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Research Article

Application of Wireless Communication Technology in Huizhou Academy Landscape

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ABSTRACT

This paper aims to explore the application strategy and specific plan of wireless communication technology in Huizhou Academy and takes the application of wireless communication technology in the landscape of Huizhou Academy as the research object. This paper proposes a visitor positioning system and wireless management system for Huizhou Academy landscape based on ZigBee technology, and analyses the power consumption of the system as well as the transmission distance and other influencing factors; secondly, this paper analyses the effect of the system's application in Huizhou Academy and proposes an improvement strategy. The main contents of this paper are as follows: (1) A wireless management system based on ZigBee is proposed, which adopts the intelligent wireless management system of human-computer interaction, and can effectively solve the problems of insufficient tour guides and loss of tourists in Huizhou Shuyuan tourist attractions. (2) The results of the analysis of system influencing factors show that the system operates reliably and has low power consumption, which achieves the expected goal of system design. (3) 80% of the operators rated the operational stability of the system at 6 points or more; nearly 70% of the operators rated the response speed of the system at 6 points or more, so it can be seen that the operational stability and response speed of the system can meet the requirements. 60% of the tourists rated the operational stability of the system at 6 points or more; nearly 92% of the operators rated the convenience of the system at 6 points or more; so it can be seen that the operational stability and convenience of the system can meet the requirements of the tourists. This shows that the operational stability and convenience of the system can meet the requirements of tourists. (4) Need to increase the publicity of the system; the tourists' operation interface needs to be more concise; need to increase the publicity of the system.

Keywords: Huizhou Academy, ZigBee, Wireless Network, Positioning System.

INTRODUCTION

Huizhou is a cultural town in China. The villages with clans living together, the tall and majestic ancestral halls and pagodas, the cultural buildings of the academies where the style of literature still exists, and the elegant and bright residential buildings highlight the strong cultural heritage of Huizhou in every way (Figure 1). As a valuable tangible cultural heritage, the Huizhou Ancient Academy is the finishing touch of Huizhou culture. It not only has cultural and architectural characteristics but also has distinctive regional characteristics of Huizhou. Visitor management of Huizhou Shuyuan Scenic Area refers to the behavioural process of the management department or institution to organize and manage the visitors by using scientific and technological, educational, economic, administrative and legal means. The goal of visitor management is to maximise visitor satisfaction and provide high quality visitor experience without destroying the environmental quality of the resources of the tourist site.

With the development of computer technology, wireless communication technology is also widely used in life

[1]. The currently existing wireless communication methods are Wi-Fi communication, cellular network communication, Bluetooth communication, etc. [2]. Wi-Fi communication is a wireless local area network (LAN) technology, which is widely used in the home, office, public places and other places. With the introduction of the Bluetooth 5.0 standard, Bluetooth communication has a bright development prospect as the most widely supported, powerful and reliable low-power wireless technology in the market. Many domestic research institutes colleges and universities have done a lot of research on low-power Bluetooth. Many companies are also researching the new features of Bluetooth 5.0, to be at the forefront of the times, so that Bluetooth technology is used in real life. Bluetooth communication has the advantages of small size, low power consumption, low radiation, and low cost, can be connected with a variety of devices, although its transmission distance is short, and small coverage, but enough to meet the test of the sensor required, and its signal source by the geographic environment has less impact, the transmission rate is not as fast as the Wi-Fi communication, cellular network communication, but it can satisfy the sensor's transmission index.

To study the application strategy of wireless communication technology in Huizhou Academy, this paper proposes the landscape visitor positioning system and wireless management system of Huizhou Academy based on ZigBee technology, and analyses the power consumption of the system as well as the transmission distance and other influencing factors; secondly, this paper analyses the effect of the system's application in Huizhou Academy and proposes the improvement strategy. It provides the theoretical basis and practical guidance for the application of wireless communication technology in the Huizhou Academy landscape.

