Construction of Green Intelligent Building Operation and Maintenance Management Platform Based on Big Data Technology

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Abstract. In the era of digital intelligence, the blessing of intelligent engineering can further enhance the practical benefits of green buildings in application services and environmental conservation, but it also increases the difficulty of green building operation and maintenance management. In this regard, based on the problems of weak unity, low coordination and poor effectiveness in the operation and maintenance management of green intelligent buildings, this paper puts forward a set of construction scheme of operation and maintenance management platform of green intelligent buildings, so as to improve the sharing and distribution of data and information and promote the reform of operation and maintenance management mode of green intelligent buildings. The system takes Hadoop cluster as the data management and processing server, Spark as the data analysis and mining engine, and combines Javaweb technology to form an interactive application system integrating online application, intelligent processing, visual analysis and other functions. Practice has proved that the system can realize the effective linkage of intelligent projects and complete real-time monitoring. It can also use data mining algorithms such as K-means, Apriori, CART random forest to build the corresponding energy consumption management analysis model, enhance the perception of green intelligent buildings, and effectively realize intelligent operation and maintenance management.

Keywords: Big data technology; green and intelligent building; operation and maintenance management; data mining; computer application

1 Introduction

With the active promotion of the "carbon peak and carbon neutrality" campaign, the construction industry, as a traditional large energy consumer of carbon emission, urgently needs a brand-new development concept to accelerate the industrial transformation and upgrading. [1] In this context, the concept of green intelligent building indicates that the intelligent upgrading of green buildings has become an important measure for the development of low-carbon economy, and will also open up a new direction for the integration and development of green buildings and intelligent

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buildings. Green intelligent building is not only an industrial concept, but also a set of operation system covering the whole life cycle of construction projects, so as to further enhance the practical benefits of green building in application services, environmental protection and saving. However, in the practical application process, there are more and more green building intelligent engineering subsystems, and the departments in charge and human operation and maintenance projects are complicated, and the systems are relatively independent, lacking interconnection foundation, forming data islands, which leads to the problems of weak unity, low coordination and poor effectiveness in the operation and maintenance management process. [2] In view of this, this paper believes that in the face of the operation and maintenance management needs of green intelligent buildings, a third-party service platform supporting multi-dimensional correlation, logical integrity and comprehensive coordination will be built with big data technology as the core, so as to improve the sharing and distribution of data information in various intelligent engineering systems and promote the reform of operation and maintenance management mode of green intelligent buildings. [3] The platform as a whole is composed of two technical systems, Hadoop and Javaweb, and contains many modules such as data acquisition, processing, analysis, visualization and interaction, which can support the realization of real-time monitoring of intelligent engineering subsystems, energy consumption pattern judgment and early warning of abnormal energy consumption, and provide technical support for promoting the rapid development of green buildings.

2 System Construction

The overall framework of the platform is divided into access layer, business application layer, data processing layer and source data layer. [4] Among them, the data processing layer takes Hadoop framework as the core to complete the overall deployment. According to the platform application requirements, Hadoop is built according to the available framework distributed cluster. It contains six functional nodes, two are master and four are worker. The hardware configuration of each node consists of 3.2GHz 4-core CPU, 16G memory and 500GB hard disk. Each node of Hadoop cluster will have an independent computer server, and the components such as FileSystem, Replicas, Mapreduce, Yarn, HDFS, Spark, Storm, Spooq, Kafka will be adjusted in turn to meet the functional requirements of data collection, data preprocessing, data storage, data mining and analysis. [5] The access layer of the platform will directly face the users to obtain their requests. The business application layer is based on the Spring architecture, builds the corresponding business logic according to the MVC pattern, and completes the processing and feedback of user requests under the control of the Web server. All the functional application modules and data transmission interfaces involved will rely on Javaweb technology. [6] In the overall development environment, MyEclipse V 2022 is the integration tool, Tomcat 8.0 is the Web server, and MySQL 5.7 is the database server.

