Refined Identification of Distribution Network Planning Survey Based on Improved Convolutional Neural Network Algorithm

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Abstract. Distribution network planning is an important guarantee for power grid construction and transformation, which can ensure the reliable, stable, economic and flexible development of the system. With the increasing capacity of distribution network, the amount of data to be processed and analyzed in distribution network planning has increased dramatically. Especially for the high voltage, medium voltage and low voltage superior power supply, distribution network structure and operation status, the workload is huge and the complexity is high. If the planning process completely depends on the planners to analyze and calculate, it is easy to have calculation errors, incomplete analysis or other uncertainty errors. Based on the improved convolutional neural network (CNN) algorithm, a new identification algorithm is proposed to improve the measurement accuracy of distribution network planning. The proposed method uses CNN to extract the first k important variables, and then combines them with the previous two methods, one uses nonlinear regression, the other uses linear regression. In addition, we propose a new metric method. In order to evaluate our results, this article uses a large number of real data sets.

Keywords: Distribution network planning · Convolution neural network · Fine identification

1 Introduction

With the continuous improvement of customer requirements and the concern of power grid companies on the reliability and economy of distribution networks, distribution network planning has become an important project for the transformation and construction of distribution networks. As a guiding text, it determines the development direction and mode of the planned area. If the design is wrong, it will bring huge cost waste to power supply enterprises and poor quality electric energy service products to residents. The superior company also gradually noticed that the limited resource allocation of power supply enterprises [1]. Therefore, more detailed requirements have been put forward in terms of management means and work content. The distribution network involves a large area, many voltage levels, and a complex interconnected structure. In

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economic construction, and residential power consumption, flexibility of power supply of medium and low voltage distribution networks, and reduce power grid losses, It also brings problems such as distorted communication between superiors and subordinates, and disjointed monitoring. Therefore, the introduction of a good communication and management mechanism is a strong guarantee [2].

In the previous planning of distribution network, the lack of comprehensive standards and guidance makes the investment and construction not suitable for the development of economy and demand, and also increases the cost of power grid construction and operation. At present, the network loss rate of the country is about 10%. The general distribution network planning is to configure and transform according to the line overload, heavy load or other voltage reasons, replace the cable with large conductor section or increase the line and capacity, rather than a complete and comprehensive construction of a reliable and reasonable network structure to adapt to the construction requirements of urbanization [3]. The state pays more and more attention to the construction of distribution network, invests more and more money, and has made many achievements. However, the foundation of distribution network is relatively weak, mainly because the equipment is old but the load is heavy, the automation level is low, and the wiring is unreasonable. In particular, the medium and low voltage distribution network urgently needs comprehensive guidance standards.

2 Related Work

2.1 Domestic Distribution Network Planning Status

The "Guidelines for the Design of Urban Power Networks" issued by the Ministry of Energy in 1993. This document has unified provisions from seven aspects, including planning requirements, load forecasting and design principles, and selection of power supply facilities, and has become an important basis for modern, the project staff should be able to take into account the impact of all aspects when planning based on the past planning experience and certain models. However, experience and subjective judgment alone cannot make full use of the collected data and information to make scientific and accurate judgments, which will consume more manpower and material resources in the actual planning, and have little guiding significance for the development of the distribution network [4].

Some large cities in China have focused on the development of distribution networks for many years. Shanghai, Yantai, Guangzhou and other cities have built a better distribution network automation and network structure, which can achieve fault isolation and dispatching automation and other functions, and even add information collection and low-voltage reactive power compensation control functions.

The distribution network planning can get better development in the above cities, which can not be separated from information technology and computer aided analysis. The computer technology that is widely used in China is mainly GIS technology. Many experts have designed some software packages and codes for the application of distribution network planning, but there is still a long way to go from comprehensive guidance and perfect software. This paper makes an in-depth study on the transformer location and line routing of the 10 kV distribution network, puts forward a preliminary research

scheme, and automatically solves simple problems with the help of language development tools. Using MapX and VB as the development language and taking advantage of the high efficiency of GIS technology, the fault data of power system can be well processed. The development of artificial intelligence technology has injected new impetus into the development of distribution network. At some stages of planning, the combination of geographical data and artificial intelligence technology is used to solve the current problems, so that the automation solution can wait for a certain development. Through heuristic rules and expert system, different planning methods are proposed for different stages to solve the problem of distribution and coordination of substation planning.

Some new genetic algorithms have improved the idea of solving nonlinear problems in distribution network planning. The scientific conclusion is greatly improved by using genetic algorithms to optimize problems. In general, some cities in China gradually introduce computer aided decision-making system in planning to increase the rationality of distribution network transformation. GIS has also been greatly promoted in some control planning, but there is still much room for improvement.

