Load Forecasting of Microgrid Based on Artificial Fish Swarm Algorithm

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Abstract

The load forecasting of microgrid is one of the difficult problems in the research of the planning and construction of power grid. Due to uncertainty, volatility, and other characteristics of microgrid load, the conventional load forecasting methods cannot be directly used in microgrid. According to the characteristics of the microgrid, the load is easily influenced by weather factor and week type. Therefore, this paper proposes a forecasting model of microgrid load ,which has to do with Artificial Fish Swarm Algorithm(AFSA) and Support Vector Machine(SVM). In the model, the role of Artificial Fish Swarm Algorithm is to get the best parameters to improve SVM. The experimental result shows that compared with load forecasting of traditional SVM, the load forecasting result of the model has higher precision and can meet the actual requirement.

Keywords

Load forecasting; Microgrid; Support; Artificial fish swarm algorithm.

1. Introduction

Short-term load forecasting is the basis of optimal operation of microgrid and energy-saving emission reduction, and the prediction accuracy directly affects the microgrid generation schedule, the quality of power supply and electric power market transaction, etc[1-2]. Whether it is the prediction of large power grid or microgrid, or it is the application of traditional forecast methods or the modern, its principle is to analyse the regulation of historical load and to predict the next period load according to external factors and time extension. From the mathematical theory, the process of establishing the model is a mathematical function, through which to find out variation and influence factor of the objects, and then predict the microgrid load[3].

The traditional method of short-term load forecasting is mainly from the moving average method and trend extrapolation method[4]. The current forecasting method mainly depends on intelligent technology, such as neural network, wavelet analysis and support vector machine. Compared with the traditional power system load, the microgrid load is more unstable, random and mutant. When the microgrid system is in the complex surrounding factors, traditional and single method cannot satisfy the requirement of short-term microgrid load forecasting with the prediction accuracy beyond the acceptable range. The combination forecasting method of artificial fish swarm algorithm optimized svm can not only eliminate the shortage of the single prediction method, but also can improve the prediction precision[5-7].

2. Support vector machine model

The mathematical models are as follows:

given a training set samples (x_i, y_i), i=1,2,…,n, $x \in R^d$, $y \in R$, the linear regression function in a high dimensional space:

$$f(x) = \omega \cdot x + b \tag{1}$$

the introduction of error function for ε :

$$\min_{\omega} \phi(\omega) = \tfrac{1}{2}\|\omega\|^2 \tag{2}$$

$$\text{subject to } y_i - \omega \cdot x_i - b \le \varepsilon \text{ , } i=1,2,\ldots,n \tag{3}$$

the introduction of slack variables ξ_i and ξ_i^* :

$$\min_{\omega,\xi} \phi(\omega,\xi) = \tfrac{1}{2}\|\omega\|^2 + C\sum_{i=1}^{n}(\xi_i + \xi_i^*) \tag{4}$$

$$\text{subject to } \; y_i - \omega \cdot x_i - b \le \varepsilon + \xi_i \tag{5}$$

$$\omega \cdot x_i + b - y_i \le \varepsilon + \xi_i^* \tag{6}$$

$$\xi_i, \xi_i^* \ge 0 \tag{7}$$

the dual is:

$$\max_{a_i,a_i^*} -\varepsilon\sum_{i=1}^{n}(a_i + a_j) + \sum_{i=1}^{n} y_i(a_i - a_i^*) - \tfrac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}(a_i - a_i^*)(a_i - a_j)(x_i \cdot x_j) \tag{8}$$

$$\text{subject to } \sum_{i}^{n}(a_i - a_i^*) = 0 \tag{9}$$

$$0 \le a_i, a_i \le C \text{ , } i=1,2,\ldots,n \tag{10}$$

3. Artificial fish swarm algorithm

The activities are as follows:

Prey behavior

Suppose the position of the fish is X_i ,in whose sight select a location for the X_j. If for the maximum problem, if $Y_i < Y_j$,, move a step to Y_j. If it is not, select X_j randomly again and determine whether it is qualified to advance. So try again several times, if it still does not satisfy the condition, move a step randomly.

Swarm behavior

Suppose the position of the fish is X_i , n is the number of companions in sight, and X_m is the center position of companions in sight. If $Y_m / n > \delta Y_i$ (δ is crowding factor), it means the center has more food and less crowded, so move a step to the center. If it is not, choose the prey behavior.

Following behavior

Suppose the position of the fish is X_i, n is the number of companion in sight and Y_j is the maximum in sight. If $Y_j / n > \delta Y_i$, it means X_j has more food and less crowded, so move a step to the X_j. If it is not, choose the prey behavior.

The process of artificial fish swarm algorithm:

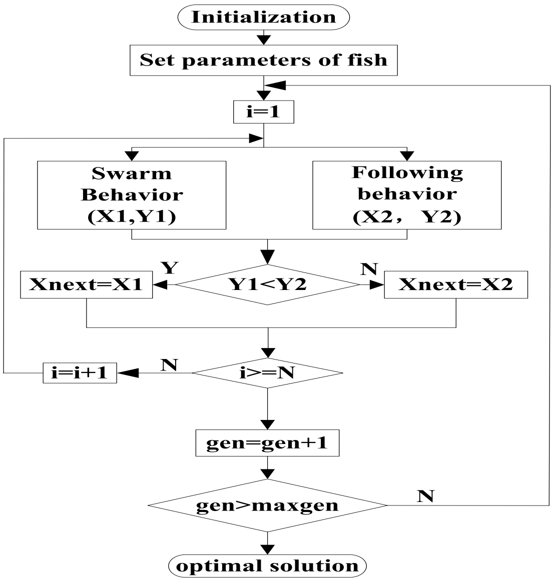

Figure 1 artificial fish swarm algorithm flow chart

4. Artificial fish swarm algorithm optimized SVM

The process of the model is as follows:

