Design and Implementation of Orchard Environment Monitoring System Based on WSN

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Abstract. In order to achieve the fine management of agriculture, this thesis has done some exploration for the low efficiency of traditional orchard management and less scientific monitoring of fruit trees growing environment. And an orchard monitoring system based on wireless sensor network (WSN) is researched and developed in this paper, combining sensor technology, ZigBee technology and embedded Linux technology. The design and implementation method of ZigBee nodes, embedded gateway and monitoring center are introduced in detail. These parameters can be adjusted by automatically controlling the corresponding facilities in the orchard. Orchard site and other monitoring parameters are able to be expanded easily according to the specific need of the orchard environment monitoring. This system provides a good solution for the meticulous fruit planting and has some good reference for the intelligent monitoring and scientific management of orchard environment.

Introduction

Domestic orchard area accounts for 21.3% of the total area of the world orchard, and the largest fruit production in the world. Although China is a big fruit producer, the production and management technology of the domestic orchard is still not perfect [1]. The environmental parameters that affect the growth of fruit shoots mainly include environmental temperature and humidity, soil temperature and humidity, light, soil pH, nutrient composition, etc., for all the important parameters of real-time monitoring and comprehensive control is an important problem [2]. Most farmers still use traditional methods to manage orchards, whether it is environmental parameters monitoring or fertilization irrigation are only rely on empirical analysis and artificial forces [3], coupled with the orchard itself has broad regional distribution, and the characteristics of the environment parameter uncertainty, it is even more difficult to measure the various environmental information of the orchard during production [4].

With the vigorous development of wireless sensor networks and Internet technologies, the real-time monitoring of orchard environment parameters and comprehensive automation control have become possible. And this research has attracted the attention of the society. The wireless sensor network is a wireless communication network composed of low-power micro-network nodes through self-organization [5], it can detect, monitor and collect micro-environmental information within the network distribution area in real time by setting up dense and collaborative nodes, and then information is processed to obtain detailed and accurate information, which provides the basis for the realization of "fine agriculture" [6]. According to the characteristics of agricultural regional environment, some researchers use multistage sensor in wireless sensor network to collect key environmental parameters and analyze data online to achieve scientific cultivation and reduce management costs, promote the modernization of agriculture [7, 8].

In order to reduce the working burden of farmers and improve the production efficiency and realize the optimal production of fruit, this paper designs a set of automatic orchard environment monitoring system with ZigBee and embedded Linux as the technical core.
Zigbee Sensing Network

The establishment of the ZigBee network is initiated by the network coordinator, which first performs energy detection and active scanning, selects the appropriate channel, and then determines its own network short address, the network PAN identifier, the network topology parameters, the beacon period Wait. The sensing layer network mainly includes the coordinator, the sensor node and the relay node.

Coordinator

The ZigBee network was originally initiated and established by the coordinator, and each ZigBee network having only one local area network (PAN) coordinator [9]. After the coordinator is powered on and completes a series of initialization, the energy detection and channel scanning are performed first, the idle channel which is not used by other network is selected, and then determine its own network short address, PAN ID, network topology parameters, beacon cycle, the initial establishment of the network completed.

At this point, the network can receive other nodes to join the network, and immediately grasp the information of all nodes in the network. At the same time, the coordinator periodically sends a device identification message to the gateway to request a connection with the gateway. When the response and device serial number message are received, the coordinator sends a heartbeat message to the gateway at regular intervals while waiting for the application connection. The communication process between the coordinator and other nodes and the gateway is shown in Figure 1.

The section headings are in boldface capital and lowercase letters. Second level headings are typed as part of the succeeding paragraph (like the subsection heading of this paragraph).

![Figure 1. The Process of Connection Session.](image)

The coordinator enters the message receiving loop after establishing the application connection with the gateway. If the coordinator receives the gateway application disconnect message, it immediately disconnects the application connection and waits for the next application connection. If the gateway receives the gateway heartbeat message timeout, the connection of the coordinator to the gateway is considered to be disconnected and the device identification message is sent again to the gateway to request the connection.

Sensor Node

The main function of the sensor node is data acquisition, processing, and coordinator or routing communication. The monitoring system mainly through the four types of sensors to collect data.

