediction model, the modeling information is less, the operation is convenient and the modeling accuracy is high, it can get a better effect in short term load forecasting of electric power system.

Modeling Process

GM (1,1) Model

Grey modeling is the use of irregular historical data generation, so that it becomes more regular sequence of generation and then set up a differential equation model. Because the solution of the differential equation of the GM model is the exponential curve, the number of the generated sequence is the exponential curve. When the power load is positive, the original sequence can be changed into an increasing number after a single accumulation.

① Given the original sequence. record as $x^{(0)}$

x(0)=(x(0)(1), x(0)(2),…, x(0)(n)

② For the original sequence to do a cumulative generate a new sequence. record as $x^{(1)}$

$$x(1)=(x(1)(1), x(1)(2),\ldots, x(1)(n))$$

$$x(1)(k)=\sum_{i=1}^{k} x(0)(i);i=1,2,3,\ldots n.$$

③ Structure accumulation matrix B and constant vector Y_n

$$B=\begin{bmatrix} -\frac{1}{2}(x^{(1)}(1)+x^{(1)}(2)) & 1 \\ -\frac{1}{2}(x^{(1)}(2)+x^{(1)}(3)) & 1 \\ \vdots & \vdots \\ -\frac{1}{2}(x^{(1)}(n-1)+x^{(1)}(n)) & 1 \end{bmatrix}$$

$$Y_n=(x^{(0)}(2), x^{(0)}(3), \ldots x^{(0)}(n))^T$$

Linear differential equation model

$$\frac{dx^{(1)}}{dt}+ax^{(1)}=u$$

④ The parameters obtained by the least square method $\widehat{A}$

$$\widehat{A}=(B^TB)^{-1}B^TY_n=\begin{pmatrix}\hat{a}\\ \hat{u}\end{pmatrix}$$

⑤ The time response function for the model

$$x^{(1)}(k+1)=\left[x^{(0)}(1)-\frac{\hat{u}}{\hat{a}}\right]e^{\hat{a}k}+\frac{\hat{u}}{\hat{a}} \qquad (k=0,1,2,3\ldots)$$

⑥ The reduction of the original series down $\hat{x}^{(0)}$

$$\hat{x}^{(0)}(k+1)=(1-e^{\hat{a}})(x^{(0)}(1)-\frac{\hat{u}}{\hat{a}})e^{-\hat{a}k} \qquad (k=0,1,2,3\ldots)$$

Posteriori test of the Model

Posteriori test is based on the statistical test of the model and the actual value of the test method, which is transplanted from the probability method. Its content is: the residual ε as the foundation, according to the absolute value of the residual size, the probability of residual small point inspection, and the forecast error variance of relevant indicators.
Specific steps are as follows:

Residual mean value: $\bar{\varepsilon}=\frac{1}{n}\sum_{k=1}^{n}\varepsilon(k)=\frac{1}{n}\sum_{k=1}^{n}[x^{(0)}(k)-\hat{x}^{(0)}(k)]$

Historical data average: $\bar{x}=\frac{1}{n}\sum_{k=1}^{n}x^{(0)}(k)$

Historical data variance: $s_1^2 = \frac{1}{n}\sum_{k=1}^{n}[x^{(0)}(k) - \bar{x}]^2$

Residual variance: $s_2^2 = \frac{1}{n}\sum_{k=1}^{n}[\varepsilon(k) - \bar{\varepsilon}]^2$

Posterior odds ratio: $C = \frac{s_2}{s_1}$

Small error probability: $P = P[|\varepsilon(k) - \bar{\varepsilon}| < 0.6745 \times s_1]$

C is smaller the better, It shows that the difference between the predicted and the actual values is not very discrete in spite of the fact that the historical data are very discrete.

P is bigger the better，The difference between the average value of the residual and the residual is less than a given value of $0.6745s_1$.

According to C and P two indicators, you can comprehensively assess the accuracy of the prediction model, as shown in Table 1-1.

Table 1-1. The small error probability (P) and posterior error ratio (c) of the synthetic evaluation model.

Prediction accuracy grade	P	C	Prediction accuracy grade	P	C
good(one-level) qualified(second level)	>0.95 >0.8	<0.35 <0.5	reluctant(three-level) unqualified(level Four)	>0.7 ≤0.7	<0.45 ≥0.65

Example Applications

Establish a Model

According to the theoretical method and procedure of the above modeling, the application program of MATLABR2016a, Xi'an City, the 2000 - 2007 of the electricity consumption in order to predict the future use of electricity.

Table 1. Xi'an City, 2006 - 2010 electricity consumption.

year	2006	2007	2008	2009	2010
$x^{(0)}$	66.80	71.03	71.69	83.21	96.94

Data from Shaanxi Province Bureau of Statistics
Calculated by:

$$B = \begin{pmatrix} -102.3150 & 1 \\ -173.6750 & 1 \\ -251.1250 & 1 \\ -341.2000 & 1 \end{pmatrix} \qquad Y_n = \begin{pmatrix} 71.03 \\ 71.69 \\ 83.21 \\ 96.94 \end{pmatrix} \qquad \hat{A} = \begin{pmatrix} -0.1139 \\ 55.9887 \end{pmatrix}$$

So the time response function of the model is:

$$x^{(1)}(k+1) = 558.3601e^{0.1139k} - 491.56$$

Posteriori test

Calculated by: $s_1^2 = 119.9366$ $s_2^2 = 13.6938$

$$|\varepsilon(k) - \bar{\varepsilon}| = (5.2298 \quad 2.2071 \quad 5.2608 \quad 2.8493 \quad 0.6732)$$

$$0.6745\sqrt{119.9366} = 7.3868$$

So, C>0.95, P=1. It shows that the accuracy of this model is level one, and the model can be used to predict the sale quantity

Application of the forecast model for the sale of electricity in 2011 and 2012 forecast

Analysis of the errors in the analysis shows Table 2.

Table 2. Sale quantity error analysis table.

Year	actual sale quantity	forecast electricity consumption	relative error	accuracy
2011	98.22	106.2453	0.081707392	0.918292608
2012	110.21	119.0647	0.080343889	0.919656111

The Table 2 shows that use the grey prediction model to predict the sale quantity can get a high precision, and it is a kind of effective forecasting technology.

Conclusion

The gray prediction model and posteriori test results, with high accuracy in the short term, but only for the original data is non negative, with exponential rule changes not very fast. On occasions to meet this condition, the gray prediction can get better prediction results.

References

[1] Study on short term electric power load forecasting at county level.

[2] Analysis and evaluation of grey GM(1,1) model _ Ji Peirong.

[3] Study on power load forecasting in Baotou District.

[4] The grey model in forecasting of power demand in the application of Kuang Shaolong.

[5] Study on short term power load forecasting of Hebei South Network.

[6] Grey neural network _ area power grid electricity demand forecasting based on Liu Yaonian.