Design and Research of Ground Control System of the UAV-borne Photoelectric Platform

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Abstract: According to the working principle of a UAV-borne photoelectric platform, as well as the main functions and characteristics of the photoelectric platform ground control system, the overall design scheme and target of this system are proposed with an introduction of its composition and working principle. On this basis, the design and research of the system are carried out from hardware and software. Specific schemes of the two aspects are given. Finally, the future of the photoelectric platform ground control system is predicted on the trend of UAV-borne photoelectric platform.

1. Introduction
Unmanned aerial vehicle (UAV) photoelectric platform is a high technology system including the fields as optics, mechanism and electricity. It is an important part of UAV airborne reconnaissance system. It mainly provides real-time battlefield television images, infrared images and platform specific parameters as the intelligence and reference for UAV battlefield surveillance and positioning [1].

2. Overall Design of Control System
As the photoelectric platform needs to be equipped with visible TV camera, forward-looking infrared instrument, laser rangefinder and other loads, therefore, in order to fully meet the requirements and purpose of stability control and function detection, the system needs to achieve these in design:

(1) Provide stable DC power supply, power addition and power failure control for UAV-borne photoelectric platform;

(2) Communicate directly with the control components of the UAV-borne photoelectric platform, completely control the system, receive and display the feedback information of each component;

(3) Control functions such as doubling and focusing of CCD sensors and infrared sensors in the UAV-borne photoelectric platform, switch and configure working states such as locking, tracking and scanning of the platform;

(4) Control the target tracking box to search the target, and achieve the target acquisition and tracking;

(5) Functions of sending and receiving right or wrong judgment instruction, fault location information display;
(6) Functions of real-time display, collection and playback of video images output from the photoelectric platform, video input and synchronous output capability;

(7) Cooperate with other test equipment to complete the performance test of the photoelectric platform, such as search angular velocity, search angular acceleration, angle measurement accuracy and stability accuracy;

(8) Control the vibration reduction lifting mechanism of the photoelectric platform to lift and down, and display the position in place;

(9) Display the power consumption of the photoelectric platform.

3. Hardware Design of Control System
The ground control system of UAV-borne photoelectric platform is mainly realized by a set of ground control cabinet.

3.1 Overall Design of Control Cabinet Hardware
The control cabinet adopts the structure of "main control computer + VXI(PXI) + desktop instrument + connector + adapter", supplemented by special adapters and control accessories[2]. The control cabinet is mainly composed of the cabinet body, main control computer, display, image acquisition module, power conversion module, communication conversion module, voltmeter, ammeter and device switch, as shown in figure 1.

![Fig.1. Control cabinet composition](image)

Adopting the frame structure, internal control cabinet is divided into independent spaces with diaphragm plate. Main control computer, display, image acquisition module, power conversion module, communication conversion module, voltmeter, ammeter, and device switch are installed in different spaces. The diaphragm plate can be moved up and down to the right place before fixation. To make the front panel operating easily and nicely presented, voltmeter, ammeter, and device switch are in a horizontal line with logos above the switch.

3.2 Selection Analysis of Main Components of Control Cabinet
Main components of the control cabinet include main control computer, power conversion module, image acquisition module and communication conversion module.

(1) Main control computer
The main control computer of the control cabinet sends instructions issued by the control software to the photoelectric platform through the communication conversion module to realize the state control, system parameter transfer and scene search of the photoelectric platform.
The main control computer is the running platform of the control software with functions of data storage and image display. It adopts industrial control computer with stable performance, which can not only meet the requirements of software operation, but also avoid the characteristics of unstable performance of desktop, so as to realize the integration and reliability of the ground control system design \cite{3}. The operator can control the photoelectric platform by operating the photoelectric platform control software of the main control computer in the cabinet.

The main control computer collects the images output from the photoelectric platform through the image acquisition module and outputs them to the display. When recording the images, it can record them through the image acquisition software for later playback.

(2) Power conversion module

The normal working voltage of the visible camera and forward-looking infrared instrument in the photoelectric platform is 28V DC (working voltage range is 24V ~ 29V), with a rated power of 250W and the maximum power of 350W. The power supply voltage is required to be stable to avoid the influence on the reliability and life span of some precision parts. In particular, the reliability of the power supply is highly required, otherwise the entire photoelectric platform will be damaged \cite{4}. Therefore, it is necessary to design a power conversion module in the control cabinet to convert 220V/50Hz alternating current into 28V DC for the use of the visible camera and forward-looking infrared instrument. The power supply conversion module of the control cabinet can choose off-line AC 220V/28V DC switching power supply.

(3) Image acquisition module

To display output images from visible light cameras and the forward-looking infrared detector within a photoelectric platform, a general monitor can do. But its control system integration is not high. Since images are needed in some function test sessions for datum positioning and data acquisition, it is unable to handle data either. Image acquisition card can solve the above two problems. It is small in size and can be conveniently installed on the PCI slot of the main control computer. We can choose the high digital video acquisition card of the YuanGang brand as the image acquisition card of the control cabinet.