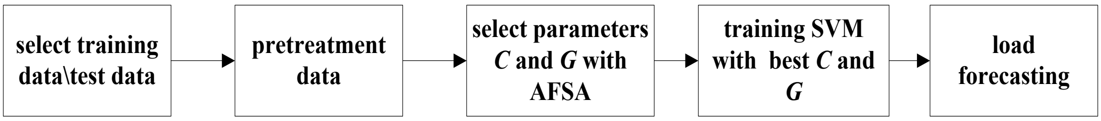

Figure 2 Model flow chart

The optimization SVM by AFSA flow chart is as follows:

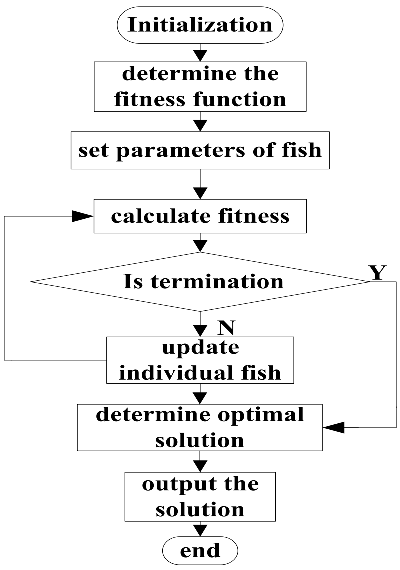

Figure 3 AFSA optimized SVM flow chart

Parameter settings. The number of fish in the AFSA N is *50*; the version field *visual* is *2*; the maximum number of attempts *Num* is 50; the maximum genetic algebra *Maxgen* is *50*; the step of fish moving is *0.732*; the crowding factor δ is *0.65*.

The process of optimization parameters is as follows:

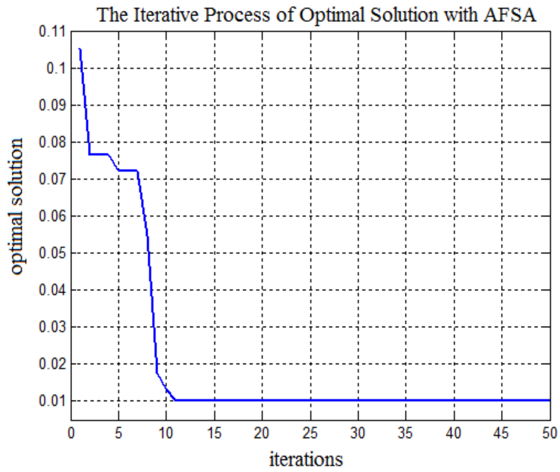

Figure 4 AFSA optimization parameter

From figure 4, the result of SVM model for training tends to be stable in 13th generation and gets the best solution. The optimal penalty factor *C* is 4.36 and the optimal kernel function parameter *G* is 0.029.

5. The example analysis

In order to verify the microgrid load forecasting accuracy from SVM optimized AFSA , the predicted result is compared with SVM and BP neural network algorithm. The data comes from a island of the south of china which is the microgrid demonstration project, which includes the users of electricity consumption for 240 hours of 10 days, historical weather, temperature and others. Based on this data, predict microgrid load in next day's 24 hours with AFSA optimized SVM; compare the predicted values and actual values; evaluate and analyse the accuracy of the model using the mean square error and the square of correlation coefficient .

The simulation results of the mean square error and the square of the correlation coefficient are shown in Table 1.

Table1 the three algorithm results

algorithm	R2	E
AFSA-SVM	97.33%	0.93%
SVM	94.16%	1.83%
BP	92.03%	2.62%

The average relative error is shown in figure 5:

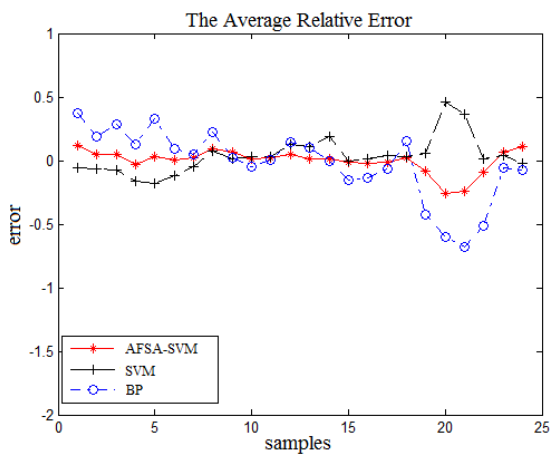

Figure 5 average relative error

From table 1andFigure5, the result of the model based on AFSA optimized SVM ,whether evaluated and analysed by the mean square error or by the square of correlation coefficient, is better than SVM and BP neural network, so the performance of the improved SVM is superior to the SVM and BP neural network.

6. Conclusions

In this paper, the support vector machine is improved, the microgrid load forecasting with AFSA optimized SVM is achieved and the adverse effects on SVM from the random selection of model parameter are overcome. The example analysis shows that the AFSA optimized SVM model can predict the changes of microgrid load better, which can not only deal with the high nonlinearity of microgrid load, but also has better adaptive ability and generalization ability, and effectively improves the accuracy of short-term microgrid load forecasting and has a certain practical value.

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