Figure 1. Representative of Huizhou Academy: Zhushan Academy

LITERATURE REVIEW

In recent years, scholars at home and abroad have conducted a lot of research on the application of wireless communication technology in life. Chen Tianshu designed an information system based on ZigBee wireless communication technology for soil moisture monitoring, environmental meteorological monitoring and automatic water and fertiliser irrigation in farmland in response to the time-consuming and laborious traditional agricultural production process and the current situation of low yield, as well as the needs of the national high-standard farmland construction. The system mainly consists of sensors for soil moisture monitoring, air temperature and humidity detection, light intensity detection, CO2 concentration detection, CC2530 networking module, ARM embedded Linux server, and remote client, which is implemented flexibly to facilitate the construction of the system in the farmland, and the construction cost is low, and the modular design reduces the cost of maintenance in the later stage. Xia Guangliang [3] studied the ZigBee low-power wireless self-organising network technology and proposed to improve the signal propagation efficiency in the tunnel through the mesh network structure adaptive networking. Tests show that this networking technology can maintain a stable connection in long and curved tunnels. Lv Pin [4] discusses the main implementation methods of wireless communication technology, analyses the specific application of wireless communication technology in fire fighting and rescue, and studies the development trend of wireless communication technology in fire fighting and rescue. He Gang [5] firstly introduces the basic principle, key technology and development trend of wireless communication technology, and secondly expounds the composition, working principle and classification of automatic fire alarm systems. Again, it focuses on analysing the application of wireless communication technology in automatic fire alarm systems. Finally, some suggestions and countermeasures are proposed for the advantages

and challenges of wireless automatic fire alarm systems to promote the development and application of wireless automatic fire alarm systems. Lei Xueyi [6] The application of wireless communication technology in agricultural production is a reform and innovation of the agricultural production mode, which makes agricultural production free from the traditional management mode and promotes the development of agricultural production in the direction of intelligence. Based on this, the article takes intelligent agricultural irrigation as the centre and researches the practical application of wireless communication technology in it. Wu Hui [7] designed an underground fire automatic alarm system through wireless communication technology, using FPGA as the core control chip and ZigBee technology as the wireless communication protocol. Each wireless node is set up to configure an aerosol sensor, carbon dioxide sensor, display module, alarm module and wireless communication function module. The software design of the communication function of each wireless node gives a specific flow chart. The validation tests show that when a simulated fire occurs, the aerosol sensor on each node accurately monitors the fire and can alarm the fire in the form of video and sound through the display module and the alarm module, and the wireless communication module also sends the fire monitoring information to the host computer smoothly. Xun Wang [8] used an STM32F103C8T6 microcontroller as the core, equipped with sensor devices to achieve environmental quality monitoring data acquisition, used an ESP8266 Wi-Fi module for data transmission, and simultaneously developed an Android application to display the workshop environmental quality monitoring data. The above research mainly focuses on the application of wireless technology in life, and less on the application of wireless technology in scenic spots.

METHODOLOGY

Wireless Management System Design Based on ZigBee

By using the electronic tracking technology of the tourist positioning management system in Huizhou Academy tourist attraction, combining the wireless sensor network technology with the tourist positioning system, the relevant staff in the scenic spot can understand the specific location of tourists in real time. ZigBee is a recently popular short-range, low-rate wireless network technology, which has the characteristics of large network capacity, low power consumption, low cost, low data transmission rate, short network delay, high security and reliability. According to these, we use ZigBee technology to build a set of tourist positioning systems in tourist attractions and set up a wireless positioning network [9].

First of all, appropriate reference nodes of the wireless positioning network are arranged in the proper locations of the Huizhou Academy tourist scenic spot. CC2430 module is adopted. On the one hand, it can transmit and forward data, realize the routing function, and serve as the routing node of the wireless positioning network. On the other hand, the coordinator node is placed in the appropriate place in the scenic spot, which can collect the relevant wireless signals and finally transmit the collected information to the upper computer through the Ethernet, playing the role of a gateway node and the difference between it and the reference node is that its internal network expansion module is added [10], [11], [12], [13].

Secondly, let Huizhou Academy tourists entering the scenic spot wear a designed electronic tag as a positioning node. It uses the CC2431 module built-in positioning engine, and each electronic tag has a unique 16-bit or 64-bit ID address and geographic location information. After each tourist wears an electronic tag, the relevant information of the tourist shall be recorded in the data terminal library [14].