After the network is initially established, the sensor node is powered on and initialized, and then scan to find the coordinator of the surrounding network. If the network is found, the node sends an access request to the coordinator based on the acquired network information and waits for a response. After the node gets the network permission, it will get a 16-bit short address and the success of the connection from the coordinator. When the sensor node joins the ZigBee network, it enters the timed sleep mode and sends the node parent-child relationship message to the coordinator at regular intervals. The perceived peripheral sensor collects the physical quantities in the environment and...
converts them into electrical signals. The processing unit converts the electrical signal into a digital signal and does some processing, and finally, the data is transmitted to the upper network node through the radio frequency signal.

The sensor node periodically wakes up from the sleep state while detecting the wireless signal and receives the message for further analysis. If the sensor data acquisition control message is received, the node will collect and process the data, then encapsulate it and send it by wireless.

**Relay Node**

The relay node's network flow and the role in the network are the same as the sensor node, which periodically sends the node's parent-child relationship message to the coordinator. But the function of the relay node is to control the electric unit of the orchard facility by relays. A relay node has four relays that can be programmed to control one or more of the four machines.

**Embedded Gateway**

The embedded gateway is an embedded server based on Linux operating system which as a communication link between the underlying sensing network and the monitoring center, its main functions include protocol conversion, message forwarding, data processing, display and staging, and offline automatic control and alarm, etc.

The gateway runs the embedded Linux operating system which need to obtain data from the coordinator through the serial port and communicate with the monitoring center through the Ethernet port [10], the system architecture shown in Figure 2.

![Figure 2. System architecture of the embedded gateway.](image)

The main functions of the gateway background service program are described below.

**Network Establish and Retails**

The information interaction between the gateway, the coordinator, and the monitoring center is divided into three categories: connection, timed message and resource data interaction. Among them, the establishment of connection and timing messages can be called network connection information interaction. As shown in Figure 3, the coordinator establishes a connection with the gateway, and the coordinator first sends a device identification message to the gateway.
After the gateway receives the device identification message, it will send the reply message and the device serial number message to the coordinator. After the coordinator is successfully connected to the gateway, the system will work properly. If the gateway is connected to the Internet at the same time, the monitoring center will initiate a connection to it, including the socket connection and the application connection. The timing message between devices is the basis for judging whether the device is disconnected, the heartbeat message is used to judge the connection status of the coordinator, the gateway and the monitoring center, the parent-child relationship message is used to determine the connection status of nodes in the ZigBee network. Once the network is established, the data resource interaction can be performed.

**Interaction of Resource Data**

The gateway sends an application connection message to the coordinator, which is the beginning of the data interaction, as shown in Figure 4.

After receiving the service response, if the gateway has connected to the monitoring center, it will first upload offline data and log, and then the monitoring center to take over the highest system permissions. The monitoring center initiates sending the node details message to the gateway, and then sends the collection control message to obtain the sensor data. The messages sent by the monitoring center are forwarded to the coordinator by the gateway. Finally, the coordinator sends the message to the corresponding node in a wireless manner, and the node uploads the node details or collects the sensor data after it receives the message. After sending a control command to a node, the node will reply to the reply message. If the node fails more than four times when sends data to the coordinator, the default node disconnects from the coordinator, it needs to be rebinding, which is to look again for the surrounding coordinator and get in the net.

If the gateway is not connected to Ethernet, after receiving the node details message and the sensor data message, it will parse and process the messages, and then display and store the corresponding results. The gateway can automatically control if it detects an abnormal environment parameter, that is, it will automatically send control messages to the corresponding node, start the relevant units, and control the environment.
The Monitoring Center Software

The monitoring center software mainly completes sensor data receiving, processing, display and storage, historical data query, and automatic adjustment of orchard environment. The monitoring center is monitoring and adjusting the parameters in real time to provide a suitable environment for the fruit tree. The main control module of the monitoring center consists of three parts: data communication, data query and system management.

Run the monitoring center software is shown in Figure 5 for the real-time display of the data.

Figure 5. Real data display interface.

Summary

Based on ZigBee and embedded Linux, this paper designs an orchard environment monitoring system based on wireless sensor network, it can realize the collection of the basic parameters of orchard environment, automatic control and abnormal alarm, and provide a solution for the on-line monitoring of large-scale orchard environmental parameters. This system has the characteristics of low cost and low power consumption, which can effectively reduce the working load of the fruit farmers, improve the production efficiency and realize the optimum production of fruit.

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