ISSN : 0974 - 7435 Volume 8 Issue 2

BioTechnology
An Indian Journal

FULL PAPER

BTAIJ, 8(2), 2013 [152-158]

Application based on feedback neural network fault current detection method

Yang Zhao*, PengGao, Yun-xia Jiang, Rui Zhang
School of Automation, Harbin University of Science and Technology, Harbin, Heilongjiang Province, 150080, (CHINA)
E-mail: zhaoy0606@163.com; hrbustjyx@163.com; zr_gh@sina.com

ABSTRACT

For some traditional current detection methods which are slow, poor reliability, and can not meet the large grid interconnection and flexible AC transmission requirements, a fault line detection method based on neural network is proposed. By BP neural network, Elman neural network, the method is used for fault signal detection error training, can detect fault signal in a short time. The effect and speed of the Elman neural network is better, and have a certain anti-jamming capability, that can quickly detect failure lines of the electric power. It has a very important significance in improving the speed and service life of the grid circuit breaker, fast switching applications power system and ensuring the safety of the power grid.

KEYWORDS

BP neural network;
Elman neural network;
Fault current detection.

INTRODUCTION

With rapid development of power grid interconnection, reliability and security of the grid lines become one of the keys to the development of the power system, so the fault circuit detection current system is particularly important. The conventional circuit breakers detect fault current by the method of comparison of the current threshold value, it is difficult to guarantee its reliability and easy to produce a malfunction. Therefore it is necessary to study a quick and effective detection method for finding line fault in a enough short time. Detecting short-circuit current by software calculation can facilitate using a variety of algorithms, it is better than hardware direct detection in functionality and flexibility. There are many methods for detecting current rapid at home and abroad[1-3], such as two-or three-point sampling method, a half weeks integral method and the Mann-Morrison algorithm, those are pure sinusoidal model-based methods, which are all based on sinusoidal signal, but the signal in the actual grid will distort in some degree, especially in the event of a short circuit. Some algorithms are based periodic function model, such as full-wave and half-wave Fourier transform, all have more desired effect, but need to calculated by cycle data, the speed is slower. The neural network is an intelligent calculation method, has excellent approximation ability to linear and non-linear function, has been applied increasingly in a power system in recent years, and has achieved a lot of results in fields of fault diagnosis and harmonic wave detection in power system[4-5]. In this paper the neural network is mainly applied to fault current detection, to identify line fault status quickly, so that the line breaker can off in a timely manner. Based

on introducing fault current detection methods by neural network, using feedback neural network to detect the fault current, the simulation results show the effectiveness and fast of the method.

DETECTION PRINCIPLES AND METHODS

The neural network has abilities of learning, generalization and fault tolerance. In recent years the neural network has been widely used in the model approximation, signal processing and pattern recognition etc. Parallel computing features of neural network make it more suitable for practical applications. Nowadays the neural network has been widely used in harmonic detection and fault detection in the power grid. According to the different of structure and realization of the neural network, there are many programs be uses in fault and short-circuit current detection.

The traditional fault current detection principle

(1) Detection based on harmonic analysis

Principle harmonic detection is shown in Figure 1, the detected current is flowed through the current transformer and the current-voltage conversion, and inputted to the neural network to detect after sampling, the neural network separates fundamental component, detected the current size of the fundamental by comparing to determine whether to generate fault circuit.

