Research on Intelligent Alarm Garbage Processing System Based on Internet of Things

Xiaotong Zhao[1], Song Jia[2], Xiaoxia Yang[1*], Chengming Zhang[1], Hui Wang[1]

[1]*Shandong Agricultural University College of Information Science and Engineering, Taian City Shandong Province, China*
[2]*China Unicom Tai'an Branch, Taian City Shandong Province, China*

Abstract

The Internet of Things is the use of sensing technologies to obtain various parameters of objects, environmental information, and back-end data analysis and processing through various wireless communication technologies to enable intelligent control of the real world[1]. At the core of IoT is connecting objects to the network. The future of the Internet of Things is an artificial intelligence that perceives life and makes decisions about actions. It can integrate blockchain, artificial intelligence[2], wearable devices, robotics, augmented reality, autonomous driving, vehicular networking[3], drones and other technologies. As people's perceptions of fire safety have improved, fire accident detection and alarm technologies are gaining more attention. A set of smart garbage alarm processing systems based on the Internet of Things has been designed to address the problem of spontaneous combustion in garbage cans that cannot be extinguished in time and cause fires. The system is based on sensor detection technology, under the control of STM32 microcontroller control system, combined with LoRa communication technology[4] and GPS positioning technology, to achieve remote automatic alarm function[5]. This research on such a system has enabled intelligent alarm processing techniques based on the Internet of Things that can accurately and timely warn of fires and can be used for garbage can alarms in communities and other public places. It is a new type of Internet of Things-based fire alarm technology that can be used in garbage alarm systems in public places.

Keywords

Internet of Things;sensor;Real-time monitoring;single chip microcomputer;GPS;LoRa

1 Introduction

From the perspective of today 's social environment, there are some people who put unextinguished cigarette butts and other items with Mars into the garbage can, causing the spontaneous combustion of the garbage can, leading to the occurrence of fires and other problems, which brings great pressure to the urban environment and safety assurance. Therefore, the design of an intelligent garbage alarm system has become an urgent problem that needs to be addressed. This design takes STM32 single chip microcomputer as the leading controller, and realizes the smoke and temperature measurement of the garbage can by means of smoke sensor and temperature sensor. When the collected data information exceeds the set threshold, the sound and light alarm immediately works to realize the close alarm processing. At the same time, the information is sent through the LoRa module, so that the staff can immediately grasp the current situation of the garbage can, so as to take certain effective measures, and then complete the function of intelligent alarm. The system can be applied to community fire alarm systems with the advantages of simplicity of construction, low cost and high stability.

At present, Bu Y[6] and others have realized a fire alarm system based on 51 single chip microcomputer, through the setting of sensors and single chip microcomputers, when the smoke concentration and temperature of environmental reach a certain threshold, it will be fed back to the fire

AIoTC2022@International Conference on Artificial Intelligence, Internet of Things and Cloud Computing Technology
EMAIL: *yangxx@sdau.edu.cn (Xiaoxia Yang)

protection system, which solves the fire alarm system in fixed places. However, due to the lack of positioning devices, it cannot be applied to moving items such as garbage cans. Xu B[7]and others have realized a fire alarm system based on ZigBee technology, using ZigBee technology to send and receive fire information, but Zigbee technology is far less than LoRa in terms of wireless transmission distance and wireless penetration ability. See Table 1 for specific performance comparisons. Compared with similar devices, the system has realized multi-function, intelligence and automation, combined with the current situation of the product market, not only the equipment cost is low, but also can achieve the effect of timely alarm and timely treatment.

Table 1 Performance comparison between ZigBee and LoRa.

	LoRa	ZigBee
Transmission distance	Long distance (up to a dozen kilometers)	Short distance (10m - 100m level)
Transmission speed	0.3-50kbps	250kps in theory, less than 100kbps in practice
Frequency range	Sub-GHz (433,868,915MHz, etc.)	Unlicense band 2.4G

2 Research content

The research of intelligent alarm garbage processing system based on Internet of Things mainly includes the research of real-time monitoring system, GPS positioning system, communication system, single chip microcomputer control system and mobile terminal function.

