A Study on Supplied Forecasting of Short-term Electrical Power using Fuzzy Compensative Algorithm

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ABSTRACT

A The estimation of electrical power consumption is becoming more important to supply stabilized electrical power recently. In this paper, we propose a supplied forecasting system of electrical power using Fuzzy Compensative Algorithm to estimate electrical load accurately than the previous. We evaluate a time series of supplied electrical power have the chaotic character using quantitative and qualitative analysis, compose a forecasting system by the maximum change rate(α) of Fuzzy Algorithm and compensative parameter. Simulating it for obtained time series, we can obtain more accurate results than the previous proposed system.

Key words

Fuzzy Algorithm, Estimation, Forecasting electrical power

I. INTRODUCTION

Generally, the necessity of electric power demand prediction may be summarized in several. Due to the character of electric power of which production is almost always attended with simultaneous demand, the electricity produced from various plants should be provided continuously keeping step with the momentarily changing electric power demand. The short-term prediction method would be needed for the operation plan of electric power equipment complied with changing consumer's demand by the hour, long-term prediction method for equipment system plan. It is the accuracy of prediction that leads to get an economical effect as well as an efficient supply.

To predict the precise maximum electric power demand, we need to consider the following several items. First, the maximum electric power demand goes down on the end and beginning of the year and on national holidays, sundays, saturdays when all of the industrial activities stop, and mondays which have the same tendency because of the first day when the industrial activities start. Secondly, temperature exerts an important effect on the electric power demand in summer and winter that are liable to increase in the demand for air-conditioning and heating. Thirdly, on summer showing the high percentage of humidity though the same temperature, climate also exercises it's influence over the electric power demand. Natural phenomena and nonlinear systems caused by some unpredictable factors prevent us from predicting the precise electric power demand. But understanding the chaotic character out of nonlinear system features and the positive application of chaotic system might enable us to obtain an admirable consequence in short-term prediction.

II. RELATED WORKS

2.1 Analysis of Chaos characteristic of Electric Amount used

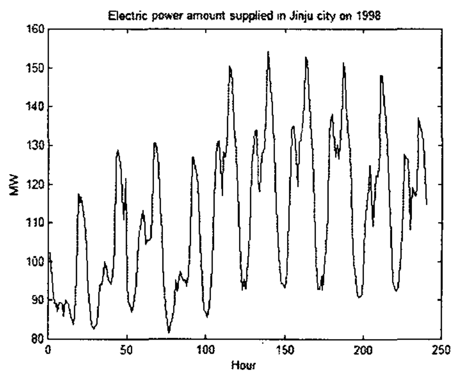

Fig. 1 One part of time series data of electric power amount supplied in Chin-Ju.

Time series data used of this paper is to measure electric power amount supplied in Chin-ju and analyze chaos characteristics in time series data with measured values from Jan. 1. 1998 to Sep. 31. 1998 with quantitative and qualitative analysis and after that use it as basic data in designing control algorithm. Observing time series data shown in Fig. 1. The change of state has a big difference and its regularity of 7 days cycle can be observed.

2.1.1 Quantitative analysis

It can be considered on relative dimension used generally as a tool of quantitative analysis. This concept is correlation integral $C(r)$ indicating probability that any two points in locus can approximate within a radius r and indicates as a sloping of a space of semi-diameter. A correlation dimension is presented to the same as the following equation.

$$\nu = \lim_{r \to 0} \frac{\log C(r)}{\log r}$$

where, the means r that a semi-diameter at any place of attractor locus, a correlation integral $C(r)$ is presented to the same as the following equation.

$$C(r) = \lim_{N \to \infty} \frac{1}{N^2} \sum_{i,j=1}^{N} H(r - |x_i - x_j|)$$

where, $H(t)$ is as a heavyside function, it has a property of the following equation.

