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Construction of prison wireless management system based on active RFID wireless sensor

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Abstract. With the increasing population base and crime ways, the population of prison inmates increased a lot, which raised higher requirements on prison management. Based on this, wireless management system is proposed to enhance the intelligent management of prison. This paper conducted a research on the construction of prison wireless management system based on active RFID wireless sensor. First, the paper analyzed RFID technology, discussed the application advantage of active RFID sensor in prison wireless management system, and then analyzed the demands of designing wireless management system, including the access control management subsystem, regional management system, prison factory personnel positioning subsystem and auxiliary systems, etc. On this basis, the research combined software systems to construct the management system and improve the functionality and reliability of the prison management system.

Key words. Active RFID, prison, wireless management.

1. Introduction

With the continuous development of computer technology and communication technology, traditional prison system can no longer satisfy the actual demands. Prison information management is an inevitable trend for the development of modern prison management. The innovative combination of all the prison systems can improve the management mechanism, organizational structure and personnel quality of the prison, promote a scientific, fair, safe and effective development of prison management based on the principles of optimization, improvement and recombination, and better perform the nature intelligence of the prison. The prison wireless management system based on active RFID wireless sensor is an effective prison management system which plays an important role in the prison management system and can satisfy various demands.

RFID (radio frequency identification) technology is originally used to improve the performance of radar recognition on target planes in World War II [1]. But

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limited to the high cost, RFID technology is not widely applied. Since the 21st century, RFID technology started to enter people's daily life. With the development of integrated circuit and network communication technology, RFID technology, featuring an accurate and rapid recognition on moving objects, entered the commercial industry as a recognition technology with its own characteristics of multi-target and non-contact recognitions, and can be used for various kinds of recognition and monitoring systems [2]. At present, RFID presented enormous development space and prospects, which is considered as one of the most potential technologies in the 21st century. Especially in the IT industry, RFID is widely concerned and is regarded as the next "gold mine" for the IT industry. Nowadays, all the software factories showed great interests in RFID and have conducted a large amount of investments on this aspect.

In recent years, with the soaring population base, current prison armed forces and traditional defense methods can no longer satisfy the actual demands, and it becomes imperative to promote the prison wireless management system. The automatic information recognition and acquisition that RFID possessed matches well with the prison detection system. Especially on monitoring moving objects, RFID has an incomparable advantage against other monitoring technologies [3]. This paper will conduct a research on the construction of prison wireless management system based on active RFID wireless sensor.

2. RFID system

2.1. Composition of RFID system

As a non-contact automatic recognition technology, RFID technology obtains the target information mainly by launching radio frequency signals. This technology is applicable for various environments without requiring human intervention. Different from traditional recognition technologies which are limited by single recognition, RFID can recognize multiple labels with certain operation convenience. RFID system mainly consists of label, reader and antenna [4].

The label mainly includes label antenna, modem, clock, storage and code generator. The label is featured with uniqueness. Each label represents one piece of information which is similar to the barcode in traditional recognition technologies. The labels in the recognizable region of RFID can be effectively recognized and the recognition process is mainly accomplished by reading and writing information through the storage. Some active electronic labels are integrated with extension units such as MEMS sensor.

The reader is a device for label reading and writing. There are mainly two types of readers: handheld reader and stationary reader. Currently, the microprocessors of many readers continued the embedded system, which has the functions of signal state control and error correction. The reader mainly consists of radio frequency module and reader module [5].

RFID antenna is designed for the spatial transmission of radio frequency signals for the label and the reader. RFID antenna is usually installed on the reader or

connects the reader through cables. In practical use, the main factors that influence the recognition distance of RFID antenna include the system power and the structure of the antenna [6].

2.2. Working principle of RFID system

The working principle sketch of RFID is shown as Fig. 1.

