Study of Power System Short-term Load Forecast Based on Artificial Neural Network and Genetic Algorithm

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***Abstract*—The correct schedule, planning and operation of power system has a tight correlation between accurate load forecast. Aims at the variant feature of power system short-term load, the author took a widely study and discussion on the method of artificial neural network applied on power system short-term load forecasting. At the base of three layered BP neural network, the author studied the meteorological factor effect on short-term load forecasting precision, present the short-term load forecasting model made of BP neural network combine with genetic algorithm. According to the load data of area grid and relevant meteorological data, the author forecasted the short-term load with method of three layered BP neural network, four layered BP neural network and four layered BP neural network combine with genetic algorithm. The result shows that four layered BP neural network combine with genetic algorithm have the advantage of fast calculating time and high precision, have value for engineering application and significance for popularization.**

Keywords-Short-term load forecasting； Artificial neural network； BP algorithm； Genetic algorithm

I. INTRODUCTION

The correct schedule, planning and operation of power system can't depart from load forecast. Accurate load forecast plays an important role in the security, reliability and economical operation of power system, meanwhile it is a potential method of energy conservation, moreover it is an important content in demand side management which is propounded at present. In the past decade, the development speed of artificial neural network surprised everyone, various models and the study algorithms emerge one after another incessantly, its application has spread many domains. We know, power load is a stochastic, time-variant nonlinear system, original method of load forecast based on linear theory often cannot be effective, but artificial neural network relies on its inherent non-linear characteristic, as well as the method of training neural network using the genetic algorithm, it can commendably solve the problems of short-time load forecast, and gain a series of nicer results.

II. ARTIFICIAL NEURAL NETWORK MODE

A. BP study algorithm

The BP network is a kind of extensive application in the neural network, because of its teacher's study algorithm; it is extremely advantageous to realize forecast function. The BP network in fact may regard as one non-linear mapping. Therefore, there are essential differences when dealing with non-linear forecast question and linear forecast method. The self-study of BP algorithm is continually correct the weight value and threshold value in the network training process, it causes error function (E) to drop along negative gradient.

Fig 1:The network not only has the input layered node, the output layered node, but also has the hidden layered node, it delivers the input information of hidden node to output node after the process function, finally produces the results. The study process of this algorithm is composed with the dissemination and the reverse dissemination. In the process of dissemination, the input signal is dealt with from the input layer to the hidden layer level by level, and passed on to the output layer, neuron condition of each layer only influences next. If cannot obtain the expectation in the output layer, then it turns to the reverse dissemination, and passes the error signal to anterior process, it can make error signal become smallest through modifying neuron weight value of every layer.

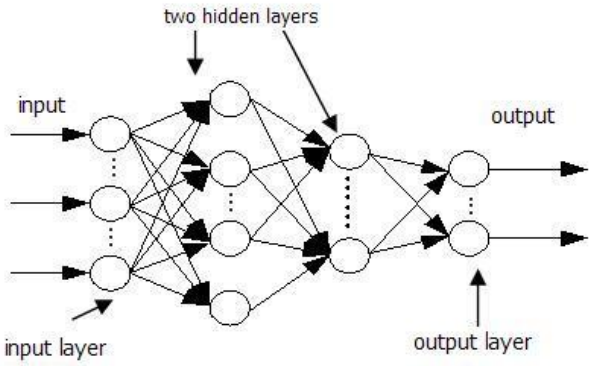

Figure 1. four layered neural network

B. Process of BP algorithm as followed:

(1)Initialization, choose a appropriate structure network, set all adjustable parameter (weight value and threshold value) to equally distributed lesser value;

(2)Calculate every input sample as followed:

1. Feed forward calculation for j unit of the first layered

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$$v_j^{(l)}(n) = \sum_{i=0}^{T} \omega_{ji}^{(l)}(n) y_i^{l-1}(n)$$

$y_j^{l-1}(n)$ is a work signal (when i=0, set $y_0^{l-1}(n) = -1$, $\omega_{j0}^{(l)}(n) = \theta_j^{(l)}(n))$ which is delivered by unit i of front layered (l-1 layered), if active function of unit *j* is sigmoid function, then

$$y_j^{(l)}(n) = \frac{1}{1 + \exp(-v_j^{(l)}(n))}$$ and

$$\varphi'(v_j(n)) = \frac{\partial y_j^{(l)}(n)}{\partial v_j(n)} = \frac{\exp(-v_j(n))}{(1+\exp(-v_j(n)))^2} = y_j(n)[1 - y_j(n)]$$

If neuron *j* belongs to the first hidden layered (that is l=1) of output, then $y_j^{(0)}(n) = x_j(n)$

If neuron *j* belongs to the output layered (l=L), then $y_j^{(L)}(n) = O_j(n)$ and $e_j(n) = x_j(n) - O_j(n)$

2．Reverse calculation δ

For output unit

$$\delta_j^{(l)}(n) = e_j^{(L)}(n) O_j(n)[1 - O_j(n)]$$

For hidden unit

$$\delta_j^{(l)}(n) = y_j^{(l)}(n)[1 - y_j^{(l)}(n)] \sum_k \delta_k^{(l+1)}(n) \omega_{kj}^{(l+1)}(n)$$

3．Correct weight value as followed

$$\omega_{jk}^{(l)}(n+1) = \omega_{ji}^{(l)}(n) + \eta \delta_j^{(l)}(n) y_i^{l-1}(n)$$

(3)n=n+1 input new samples(or new period samples), then E_{AV} can achieve expectant claim.

