Application of Internet of Things Technology in Forest Fire Warning of Jizhou District

Junde Han*
Tianjin Agricultural University, Tianjin, China

*Corresponding author e-mail: robert1362@163.com

Abstract. With the IoT technology as the entry point, this paper designs the general plan for the IoT-based forest fire warning & monitoring system of Jizhou District, through the analysis of the application of IoT technology in the forest fire prevention of Tianjin; builds the workflow of the IoT-based forest fire warning system; and put forward the suggestions and countermeasures for the development of forest fire warning system in Jizhou District, thus providing theoretical basis and realistic foundation for improving the efficiency of Tianjin forest disaster prevention and mitigation.

1. Introduction

Tianjin, has a relatively small total amount of forest resources. From the topography and landform, it is located in the area where the terrain is transmitting from northern and northwestern mountains to the plains. The main forest areas are concentrated in the northern Jizhou District. Jizhou District is also known as the “Back Garden of Tianjin”, which is the main leisure and entertainment place for Beijing-Tianjin citizens; and is also the main water source and ecological conservation area of Tianjin. Therefore, the forest resources of Jizhou District play an irreplaceable role in the ecological, economic and social development of Tianjin, and they are important resources to maintain the regional ecological balance, develop the regional forestry economy and thus promote the development of northern mountainous areas.

At present, forest fires are the main disaster that threaten forest resources. Preventing and reducing forest fires is one of the most important tasks in forest disaster prevention and mitigation to protect forest resources. The forest areas of Jizhou District has a large coverage, where there are a large number of tourists in addition to permanent residents. As they are located remotely, without convenient transportation, and most of the areas are less guarded or only guarded by a few people. especially the spring and autumn last long in Tianjin, the wind is strong and the weather is relatively dry. Once a fire breaks out, the situation will be difficult to control if not discovered in time. Conventional monitoring measures like manual patrols and observation towers have disadvantages like low efficiency, and inaccurate and untimely detection results, which will bring many unpredictable obstacles to forest fire fighting. For example, the conventional forest fire monitoring and rescue process information is scattered and disorder, failing to form a system, so it will cause a lot of troubles for decision-making, and a waste of manpower and material resources. With the IoT technology, the forest fire monitoring, warning, and rescue processes will be integrated. Through the introduction of technology, the existing forest fire prevention resources can be integrated to achieve the platform management, thereby improving the fire monitoring efficiency, and reducing the fire-fighting costs. The IoT technology can effectively capture and analyze forest fire information, and
realize the high-efficiency discovery of forest fires through data collection and mining, with the advantages of accurate positioning as well as flexible and automatic processing, greatly optimizing the forest fire monitoring process. Based on the IoT technology, the environmental factors like temperature, humidity, illumination intensity and smoke concentration of the forest can be tested and tracked using the Zigbee wireless sensor network; the remote data can be transmitted via GPRS data communication and existing communication networks, and then the analyzed and processed data can be transferred to the system platform, achieving timely and accurate acquisition, sharing and feedback of forest fire information. In this way, the human, property and material resources may be allocated rationally in the whole forest fire monitoring process, meeting such requirements for the forest disaster prevention and reduction that “Prevention should come first, to ensure timely detection, accurate locating and automated decision-making, so that forest fires are the eliminated in the bud. With the new technology proposed in this paper, the three-dimensional benefits of forest resources will be fully achieved, thus better serving the people of Tianjin.