3 Functional Implementation

3.1 Real-Time Monitoring

Under this function module, users can intuitively see the real-time push of monitoring data of intelligent engineering subsystem, and display it in the form of data visualization on Web pages. The realization of this function requires the Web Server to call Hadoop framework to complete data collection, cleaning and transmission, and complete real-time calculation of some data with Spark Streaming computing framework under the resource scheduling of Zookeeper. [7] At the same time, the visual display is completed by combining D3.js class library in the front-end interface. Figure 1 shows the 24-hour energy consumption curves of different intelligent engineering subsystems, in which the abscissa is time and the ordinate is power consumption.

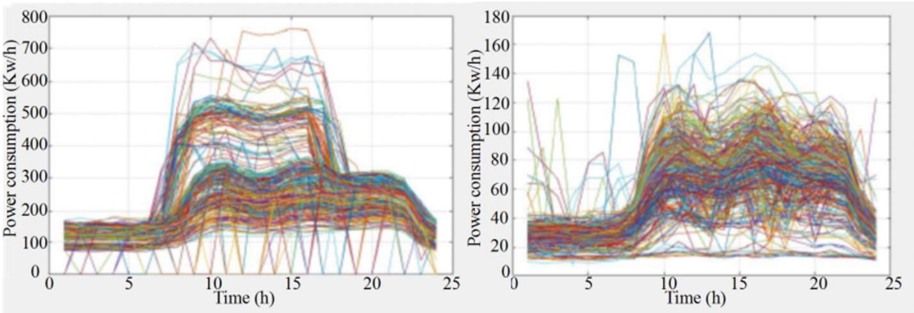

Fig. 1. Power consumption curve of different intelligent engineering subsystems

3.2 Energy Consumption Pattern Determination

With the help of data analysis and mining under big data technology, the platform will make cluster analysis and decision tree judgment on the historical energy consumption data of intelligent engineering subsystems, and make clear the energy consumption patterns of each intelligent engineering subsystem. When the user operates the historical data of a subsystem, the system will automatically preprocess the data, and according to the characteristics of large volume, noise and complex data cluster of the subsystem, DBSCAN density clustering algorithm is selected to complete the construction of the analysis model. [8]

Two important parameters in DBSCAN density clustering algorithm are Epsilon and Minpts respectively. Where Epsilon represents the radius of the adjacent area around a point, and Minpts represents the number of points in the adjacent area at least. The algorithm chooses a certain point and judges it. If it is a core point, a class is established around it, otherwise it is defined as a peripheral point. Then traverse other points until the edge point of this class is determined. Finally, the final clustering result is obtained after repeated loop operations, as shown in Figure 2. The corresponding parameters of the result are Epsilon 0.214 and Minpts 4. The results show that the intelligent engineering subsystem has three energy consumption modes, which are defined as low energy consumption, medium energy consumption and high energy consumption according to the numerical interval.

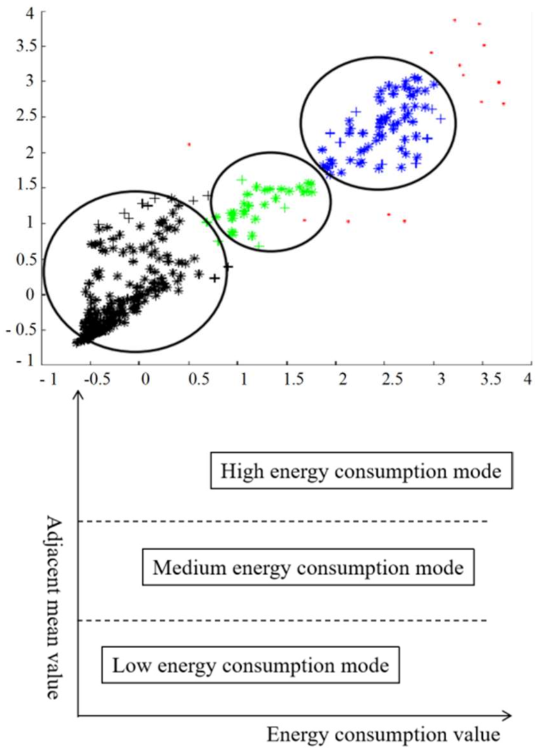

Fig. 2. Cluster results of energy consumption data

According to the energy consumption curve of intelligent engineering subsystem within 24 hours, it can be clear that the energy consumption level of intelligent engineering subsystem is different in different time periods and different dates. Based on the energy consumption pattern, the system needs to use CRAT decision tree model to further determine the energy consumption pattern. As shown in Formula 1, the formula for calculating the minimum split Gini coefficient in the process of CRAT decision tree construction, where D, D_1 and D_2 are the number of samples in the sample set. [9] Table 1 shows the corresponding energy consumption pattern judgment results obtained by CRAT decision tree model after training and learning.