$$H(t) = \begin{cases} 1 & (t \geqq 0) \\ 0 & (t < 0) \end{cases}$$

That is to say, the $C(r)$ is the sum total of separately difference x_i and x_j is less than r an absolute values in the number. If the value of r is very big, $C(r)$ becomes 1, then $\nu=0$ but relatively small r is same as the following equation.

$$C(r) = constant \times r^{\nu}$$

According to the Takens' theory relation to a recomposition of attractor has been proved to have the same value as embedding dimension in relation to a very small r. In this paper time series signals collected over the long-term period have been employed to minutely calculate correlation dimension, and simulation is carried out, with embedding dimension changed from level 1 to level 6.

Table 1 Correlation dimension with embedding dimension changed

A division	1	2	3	4	5	6
Power	0.9526	1.8437	1.9655	1.5393	1.1781	0.8771

2.1.2 Qualitative analysis

There are two major ways in qualitative analysis - electric power spectrum and self-correlative function - which are used to analyze, by means of energy distribution shown on the frequency planes, the chaotic characteristics. While, in case of pure noise, energy is distributed all over the range, it is distributed to much narrower range in case of time series data. Next, The following is an analysis on self-correlative function by which the comparative characteristics of periodic and non periodic signals can be well clarified. Although there is a difficulty discerning noise signals and chaos signals, it can be said from the average values that the latter has a greater values than the former.

2.2 The predictive system of electric power using Fuzzy compensative algorithm

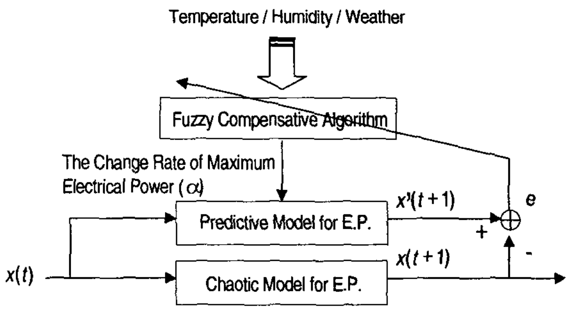

Fig. 2 A block diagram of predictive system using Fuzzy compensative algorithm

The predictive system proposed in this paper first analyzes the chaotic characteristics of time series data, then if it's available, calculate, based on the results of inference which is obtained from the Chaos Fuzzy algorithm and the proposed one. Considering various values of input, the rate of changes of maximum demand electric power, and predict the next maximum demand electric power in comparison with that of the present. The basic system is as Fig 2.

The input data of the predictive system are weather-related ones, such as temperature, climate, and the increase of temperature. Some linguistic statement, rules, membership function, and look-up table of Fuzzy algorithm presented in this paper are as table 2 and Fig. 3, 4. If weather is *very cold*, change of weather is no change and humidity is dry then change of weather is large change

Table 2. Fuzzy Rule

$\Delta\omega$ \ ω	NB	NS	ZO	PS	PB
NB	NB	NB	NB	NS	ZO
NS	NB	NS	NS	ZO	PS
ZO	NB	NS	ZO	PS	PB
PS	NS	ZO	PS	PS	PB
PB	ZO	PB	PB	PB	PB

