

Research on Key Technologies of Video Intelligent Identification and Security Management and Control System in Substation

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Abstract — With the development of substation automation technology, unmanned substation operation mode has become a trend, at present, many substations to achieve the "remote viewing" function, will be the scene of the substation, the equipment state to video image transmission to the remote control center (set control station). And scheduling center (set control station) on live video equipment to control and adjust, however traditional remote vision system can improve the automation level of substation, but due to technical, management and other aspects of the reasons, it is difficult to achieve substation real unattended, not completely reached synergism of depletion of numbers and intrinsically safe. Substation operation, management personnel not only need to see every corner of the substation in the remote monitoring center, but also the abnormal phenomenon of the environment in time, and remote control to dispose of. With the rapid development of science and technology and the revolutionary breakthrough of video processing technology, this paper introduces the key technology of "intelligent video image analysis technology", and the new generation of "large video management and control software platform", which is based on the new design concept. The system can provide remote vision system in the field of substation, the running state of the equipment, the image switching operation process state image, state instrument image, and on-site maintenance work on-site real-time image at the same time; in contact with the original substation communication equipment and electrical equipment case, digital remote video image acquisition equipment, and carries on the analysis the automatic processing and recognition, equipment and staff positions, knife gate opening and closing state change of power system, the instrument display read the contents of monitoring, and issued a warning signal according to the set requirements, provide a new method for automatic detection of fault diagnosis, unattended substation monitoring and control, through accurate fault, timely early warning information accident analysis, auxiliary diagnosis, to improve the reliability of grid, reducing safety accidents, is of great significance to reduce monitoring cost of operation and maintenance. This paper presents the results of project development for power dispatch, high voltage operation (interval protection), high pressure area equipment maintenance, provide on-site abnormal image automatic alarm display, and the scene of automatic alarm and alarm, so as to achieve the "safe operation of the substation" visual, from the technical means to further the substation safe production, in particular, to effectively prevent personal injury, provide a strong guarantee.

Key words-Substation; intelligent; video recognition; safety control

I. INTRODUCTION

The project is the System architecture of intelligent video identification [1] and security management system, the core of the project is remote digital video monitoring and image recognition technology. It refers to the digital video signal that can be received in the remote field, and is transmitted to the monitoring center in real time. It can control the remote camera movements in the monitoring center. It mainly consists of two parts: remote digital video monitoring and digital image recognition [2]. These two parts of the past belong to two independent research areas, but the rapid development of digital technology, computer and communication technology to make these two parts of the function of the combination possible. Video capture uses standard digital video compression format, such as MPEG-2, MPEG-4, H.263, MJPEG, H.261, etc. Web technology system is widely used in video transmission, supports Internet

technology standards, including support for HTTP, FTP, SMTP, TCP/IP and other protocols, customers can access the browser. The whole monitoring network can be directly connected with the Intranet or Internet in the computer network, the enterprise can be directly used in the digital image recognition technology to process the captured video image [3]. Therefore, digital video monitoring and digital image recognition technology is a hot spot in digital image processing. The video monitoring system has been widely used in electric power, communication, traffic and other fields, such as banks, factories, museums and hotels. It can be used to realize the function of production process monitoring, scheduling, security and fire. Sound, light and electricity can be used in the process of monitoring, and the image recognition technology is applied in word recognition, fingerprint recognition, face recognition, product detection, military reconnaissance, weather analysis, pathological analysis, natural disaster prediction [4]. This paper mainly introduces the application of video

intelligent identification in substation.

II. CONSTRUCTION TARGET

A. Monitoring and Warning of Indoor Proximity Equipment

The staff who enter into indoor production (construction) site and into the protection region of the device is easy to cause damage to the equipment and cause safety accidents, the system can be automatic voice reminding when the operator is near or enter into the field of equipment protection zones [5], also Automatically upload the video images, the duty officer can see the scene video images.

B. Monitoring and Warning of Outdoor Access Protection Area

It is easy to cause safety accidents in production to the staff in outdoor production (construction) site, such as the occurrence of strayed into the reserve or climb site protection fence acts in violation of operation rules, the system can be automatic voice reminding when the operator is near or enter into the field of equipment protection zones [6], also Automatically upload the video images, the duty officer can see the scene video images.

C. Condition Monitoring and Alarm For the Opening and Closing of the Transformer Substation

In the transformer substation, the switch of the circuit breaker has a tripping phenomenon, it is easy to appear the large area of the power failure, thus causing the tripping accident; After the system construction, the system monitors the state of the knife gate, generates the alarm when the state changes, and automatically upload the video images.

