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Full Length Research Paper

Design of airport enclosures remote laser intrusion detection and alarm system

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An airport enclosures intrusion detection system was proposed. Laser was used as detection means of alarm information in the system, intrusion event and region were detected through various means such as laser signal processing, visual information, information fusion and decision, etc., the alarm will be send to monitor center in time through CAN (Controller-area network) bus network and ethernet. The system has the following features: high sensitivity, good stability, strong anti-interference, low implementation and low maintenance costs, without interference to airport equipment, flexible, etc., and it can achieve continuous security monitoring while raining, snowing or fogging, the reliability of the system was improved by a wide margin.

Key words: Airport enclosures, laser, intrusion detection, alarm system.

INTRODUCTION

Enclosures intrusion alarm system is an important part of airport security defense, the airport security can be effectively ensured through the invasion and the destruction behavior to the enclosures were early warned (Botao, 2010; Hongbo, 2007).Currently, usual front-end detection technology mainly conclude vibration cable, infrared detection, laser shot, buried cables, tension fences, video analysis, etc. the needs of enclosures intrusion detection such as resisting the possible interference, as far as possible fewer distortion and omission, high sensitivity, wide operating range and coverage should be taken into account when choosing the detector. As laser detection system has the following advantages: 1. low false alarm rate; 2. stable; 3. effective prevention; 4. anti-jamming and 5. easy maintenance and debugging, so it is one of the best choice (Wei, 2010; Yue, 2008; Jijian, 2006; Mazel, 2006; Butler, 2009; Yuheng and Chao, 2007).

At present, intrusion alarm system based on laser shot method applied in the airport area is relatively less or immature. An airport enclosures remote laser distributed network intrusion alarm system was presented in this paper, and the laser was used as detection means of alarm information, CAN (Controller- area network) bus network and ethernet network were adopted as communications carrier to complete the design of distributed network detection alarm system.

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CONSTITUTION OF AIRPORT ENCLOSURES INTRUSION DETECTION AND ALARM SYSTEM

Intrusion detection alarm system based on CAN bus and ethernet includes airport enclosures alarm subsystem, linkage control subsystem, video monitoring subsystem and security management platform (Qinping, 2005), its constitution is shown in Figure1.

Enclosures alarm subsystem

Enclosures alarm subsystem includes embedded alarm detection controller, laser transmitter, laser receiver circuits and CAN bus network. Its function includes laser optical signal acquisition and amplification, signal processing aiming at interference, analyzing and identifying to extracted characteristic signal, alarm information judge, bus communication among nodes, transmission of node alarm signal, system status monitoring, fault diagnostics and so on.

