Journal of Electronics and Information Science (2020) 5: 17-22
Clausius Scientific Press, Canada

DOI: 10.23977/jeis.2020.51004
ISSN 2371-9524

Research on Short-Term Load Forecasting of Micro-Grid Based on PSO-SVM Model

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Keywords: Micro-grid, Support Vector Machine, Short-term Load Forecasting.

Abstract: Due to the uncertainty and volatility of micro-grid load, conventional load forecasting methods cannot be directly used in micro-grid load forecasting. Therefore a hybrid load forecasting model of micro-grid based on particle swarm optimization (PSO) and Support Vector Machine (SVM) is proposed in this paper. Particle swarm optimization (PSO) was used to optimize the model parameters of SVM regression, and the optimized SVM prediction model was obtained. Through the comparative analysis of the experiment, it is concluded that the hybrid prediction model of PSO-SVM is more accurate for the load prediction of micro grid, which can provide a decision basis for the safe and economic dispatch of micro grid and play a positive role in the stable operation of micro grid power system.

1. Introduction

With the rapid development of smart grid technology and effective promotion, as well as the electric power market is increasingly perfect, energy, the development of the Internet, the boost of electricity market reform, and the popularization of distributed power generation, energy storage, electric cars, a large number of consumers will be evolved to produce away [1], the perfection of market mechanism and distributed power supply full liberation of the market, it gives the distributed power in electricity market auction trading opportunities, there will be more and more distributed power into the electric power market competition, micro power grid as an effective means of distributed power distribution network access arises at the historic moment. Micro-grid refers to a small power distribution system which is composed of distributed power supply, energy storage device, energy conversion device, relevant load and monitoring, and protection device. It can be connected to the external power grid or run in isolation. Although the mixed prediction model was adopted in the load prediction in literature [2] and the load was decomposed and predicted at several levels, the parameters in the support vector model were not optimized. However, the mixed model adopted in this paper could optimize the parameters in the support vector machine,

with obvious effects. Literature [3] demand response model of micro power grid operation is put forward, is based on the incentive scheme based on time and review and application, there is no process to predict parameters of the model experiment, and the prediction model is adopted by the algorithm difference performance in the handling of the parameters, this paper predicts effect is relatively obvious. Literature [4] used in the operation of the micro grid is put forward based on demand response of the incentive plan to motivate consumers to change their requirements during peak hours. Literature [5] applicability problem is pointed out that the traditional load forecasting method, but no too much on the prediction model in the prediction algorithm optimization. Literature [6] hybrid prediction model with a variety of algorithms, due to the complexity of algorithm in the cost of time and space is larger, with some limitations. Literature [7] to particle swarm optimization algorithm and the chaotic mechanism is introduced into the conventional artificial fish algorithm, carries on the improvement, can improve the population diversity and global optimization ability. Literature [8] considering probability interval of micro grid is a kind of multiple objective short-term load forecasting method, the optimization model of the parameters in the algorithm the same purpose, improve the micro power network short-term load interval prediction accuracy and reliability. Literature [9] put forward a kind of support vector machine (SVM) based on data mining building short-term load forecasting method, the K-means algorithm is adopted to sample data sets of meteorological data, and it is similar to this paper, the optimization of the parameters can improve the prediction accuracy.

In mathematical theory, the process of establishing a load prediction [10] model is to establish a mathematical function, find out the change rule of the predicted object through the mathematical function, and then predict the micro-grid load according to the change rule and influence factor .

2. Related Technology

2.1 Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO) was first proposed by Eberhart and Kennedy in 1995. The basic concept of Particle Swarm Optimization (PSO) was based on the study of the foraging behavior of birds. PSO algorithm is inspired from this population behavior characteristics and is used to solve optimization problem, in PSO, each potential solution of optimization problem can imagine a point on the d dimensional search space, which we call "particles", all of the particles have a fitness is determined by the objective function, each particle has a speed decided they fly out direction and distance, and the optimal particle particle are to follow the current search in the solution space.

2.2 Support Vector Machine (SVM)

Support vector machine (SVM) is a kind of generalized linear classifier which classifies data binary according to supervised learning method. SVM was proposed in 1964, after the 90 s to get fast development and derive a series of improvement and extension algorithm, in portrait recognition, text classification and so on have been applied in pattern recognition problem, the SVM using the hinge loss function to calculate the empirical risk and joined the regularization item in solving system to optimize the structure of risk, is one who has a sparse and robustness of the

classifier. SVM can be classified non-linearly by kernel method, which is one of the common kernel learning methods.

3. Design of Load Prediction Model Based on PSO-SVM

3.1 Design Idea

In this paper, by comparing the prediction algorithm of support vector machine model in the research literature [10], the prediction parameters in the algorithm model were not processed too much, and the time and space consumption in the experiment process increased. However, the load prediction model in this paper adopts particle swarm optimization method to optimize the parameters of the support vector model to obtain the optimized SVM prediction model, which improves the prediction efficiency of the experimental process and reduces the cost of the experiment.