D. Monitoring and Alarm of Instrument Reading In Substations

Using the camera to review the digital meter reading of the transformer substation equipment, through the acquisition and processing of the digital meter image of the station equipment, complete the automatic identification of digital instruments [7]. The digital meter is automatic identified and converted to digital signals which displayed by the camera in real time. At the same time, the instrument can be used to detect the range of reading, if it is outside the specified range of the alarm, automatically upload the video images; the duty officer can see the scene video images.

III. SYSTEM ARCHITECTURE

According to the requirements of the construction of smart substation, the construction goal of substation intelligent video identification and safety control system is: Implement any remote screen real-time monitor, remote video playback; The cloth, removal of implementation of remote stations, remote alarm monitoring center can have

alarm text, voice prompt, can pop up at the same time corresponding alarm location video images [8]; It can realize monitoring dispatching center and substations local networking point; To achieve remote PTZ camera control, remote system settings and equipment condition monitoring, also joined the advanced intelligent products, realize alarm function of the front end of the abnormal behavior analysis.

Substation intelligent video identification and security management and control system construction will focus on the goal to design and construction. Support for intelligent video platform will be uploaded to the monitoring center of the substation information, at the same time, the power grid dispatching and monitoring center can monitor the scene of the substation, and the management of the front-end equipment [9, 10]. According to the design plan of the new or rebuilt substation intelligent video identification and security control system, can achieve the user's functional requirements, and ensure the stability of the system.

For the substation that has been building an industrial video surveillance system, the system supports the transformation of the old industrial TV system in the substation, and the system architecture of the old industrial TV system in the substation:

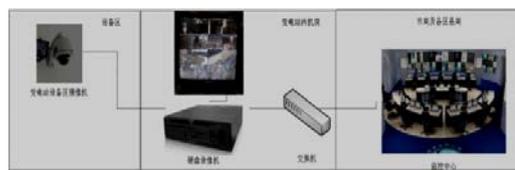


Fig.1 Old Industrial TV System Architecture

In substations, the camera through the hard disk recorders video transmission lines to the substation room, analog video signal transformation into digital through network transmission to the Council monitoring center. After the intelligent transformation system architecture:



Fig.2 Intelligent Industrial TV System Architecture

For the newly erected industrial video surveillance camera device, the video intelligent recognition and security management are realized by the access to the intelligent video processing device

In substations, the camera through a video line first

transmission to the substation room intelligent video processor, then the intelligent processing of image feedback to the hard disk recorders, also intelligent video processor will field installation of a new voice control alarm horn, if detected alarm is alarm types of different control on-site voice alarm horn that according to and through the network

can also be will signal transmission of intelligent video processor to our deployed in the monitoring center of the city Bureau of the background management module[11].

IV. BUSINESS SCENARIO

TABLE I. BUSINESS SCENARIO

Area	Video Intelligent Recognition	Function Description
Substation walls around	Invasion of automatic detection	For substation walls around, once a person intrusion system automatic alarm, open the voice reminds, platform will immediately provide real-time monitoring picture.
Charged warning line	Operating personnel through the charged warning line	On the maintenance operation of the charged area of the warning line, once the operating personnel through the system automatic alarm, to open the voice of the scene, the platform will give real-time monitoring screen.
Indoor switchgear	Detection of anti mal operation of charged switch cabinet	Operating personnel close to or misuse of the charging switch cabinet, the system automatically alarm, open the voice of the scene, the platform will give real-time monitoring screen.
Outdoor switching field	Operation personnel entering the danger zone and automatic detection of switch operation	For all switch region partition deployment. Once the workers entering the zone electrophoresis system automatic alarm, open field of voice reminding, the platform will immediately give real-time monitoring screen.
All knives	Condition monitoring of the opening and closing of the transformer substation	When the opening and closing state of the knife is changed, the system automatically alarm, and the voice on the spot is opened, the platform will give a real-time monitoring screen.
Indoor instrument cabinet	Substation instrument reading test	In the substation equipment digital meter reading, and can output the identified number, if the number exceeds the specified range is automatically alarm, the platform will give real-time monitoring screen.
cameras	Video exception	When the camera is blocked, unexpected power outages, abnormal signal will alarm.

V. CORE FUCTION

A. The Basic Goal of Identifying the Type of Object

This is the basic function module of the intelligent image processor, automatic identification of the moving target detection, such as: people, people, cars, specific electrical equipment, etc.

