“Open space” integrated mangrove intelligent monitoring platform based on the Internet of Things

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Abstract: In order to comprehensively promote mangrove restoration, this paper developed a set of “open space” integrated mangrove intelligent monitoring platform based on the Internet of Things, in order to solve the problems of traditional mangrove monitoring technology, such as simple means and small scale. The platform built LoRa Mesh AD hoc network and NB-IoT Internet of things to collect and transmit mangrove wetland environmental data, developed the upper computer website and the lower computer control system for real-time monitoring of environmental sensor data, and carried out imaging hyperspectral load with UAV to collect mangrove plant species and distribution and perform spectral analysis. It aims to use information technology to help the construction of ecological civilization, and contribute to fully supporting Zhanjiang to build a “mangrove city”. The test results show that the data transmission is normal, the hyperspectral image picture is clear, the PC analysis is complete, the abnormal environmental data alarm is accurate and rapid, and the control system responds in time.

Key words: Internet of Things; Mangrove; Hyperspectral; Data acquisition; Intelligent monitoring system platform

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1. Introduction

Zhanjiang is located in the southernmost part of mainland China, with a coastline of 2023.6 kilometers. There are 6,398.3 hectares of mangroves distributed in Zhanjiang, accounting for 23.7% of the total area of mangroves in China and 60.1% of the total area of mangroves in Guangdong Province. Moreover, Zhanjiang Mangrove National Nature Reserve is the nature reserve with the largest area and various species of mangroves in China. However, due to the development of industrial and agricultural production and the increase of population, the ecological environment of mangrove wetland has been seriously polluted and destroyed, so the restoration of wetland and environmental protection are urgent.

At present, there are many problems in the traditional mangrove monitoring in Zhanjiang: (1) Mangrove monitoring is often conducted by human resources with the help of geographic information, remote sensing and other technologies; (2) Lack of long-term and systematic monitoring on a large scale; (3) there is no mangrove monitoring system and monitoring network for the integration of open space.

To solve the above problems, this paper proposes a set of “open space” integrated mangrove intelligent monitoring platform based on the Internet of Things, which solves the problems of traditional mangrove monitoring technology and means of simplification, small scale and insufficient systematization, and helps the mangrove restoration work in Zhanjiang City.

2. The system function design

This system is based on the Internet of Things technology, STM32F103ZET6 as the control core, through LoRa Mesh networking, NB-IoT transmission to build “open space” integrated mangrove intelligent monitoring platform, DJI M300 is equipped with Nano-Hyperspec micro airborne hyperspectral imager, Collect mangrove plant species and distribution and other environmental data, through ENVI software for hyperspectral analysis, set visualization, environmental sensing detection, hyperspectral imaging and spectral analysis technology in one mangrove monitoring system.

3. System design

This system is mainly composed of lower computer, airborne hyperspectral equipment, upper computer three parts. The lower computer includes the main control CPU unit, sensor module, communication module, etc. The airborne hyperspectral equipment includes UAV module and hyperspectral imager module; The upper computer web page is deployed in Alibaba Cloud server. The system composition is shown in Figure 1.

3.1 system lower machine design

The lower computer program is deployed in the main control unit STM32F103ZET6, which will complete the collection, processing and upload of ground environmental data and water quality parameters. The ground environment data is mainly collected and uploaded by soil moisture sensor, soil pH sensor, etc. The water quality parameters are mainly collected by temperature sensor, pH sensor, water turbidity sensor, dissolved oxygen sensor, etc. The data of each area is transmitted to the gateway by LoRa, and the data summary is uploaded to the platform by NB-IoT module.