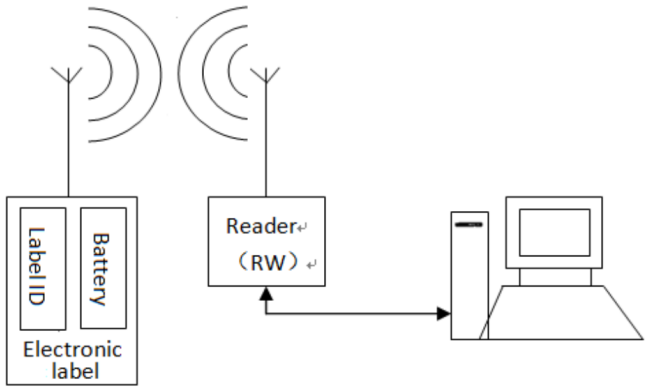

Fig. 1. RFID working principle sketch

According to Fig. 1, the RFID system working principle is shown as below: First, set the data and radio carrier signal mode through the reader as "send out by antenna". At this time, the monitoring is started in a certain area. When a RFID label enters the area, it will be detected and transmitted to the system through the antenna after checking the information code in the reader. When receiving the carrier signals of the RFID label, the system will transmit the signals to the reader and decode the signals through the modem and then deliver to the backend computer controller. After that, the computer controller will judge the validity of the RFID label by logic operation, make corresponding control treatment on different settings, and send commands to control the actions of the actuator. Upon receiving the signals, the actuator will execute the corresponding commands. Through the computer communication network, all the monitoring points can be effectively connected to compose a general information control platform and realize the expected functions by designing different software for different projects [7].

2.3. Active RFID system

According to different working initiatives, RFID technologies can be divided into active RFID and passive RFID [8]. In real applications, active RFID and passive RFID can be combined to accomplish specific projects. However, in the future development, active RFID technology will certainly become an important development direction. Passive RFID technology is only applicable for simple and short-distance recognition, which cannot be used for positioning and multi-target and wide-range

management. Essentially, the performance of active RFID is much better than passive RFID. Active RFID technology possesses the sensing ability between label and reader, interaction ability between label and reader, anti-collision ability, ability of avoiding the influences from human body, metal and fluid, ability of loading sensing technology and data security, etc. In addition, active RFID technology can be used to search specific persons or objects, with externally embedded sensor or LED lights available. The positioning computation of active RFID technology is conducted by maximum likelihood method, as shown in Fig. 2 [9].

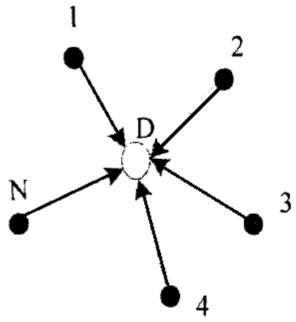

Fig. 2. Maximum likelihood method

Assume the coordinates of $1-N$ points in Fig. 2 are (x_1, y_1), (x_2, y_2),...(x_n, y_n), respectively, then the distances between these points to the nodes are $d_1, d_2, ...d_n$, respectively, and the coordinate of point D is (x, y). Then:

$$\begin{cases} (x_1 - x)^2 + (y_1 - y)^2 = d_1^2, \\ \quad\quad ... \\ (x_n - x)^2 + (y_n - y)^2 = d_n^2. \end{cases} \tag{1}$$

That is

$$\begin{array}{c} x_1^2 - x_n^2 - 2(x_1 - x_n)x + y_1^2 - y_n^2 - 2(y_1 - y_n) = d_1^2 - d_n^2, \\ x_{n-1}^2 - x_n^2 - 2(x_{n-1} - x_n)x + y_{n-1}^2 - y_n^2 - 2(y_{n-1} - y_n) = d_{n-1}^2 - d_n^2. \end{array} \tag{2}$$

The linear equation $AX = b$:

$$A = \begin{bmatrix} 2(x_1 - x_n) & 2(y_1 - y_n) \\ ... & ... \\ 2(x_{n-1} - x_n) & 2(y_{n-1} - y_n) \end{bmatrix},$$

$$b = \begin{bmatrix} x_1^2 - x_n^2 + y_1^2 - y_n^2 - d_1^2 + d_n^2 \\ ... \\ x_{n-1}^2 - x_n^2 + y_{n-1}^2 - y_n^2 + d_n^2 - d_{n-2}^2 \end{bmatrix}. \tag{3}$$

So the coordinates of point D will be

$$\hat{X} = \left(A^{\mathrm{T}}A\right)^{-1} A^{\mathrm{T}}B\,. \tag{4}$$

3. General design of prison wireless management system based on active RFID sensor

3.1. Demand analysis of the system design

As an integrated comprehensive system, prison management system mainly contains computer control, automatic control, sensor and communication network technology, including RFID personnel management system, positioning and digital video monitoring system [10–12], Active detection system. Considering the technical integrity and functional complexity, the designing of the management system shall stick to the principles of standardization, security and reliability, advancement, openness and extensibility, easy in implementation, and maintainability.

