Application of Artificial Intelligence Technology in Power Grid Enterprises based on Enterprise Architecture Method

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Abstract. The rapid development of contemporary new information technology provides new opportunities and challenges for power grid enterprises. As a new technology with rapid development, artificial intelligence technology has begun to play an important role in related fields. Because of the complexity of power grid enterprise structure, how to realize the in-depth implementation of artificial intelligence has become the current concern of power grid enterprises. In order to solve the problem, the enterprise architecture method is used to deeply analyse the power grid enterprise architecture, and the application of artificial intelligence is clearly planned according to the architecture system level. Based on the planning of business category, application category, technology category and data category, artificial intelligence can be applied to complex power grid structure more thoroughly. Successful application cases of artificial intelligence in power grid enterprise are be used as an example analysis. The application of artificial intelligence technology in power grid enterprises, the efficiency and ability of enterprises, and the pace of energy transformation will be improved.

1. Introduction

The development of information technology has already changed enterprises working mode to a great extent. Enterprises are also introducing some new information technologies, such as advanced artificial intelligence technology, to improve work efficiency and accuracy and reduce operating cost and errors. Power grid enterprises are involved in power generation, transmission, distribution and electricity consumption. Power grid enterprises have their unique corporate nature and characteristics. They have the functions of traditional manufacturing infrastructure enterprises and comprehensive functions such as energy regulation, marketing, and government coordination. If the formed application of new information technology is simply introduced, it will be difficult to meet the needs of power grid enterprises, and the application value of the technology will be greatly reduced.

In recent years, artificial intelligence technology has played an important role in more and more information fields. It can be used in many aspects such as dispatching, marketing, infrastructure, business management, operation inspection, and safety supervision of power grid enterprises. However, most of the current grid enterprises have the characteristics of complex departments and systems. When artificial intelligence is directly applied, there will be shown many problems such as applications that do not fit the reality, technical efficiency will be wasted. So, the enterprise architecture methodology is used to systematically sort out the grid enterprises, clarify the vision, structure, requirements, technologies, assets, and so on. In this way, artificial intelligence technology can be applied to the
construction of power grid informatization more deeply. The overall technology utilization efficiency and value can be improved, so that “the new technology has something to use, and the material exceeds what is used.”

2. Theoretical overview

2.1. Overview of enterprise architecture methodology
At present, enterprise architecture methodology has developed into a relatively complete research system. How to understand, analyse, design, build, integrate, expand, operate, manage information systems based on business oriented and driven architecture as well as how to build a complex architecture are the focus of enterprise architecture methodology. Xu Haiqing and others elaborated on the enterprise architecture as the core, and applied the enterprise architecture method to the whole process of information management planning, construction, operation and maintenance, and evaluation[1]; Wang Jijun and others proposed a data sharing and business integration demand analysis method based on enterprise architecture, using enterprise architecture to realize the integration of data and business[2]; Yiwei Gong discusses the role and capability of enterprise architecture using big data analysis, and studies how to integrate analysis into the current complex IT environment[3].

Enterprise architecture is also widely used in the field of power grid., Wang qiaowen and others proposed an enterprise architecture framework for power grid industry referring to the mature enterprise architecture theory Zachman, TOGAF and FEAF[4]; Lin Yongfeng and others provided a series of standardized and standardized architecture views for the whole life cycle management of informatization project construction of power grid enterprises[5];Li Yijin and others analysed the construction method and key work of framework planning of asset management system of power grid enterprises[6]; Pierre Hadaya and others based on the literature review and work review, a specific and detailed example of enterprise architecture planning is presented to illustrate the importance of literature and work backtracking[7]. Ford Lumban Gaol and others analyse the business process of ERP enterprise from the aspect of enterprise architecture by combining the requirement engineering method oriented to organizational goals[8].

2.2. Overview of the development and application of artificial intelligence technology in the power grid area
With the continuous development of artificial intelligence technology, the power grid field has also begun to use artificial intelligence technology to solve power grid problems, improve power grid capabilities, and achieve rapid development of the power grid industry. Video intelligent analysis pilots are used in field operations. Artificial intelligence tools are used to realize the intelligent identification of typical serious violations, which can assist human in performing corresponding tasks through alarms and records. The Artificial intelligence image recognition cloud service has also begun to be applied to the inspection of some power grid equipment. Through the real-time information sharing, the human-machine mutual assistance mode is realized. The artificial intelligence distribution network live-working robot can replace part of the manual work, reduce the manual intervention of dangerous and urgent work and ensure the physical and mental health of staff. Combining artificial intelligence technology and applications such as intelligent business halls and intelligent voice customer service have begun to be piloted in business halls. The intelligent customer service judges some fixed needs of customers and intelligently responds to realize automatic and intelligent basic business consultation and business handling recommendations.