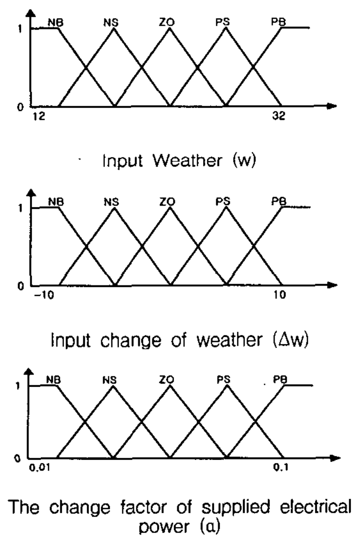

Fig. 3 Membership Function

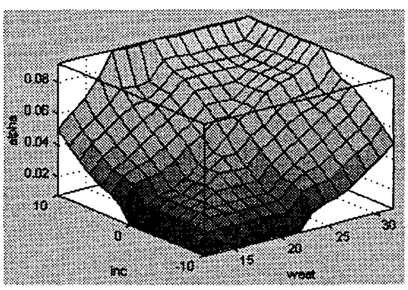

Fig. 4 Look-up Table

III. SIMULATIONS

In this paper, we propose the predictive system with Fuzzy compensative algorithm to analyze the chaotic characters of time series obtained from the specific plant and to predict the short-term for electric power demand of the plant. We compare the predicted data with the active ones and checked the error generated by the Chaos Fuzzy predictive system and the proposed system.

3.1 The rate of maximum electric power needed

The rate of needed maximum electric power demand generated from those system is diagramed in Fig. 5 The more diversified and the more accurate the variables, the more precise the rate of changes of maximum electric power. As the weather-related data are made out of those based on ordinary ones, the error between actual data and predicted data is said to arise from those weather-related data.

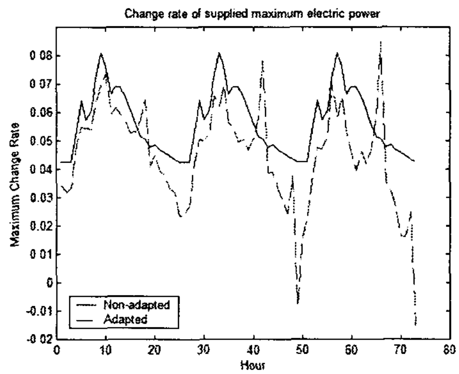

Fig. 5 The rate of needed maximum electric demand power between compensative algorithm and it not-applied

3.2 The result of simulation

The simulation performed in this paper is a method to predict, considering the rate of changes generated from the predictive system of Fuzzy compensative algorithm, the next time series data in comparison with those of the present. Each simulation process has been carried out through subdivided four seasons: spring, summer, fall, and winter, and the result has been analyzed.

Fig. 6 and 7 indicate the data of maximum demand electric power in summer and winter when Fuzzy compensative algorithm not applied and applied. Fig. 8 indicate an error between predicted data and active one, which compensative algorithm is applied and not applied. It can be classified each other by the above figure.

The result of simulation makes us find the fact that actual data are a little bit behind predicted data in a case of compensative algorithm being applied and not applied.

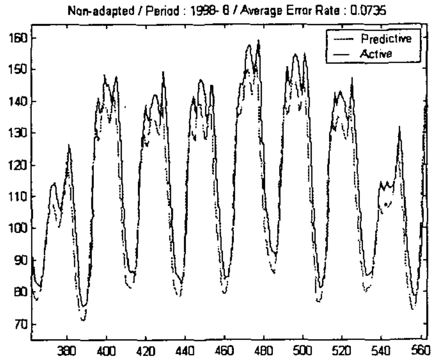

Fig. 6 Predicted and active data plotting of 1998. 8
when compensative algorithm not applied

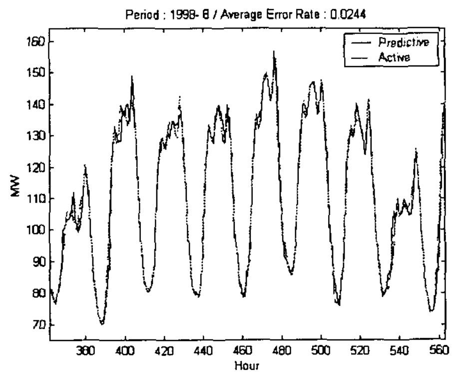

Fig. 7 Predicted and active data plotting of 1998. 8
when compensative algorithm applied

