Application of Combination Forecast Model in the Medium and Long term Power Load Forecast

Ke Zhao[1] ,Lin Gan[2],hong Wang[3],Ai hua Ye[4]

[1]**College of Information Engineering, Nanchang Hangkong University,**
Nan Chang, Jiangxi, China

[2]**College of Information Engineering, Nanchang Hangkong University,**
Nan Chang, Jiangxi, China

[3]**College of Information Engineering, Nanchang Hangkong University,**
Nan Chang, Jiangxi, China

[4]**College of Information Engineering, Nanchang Hangkong University,**
Nan Chang, Jiangxi, China

Abstract

The gain of SVC depends upon the type of reactive power load for optimum performance. As the load and input wind power conditions are variable, the gain setting of SVC needs to be adjusted or tuned. In this paper, an ANN based approach has been used to tune the gained parameters of the SVC controller over a wide range of load characteristics. The multi-layer feed-forward ANN tool with the error back-propagation training method is employed. Loads have been taken as the function of voltage. Analytical techniques have mostly been based on impedance load reduced network models, which suffer from several disadvantages, including inadequate load representation and lack of structural integrity. The ability of ANNs to spontaneously learn from examples, reason over inexact and fuzzy data and provide adequate and quick responses to new information not previously stored in memory has generated high performance dynamical system with unprecedented robustness. ANNs models have been developed for different hybrid power system configurations for tuning the proportional-integral controller for SVC. Transient responses of different autonomous configurations show that SVC controller with its gained tuned by the ANNs which provide optimum system performance for a variety of loads.

Keywords: *Power Load, Combination Forecasts, Moving Average, Gray Model, Linear Regression Model.*

1. Introduction

Long-term load forecasting of power system is based on annual and quarterly forecasting. Its significance is to help determine the new installation of generating units (including capacity size, type, location and time) and network's planning, capacity increase and conversion. So the long-term load forecasting of power system is an important task of electricity planning sector [1]. The core issue of the forecast is the technical methods: a mathematical model of the forecast. The method of the load forecast is divided into experience load forecast and quantitative load forecast. The former are mainly experts forecasting method, analogy method and subjective probability method, etc.. The latter are unit consumption method, elastic coefficient, regression analysis, time series, artificial neural network and gray model method, and so on [2].

As the load of the power system is easily influenced by random factors, such as weather, economic conditions, social activities. Uncertainties are too much. Gray prediction method can be used for power load forecasting. The prediction of gray GM(1,1) model is a more effective method for the forecasting. GM(1,1) model has the characteristic with less data, poor information, simple calculation and high precision. But its long-term forecast of interference is not strong. As the power load data has obvious seasonal characteristics, volatility, which makes the GM(1,1) model for long-term power load forecasting has been limited. The linear regression model for long-term prediction has strong anti-interference, but highly dependent on raw data, and requires a lot of data. More original data, more laws, and higher accuracy are required. The linear regression model for long-term prediction is suitable for large sample model. Therefore, any one to predict has greater risk. In this paper, a new combination predictive model is proposed, which is based on gray GM(1,1) model and linear regression model, for forecasting the seasonal electricity load. The result has more accurate and higher effective through specific examples, compared to conventional method.

2. The Construction of the Model

GM(1,1) model is the most common kind of gray model. The first is to accumulate the original data ans generates data, that is a new data exponentially law, after get the original series accumulate. Obtain fitting curve through the establishment of the differential equation model, and then predicted values can be obtained by reduction[4-5]. linear regression model is the right use of the most recent observations

$x_{T-n+1},\dots,x_{T-1,}x_T$, use least squares method to establish the future of the first t time T periods of the prediction model. GM(1,1) simulation sequence in line with exponential, linear regression sequence in line with the linear of rules, both models are applied to predict monotonically increasing or monotonically decreasing sequence of indices. For the cyclical changes in the electrical load, direct application of GM(1,1) model or the linear regression model to predict the accuracy is not high, the original time series should be handled, so that the data tend to be smooth and stable. A moving average method is taken in this paper, the specific treatment method is:

Let $x_i(i=1,2,\dots,n)$ as the original time series, x_t is the first observation at time t, n is the number of proposed hours, M_T to calculate the time T of the sliding average.

$$M_T=\frac{x_{T-n+1}+\dots+x_{T-1}+x_T}{n} \qquad (1)$$

Moving average method can be used to eliminate these factors, and show the direction of events and trends, when the value of time series subject to cyclical and random fluctuations, largely up and down, and difficult to show the development of the trend. As the power loaded with seasonal periodicity, average processing is made for the moving of the original time series for n = 4. After that you can eliminate the seasonal periodicity, obtain a new time series in monotonic change, and then make Grey GM (1,1) model and the linear regression model more accurate.