2. General Plan of the IoT-based Forest Fire Warning Monitoring System

The IoT-based structure system consists of three main components, i.e. the sensing layer, the information transmission layer, and the actual application layer. As shown in Fig. 1: The sensing layer mainly achieves information sensing and acquisition, and it is composed of a sensor, a controller, an acquisition controller, and an edge gateway, functioning in data acquisition, communication, and collaborative information processing. In the forest fire prevention system, the main tasks are to acquire the information about temperature, humidity, illumination intensity, as well as wind speed and precipitation. The sensing layer mainly adopts RFID technology to realize intelligent management like forest environmental information labeling and automatic identification. The ZigBee detection nodes are scattered within the scope of the detection area according to the actual geographical environment, and they are responsible for the capture of meteorological information data, and realizing the timely communication between nodes in a collaborative manner based on interconnection and intercommunication. Besides, this technology also has the advantages of low transmission rate of information, short transmission distance, low cost, safe and reliable performance, thereby, satisfying the normal operation requirements of the equipment under the harsh natural conditions of the forest area. In the forest fire warning system-sensor module of this project, the 50L gas concentration sensor, HM1350 temperature and humidity sensor; PSWS/WD-mode wind speed and direction sensor are used to acquire forest environment information; and in the information processing module, the MSP430 chip is used; and the power module adopts solar panels to solve power supply problems in remote regions.

The information transmission layer supports that the data information acquired by the sensing layer securely is securely and reliably transmitted to the background control system, without being obstructed. This project adopts optical cable transmission and the public communication network of the local mobile operator is selected, and accessed to the Internet, which can effectively reduce the communication cost, achieve the timely and reliable transmission of data, and improve the operation efficiency of the project. The forest areas of Jizhou District are generally located in remote regions, and the power supply at the detection site is a major bottleneck restricting the operation of equipment. The existing battery device has a large operating load so its service life is greatly reduced. In this project, a reasonable access control policy is configured, to limit the time interval for receiving the data from the detection nodes, so that the detection nodes will be automatically activated when data acquisition is required, and the device will automatically enters the sleep state once the information acquisition is completed. In this way, it is ensured that the detection nodes will not send real-time data when there is responding warning information, and when a fire warning occurs, the system can send an information query command to a specific node through the integrated management platform, to acquire all the information of the node in real time.
The actual application layer is the central system for forest fire prevention. It can enable the firefighters to arrive at the site quickly and make a rapid judgment to put out the fire promptly based on the collection acquisition, and the automatic decision-making system's fire analysis such as identification of fire severity, classification, analysis and processing. The application layer is a human-computer interaction interface, the key to realize the sharing and interworking functions of subsystems, and the basis to realize the functions of the other layers.

3. Composition and Workflow of the IoT-based Forest Fire Warning System

3.1 Composition

The sensor-based forest fire warning system is an example of application of the IoT technology in forest fire prevention, and it involves various technologies such as sensing technology, geographic information system and artificial intelligence. With the all-weather, digital and full-coverage features for protection, development and utilization of forest resources, it can really achieve the purpose of “early discovery, and early extinguishment” according to the prevention and control combination principle for forest fires. This system consists of four components, i.e. the fire detection sensor network, the fire protection base station, the mobile auxiliary system and the GIS warning platform. The fire detection sensor network is deployed according to the actual topography, and it can detect the information of the early-stage fire with the affected area of less than 1m² within 100 meters within 10 seconds, send fire information to the neighboring detectors through wireless communication, and achieve jump transmission automatically in the network in the “relay” mode, until the fire information...
is transmitted to the fire base station, and then remotely transmitted wirelessly to the GIS warning system by the fire base station via GPRS, so that the site fire situation is finally presented in a three-dimensional electronic sand table map via the background management system.

![Forest Fire Sensor Network Warning System](image)

**Fig.2 Forest Fire Sensor Network Warning System**

### 3.2 Workflow of the System

The workflow of the sensor-based forest warning system is as shown in the figure: When the sensor detects the corresponding fire information, the small weather station can find the fire with the affected area of no more than 1 m² within the detection window within 20 seconds, and send the fire location information to the fire warning base station with the shortest transmission path by the neighboring detectors in the mode of wireless jump transmission. Then, the fire warning base station will send the fire location information to the GIS warning system platform and the background SMS service platform through GPRS and the dedicated network while making sound and light alarm. Next, the background SMS service platform will send the SMS alarm to relevant personnel. The command and management personnel receiving the alarm message can view the site map through the GIS warning system service platform, and they can also watch the live video sent back by the relevant mobile video assistant system, so that they can command the rescue in combination with fire prevention plan.
4. **Suggestions and Countermeasures for the Development of Forest Fire Warning System of Jizhou District**

First, the construction of the integrated platform for forest fire warning management requires long-term and continuous investment.

