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Research on key technology of intelligent power preservation digital platform based on multimodal large model

Shucui Tan[1], Yu Wang[2,✉], Jing Yang[2], Chongjie Gao[2], Chunlin Pang[3]

[1] *Yulin Power Supply Bureau of Guangxi Power Grid Co., Ltd., Yulin, Guangxi, 537000, China*
[2] *Nanning Power Supply Bureau of Guangxi Power Grid Co., Ltd., Nanning, Guangxi, 535000, China*
[3] *Baise Power Supply Bureau of Guangxi Power Grid Co., Ltd., Baise, Guangxi, 533000, China*

ABSTRACT
Intelligent power preservation automation terminal is an important part of the smart grid, which plays an important role in improving the power supply quality of the power system. In this study, the CAB module is utilized to extract the multimodal features of visible images and infrared images during distribution network line operation. The weighted feature maps of each part of the distribution network operation are obtained by fusing different modal features through the average fusion strategy to realize line quality monitoring and fault detection and localization. The batch normalization layer and Relu function are also used to improve the image feature quality extraction performance of the model, which is then piggybacked on the model to construct a digital platform for intelligent power protection. The empirical analysis of the case found that the power supply reliability rate of L power supply company increased from 85.060% to 99.87% after the application of the smart power protection digital platform, the average power supply restoration time of non-faulty sections in the grid can be shortened to 3.24 minutes, and the line loss rate in the distribution network has been reduced to a certain extent. This study carries out the exploration of the practical application of the intelligent power preservation digital platform system, which lays the foundation for the stable operation of the distribution network and the improvement of power supply reliability.

Keywords: CAB module, feature extraction, average fusion strategy, Relu function, intelligent power preservation technology

1. Introduction

With the continuous improvement of power supply quality requirements, there are more and more users with power protection needs [1]. As the main power grid emergency power supply equipment,

✉ Corresponding author.
E-mail address: Wangyu_1975@outlook.com (Y. Wang).
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mobile emergency power supply vehicle has the advantages of mobility and flexibility, mature technology, rapid start-up and many other advantages [2-3], such as the Spring Festival Gala and the college entrance exams of these political power protection, urban power grid emergency, against major natural disasters and power shortage areas such as temporary power and other small and medium-sized places of power supply as an uninterruptible power supply [4-6].

Power supply enterprises in the power protection service is a complex and systematic work, including hidden danger investigation, facilities renovation, power protection program development and emergency rehearsal and other aspects of the content [7-8]. However, the lack of informatization tools has caused many problems in the current management of power protection [9]. In this case, there is a lack of effective monitoring screen for power preservation command and decision making, a high dependence on manual experience, difficulty in forming an effective emergency response mechanism, and no reasonable evaluation mechanism for power preservation management [10-11].

With the development of China's economy, more and more international events and conferences are organized, and the requirements for power protection work are getting higher and higher [12]. However, at present, there are still problems such as incomplete analysis of equipment status monitoring, low execution efficiency of inspection task management, low level of informatization of emergency repair, and improvement of command effectiveness at the protection site [13-14]. In recent years, cloud computing, big data, Internet of Things, mobile communication technology, smart city (“cloud, big things, mobile and intelligence”) and other information and communication technologies are developing rapidly, the application of Internet of Things on different platforms in different industries is gradually maturing, and more and more traditional industries are more diversified with the integration and application of Internet of Things technology [15-17]. Therefore, it is necessary to design an intelligent power supply guarantee and command system (hereinafter referred to as the power supply guarantee system) construction plan centered on the intelligent power supply guarantee platform and intelligent power distribution stations to realize the intelligent full control of the power supply guarantee by combining the power distribution IoT technology [18-20].

In this paper, infrared and visible light images of lines and so on during the operation of the power grid system are collected, and important spatial regions of the relevant images of the power grid system are extracted by means of the convolutional layer and coordinate attention module. The C1 structure in the CAB module is utilized for preliminary feature extraction, and DC1 and other structures are used for deeper feature extraction, and then transformed and combined through the Coordinate Attention generation mechanism to obtain the feature information of the grid system images. The infrared image features and visible image features are fused and processed through the average fusion strategy to obtain the fused multimodal weighted feature map. Then the batch normalization layer and Relu function are used to enhance the processing capability of the large multimodal model, to establish the fault detection and localization of the grid system and line quality monitoring technology based on the multimodal model, and finally to design a digital platform for intelligent power preservation by using this technology. This study takes L power supply company as the research object, constructs the intelligent power preservation digital platform in its distribution station system, analyzes the power supply reliability of various types of power supply stations under the power supply company before and after the construction and application of the intelligent power preservation digital platform, and explores the application effect of the intelligent power preservation digital platform.