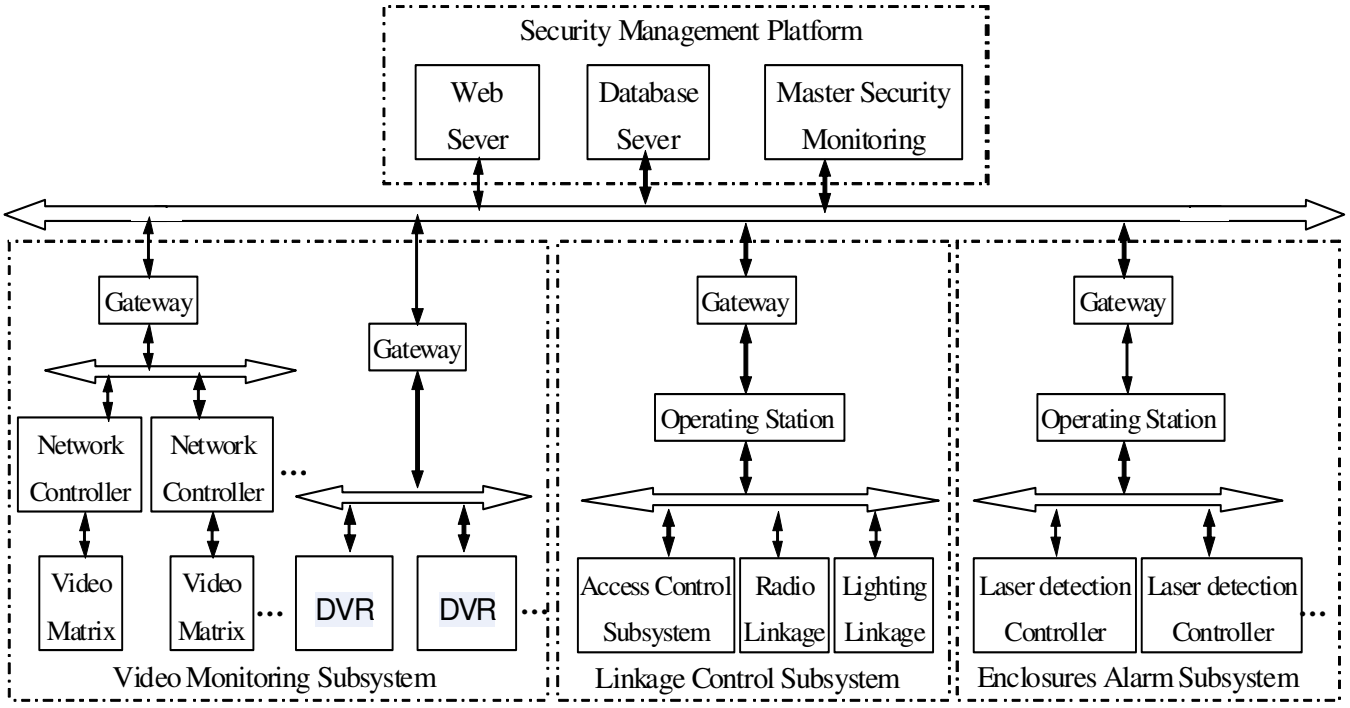

Figure 1. Airport enclosures distributed alarm network system diagram.

Video monitoring subsystem

Cameras located in the airport constitute a network through the video matrix and they were connected to network controllers. Monitoring stations can control the video matrix through communicating with the network controllers, then, a series of actions such as the lens calling and tripod head control can be completed. DVR (digital video recorder) of the airport are divided into continuous recorder and alarm recorder. Continuous recorders installed in the engine room of the airport were used as the entire recording of all cameras; however, alarm recorders installed in the security monitoring center would work only when the alarm happened. Monitoring server can complete the specific operation instructions through the gateway, and the corresponding recorded history can also be inquired about.

Linkage control subsystem

Each alarm nodes were assigned a partition number according to the topology of communication bus and geographical distribution, each bus node detects a certain area, correspondingly, the management system determine the suspect area according to nodes alarm information, and infrared visual telephoto system was scheduled automatically to complete night vision, which can further determine the intrusion alarm events to reduce the false alarm rate, after the alarm is confirmed. Lighting and radio linkage were started and the access control subsystems were also scheduled correspondingly.

Security management platform

As the core of the alarm system, security management platform is responsible for alarm information management and the coordination and scheduling among the various subsystems through the hybrid networks based on CAN bus and Ethernet. As the design core of the distributed alarm network system, the airport enclosures alarm subsystem is the key part that ensures the whole system work normally, this paper focuses on the working principle of airport enclosures alarm subsystem.

PRINCIPLE OF AIRPORT ENCLOSURES ALARM SUBSYSTEM

Constitution of airport enclosures alarm subsystems is shown in Figure 2. Laser alarms distributed at the airport enclosures detected whether the intrusion events happened, which is responsible for sending the intrusion alarm signal to controller in real-time, after the extracted characteristics signal were analyzed and recognized by the controller. The alarm information will be determined and then be reported to the remote monitoring station if it is a true alarm.

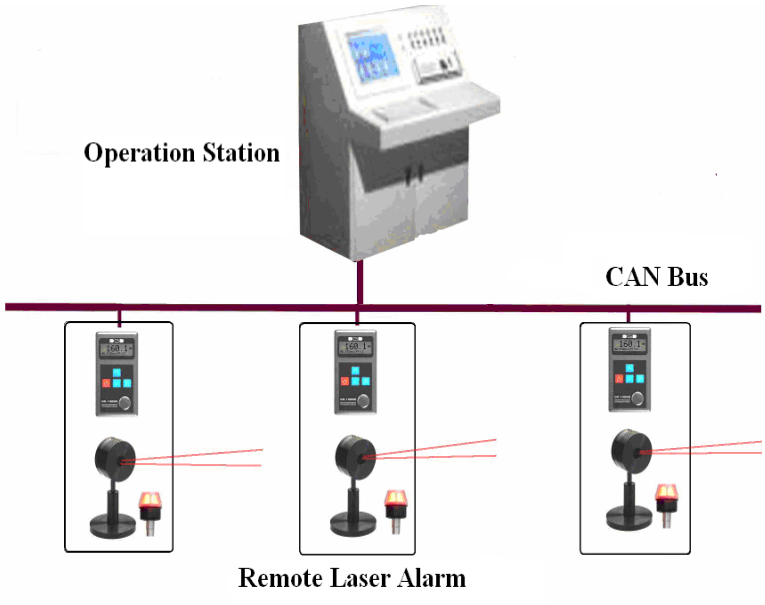

Figure 2. Airport enclosures alarm subsystem diagram.