$$Gini(D,D_1,D_2)=\frac{D_1}{D}Gini(D_1)+\frac{D_2}{D}Gini(D_2) \tag{1}$$

Table 1. The corresponding energy consumption pattern judgment results

Time periods	Dates	Judgement result
00:00-06:59	Workdays	Low energy consumption

07:00-10:59	Workdays	High energy consumption
11:00-12:59	Workdays	Medium energy consumption
13:00-15:59	Workdays	High energy consumption
16:00-17:59	Workdays	Medium energy consumption
18:00-23:59	Workdays	Low energy consumption
00:00-24:00	Nonworkdays	Low energy consumption

3.3 Early Warning of Abnormal Energy Consumption

The platform can not only monitor the energy consumption data of intelligent engineering subsystem in real time, but also give an early warning of abnormal energy consumption. The realization of this function will be based on the energy consumption pattern discrimination and judgment of intelligent engineering subsystem. When there are abnormal data in the intelligent engineering subsystem, the platform will use density outlier detection algorithm (LOF) to judge the abnormal data, determine whether it is within the normal data range, and then clarify the possibility of abnormality and issue an early warning. [10] In the simulation test experiment, the energy consumption sequence of an intelligent engineering subsystem running for 24 hours is shown in Figure 3. Among them, there is high power consumption data between 20: 00 and 22: 00, which is obviously different from the energy consumption mode of intelligent engineering subsystem. After LOF algorithm verification, the value interval of normal points in the energy consumption data cluster of intelligent engineering subsystem is [0.953,1.813], so the overall threshold is 2. And the LOF value between 20: 00 and 22: 00 is 4.4877, which far exceeds the threshold, and the three points are continuous anomalies, so an early warning can be issued.

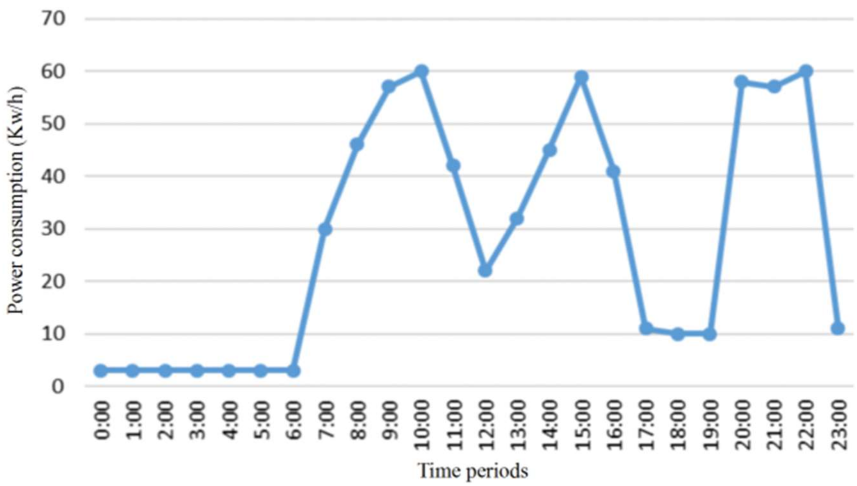

Fig. 3. Energy consumption sequence of the intelligent engineering subsystem

4 Conclusions

In order to promote the transformation of green intelligent building operation and maintenance management mode, this paper aims at many problems faced by the traditional model, and constructs a green intelligent building operation and maintenance management platform. The platform takes big data technology as the core, realizes the effective linkage of intelligent projects, completes real-time monitoring, strengthens energy consumption management and realizes intelligent operation and maintenance management. In the follow-up research, the platform will further enhance the dimension of data management, optimize various algorithms of the platform, and provide technical support for the rapid development of green buildings.

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