Prison management system is an application system integrated with hardware and software, which is specially designed for prison monitoring. In its real application, the system can recognize the personnel type safely and reliably, employ an intelligent one-to-one management between prisoners and system recorded personnel, and realize a true automatic information management. The system can manage the population and personal information of the inmates in each control area of the prison, prevent them escaping from the prison, and effectively reduce the probabilities of criminals making trouble in the prison. In addition, the system can adopt private monitoring for high-level criminals, keep a close eye on the prison to avoid violent incidents, and assure the stable operation of the prison as well as the safety of the inmates to the maximum. Meanwhile, the system can monitor the population of specific areas, detect the outbound personnel dynamically, and reduce the workloads of the prison personnel. When an emergency occurs, the system can position all the police officers rapidly.

Access control: The system will conduct real-time monitoring at each entrance, take real-time videos of all the personnel entering and exiting the prison, automatically record the time and the information of the personnel, and report an alarm when abnormal situation is detected; Real-time monitoring: a real-time monitoring will cover all the workplaces, important monitoring areas, prison hospital, washrooms and recreation yards, etc. The system will set an information feedback interval cycle, and submit a personnel monitoring report to the center at each cycle. When the monitoring personnel is out of the designated area, an alarm will be triggered, and the real-time information of the violator will be reported the management personnel; Police sentry positioning: the system will position the personnel on duty to assure they act in a certain area. As soon as they are away from the sentry unexpectedly, the system will send a warning, and restrict the personnel at the non-duty area. In case any non-duty personnel enters the duty area, the system will deliver a warning automatically; Prison factory management: during the prison period, labor inmates shall not leave their workplaces. They are under a whole process of monitoring. For inmates who leave their workplaces unexpectedly, the system will send a warning, report the information to the management personnel, and record the position of the inmate (s) in real time; for inmates working at farms or mines, handheld devices can be used to conduct real-time monitoring on certain personnel in the area. Once

escape occurs, the device will report an alarm and inform all the police officers to take arrestment; video monitoring and control: a remote real-time monitoring is conducted at the connection between the prison and the outside world. In addition, the system will control the monitoring devices, environment light and sound equipment respectively according to different priority levels so that to accurately monitor the places with frequent situations.

3.2. Construction of prison wireless management system based on active RFID wireless sensor

The prison wireless management system based on active RFID wireless sensor mainly consists of access control management subsystem, regional management subsystem, prison factory personnel positioning subsystem and auxiliary system.

Software design. Software design mainly includes personnel management and data base. VB 6.0 is used to develop personnel management part, and SQL Server is used to design the data part. The designing rule of the personnel management part is similar to the above, including access control management subsystem, regional management subsystem and prison factory personnel positioning subsystem. An effective control on the personnel can be realized by establishing related data sheet and inputting them in the system. For example, an access record table as shown in Table 1 can be established.

Table 1. Access record table

Field name	Content	Type	Length	Remarks
ID	Card no.	Text	5	NOT NULL
DoorID	Gate no.	Text	4	NOT NULL
InDate	Entry date	Date	8	NULL
InTime	Entry time	Time	6	NULL
OutDate	Exit date	Date	8	NULL
OutTime	Exit time	Time	6	NULL
State	Access control state	Yes/No	2	NULL
Alart	Alarm	Yes/No	2	NULL

Access control management subsystem. As a modern security management system, access control management subsystem plays an important role in working environment security and personnel attendance, which is an effective measure taken by prisons to conduct security guard management. The working principle is to make various magnetic cards according to different activity areas of the personnel, set the activity area in the magnetic cards, establish access controls at important places as the entrances, elevators, equipment control center and warehouse of the main management areas inside the prison building, assure the security of all the areas through real-time monitoring, and realize the real-time monitoring and control of all the regions only by the control center. When entering related area, the entrant should use a magnetic card with related permission to release the access control. The system would also perform a real-time monitoring through the active RFID sensors installed

at each access control, and lock the facial information of the personnel. As soon as the violator enters unauthorized area, the system will effect an alarm, lock the real-time position of the violator, inform the police officers of other areas to head for the site to take actions. In actual designing, separated structured active RFID sensors are used to conduct access control management on related personnel. As the access control recognition device, the active RFID sensors are installed at key positions of the monitoring areas respectively, which are connected to the control center through Ethernet network to assure the flexibility, communication and real-time monitoring and control of the system.