Finally, when tourists enter a scenic spot in Huizhou Academy, the electronic tag will be triggered [15]. The positioning node will start the built-in positioning engine for identification, and then the corresponding positioning information, tourist ID number, and other information will be transmitted to the gateway node through a certain number of routing nodes in a multi-hop way, and finally transmitted to the host computer database for corresponding processing through Ethernet [16], [17].

Examination of System Operation Effects and Influencing Factors

To study the application effect of the positioning and communication system proposed in this paper, Huizhou College was selected for testing to analyse the operation effect of the system as well as the influencing factors, which mainly include the stability of the system as well as the response speed of the system. It is mainly carried out in the form of scoring by visitors and staff. The influencing factors of the system operation effect are mainly divided into power consumption tests and transmission distance tests.

Power Consumption Testing of Zig Bee Based Wireless Management System

Low power consumption is an important performance indicator for wireless communication modules. In the paper, the power consumption of wireless transceiver module, the power consumption of wireless transceiver

module is tested in this paper.

1. Test conditions

Power supply: Battery power is used during the test.

Measuring instrument: a multimeter of UT58A.

2. Test method

Connect a multimeter in series between the battery power supply pin and the power input of the module under test, set it to current measurement and observe the measured current value.

Testing the Communication Distance of Zig Bee-Based Wireless Management System

Venue: Outdoor.

Weather: Breeze, Sunny, 25 °C

Conditions: Fix the transmitter and place it at a height of 20m, and move the receiver.

Testing the Communication Distance of Zig Bee-Based Wireless Management System

1. Test conditions

Power supply: Battery power is used for the test.

Measuring Instrument: UT58A multimeter.

Fix the transmitter and place it at a height of 20 metres, move the receiver: Fix the transmitter and place it at a height of 20 metres, move the receiver.

2. Test method

Connect the multimeter in series between the battery power supply pin and the power input of the module under test, set it to current measurement, and observe the measured current value.

Test Location: Outdoor Outdoor.

Test Weather: Weather Breezy, sunny, 25 °C/20 °C.

Study on the Application Effect of Wireless Gateway System

To test the operation of the system, this paper investigates the application of the system under study and conducts a questionnaire survey on 170 operating system staff of 10 scenic spots applying the system, which is designed to cover the scoring of the stability of the system as well as the response speed of the system, with a total score of 10 points. In the data collection stage, 170 questionnaires were collected and 150 valid questionnaires were confirmed after data cleaning and validation. Similarly, to test the application effect of the system, 200 tourists from a scenic spot were selected to score the system's stability and convenience wake-up. A total of 192 questionnaires were collected, and 150 valid questionnaires were confirmed after data cleaning and validation. Data preprocessing included removing missing values, eliminating outliers and data normalisation to ensure the quality and consistency of the input data. The stratified sampling technique was also continued to ensure that the data set was representative of the various assessment indicators and to maintain data diversity and consistency.

RESULTS AND DISCUSSION

Visitor Positioning and Communication System of Huizhou Academy Scenic Spot Based on Zigbee Technology

The system construction diagram is shown in Figure 2.

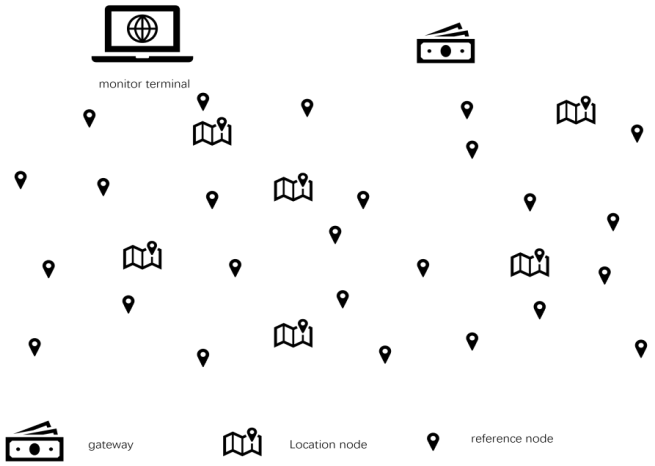


Figure 2. Schematic Diagram of Positioning System Frame

The location node is the electronic tag the tourist carries, that is, the terminal node. Tourists walk around freely in the scenic spot, so the terminal nodes are arbitrarily distributed in the scenic spot, and the terminal nodes communicate wirelessly with the routing nodes to achieve the transmission of positioning information. Reference nodes are static nodes reasonably distributed in scenic spots according to needs, that is, routing nodes [18]. After the location node transmits the location information to the appropriate routing node, the data is transmitted to the gateway node in a multi-hop mode using the radio wave relay mode. The gateway node can process the information transmitted by the routing node and then send it to the monitoring centre (host computer). The host computer can know the tourists' location information in real time [19].

Locate the Node

The CC2431 module designs the location node, whose built-in engine calculates its geographical location and then transmits the information to the gateway node. By collecting the received signal strength values of the reference nodes in an appropriate number of positioning areas, the positioning algorithm is used to calculate the geographic coordinates.

The essential points of locating nodes are as follows: Firstly, finding nodes must apply for joining the network and obtain the corresponding network configuration data to work and realize the wireless transmission of data. Secondly, it should enable the reference node to collect the received signal strength value during the communication between the positioning node and the reference node, calculate the average value, and then transmit it to the positioning node to provide data for the positioning node to calculate its position coordinates by using the positioning algorithm. Finally, the location node transmits its geographical location information and number information to the appropriate routing node, then sends it to the gateway through the routing node, and finally, sends it to the host computer [20], [21].

In addition, locate A node to ensure that the data configured for the node (such as A value, N value, mode, collection wait time, and minimum number of reference nodes) will not be lost when the system is powered off. If the location node is joining the network for the first time, the data is written into the flash. If it is not joining the network for the first time, the data stored in the flash is read out.

Reference Node

The reference node is designed with the CC2430 module, which is a known static node, and its coordinate value is fixed. The reference node should be reasonably allocated in the positioning area, and it will send its coordinates, RSSI average and other information to the positioning node [22]. The main points of its work are as follows: First of all, the reference node should be reasonably distributed in the scenic spot so that its communication range can cover the whole scenic spot. After the system is powered on, the reference node applies for joining the network, and the system allocates corresponding network data (geographical location coordinates, ID number and other information) to it [23]. After the system is powered off, these configuration parameters should not be lost. If the reference node is not added to the network for the first time, the system reads the corresponding configuration parameters from the flash. Secondly, when the reference node participates in the positioning calculation of the positioning node, a certain number of received signal strength values should be collected, and the average value should be sent to the positioning node so that it can calculate its geographical position. Finally, after the positioning node calculates its coordinate value, the corresponding information should

be transmitted to the nearby suitable reference node, and then the information is transmitted to the gateway in a multi-hop mode on the reference node [24].

Function and Design of Gateway

The gateway node is also designed with a CC2430 module, which should realize the function of establishing a wireless positioning network and wireless data sending and receiving. It is a crucial module in the system [29]. On the one hand, the gateway should receive the configuration data of each reference node and positioning node provided by the monitoring software and send it to the corresponding node in different ways. On the other hand, it also receives feedback data from each node, judges the effectiveness of the data, and transmits it to the monitoring centre [25].

The whole process control of the positioning system is realized by the control of string commands, and each function has corresponding string commands. The gateway involves relatively few string commands and is a central control station. The gateway processes the data sent from each node. These data include coordinate data length and coordinate data, string ID, node network address, operating system value, and effective data length.

Tourist Location Algorithm

According to the different positioning mechanisms, there are two types of positioning algorithms: range-based positioning algorithm and location algorithm without distance measurement. In the positioning algorithm based on the received signal strength indicator RSSI, the signal strength of the transmitting node is known, and the receiving node calculates the signal propagation loss according to the received signal strength [26], [27]. The transmission loss is converted into distance by the theoretical and empirical model, and the specific location of the node is calculated by using the existing algorithm. The theoretical value of the received signal strength RSSI can be obtained by the formula RSSI= -(10nlgd + A). Where n represents the signal propagation constant, also known as the propagation index; d represents the distance from the transmitter; and A stands for receiving signal strength at a distance of 1m. Therefore, the relationship between the attenuation of the wireless signal and the attenuation of distance pairs can be used for positioning calculation, that is, positioning algorithm. Because the distance d from the positioning node to the reference node is smaller, the distance error caused by the deviation of the RSSI value is smaller. When the distance is greater than a certain value, the distance error caused by the fluctuation of the RSSI value will be large. Therefore, when designing the positioning algorithm, a distance threshold D value is set [28]. When the distance d is greater than D, a positioning algorithm is adopted. When the distance d is less than D, another positioning algorithm is used, which can reduce the distance error and improve the positioning accuracy. This is the hybrid positioning algorithm based on RSSI proposed in this system, and its process is shown in Figure 3. Where MN is the positioning node, BN is the reference node, d is the distance between the positioning node and the reference node, and D is the distance threshold. This value is determined by field measurement. When the communication distance d between the positioning node and the reference node is less than D, the system automatically starts the curve fitting positioning algorithm after recognition and promptly corrects the communication distance d value. When d is greater than D, the system automatically starts the signal intensity distribution (sample value database) location algorithm after recognition and also corrects the d value [29], [30].

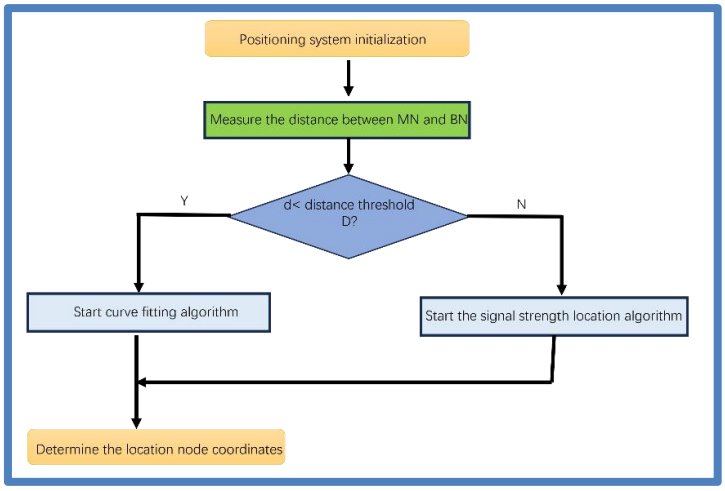


Figure 3. Flow Chart of Personnel Location Algorithm

Because the hybrid positioning algorithm is optimized according to the RSSI fluctuation law, it has the advantages of low price, high precision and a small amount of computation, but the disadvantage is that it takes a lot of work to build the database from the collected data. After consideration, this paper selects the hybrid

positioning algorithm, which can effectively improve positioning accuracy and is well applied to the tourist positioning system in Huizhou Academy scenic spot.

Power Consumption Testing of Zig Bee Based Wireless Management System

Low power consumption is an important performance indicator for wireless communication modules. The test results are as follows:

Test results

The corresponding current values when transmitting with four types of transmission power are as follows:

Table 1. Test Results

Output Power	-10dbm	-2dbm	6dbm	10dbm
Current Value	11.76mA	14.04mA	19.08mA	29.2mA

From P=UI,the power consumption of wireless transceiver module in four sending modes are 9.03mW,10.10mW,11.70mW,12.65mW respectively.

The 3.7V mobile phone battery is used to power supply, so that the NRF9E5 continuously sends data, and the current value is observed after 20 seconds of powering up.

The test results are as follows:

The corresponding current values when sending with the four transmission powers respectively are:

Table 2. Test Results

Output Power	-10dbm	-2dbm	6dbm	10dbm
Current Value	11.04mA	13.76mA	19.01mA	28.52mA

From P=UI,the power consumption of wireless transceiver module in four sending modes is 40.85mW,50.91mW,70.34mW,105.52mW respectively.

The 4.8V mobile phone battery is used to supply power, so that the NRF9E5 continuously sends data, and the current value is observed after 20 seconds of powering up.

The test results are as follows:

The corresponding current values when sending with the four transmission powers respectively are:

Table 3. Test Results

Output Power	-10dbm	-2dbm	6dbm	10dbm
Current Value	11.76mA	14.04mA	19.08mA	29.2mA

From P=UI,the power consumption of wireless transceiver module in four sending modes is 56.49mW,67.25mW,91.58mW,140.16mW respectively.

Using 4.8V mobile phone battery power supply, the wireless module is placed in the waiting state to receive, after 20 seconds of power-up, observe the current value of 15mA, then the power is 72mW.

Summary

The above were measured under the wireless transceiver module continuous transmission and continuous reception of the current value, compared with the above test results, the following conclusions can be drawn:

1. With the same 3.3V battery, the transceiver module consumes much less power to send data intermittently than it does to send data continuously.

2. The value of current consumption when sending data continuously is the average current value of the whole RF sending data, which is smaller than the theoretical value of current consumption when sending data given in the nRF9E5 chip manual, which is determined by the internal working mechanism of nRF9E5.

3. Test results show that the system has low power consumption.

Testing the Communication Distance of Zig Bee-Based Wireless Management System

Test results

Test 1

The test results of measuring the communication distance of the prototype for the four transmission power cases are as follows：

Table 4. Transmission Distance Measurement Results

Output Power	10dbm	6dbm	-2dbm	-10dbm
Gap	96.5m	63.5m	32.5m	12m

Test 2

The test results of measuring the communication distance of the prototype for the four transmission power cases are as follows:

Table 5. Transmission Distance Measurement Results

Output power	10dbm	6dbm	-2dbm	-10dbm
Gap	32.6m	18.7m	10.5m	3.2m

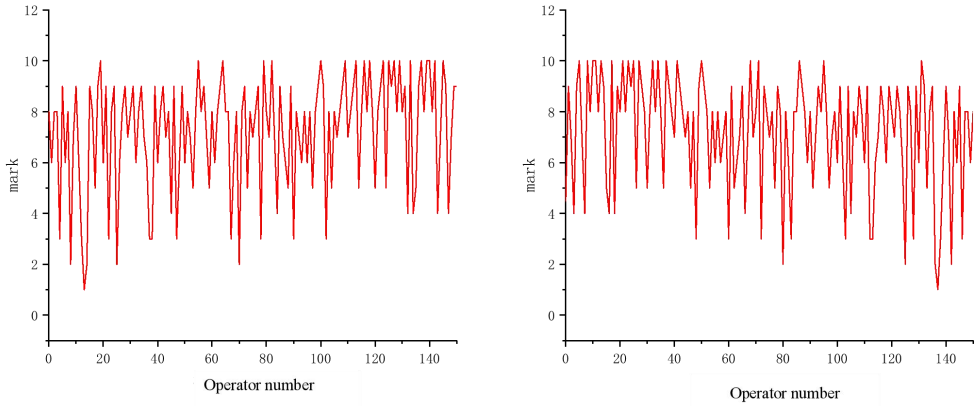
Summary

1. Wireless communication is affected by various external factors such as atmosphere, obstacles, multipath and other losses, so the actual measured transmission distance is often a certain gap with the theoretical value. In outdoor open space, the transmission distance is closer to the theoretical value. Compared with outdoor transmission, indoor transmission loss is more serious, with different floors, and different structures of the room, the impact of various losses on the transmission distance is not the same.

2. From the test results of this paper, outdoor non-complete open space transmission distance of up to nearly 100 metres, indoor transmission distance up to nearly 40 metres, and the nearest up to 3 metres, in line with the design requirements.

Analysis of the Operational Status of the System

The scoring of the system operation is shown in Figure 4. 80% of the operators scored more than 6 points for the operation stability of the system, and 26% scored more than 8 points; close to 70% of the operators scored more than 6 points for the response speed of the system, and close to 35% scored more than 8 points; thus it can be seen that the operation stability and response speed of the system can meet the requirements. However, it still needs to be improved. Through interviewing the operators who participated in the scoring, the main areas for improvement are as follows: the simplicity of the system's operation interface, the difficulty of the system's installation, and the suggestion of combining it with the monitoring system.