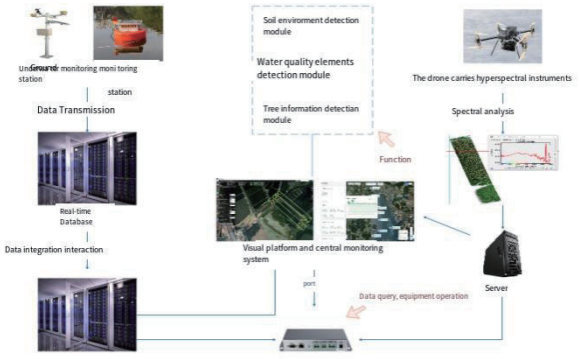

Figure 1 System composition

1. Main control CPU

This system uses STM32 single chip microcomputer as the data acquisition control unit, which can easily communicate with other controllers or sensors. In addition, in order to meet the memory requirements of the whole system, the main control chip STM32F013ZET6 is selected. The main control CPU has high data processing capacity and fast running speed, and can provide enough storage space to save historical data and configuration information. After the data is collected by the master chip, it is transmitted to Alibaba Cloud through NB-IoT Internet of Things technology to realize the visualization of real-time environmental parameters.

2. Sensing module

The sensor module mainly measures the ground environment parameters such as soil moisture, soil pH value and water quality parameters such as temperature, pH, water turbidity, salinity, dissolved oxygen and heavy metal content of mangroves in the installation area of the lower machine.

3. Communication module

Mangroves are usually distributed in places with complex ecological environment. Considering the uncertainty of environmental factors and the demand for long-distance transmission, this system chooses NB-IoT cellular network as the communication scheme between the lower computer and the upper computer. NB-IoT is a narrowband Internet of Things technology, which has the characteristics of long distance transmission, low power consumption and the ability to penetrate physical barriers, and can provide stable and reliable communication capabilities in the complex mangrove ecosystem.

3.2 Airborne hyperspectral equipment

The airborne hyperspectral equipment mainly consists of the UAV module and the hyperspectral imager module. The UAV DJI M300 is equipped with the Nano-Hyperspec micro-airborne hyperspectral imager to capture images of mangrove trees in high resolution, high spectral resolution and a wide range of spectral bands. To track and monitor the distribution status of mangroves, the species of mangroves and the development and utilization status of shorelines in a long time series, so as to comprehensively grasp the status of mangroves and their changes.

1. Uav module

This system uses the UAV DJI M300 as the UAV module, DJI M300 has the advantages of high stability, high efficiency, long endurance and so on, can fly stably in the complex terrain environment; The sustainable flight time is as long as 55 minutes, which can complete a large number of data acquisition work in a flight; Wind resistance level 7, and high-quality data can still be obtained under level 5 wind.

2. Hyperspectral imager module

This system uses Nano-Hyperspec as the hyperspectral imager module, its spectral range is 400-1000nm, the number of spectral channels is 270, the spectral sampling rate is about 2.2nm/pixel, the number of spatial channels is 640, the optical system adopts the coaxial reflection convex holographic grating splitting technology. The instrument does not contain any moving parts inside, and the imaging shot by external scanning not only greatly improves the signal-to-noise ratio of the system, reduces the interference of signal-to-noise ratio and stray light, but also can be used in a variety of harsh environment.

(3) Design of the upper computer of the system

The host computer is the core control unit in the control system. The host computer website of this project is deployed on Ali Cloud server. The front end mainly uses Vue framework for data display, and the visualization part uses ECharts framework to realize diversified chart display. The back end uses Springboot framework to provide Resful interface, and uses MyBatis plus framework to implement persistence layer and interact with MySQL database. Through NB-IoT technology, the hardware side can upload the data to the server, and the client side can receive the data from the server, so as to realize the data transmission between software and hardware.

4. System test and testing

4.1 Data reception

After the client is started, the platform will automatically connect to the server, receive the data sent by the server, and convert the data

into Json format through the back-end processing, so as to analyze real-time data, including real-time water quality data and geological real-time data, etc. After the test, the analyzed value is complete and can be normally displayed on the front end.