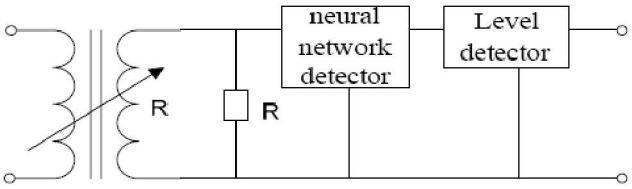

Figure 1 : Configuration of detecting system

Harmonic current can be detected by RBF, which is radial basis feed-forward network, with higher computing speed and global convergence performance than BP network[6-7]. The neural network input, $[x_1, x_2, \cdots, x_m]^T$, is the sample point data of the signal to be measured, the input sample when the offline training is the sampled value sequence of the signals in entire cycle or half-cycle, the input samples is a time-delay sequence of the signal samples when it is online training. The output of the network, $[a_1, b_1, \cdots, a_n, b_n]^T$, is the current signal amplitude of the fundamental wave to be detected and each harmonic. This method is actually equivalent to training a neural network filters, need to enter whole or half cycle of sampled data when it is use online, same as the full-wave or half-wave Fourier algorithm, despite the actual use is better, but the detection rate is not enough good.

(2) Detection based on fault diagnosis

The ability of the pattern recognition and classification of the neural network can also be effectively used to achieve the detection of the fault current. This method need to extract the fault current feature of the sampling signals, train the neural network by those so that the network has a capability of fault current classification and identification. There is a special relationship between the wavelet transform and the signal singularity, particularly effective on processing and feature extraction of edge signal and peak mutation signal. So wavelet transform and neural network classifiers can be combined, with the characteristics of extracting the fault current by wavelet transform, and then input to the neural network to identify failure. Doing so can reduce the number of neural network input, simplify the neural network structure, short the training time and improve the identification ability of failure categories[8-9].

Fault detection based on feedback neural network

In order to achieve effective fault detection, the historical memory effect of the feedback neural network should be applied to forecast and compare with the signal. Common neural networks are BP neural network and the Elman neural network.

There are more specialized literature discourse the detection method based on harmonic analysis and fault diagnosis. So this article only simulates and analyzes the detection method based on feedback neural network.

BP neural network is defined as basing on error back propagation algorithm (BP algorithm) and forward multilayer neural network, has become wider using. The typical BP network is a three-tier network, including input layer, hidden layer and output layer[10-11]. The structural principle is shown in Figure 2.

xi is the input layer nodes, yj is the hidden layer nodes, Ok is the output layer nodes. Vij,Wjk are the

FULL PAPER

weights between input layer and hidden layer, the weights between hidden layer and output layer weights. BP network characteristic expressions are:

Hidden layer: $y_j = f(\sum_{i=0}^{n} v_{ij}x_i)$, j=1,2,...m **(1)**

Output layer: $O_k = f(\sum_{j=0}^{m} w_{jk}y_j)$, k=1,2...l **(2)**

Network error: $E = \frac{1}{2}\sum_{k=1}^{l}(d_k - O_i)$

$$= \frac{1}{2}\sum_{k=1}^{l}\{d_k - f[\sum_{j=0}^{m} w_{jk} f(\sum_{i=0}^{n} v_{ij}x_i)]\}^2 \quad \textbf{(3)}$$

f(x) is the activation function of neurons, *dk* is network expectations for, E is network error.

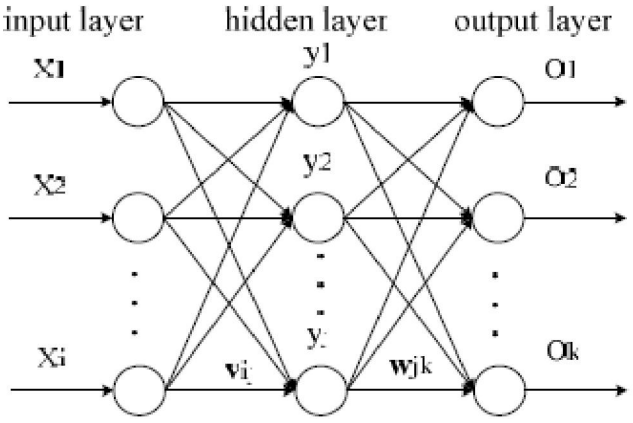

Figure 2 : Structural model of BP neural network

BP network is consists of four process, those are, "mode forward dissemination" process of input mode is from the input layer through the middle layer to the output layer, "mode reverse dissemination" process of the error signal between desired output and output of the network gradually connect from the output layer through the middle layer to the input layer, the" memory training" process of network is by repeating alternately between "mode forward dissemination" process and "mode reverse dissemination" process, the" learning convergence " process is looked as that the global error of network tends to a minimum value.

