Intelligent Crop Planting Management and Quality Traceability System

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Abstract. Aiming at the farmland management problems, soil heavy metal pollutions problems and the agricultural product quality security problems, the system develops a link planting, acquisition, processing, logistics and distribution each link of intelligent crop planting management and achieves quality tracing based centralized service data gateway. This system extracts the information in real time from crop planting to agricultural product sales. It is conducive to the implementation of scientific planting and the sustainable development of agriculture, and it enables consumers to trace the quality of agricultural products. The main work of this research is as follow. The first is the construction of crop planting information management subsystem. It contains the information about field information, seeding, fertilizing, irrigation, weeding, pest controlling, spraying insecticide and harvest. The second is the construction of crop planting environmental monitoring subsystem based on sensor technology. It contains real-time environmental information in the process of crop growth, such as soil temperature and humidity, air temperatures and humidity, light intensity and video information, and it realizes remote monitoring of crops. The third is agricultural product quality traceability subsystem oriented to consumers.

1. Introduction
The future trend of China's agricultural development is to build a smart agricultural system and to make the actual production process of agriculture more intelligent. It refers to the implementation of a refined and scientific management model and the structure optimization of agricultural industry, and the improvement of land resource utilization rate, which ensures the quality of agricultural products and achieves the pollution-free green production [1, 2].

In the smart agricultural system, field management information such as crop sowing, weeding, irrigation, fertilization, and spraying should be recorded, including air temperature, air humidity, light intensity, carbon dioxide concentration, soil pH, soil moisture, and soil nutrients, heavy metal content and other environmental parameters [3, 4]. Through the real-time monitoring and quantitative and precise management true smart agriculture will be achieved [5, 6].

Intelligent crop planting management and quality traceability system based on a variety of advanced technologies can real-time monitor and analyze crop information and environmental
information during the growth of crops and agricultural product circulation information to provide the traceability of agricultural products, which is a big step towards smart agriculture [7].

2. Method

The intelligent crop planting management and quality traceability system in this study mainly collects farmland information, field management information and environmental information during crop planting, and processing and circulation of agricultural products to provide farmland planting management scientific guidance, which can improve agricultural productivity and reduce heavy metal pollution in soil, and ensure the quality and safety of agricultural products [8].

When field management information is collected in the process of crop planting, firstly ID of each field is set up for each farmland, and the system records information about sowing, fertilization, irrigation, weeding, pest control, spraying, harvesting, acquisition, processing, transportation of the agricultural products and other information. The environmental information in the process of crop planting is collected in real time through sensors and cameras. It mainly collects information such as temperature and humidity, light and video. The information on heavy metals in the soil is collected at intervals. A specific soil tester is used to measure soil heavy metal data.

SQL Server 2008 R2 is used to design the database. After the harvest of the crop is completed, relevant information on the processing and sales of the agricultural product is manually inputted into the database, and finally the traceability information is obtained by using the unique two-dimensional code of the agricultural product. The technical route is shown in Figure 1.

![Technology roadmap](image-url)

**Figure 1.** Technology roadmap.
3. System design

Agriculture is an important industry in the national economy and is constantly developing in the direction of automation, intelligence and information. Smart farming will be the future trend of agriculture. Smart farming refers to the adoption of a refined and scientific management model. Information technology is used in the agricultural production process to achieve sustainable development and traceability of agricultural products which could meet consumer demand for food safety.

3.1 Hardware design

The hardware part of the system mainly includes five modules, which are power supply module, sensor module, ZigBee module, gateway module and video acquisition module. The power supply module supplies power to other modules. The sensor module collects environmental data in real time, and then transmits the data to the gateway module through the ZigBee module. Finally, the gateway module transmits the data to the database through a specific serial communication program. The video capture module stores the video information into a video storage module called a video server, and the video storage module directly supplies power directly through an external power supply. The hardware block diagram is shown in Figure 2.

3.2 Software design

The gateway module of the hardware part transmits the real-time data collected by the sensor to the database through the serial port communication, and the Web client interacts with the database directly, and performs operations such as adding, deleting, and changing data. At the same time, the web side can directly access the video server to realize the remote video monitoring and can adjust the angle of the camera by controlling the gimbal, so as to observe the field situation in different directions and can also store additional video for a specific time period. The software architecture diagram is shown in Figure 3.

![Figure 2. Hardware block.](image-url)
4. System implementation
The whole system was designed based on some advanced technologies such as sensors, smart gateways, WEB, Quick Response (QR) code, Internet, mobile communication and wireless network transmission. It realized intelligent crop planting management platform supported by Internet of Things technology and data analysis, including farmland planting management module, crop growth management module, a real-time monitoring module for crop growth environment and a traceability module for agricultural products.

