Research on Key Technologies of New Energy Microgrid Based on Artificial Neural Network

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Abstract. The new energy microgrid is a new and complex power generation and distribution system. Due to the instability of the new energy wind power generation that constitutes the microgrid, it affects the stable operation of the microgrid. The use of artificial intelligence methods to predict load and wind power generation can improve forecast accuracy, which is beneficial to the energy management and operation optimization of the microgrid. The stable operation of the microgrid is of great significance. This paper takes the new energy microgrid as the research object, and uses artificial intelligence neural network as the technology drive. The short-term load forecasting model and wind power generation forecasting model based on neural network are established. Compared with the traditional forecasting model, the future short-term load and wind power generation are compared respectively. The accuracy of the proposed method is verified by the prediction of the measured quantities. The results show that both the short-term load forecasting method based on neural networks and the forecasting method of wind power generation are suitable for new energy microgrid systems.

Keywords: Artificial intelligence; neural network; new energy; microgrid technology.

1. Introduction
With the continuous depletion of fossil energy with oil and coal as its core and increasingly serious environmental pollution problems, the traditional era of energy production and consumption is coming to an end [1-3]. Therefore, building a new energy supply and demand system with renewable energy sources such as wind and solar energy as the core has become an important development direction of the energy revolution [4]. In recent years, with the rapid development of science and technology, the development of new energy power has become more and more rapid, and now has a certain scale [5].

At present, on the one hand, due to the increasing power load, the decreasing fossil energy, the instability of the energy market and the increasingly severe environmental threats; on the other hand, due to the inexhaustible availability of renewable energy such as wind and solar Inexhaustible use of wind power, solar power and other new energy power generation technologies has received more and more attention [6-7]. At the same time, the demand for electricity in remote areas is increasing day by day, and it is not practical to establish a complete power supply network in each area [8]. Therefore, the proposal of the microgrid greatly eases the power consumption in these areas and also contributes to the efficiency of power systems. Operation provides new ideas. Micro-grid is an autonomous operating...
system that can realize K-domain autonomy and self-use of electric energy. Specifically, the emergence of microgrids has the following advantages:

1. It can effectively solve the problem of power supply and use in remote areas, and realize the regional full use of natural resources for regional autonomy of power;
2. Energy conservation and environmental protection, large-scale use of renewable energy can effectively alleviate the troubled environmental pollution problems;
3. Achieved the goals of low cost, low risk, and high stability of the power system, which can fully meet the power quality requirements of power users. The micro-grid structure is shown in Figure 1.

![Figure 1. Schematic diagram of microgrid structure](image)

From a global perspective, the risk factors in the microgrid are combed and analyzed, and quantitative methods are used to study the risk factors involved, and the relationship between them is determined [9]. Based on the results of the risk factor analysis, the quantitative method is used for the microgrid. The key risk factors were evaluated and suggestions for risk management and control were put forward [10-12]. Focus on the research of micro-grid risk management and control from the three aspects of power generation, distribution and demand, select risk factors that are important in each aspect, and use intelligent algorithms such as intelligent optimization algorithms and prediction algorithms to quantitatively study the risk factors.

In this paper, the advanced information technology of artificial intelligence neural network is applied to the research of microgrid risk management and control, which can improve the operation efficiency and accuracy of related algorithms, and can stably and effectively predict the random and fluctuating power of wind power and solar photovoltaic power generation.

2. Artificial Neural Network

Artificial intelligence is a marginal and integrated discipline. Currently, artificial intelligence technologies widely used in microgrids include: expert systems, artificial neural networks, evolutionary algorithms (genetic algorithms, particle swarm optimization, simulated annealing algorithms, etc.), fuzzy logic theory, and multi-agent systems. These technologies play an irreplaceable role in distributed generation forecasting, energy management, monitoring and early warning of microgrids. As shown in Figure 2, the following five artificial intelligence technologies will be briefly introduced:

1. Expert system. Expert system is the most active and relatively high usage method in artificial intelligence. It is also a branch of the earliest artificial intelligence. It is an intelligent computer system that contains the knowledge and experience of a large number of experts in the field. This knowledge and experience can be used to solve some complex problems in the field.
(2) Artificial neural network. Artificial neural network is an important branch of artificial intelligence. It abstracts human brain neurons, builds simple models, and forms networks through different connection methods. It is a very effective predictive model.

![Artificial intelligence contains technology](image)

(3) Evolutionary algorithms. Evolutionary algorithm is also called evolutionary algorithm, which is a simulation of the evolutionary process of organisms in nature. These evolutionary operations generally include gene coding, cross-compilation, and population initialization. Compared with traditional optimization algorithms, evolutionary algorithms are global optimization algorithms with high robustness and wide practicality. Because of its self-organization, self-adaptation, and self-learning, evolutionary algorithms can effectively deal with complex problems that are difficult to optimize by traditional algorithms, such as parameter optimization, scheduling, and resource allocation. Currently, more evolutionary algorithms are used, such as genetic algorithms, particle swarm algorithms, and simulated annealing algorithms.

