Power System Fault Diagnosis and Prediction System Based on Graph Neural Network

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ABSTRACT

The stability and reliability of the power system are of utmost significance in upholding the smooth functioning of modern society. Fault diagnosis and prediction represent pivotal factors in the operation and maintenance of the power system. This article presents an approach employing graph neural network (GNN) to enhance the precision and efficiency of power system fault diagnosis and prediction. The system's efficacy lies in its ability to capture the intricate interconnections and dynamic variations within the power system by conceptualizing it as a graph structure and harnessing the capabilities of GNN. In this study, the authors introduce a substitution for the pooling layer with a convolution operation. A central role is played by the global average pooling layer, connecting the convolution layer and the fully connected layer. The fully connected layer carries out nonlinear computations, ultimately providing the classification at the top-level output layer. In experiments and tests, we verified the performance of the system.

KEYWORDS

fault diagnosis, graph neural network, power system, prediction

1. INTRODUCTION

Power system is one of the indispensable infrastructures in modern society, which provides a stable power supply for our daily life and industrial production. However, the power system is also facing various potential faults and problems, which may lead to power failure, equipment damage and economic losses (Zheng, Y, et al., 2022). Therefore, the fault diagnosis and prediction of power system becomes very important to ensure the reliability and stability of power supply.

Compared to existing methods, our Graph Neural Network (GNN) model exhibits unique aspects in both structural design and performance, which we will elaborate on in this section.The faults of power system usually have diversity and complexity, including line faults, equipment damage,

DOI: 10.4018/IJITSA.336475
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abnormal load and so on (Wang, J, et al., 2019). Traditional methods usually rely on rules and experience for fault diagnosis and prediction, but it is difficult to deal with this complex and changeable situation. Wang, X, et al., (2022) finds out the law of current mutation by monitoring the change of current at different sampling times, so as to realize fault phase selection in power system. Tan, B, et al., (2017) introduces a fault phase selection principle centered on high-frequency components within fault elements. This principle leverages the high-frequency component of voltage faults to achieve phase selection by comparing the frequency domain characteristics of mode transformation in the three-phase voltage across various phases. The utilization of data mining technology is discussed for the establishment of a decision tree within the power system fault model(Zhao, Y, et al., 2017) (Jones & Venable, 2022). Furthermore, enhancements to this decision tree result in the development of a prediction system that encompasses an inference engine, interpreter, decision tree algorithm, and a comprehensive graphical user interface. To address fault location, a wavelet neural network is constructed and applied. It is worth noting that the fusion of wavelet analysis and neural networks can take various forms, and wavelet mother waves can be categorized into multiple types (Wang, L, et al., 2022). We can try to improve the traditional neural network with other mother waves in order to achieve better results (Yang, X, et al., 2019). In contrast, the method based on graph neural network (GNN) has stronger adaptability and generalization ability. It can learn patterns from a large number of power system data, automatically identify anomalies and predict faults, and improve the efficiency and accuracy of fault handling (Santos et al., 2022).

With the rapid development of deep learning and artificial intelligence, GNN and other technologies have attracted extensive attention and achieved remarkable success in various fields. In the field of power system, using GNN to diagnose and predict power system faults has become an important direction that attracts much attention of researchers. GNN can effectively capture the complex relationships among various components in the power system, including generators, transmission lines, transformers, etc. The interaction between these components is very important for the operation of the power system. The purpose of this study is to develop a power system fault diagnosis and prediction system based on GNN to meet the challenge of power system fault (Savoli & Bhatt, 2022).

The results of this study will not only help to improve the reliability and stability of the power system, but also provide an advanced fault management tool for the power industry and promote the modernization and intelligent development of the power system. At the same time, this study will also provide strong support for the feasibility and effectiveness of GNN in practical engineering applications, and broaden its application prospects in various fields (Yanuarifiani et al., 2022).

2. FAULT DIAGNOSIS AND PREDICTION OF POWER SYSTEM BASED ON GNN

2.1. Overview of GNN

GNN is a deep learning model, which aims at processing graph structure data. Graph structure data usually includes nodes and edges, such as data in social networks, recommendation systems, molecular chemistry and power systems (Ewert, P, et al., 2020). GNN carries out various tasks by learning the relationship between nodes and the characteristics of nodes themselves, such as node classification, graph classification, link prediction and so on (Li, Q., & Liu, X. F, 2019).

The principle of GNN is based on information transmission and aggregation, and it draws lessons from the structure and connectivity of graphs. In a typical graph structure, nodes represent entities and edges represent relationships between entities. The core idea of GNN is to update the representation of each node through the information of neighboring nodes in step polymerization. This process can be described by the following steps: