Design of a Stereo Monitoring System Based on Wireless Sensor Networks

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Abstract. Recently, Wireless sensor network is regarded as a new information acquisition platform, its relevant technologies have been widely used as the basis of the Internet of Things. In order to realize the campus information construction, a campus stereo monitoring system based on wireless sensor network is designed in this paper. Such technologies as the intelligent information processing technology of wireless sensor network, the remote WIFI wireless data communication technology, the cloud services technology and the management query technology for monitoring points based on the internet display platform are adopted in this system synthetically, realize on line real time monitoring and location, which can not only reduce the human cost, but also has important significance in maintaining campus safety and campus management.

Keywords: Wireless Sensor Network, WIFI, Location, Wireless Communication.

1. Introduction

In recent years, the campus of colleges and universities is becoming more and more open, which has created a relaxed atmosphere of study and life for students, but also brought great challenges to campus management and safety monitoring. Campus security issues are increasingly prominent, including the following aspects, on the one hand, due to the aging of circuits and illegal use of electrical appliances, campus fires occur frequently, causing great harm to campus life and property. On the other hand, campus theft cases are common, but the existing wired monitoring methods can not achieve effective positioning and early warning function. Therefore, it is necessary to construct a comprehensive campus monitoring and early warning system.

At present, with the rapid development of broadband communication technology, a large number of wired monitoring facilities have been gradually applied to the campus security system, but it is still unable to achieve real-time and all-round coverage of campus security management. With the help of the construction of information and digital campus, the wireless way to realize the omni-directional monitoring of the campus can not only reduce the labor cost, but also have important significance in maintaining safety and campus management.

Wireless Sensor Network is a new network information acquisition, transmission and processing technology, which has the characteristics of low power consumption, low cost, self-organization and strong invulnerability. It can reduce the unnecessary cost of setting up the line and make up for the deficiency of the wired coverage network effectively. Therefore, aiming at the deficiency of campus
security management, this paper puts forward a wireless monitoring network based on wireless sensor network technology, and combines wireless WIFI technology to realize real-time monitoring and early warning of campus[1-2].

2. The monitoring system architecture
In order to realize the omni-directional campus security management, a three-dimensional monitoring system based on wireless sensor network is constructed. The system can not only realize the monitoring and early warning of campus fire, but also realize the real-time positioning of campus theft elements. The stereo monitoring model based on wireless sensor network is shown in figure 1.

![Diagram of the overall structure of the system](image)

**Figure 1.** the overall structure of the system

The system is mainly composed of wireless sensor monitoring network, remote monitoring and management center and gateway node. The monitored sensor nodes are distributed in the campus area, which is responsible for collecting environmental parameters, location, video data and so on in real time, and communicating with the gateway nodes. Each terminal node transmits the monitoring data to the gateway node through the self-organized multi-hop routing network. After data preprocessing, the received data is transmitted by the gateway node to the remote monitoring and management center through the WIFI module. The remote monitoring and management center analyzes, processes, stores and visualizes the received data information. At the same time, combined with geographic information system, it can realize all-round monitoring and accurate early warning of campus.

3. System Hardware Design

3.1. Sensor Node Hardware Design
The sensor network node adopts the low power CC2530 wireless chip produced by TI-Chipcon company. The chip that integrates RF front-end, memory, and microprocessor, used 8-bit MCU (8051), 8 KB RAM and 128 KB Flash [3]. There are also analog-to-digital ADC, timers, AES128 co-processors, watchdog timers, 21 programmable I/O pins, and serial ports of SPI, I2C (Inter-Integrated Circuit) and UART. The internal structure of sensor network nodes is shown in figure 2.

Firstly, the digital or analog signals collected by the sensor are input into the microprocessor unit through the data acquisition module. Then after A/D conversion and related data processing, the CC22530 RF module sends the data to the next hop node. Conversely, the control signal for the sensor node can be received from the CC22530 antenna, transmitted to the microprocessor through the SPI, and transmitted to the sensor node through the corresponding universal I/O port after its judgment and processing to realize the sensor Node correlation control. Because the sensor node has FLASH storage
module and has certain storage ability to the collected data, it can reduce the frequency of RF operation. And then reduce the power consumption.

3.2. Gateway Node Design
Gateway node consists of coordinator node (sink) and STM32 gateway[4]. The internal structure is shown in Figure 3. The sink node which also have the same wireless communication module as the sensor node is mainly responsible for monitoring data receiving and controlling information forwarding. The STM32 gateway is primarily responsible for ZigBee and GPRS data conversion. The C8051F320 main processor developed by Cygnal company communicates with the STM32 gateway through the serial port which can realize full duplex communication, which is suitable for large-scale and low-cost wireless sensor networks.
4. System Software Design

4.1. Network Model
There are five assumptions made for the sensor nodes.

1. The sensor nodes and the Base Station are all stationary after deployment and the BS is deployed at a fixed location outside the sensing field.
2. Sensor nodes are homogeneous.
3. Sensor nodes have power control capabilities to vary their transmitted power.
4. Sensor nodes know its own geographical information.
5. Data fusion is used to reduce the total data message.

