Short-term Load Forecasting Based on VPSO-Elman Neural Network

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Abstract. Because of the shortcomings which Elman neural network in the short-term load forecasting of power system is easy to fall into local minimum, slow convergence, Use VPSO(Variance Particle Swarm Optimization)to train Elman neural network in order to get optimal weights and thresholds. The optimized Elman network can avoid the convergence speed and getting into local minimum solution and other defects to the full. So it possesses best potential application in the field of short-term load forecasting.

1. Introduction

Short-term load forecasting of power system is network planning, dispatching, and production planning and quality-based power. Also in the electricity market trend, the measure is an important indicator of whether the powers supply enterprise modernization. It seeks to achieve an optimum precision of load forecasting method has important significance and practical value.

As used herein, mutation PSO on Elman neural network optimization, load forecasting model to build an optimal, overcomes the greatest degree of Elman neural network in a massive load forecasting slow convergence rate, easy to fall into local minimum defects.

2. Theory of VPSO

PSO is a group of artificial intelligence optimization algorithm, based on the principles of population and evolution, through collaboration between the populations of individual competition, may be implemented in a complex solution space optimization.

Since PSO is gathered by the particles in the direction of the optimal solution of evolutionary. It search based on particles between itself and the memory of all the groups and group collaboration. It’s late in the search, easy to fall into local optimal solution, resulting in premature convergence and other defects. To solve this problem, this paper improves the "critical threshold particle velocity variations" optimization algorithm.

The basic idea mutation particle swarm algorithm is: in search of the evolutionary process of particle, the particle speed to set a threshold, when the particle speed is less than the set threshold, give this a more applied Great acceleration impulse to re-initialize the speed and landed on the range, and then re-flying search, was originally may fall into a local minimum or precocious group particle redistribution variation to extend the search to achieve global optimum goal. Threshold set general admission. This variation of the process described by a formula:

$$v'_{id} = (1+\lambda)\cdot r_3 \cdot v_{\max} \quad (3\text{-}1)$$

VPSO-Elman network is the input layer of the neural network - hidden layer, hidden layer - output layer, hidden layer - receiving layer connection weights and thresholds between the hidden layer and output layer particle as optimization algorithm positional parameters is the number of dimensions of each particle population threshold neural networks and weights. It used W^1, W^2, W^3 represents the input layer - hidden layer, to undertake layer - hidden layer, hidden layer - the output layer connection weights between the hidden layer and output represents the threshold level, the particle positions are described by the following equation:

$$X = [W^1, W^2, W^3, \theta^1, \theta^2]' \quad (3\text{-}2)$$

Assume Elman neural network input layer neuron number is N_1, the hidden layer neuron number is N_2, number of neurons in the output layer is N_3, to undertake layer neuron number is N_2. The neural network will have the right number and thresholds are:

$N = N_2 \times (N_1 + N_2 + N_3) + (N_2 + N_3)$ (3-3)

The space dimension of VPSO Algorithm D=N.

$\tilde{y}(t,\Omega)$ is Network output. $\tilde{f}$ is Elman neural network model. $\Omega = [W^1, W^2, W^3, \theta^1, \theta^2]'$ is Elman neural network ownership threshold value vectors and composition. There are:

$\tilde{y}(t,\Omega) = \tilde{f}(u(t),\Omega) = \sum_{t=1}^{N_2} \omega_{kj}^3 O_j^2(t)$ (3-4)

The neural network optimization is mainly to determine the parameters of the derivative:

$\delta(t,\Omega) = [\frac{d\tilde{y}(t,\Omega)}{d\Omega}]' = \tilde{g}(x(t),\Omega)$ (3-5)

$\delta(t,\Omega)$ is a $N_1 \times N_3$ matrix.

Set the desired output of neural network is $y(t)$ and actual output is $\tilde{y}(t,\Omega)$. Their error is

$e(t,\Omega) = y(t) - \tilde{y}(t,\Omega)$ (3-6)

The so-called VPSO-Elman neural network is actually a set of search algorithms with VPSO optimal threshold value and the right to Elman neural network, the network structure adjustment, so that the neural network of the actual output and the desired relative error is minimized, you can define fitness functions:

$$J(\Omega) = \frac{1}{2N_p} \sum_{t=1}^{N_p} (e'(t,\Omega) \wedge^{-1} e(t,\Omega)) \quad (3\text{-}7)$$

3. Case Study

In order to verify the prediction performance VPSO-Elman neural network, using a city April 1, 2009 to the 25th day, the odd moment of historical load data as samples of VPSO-Elman neural network is trained for each application MATLAB7 every 26 hours, a total of 12 load predicted.