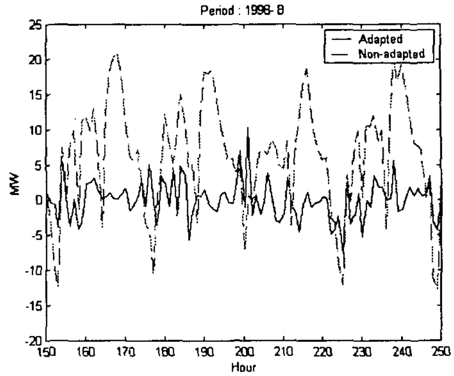

Fig. 8 Error, between predicted data and active one, which compensative algorithm is applied and not applied

The average error between predicted data and actual ones for the experimental period resulted in 7.27% and 2.46% as Table. 3, despite of its relatively satisfactory results, which is caused by the accuracy of data in relation to the weather, invented for the convenience of input to the Fuzzy compensative predictive system. To minimize error and compose the predictive system which can measure a precise coefficient of variation, it is necessary to collect various weather-related data and apply them to the proposed system.

VI. CONCLUSIONS

In this paper, we propose the predictive system with Fuzzy compensative which can analyze the chaotic character by inputting time series data and predict the short-term electric power demand of a specific plant from the induced data. The time series data of short-term electric power demand of a specific region classified by seasons are inputted to the predictive system and compared with the actual ones, following performing the simulation.

Table 3. Error table of compensative value being not applied and applied with different values.

Year-Mon	Non-app.	App-10	App-5	App-2
1998- 1	0.0749	0.0333	0.0268	0.0241
1998- 2	0.0711	0.0315	0.0242	0.0211
1998- 3	0.0768	0.0366	0.0310	0.0291
1998- 4	0.0714	0.0337	0.0281	0.0269
1998- 5	0.0722	0.0335	0.0287	0.0276
1998- 6	0.0705	0.0303	0.0248	0.0233
1998- 7	0.0716	0.0311	0.0252	0.0230
1998- 8	0.0735	0.0319	0.0259	0.0244
1998- 9	0.0713	0.0330	0.0271	0.0251
1998-10	0.0734	0.0330	0.0280	0.0262
1998-11	0.0733	0.0282	0.0218	0.0197
1998-12	0.0718	0.0311	0.0260	0.0248
Average	**0.0727**	**0.0323**	**0.0265**	**0.0246**

Also we simulate above process without compensative algorithm. As results, it indicates that the latter has larger an error than the former. We can obtain more accurate results from the predictive system of compensative algorithm being applied compared with not applied.

Minimizing the error of short-term predicted data can be realized through the various and precise data acquisition of climate and temperature and the continuous grip of ceaselessly changing resident and industrial environment, namely through Fuzzy rules based on various parameters resulting in accuracy and improvement.

REFERENCES

[1] C.E. Asbury, "Weather load model for electric demand and energy forecasting", *IEEE Trans. on Power Appr. and Sys.*, vol. PAS-94, p.1111-1116, 1975

[2] Edward Ott., "Chaos in Dynamical Systems", *Cambridge University Press,* 1993

[3] G.L.Baker and J.P.Gollub, "Chaotic Dynamics", *Cambridge University Press,* New York, 1996

[4] Heinz-otto Peitgen, Hartmut Jürgens, Dietmar Saupe, "Chaos and Fractals, New frontiers of science", *Springer-Verlag,* 1992

[5] Jong Hyun Kim and John Stringer, "Applied Chaos", *A Wiley-Interscience Publication,* 1992

[6] Kazuyuki Aihara & Ryuuji Tokunaga, "Kaosu Ouyousenryaku", *Ohmsha,* Tokyo, 1993

[7] N.J. Thadani, J.A. Findlay, M.N. Katz, B.D. Mackay, D.M. Frances, and C.T. Chan, "An intergrated, hierarchical forecasting, scheduling, monitoring and dispatching system for a large hydro-thermal power system", in *Proc. IFAC Conf.* on Power Systems and Power Plant Control, p.445-450, 1986.