Regional management subsystem. This part mainly includes roll call of the personal in the region, sentry inspection of the on-duty police officer, and work of laborers. The prisoners need to be gathered in a certain area when proceeding roll calls, recreation, dining or working. At this time, the prison guard should know the number of the inmates in the area, and notice when there is any absence or departure. Except for the management on the inmates, the on-duty prison guard should be also managed to enhance a full play of their monitoring and management functions. At this time, active RFID sensors can be used for the real-time management on the inmates and the prison guard. The actual design of regional management subsystem continued the way of access control management subsystem. The hardware mainly consists of active RFID sensor and label. In a certain gathering area, the inmates and prison guard are under a real-time monitoring, and their real-time information will be transmitted to the control center every 10 seconds. Based on the standard data entered in the data base, if any abnormal situation occurs, a notice and warning will be delivered. The regional management function sketch is shown as Fig. 3.

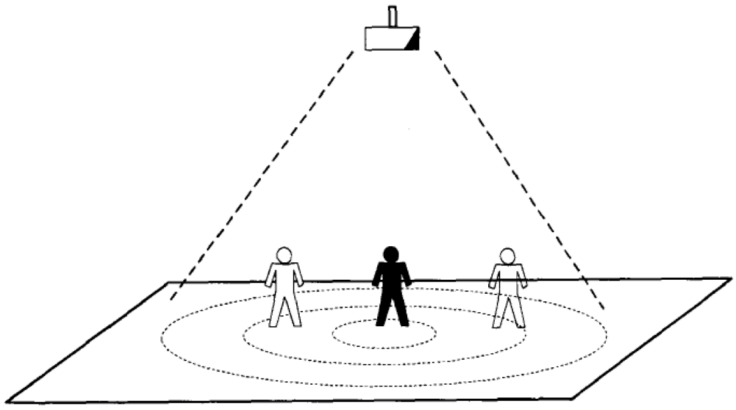

Fig. 3. Regional management function sketch

Prison factory personnel positioning subsystem. Due to the particularity of the factors (environment and personnel, etc.) in the prison factory, it should be assured that the inmates shall not escape the required area during the prison time, and the required area should be under real-time management. The analysis is conducted by taking the factory internal management during the labor reforming process as the

example. In real management, based on the positioning performance of active RFID, the control range of RFID sensor is set as 80 meters. The number of installations is calculated according to the range of each workshop, which can satisfy the real-time monitoring demands of all the workshop ranges. Then, the working positions of the personnel are decided through the positioning algorithm, and the RFID label is positioned to realize the label roll call and warning functions.

Auxiliary system. Except for the above system and related software systems, auxiliary systems are also required to satisfy the management demand of the prison. Generally speaking, the management with active RFID wireless sensor can satisfy the normal management demand of prison. However, the inmates may tend to resist the management of the prison. Hence, during the management process, some inmates may destroy the active RFID wireless sensor intentionally or discard the label maliciously. Hence, auxiliary management systems are also required on the basis of wireless management system. The auxiliary management system mainly includes video monitoring system, infrared boundary system and boundary escaping prevention system. With these systems as the backup for RFID wireless management system, even malicious prison break occurs, the auxiliary management system will detect the situation and inform the management personnel to take arrestment.

4. Conclusion

As a non-contact automatic recognition technology, RFID technology mainly obtains and recognizes the target information by sending radio frequency signals. This technology is applicable for various environments without requiring human intervention. Different from traditional recognition technologies which are limited by single recognition, RFID can recognize multiple labels simultaneously with certain operation convenience. RFID system mainly consists of label, reader and antenna. Active RFID technology possesses the sensing ability between label and reader, interaction ability between label and reader, anti-collision ability, ability of avoiding the influences from human body, metal and fluid, ability of loading sensing technology and data security, etc. As an integrated comprehensive system, prison management system based on active RFID sensor mainly contains computer control, automatic control, sensor and communication network technology, including RFID personnel management system, positioning and digital video monitoring system, active detection system. This management system can realize the functions of access control management, real-time monitoring, police sentry positioning, prison factory management, video monitoring and control, etc. The prison wireless management system based on active RFID wireless sensor mainly includes access control management system, regional management subsystem, prison factory personnel positioning subsystem and auxiliary systems, etc. Combined with hardware and software designing, the management system functionality can be improved gradually to assure the effective running of prison.

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