3.2 Design and Implementation

3.2.1 Support Vector machine Model

Support vector machines (SVM), first proposed by Vapnik, is a machine learning method based on the VC dimension theory of statistics and the principle of structural risk minimization. Like many layers of perceptron networks and radial basis function networks, SVM can be used for pattern classification and nonlinear regression. The main idea used in regression fitting is to find an optimal classification plane so as to minimize the error of all training samples from the optimal classification plane. Its mathematical model is as follows:

Let the training set sample be:

$$(x_i, y_i),\ j = 1,2,\cdots,n,\ x \in R^d,\ y \in R \qquad (1)$$

Linear regression function in high-dimensional space is:

$$f(x) = \omega x + b \qquad (2)$$

The nonlinear regression problem is mapped to a high-dimensional space, and the radial basis function is selected as the kernel function:

$$K(x, x_i) = \exp[-\| x - x_i \|^2 / (2\mu^2)] \qquad (3)$$

Substitute the kernel function into the inner product (xi· x) of the above equation, then equation is:

$$f(\mathrm{x}) = \sum_{i}^{n} (a_i - a_i^*) K(x_i \cdot x) + b \qquad (4)$$

3.2.2 Particle Swarm Optimization Algorithm

Particle swarm optimization algorithm PSO is an outstanding group intelligent stochastic optimization algorithm, with strong global optimization ability, simple structure and easy implementation. Each particle in PSO can be represented as a point in the n dimensional solution

space, using an n dimensional vector to represent the particle velocity. Each particle has an individual fitness related to the objective function, and adjusts its motion trajectory according to its own experience and group experience to get close to the best. The update speed and position of particles are based on the following formula:

$$V_i^{k+1} = \omega V_i^k + c_1 r_1 \left(P_{best} - X_i^k\right) + c_2 r_2 \left(g_{best} - X_i^k\right) \quad (5)$$

$$X_i^{k+1} = X_i^k + V_i^{k+1} \quad (6)$$

Where X is the position of the particle; V is the particle velocity; P_{best} is the optimal position experienced by the particle. g_{best} is the optimal position experienced by the population. K is the number of iterations, r_1 and r_2 are random Numbers distributed between [0,1]. c_1 and c_2 are two acceleration factors. ω is the inertia weight. The increase and decrease of w can enhance the global and local search capabilities respectively.

3.2.3 Model Based on PSO-SVM

The PSO-SVM prediction method proposed in this paper is as follows:

(1) Initialize PSO parameter. Initial population X: $(x_1, x_2, \cdots, x_n)$, where x_i represents a random particle in n dimensional R_n.

(2) Evaluate the current population X. An evaluation function was set $F = \sum_i^m \left(y_{ij} - \hat{y}_{ij} \right)^2$, in which y_{ij}, $\hat{y}_{ij}$, respectively represented the actual load value and SVM predicted value. The smaller the function value, the better the position of the population.

(3) Update the population position and velocity matrix according to equations (1) and (2) to generate a new population.

(4) Check the termination conditions. If the current number of iterations is k or the value of the evaluation function is less than the given expected value, the algorithm performs beam optimization; otherwise, step (2) is returned.

(5) The particle optimization position (C,σ,ε) found is transferred to SVM, and the SVM model is used for regression training of the training samples, and the generated model is used for prediction.

4 Performance and Result Analysis

4.1 Results of PSO-SVM Model

4.1.1 Micro-Grid Load Sample Analysis

Compared with traditional power system, the operation of micro-grid is quite different from that of conventional power grid due to its own characteristics in power supply. For micro grid with small operation scale, the load of micro grid has obvious fluctuation and mutation, which leads to its load characteristic curve is not smooth. For load forecasting, the greater the variation of load characteristics, the lower the prediction accuracy. Therefore, it is more difficult to predict the short-term load of micro-grid. The selection based on the data on China's southern island of

demonstrative project of micro grid user side 10 day 240 h power consumption as well as the historical weather and temperature data as the training set, and the next day 24 h load data as the test set, once every 15 min to collect data, a total of 96 experimental data, as an original sampling data. Based on this data, the PSO-SVM hybrid prediction model was used to predict the 24h micro-grid load, and the predicted value was compared with the actual value data, and the root mean square error (RMSE) and mean absolute error (MAE) were used to analyze the accuracy of the model respectively.

4.1.2 Result Analysis

In the experiment, an improved hybrid support vector machine model was adopted to predict the daily load in this area. Compared with other algorithms, the algorithm model used in this experiment has obvious advantages, and the predicted results are closer to the real data (where the blue square point is the original data). The curve of the predicted results is shown in Figure 1.