B. Monitoring and Alarming Of Through the Cordon Charging Zone

In the charged region, the substation perimeter, cordon and all visible or invisible borders [12], the device can directly complete the perimeter alarm alert task by recognizing the screen content collected through surveillance cameras:

- a. Virtual cordon can be freely defined in direct on the video monitor screen.
- b. Free to set the prevailing direction of cordon banning , including coming to, whereabouts and bidirectional.

c. Free to define the target nature of the warning line control: person, vehicle, flight target or all of the targets.

d. After the completion of the alert rules, automatically enter the alert identification state, without any manual operation in the process of monitoring.

e. Once the target in line with the warning rule, equipment immediately issued a warning to the monitoring personnel in real time through the video surveillance system.

f. Multiple cordons can be set on the same screen.

g. Exclude the disturbance of the shaking branches, wild animals, children and other factors; realize the identification, tracking and warning.

h. Eliminate the interference factors such as the surface wave, the solar emission and so on, realize the identification, tracking and warning.

C. Perimeter Intrusion Alarm and Monitoring In Substation

a. Automatic detection of moving targets in the alert zone and setting filter conditions.

b. The warning area: prompt alert, warning area.

c. The alert tripwire type: unidirectional, bidirectional

alert tripwire.

d. The target motion characteristics: direction, target size.

e. The target species: human, animal, automobile etc.

The background modeling and moving target detection is the most important in perimeter intrusion detection, moving target detection is to separate the moving objects in video sequences from the background image [13]. At present, the most commonly used three methods is optical flow method, frame difference method and background subtraction method. These three methods all needs background modeling, so we use background subtraction to detect moving targets; the specific algorithm is shown as follows:

$$D_k(x, y) = \begin{cases} 1; & |I_k(x, y) - B_k(x, y)| \gg T \\ 0; & |I_k(x, y) - B_k(x, y)| < T \end{cases} \quad (1)$$

Among them, the current frame image, is the background image, T is the threshold size, is a differential threshold image. When the difference between the corresponding pixels of the background image and the background image is greater than the threshold T, the binarization is 1, which is considered as the background. The key initial background model of the method is established and the background of different scene change is updated. The formula for background update is shown below:

$$B_k(x, y) = \begin{cases} \theta B_{k-1}(x, y) + (1 - \theta)F_k(x, y) \\ B_{k-1}(x, y) \end{cases} \quad (2)$$

The current frame and the background of the previous frame, the difference of the pixel value is less than the threshold T, the pixel is used to update the background image [14], and the background image remains unchanged. Update background update rate decision coefficient well, according to the speed of change in the environment, set the appropriate value.

D. Monitoring and Alarm of Indoor and Outdoor Close to Equipment Protected Area

The existing camera in the substation and in switch area site of the new set up cameras, the realization of all image monitoring, through the intelligent video analysis equipment to the scene image partition management, each switch area of deployment operation. When someone enters defense area, the system automatically alarm. At the same time to the various switches for intelligent monitoring, once a circuit breaker, the system automatically alarm, the platform will give real-time monitoring screen.

When the need for a road switch operation, automatic transfer switch out of the way should a video image, while the intelligent device management channel switch zone disarm operations, allowing workers to work in the region

[15]. Once the worker being diverted to other switching area, the system automatically starts live voice device prompts workers, while in the center of the pop-up live video screen management system automatically recording of this process. Job ending system can automatically manage arming operations of smart devices in the channel switch zone.

E. Condition Monitoring and Alarm For the Opening and Closing of the Transformer Substation

In the substation automation system, the state of the switch of the circuit breaker is needed to determine. At present, the status and position of the switch are mainly based on the auxiliary node, but due to corrosion, wear, aging and other reasons, auxiliary switch is not in place, can't correctly determine the true position of the switch to provide the wrong information to the dispatch command[16]. At this point, we need to carry out on-site observation, and troubleshooting generally require a long time, the power supply to the power supply is not a factor, and even power outage maintenance; But the main switch equipment is linked to a combined, sub indicator, intelligent video identification and security management system in substation can identify the location of the switch through the integration of the sub signs of the image recognition.