(1)Without weather factors

a. Three layered neural network

Input layer nodes of neural network are eighteen, according to theorem of mapping network existence, hidden layer nodes are thirty-seven, output layer nodes are six.

b. Four layered neural network

If neuron number of input layer is N, hidden layer neuron number is （ $\frac{N}{2} + 3$ ） , then four layer neural network can approach any continuous function. Input layer nodes of neural network are eighteen, according to the method, the first hidden layer and the second hidden layer's neuron number are twelve respectively, output layer nodes are six.

c. Four layered neural network with genetic algorithm

According to the method have referred above and the operation of genetic operator, input layer nodes of neural network are eighteen, the first hidden layer and the second hidden layer's neuron number are twelve respectively, output layer nodes are six.

(2)With weather factors

a. Three layered neural network

Theorem of mapping network existence: preset either continuous function f: $U^n \rightarrow R^m$, f(X)=Y, here U is a closed interval [0,1], f can be realized with a three layer forward network, the first layer (that is input layer) of next network includes n unit, medium layer includes 2n＋1 unit, the third layer (that is output layer) includes m unit.

Input layer nodes of neural network are twenty-two, according to theorem of mapping network existence, hidden layer nodes are forty-five, output layer nodes are six.

b. Four layered neural network

According to the method have referred above, input layer nodes of neural network are twenty-two, the first hidden layer and the second hidden layer's neuron number are fourteen respectively, output layer nodes are six.

c. Four layered neural network with genetic algorithm

According to the method have referred above and the operation of genetic operator, input layer nodes of neural network are twenty-two, the first hidden layer and the second hidden layer's neuron number are fourteen respectively, output layer nodes are six.

III. GENETIC ALGORITHM

A. Genetic algorithm(GA)

Genetic algorithm, which mechanism is based on the survival of the fittest principle of Darwinism, is a kind of artificial intelligence method, it simulates the process of organic evolution and introduces propagation, hybridation, dissociation, competition and choice to the algorithm. It improves the shift track and trend of feasible solution in the multidimensional space through maintaining a set of feasible solution and resetting feasible solution and finally trends towards optimum solution. It overcomes the fault of easily falling into local minimum point using traditional optimization method, and it is a kind of global optimization method.

Genetic algorithm is a kind of non-gradient random optimal method based on natural selection and evolving notions. Its basic operation has coding, choice of fitness function and genetic operator. Crossover operator of weight and Variation operator of weight are mainly introduced in this thesis.

(1)Crossover operator of weight: crossover operator selects randomly some positions in two parents chromosome, cross those weight at those position. So, filial generation chromosomes are born, and have genetics of their parent chromosome.

(2)Variation operator of weight: variation operator selects a random value at a probability pm in initial probability distribution, then every weight of filial generation chromosome add the value.

B. Process of genetic algorithm as followed:

(1)Defines one objective function.

(2)Initialize feasible solution in some determinate constraint condition, coding one feasible solution with one vector x, that is one chromosome, component of the vector represent gene, corresponding to some decision-making variation of feasible solution.

(3)Calculate goal function value of every chromosome x_i ($i=1，2，3\cdots\cdots n$) in the colony and the adaptive value F_i, and then evaluate if the feasible solution is good or not through the size of F_i.

(4)Eliminate the chromosome which has bad adaptation by the mechanism of superior and inferior; at random choose surviving chromosome whose adaptive value is good or not, and then propagate, finally form new colony.

(5)Generate filial generation through the operation of hybridation and dissociation. Hybridation is to choose two chromosomes (parents), exchange some one or the multi-spots gene to generate two new individuals. Dissociation is that some one or the multi-spots occurs the sudden change.

(6)Repeat the operation of process (3)～(5) for filial generation colony, become new process of genetic evolution, until it achieves iterative astriction, that is find optimum solution.

IV. RESULT OF FORECASTING AND SIMULATION ANALYSIS

It forecasts 24 integral points load in some local certain day using BP algorithm and genetic algorithm, then extracts its average absolutely percentage error, compares and analyzes these data results, then makes actual load curve of some day as well as forecasting load curve and percent error curve when using different method, obtains the related conclusion.