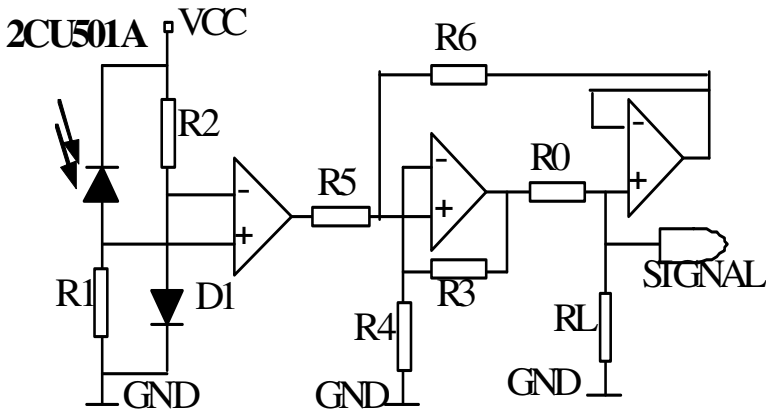

Figure 3. Photoelectric conversion circuit.

The laser source

Industrial-grade lasers were adopted as the laser source to produce optical detection signal, which was equipped with high-quality industrial laser diodes, driving circuit and optical lens. It has high reliability, stable performance, consistency and long service life. Custom indicators are as follows: laser wavelength, near-infrared section of 980 nm, good penetrating power in the atmosphere, good performance in the rain and fog, laser power, more than 60 mw, laser type: semiconductor lasers, laser spot forms and point light source. If the laser divergence is 0.2 mrad, the light intensity is about 100 Lux in the conditions of 1 km distance, which is enough to receiving circuit.

Optical signal receiver and the photoelectric conversion circuit

Receiving circuit shown in Figure 3 is the photoelectric conversion device adopts 2CU501A, it is equal to open circuit when no light irradiate the photodiode, and diode D1 is forward conduction, the forward voltage is about 0.7 V, the output signal is about 0 V (measured value is 25 mV). When light irradiate the photodiode, it is equal to a diode, output signal is 2.67 V at this time. The latter part

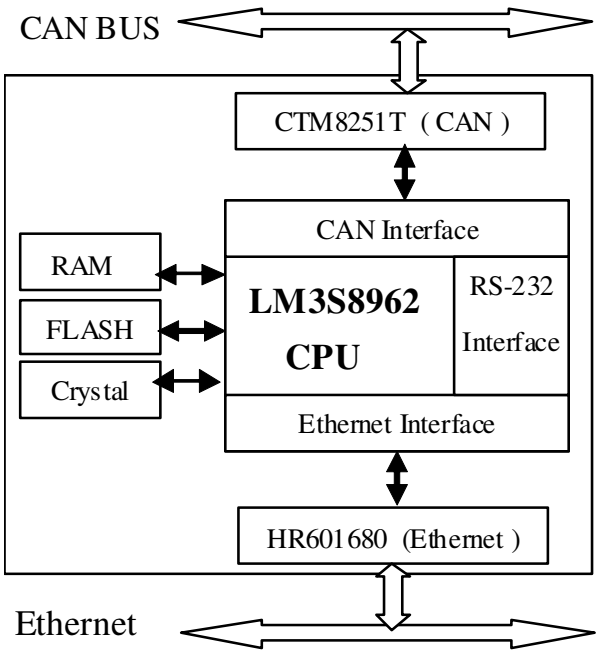

Figure 4. The block diagram of controller.

of the circuit can be regarded as a constant current source, which is used for ensuring stable output TTL level.

Control circuit

As one of high the performance LM3S8000 series chip, LM3S8962 chip was selected as CPU, it supports 32 bit RISC, which has 256 KB single cycle flash, 64 KB single cycle access SRAM. Furthermore, LM3S8962 chip was equipped with a large number of on-chip devices, this provided convenience for developer in great degree. The chip itself contains two CAN controllers. TTL level of CPU need to be switched to differential level of CAN bus during the process of CAN communication, CTM8251T was used to the transceiver here, as shown in shown in Figure 4. LM3S8962CPU has ethernet interfaces, ethernet communication needs a network adapter, HR601680 was used here, because, it is easy to implement the conversion between CAN bus networks and Ethernet, which provides convenience for hybrid network communication. RS-232 interface was used to connect a smart terminal, which was used to realize local control to alarm, certainly, remote control can also be realized through network communication.