For the OFF state knife, if it is in series, the switch number for the connection of the knife gate is i. The switch state is represented by, the 1 is closed, and the 0 is disconnected. Rule 1 is expressed as:

(3)

The active and reactive power of the branch at both ends of the branch. According to Kirchhoff's law, considering the existence of power loss, charging power and the meter error, identification rule 2 is expressed as:

(4)

(5)

(6)

(7)

In the formula, K1, K3 K2, K4 are more than 0, is set as the limit value. If the knife switch is connected in parallel, the n device (line and transformer branch, Bus coupler switch) is connected with the bus bar, is active power algebra and a link to the bus bar that is active imbalance power of bus:

(8)

Among them, is the active power of the bus side of the i device. According to the above rules can determine whether the knife gate is open state.

The whole process monitoring and controlling of the machine tool is carried out by the camera. Through intelligent video analysis on gate field equipment protection operation, the system automatically alarm when the

equipment is changed. Platform will give real-time monitoring of the picture, the duty officer at the same time to see the live video images [17].

F. *Monitoring and Alarm of Instrument Reading In Substations*

Substation intelligent video identification and security control system uses a digital camera to the substation equipment meter readings for review. Through the acquisition and processing of the digital instrument image of the station equipment, automatic identification of digital instruments is accomplished. The digital meter is automatic identified and converted to digital signals which displayed by the camera in real time. At the same time, the instrument can be used to detect the range of reading, if it is outside the specified range of the alarm, automatically upload the video images; the duty officer can see the scene video images.

G. *Camera Video Signal Abnormalities Intelligent Alarm*

Real-time video signal acquired front camera analyze whether the monitor video signal is blocked, if the monitoring camera installation position is changed, if it is found abnormal signal automatically alarm and automatically alarming through plans, while retaining the current video and images to facilitate future forensics [18].

We can judge whether the camera is occluded according to the brightness anomaly, and can be used in the color space based on the subjective judgment method, the mean value of the image on the L component of the M*N image:

(9)

As shown above, we can get the following conclusions:

(10)

If the L component value more than partial light threshold T_b , partial light may frame is C_b+1 , dark frames may be C_d-1 ; On the contrary, the bluish might frames is C_d+1 , bright side might is frame C_b-1 . If the video brightness is anomaly for a sufficient number of frames, then an alarm is occurred.

H. *Automatic Alarm and Video*

The device is not interrupted to analysis automatically of the camera screen, automatic detection of the target immediately after the alarm to the monitoring personnel to send an alarm, to remind them to carry out on-site processing. At the same time, the device informs the substation intelligent video identification and security control system to automatically start the video, and can set the video content in the automatic video recording to specify the length of time before the alarm event.

VI. TECHNOLOGY PRINCIPLE

Substation intelligent video identification and security control system is based on the digital and network video monitoring, but also different from the general network

video surveillance, it is a more high-end video surveillance application. Intelligent video surveillance system is able to automatically identify different objects, found abnormal situation monitoring screen, and sound the alarm and provide useful information to the fastest and best way, which can more effectively assist the security personnel to deal with the crisis, and to maximize the reduce false positives and false negatives.

Intelligent video surveillance is based on computer vision technology to analyze the content of the video image, extract the key information from the scene, and form the monitoring mode of the corresponding event and alarm. It is a new generation of monitoring system based on video content analysis. If the camera is the eye of people, and the intelligent video surveillance system or equipment can be regarded as the human brain [19]. Intelligent video surveillance technology is a powerful data processing function of the computer, the mass data in the video screen is analyzed, and the information that the user is not concerned is filtered.

VII. PROJECT EFFECT

a. Provide intelligent video surveillance solution of "prevention first, processing evidence collection as a supplement".

b. Inheritance the advantages and features of the traditional security system.

c. Strong system stability and environmental adaptability.

d. Avoid the attention caused by the visual fatigue caused by the long time watching, and can identify the subtle changes in the human eye, including: remote distance, lack of light, environment, etc., to achieve real time 7 x 24 hours all-weather monitoring.

VIII. CONCLUSION

The substation intelligent video identification and security management system can be completed with the existing power grid management system and automatic system seamless connection, according to the above system requirements, provide substation, field equipment running state image, switch operation process state image, instrument working state image, as well as substation inspection, maintenance, testing and other work on-site real-time image display and storage; And in accordance with the instructions of the scheduling system, manually or automatically set the corresponding standoff cloth from a defended position, abnormal phenomenon of power dispatch, high operation (guard interval), high pressure equipment on-site maintenance, equipment operation state and switch movement, etc. to provide field anomaly image automatic alarm display and live voice auto play, so as to

achieve the "safe operation of the transformer substation" visualization and intelligent monitoring and management. And from the technical means to further on the substation safety production, especially to effectively prevent the personal injury accident, provide a strong guarantee.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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