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Design and Realization of Cluster Monitoring System Based on IoT Technology

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Abstract:

With the increasing global awareness of ecological protection, this project responds to the relevant policies of Guangdong Province and the initiative of the National Beautiful China Pioneer Zone, aiming to develop a multi-point cluster monitoring system through artificial intelligence and Internet of Things technologies to realize intelligent monitoring and protection of mangrove forests. The system utilizes real-time monitoring technologies, including the detection of oxygen and carbon dioxide concentrations to assess the carbon sequestration capacity of the trees, and a soil monitoring function to provide a comprehensive understanding of the environmental conditions under which the trees are growing. The system also enables real-time alarms for any abnormal conditions and automatic intelligent irrigation management when soil moisture content falls below the growth requirement threshold. The data is read in real time by the sensors and uploaded to the MixIO cloud platform using the MQTT protocol, enabling real-time updating and visualization of the data, making the monitoring, protection, and management of trees and the environment easier and more efficient.

Keywords:

Old and valuable trees protection
Artificial intelligence
Internet of Things
Ecological monitoring
Cluster monitoring

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1. Major problems with current mangrove testing

(1) Inconsistent data standards and inadequate integration: Domestic tree monitoring systems have different standards for data collection, processing, and storage, insufficient data integration, and a lack of integrated management platforms, resulting in inconsistent data formats that are difficult to share and analyze [1]. This project will improve data quality based on

formal collection indicators.

(2) Lack of long-term monitoring data: Long-term continuous monitoring data are critical for the study of mangrove-environment interactions, particularly with regard to climate change resilience and soil erosion impacts [2]. However, the accumulation of available data is insufficient, limiting the understanding of the ecological response of mangroves and the effective development of conservation measures.

(3) Lack of integrated platforms: Existing mangrove monitoring systems often focus on a single indicator and lack a comprehensive platform to integrate multiple data sources [3]. It is difficult to fully reflect the complex interactions between mangroves and the environment, such as photosynthesis, carbon sink capacity, water circulation, and ecological service functions.

2. System design and implementation

This project builds a data network for tree growth assessment that integrates real-time multi-point monitoring and intelligent cloud data management. Each node is equipped with a variety of sensors and devices to continuously measure key indicators of tree growth in real time, evaluate carbon storage and sequestration capacity in combination with ecological models, and analyze changes in carbon footprints caused by greening activities. It also analyses important environmental parameters that affect plant health, such as soil temperature, humidity, pH, and conductivity. This kind of all-round data collection provides managers with a basis for decision-making and grasps the growth status of trees and environmental changes (**Figure 1**).

The project allows the public to adopt mangrove forests online and monitor their growth in real time through an intelligent cloud planting platform. The system integrates the data to generate reports to help the adopters grasp the health and growth of the trees and to promote the ecological construction of green Guangdong.