(4) Fuzzy logic theory. Fuzzy logic theory enables computers to consider and reason about some vague language expressions in real life according to the way humans think. For example, there is no clear standard for distinguishing between concepts such as fast and slow. The essence of fuzzy logic theory is to enable computers to deal with these fuzzy language expressions by fuzzy rules.

(5) MAS technology cross-integrates multi-disciplinary fields such as artificial intelligence, distributed computing, and system theory. It goes beyond the ability of a single agent to handle problems and can be used to solve relatively large and complex problems in real life. Multi-agents, in short, is the combination of multiple agents. The goal is to refer to large and complex systems as small ones, which can communicate and collaborate with each other quickly, and are easy to manage systems. Solve realistic decision-making problems of uncertainty and complexity of the environment.

3. Research on artificial neural network in microgrid

The DEMATEL method is a method based on graph theory and matrix theory. It is used to screen the components of complex systems and study the relationship between them. The advantage of this method is to make the best use of the experience and knowledge of experts to effectively deal with the uncertain relationship between the elements. In the traditional DEMATEL method, experts are required to directly give the magnitude of the influence relationship between factors. This increases the subjectivity of expert evaluation and the ambiguity of language evaluation to a certain extent. The concept of membership is introduced, and in order to maximize the information fusion results of experts in different fields, the concept of D-number fusion is proposed. Table 1 shows the comparison matrix of experts in the field of electric power operation.
Table 1. Comparison matrix of power operation experts

| Expert Matrix in Electric Power Operation | C1   | C2   |
|------------------------------------------|------|------|
|                                          | 0    | 1    | 2    | 3    | 0    | 1    | 2    | 3    |
| C1                                       | 0    | 0    | 0    | 0    | 0    | 0.3  | 0.2  | 0.3  |
| C2                                       | 0    | 0    | 0.3  | 0.8  | 0    | 0    | 0    | 0    |
| C3                                       | 0    | 0    | 0.3  | 0.7  | 0    | 0    | 0    | 1    |
| C4                                       | 0    | 0.4  | 0.5  | 0    | 0.7  | 0.2  | 0.3  | 0    |

In order to make the matrix have a uniform measure, the formula is used to standardize the direct impact relationship matrix. After that, in order to make the numbers in the table not only represent the direct impact relationship between two elements, but also the indirect impact relationship between each element, It is necessary to calculate the matrix to obtain a comprehensive impact matrix. Through the comparative analysis of other risk factors, and using the above steps, the final degree of influence, degree of influence, centrality, and cause of the 18 indicators are obtained as shown in table 2.

According to the centrality, the six risk factors are sorted to obtain C6> C5> C3> C4> C2> C1. It can be seen that the prediction accuracy of C6, which is the output of new energy power generation, is the most important factor in all risks on the power generation side. The prediction accuracy of new energy power output also directly affects the safe and stable operation of the microgrid, so it is especially critical to propose a model with high prediction accuracy and good prediction efficiency.

Table 2. Characteristics of risk factor indicators

| /  | Di   | Ri   | Di+Ri  | Di-Ri |
|----|------|------|--------|-------|
| C1 | 4.28 | 4.11 | 8.39   | 0.17  |
| C2 | 4.76 | 4.66 | 9.42   | 0.1   |
| C3 | 3.04 | 3    | 6.04   | 0.04  |
| C4 | 2.48 | 2.29 | 4.77   | 0.19  |
| C5 | 4.27 | 3.76 | 8.03   | 0.51  |
| C6 | 2.64 | 2.44 | 5.08   | 0.2   |
| C7 | 3.48 | 3.27 | 6.75   | 0.21  |
| C8 | 2.86 | 2.68 | 5.54   | 0.18  |
| C9 | 1.51 | 4.65 | 6.16   | -3.14 |
| C10| 1.18 | 1.34 | 2.52   | -0.16 |
| C11| 2.16 | 1.93 | 4.09   | 0.23  |
| C12| 3.52 | 3.38 | 6.9    | 0.14  |
| C13| 3.99 | 3.58 | 7.57   | 0.41  |
| C14| 4.66 | 4.57 | 9.23   | 0.09  |
| C15| 2.9  | 2.83 | 5.73   | 0.07  |
| C16| 2.02 | 1.89 | 3.91   | 0.13  |
| C17| 2.69 | 2.43 | 5.12   | 0.26  |
| C18| 3.79 | 3.74 | 7.53   | 0.05  |
The power generation side of the microgrid is the source of electrical energy. According to the network structure of the microgrid, it can be known that the microgrid mainly depends on the electrical energy generated by distributed generation equipment to meet the load demand. As can be seen from the analysis in Figure 3, geographical and climatic factors have a great impact on the randomness and volatility of new energy power generation, and the former two are causal factors, and the latter are result factors. Similarly, the impact of policies and regulations is also the cause W Su. Among the technical factors, both the maturity of power generation technology and the accuracy of power generation prediction will affect the stability of new energy power generation and the safety level of the entire microgrid. Among all the risk factors on the power generation side, the accuracy of new energy power generation forecasting has the highest degree of centrality, that is, among these risk factors, the prediction technology has the most importance and has the deepest impact on the microgrid.