2. Method

2.1. Multi-modal based grid quality and fault detection techniques

Facing the challenges of visible light images being susceptible to environmental conditions and infrared images being difficult to retain texture features, this paper improves a multimodal image fusion network for fault localization and quality monitoring in power grid systems by introducing a coordinate attention module in the model, which enables it to fuse images from different modalities more effectively.

2.1.1. Grid image feature extraction methods. First, after the input image passes through the CAB module, the spatial dependence of the input features is learned through the convolutional layer with the coordinate attention module, which allows focusing on important spatial regions in the image. Preliminary feature extraction, such as edges and texture, is performed using C1, which lays the foundation for deeper feature extraction. Deep feature extraction is performed through the densely connected structure of DC1, DC2, and DC3, and integrates the information from all the previous layers to increase the depth and width of the network so as to extract more representative fusion features. This ultimately improves the performance of the fused image in terms of preserving salient features and details while maintaining the visualization quality of the image.

In the implementation of this strategy, global pooling is used to synthesize information from space to capture global features. However, this approach pools spatial information into channel descriptors, often losing important positional information. In vision tasks, accurate location information is critical for understanding the spatial structure of images associated with the operation of the grid system. In order to optimize the attention mechanism to make more effective use of location information and capture the long distance dependence in spatial dimension, i.e., global pooling is decomposed into a sequence of one-dimensional feature encoding process, which can be seen in Equation (1):

$$z_c = \frac{1}{H \times W} \sum_{i=1}^{H} \sum_{j=1}^{W} x_c(i, j) \tag{1}$$

where, given an image input of X, encoding operations are performed on channels with different horizontal and vertical directions by pooling kernels of $(H,1)$ or $(1,W)$. Height h The final output of channel c is given by equation (2):

$$z_c^h(h) = \frac{1}{W} \sum_{0 \le i < W} x_c(h,i) \tag{2}$$

In the same way, the final output of channel c of width w can be expressed by equation (3):

$$z_c^w(w) = \frac{1}{H} \sum_{0 \le j < H} x_c(j,w) \tag{3}$$

The CAB module effectively acquires the global receptive field after the above transformations and successfully encodes the precise location information. In order to fully utilize these generated feature representations, a Coordinate Attention generation mechanism is introduced [21]. This mechanism uses a splicing operation to combine the transformation results after the features have been transformed as described above, and then these combined features are further processed by the convolutional transform function, thus realizing the effective utilization of feature information. The formula is as follows:

$$f = \delta\left(F_1\left(\left[z^h, z^w\right]\right)\right) \tag{4}$$

$$g^h = \sigma\left(F_h\left(f^h\right)\right) \tag{5}$$

$$g^w = \sigma\left(F_w\left(f^w\right)\right) \tag{6}$$

where $[\cdot,\cdot]$ denotes a cascade operation along the dimension of space, while σ represents an employed nonlinear activation function, and $f \in \mathbb{R}^{C/r \times (H+W)}$ encodes the different feature maps in the spatial information horizontally and vertically. Scaling R is used to adjust the scaling ratio of the block dimensions inside the SEBlock. The f is decomposed into two tensors $f^h \in \mathbb{R}^{C/r\times H}$, $f^\omega \in \mathbb{R}^{C/r\times W}$. The input X is converted into a tensor with the same number of channels as the original input through two 1×1 convolutional layers, respectively, to produce g^h, g^ω. σ represents the activation function of the algorithm. The number of channels in f is reduced by appropriate scaling to achieve complexity reduction with computational cost. Finally, the output of the coordinate attention block Y is:

$$y_c(i,j) = x_c(i,j)\times g_c^h(i)\times g_c^w(j) \tag{7}$$

2.1.2. Feature fusion phase. Infrared and visible image feature fusion in grid smart power preservation technology involves integrating features from different modal sources, which is a key step in the deep fusion model architecture. Fusion of these features can be performed using either averaging or $\ell 1$-paradigm based methods.

The averaging fusion strategy [22] averages two sets of features by adding them together. The mathematical expression is shown in equation (8):

$$F_{addition} = \frac{E_1 + E_2}{2} \tag{8}$$

where E_1 and E_2 are the two input features respectively and $F_{addition}$ is the fused feature, in this strategy, the average fusion of each feature contributes equally to the final fusion result.