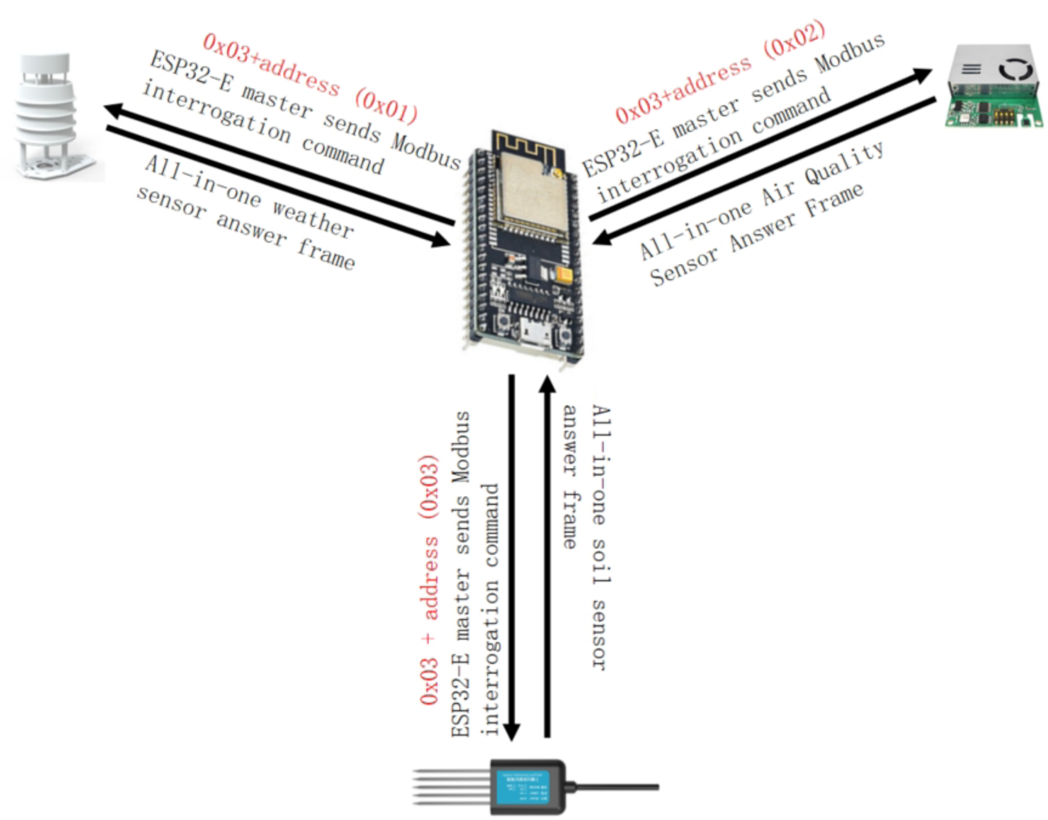

Figure 1. Schematic diagram of the main functions of the work

2.1. MixIO web-side data visualization and display function

The all-in-one soil sensor is connected to the ESP32 main control board via the RS485 bus and the same serial communication parameters are set (**Figure 2**). The main control board sends query commands to obtain the sensed data and parse them and then uploads the processed data to the MixIO cloud platform to realize real-time monitoring and statistics of the mangrove growth environment. A text display is created on MixIO to show real-time tree growth data monitored by an all-in-one soil sensor and AI camera. The data is uploaded to the cloud platform via MQTT protocol for real-time visualization of the tree growth environment. The camera in the system monitors mangrove growth in real time, and through a network connection, the image data is transmitted in real time to a cloud server and analyzed using open-source image processing libraries in order to monitor indicators such as the number of leaves, colors, and trunk thickness.

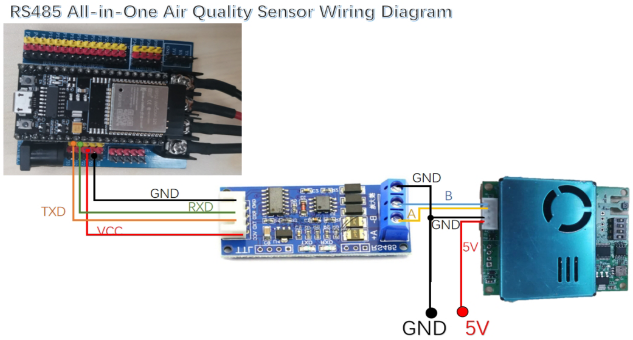

Figure 2. RS485 all-in-one air quality sensor wiring diagram

2.2. Data anomaly warning function

In this project, by setting the mangrove soil health data range, if the data measured by the industrial grade all-in-one soil sensor is out of this normal range, the warning light on the IoT cloud platform will turn red, and if it is normal, the warning light will turn green.

The normal range of soil health data is set, such as temperature, humidity, and pH. If the data is abnormal, control the warning light to turn red as a reminder through the MQTT protocol; if it is normal, keep the green light. This mechanism assists the administrator in adjusting and handling the abnormality in time.

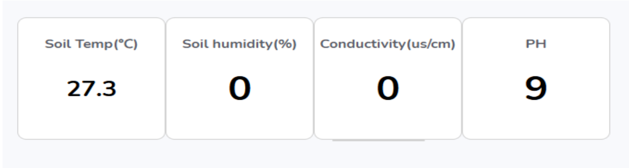

Figure 3. Warning light effect display

2.3. Local visualization function

The USART HMI software is used to design the touch screen page, in which the text display box of corresponding data is set. As the main interface between the user and the system, the touch screen mainly realizes the visual display of data and user interaction. The project flowchart is shown in **Figure 4**.

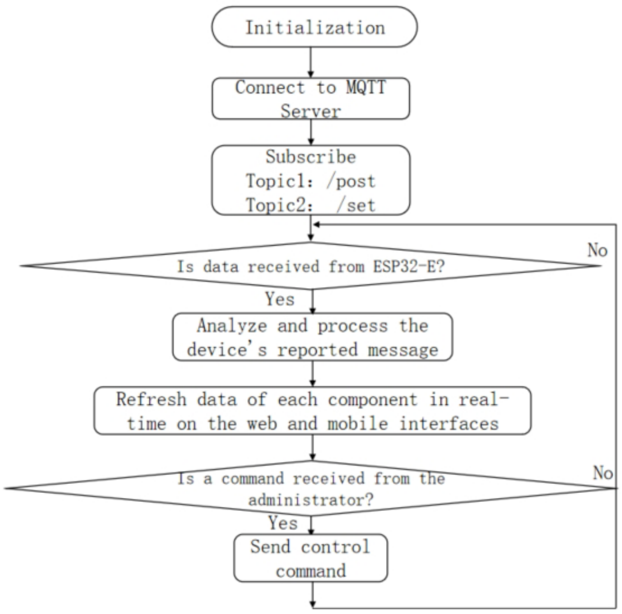

Figure 4. Project flowchart

2.4. Intelligent cloud cultivation

The project introduces intelligent cloud planting, "AI + wisdom to help farmers" new model, empowering the planting industry to reduce costs and increase efficiency, activate the industry's "blood" function, and help the transformation of "sweat agriculture." "Intelligent agriculture" allows community members to adopt mangrove forests online. The multi-point monitoring system can track growth in real time and generate daily reports. Based on the report data, suspicious data of adopters can be reported at any time, and administrators can solve and provide feedback.