Elman is constituted by an input layer, a number of hidden layers and output layers, each of the hidden layer nodes has a corresponding node of undertaking associated layer, shown in Figure 3.

Difference between Elman neural network and BP network is the presence of its associated layer node. The associated layer nodes output of Elman neural network store the network internal state actually, the connection of associated layer and middle layer is similar to state feedback within the systems[12-14]. The state space is expressed as:

$$\begin{aligned} x(k) &= f(w^1 x_c(k) + w^2(u(k-1))) \\ x_c(k) &= x(k-1) \\ y(k) &= g(w^3 x(k)) \end{aligned} \quad \textbf{(4)}$$

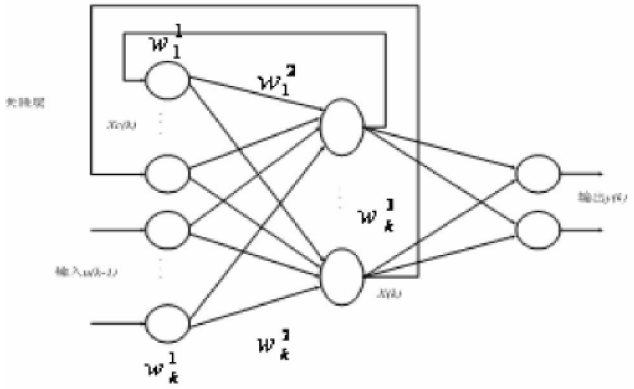

Figure.3 : Structural model of Elman neural network

Respectively, where x, y, u, x_c are the output vector of the hidden layer, the output vector of the output layer, input vector and feedback state vector. w^3, w^2, w^1 are the connection weights of hidden layer to the output layer, the input layer to the hidden layer and undertaking associated layer to the hidden layer. f and g are transfer the function of hidden layer and output layer[15-17]. Thus it can be seen, Xc(k) depends on the different times in the past, is a dynamic recursion process. Elman network corrects weights by BP algorithm, learns indicator function by the sum of squared errors:

$$E(w) = \sum_{k=1}^{n}[y_k(w) - \hat{y}_k(w)]^2 \quad \textbf{(5)}$$

In which, $\hat{y}_k(w)$ is target output vector.

The typical BP network includes an input layer, a hidden layer and an output layer. In which the hidden layer usually uses sigmoid neurons, the output layer usually uses purelin neurons. Elman neural network is usually composed of two layers of neuron, especially it has a delayed feedback in his return neurons between input and output. All of those makes the network learn not spatial model but time model. In Elman neural network, regression layer adopt tansig neurons, the input layer adopts purelin. So that Elman neural network can ap-

proximate follow any function by any precision (memory limited intermittent), Premise is that neurons of the regression layer is enough.

These types of neural networks can reflect the current changes quickly, and then to make a prediction by changing data. If the measured current value exist larger deviation with the neural network predictive value, then that circuit is abnormal, principle shown in Figure 2.

SIMULATION ANALYSIS BASED ON FEEDBACK NEURAL NETWORK DETECTION

Matlab neural network toolbox can be used in simulation of BP and Elman neural network, training samples emerge from simulation. Harmonic components, multiple superiorities by single-phase fundament, can simplify and instead by available sine function. Selecting frequency sinusoidal signal of different amplitudes and multiple cycles as input samples, try it to cover the signal amplitude range when it is normal, the same signal is as the output samples. The two methods update the weights at the same time may consider the gradient direction of the current time and the previous time, thereby improving the training efficiency of the network, effectively inhibiting the emergence of local minimum values . The level detector can use the window comparator, detection time of short circuit current relates to the threshold of the level detector. If the threshold value is too small, erroneous operation is easy to produce. If the threshold value is too large, time of detecting action will be prolonged. Considering various factors, the best threshold voltage is selected by simulation.