The $\ell 1$-paradigm based feature fusion rule selects salient features by calculating the activity level map of the feature graph. First, for each feature graph ϕ_i^m, its initial activity level map C_i is computed by applying the $\ell 1$-paradigm number, i.e:

$$C_i(x,y) = \left\|\phi_i^{1:M}(x,y)\right\|_2 \tag{9}$$

where the $\ell 1$-parameter is computed to quantify the activity level of the feature map at each pixel point (x, y), which captures significant variations in the feature map.

Next, the activity level map is smoothed using a block-based averaging operation to obtain the final activity level map $\hat{C}_i$:

$$\hat{C}_i(x,y) = \frac{1}{(2r+1)^2}\sum_{a=-r}^{r}\sum_{b=-r}^{r} C_i(x+a, y+b) \tag{10}$$

where r determines the size of the block, and in this strategy $r=1$, the representation is averaged over the domain of 3×3.

Finally, the fused feature map f_m is computed by summing the weighted feature maps ϕ_i^m, and the weights ω_i are obtained by normalizing the activity level map $\hat{C}_i$ at each position with the sum of the activity level maps of all feature maps, Eq:

$$f_m(x,y) = \sum_{i=1}^{k} w_i(x,y)\times \phi_i^m(x,y) \tag{11}$$

$$w_i(x,y) = \frac{\hat{C}_i(x,y)}{\sum_{n=1}^{k}\hat{C}_n(x,y)} \tag{12}$$

where w_i is the normalized weight, which ensures that the sum of weights at all positions is 1, so that energy conservation can be maintained during the fusion process.

2.1.3. Fused image reconstruction stage. In the feature reconstruction phase, the network design also adopts a structure that contains convolutional layers and coordinate attention (CAB) modules, which contain a convolutional layer, a batch normalization layer, and an activation function layer in each convolutional block.The CAB modules enhance the spatial localization of the network on the input features, which allows the attention to be focused more on the key areas of the feature maps, thus improving the effectiveness of the feature representation and ensuring that the network can focus on the parts that contribute the most to the final fusion results in the reconstruction phase the network is able to focus on the parts that contribute the most to the final fusion result. The convolutional layer is mainly responsible for reducing the number of feature channels, and in order to improve the convergence rate and solve the problem of gradient vanishing, a batch normalization layer is introduced to enhance the stability and generalization ability of the model. And based on the Relu function [23], the learning ability of the model is enhanced, which makes the reconstructed grid system fusion image have higher clarity and better quality. The fused image can identify and locate the fault points and line quality problems in the grid system more clearly, so that the quality acceptance of the equipment in the distribution room is no longer dependent on manual experience, and automated and intelligent fault and quality detection can be realized, which can provide reliable technical support for the establishment of the intelligent power protection system.

2.2. Intelligent power preservation digital platform design

The structure of the new smart power preservation digital platform designed in this paper based on the multimodal grid fault detection model is shown in Figure 1. The design of the intelligent power preservation automation digital platform follows international standards such as IEC61968, IEC61970, IEC61850, etc. It adopts a layered structure, and in order to realize the distributed application between different structural platforms, it adopts a middleware structure to shield the operation of the underlying platforms, so that it can effectively shield the influence of the underlying operation, and realize the interaction and sharing of the information between the platforms of the external network.

1) Operating system layer. The workstations and servers of this design use HPUX, AIX, Solaris, Linux, and the database uses Oracle database [24]. The operating system is stable and reliable, and can meet the rapid access and processing of data, as well as meet the technical requirements of multimodal large model.

2) Platform layer. The platform layer is divided into two layers, namely the integrated bus structure layer and the data bus structure layer.

(1) Integration bus structure layer. The integration bus structure layer is the foundation between the intelligent power preservation digital platform and the third-party platform, which can provide the corresponding public service platform and different types of applications for the system. At the same time, it standardizes the interaction mechanism between the third-party platform and the automation system, which needs to follow the IEC61970 and IEC61968 standards.

(2) Data bus structure layer. Based on the underlying integration bus layer, the data bus structure layer with high reliability and large data transmission is built to meet the data service requirements of distributed databases, such as real-time databases, commercial databases and other types of data access intermediate libraries.

3) Service Component Layer. The service component structure layer mainly realizes the software display, management, editing, analysis, management and other functions of the intelligent power preservation digital platform, which is more in favor of the functional application aspects of the

software itself, such as monitoring service, process service, system management, security service and so on.

