

Design of Intelligent Beehive System based on Internet of Things Technology

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Abstract. Aiming at the problem that traditional beekeeping does not form a pattern management and requires a lot of manpower, it is difficult to monitor the status of beehives, an intelligent beehive system for real-time monitoring of beehive status is proposed. The system is composed of a single honeycomb, a honeycomb node and a monitoring center. The hardware system of the hive uses STM32L151C8T6 chip as the main control chip, uses the DHT11 digital temperature and humidity sensor to collect the temperature and humidity information, HX711 chip collects the weight of the beehive, and uses the MMA7361 sensor to collect the posture information of the bee. The Air800_M4 module is used to locate the Global Positioning System (GPS) and upload data to the monitoring center. The experimental results show that the manager can view all the beehives' information at any time through the communication tools such as mobile phone, flat panel and so on, and realize the real-time monitoring function of the beehive status.

Keywords: single chip microcomputer, smart hive, internet of things, monitoring center.

1. Introduction

China's beekeeping industry has always occupied a huge market space. However, traditional bee farming has major drawbacks. Traditional beehives are susceptible to external factors, resulting in bees fleeing from beehives, beehives dumping, and beehives being stolen. At the same time, management difficulties during large-scale farming require a large number of manpower to carry out [1]; and the traditional beekeeping did not form a pattern, can not achieve strict monitoring of the beehive environment, thus greatly reducing the quality of honey, can not meet the current requirements for the quality of bees.

In view of the above problems, this paper designs a smart beehive system, which can better realize scientific beekeeping and intelligent management [2]. The system adopts distributed distributed data acquisition and monitoring structure, which consists of a single beehive, a beehive group node and a monitoring center three-level structure. The system realizes the functions of temperature and humidity monitoring, weight monitoring and attitude monitoring. It can monitor the environment inside the beehives in real time, and feedback the parameters in the beehives to the beekeepers in real time. The beekeepers can get the beehive environment in time without opening the beehives. The parameters reduce the disturbance caused by the beekeepers out of the box and help the beekeepers to scientifically and reasonably take honey [3]. At the same time, the use of remote centralized management facilitates the monitoring of individual individuals, changes the current artificially extensive and backward farming mode, and gradually develops bee farming towards standardization, standardization and refinement, and greatly improves labor efficiency, saves labor costs.

2. Intelligent Beehive System Design

2.1 System Structure Design

The system adopts a distributed data acquisition and monitoring structure, which consists of a single beehive, a beehive group node and a monitoring center. A signal acquisition device such as a temperature sensor, a humidity sensor, a weight sensor, and an attitude sensor is installed in each beehive to collect the living environment parameters of the bee of a single beehive [4]. Each beehive is equipped with a solar power supply device, and the solar power supply device supplies power to

the detection components, control devices and communication modules in the beehive. At the same time, each beehive and the monitoring center adopts a decentralized independent control mode. Each beehive is equipped with a communication module that can be uplink and downlink, and is responsible for data transmission and control with the monitoring center. General Packet Radio Service (GPRS) network is used to transmit data between beehive and monitoring center. GPRS is charged according to data flow, which improves the utilization rate of resources. GPRS network communication can achieve long-distance transmission, and is very suitable for outdoor data transmission [5]. The communication module collects information such as the temperature, humidity, weight, and bee flight noise of the beehive, and sends it directly to the monitoring center. The manager can check the status of all the beehives through the monitoring center. When there is an abnormality in the environment inside the beehive, the monitoring center will promptly send a reminder or warning signal to remind the beekeeper to take measures. When the weight of the beehive reaches the set weight, the monitoring center will remind the beekeeper to collect honey in time. The monitoring center manager can query the beehive information at any time through the account and password. At the same time, each node is equipped with a webcam, and the monitoring center can view the environmental conditions of the node through the webcam [6].