Using Matlab software, training through the BP neural network and the Elman neural network respectively, setting input and the output signal of training samples as 1v to 5v sine wave. When the number of training samples is more than 200 times, the convergence number of two type network achieves 300 times, the target accuracy can be less than 0.005. Setting the threshold value of level detection as $\pm 1v$, testing BP and Elman neural network which completed training for fault detection, the test signal is shown in Figure 4.

Let 53ms the grid produces abnormal signal, the error detection results of the BP neural network shown in Figure 5, the level of the threshold value comparison result is shown in Figure 6, Elman neural network error detection results is shown in Figure 7, the comparison results of the level threshold value are shown in Figure 8.

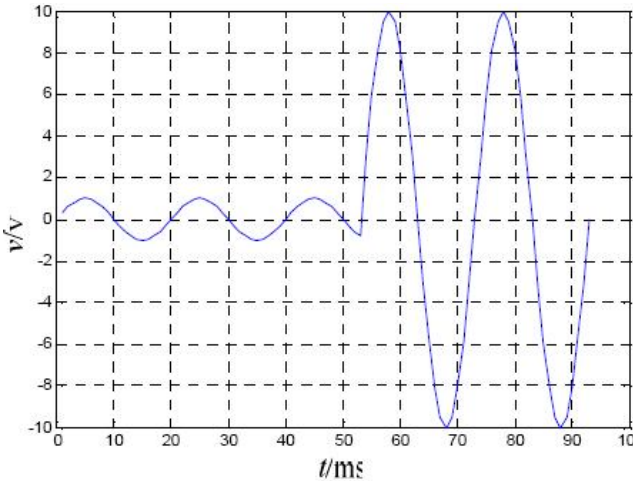

Figure 4 : Simulation of fault signal

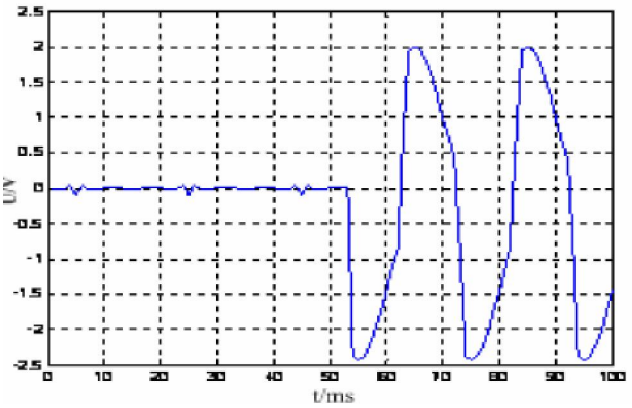

Figure 5 BP network output error

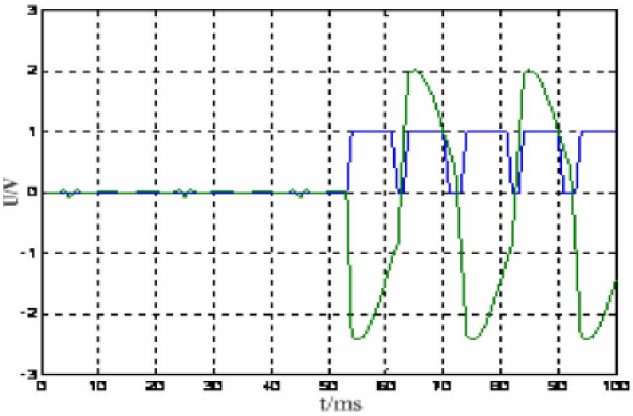

Figure 6 : Result of BP network voltage level detection

Seen from figure, when the grid is normal, the predictive value of neural network is consistent with and the actual signal value, the error detection results shall be zero approximately. When abnormal signal is emerging (53ms), the input signal mutates, then the measured

FULL PAPER

current value greater than the prediction value of neural network, the error detection result of neural network suddenly increases. When the result is out of the range of the level detection threshold, the detection circuit will be able to issue a signal in a timely manner.