2.5. Intelligent watering function

This system can automatically adjust the watering amount and frequency according to the growth demand of the trees to achieve automated watering. It precisely adjusts the watering strategy to avoid over or under-watering and save water resources. Such intelligent management not only improves the watering efficiency, but also reduces the cost of manual operation and the waste of water resources.

2.6. Climate, pest, and disease detection and carbon stock assessment functions

Monitoring carbon dioxide concentration and wind direction and speed through meteorological and air quality sensors can assess the carbon neutral capacity of the environment. High-definition cameras and AI technology can monitor pests and diseases and support the precise application of medication. AI applet provides online identification of pests and diseases, which allows quick access to prevention and control recommendations and reduces farmers' loss [4].

3. Innovation point

3.1. AI-enabled data collection and management

3.1.1. Mangrove soil data monitoring

The Mangrove Monitoring System uses AIoT technology to monitor the soil environment in real time with all-in-one soil sensors. The data supports an accurate assessment of soil health and optimization of growing conditions. The monitoring device collects data and transmits it to the management center, reducing the frequency of site visits and reducing the labor load.

3.1.2. Mangrove growth data monitoring

Through AI height measurement technology, the system is able to accurately measure the height of mangroves. While traditional measurement methods may be limited by the angle of vision or the accuracy of the measurement tool, AI models can achieve accurate height measurements by analyzing tree image data. While traditional age estimation often relies on tree ring rings or dendrochronological methods, AI models can combine machine learning algorithms with growth data and image analysis to provide more accurate and non-destructive measurements [5]. AI models provide a more accurate and non-destructive approach to age estimation, providing managers with recommendations to optimize growing conditions.

3.2. Establishment of a multi-regional mangrove cluster management system and early warning mechanism

3.2.1. Cluster management system

The cluster system is capable of real-time monitoring of multiple mangrove forests in multiple areas, thus achieving centralized management of multiple trees in multiple areas. This innovative idea breaks the limitations of traditional single-point monitoring, enabling managers to obtain a comprehensive understanding of the growth of mangrove forests in multiple areas on a unified platform, so as to make management decisions more effectively.

3.2.2. Early warning mechanisms

The system is equipped with a data abnormality warning mechanism. On the one hand, the camera's real-time monitoring and system analysis can predict the abnormal phenomena of mangrove growth, such as sudden changes in growth rate and abnormal leaf color, to remind the relevant management personnel to carry out further investigation and treatment. On the other hand, the system can detect and judge whether the plants lack water and how much water is needed to meet their growth needs. Meanwhile, if the tree is cut down by unauthorized people, the sensor will trigger the transceiver to send the tag ID and alarm signal to the control room [6].

4. Conclusion

This paper discussed advanced monitoring technologies and management experiences at home and abroad, and put forward strategic suggestions such as optimizing monitoring tools, strengthening data open sharing, and upgrading the monitoring network layout. The specific project introduces a data network for assessing tree growth conditions, which utilizes multi-point real-time monitoring and intelligent cloud data management technologies to achieve an accurate assessment of tree growth indicators and environmental parameters and mangrove cluster management, providing managers with a scientific and effective basis for decision-making. The smart cloud planting concept introduced in the project encourages community participation and public education to enhance public awareness and participation in ecological environmental protection. Through these measures, this paper aims to provide technical support and practical implementation for the sustainable improvement of ecological environment quality and the construction of ecological civilization in China in the future.

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Disclosure statement

The authors declare no conflict of interest.

References

[1] Wu K, Zhao X, Peng H, et al., 2023, Design and Implementation of Decision Analysis Platform for Tree Protection Special Chapter. Urban Surveying, 2023(2): 35–38.

[2] Deng J, 2020, Conservation and Rehabilitation Measures of Ancient and Famous Trees—Taking the Conservation and Rehabilitation of Yongtai Songkou Ancient Banyan Tree as an Example. Fujian Forestry, 2020(03): 44–48.

[3] Matasov V, Marchesini BL, Yaroslavtsev A, et al., 2020, IoT Monitoring of Urban Tree Ecosystem Services: Possibilities and Challenges. Forests, 2020(7): 775.

[4] Li JQ, Xing B, 2024, Technological Innovation of Tree Disease Monitoring and Diagnosis. Hebei Agricultural Machinery, 2024(02): 96–99.

[5] Yu C, Li H, Bao J, et al., 2019, Research on a Portable Tree Breast Diameter Monitoring Device. Forestry Survey and Design, 2019(02): 6–8.

[6] Srinivasan S, Ranganathan H, 2013, RFID Sensor Network-Based Automation System for Monitoring and Tracking of Sandalwood Trees. Int. J. of Computational Science and Engineering, 2013(2): 154–161.