Combination forecasting model is optimized combination for a variety of model predictions. As follows:

Use the combination forecasting of GM (1,1) model and linear regression model as an example. Set f_1 and f_2 respectively as the model predicted values, f_c is the optimal combination of the predictive value, e_1 and e_2 the prediction error, obtain w_1 and w_2 as the corresponding weights, and $w_1+w_2=1$,so:

$$f_c=w_1f_1+w_2f_2 \qquad (2)$$

Then the error and variance were:

$$e_c=w_1e_1+w_2e_2 \qquad (3)$$

$$D(e_c)=w_1^2D(e_1)+w_2^2D(e_2)+2w_1w_2\operatorname{cov}(e_1,e_2) \qquad (4)$$

Minimum $D(e_2)$:

$$w_1=\frac{D(e_2)-\operatorname{cov}(e_1,e_2)}{D(e_1)+D(e_2)-2\operatorname{cov}(e_1,e_2)}) \qquad (5)$$

Because e_1 and e_2 are independent of each other, $\operatorname{cov}(e_1, e_2) = 0$. According to $w_1 + w_2 = 1$,so:

$$w_1 = \frac{D(e_2)}{D(e_1) + D(e_2)}$$

$$w_2 = \frac{D(e_1)}{D(e_1) + D(e_2)} \qquad (6)$$

The combination has proven superior to any single model in theoretical, thus the optimal combination of the final model obtained, for the three or more models can use this way.

In this paper, it takes each quarter data of the 2004-2009 of the power company in Jiangxi as an example. Comparing the actual data obtained in 2010 with the projections of the first two quarters of 2011, and verifying the effectiveness of the method by error. As can be seen from Table 1, the power load has both electric load growth and seasonal fluctuations of the double trend, the change is more complex.

Table 2 running average electricity consumption of county power company in each quarter

nit: million KWH

Years	First quarter	Second quarter	Third quarter	Fourth quarter	Total
2004	4530.15	4490.02	6007.42	4937.28	19964.88
2005	6140.19	5708.09	7515.79	6077.23	25441.30
2006	7928.24	7449.90	9428.82	8365.64	33172.60
2007	8806.27	9968.47	11889.47	11418.67	42082.87
2008	10980.86	13273.38	14279.89	12111.51	50645.64
2009	13062.15	14791.18	18174.83	16730.17	62758.32
2010	18097.19	19136.82	22439.42	20687.23	80360.65
2011	21763.28	26876.16			

U
nit: million KWH

Suite	Sliding average	Suite	Sliding average	Suite	Sliding average	Suite	Sliding average
1	4991.22	8	7721.05	15	11890.60	22	16948.33
2	5393.73	9	8293.15	16	12488.20	23	18034.74
3	5698.25	10	8512.66	17	12661.41	24	19100.89
4	6075.34	11	9142.30	18	13181.74	25	20090.16
5	6360.33	12	9757.47	19	13561.19	26	21006.69
6	6807.34	13	10520.72	20	14534.92	27	22941.52
7	7242.79	14	11064.37	21	15689.58		

3. Applications

Table 1 Table of county power company electricity consumption of each quarter from 2004 to 2010.

According to the formula (1) of the method, do the sliding average processing to the original time series for n = 4 in Table 1 [3], the results are shown in Table 2. Number 1 in Table 2 is for the 2004 first, second, third and fourth quarters of the average power load, the number 2 is the average power load for the 2004 second, third and fourth quarter and first quarter of 2005, the rest and so on. Table 2 shows, the new moving average time series increased monotonically after treatment, suitable for gray GM(1, 1) model, also can use the linear regression model.

Table 3 the moving average model prediction of electricity consumption in each quarter of 2010 in one county power company.

U
nit: million KWH

Suite	Sliding average	Model of GM(1,1)	Predicted error $\lvert e_1 \rvert$	Linear regression model	Predicted error $\lvert e_2 \rvert$	Combinational model
22	16948.33	16608.39	339.94	16844.24	104.09	16725.68
23	18034.74	17536.33	498.41	17998.90	35.84	17766.37
24	19100.89	18516.11	584.78	19153.56	52.67	18833.11
25	20090.16	19550.63	539.53	20308.22	218.06	19927.38
26	21006.69	20642.95	363.74	21462.88	819.93	21050.70
27	22941.52	21796.32	1145.2	22617.54	323.98	22204.71

The first 21 new time series in table 2 after treatment were applied to GM (1,1) model and the linear regression model, the predicted values of GM (1,1) model and the linear regression model are obtained by the DPS data processing software. As table 3 shows, calculate the error variance $D(e_1)$ =86430.81, $D(e_2)$ =87382.09 of each model according to the prediction error value of the table. Get the combined predictive value of sliding averages of the 2010 fourth quarter and two quarters of 2011 by the application of the formula (2), (6) in combination forecasting.