At present, more and more artificial intelligence tools are beginning to be used in the first-line power grid scenarios. Through the continuous improvement of artificial intelligence, many tools have replaced humans in more and more area. They can complete manual tasks more accurately and continue to do machine-learning. During the learning process, they can more and more accurately judge and deal with the problems encountered in work. At present, artificial intelligence tools have gradually matured, and some machine learning models have gradually been applied to data processing. However, the relevance
of artificial intelligence technology is still insufficient. Many technologies are limited in pure tool application rather than penetrating into all aspects of power grid enterprises. Form a strong association and knowledge base. Therefore, analysing how to apply artificial intelligence technology to all aspects of power grid enterprises to form a large-scale artificial intelligence application system is an important research direction in the future.

3. Application of artificial intelligence technology based on Enterprise Architecture

3.1. Structure and demand of power grid enterprises by enterprise architecture method

Through the analysis of the specific conditions of the power grid enterprises, combined with the specific requirements and conditions of technology applications, the enterprise architecture methodology is used to analyse the new technology application architecture of the power grid enterprises. By analysing the vision and structure of power grid enterprises, the technology application architecture of power grid enterprises is constructed from the four general corporate architecture analysis levels of business, application, data, and technology. Taking into account the high security requirements and strict controls of the power grid and the energy industry, a security aspect is added to the analysis of the general enterprise architecture to make the entire technology application architecture more suitable for the actual needs of power grid enterprises.

The functions and requirements of the five levels of power grid enterprises after deconstruction are shown in Figure 1.

![Figure 1. Power grid enterprise function and demand analysis chart.](image-url)

The main content of the business structure of power grid enterprise is focused on the clarification of the work theme and management functions. The analysis of the business structure clarifies the content and connections of the various enterprise business scenarios. It can derive specific functional focus and requirements according to different business scenarios, work topics and management functions. Artificial intelligence technology needs to meet the different difficulties and pain points of specific business functions, improve the needs of business scene association and interaction, and arrange the specific content of the data category and application category according to the different conditions of the business category. By sorting out the data architecture, it is possible to clarify the data storage situation of power grid enterprises and current data problems. Then, use relevant technologies where
artificial intelligence can accurately solve the problems and improve the stability and security of the data architecture. The application category is an important realization category of artificial intelligence. By analysing the situation of the application category, accurate application, reasonable application, and efficient application of new technologies can be realized. The technology category needs to consider the connection, selection and coupling of technologies.

3.2. Application of artificial intelligence based on Power Grid Enterprise Architecture
Combined with the analysis of the grid enterprise architecture, analyse the specific application of artificial intelligence in the grid enterprise architecture. The application architecture diagram of artificial intelligence is shown in Figure 2.

When analysing specific artificial intelligence applications, a complete artificial intelligence application architecture system is built before the application to ensure that the application construction and use process can meet the optimal requirements for the specific situation of the power grid enterprise. The application of technology should be combined with the characteristics of power grid architecture and artificial intelligence technology at the same time. Cost and use issues should be fully considered during the application process to avoid technical vacancies, technology isolation, and lack of technical support that may arise in the process of technology construction.

4. Taking the construction of Smart Substation as an example to verify the application of artificial intelligence technology

4.1. Overview of functional requirements of traditional substation
Substations are responsible for the heavy tasks of electric energy conversion and electric energy redistribution, and play a pivotal role in the safety and economic operation of the power grid. At present, traditional substations need to manually carry out inspection operations and live detection in daily operation and maintenance work. The development of the power grid will inevitably lead to a large increase in the number of substations, greater functional requirements, higher safety requirements, and more complex response situations. The above changes have also increased the work pressure of substation operation and maintenance personnel year by year, faced more and more problems and challenges in the operation and maintenance process. However, simply using technology to improve a certain function of the substation (such as using robots to pick up some points manually) cannot fundamentally meet the needs of the substation. It can only "treat the symptoms rather than the root cause." Therefore, the use of artificial intelligence and mobile Internet advanced information technology means to build a smart substation with comprehensive status perception, information interconnection and sharing, and popularize new technologies to every part of the substation system, and build "operation one-key sequence control, automatic equipment inspection, and main Intelligent substation applications such as "Intelligent Linkage of Auxiliary Equipment" will further promote the intelligentization and modernization of substation operation and maintenance management, improve the safety level and
operation inspection quality of substations, and greatly increase the benefits of operation and maintenance.