(1) Monitoring services - including multimodal grid fault and quality monitoring model, public display model, public mapping function, public graphic package, providing the platform's graphic display, image editing, gallery call and other functions. The intelligent graphic generation function is added, which is able to present the ring structure map of the contact relationship between distribution lines and the power supply range map of distribution stations in a more concise way. And do not need to GIS basis to draw, which can greatly reduce the workload, and with the more frequent transformation of the distribution network, the subsequent maintenance workload is also greatly reduced.

(2) process services - including service form customization, process customization and process driver/monitoring, etc., can meet the needs of each application to produce reports, in which the form development and process services for this part of the distribution automation network mainly to provide services to the scheduling operations.

(3) System management services - system management mainly includes software parameter management, task management, timer management, redundancy configuration, resource monitoring, logging/printing management, etc. System management services can assist different applications in the realization of the system.

(4) Security services - security services mainly include department/personnel management, functional rights management, through the setting of different rights to achieve multi-level management of different functions, roles, users.

(5) Other services - This part mainly includes curve tools, public alarms, information retrieval, diagnosis and debugging, network topology analysis, database editing, formula calculation, etc., of which public alarms can prompt and handle various alarms, faults and events, and record, keep and print events separately by time, and at the same time, it can also fulfill the search and intelligent analysis functions.