2.1 Real-time monitoring module

The research of real-time monitoring module mainly includes the research of real-time monitoring of smoke concentration and real-time monitoring of temperature. The module is combined with the ground sensor network to comprehensively analyze the running condition and status of the equipment, so as to realize the function of real-time monitoring. For the development of this module can promote cloud computing, big data and other new generation of information technology applied to fire safety work, which is conducive to the realization of fire rescue and fire prevention of scientific, accurate, improve the fire safety equipment monitoring system intelligence and automation level. The real-time monitoring and intelligent early-warning system is connected with the fire control remote monitoring platform, so as to further study the implementation scheme of data fusion technology to realize real-time monitoring and information transmission.

2.2 GPS positioning module

The research of GPS positioning module mainly includes the research of automatic navigation system for GPS positioning, including position analysis, real-time positioning management and precise navigation of GPS positioning information, and how to ensure the accuracy of positioning on the basis of positioning. In addition, it is necessary to realize the path planning of the receiving position and the sending position, such as the combination of vehicle information service and positioning tracking service in smart city and smart countryside, tracking management in logistics, accurate positioning in agriculture, real-time monitoring of geological disasters and meteorological conditions.

2.3 Communication module

The research and application of the communication module mainly includes how to intelligently process and reliably transmit the information such as smoke concentration and temperature in the garbage can, and send it to the remote terminal in low power consumption, long distance and in time. The staff of the remote fire monitoring platform can predict and process the data transmitted by the communication module to realize intelligent monitoring and timely control, so as to ensure the accuracy, high efficiency and reliability of information transmission.

2.4 Single Chip Microcomputer control module

The research and application of single chip microcomputer control module mainly include overall perception, intelligent processing and reliable transmission. The branch transfer ability, logical operation of I/O port and position processing ability of alarm system are realized. While integrating resources, setting functions and initializing modules of the whole system, the whole peripheral circuit is controlled to make each system module run smoothly and efficiently. Real-time monitoring and intelligent control can be achieved through the above application while utilizing smoke and temperature sensors.

2.5 Mobile intelligent terminal module

The research and application of mobile intelligent terminal module mainly include how to realize the monitoring of remote equipment through the software design of the received information, so as to ensure the safety and high efficiency of garbage can alarm. Mobile intelligent terminal module integrates smoke concentration display, temperature information display, alarm reminder, docking remote fire platform and other functions to ensure the normal operation of the system.

3 System principle

The intelligent alarm garbage processing system based on the Internet of Things uses smoke and temperature sensors to monitor the garbage in the garbage can in real time, so as to avoid the occurrence of fire caused by the spontaneous combustion of the garbage can. The project is based on real-time monitoring technology, using positioning technology and communication technology to achieve the effect of timely alarm. In order to ensure the performance of the system, the power supply part of the system adopts AC step-down, and supplies power to the system through voltage stabilization, rectification and filtering. See Figure 1 for a schematic diagram of this system.

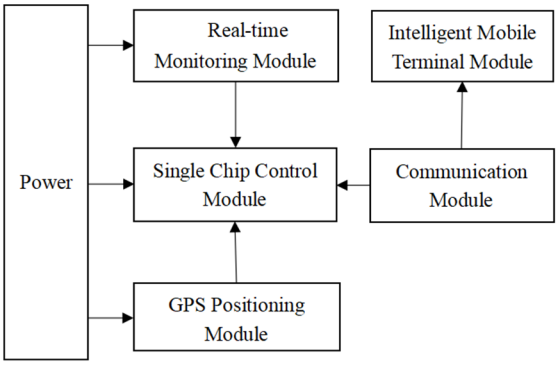

Figure 1 The schematic representation of the system.

Real-time monitoring module includes smoke concentration detection module and temperature monitoring module. The photoelectric smoke sensor is used in the smoke concentration detection module. The function of the photoelectric smoke sensor is to realize the fire prevention function by

detecting the concentration of smoke in the environment. It is an advanced, stable and reliable sensor. It has also been widely used in various fire alarm systems, including public places, smart homes. The performance is far superior to most of the gas-sensitive resistance fire alarm sensors. This temperature detection module adopts DS18B20 temperature sensor[8]. This sensor outputs digital signals and is characterized by low overhead, high accuracy, small size and strong anti-jamming capability. Under the premise of setting the smoke concentration and temperature threshold by the single chip microcomputer, the photoelectric smoke sensor and the DS18B20 temperature sensor are detected in real time. Once the preset threshold is reached or exceeded, the alarm is sent to the single chip microcomputer and the smoke concentration and temperature information are sent.