4.2. Establishment of Network Node Routing
In order to facilitate the control of nodes and resource utilization, the TinyOS 2.0 operating system is transplanted to the CC2530 chip.

TinyOS provides the function of node automatic networking and routing, and proposes the acquisition tree protocol for data routing transmission (CTP)[5]. In this protocol, the gateway is set as the root node, and the other nodes dynamically select the parent node as the next hop to form the route to the root node according to the routing gradient, thus forming the collection tree network to the root node. CTP provides multi-hop data transmission to the root node, which has a routing selection mechanism to ensure the reliability of transmission. In addition, the repeated transmission and routing loop are suppressed by checking packet repetition. Hence, CTP protocol is chosen as the underlying communication protocol for monitoring data transmission.

4.3. Selection of Collection Mode
In order to avoid the sensor nodes to reduce the collection and transmission of useless data, the sensor nodes adopt the threshold-based operation mode. When the monitoring data is less than the reporting threshold, it is not sent. When the monitoring data is greater than the reporting threshold and less than the alarm threshold, the real-time data is reported with a longer cycle, and when the monitoring data exceeds the alarm threshold, report real-time data with a shorter cycle. Figure 4 shows the flow chart of node acquisition cycle.

This method not only ensures the reliable acquisition of key real-time data, but also reduces the energy consumption of sending useless data frequently.

Figure 4. The flow chart of node acquisition cycle
4.4. **Selection of Collection Mode**

Sensor nodes are manually deployed, each node is assigned a unique ID number[6]. Integrated with GIS, monitoring data for each region can be accurately displayed on the user interface. Compared with GPS positioning technology, this method is more suitable for large-scale, low-cost, self-organized monitoring network, and the accuracy of indoor positioning is better.

4.5. **Working Mode of the Gateway**

The gateway node consists of two parts. The one part is the data exchange between the root node and other sensor nodes in the network, and the monitoring data, node location and time information are collected periodically; the other part sends the monitoring data to the monitoring center in real time through the WIFI module. The sensor network data is transmitted to the WIFI wireless module through the UART, which a bridge role between the two, and the transmission process is transparent.

4.6. **Management of the Monitoring Center**

The monitoring center stores the data in the cloud server, and provides the user interface for visual display, and carries on the early warning prompt to the user according to the data analysis result.

Visual presentation includes two parts. In order to facilitate the monitor to grasp the global monitoring results, the location and real-time data of all sensor nodes are displayed on the map in combination with GIS. Based on the display of node identification, all nodes are displayed in real-time data and node status according to the size of identification in the network, so as to facilitate the monitor to extract and export monitoring data and observe the abnormal state of nodes at the same time. Maintain the whole network system in time and effectively.

The functions of the early warning mechanism include displaying the alarm prompt information of the special mark on the software interface; issuing the alarm prompt sound through the multimedia equipment in the monitoring center; sending the alarm prompt monitor's personal mobile device.

5. **Analysis of measurement results**

The monitoring system based on wireless sensor network, combined with wired monitoring system, forms a fully automatic monitoring, full coverage, real-time monitoring system. At present, the field test experiment is completed in the server room of Hezhou University. Figure 5 shows the hardware System platform of the system.
Table 1. Temperature and humidity sensor measurement data.

| Indicator | Sensor 1 | Sensor 2 | Sensor 3 | Sensor 4 | Sensor 5 | Actual value |
|-----------|----------|----------|----------|----------|----------|--------------|
| Temperature (°C) | 22.50 | 22.48 | 22.46 | 22.52 | 23.01 | 22.50 |
| Humidity (%) | 48 | 49 | 47 | 48 | 49 | 49 |

Table 1 shows data on temperature and humidity measured at a particular time in the server room. Temperature and humidity data range in line with the computer room safety environmental data range. The experimental results show that the system is stable and meets the expected requirements.

6. Conclusion
The three-dimensional monitoring and early warning system based on wireless sensor network has the advantages of automatic monitoring, rapid deployment and low cost. The field test of the prototype system has been carried out in advance on the test section, which has completely reached the expected target. It has high application value and practical significance.

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References
[1] Potdar V., Sharif A., Chang E. Wireless Sensor Networks: A Survey[C]// International Conference on Advanced Information Networking & Applications Workshops. IEEE, 2009.
[2] Garzon C A L, Riveros O J R. Temperature, humidity and luminescence monitoring system using Wireless Sensor Networks (WSN) in flowers growing[C]// Andescon. IEEE, 2010.
[3] Jun-Bin L I, Yong-Zhong H U. Design of ZigBee network based on CC2530[J]. Electronic Design Engineering, 2011.
[4] Xu Z. Design of electric power data acquisition system based on STM32[J]. Electronic Measurement Technology, 2010.
[5] Meka S, Fonseca B. Improving Route Selections in ZigBee Wireless Sensor Networks[J]. Sensors, 2019, 20(1):164.
[6] Ioannou C, Vassiliou V, Sergiou C. An Intrusion Detection System for Wireless Sensor Networks[C]// Wireless And Mobile Computing, Networking And Communications, 2005, IEEE International Conference on. IEEE, 2017.