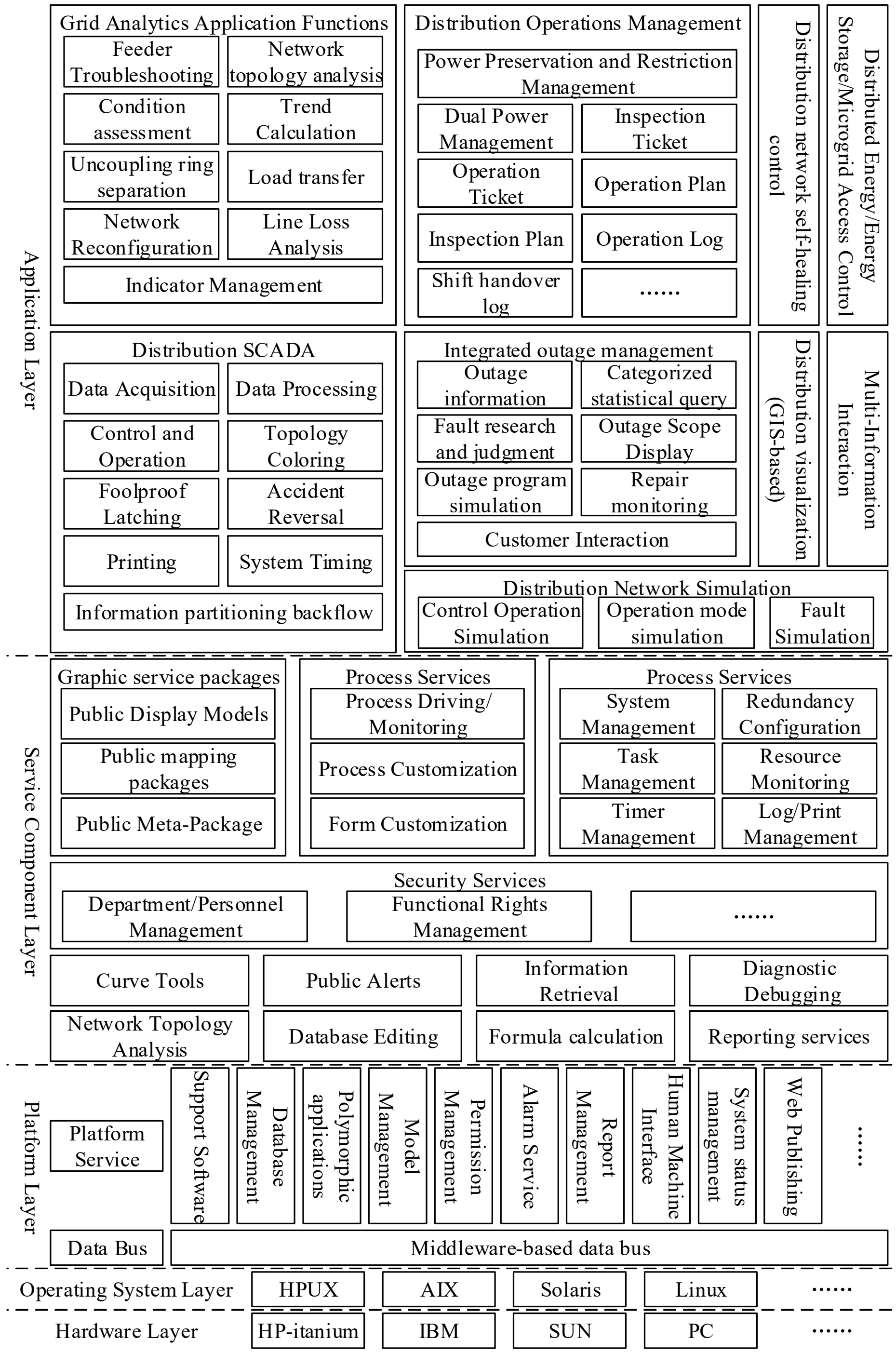

Fig. 1. Intelligent electronic digital platform architecture

3. Results and discussion

3.1. Overview of L Power Company

3.1.1. Introduction to electricity supply companies. Company L is a county-level power supply enterprise under J Province Electric Power Co., Ltd. and is responsible for the power supply and consumption of 5 towns and 8 streets in the district, as well as the construction, operation and maintenance of the power grid. The area is 35.69 kilometers longest from east to west and 19.42 kilometers wide from north to south, and the terrain is mainly plain, with an average elevation of about 3.2 meters above sea level. The total area of the district is about 296.1 square kilometers, the total population is close to 600,000, and there are more than 30,000 private enterprises.L Company has set up a total of 14 functional departments and offices, 15 business organizations, including substation operation and maintenance classes, substation maintenance classes, 6 subordinate power supply offices, and transmission operation and inspection classes, etc., and serves more than 300,000 users, 5 important users in the district (troops, civil aviation stations, hospitals, waterworks, and governmental organs, etc.), and 54 dual-power supply There are 54 dual power supply users. The State Grid Corporation divides the company's operating area into six categories of power supply areas, namely, A+, A, B, C, D and E, according to the administrative level of the power supply area, the level of load density in the planning level year and other factors. According to the regulations, the six power supply offices under Company L are divided into two categories of B and C power supply areas. The power supply area of three of the subordinate power supply offices is classified as B. The power supply area of class B power supply area is 112.36 square kilometers, with 152,300 customers and an average household distribution capacity of 5.48 kVA/household. The other three power supply offices are classified as Class C, with a power supply area of 1,837,400 square kilometers, 445,700 customers, and an average household distribution capacity of 4.62 kVA/household. 3,652,000,000,000 kWh of electricity will be sold in 2022, a year-on-year increase of 1.26%, and the maximum load will be 826,300 kW, a year-on-year increase of 4.96%.

3.1.2. Distribution of electricity grids of power supply companies. There are 5 220 kV substations with 10 main transformers and 1724 MVA capacity under the jurisdiction of Company L, which can basically meet the demand of electricity consumption in the power supply area of Company L. There are 13 110 kV substations with 26 main transformers and 1487 MVA capacity, and there are 369 10 kV lines in Company L, with 35.49% cableization rate and 32.64% aerial insulation rate, of which 351 lines are public lines and 18 lines are dedicated for power users. 32.64%, of which 351 are public lines and 18 are private lines for power users. The proportion of multi-contact, single-contact, and single-radial in class B and class C power supply areas of L power supply company are counted separately, and the structure of 10 kV overhead network and cable network of L company is shown in Table 1.There are 255 10 kV overhead network utility lines in total, and L company's overhead lines are dominated by single-contact, which accounts for 74.81%, and single-radial lines account for only 12.80%. Although there are far more overhead lines in class C power supply area (168) than in class B power supply area (87), the proportion of multi-contact in class B power supply area (29.72%) is significantly higher than that in class C power supply area (4.69%). From the analysis of cable network structure, there are 96 public lines of 10kV cable network in Company L. The wiring of cable lines is dominated by single-ring network, accounting for 64.29%, and the proportion of single-radial is only 10.08%. There are far more cable lines in class B power supply areas than in class C power supply areas, and at the same time the proportion of double-ring network in class B power supply areas is also significantly higher than that in class C power supply areas.