LoRa communication module is adopted in the communication module. LoRa is a long-distance radio, which is a low-power, LAN wireless standard, and also a modulation method based on spread spectrum. The corresponding sensitivities of different spreading factors are shown in **Table 2**.

Table 2 The corresponding sensitivity of different spread spectrum factors in LoRa system.

SF	Spreading Factor	S/NR.(dB)	Eb/Nb. (*dB*)	Sensitivity. (dBm)
7	128	-9.0	4.6	-125
8	256	-11.5	4.5	-127.5
9	512	-14.0	4.5	-130
10	1024	-16.5	4.6	-132.5
11	2048	-19.0	4.7	-135
12	4096	-21.5	4.8	-137.5

LoRa modulation signal usually adopts rising linear frequency modulation, and its frequency function is expressed as a piecewise function in a signal period. The LoRa signal frequency function can be expressed as:

$$f(t) = \begin{cases} \mu t + f_0, & 0 \le t \le T_0 \\ \mu t + f - B, T_0 \le t \le T \end{cases}$$

In the formula: f (t) is the signal frequency function; t is the effective duration of the signal; $\mu>0$ represents rising linear frequency modulation; f_0 is the initial frequency after modulation; B is the LoRa signal bandwidth. The time-varying frequency of the LoRa signal corresponding to the formula is shown in **Figure 2**.

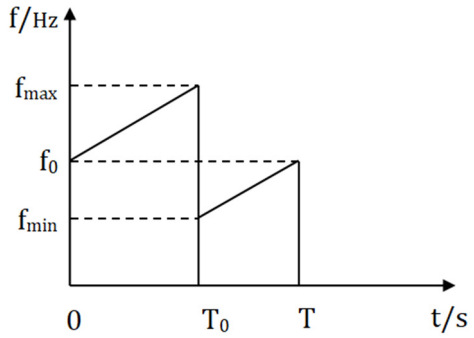

Figure 2 LoRa signal frequency change diagram.

Under the same power consumption condition, it can spread farther than other wireless methods, which is its biggest feature. It achieves both low power consumption and long-distance transmission. It can expand the distance by 3-5 times compared with other traditional radio frequency communication under the same power consumption. Under the control of the single chip microcomputer, the LoRa transmitter sends the information in the garbage can, including smoke concentration information, temperature information, and location information, to the remote mobile terminal in time for remote alarm and early treatment of the spontaneous combustion of the garbage can.

The positioning module uses GPS positioning device, which is a kind of radio frequency chip module integrated in the motherboard. It can communicate with the global positioning system of the United

States and realize positioning and navigation functions without consuming traffic. Moreover, the manufacturer of GPS chip has signed an agreement with the operator. All devices equipped with GPS modules can communicate with GPS synchronous satellites anywhere, anytime, and for free.

The single chip microcomputer control module uses STM32 MCU[9], which is a powerful and cost-effective single chip microcomputer, and has a good performance in power consumption and integration. The STM32 single chip microcomputer control module includes setting the alarm threshold of the photoelectric smoke sensor and the DS18B20 temperature sensor, controlling the GPS positioning module to obtain the position information, and sending the smoke concentration information, temperature information and position information through the transmitter of the LoRa communication module to the remote mobile terminal for remote alarm. At the same time, the module is also equipped with a sound and light alarm, after receiving smoke, temperature and other alarm information, immediately send out sound and light signals for close alarm.

The mobile intelligent terminal module mainly receives alarm information such as smoke and temperature on the mobile terminal, and connects with the fire remote monitoring platform. The information sensed by the sensor is sent to the mobile intelligent terminal of the staff through the LoRa transmitter under the control of the single chip microcomputer control module, and the staff is reminded in time, so that the staff can receive the smoke and temperature information in time and make the corresponding processing strategy, so as to carry out timely fire extinguishing and avoid the happening of the fire to bring unnecessary security hidden danger.

4 Hardware design of the system

The hardware part of the system circuit consists of several circuits: smoke, temperature sensor circuit, STM32 single chip microcomputer control circuit, GPS positioning module circuit, LoRa communication module circuit. In order to facilitate circuit design, the output signals of various sensors are relay on-off signal. The LoRa module is connected to the microcontroller via a UART communication serial port. (UART is a full-duplex, asynchronous, serial communication protocol, which is widely used in the field of embedded technology.)