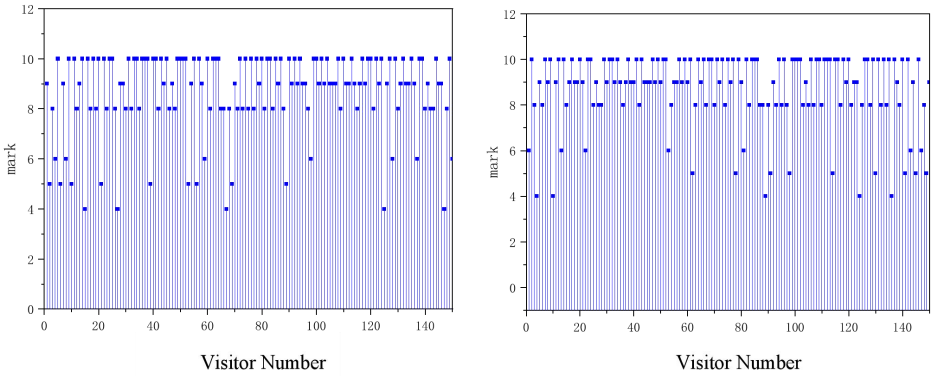


(1)Stability of the system (2)Speed of response of the system

Figure 4. Operator Rating Scores

Analysis of System Operation Effect

The scoring of the system's operation effect is shown in Figure 5, 86% of the tourists scored more than 6 points for the system's operation stability, and 80% of the operators scored more than 8 points; close to 92% of the operators scored more than 6 points for the system's convenience, and close to 80% of the operators scored more than 8 points; thus, it can be seen that the system's operation stability and convenience meet the requirements of the tourists. However, the system still needs to be improved. Through interviewing the tourists concerned, the main areas for improvement are as follows: the publicity of the system needs to be increased, as most of the tourists don't know that there is such a system, and the operation interface of the tourists needs to be more simple.



(1)Stability of the system (2)Ease of access to the system

Figure 5. Visitor Ratings

CONCLUSION

This paper proposes a visitor positioning system and wireless management system for Huizhou Academy landscape based on ZigBee technology, and analyses the power consumption of the system as well as the transmission distance and other influencing factors; secondly, this paper analyses the effect of the system's application in Huizhou Academy and proposes an improvement strategy. The main contents of this paper are as follows:

1. The wireless management system based on ZigBee is put forward, which adopts the intelligent wireless management system of human-computer interaction, which can effectively solve the problems of insufficient tour guides and loss of tourists in Huizhou Academy tourist attractions.

2. It can realize the wireless network, the regional personnel information statistics, management and location identification functions, and also complete the emergency search and rescue work. The system can also take corresponding measures according to the needs of different scenic spots and different occasions to effectively alleviate the problem of insufficient tour guides. It also features proprietary missing persons tracking and alarm models.

3. The test results of the prototype show that the reliable system operation and low power consumption reach the expected goal of the system design.

4. 80% of the operators scored more than 6 points for the operation stability of the system, and 26% scored more than 8 points; close to 70% of the operators scored more than 6 points for the response speed of the system, and close to 35% scored more than 8 points; thus it can be seen that the operation stability and response speed of the system can meet the requirements. 60% of the tourists scored more than 6 points for the system's operation stability, and 80% of the operators scored more than 8 points; close to 92% of the operators scored more than 6 points for the system's convenience, and close to 80% of the operators scored more than 8 points; thus, it can be seen that the system's operation stability and convenience meet the requirements of the tourists.

5. The publicity of the system needs to be increased, as most of the tourists don't know that there is such a system, and the operation interface of the tourists needs to be more simple; the publicity of the system needs to be increased, as most of the tourists don't know that there is such a system, and the operation interface of the tourists needs to be more simple.

ETHICAL DECLARATION

Conflict of interest: No declaration required. **Financing:** No reporting required. **Peer review:** Double anonymous peer review.

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