Table 1. The structure of the company's 10 KV and grid

Overhead network structure				
Supply area	Line quantity	Multiple contact ratio	Single contact ratio	Single radiation ratio
Class B power supply area	87	29.72%	58.49%	11.79%
Class C power supply area	168	4.69%	85.63%	9.68%
Total	255	12.39%	74.81%	12.80%
Cable structure				
Supply area	Line quantity	Double link ratio	Single ring network ratio	Single radiation ratio
Class B power supply area	82	25.49%	65.97%	8.54%
Class C power supply area	14	0.00%	100.00%	0.00%
Total	96	25.63%	64.29%	10.08%

The 351 10 kV utility lines of power supply company L are categorized and counted in different power supply areas according to the maximum load factor of 20%, 40%, 60% and 80%, and the distribution of the maximum load factor of the lines is obtained as shown in Table 2. There are 200 lines with maximum load factor between 20% and 60%, accounting for 56.98% (200/351). There are 78 lines with maximum load factor between 60% and 80%, accounting for 22.22% (78/351).

Table 2. The maximum load rate distribution of the 10 KV circuit of l company

Supply area			Class B power supply area	Class C power supply area	Total
Line maximum load rate	[0,20%]	Line quantity	18	17	35
		Proportion	5.13%	4.84%	9.97%
	[20%,40%]	Line quantity	45	53	98
		Proportion	12.82%	15.10%	27.92%
	[40%,60%]	Line quantity	52	50	102
		Proportion	14.81%	14.25%	29.06%
	[60%,80%]	Line quantity	34	44	78
		Proportion	9.69%	12.54%	22.22%
	>80%	Line quantity	15	23	38
		Proportion	4.27%	6.55%	10.83%

The passing rate of N-1 calibration of 10 kV utility line is 79.42%. The passing rate of N-1 of line in B class supply area is 81.42%, and the contact rate is 87.95%. The passing rate of N-1 of line in C class supply area is 78.94%, and the contact rate is 85.62%. By calculating the ratio of the maximum transferable load between stations and the maximum load of substations in the supply areas of categories B and C, the transfer capability of the 10 kV grid of Company L is analyzed as shown in Table 3.The transfer capability of the distribution network of Company L is poor, and the transferable load accounts for 70.40%. From the perspective of long-term planning of distribution network, Company L urgently needs to gradually optimize the network framework through grid construction and renovation, continuously improve the grid transfer capability, and then improve the power supply reliability rate of distribution network and the safe operation level of grid operation. Therefore, this study applies the intelligent power preservation digital platform based on multimodal large model design to the distribution grid system of L Power Supply Company in January 2022 to realize the automated detection and analysis of grid system faults and circuit quality.

Table 3. L company's 10 KV power grid transfer capacity

Supply area	Transfer load in the station (Megawatt)	Maximum load of substation (Megawatt)	Transfer load ratio
Class B power supply area	148.49	218.94	67.82%
Class C power supply area	327.99	457.89	71.63%
Total	476.47	676.83	70.40%

3.2. Analysis of improvements in distribution network power supply

3.2.1. Analysis of distribution network power supply before the application of digital platforms:

1) Power supply reliability analysis results. ASAI is the average service availability index, which is an important index to measure the reliability of the power supply system of the grid, and can intuitively reflect the overall reliability and service quality of the power supply system.This study takes ASAI as the main analysis index to explore the impact of the application of the digital platform of the intelligent power preservation on the power supply system.The results of the analysis of the power supply reliability of Company L during the period of 2018-2023 are shown in Figure 2. During the period from 2018 to 2021, the ASAI of L power supply company is lower than the average level of the province. In 2018, the ASAI of L company is higher at 92.92% because of all kinds of outages, which generate a total of 10,314 hours of households, of which 8,752 hours of households are generated by pre-scheduled outages and 1,562 hours of households are generated by faulty outages, respectively. The ASAI indicator for Company L has been on a decreasing trend for the next three years and the ASAI indicator decreases to 85.60% in 2021, with 2,365 and 11,676 household hours generated by pre-scheduled outages and faulty outages, respectively.