2.2 Hardware System Structure Design

The intelligent beehive is mainly composed of STM32L151C8T6, weighing signal acquisition circuit, digital temperature and humidity sensor, attitude detection sensor, Air800_M4 module with GPS and GPRS function, recording device, communication interface circuit and charging control circuit [7]. The weighing sensor, the conditioning circuit, the digital-to-analog conversion circuit and the like constitute a weighing signal acquisition circuit. When the measured load is loaded on the scale body, the load cell installed under the scale body generates a voltage signal proportional to the measured load. After the conditioning circuit is amplified, filtered, and digital-to-analog converted, it is transmitted to the MCU to complete the weighing signal acquisition. The single-chip computer uses the ambient temperature and humidity signal collected by the digital temperature sensor to obtain the current temperature and humidity value. On the other hand, according to the temperature compensation algorithm, the temperature compensation of the measured load weighing result is completed, and the median filtering algorithm is added to obtain the final Weigh the results. The system uses MMA7361 to obtain the attitude of the box. When the box inclines or collides, the acceleration along the X, Y and Z axes will change, and the voltage value proportional to the acceleration will be output. After filtering, digital-analog conversion, inverse triangulation calculation and attitude calculation, the current attitude of the box can be obtained. The MCU interacts with the Air800_M4 through a serial port according to a certain protocol [8]. The Air800_M4 packages the obtained data value and the GPS and sound information collected by itself to the client to complete the function of the whole system. The specific system hardware structure diagram is shown in Fig.1.

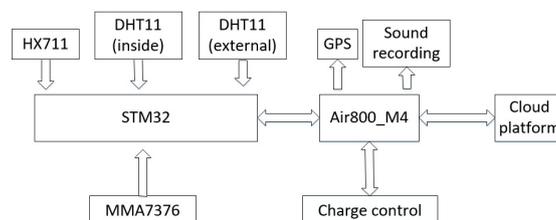


Figure 1. System hardware design structure.

2.3 Design of Monitoring Center Software

Each beehive passes the beehive status data to the cloud platform via the Air800_M4 module. In the choice of cloud platform, the system adopts the open platform of China Mobile Internet of Things. First build your own product on the cloud platform, get the ID of the product, then add your own

beehive device under the product, each device corresponds to different device ID and authentication information. The data is uploaded by the IP address and port address of the Message Queuing Telemetry Transport (MQTT) protocol provided by the mid-hop Internet of things platform. The MQTT protocol is a protocol designed for the communication of remote sensors and control devices with limited computing power and working in low-bandwidth, unreliable networks [9]. In the MQTT protocol, an MQTT data packet consists of three parts: a fixed header, a variable header, and a message body. The system creates a data stream in the message body, packs the data stream, and then creates a client of the MQTT protocol, which includes the product ID, device ID, authentication information, heartbeat packet, and the like. The client through the MQTT protocol is connected with the IP address and port provided by the medium-moving IoT platform, and then the packaged data stream is sent to the medium-moving IoT platform by using the MQTT protocol. In this way, the data information of all beehives can be obtained on the medium-moving IoT platform, and the user can view the status of the beehives at any time through the monitoring center.

3. Experiment and Result Analysis

In order to test the function of the intelligent beehive, a one-week test on the beehive was launched in Yunyang County, Chongqing. The test environment was a mountainous area with a harsh environment. During the week, it experienced the scorching sun and rainy days. It has been proved by practice that the beehive system can basically achieve the expected effect, and the specific function realization results are as follows.

3.1 Monitoring the Temperature and Humidity of the Beehive

During the experiment, the temperature and humidity inside and outside the beehive were monitored in real time, and the internal humidity results and external temperature results are shown in Fig.2 and Fig.3. The abscissa in Fig.2 is time, and the ordinate is the internal humidity of the beehive in units of %. In Fig.3, the abscissa is time and the ordinate is external temperature in °C. It can be seen from the figure that the intelligent beehive system can achieve the measurement of temperature and humidity very well. After comparing the temperature and humidity of the beehive on the spot, the results show that the measurement accuracy of the temperature and humidity of the beehive is higher, and the experimental effect is better.

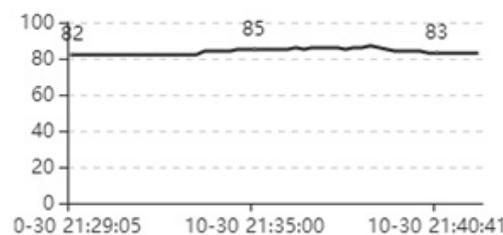


Figure.2 Beehive internal temperature results.

