Scientific Research on Agricultural Low-Altitude Remote Sensing Platform Based On Dual CPU Structure

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Abstract. With the support of the Jilin Province Education Department "13th Five-Year" Science and Technology Research Project Fund (JJKH20190974KJ), this paper, relying on the Jilin Province Digital Agriculture Key Discipline, carries out the research and practice of micro low-altitude remote sensing platform and its application in agricultural situation detection. This paper describes a kind of agricultural low-altitude remote sensing platform, which adopts dual CPU structure about central control layer and FMU flight control layer. This paper describes in detail the development status of low-altitude remote sensing, key technologies, experimental implementation schemes, core system design and so on. After field test, the operation effect is good.

Keywords: Low-altitude Remote Sensing Platform, Flight Control, Embedded Microprocessor

1. Overview of Agricultural Low-Altitude Remote Sensing Technology

1.1. Development Status At Home and Abroad
The application of low-altitude remote sensing technology to agriculture is a new technical innovation in the field of agricultural production. The low-altitude remote sensing platform can compensate for the problems of the traditional monitoring equipment, such as small operation scope and difficult real-time monitoring, and at the same time compensate for the problems of the satellite remote sensing, such as the high cost and the great influence of weather conditions. The micro low-altitude remote sensing platform can obtain agricultural production information such as soil moisture, monitor crop growth, diseases and insect pests help farmland managers detect farmland, change the previous rough operation method of extensive fertilization and more pesticides, and achieve the purpose of saving costs and achieving precise operations [1]. Complete the transformation from traditional agriculture to digital agriculture.

Agricultural low-altitude remote sensing technology has been used early in the United States, Japan and other developed countries, and has become the main force in the field of plant protection. At present, low-altitude remote sensing is in its infancy in China, and it has been mainly applied in agricultural insurance compensation and pesticide spraying in small areas of farmland. The
development of low-altitude remote sensing platform has become a new field of agricultural equipment industry.

1.2. Guarantee Conditions of Project Research
First of all, the Intelligent Agriculture Engineering Research Center has completed the intelligent agriculture Internet of Things laboratory. The laboratory contains the intelligent agriculture sandbox simulation system about the Internet of Things, which provides the spatial environment simulation information data of crop growth for the debugging of the UAV low-altitude remote sensing system. Secondly, the Intelligent Agricultural Engineering Research Center has built a modern intelligent greenhouse, which includes intelligent irrigation system, intelligent spray system, intelligent temperature control system and intelligent external shading control system, providing physical experiment scenes for the debugging of UAV low-altitude remote sensing system. Thirdly, the Intelligent Agricultural Engineering Research Center has purchased more than 10 quad rotor aircraft to provide a hardware platform for the debugging of low-altitude remote sensing system [2]. Finally, the project team's research achievement "measurement and control system based on ARM" won the first prize of Jilin Science and Technology Progress Award in 2015, and the aircraft competition project of the Provincial College Students Electronic Design Competition won 5 second prizes and 2 third prizes, which provided rich experience accumulation of low-altitude remote sensing technology for the project implementation.

2. Key Technologies of Low-Altitude Remote Sensing Platform
In response to the current needs of distributed monitoring technology for environmental information in greenhouses and agricultural fields, this paper designs a program-controlled autonomous flight UAV low-altitude remote sensing system. The system is small and flexible, and can autonomously control flight attitude, autonomously locate and navigate, autonomously avoid obstacles, and complete information data analysis and processing [3]. In this paper, the low-altitude remote sensing system of unmanned aerial vehicle is used to identify crop types. The low-altitude remote sensing image in the visible light region is more sensitive to the response of crop types, so the types of crops can be judged. The low-altitude remote sensing system of unmanned aerial vehicle is used to identify crop growth. According to the different reflection characteristics of the different crops leaves to different electromagnetic waves, the crop growth can be analyzed. At the same time, research on vegetation coverage rate monitoring, soil temperature and humidity monitoring and other fields are carried out. The key technologies are as follows:

(a) Hardware system design of UAV low-altitude remote sensing platform. UAV low-altitude remote sensing platform should be small, flexible and have a certain amount of load as the basic design principles to be able to fly flexibly in the growing space of crops. (b) Detach from RC remote control to realize program-controlled flight, complete intelligent hover setting altitude and intelligent flight according to pre-set planning path. (c) Get rid of RC remote control, realize program-controlled flight, and complete intelligent avoidance of farmland crop production facilities. (d) Wireless transmission of information and data acquisition. The main purpose is to transmit the collected space environment data to the environment controller through wireless technology as the basis of environment control. (e) Attitude control of aircraft. The measurement of space environment information is realized on the premise of ensuring the stable flight of aircraft in the growing space of crops [4].