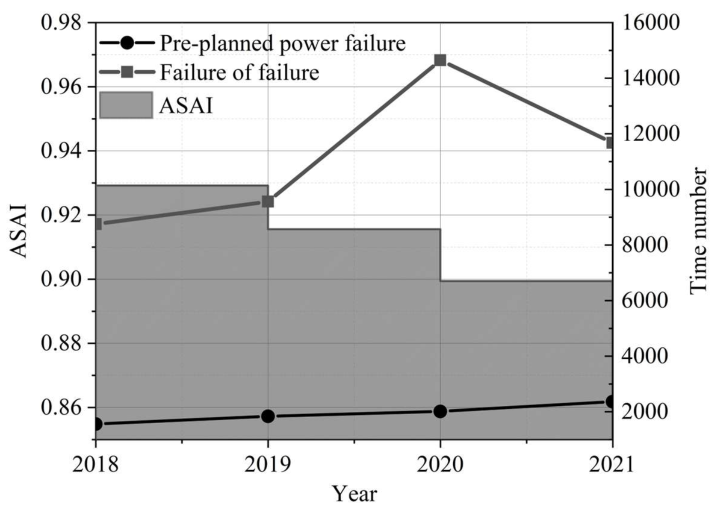

Fig. 2. The number of calls and the ASAI analysis

2) Analysis results of fault outage situation. The pre-scheduled outage hourly households and fault outage hourly households of L Power Supply Company in 2020 and 2021 are categorized and statistically analyzed according to specific outage reasons, and the results of the analysis of grid outage reasons and hourly households are shown in Table 4. In both 2020 and 2021, the number of outage hours in Company L due to distribution network equipment failure is the highest, generating a total of 5,264 hours and 3,625 hours, accounting for 35.94% and 31.05%, respectively. This is followed by 19.76% and 16.72% of outages due to faults in the higher-level grid, generating a total of 2,894 and 1,952 hours, respectively, and 10.44% and 11.36% of outages due to external damage. This further confirms that there is an urgent need to improve the distribution network system of L Power Company

by implementing automated power preservation techniques during grid operation to improve the reliability of power supply in the distribution network.

Table 4. The analysis of the number of households in the failure of the company

Failure cause	2020		2021	
	Power failure	Proportion	Power failure	Proportion
Equipment failure of the distribution network	5264	35.94%	3625	31.05%
Higher power grid failure	2894	19.76%	1952	16.72%
External damage	1529	10.44%	1326	11.36%
Pour load	1487	10.15%	1145	9.81%
Branch touch	1263	8.62%	1062	9.10%
User failure	859	5.87%	986	8.44%
Normal transmission	632	4.32%	842	7.21%
Natural factor	594	4.06%	623	5.34%
Other	123	0.84%	115	0.98%
Total	14645	100%	11676	100%

3.2.2. Analysis of the effect of supply reliability improvement:

1) Improvement of power supply reliability. L power supply company completed the construction of the intelligent power preservation automation system of the distribution network in January 2022, and the fault finding time and power supply restoration time of non-fault zones in the power supply company have been drastically reduced. The operation of the distribution network of Company L during the period of 2018-2023 is analyzed, and the results of the analysis of the effectiveness of power supply reliability obtained by displaying in the form of stacked diagrams are shown in Figure 3. The average power supply restoration time in non-faulty sections of the grid is reduced from 79.17 minutes in 2018 to 3.24 minutes in 2023. On the other hand, by adding the smart power preservation digitalization platform to the system of each power supply station of L Company, so that the normal operation of the line will not be affected in case of the failure of the customer's equipment, the average power outage time of the customers under the power supply company of L Company is reduced to 10.90 minutes in 2023. Reasonable monitoring of lines through the intelligent power preservation digital platform effectively reduces the impact of planned power outages and fault outages. And by applying scientific and reasonable maintenance plans as well as optimizing and adjusting the operation mode of power distribution equipment, the time for line reversal operations has also been substantially reduced through integrated regulation, with the average line outage and transmission time reduced from 28.88 minutes previously (2018) to 2.52 minutes now (2023).The reliability of power supply under the L Power Supply Company has also risen from 85.60% in 2021 to 99.87% in 2023.