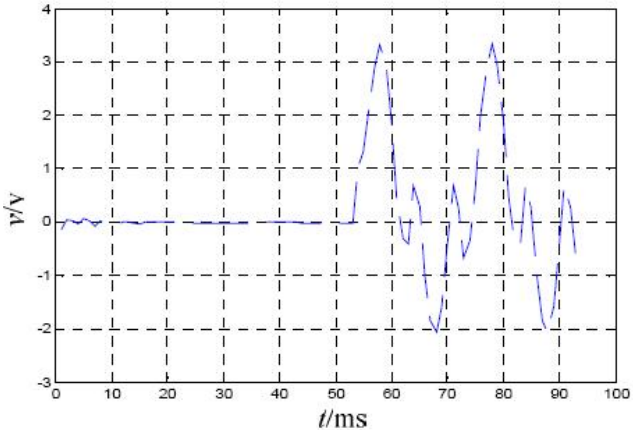

Figure 7 : Network output error

In this process, the time of abnormal occurrence is different, the phase angle in the moment is different, it is detected that the operation time of the abnormality signal is also different. Experimental results of BP neural network and the Elman neural network are respectively shown in TABLES 1 and 2 below.

TABLE 1 : Response time of detecting by different angle of BP neural network

Fault time (ms)	Phase Angle (°)	Operation Time (ms)
80	0	1.98
81	18	2.06
82	36	2.56
83	54	2.61
84	72	2.59
85	90	2.51
86	108	2.32
87	126	2.78
88	144	2.71
89	162	2.35

TABLE 2 : Response time of detecting by different angle

Fault time (ms)	Phase Angle (°)	Operation Time (ms)
80	0	1.73
81	18	1.95
82	36	2.21
83	54	2.29
84	72	2.25
85	90	2.21
86	108	2.22
87	126	2.17
88	144	2.09
89	162	2.96

It can be seen that the two types of neural networks can detect fault state within 2.8ms. Response speed of Elman neural network is faster than the one of BP neural network, so the detection effect is better. Detecting the other types of abnormality signal, the results have shown that the type detection method can quickly detect abnormality signal of the grid within 2.8ms.

In addition, there are various disturbances in practical applications, so the current is not good sine signal, and Figure 9 shows that the higher harmonic signal is present in the grid.