The data error of the original data set can be divided into two categories: one is that the wind speed, direction, or energy output value is negative, and the other is that the energy output is zero when the wind speed value is not zero. Therefore, correcting this data is necessary, and data mining is a suitable method. Because wind speed has the greatest impact on energy output, this paper uses a curve fitting method to simulate the relationship between these two variables. According to the adjusted r-squared and SSE, the commonly used methods are compared, including Gaussian fitting, Fourier and polynomial fitting. Table 3 shows the formulas and results of different fitting methods.

| Fitting method | Formula | Adjustment R-square | SSE | Order |
|----------------|---------|---------------------|-----|-------|
| Fourier        | $f(x)=7.187-5.542\cos(0.217x)-4.413\sin(0.217x)$ | 0.922 | 2321 | 1     |
| Gaussian       | $f(x)=1463\exp(-((x-17.3)/7.68)^2)$ | 0.919 | 2421 | 3     |
| Polynomial(1)  | $f(x)=1.019x-4.061$ | 0.865 | 4063 | 5     |
| Polynomial(2)  | $f(x)=-0.0018x^2+1.055x-4.215$ | 0.865 | 4059 | 4     |
| Polynomial(3)  | $f(x)=-0.008x^3+0.269x^2-1.429x+2.077$ | 0.921 | 2352 | 2     |

**Figure 3. Fourier Transform Fitting Results**

The results show that the Fourier fitting method is the optimal method with the largest adjustment coefficient r-square and the smallest SSE. Therefore, this paper uses Fourier fitting to fit the curve of wind speed and power output. The results of the Fourier transform are shown in Figure 3. According to the fitting results, the rules for processing error data are as follows:

a) When the wind speed is less than 4 m / s, the wind power is 0;

b) When the wind speed is greater than 4 m / s, the output value is calculated using the Fourier fitting function.
There are a lot of full-character samples in the original data set, which means that this value has been mistyped or not entered due to equipment failure. For these samples, there are two main solutions:

a) When the wind speed value is not "-", the Fourier fitting equation is also applicable;
b) If the wind speed and output power are both "-", fill the gap with the average of the last day and the next day.

In order to improve the efficiency of prediction, this paper applies the WTO analysis to the noise reduction of the data set. Through this method, the raw data processed by DM is decomposed into approximate components and detail components, as shown in Figure 4.

![Figure 4. Data signal after DM processing](image)

60 days and 1,440 samples were selected as training data, where wind speed and direction were input variables and power was output variable. The input data is shown in Figure 5. Based on these data and the DM-WT-CS-SVM model, 72 samples of predicted wind power in the next 3 days can be obtained.

![Figure 5. The input data](image)

Based on the CS algorithm, the optimal value of the kernel function and the penalty factor C are 45.87 and 0.15, respectively. Then, the results of DM-WT-CS-SVM (the proposed method), DM-CS-SVM, DM-SVM, DM-WT-SVM, WT-CS-SVM, and SVM are shown in Figure 6. In traditional SVM, the parameters $\varepsilon$ and C are 5 and 10, respectively.
4. Conclusion
The risk factors of the power generation side of the new energy microgrid were briefly analyzed, and it was clarified that the main object of the study was the risk factor of power generation forecast accuracy. This paper takes wind power forecasting and solar photovoltaic power generation forecasting as research objects, proposes the idea of combining artificial intelligence neural networks, and sorts out the research ideas of this technology in wind and photovoltaic power generation forecasting. Then, for wind power forecasting and solar photovoltaic power generation forecasting, prediction models based on DM-WT-CS-SVM and DN are proposed respectively. In order to verify the accuracy of the proposed model, they are simulated and verified separately with other algorithms. A comparative analysis is performed. The analysis results show that compared with the traditional prediction methods, the research method proposed in this paper has higher prediction accuracy and can predict the random and fluctuating power of wind power and solar photovoltaic power generation stably and effectively.

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