(4) Communication conversion module

RS-232 and RS-422 are both standard serial communication interfaces. In general photoelectric systems, the standard RS-422 interface is used for communication, while ordinary computers are the standard serial communication interface of RS-232, so conversion is required \cite{5}. RS-422 / RS-232 communication interface converter has got mature technology and products, so a conversion interface card is enough. A bi-directional communication protocol converter of the ShengWei brand can be selected as the converter of the control cabinet.

4. Control System Software Design

4.1 Control Software Design

The control software is integrated into the control cabinet running in the main control computer. It is mainly composed of initialization subroutine module, human-computer interaction subroutine module, timing interrupt subroutine module and feedback processing subroutine module, as shown in figure 2.
Fig. 2. Process chart of control software program

The initialization subroutine mainly completes the initial settings of serial port control, human-computer interaction control, timer control and data variables. Specifically, it mainly includes the definition of serial port baud rate, port number, working mode, check mode, human-computer interaction mode and timer interrupt cycle, as well as the assignment of data variables.

Human-computer interaction subroutine mainly completes the human-computer interaction between ground control system and the task operator. When the task operator operates the software control interface through the mouse or keyboard, the control software program responds to the operation control through buttons, check boxes, text boxes and other controls. The control software will judge the correctness of the command, and identify the type of the command, as well as make corresponding processing according to different types of operation commands.

The timing interrupt subroutine is mainly used to complete the instruction transmission to the photoelectric platform. The timing interrupt subroutine interrupts every 80ms and sends the corresponding control instruction to the photoelectric platform by calling the serial port control. What needs to be explained here is that sending an instruction to the photoelectric platform and receiving a set of feedback messages from the photoelectric platform is called an instruction cycle, and the time of an instruction cycle is 80ms. In theory, the program runs until the user turns off the software control interface. The timing interrupt subroutine is used to determine whether human-computer interaction existed during the last 80ms. If there is human-computer interaction, the control instruction of task operator is sent to the photoelectric platform \cite{6}. On the contrary, maintenance communication instructions will be sent to the photoelectric platform and displayed on the software control interface.

The feedback processing subroutine is mainly used to receive the feedback data from the photoelectric platform, store the feedback data into an array, and display the received feedback data on the software control interface. Meanwhile, status information corresponding to the photoelectric platform is displayed in text form on the software control interface.

4.2 Control Software Interface Design

The main interface of UAV photoelectric platform control software is shown in figure 3. The control interface is developed based on Visual C++ software, which mainly sends instructions to the photoelectric platform through the serial port of the main controller and collects the feedback information of the photoelectric platform.
Fig. 3. Main interface of control software

The main interface includes visible light/infrared sensor control, infrared sensor special control, photoelectric pod working mode control, data transmission and reception, tracking control, laser control and status display modules.

1. The visible light/infrared sensor control part includes the adjustment of the focal length and field of view of the sensor;
2. The infrared sensor special control part mainly aims at image gain and brightness adjustment, control mode setting, positive and negative image switching, image correction, etc., and can also control power supply and power off.
3. The photoelectric pod working mode control part is used to switch operating modes of it: start, inertia, recovery, hold, lock, automatic scan, and setting azimuth and pitch angle under the lock and scan working state.
4. The data transmission and reception part is used to display the data sent and received, which will increase after the system is powered up;
5. The tracking control part is used to confirm the target and implement tracking or change the tracking target;
6. The laser control part is used for laser ranging and laser emission period determination, etc.;
7. The status display contents include video source type, focal length value, azimuth and pitch angle value of rotary table, timing, etc.

5. Conclusion

With the progress of science and technology and the development of modern war, UAV-borne photoelectric platform develops rapidly. It mainly advances towards the three-dimensional space, the diversification and miniaturization of structural forms, the integration of sensors, and the integration of observation and strike. Therefore, the ground control system of UAV-borne photoelectric platform needs to be developed in the following aspects: optimize the structure form, reduce the volume of control cabinet, and reduce the weight; It also needs to be easily compatible with a variety of photoelectric platforms; The stability accuracy of the control system gets gradually improved, and the integration and modularization become more prominent.

References

[1] Shi lixia. Research on target tracking jamming technology of airborne photoelectric countermeasure stabilized platform [D]. Changchun: changchun university of science and technology, 2009.

[2] Liu wei. Research on stable platform control system of airship photodetector [M]. Changsha: national university of defense technology, 2009.
[3] Xie haoyu. Research on optimization technology of stable platform structure of airship detector [M]. Changsha: national university of defense technology, 2008.
[4] Guan wei. Research on low speed and positioning of airborne photoelectric platform [M]. Changchun: changchun university of technology, 2007.
[5] Wu shuping. Development of vehicle triaxial stabilized platform control system [M]. Nanjing: nanjing university of science and technology, 2007.
[6] Zhang zhiyong. Research on key measurement and control problems of photoelectric stabilized servo mechanism [D]. Changsha: national university of defense technology, 2006.