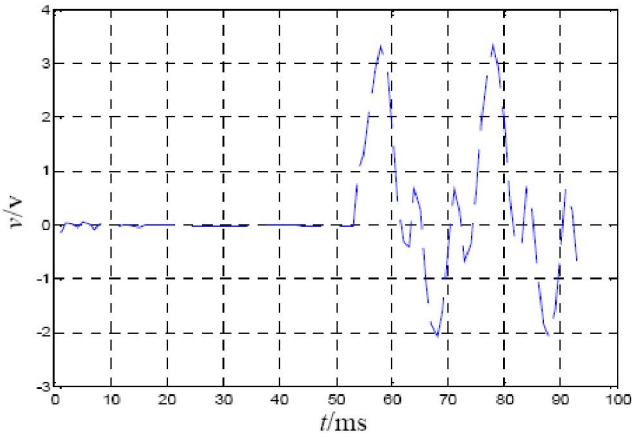

Figure 8 : Result of electric level detection level detection

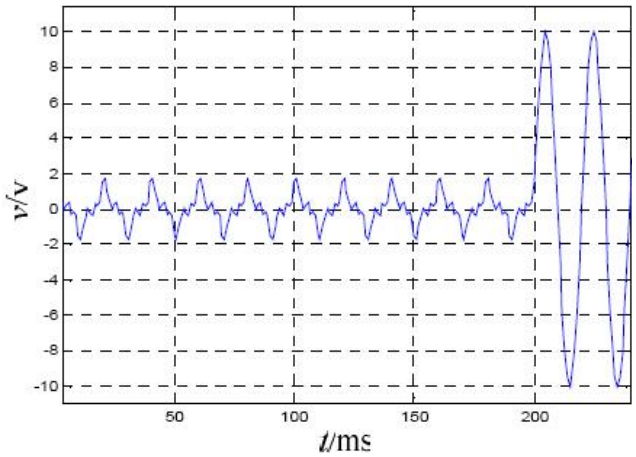

Figure 9 : Signal waveform of including harmony

Using the BP, Elman network detection which have been trained to detect, the simulation results of the output error and the level detection is shown in Figure 10, 11. It is visible that the short circuit fault current can be detected rapidly within 5ms when the grid has harmonic interference. Due to predictive role of the neural network, some harmonic Interference in the circuit does not affect the detection results.

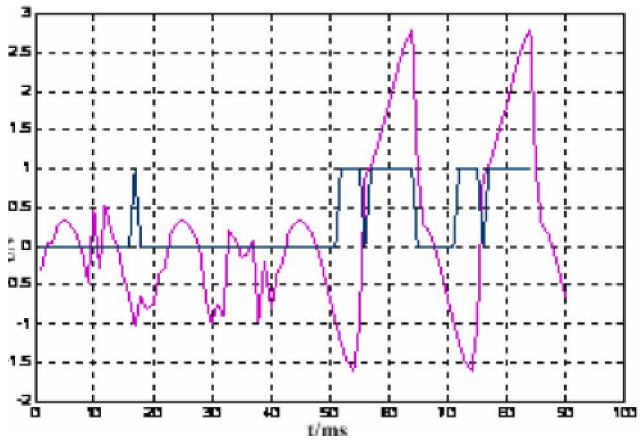

Figure 10 : Output error of BP neural network and result of harmony

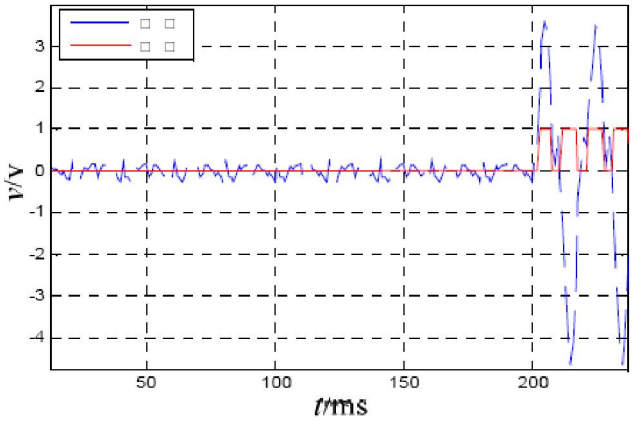

Figure 11 : Output error of Elman neural network and result of electric level detection

We can see from the above simulation results that neural network detection method are compared in the paper two, Elman network's effectis better than the one of BP network, compared with the traditional detection method, has faster speed and stronger anti-interference ability.

Further enrich BP, Elman network training samples and training times, you can get a better approximate performance. Neural network can be trained based on the different actual situation. Static and dynamic network can also be combinated to apply, combine with harmonic detection, filtering and fault detection function to achieve better effect.

CONCLUSIONS

Through the above analysis can be drawn, based on the description of the detection principle of harmonic analysis and fault diagnosis, two feedback neural networks for fault line detection, are able to achieve grid failure. In which, the fault current detection method based on Elman neural network is proven its movement speed and detection performance better than BP neural network, the fault signal can be detected in a shorter time line. This detection method can be applied in some fault current protection device of lines or in some of the fault current detecting means. It has an important significance for ensuring the grid security.

REFERENCES

[1] Xue-Feng Jiang; An Effective Decision Support System based on Neural Networks and Its Application, IJACT, **5(1)**, 37-45 **(2013)**.