4.1 Farmland planting management module
The farmland planting management module contains three parts: farmland information management, farmland location browsing and farmland labelling map. Figure 4 shows farmland planting information. Figure 5 shows farmland location information.

| NO | NAME | FIELD_NUM | CROP_TYPE | CROP_DETAIL |
|----|------|-----------|-----------|-------------|
| 2010990 | John | 10001 | Maize | sweet single 104 |
| 20170301 | David | 10001 | Maize | No. 6 sweet jady |
| 20170302 | Paul | 10002 | Maize | No. 6 sweet jady |
| 20170303 | Sarah | 10003 | Wheat | White hard wheat |
| 20170304 | Jill | 10004 | Wheat | Red hard wheat |
| 20170305 | Kim | 10005 | Apple | Red Fuji |
| 20170314 | Penny | 10014 | cucumber | Fruit cucumber |
4.2 Crop growth management module

The crop growth management module consists of 8 parts: seeding, fertilization, irrigation, weeding, pest control, spraying, harvesting and pesticide residue testing. This part is the core content of farmland planting management. It can increase, modify and browse all kinds of information in the planting process. Figure 6 shows the seeding information. Figure 7 is a line diagram of the harvest information.

| Field  | Seed_Time | Quantity | Seed_Type | Seed_Depth | Reseed_09_Bot |
|--------|-----------|----------|-----------|------------|--------------|
| 1001   | 2016/6/24 | 0.00:00  | 0.12      | Shallow    | Yes          |
| 1002   | 2016/6/1  | 0.00:00  | 0.10      | Deep       | No           |
| 1003   | 2016/6/16 | 0.00:00  | 0.12      | Shallow    | No           |
| 1004   | 2016/1/23 | 0.00:00  | 0.10      | Shallow    | No           |
| 1005   | 2016/1/22 | 0.00:00  | 0.12      | Deep       | No           |
| 1006   | 2016/2/3  | 0.00:00  | 0.12      | Shallow    | Yes          |
| 1007   | 2016/4/2  | 0.00:00  | 0.10      | Spindle    | No           |
| 1008   | 2015/3/8  | 0.00:00  | 0.10      | Trunk      | No           |

Figure 6. Seeding information.

Figure 7. Harvest information.

Pesticide residue detection is an important reference data for quality traceability. Special modules are also defined in the system for management. According to the query requirements, the pesticide residue detection information of specific targets (farmland) in the database can be displayed. Figure 8 shows the ratio of pesticide residues in agricultural products.
4.3 The real-time monitoring module for crop growth environment

The real-time monitoring module for crop growth environment consists of three parts: real-time sensor monitoring, real-time video monitoring and soil environmental monitoring.

The real-time sensor monitoring module transmits the real-time data collected by the sensor module to the monitoring table of the sensor in the database. Figure 9 is a comprehensive view of sensor history monitoring information.

The video real-time monitoring module performs dynamic real-time monitoring of farmland. Figure 10 is a video monitoring screen.
The soil environmental monitoring module uses the soil detector to perform heavy metal detection on the soil and records the data in the soil environmental monitoring table. Figure 11 shows the quality traceability of agricultural products for soil heavy metal detection.

![Figure 11. The quality traceability for soil heavy metal detection.](image)

### 4.4 The agricultural product quality traceability module

The agricultural product quality traceability module includes the traceability of farmland soil heavy metal information, the comprehensive traceability of agricultural product quality, and the two-dimensional code image of agricultural product information.

According to the source code query, the corresponding heavy metal detection information of farmland soil and the information of agricultural products from production to sell can be obtained. The administrator will post the two-dimensional code image of the agricultural product traceability information on the packaging of the agricultural product, and the consumer can directly scan the two-dimensional code image to quickly obtain the relevant information of the agricultural product. Figure 12 is a two-dimensional code generation display of agricultural product information.

![Figure 12. Dimensional code of agricultural product information.](image)

### 5. Conclusion

This system was designed based on a variety of IoT technologies to develop intelligent crop planting management and quality traceability system, which connected crop planting, management, acquisition, processing, logistics and distribution parts. It has realized the functions of agricultural visual remote monitoring, remote operation, disaster warning, agricultural precision planting, visual management and intelligent decision-making through the data analysis of farmland management activities and crop
growth information. The information coverage is very comprehensive, and it also provides an effective solution to food safety issue.

There are still many limitations. The information in the process of crop planting management is mainly manually inputted by the administrator. The environmental parameters in the process of real-time monitoring of crop growth environment are still too small. The system only collects five environmental parameters such as air temperature and humidity, soil temperature and humidity and light intensity.

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