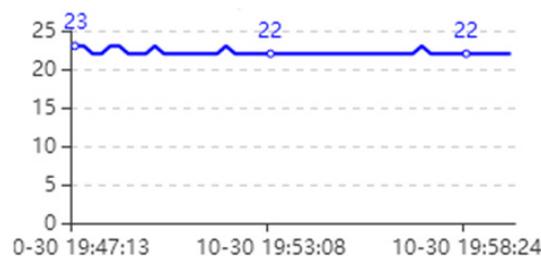


Figure.3 Beech box external temperature results.

3.2 Monitoring the Weight of the Beehive

In order to check whether the system can realize the weight detection of the beehive, the weight of the beehive is artificially added and reduced during the test, and the weight monitoring result is shown in Fig.4. The abscissa of Fig.4 is time, and the ordinate is the weight of the beehive, and the unit is kg. As can be seen from Fig.4, the intelligent beehive system is sensitive to the detection of weight and achieves good results. In order to further confirm that the detection of the weight of the beehive is accurate, the experiment uses a set of accurate electronic scales for proofreading. It turns out that the error is small and the experimental effect is good.

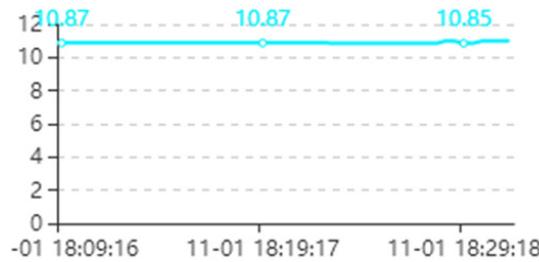


Figure.4 Beehive weight test results.

3.3 Positioning the Position of the Beehive

In order to test the positioning function of the intelligent beehive system, ten sets of tests were carried out on the beehive. Each time the beehive was placed in a different place to detect its position and positioning, the test result is shown in Fig.5. Tests have proved that the intelligent beehive system can achieve accurate positioning of the beehive.



Figure.5 Beehive position positioning test chart.

3.4 Monitoring the Posture of the Beehive

In the field test, the attitude detection result is obtained by placing the beehives at different angles as shown in Fig.6. The abscissa of Fig.6 is time, and the ordinate is the bevel angle of the beehive, and the unit is $^{\circ}$. It can be seen from the figure that the change of the tilt angle of the beehive is more sensitive, and the detection of the beehive posture can be well realized. The user can check whether the beehive is dumped or not in the monitoring center.

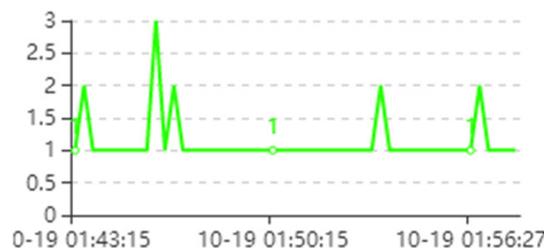


Figure.6 Beehive posture test chart.

3.5 Remote Monitoring of the Opening of the Beehive Cover

The system utilizes the working principle of the relay to realize the opening of the beehive, the high and low level controls the opening of the beehive cover, the low level indicates the closed state of the beehive cover, the high level indicates the open state of the beehive cover, and then the open state of the beehive cover is displayed. In the monitoring center, the beekeeper can monitor the opening status of the beehive cover in real time in the monitoring center.

3.6 Shooting and Transmitting the Beehive Image

The test results shown in Figure 7 were obtained by testing the node camera on site. As can be seen from Fig.7, the camera can clearly capture the state of the beehive in the node area, which is a good function of capturing and transmitting the picture of the beehive. The user can view the shooting picture of the state near the beehive in the monitoring center in real time.



Figure.7 Camera shooting screen.

4. Conclusion

The intelligent beehive system designed in this paper realizes the real-time monitoring function of the status information of the inside and outside of the beehive, the weight of the beehive, the attitude of the beehive, etc. The beekeeper can check the status of the beehive in real time in the monitoring center, effectively solving the problem of modeless management. It reduces the frequency of beekeepers unpacking and saves a lot of labor. At the same time, it also improved the quality of honey and greatly promoted the rapid development of the beekeeping industry. The next step is to reduce the power consumption of the intelligent beehive system and make the system more reasonable and scientific. Combined with the intelligent beehive system to detect the sound of bees and count the number of bees entering and leaving the bees, this will be an important research work in the future.

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