Design of the Fiber-optic Fence Warning System with Distributed Video Real-Time Display Function

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Abstract. In order to reduce false alarm rate and empty alarm rate of the fiber-optic fence warning system in intrusion detection, the paper proposes a kind of fiber-optic fence warning system with distributed video real-time display function, focuses mainly on the network formation of the warning system, fiber-optic fence detector terminals design, fiber-optic fence and video linkage real-time display function model design and software system design.

Introduction

With the rapid development of optical fiber sensing techniques, the researches on this area and the applications are widely used, on which the fiber-optic fence warning system with higher monitoring distance, higher location accuracy and stronger real-time warning will be a highlight in the intrusion detection field. Traditional fiber-optic fence warning system only used optical fiber sensor to position the intrusion point. Due to geographical differences of layout environment and various kinds of early warning trigger by accident, it keeps higher false alarm rate and empty alarm rate, which make it more difficult and also create more work. More importantly, it couldn’t satisfy the requirements of the intrusion detection. So, in order to improve the ability of the intrusion detection and reduce false alarm rate and empty alarm rate, this paper presents a design of the fiber-optic fence warning system with distributed video real-time display function. It put the distributed video real-time display function onto the fiber-optic fence warning system, which combine the sensing fiber-optic layout area with the real-time camera. After detecting the early warning by the fiber-optic detecting terminal, it will automatically invoke the video data from video server based on the time and the area of early warning. And supervisors simply need to look at the warning interface of intrusion system and handle it.

Early Warning System Application Networking

The network of distributed video real-time fiber-optic fence warning system is composed of the fiber-optic detecting terminal and distributed real-time cameras. It divides the sensing fiber into several segments. Then, distributed real-time cameras will adjust its view and bring the visual angle of video into the detection ranges, to make sure its full coverage of the sensing fiber-optic section of the video. The warning system application network is shown in figure 1.

In the network of distributed video real-time fiber-optic fence warning system, the sensing fence-fiber will be laid along the fence. The number of the fiber-optic fence detecting terminal will be determined by the distance, while the length of the optical fiber sensing section will be decided by the maximum angle of view and the detection sensitivity. After numbering the sensing fiber segmentation and cameras by the warning system, it will create a highly linked of the fiber-optical fence warning and the real-time video. Then, after the connection of the fiber-optic detecting terminal and monitoring rooms by transmission fibers, and the connection of the cameras and the monitoring rooms by the cables, the switch will gather and analyze all the distributed data. Finally it will form a linkage between the fiber-optic fence and the video real-time displays, the final early warning data will be displayed in a graphical manner by the software system.
The Design of the Fiber-optic Fence Detecting Terminal

With the higher sensitivity, stronger anti-electromagnetic inference and corrosion resistance of the sensing fiber, the fiber-optic fence technique has been applied to the national defense, oil pipelines and the security detection, etc. It is a kind of distributed sensing system which uses the optical fiber as the sensing medium and the transmission medium. It uses the coupling method to deal with the lights of steady laser source, then, pours it into the sensing fiber. After the sensing fiber is affected by the outside, the property has been changed. Then, the fiber-optic fence early warning is obtained by demodulation.

As shown in figure 2, it is a composition diagram of the fiber-optic fence warning detecting terminal. Pulsed laser offers light sources for the optical fence sensing fiber. Coupler is in charge of the transmission of light source produced by pulsed laser to the sensing fiber, and the injection of the returned optical signal into optical detector. The optical detector will convert the optical signal into the electric signal. All the original signals will be initially functionalized by the early warning-processed module. In this process, all the early warning data, including distance, time and intensity will be analyzed from the original data. Early warning detecting terminal send/receive module is in charge of the encapsulation of Ethernet packet, and transfers it into the monitoring rooms through the Ethernet port provided by the fiber-optic fence detecting terminal. It also has an analytical ability for the configuration instruction sent by the fiber-optic fence detection terminal on the software system.

Optical fiber warning detection terminal puts the narrow-band laser pulse into the sensing optical fiber through the coupler. The narrow-band laser pulse returns all the backward Rayleigh scattering light into the optical injection. After it enters the optical detector, the optical signals will be converted into electrical signals by original signals processing system. Then, the electrical signals will be processed by the early warning data processing module. After that, the early warning data processing
module will extract the distance, time and intensity for the early warning from the original data, and send all the functionalized warning data to the warning detecting send/receive module. Next, the warning detecting send/receive module will receive the configuration command from the warning software system, and analyze it into the parameters for the original processing of the optical fiber fence detection terminal and the parameters for the early warning data processing module. Users can do all kinds of function configuration according to the practical application.

**Design for the Optical Fiber Fence and Video Linkage Real-Time Display Function Module**

The optical fiber fence and video linkage module is shown as the following Figure 3.