3. Implementation Schemes of Low-Altitude Remote Sensing Platform
The key and difficult points of designing low altitude remote sensing platform include stable attitude control and height setting control. The core technology includes agricultural information collection and information analysis and processing, realizing the intelligence and modernization of the field of digital agricultural situation detection [5].
The task implementation of low-altitude remote sensing platform design includes: First, select the embedded microprocessor model of the central control layer. The central control layer uses three UART communication interfaces to communicate with FMU flight control layer, information acquisition layer and debugging module of the central control layer respectively. The system requires real-time data processing and needs to run embedded operating system. The low-power 32-bit microprocessor STM32F103 chip is selected based on the above factors. Secondly, the module model selection of FMU flight control layer. Considering the stability of flight control effect and robustness of flight control code, PixHawk, a 32-bit open source flight control module based on ARM, was selected. PixHawk open source hardware design and open source flight control source code are fully utilized to realize stable attitude control of low-altitude remote sensing platform. Then, select the type of camera sensor for the information acquisition layer. In the acquisition layer, OV7725 camera is mainly used to complete agricultural information acquisition and image information processing, and output binary images. Finally, the flight test of the whole machine [6].

4. The Core System Design of Low-Altitude Remote Sensing Platform

4.1. Overall Design of System Functions
The low altitude remote sensing platform adopts the method of layered design. The system is divided into central control layer, FMU flight control layer, servo drive layer and information acquisition layer according to the functional level. The central control layer is mainly responsible for receiving the low-altitude environment parameters from the information acquisition layer, processing and analyzing to obtain the control increment of the flight control, and sending the control increment to the FMU flight control layer. The FMU flight control layer is mainly responsible for receiving the control information from the central control layer and the control information from the RC remote control handle, and converting the control information into control pulses and sending them to the servo drive layer. The servo drive layer is mainly responsible for receiving the control pulse of the FMU flight control layer, and controlling the brushless motor rotation through the electronic governor, so as to adjust the attitude, height and angle of the remote sensing platform. The information acquisition layer is mainly responsible for collecting low-altitude environmental parameters through sensors such as cameras and sending the information to the central control layer [7].

4.2. Detailed Design of Functional Modules
4.2.1. Design of central control layer. The central control layer is responsible for calculating the control amount required by the low-altitude remote sensing platform at the next moment and sending the encapsulated data structure to the FMU flight control layer. This function is similar to the control increment of RC remote control handle. At the same time, the attitude angle and height values measured by the FMU flight control layer are sent to the acquisition layer for self-compensation of the parameters of the acquisition layer.

According to the functions of the central control layer circuit board, the modules designed include: embedded microprocessor module STM32F103, key module, buzzer module, LED indicator module, dial code switch module, UART interface module. The central control layer circuit board includes UART interface for communication with FMU flight control layer, UART interface for communication with acquisition layer and UART interface for debugging. The central control layer circuit board uses the key module to switch the remote control mode of remote sensing platform or the program-controlled autonomous flight mode, and uses the dial code switch module to lock the autonomous hover, GPRS positioning and other flight modes [8].

4.2.2. Design of flight control layer. In the flight control layer, open source PixHawk flight control module is adopted to receive the control volume of RC remote control handle or the control volume sent by UART in the central control layer and send it to the electronic governor control pulse to adjust
the attitude Angle and height value of the low-altitude remote control platform. At the same time, the FMU flight control layer transmits the current control amount and the attitude Angle acquired by the sensor to the central control board for calculating the control amount at the next moment.

4.2.3. Design of data acquisition layer. The data acquisition layer is equipped with OV7725 camera to send the collected farmland crop information. According to the current attitude Angle and other information sent by the central control layer, the algorithm compensates the information actually collected. Finally, the calculated position information is sent to the control layer. The images are divided into gray images or binary images. The gray image outputs the image with a width/height ratio of 4:3. When the resolution is less than the maximum, it always outputs the central part collected. Linearization image sets the gray value of the points on the image to 0 or 255, that is, the whole image presents an obvious black and white effect. The linearization images with 256 brightness levels are obtained by selecting appropriate thresholds, which can still reflect the overall and local features of the image [9].

4.2.4. Design of servo drive layer. The servo drive layer is composed of 20A brushless motor electronic governor, high power 2212 brushless motor and 9450 self-locking pulp. The input of the electronic governor of 20A brushless motor is DC, powered by 3 lithium batteries, and the output is three-phase AC, directly driving the high-power 2212 brushless motor.

5. Application Prospect of Low-Altitude Remote Sensing Platform

To monitor agricultural information, use agricultural micro-UAVs as low-altitude remote sensing platforms to obtain high-resolution low-altitude remote sensing images. The platforms are fast, flexible, low-cost, economical and practical. It is an effective scheme for traditional farmland information acquisition. In terms of improving the effective utilization of pesticides, reducing labor, improving work efficiency, reducing crop damage, and reducing repeated rolling on the soil, its superiority has far exceeded the effect of ground machinery. Therefore, changing traditional farming methods and using low-altitude remote sensing platforms for agricultural information detection has huge development potential and application prospects in China [10].

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