4.2. Planning Smart Substation Construction with enterprise architecture method

Based on the actual needs of lean management of substation operation and maintenance, combined with the existing traditional wired method of the perception category in current substation and the LoRa narrowband wireless Internet of Things communication technology, the specific structure of the smart substation is planned to use the enterprise architecture method. According to the specific survey of power grid companies, the planned substation architecture is shown in Figure 3 below.

![Overall architecture of integrated smart substation platform](image)

**Figure 3. The schematic diagram of overall architecture of integrated smart substation platform**

The business category mainly analyses the business application scenarios and requirements of the substation and summarizes the business functions of the substation. The application category implements visual display and intelligent human-computer interaction according to business requirements and realizes real-time station management, equipment management, and planning management. While set up online monitoring, environmental monitoring, security monitoring and other real-time monitoring applications, combining management with monitoring, six modules including online monitoring module, environmental monitoring module, fire warning module, intelligent auxiliary control module, intelligent patrol are integrated to build a smart substation platform. The data category, combined with the perception category, includes transformer voiceprint, GIS UHF partial discharge, switchgear connector temperature measurement, opening and closing coils, current and voltage monitoring, current monitoring during continuous operation of lightning arresters, installation of equipment sensing devices such as indoor and outdoor inspection robots, and intelligent upgrade of auxiliary facilities to ensure the accuracy, real-time, availability and reliability of the data category. While data access modules are used for data classified access and pre-processing to ensure the clarity of data storage. Technical category specially sets up intelligent analysis algorithm model library.

4.3. Application of artificial intelligence technology in Smart Substation

Smart substations can realize the following seven functional transformations: First, realize the display analysis and multi-dimensional operating condition information of main equipment such as main transformers, GIS combination appliances, SF6 pressure gauges, switch cabinets, cable bodies, and batteries trend research and judgment. The second is to realize the collection of micro-meteorological data including wind speed and direction, rainfall, PM2.5, PM10, etc., combined with the high-definition
camera in the station and artificial intelligence image recognition technology, to assist in checking whether there are hidden water and floating foreign objects in the station and trend tracking. The third is to realize the remote control of station access control, air-conditioning, fans, lighting, SF6 gas leakage, cable trenches and shafts of all ultra-fine dry powder fire extinguishing devices, emergency linkage disposal and self-checking of the health status of auxiliary facilities. The fourth is all the present monitoring points of all HD cameras in the station can be remotely patrolled in the application mode of "relevant camera terminals with the monitoring object as the core", combined with artificial intelligence image recognition technology to realize automatic recognition of meter data and opening and closing signs, The average recognition accuracy rate reaches 99.95%. The fifth is to realize the data collection of the switchgear in the station, including panel status indication, partial discharge, and cabinet temperature, and to realize the coverage of wheeled inspection robots for common outdoor inspection points. The sixth is the comprehensive use of the station high-definition video, robots, and various main equipment, auxiliary equipment, and environmental sensor monitoring device information realize comprehensive inspections (75% replacement rate), routine inspections (100% replacement rate), and special inspections (special inspections of bird's nest and floating objects). The seventh is to realize the high-definition video remote monitoring of the work area based on the work ticket information, and realize the real-time alarm of the work area control and personnel safety measures based on artificial intelligence image recognition algorithm technology.

5. Conclusion
The application of artificial intelligence technology in power grid enterprises is explored by using enterprise architecture method. Through the use of enterprise architecture method, the architecture and technology application architecture of power grid enterprises are constructed to promote the further implementation of artificial intelligence technology and ensure the full application of new technology in large-scale application system. Through the analysis of enterprise architecture method, a very complete system technology application framework is obtained to assist enterprises in the construction of large-scale artificial intelligence system. At the same time, the case analysis shows that the use of enterprise architecture method for artificial intelligence technology planning is reliable, the application of corresponding technology can solve the problems in reality, achieve higher intelligent human-computer interaction, improve the ability and efficiency of work and service, and further promote the transformation of enterprises and the development of energy industry.

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