2.2 Research Status of Distribution Network Planning Software

With the continuous improvement of customer requirements and the concern of power grid companies on the reliability and economy of distribution networks, distribution network planning has become an important project for the transformation and construction of distribution networks. Distribution network planning requires a large amount of data to comprehensively analyze the superior power supply, distribution network structure and operation status of the distribution network. The workload is large and the complexity is high. If the planning process completely relies on the planners to analyze and calculate, it is easy to have calculation errors, incomplete analysis and other problems.

Some front-line employees reported that many of the data collected each year were collected last year or before, and the design unit did not sufficiently inherit the data, resulting in heavy workload and low efficiency. Because the investigation takes up a lot of time of the front-line infrastructure department staff, if we can quickly get all the analysis indicators and perfect planning reports after obtaining the original data, and deal with the problems found in the correction of errors and the status quo analysis reduce the interference to the normal work of front-line staff. Guangdong Power Grid Corporation has a detailed guidance process for the revision of the entire distribution network planning. However, due to unexpected problems such as wrong capital collection and re revision, the design unit often has to make important changes or make major changes when handling the revision task of the distribution network planning in the previous year. In serious cases, the task cannot be completed within the specified time, resulting in the rescheduling of the subsequent schedule, which wastes human and material resources. The provincial power grid corporation also expressed dissatisfaction with this. In addition, the design process of different design units is different, and the final report may be different in data format and table text format, which is not standardized and neat enough.

Static voltage stability analysis and security risk assessment, and the database is used to uniformly manage the data required by each module. However, in the planning process, only N-1 criteria and part of N-2 security verification are verified, lacking other indicators that comprehensively reflect the current situation of the network.

3 Distribution Network Planning Based on Improved Convolutional Neural Network Algorithm

3.1 Graph Convolution Neural Network

At present, convolution based on spatial method and convolution based on spectral method are two main research directions of graph neural network. Graph convolution neural network is a representative model based on spectral method convolution. With its excellent processing ability for non Euclidean spatial data, it has rapidly become a research hotspot in the field of artificial intelligence. Graph neural network based on spectral method is widely concerned because of its simpler model structure and lower computational complexity. The convolution method used in this paper is graph convolution technology based on spectral method, which is introduced below.

In 2009, Graph Neural Network (GNN) was proposed. It uses the structure of traditional neural networks for reference to directly process data in non Euclidean space, which is the enlightenment work of graph neural networks and lays in the future. Laplace operator and Fourier transform are used to solve the problem of convolution calculation of graph data, and the first graph convolution neural network is proposed. The GCN model is proposed by using the idea of first-order adjacent order aggregation, which is used as the basic GCN model by most subsequent studies.

Before using Laplacian matrix, graph convolution neural network needs to use two tricks to improve its performance: (1) add a self loop to all nodes to ensure that nodes themselves and their neighbors participate in reasoning together, that is, $A \leftarrow A + I$ (it is still recorded as A in this paper); (2) Normalization is carried out to prevent gradient explosion or disappearance, as shown in Fig. 1.

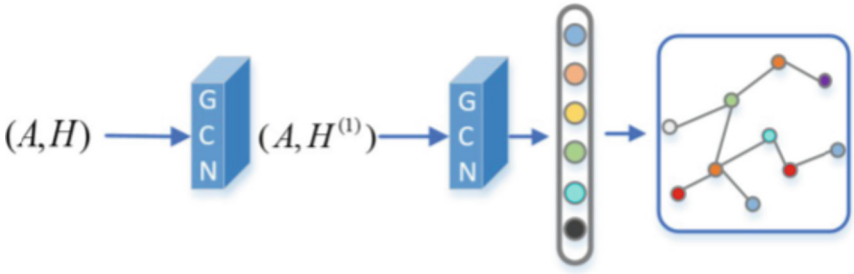

Fig. 1 Structural model of graph convolution neural network

3.2 Transformation Method of Distribution Network

The reliability of power supply and distribution is increasingly concerned by the whole society and power supply enterprises. At present, the transformation method of the current distribution network mainly depends on the established technical standards and the experience of the staff.

First, determine the construction in progress and planned scheme of high-voltage power supply in the distribution network, analyze the transformation of substation planning and medium and low-voltage distribution network planning in the previous year, investigate the load adjustment of medium and heavy load, overload lines and distribution transformers in the overall and all areas, and improve the problem index value; Secondly, according to the situation of enterprises and large customers using telegraphy, combined with the city's industrial layout and development, social natural growth rate, and the service factor of telegraphy, load forecasting is carried out from top to bottom and from bottom to top, so as to obtain the power demand of the whole city and districts; Before formulating the project transformation scheme, it is necessary to have a comprehensive understanding of the power balance and planning and design principles, including the electricity demand analysis of power balance and step-down capacity, the detailed discussion on the design principles of the capacity load ratio, grid structure and guide section of high-voltage distribution network, and the technical principles of the structure, switch stations, distribution lines and distribution devices of medium and low-voltage networks, taking into account their actual application; Then, carry out a comprehensive design of high-voltage, medium and low-voltage distribution network transformation scheme. The transformation scheme of high-voltage distribution network mainly considers the current situation and development prospects of its high-voltage distribution network connection mode, and plans the distribution points and network structure of the substation, and carries out sensitivity analysis and risk check on the implementation

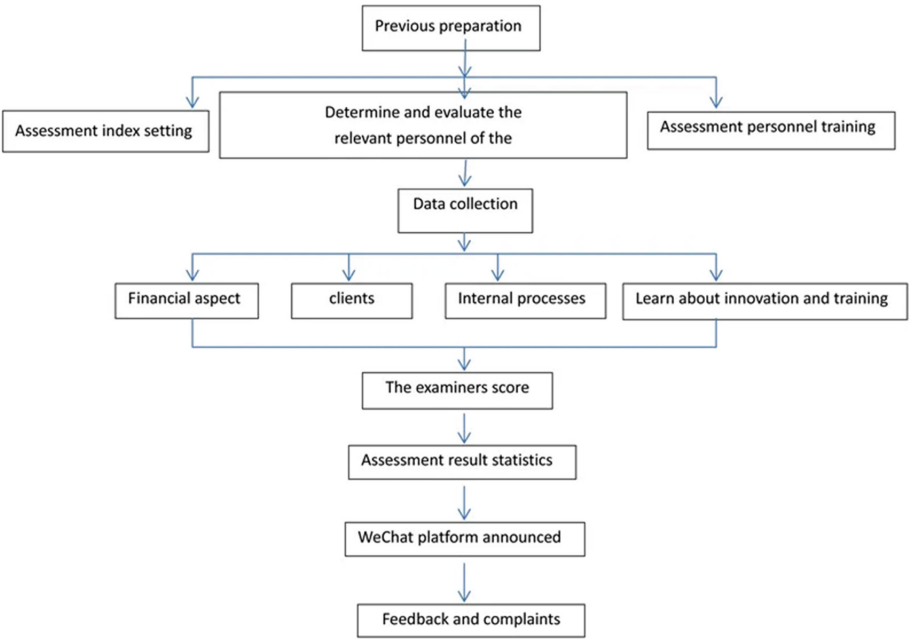

Fig. 2 Flow Chart of Distribution Network Transformation Scheme

scheme. For the medium and low-voltage distribution network, according to the planning of high-voltage substation and power supply scope, the new outgoing lines Medium voltage grid transformation and low-voltage grid improvement projects, and analyze the rationality of its high, medium and low schemes. The final transformation plan also needs to carry out investment estimation and economic evaluation, which are detailed to the estimation of the main network, distribution network and the whole network; In addition, it also evaluates the effectiveness of the whole planning project, such as the degree of solution to the problems existing in high-voltage and low-voltage distribution networks and the reliability of power supply, and analyzes the line loss rate and investment efficiency rate after the implementation of the scheme. The process is shown in Fig. 2.

4 Conclusion

With the rapid development of distribution network reconstruction in China, distribution network planning has become a task with huge amount of data and various processing indicators. It is urgent to change from the previous experience oriented planning to an efficient and accurate planning method combining theory and experience. It is an urgent goal to develop a convenient and practical intelligent network planning computer aided system. The intelligent auxiliary analysis system for distribution network planning introduced in this paper is guided by the technical regulations for distribution network planning, which is based on Access 2003 database and VB NET language programming to realize the interaction between the computer and the planners, and realize the automatic calculation and analysis of different index values. Combined with the characteristics of various forms and types of capital collection data, the rationality judgment for digital information and the specification rules for text information are formulated. With this function, the data can be kept in a reasonable range and accuracy. The text data specification can be correctly invoked by the system.

References

1. Wang, J., Huang, C., Zhao, L., et al.: Lightweight identification of retail products based on improved convolutional neural network. Multimedia Tools Appl. **81**(22), 31313–31328 (2022)
2. Li, S., Yin, S., Deng, H.: Lipid droplet recognition based on watershed algorithm and convolutional neural network. In: ICMIP 2021: 2021 6th International Conference on Multimedia and Image Processing (2021)
3. Qu, M., Wang, T., Li, F., et al.: Distribution network electrical topology identification algorithm based on deep learning. IOP Conf. Ser. Earth Environ. Sci. **645**, 012076 (2021)
4. Ponciroli, R., Rovinelli, A., Ibarra, L.: A convolutional neural network-based approach to field reconstruction (2021)