Forecast and simulation result as follows:

1.Load curves

（1）with weather factors

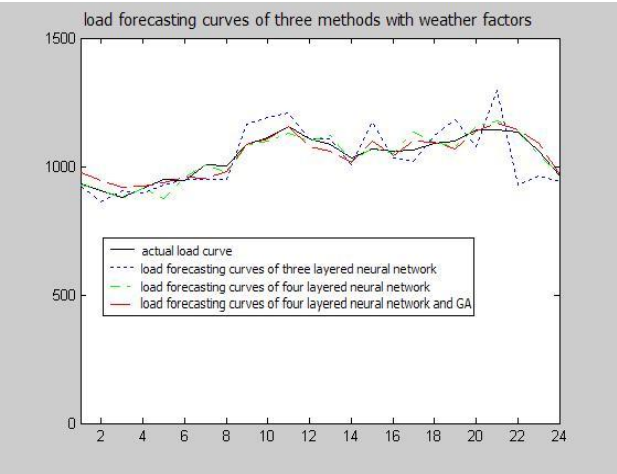

Figure 2. load forecasting curves of three methods with weather factors

（2）without weather factors

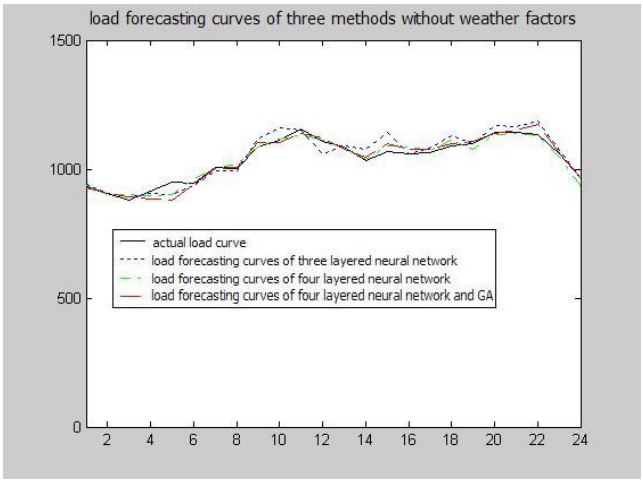

Figure 3. load forecasting curves of three methods without weather factors

2.Error curves

（1）with weather factors

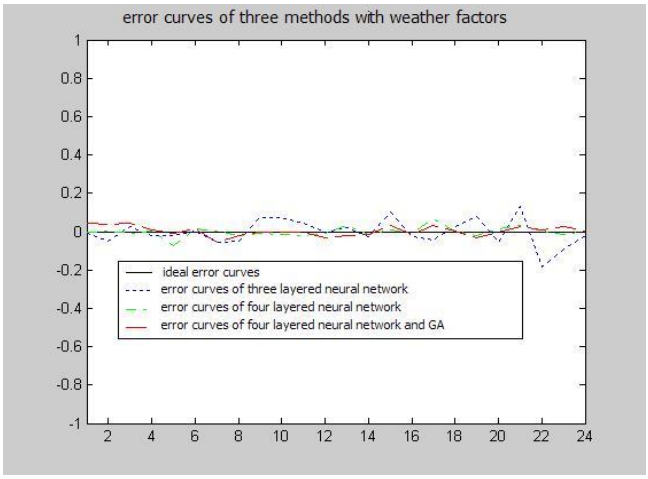

Figure 4. error curves of three methods with weather factors

（2）without weather factors

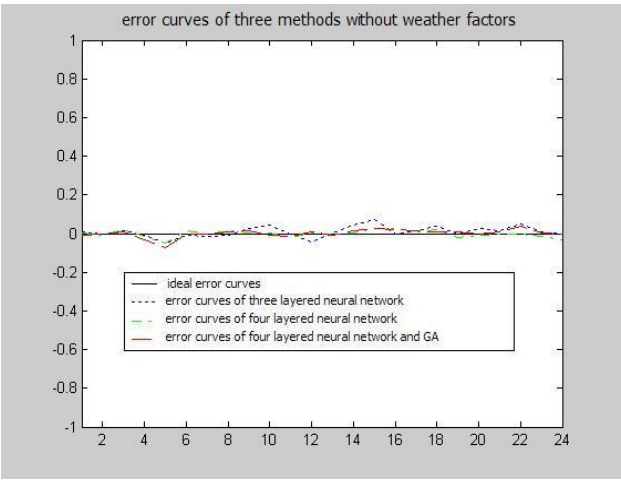

Figure 5. error curves of three methods without weather factors

V. CONCLUSION

This thesis propounds a kind of method with three layered neural network, four layered neural network and four layered neural network with genetic algorithm, considering both with weather factors and without weather factors. Lots of forecasting results show that mapping ability of four-layered neural network is superior to that of three-layered neural network, moreover four-layered neural network has less neuron comparing to three-layered neural network. When forecasts short-term load using four layered neural network with genetic algorithm, the chromogene obviously reduces. It can save the operation time, effectively overcame the defection that neural network is easy to fall into the local minimum point, and achieve the forecast precision.

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