![Figure 3. The optical fiber fence and video linkage module.](image)

The optical fiber fence and video linkage module is to link the real-time warning information of optical fiber fence detecting terminal with the video real-time display. The warning number will be linked to the video clips from the same time and be rendered in real-time on the early warning software system, through optical fiber fence warning and video server. The optical fiber fence warning information interface set will connect the optical fiber fence detecting terminal to the monitoring rooms through three-layer switch, and be in charge of receiving the early warning data from the remote optical fiber detecting terminal. The optical fiber fence warning data base is mainly to store the early warning information and provide data support for viewing historical data. The optical fiber fence warning data processing sub-module is mainly responsible for processing the collected early warning data and classifies all the data and provides the data operation interface. The interface set of camera video data is primarily responsible for the connection of remote cameras with the three-layer switch in the monitoring room, and the reception of the remote video stream data, through the Ethernet interface. The processing sub-module of video stream information is in charge of classifying the transmitted data from video data interface, and adding the time-stamp on all the video stream information, then providing operation interface functions for video stream data base and access operation interfaces for video server. Video information server is mainly to store video stream in the video format and provide layout environment for the video management database. Video management database is mainly responsible for storing all the video streams based on the number of cameras and time, and combines the data stored on video server to achieve the function of obtaining the video streams paths conditionally. Linkage data processing sub-module is mainly responsible for the combination of the optical fiber fence warning data and video stream, the analyses of all the early warning data, the obtainment of the number and the time for early warning, lastly links it with the related video stream. External interface of the linage module is primarily responsible for providing a series of operation interface functions, and makes sure the comprehensively display of the early warning information.

There are two directions for the data stream of the optical fiber fence and video real-time display linkage module, including configuration management data stream and early warning processing data stream. Configuration management data stream is mainly responsible for the parameter configuration
of the optical fiber fence detecting terminal and cameras, on which it will configure all the parameters based on practical requirements of the linkage module of the optical fiber fence and video real-time display. Early warning processing data stream is responsible for processing all data from the optical fence warning data interfaces and the camera video data interfaces.

Configuration Management Data Stream

Linkage module external interface receives the configuration command data from the early warning software system, and then transmits it into the linkage data processing sub-module to be classified. Configuration data of the Optical fiber detecting terminal was transmitted into optical fiber warning data processing sub-module, in which the data was classified and transferred to the remote optical fiber detecting terminal through the related Ethernet IP address, based on the analytical interface numbers. Camera configuration data was transmitted into video stream processing sub-module, in which the data was classified and transmitted into the remote cameras, based on the analytical interface numbers and the destination IP address.

Early Warning Data Processing Module

Optical fiber fence warning information interface will put the warning data into the optical fiber fence warning data processing sub-module, in which all the warning data will be classified and analyzed its warning time, detector numbers and warning intensity, etc. Then, all the information will be stored into the optical fiber fence warning data base and memory data structure. Camera video data interface will put all the received video stream data into the video stream information processing sub-module, in which the data will be stored into video server, at the same time, all the numbers of video stream, receiving times and storage paths will also be stored into the video management database. Linkage data processing sub-module is responsible for the combination of all the warning data from the optical fiber fence warning processing sub-module with the video from video server, and it will obtain the video stream on the warning time. At the same time, external interface of linkage module will display all the warning data from the optical fence warning system, and the video stream on the warning time.

Design for early Warning Software System

Early warning software system is to provide configuration management and early warning display for the terminal device, and simulates real optical fiber fence layout environment through the visual user interface. And it will number all the sensing optical fiber segmentation with cameras, then form a linkage of optical fiber warning segmentation and video real-time display. Figure 4 shows the schematic of the early warning software system.

![Figure 4. The frame of early warning system.](image)

Early software system obtains the optical fiber fence warning data and early warning video data uploaded initiatively by linkage module. Then, optical fiber warning data processing module will
classify all the data according to their section number and offers the early warning on the related place of the setting topology of the early warning software system. Users can simply double-click to watch the real-time video based on the early warning prompt (according to the color and voice prompts of different levels), and decided the early warning solution. It is very intuitive for dealing with the false alarm and empty alarm.

Early warning software system will achieve its configuration management for the terminal hardware, through configuration management module and optical fiber fence topology management. All the configuration data was firstly processed by optical fiber warning data processing module, and then transmitted into the remote fence detecting terminal and cameras through Ethernet transport protocol.

Conclusion
In order to promote the application of optical fiber fence technology in the important field, this paper presents a design for optical fiber fence warning system with distributed video real-time display function. Through the early warning video real-time display system, the design could fundamentally solve the warning defects on the optical fiber fence technology, which supervisors couldn’t intuitively know the problems on the spot. And it would greatly reduce the false alarm rate and the empty alarm rate with the help of supervisors, and ensures the improvement of quality to a larger extent.

References
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