To avoid abnormal load data, load data using vertical and horizontal approach to deal with the historical load data processing, and then uses the type of data normalization process:

$x(n) = [x(n) - X_{\min}] / (X_{\max} - X_{\min})$ (4-1)

Of this case, the size of the particle population is the number of particles selected as sizepop = 20, the dimension of each case in accordance with the formulashows that for the 199, the maximum number of iterations is set to maxgen = 1000. $c1$=2, $c2$=2,, maximum and minimum individual and speed are set as follows: popmax=5, popmin=-5;Vmax=1,Vmin=-1。 $w_{\max}$ =0.9, $w_{\min}$ =0.4

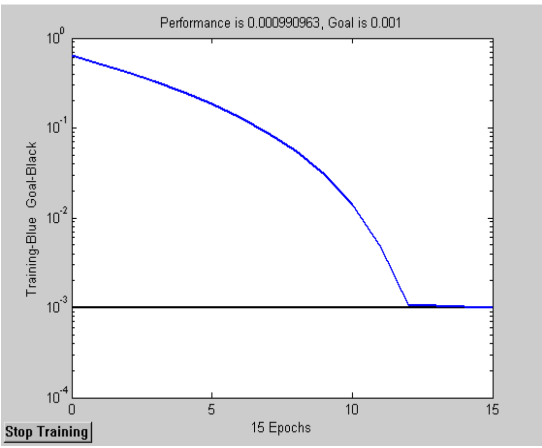

Figure 1. VPSO-Elman model training error curve

ELman neural network training set the maximum number of steps in 1000, the training error is set to 0.001.

By means of MATLAB software VPSO-Elman neural network training and simulation, with historical load data April 1, 2009 to April 25 of as training samples, and then load the data on the 24th and 25th as well as the trained load forecasting model to predict 26. As can be seen from the figure, the convergence rate VPSO-Elman model is significantly faster than mere Elman model.

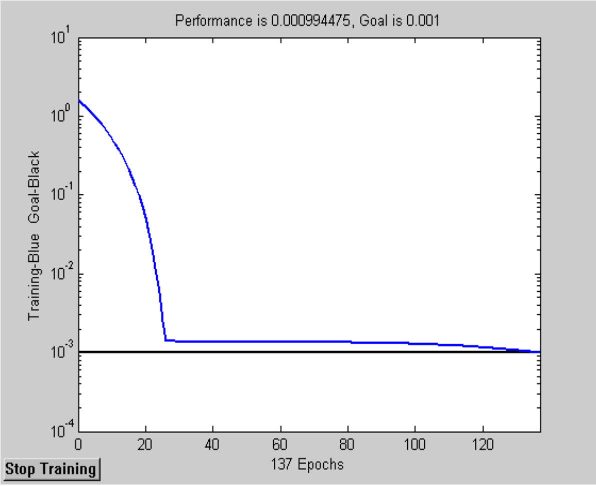

Figure 2. Elman model training error curve

The figure can be learned by using VPSO-ELman model predicts the 26th load, the maximum relative error of the load 23:00, the error is 2.12%, while the use of a single model to predict the 26th ELman load, the maximum error also appears in 23:00 time, the maximum error is -2.37%. At other times, VPSO-ELman model prediction error is basically controlled within 1.5%, the error is significantly less than with a single model prediction error, to achieve short-term load forecasting requirements.

Figure 3 shows the predicted results:

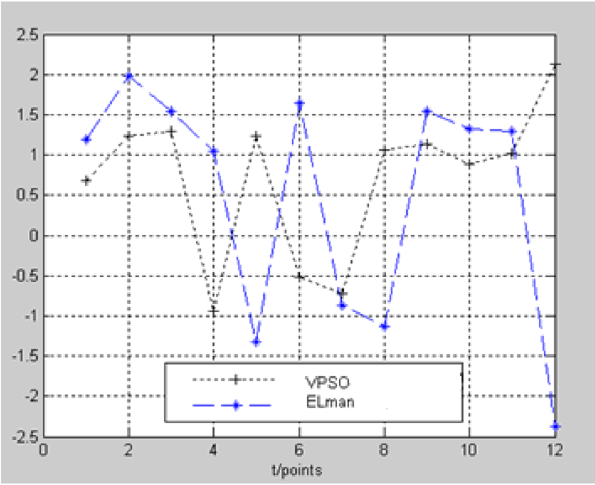

Figure 3: Two predictions compare relative error curve

4. Summary

Establish appropriate model is the key to predict the exact load results, we propose a "mutation particle swarm optimization method" Elman neural network optimization training, obtain an optimal set of weights and thresholds. So you can search for optimal solutions. This method is compared with the predicted results Elman neural network forecasting a simple neural network and only PSO algorithm optimization, fast convergence, easy to program, the prediction accuracy has been greatly improved. The proposed mutation particle swarm optimization in real power system load forecasting, access to good effect, resulting in a certain value.

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