The microcontroller of the system adopts STM32 microcontroller, which has the characteristics of high performance, low cost and low power consumption, and is suitable for embedded development. The hardware of the system uses the wiring principle of double-layer boards, and most of the components are packaged in SMD (Surface Mounted Devices) patches to reduce the volume of the PCB board. Because the system involves some RF circuits, in order to enhance the electromagnetic compatibility of the system, the digital circuit part and the radio-frequency circuit part are isolated during PCB layout.

5 Software design of the system

The main function module of the intelligent alarm garbage processing system software based on the Internet of Things is to initialize each module through the remote mobile terminal control single chip microcomputer. Among them, the real-time monitoring module is used to initialize the smoke concentration sensor and temperature sensor and determine the threshold to complete the information monitoring function; the communication module is used to initialize the LoRa transmitter and receiver to complete the information transmission function; the positioning module is used to initialize the GPS locator to complete the positioning and navigation functions, ensuring real-time and accuracy. The mobile terminal module is used to realize the real-time monitoring of the device and the operation of various practical functions through smart mobile terminals such as mobile phones to ensure the efficient operation and safe use of each function.

6 Experimental analysis

In order to verify the accuracy and timeliness of the alarm system in this paper, the experimental object is selected in a community, and the ZigBee alarm system is selected for comparative analysis

with the alarm system. Among them, the lower limits of the smoke concentration features for the fire alarm, temperature alarm threshold and other systems are 25 percent, 25 percent and 5 percent, respectively, and the smoke, temperature alarm limit is 1 percent. The experimental results are shown in **Table 3**.

Table 3 Comparison of alarm time and accuracy of two systems.

check point	ZigBee alarm system		This alarm system	
	Alarm time/s	Accuracy/%	Alarm time/s	Accuracy/%
1	6.9	88	2.3	93
2	5.6	90	1.9	96
3	5.8	82	2.4	92
4	6.7	85	2.6	95
5	6.2	87	1.2	94
6	6.2	80	2.5	97

As can be seen from **Table 3**, the detection time of different detection points of smoke concentration in the area is significantly lower than that of the ZigBee alarm system. Among them, the alarm time of this alarm system is 3 to 5 s faster compared to the ZigBee type. In Table, the detection accuracy of this alarm system is 5 to 10 percent higher than that of the ZigBee type automatic alarm system, indicating that the system can accurately detect the garbage fire situation and achieve timely and accurate alarm.

7 Conclusion

The system makes full use of the information transfer between the sensing layer, the network layer and the application layer using IoT technology. Combined with the demand for such products in today 's society, the system meets the needs of the construction trash can alarm system. It enables real-time monitoring of the spontaneous combustion of garbage cans and automatic remote alarm functions, and can fully exploit the role of intelligence and automation. It can be alerted in a timely manner and dealt with in a timely manner, so as to avoid as much as possible the occurrence of fires caused by spontaneous combustion of garbage bins, thus reducing financial losses, avoiding casualties and protecting the living environment.

8 References

[1] Xu Y and Wang Y 2020 Design and research on intelligent control system of intelligent agriculture based on internet of things.J. Agriculture of Henan, 2020(20) :63-64

[2] Ye N 2021 Research on intelligent baggage security check system based on internet of things and artificial intelligence technology.J. Wireless Internet Technology, 18(04): 16-17+60

[3] Xiong F and Mei G 2022 Application of space-based internet of things in vehicle networking.J. Digital Communication World, 2022(04):72-74

[4] Qi B, Hu B and Wang X 2021 Design of wireless fire alarm system based on lora and gprs.J. Fire Science and Technology, 40(02):242-245

[5] Ruan C, Li Q, Zeng D, Yang J, Li Q and Wu H 2021 Design and implementation of intelligent smoke alarm control system J. Journal of Heilongjiang University of Technology(Comprehensive Edition), 21(09):48-53

[6] Bu Y, Guo J and Liu H 2021 Design and implementation of intelligent fire alarm system based on 51 mcu.J. Journal of Qilu University of Technology, 35(04):53-58

[7] Xu B and Wei L 2022 Design of fire alarm system for distribution low-voltage electrical appliances based on zigbee technology.J. Electrical Appliances, 2022(07):47-50

[8] Jia H 2021 Design of intelligent temperature measurement system based on ds18b20.J. Computer Knowledge and Technology, 17(09):251-252

[9] Zhu S and Liang J 2021 Design of narrowband internet of things oven based on stm32.J. Computing Technology and Automation, 40(02):25-30