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A review of applications of deep learning in power systems

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Abstract: Deep learning is a major branch of machine learning. Combining its powerful data processing capabilities with power systems is an important path to promote the intelligence of power systems. This paper first introduces the application characteristics and scope of application of deep learning, and then introduces the technical characteristics of power systems such as massive data, interconnectivity, and efficient intelligence. The application status of deep learning and power system integration in various aspects such as power system and equipment fault diagnosis, power load and new energy power prediction, and power system operation control is reviewed. On this basis, the challenges and key technologies of the operation of the new power system are discussed, and the application of the deep learning model in the power system is prospected.

1. Preface

In recent years, the social economy has developed steadily, and the society has made continuous progress. But behind the development will inevitably bring some negative effects such as excessive consumption of resources and continuous destruction of the environment. In order to achieve sustainable development, it is a key to steadily promote the low-carbon transformation of energy. Among them, the power system, as the core carrier of energy conversion, is also an important object to promote the reform of energy consumption model, which is of great significance. As a research hotspot in various disciplines today, deep learning has made rapid progress and provided new ideas for the transformation and development of power systems. Deep learning models can be used for data forecasting, power system planning and design, operation regulation, maintenance, etc. [1], so the application of deep learning in power systems is getting more and more attention. Starting from the basic principles of deep learning, this paper analyzes the application status of deep learning models in power systems, and discusses the key technologies and challenges of new power systems. The future is prospected, hoping to provide some reference for the further application and development of deep learning in power system.

2. Application characteristics of deep learning

The generalization ability of the model refers to giving the model a certain training set. Through machine learning, we can master the rules between the input and output of the training set samples, and then give new samples to the trained model, and the model can also give Adaptability to produce

suitable output.

Since the training sample set cannot be infinitely many, there will always be a generalization error in the model because some data is not in the training set [2]. The generalization ability of the model is related to the completeness of the training sample set, and because the deep learning mainly adopts the mode of offline training and online application, the generalization ability of the model is even more important [1].

Feature learning of data refers to converting original data into an effective form that can be learned by machine in machine learning. While learning to use features, computers also learn how to extract features, that is, learn how to learn. Deep learning is derived from artificial neural network, which imitates the process of human brain processing data, that is, the cognitive process is carried out layer by layer and gradually abstracted. The deep learning model has good mathematical modeling capabilities. Through supervised or unsupervised methods, it can automatically represent the objective function as a feature vector. In each layer, through nonlinear transformation, it can generate more complex abstractions step by step. Compared with manual calculation, the deep learning model effectively reduces the complexity of calculating feature vectors [3].

When applying deep learning to solve power system problems, first of all, it is necessary to measure the scale and quality of the training sample set, analyze the relationship between the data, and perform data cleaning; secondly, determine the sample data feature generation mechanism and the complexity of the model, when the complexity is low, choose shallow learning, when the complexity is high, choose deep learning model to solve the problem. In addition, since the calculation of the deep learning model includes a large number of floating-point operations and matrix operations, the computer system needs to have strong data storage capacity and efficient computing power when using this method.

3. Technical characteristics of the power system using deep learning

3.1 Massive data

Due to the characteristics of wide distribution, power balance, huge transmission energy, extremely fast transmission speed, and instantaneous expansion of faults, the power system determines the large amount, fast growth, and various types of data generated during the operation of the power system. At the same time, in the era of intelligence, the digitization and informatization of power systems continue to develop, which also brings more data. In addition, with the increasing requirements for the power system to obtain a large amount of comprehensive and comprehensive information and data, the amount of data in the power system has increased in many aspects such as spatial breadth, measurement frequency and data types [4].

3.2 Interconnection

The information of the traditional power grid flows in one direction, and the lack of information sharing within the system makes each local system fragmented and isolated [7]. The smart grid will strengthen the ability to obtain all-round information related to the power system. By integrating various operating information of the power system, it will strengthen real-time analysis, diagnosis and optimization to maximize the realization of safer, high-quality, economical and environmentally friendly power system management. [5].

3.3 Efficient and intelligent

With the gradual construction of power system intelligence and the development and application

of big data technology, it has become possible to realize cross-domain access in a distributed environment, providing an efficient information exchange method for cross-domain intelligence of power system, thereby It effectively improves the intelligence of the power system and provides an effective technical guarantee for the realization of the cross-domain interoperability of the power system [6]. This enables the power system to actively coordinate different services at the macro level while meeting the traditional requirements of business intelligence, thereby achieving cross-domain efficient intelligence [4].

4. Application status of deep learning model in power system

4.1 Fault diagnosis of power equipment and systems

When dealing with complex faults in the face of massive, multi-source, high-dimensional data, the traditional methods are relatively inefficient in diagnosing faults. Compared with this, deep learning has the following advantages:

1) Deep learning mostly inputs data from the hidden layer. In an unsupervised way, it can train layer by layer and abstract the data to obtain complex fault feature vectors, which reduces the difficulty of manual data processing and mathematical modeling.

2) Deep learning does not depend on the periodicity of the signal, and can be used for multi-source signals with different sampling periods and asynchronous clocks [1].

3) It does not depend on the current signal processing technology and manual diagnosis experience, can be used for complex nonlinear data, and has strong adaptive ability [1].

For example, literature [7] proposed a method of fault identification and fault phase selection in and out of the transmission line based on convolutional neural network (CNN). Two Softmax classifiers were used to solve the problem of fault judgment and phase selection in and out of the district simultaneously with the same CNN. Two dependent classification problems. The CNN model constructed in this paper does not need to tune any parameters, and is not affected by factors such as fault location.

4.2 Power load and new energy power forecast

Load forecasting is the main content of power system work, but traditional forecasting methods have problems such as complicated operation and inaccurate eigenvector acquisition. Deep learning has advantages in nonlinear fitting and avoiding the curse of dimensionality [1]. In the new energy power prediction, the time series prediction function of deep learning can make full use of the known historical power data to train the deep learning model, so as to obtain more accurate prediction data [1]. The results of literature [8] show that long short-term memory network (LSTM) exhibits stronger ability to predict time series data due to its reliability and generality. The application of deep learning to the power system can improve the accuracy of power load and new energy power prediction, which is conducive to improving the utilization efficiency of new energy, and thus improving the economy of the power system.

4.3 Power system operation regulation

Power system is a high-dimensional nonlinear system with multiple inputs and outputs at the same time, and deep learning has advantages in complex data feature extraction and model fitting, so it is introduced into power system operation regulation [1]. Reference [9] proposes a power system cut-off control strategy based on deep reinforcement learning. It uses the Q-Learning method to extract the operating characteristics of the power grid by using a deep convolutional network, and then combines

reinforcement learning. The reinforcement learning adopts double Q-Learning. Calculate the Q value with the competitive Q-Learning model, and obtain the best cutting plan by comparing the size of the Q value.

At present, the application prospect of deep learning in power system operation and regulation is broad, and its application in static voltage stability, power quality detection and transient instability emergency control needs to be further explored.

5. Application prospect of deep learning model in power system

Considering the massive data brought by the era of intelligence and the complex relationships and characteristics among power sources, power grids, and loads, the operation of power systems has become one of the systematic projects with high complexity and nonlinearity. Using deep learning's powerful ability to extract complex nonlinear features, it is expected to enhance the intelligence and security of the power system by integrating it with the power system. In addition, in the process of studying the application of deep learning in the power system, we must put the security of the network first, build a key technology system suitable for the intelligent era, and design a power system development path suitable for China's national conditions.

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