[2] Feng Jun-Ping, Hang Wei-Xing, Zhao Liang, Huang Shi-Hui; Endurance Mileage Estimation of the State of Charge for Electric Vehiclesm Based on the Fuzzy Inference of Artificial Neural Network", IJACT, **5(1)**, 540-548 **(2013)**.

[3] Desheng Liu, Keqi Wang; Flow Meter online Compensation Based on Neural Network Algorithm, IJACT, **5(1)**, 297-303 **(2013)**.

[4] Hongchun.Shu, Gefei.Qiu, Chaofan.Li; A Fault Line Selection Algorithm Using Neural Network Based on Stransform Energy, 2010 Sixth International Conference on Natural Computation (ICNC 2010), **22(09)**, 1478-1482 **(2010)**.

[5] Bin. Lu, Yaoyu.Li, Xin.Wu, Zhongzhou.Yang; A Review of Recent Advances in Wind Turbine condition monitoring and fault diagnosis, In Proc. IEEE Conference on Power Electronics and Machines in Wind Applications, 1-7 **(2009)**.

[6] Guangyuan Song; Self-Localization System of the Explosive Ordnance Disposal Robot based on Danger Model Immune Wavelet Neural Network, JDCTA, **7(1)**, 643-651 **(2013)**.

[7] Jie Zhang, Youling Chen, Hongxi Zhao, Xiangzhen Lu; Novel Calculation Method of Man-hour Quota Based on Parts Similarity and Neural Networks, JDCTA, **7(1)**, 469-476 **(2013)**.

[8] WWEA; World Wind Energy Report 2009. [Online]. Available: http://www.wwindea.org., Mar. **(2010)**.

[9] EWEA; Wind Directions, [Online]. Available: http://www.ewea.org., Jun. **(2010)**.

[10] M.El-Banna, D.Filev, R.B.Chinnam; Online Qualitative Nugget Classification by Using a Linear Vector Quantization Neural Network for Resistance Spot Welding, Int.J.Adv.Manuf.Technol., **36(2–4)**,

FULL PAPER

237–248 **(2008)**.

[11] K.De¡zelak, G.˘Stumberger, B.Klopˇciˇc, D.Dolinar, J.Pihler; Iron Core Saturation Detector Supplemented by An Artificial Neural Network", Prz. Elektrotech., **84(12)**, 157–159 **(2008)**.

[12] Zhong-xiao Chen, Yan-fang Li, Li-guang Zhang, Xing-yu Chen, Xue-liang Zhu; Based On Fuzzy Neural Network of Inverter Power Supply The Controller Design, JDCTA, **7(1)**, 379-385 **(2013)**.

[13] Chunjiao Dong, Chunfu Shao, Zhihua Xiong, Juan Li; Short-term Traffic Flow Forecasting of Road Network Based on Elman Neural Network, Journal of Transportation Systems Engineering and Information Technology, **10(1)**, 145-151 **(2010)**.

[14] Yunlong Zhou, Fei Chen, Chuan Liu; Identification Method of Gas-liquid Two-phase Flow Regime Based on Images Processing and Elman Neural Network, Proceedings of the CSEE, **27(29)**, 108-112 **(2007)**.

[15] Jiazhong Qian, Chun Lv, Weidong Zhao, Jing Pan; Comparison of Application on Elman and BP Neural Network in Discriminating Water Bursting Source of Coal Mine, Systems Engineering — Theory and Practice, **30(1)**, 145-150 **(2010)**.

[16] Xiaohu Shi, Yanchun Liang, Xu Xu; An Improved Elman Model and Recurrent Back-Propagation Control Neural Networks, Journal of Software, **14(6)**, 1110-1119 **(2003)**.

[17] Lvgao Zheng, Lingjiang Zhou, Shai Wang; Research on Electrical Load Forecasting Based on Elman Neural Network, Power System Technology, **19(9)**, 32-34 **(2012)**.