The forest fire prevention intelligent monitoring system is a complex system involving various aspects such as technology, management, talents, training, etc. It has the characteristics of large investment, high technical standards and complex maintenance at the later stage, especially for the projects covering a wide area and with multiple levels, professional knowledge and rigorous attitude are more required to build the system. The system involves modern audio and video compression technology, network communication technology, computer control technology, streaming media transmission technology, data acquisition technology, GIS technology and so on. The introduction, digestion, absorption and application of technologies is a long-period process, which must be constantly supplemented and improved according to actual needs. Besides, after the system is established, it is required that multiple systems work in the interlocked mode to realize the real-time monitoring and warning of forest fires and forest security. The front-end information acquisition system is used for real-time data acquisition, and the background assistant decision system and the integrated command system are responsible for the fire point location, allocation of human and material resources, as well as the scientific and rational planning of rescue routes to ensure the forest fire is detected timely, and eliminated as early as possible, so that the forest resources are protected effectively. This requires all the forest fire prevention intelligent platforms achieve interconnection and information sharing based on the same platform, which needs to be gradually realized through the construction of the system.

Second, the efficiency of the forest fire warning system is the result of a combination of multiple factors.

The forest fire warning system is a very complicated system, and it requires a professional and rigorous scientific attitude in the building and integration of the system. What’s the most important is to establish a professional man-computer team with the advanced IoT warning device as the basis, and a majority of professional forestry workers as the support, of which, the technology, system and management determine the operational efficiency of the whole system. The technical system of the forest fire warning system requires a huge system that performs acquiring, transmitting, controlling, displaying and comprehensively monitoring and managing on the video, audio and other related data. In particular, the information integration technology is the key to realize the effective combination of software and hardware and complete quick and efficient warning and disposal, where, the biggest
difficulty is to achieve the effective combination of analysis software and hardware acquisition information; and,

Third, we should gradually establish a multi-level collaborative warning system; determine the main framework for the IoT-based forest fire prevention intelligent monitoring and management system, based on the current situation of disaster prevention in forest areas of Tianjin, with the intelligent monitoring and drone as the main line, combining with the sensor technology, network technology, image technology and database technology, in light of the present status of environmental monitoring equipment, electrification and network, considering from the basic requirements for fire prevention in forest areas; promote the integration of forest fire prevention systems; establish the architecture with the geographic information system and Beidou navigation system as the base, and the alarm answering and verification, decision-making assistance, command and dispatch as the main line, face the multi-level forestry fire prevention departments of the state, provinces and cities; integrate various forestry fire prevention resources data; link various stages of fire monitoring, emergency guarding, fire alarming, emergency response, fire elimination, and post-disaster reporting for fire emergency; and provide emergency simulation training, thereby achieving the forestry fire prevention management mode of “normal and emergency combination, rapid response, and multi-level collaboration” based on a map for forestry fire prevention.

References

[1] Wang Dong et al. Design of Big Data-based Forest Fire Prevention Management System [J]. Journal of Central South University of Forestry & Technology, 2017, 37(11): 30-37.

[2] Lin Ping, Peng Xujian, Zheng Huaibing, et al. Discussion on the Construction of Forest Fire Prevention Law System [J]. Forest Fire Protection, 2017 (1): 1-4.

[3] Xu Ruifen. Research on the law of forest fire occurrence in Wanxian County, Sichuan Province[J]. Journal of Geographical Sciences,2007,(10):60-62.

[4] Lu Yuan. Discussion on the problems in forest fire prevention in Liaoning Province [J]. Inner Mongolia Forestry Investigation and Design, 2016, 39(6): 84-85, 87.

[5] Li Cheng. Discussion on Effective Prevention of Forest Fires [D]. Beijing: Beijing Publishing House, 2013.

[6] Wang Mingyu. Key Parameters and Methods for Designing of Fire Protection Forest Belts in North China[J]. Forest Fire Protection, 2012(4): 87-89.