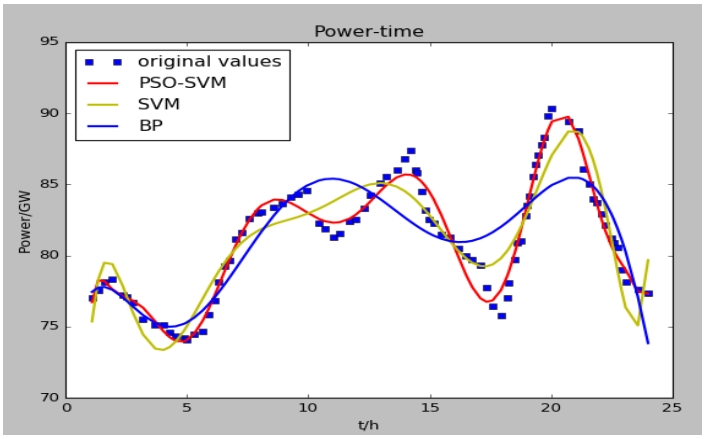

Figure 1: Load prediction curve

4.2 Evaluation Criteria for Prediction Results

Root Mean square Error: $$RMSE = \sqrt{\frac{1}{m}\sum_{i=1}^{m}\left(y_i - \hat{y}_i\right)^2} \quad (7)$$

Mean absolute error: $$MAE = \frac{1}{m}\sum_{i=1}^{m}\left|\left(y_i - \hat{y}_i\right)\right| \quad (8)$$

Table 1: Algorithm comparison data results

Algorithm	RMSE	MAE
PSO-SVM	0.779%	0.590%
SVM	1.649%	1.367%
BP	2.376%	1.819%

Conclusion: according to the experimental comparison data in the table, the average absolute error of PSO optimized SVM method is 0.590%, 0.77 percentage points lower than 1.367% of

conventional SVM method, and 1.22 percentage points lower than 1.819% of BP neural network. Under similar when consumption, change some time load sequence is smooth, three methods were similar, prediction error when a big shift in power load, the BP method and the single SVM method to this adaptability is poorer, the mixture of the PSO-SVM model method, on the distribution of power load adaptive ability is stronger, affected by load distribution sequence fluctuation is small, the model predicted values and the real value close to. Analysis shows that PSO-SVM method has obvious advantages over SVM method in improving the overall prediction accuracy.

5 Conclusions

A power load prediction model based on PSO-SVM is proposed in this paper, in which PSO algorithm is used to optimize the model parameters of SVM to overcome the blindness of SVM parameter selection. Compared with the single support vector machine method, the optimized support vector machine model proposed in this paper can not only deal with the highly non-linear micro-grid load, but also has better adaptive ability and generalization ability, which effectively improves the accuracy of short-term load prediction of micro-grid and has certain practical value. Finally, what needs to be further studied in this paper is the uncertainty of the operation of the micro grid, including the power and fault of the generator set, as well as related factors such as solar radiation and wind speed.

References

[1]Tai Xue, sun Hongbin, Guo Qinglai. Power trading and congestion management based on blockchain in energy Internet [J]. Grid technology, 2016, 40 (12): 3630-3638

[2]Su Xiaolin, Liu Xiaojie, Yan Xiaoxia, Wang Muqing, Han Xuenan. Short-term load prediction of active distribution network based on demand response [J]. Power system automation,2018,42(10):60-66+134.

[3]Mahmood Hosseini Imani,M. Jabbari Ghadi,Sahand Ghavidel,Li Li. Demand Response Modeling in Micro-grid Operation: a Review and Application for Incentive-Based and Time-Based Programs[J]. Renewable and Sustainable Energy Reviews,2018,94.486-499.

[4]Pouria Sheikhahmadi, Ramyar Mafakheri ,Salah Bahramara.Risk-Based Two-Stage Stochastic Optimization Problem of Micro-Grid Operation with Renewables and Incentive-Based Demand Response Programs. Energies 2018, 11,1-17.

[5]Luan Kaining, Bao min, Yi Yongxian, Zhao Shuangshuang. Research on short-term prediction technology of large user load based on power consumption pattern number [J]. Power engineering technology,2018,37(03):33-37.

[6]Tang Qingfeng, Liu nian, Zhang Jianhua, Yu Zhuangzhuang, Zhang Qingxin, Lei Jinyong. A short-term load forecasting method based on EMD-KELM-EKF and parameter optimization for user-side micro-grid[J]. Power grid technology, 2014, 38(10):2691 -2699.

[7]Qian zhi. Short-term load prediction of power grid based on improved SVR [J]. China electric power, 2016, 49(08): 54-58.

[8]Lin shunfu, Hao chao, Tang Xiaodong, Li Dongdong, Fu yang. Research on short-term load prediction method of building based on data mining [J]. Power system protection and control,2016,44(07):83-89.

[9]Yu Xinyan, Shen Yanxia, Chen Jie. A Multi-Objective Prediction Method for Short-Term Micro-grid Load Considering Interval Probability, 2017(04): 165-171.

[10]Xu Jianjun, Zhang Yanfu. Load prediction method of micro grid based on improved support vector machine and its simulation analysis [J]. Automation technology and application,2017,36(03):64-66+74.