4.2 The system PC test

The upper computer can visualize the real-time water quality data, geological real-time data, UAV real photo, spectral analysis map and other information collected by the sensor of the lower computer, which can greatly help users avoid risks, effectively master the changes of mangrove ecology, and provide data basis for the development of mangrove protection work. When there is an abnormal phenomenon, the system will alarm, and remind the user of the abnormal occurrence start time, abnormal equipment id, abnormal description and whether to solve the information, so as to facilitate the management personnel to improve the mangrove ecological environment in time, make the mangrove grow in a suitable environment, so as to achieve standardized management. The real-time monitoring test of the upper computer is shown in Figure 2.

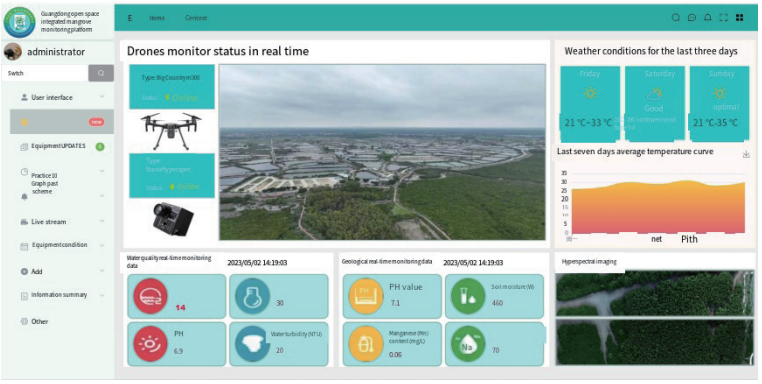

Figure 2 Real-time monitoring test of the upper computer

5. Conclusion

The “open space” integrated mangrove intelligent monitoring platform based on the Internet of Things in this system includes login module, data acquisition and transmission module, data visualization module, abnormal alarm reminding module, etc., which is characterized by tracking and monitoring the distribution status of mangroves and the dynamic changes of mangrove plant species in a long time series through airborne hyperspectral instruments, with the data acquisition module of the lower computer. Monitor environmental parameters, and fully grasp the status and changes of mangroves. Through LoRa Mesh AD hoc networking and NB-IoT wireless sensor module, the reliability of the work meets the protocol requirements, realizes wireless transparent transmission of communication, synchronously upload the collected data to the cloud platform, and realizes data communication, data storage, data visualization, exception management and other functions of the on-screen display terminal, creating an intelligent platform to help the construction of ecological civilization. Contribute to fully supporting Zhanjiang to build a “mangrove city”.

References:

[1] Yihong Shao,Xin Zhan,Yin Lin. Building a “Mangrove City” promotes the transformation of ecological advantages into development advantages [N]. Nanfang Daily.2023-01-23.

[2] Ruili Li,Fang Yang,Hui Wang, etal. [J]. Journal of Peking University (Natural Science),2022,58(5):916-928.

[3] Cairong Zhong, Cheng Cheng,Luzhen Chen, etal. Construction of mangrove wetland monitoring system and monitoring methods in Hainan Province [J]. Wetland Science, 2019,19(5):646-650.

[4] Manmi Zhou,Zhongmao Jiang,Qianli Yang. Monitoring analysis of mangrove soil and water quality in Cuiheng National Wetland Park, Zhongshan [J]. Forestry Science and Technology Communication,2022(10):33-36.

[5] Zaiming Zhou,Benqing Chen,Ran Xu, etal. [J] Mangrove population identification based on UAV hyperspectral features: A case study of Zhangjiangkou Mangrove National Nature Reserve [J]. Acta Oceanologica Sinica, 21,43(9):137-145.

[6] Xin Wen,Mingming Jia,Xiaoyan Li, etal. Recognition of mangrove canopy community based on unmanned aerial vehicle visible light image [J]. Journal of Forestry and Environment,20,40(5):486-496.

[7] Tao Ding,Chao Liu,Ye Deng, etal. Application of DJI M300 RTK UAV in rural cadastral survey [J]. Journal of Anhui University of Science and Technology,2021,35(3):23-29.

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