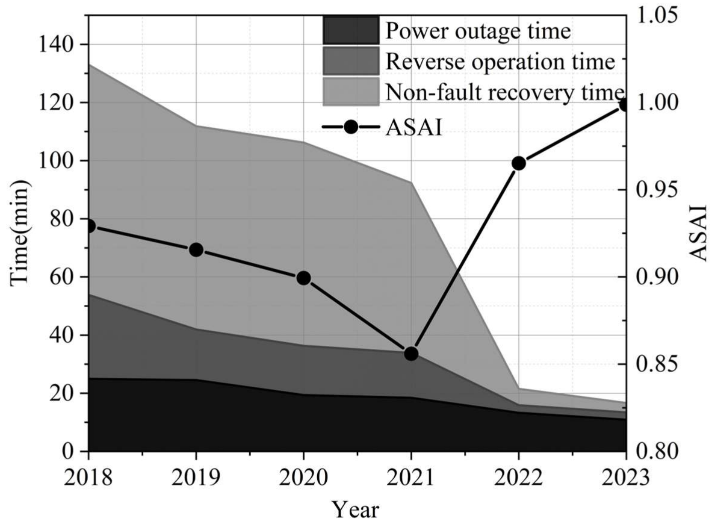

Fig. 3. Comparison analysis of power supply reliability

2) Analysis of changes in comprehensive line loss rate. The distribution stations under L Power Supply Company have implemented primary network frame optimization and reconstruction in combination with the construction of the digital platform for intelligent power preservation, and the changes in the distribution network frames of Class B and Class C power supply areas are shown in Table 5. 15 and 19 lines were newly constructed in Class B power supply areas and Class C power supply areas in total, and 22 and 27 lines were reconstructed or newly added to the contact, and the contact rate of the distribution lines has increased to 94.02% on average from 86.79%, and the average radius of power supply lines was shortened to 8.66 km from 9.55 km, further reducing the distribution line losses. The average power supply radius of distribution lines was shortened from 9.55 kilometers to 8.66 kilometers, which further reduced the loss of distribution lines. The number of line segments of Class B and Class C power supply stations under L Power Supply Company became more reasonable through the implementation of the intelligent power preservation automation platform, and the average number of segments increased from 2.45 to 3.55. With the help of the voltage, current and other electrical quantities of the segmented switches of the intelligent power preservation digital platform, it is possible to realize the segmented monitoring of distribution line line loss, which is more convenient to analyze the problems of line loss of distribution lines and stations, and is conducive to the formulation of corrective measures for line loss. According to the calculation of L Power Supply Company's line loss model for the same period, the 10KV comprehensive line loss decreased from 6.46% to 5.32%.

Table 5. Analysis of the performance comparison of distribution network

Year	Region	Distribution line contact rate	Average power radius	Average segment number	10 KV line loss
2021	Class B power supply area	87.95%	9.86 km	2.5	6.95%
	Class C power supply area	85.62%	9.23 km	2.4	5.97%
	Total	86.79%	9.55 km	2.45	6.46%
2023	Class B power supply area	93.26%	8.89 km	3.6	5.42%
	Class C power supply area	94.78%	8.42 km	3.5	5.21%
	Total	94.02%	8.66 km	3.55	5.32%

3) Enhancing the effectiveness of distribution network construction. Through the application of distribution automation system, it realizes the multi-level penetration of basic data of distribution

network of L power supply company. Through the system, distribution equipment operation and maintenance and management personnel can monitor the operation of distribution lines, distribution transformers and user equipment in real time without leaving home, realizing panoramic and transparent distribution network equipment management. Using the intelligent power protection digital platform, the operation data of distribution equipment can be obtained through the multimodal monitoring of the production management system and distribution automation system. 12 new distribution lines were built in the distribution network infrastructure project of L Power Supply Company, and the average load ratio of the 12 lines was 20.36%, with the maximum load ratio of no more than 38%, and there was no light empty load line. Using the real-time and historical multimodal data collected by the intelligent power preservation digital platform system, the hidden dangers or defects existing in the power grid system were analyzed to guide the planning and construction of the distribution network, which made the distribution network structure more reasonable, the equipment level significantly improved, and the investment in the renovation of the distribution network more accurate.

4. Conclusion

This paper collects visible images and infrared images of each part of the grid system, extracts different image modal features using CAB module, fuses the features of different modules and processes them, identifies grid line fault problems and quality problems based on the results of the feature map analysis, and builds a digital platform for intelligent power preservation by piggybacking on the method.The ASAI indicator of power supply of power supply of L Power Supply Company is in the trend of gradual decline during 2018-2021 , and the ASAI indicator decreases to 85.60% by 2021, with pre-scheduled outages and fault outages generating 2,365 hours of households and 11,676 hours of households, respectively. Among them, the largest number of outage hours is caused by distribution network equipment failure, accounting for 31.05%. The practical application of the intelligent power preservation digital platform in this power supply company found that the average power supply restoration time in non-faulty sections of the grid in 2023 was reduced to 3.24 minutes from 79.17 minutes before the application. The time for line reversing operation has also been significantly reduced, with the average line outage time reduced from 28.88 minutes to 2.52 minutes. In addition, the power supply reliability rate is improved to 99.87% by 2023. This indicates that the intelligent power preservation digital platform proposed in this paper based on the multimodal model has achieved remarkable results in practical applications, and is of great theoretical and practical significance for the study of power preservation systems in distribution networks.

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