MEANS TO REDUCE THE FALSE ALARM RATE

Non-detection light source interference

It would cause interference on the detection devices when the light with the same wavelength of laser source (natural or artificial) irradiate the receiver, especially sun light. Sun light contains the spectrum of laser intrusion detectors, when sunlight irradiates the receiver directly, this will induce false alarms. In order to avoid sunlight irradiating the receiver directly, the transmitter and receiver were installed between the ends of enclosures simultaneity, and the following measures were adopted at the same time (Wei, 2010):

1. Using narrow-band filter.
2. Sunshade was installed in laser transmitter and receiver.
3. Transmitter and receiver should be installed backlight.

False alarms caused by birds and animals

Flying birds has a great influence on the stability of the laser alarm system. Setting of the alarm delay time can solve such false alarm. Flight speed of birds is very quickly, and the bird generally does not stop in one place, so it only takes a very short time for the birds passing through the laser beam. When the laser is blocked for a short period of time, no alarm will output at this time, if the size of birds is not big enough to block the laser beam, same as before, this improved the stability to a great degree.

Interference between the adjacent laser devices

Interference will occurs when several consecutive laser devices installed in the airport enclosures, because the transmitter's laser beam can be transmitted very far, and with the increase of distance, the beam area also increased linearly. Therefore, it is possible for the own laser to be blocked, but can still receive the other adjacent laser beam, thus, false alarms will happen in this case. In order to solve this problem, transmitting frequency of adjacent laser devices should be adjusted. Different transmitters have different transmitting frequency, no alarm will output if the receiver receives the beam with the correct frequency, system will output alarm signal on the contrary, and therefore such problems could be avoided.

Optimization of the alarm threshold time

Sometimes the smallest error rate criterion is not the most important or the best indicator. For speech recognition and text recognition, it may be the most important indicator. But in some cases, it can be tolerated to increase general error rate for reduce losses and serious consequences. Therefore, the broader concept than the loss-risk was introduced, in considering the losses caused by wrongful judge and the loss was

minimize. If every decision was made on the premise that all the conditions risk was the smallest, thus, its expected risk is bound to the minimum when the decision was made for all events, and this decision is the minimum risk Bayes decision. Minimum risk Bayesian decision step (Xueling, 2010):

1. Suppose prior probability $P(\omega_j)$, conditional probability density function, $p(x \mid \omega_j)$ j = 1,2, ..., m, and x to be identified were given out, then posterior probability can be calculated according to the Bayesian formula:

$$P\left(\omega_j \mid x\right) = \frac{P\left(x \mid \omega_j\right) P\left(\omega_j\right)}{\sum_{i=1}^{m} P\left(x \mid \omega_i\right) P\left(\omega_i\right)}, \; j = 1, 2, \ldots, m$$

2. Combined with the posterior probability and decision table, condition risk $R(\alpha_i / \boldsymbol{x})$ (i = 1,2, ..., a.) can be calculated.

3. Compare $R(\alpha_i / \boldsymbol{x})$, (i = 1,2, ..., a) obtained in Step 2, find out the least risky decision α_k, $R(\alpha_k / \boldsymbol{x}) = \min_{i=1,2,\ldots,a} R(\alpha_i / \boldsymbol{x})$, then it is the minimum risk Bayes decision. The minimum risk decision model was introduced in real data sets to finish the test. The experimental results showed that good results can be achieved by the Bayes risk decision in the minimum false risk assessment.

Experiment

Experimental conditions of laser wavelength (980 nm), power (60 mw), light source forms (point-like laser) and transmission distance (500 m) when the following holds:

1. Normal weather conditions: the system is still working properly even if the laser power was reduced to 60%.
2. The visibility less than 50 m (thick fog: the system is capable of normal operation. The system is still working properly when the laser power was reduced to 60%. The same result to rain, high temperatures and strong winds when the distance is reduced to 80 m and the system is still working properly when the laser power was reduced to 50%.
3. The distance is reduced to 100 m: the device does not alarm when the receiver was irradiated by flashlight or sunlight, which indicates that the intrusion detection system has good resistance to stray light interference. The device alarm when personnel pass through the transmitter and receiver, but fast swing arm would not cause alarm, which reflects the validity of the threshold time control.

CONCLUSION

People are increasingly paying more attention to airport security, and it has become a primary task to establish a stable and efficient airport enclosure security system. Laser technology was used to realize the front-end detection, which is a high reliability solution for airport enclosure security system. And preferable experimental results were also achieved; the system has automatic monitoring function to the invasion, which is worth spreading in security area.

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