Table 4 predictions of the combination model in county power company in each quarter of 2010

U
nit: million KWH

Years/quarters	Actual	Predictions of GM(1,1)	Relative error (%)	Linear regression values	Relative error (%)	Predictions of combination model	Relative error (%)
2010/1	18097.19	16737.38	7.5139	17680.78	2.3010	17206.54	4.9215
2010/2	19136.82	18502.94	3.3124	19409.82	1.4266	18953.94	0.9556
2010/3	22439.42	22093.95	1.5396	22793.47	1.5778	22441.79	0.0106
2010/4	20687.23	20868.25	0.8750	21348.81	3.1980	21107.25	2.0303
2011/1	21763.28	21106.66	3.0171	22299.42	2.4635	21699.82	0.2916
2011/2	26876.16	23116.42	13.989	24028.46	10.596	23569.98	12.302

initially, the model data in Table 3 is inversed by the moving average. Get the power load forecast of the fourth quarter of 2010 and the first two quarters of 2011, the results are shown in Table 4. Table 4 shows that the combined average relative error of prediction model is minimum, compared to three models to predict the data. On the terms to forecasting methods for the combination, find the first five forecast numerical accuracy more accurate in the fourth quarter of 2010 and the first two quarters of 2011for the electricity load forecasting, the final set of data is slightly too large. It is due to the county power company took over more than a few 10kv lines in April 2011, resulting in the consumption has greatly improved in the second quarter than in previous years. Abandon the last set of forecast data, the maximum relative error of the combined model is 4.9215%, and the mean relative error is only 1.6419%, indicating that no major unexpected circumstances, the method has high prediction accuracy, and better prediction.

4. Conclusion

According to the seasonal characteristics of the power load, this paper presents a moving average method with the original time series processing, and then slide to establish the average gray GM(1,1) model, the linear regression model and optimization of it . The results from the previous 5 sets of data show that the method has high prediction accuracy, the average relative error is less than 2%, the maximum relative error is less than 5%. The prediction accuracy can meet the needs of practical applications for urban, has some practical value to the planning in the long-term power load forecasting. But in the last group of forecast data can be seen, the method is weak against unexpected situations, how to abandon precipitating factors in the method, making predictions more accurate, and further investigation is needed.

References：

[1] Li Zhang, Peirong Ji, Aihua Du, Qixin He. Several long-term power load forecasting comparison of gray prediction model and its application [J]. Three Gorges University: Natural Science, 2009,31 (3) :41-45.
[2] Junyou Zhao. Grey GM (1,1) model and its optimization in power load forecasting application [J]. Shenyang Institute of Technology: Natural Science, 2007,3 (1) :35-37.
[3] Wanming Zhao, Yanquan Huang, Guihui Chen. Seasonal electricity load forecasting in rural areas based on optimization Gray model [J]. Anhui Agricultural Sciences, 2010,38 (3): 1448-1449.
[4] Zhenjun Tang. Long-term power load forecasting based on improved Gray model [J]. Chizhou power supply companies, 2009,23 (6) :42-43.
[5] Liwen Yao, Xiaoming Bai, Yi Chen. Power load forecasting model based on gray theory [J]. Nanchang University: Science Edition, 2010,34 (5) :507-510.
[6] Chongqin Kan, Qing Xia, Yu Shen, Niande Xiang. The integrated model of power system load forecasting [J]. Tsinghua University: Natural Science, 1999,39 (1) :8-11.

[7] Shang Jun-liang, Fang Min. New Optimized Method of High-Precision Grey GM(1,1) Forecasting Model [J]. Journal of Electronics & Information Technology: Vol.32No.6, Jun. 2010:1301-1305
[8] Li H,Su L D,Butterworth J. Grey forecasting model for active vibration control systems .Journal of Sound and Vibration, 2009, 322 (4-5) :690-706 .
[9] Lin Y H,Lee P C,Chang T P. Adaptive and high-precision grey forecasting model .Expert Systems with Applications, 2009, 36 (6) :9658-9662 .
[10] Wei L S,Fei M R,Zhao W Q. Analysis of grey prediction based iterative learning control .Prceedings of the2008IEEE International Conterence on Information and Automation. Hubei. 2008, :1096-1100 .
[11] Wu W Y, Chen S P. A prediction method using the grey model GMC(1,n) combined with the grey relational analysis: a case study on Internet access population forecast .Applied mathematics and computation, 2005, 169 :198-217 .
[12] Tzu-Li Tien. The indirect measurement of tensile strength of material by the grey prediction model GMC(1, n) .Measurement Science and Technology, 2005, 16 (6) :1322-1328 .

Ke Zhao received the degree in Software Engineering from Nanjing University of Aeronautics and Astronautics, in 2006. he is an Associate Professor at Nanchang Hangkong University, His research interests include FACTS, Power System Dynamics and Predictive Control.