Design of optoelectronic pod system for Z-3 unmanned helicopter

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Abstract. Aerial survey of geological disasters have higher demand to the stability of the payload, especially with a payload of optoelectronic pod can absorb the unmanned helicopter attitude and vibration and compensates the attitude angle change. Keeping the payload optical axis perpendicular is to the horizontal plane. Based on the analysis of posture change and vibration frequency, optoelectronic pod system that is based on TMS320f2812 as the main controller, adopting the closed-loop control system. The results of field demonstration flight indicate that the optoelectronic pod compensates the attitude angle change due to the unmanned helicopter attitude and vibration. The high quality images which were obtained by demonstration flight satisfy low-altitude digital aerophotogrammetry.

Keywords: optoelectronic pod; Z-3 unmanned helicopterimage; stabilization; demonstration flight.

1 Introduction

Z-3 unmanned helicopter which relative to the fixed wing aircraft and airship, has low maximum speed, but more severe vibration. This is one of the main factors influencing quality of remote sensing image. During Z-3 unmanned helicopter aerophotogrammetry platform system, if the payload directly is mounted on the Z-3 unmanned helicopter, on the one hand, the body which has high frequency vibration significantly cause high frequency jitter of the payload and low definition of image, on the other hand, the azimuth and attitude of payload is out of control. Therefore, the effective payload of optoelectronic pod direct influence the quality of image. Now police unmanned helicopter optoelectronic pod and large aerial orthographic platform have mature application, but the Z-3 unmanned helicopter is limited by not more than 20 kg of payload, mature optoelectronicpod cannot be directly mounted to the Z-3 unmanned helicopter because of the control mode, the weight and volume.

To meet the requirements of aerial survey of geological disasters on optoelectronic pod performance. According to Z-3 unmanned helicopter platform, with TMS320f2812 as the main controller, on the basis of analysis of attitude change and vibration frequency of unmanned helicopter, finishing the design of optoelectronic pod system with image stabilization principle [1]. It can effectively eliminate the high frequency and automatic compensate the jitter, pitch, roll of angle deviation [2]. The high quality images which were obtained by demonstration flight satisfy low-altitude digital aero photo grammetry.

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2 Structure theory of photoelectric pod

Optoelectronic pod based on the overall technical indicators, the use of environment and the task of mission requirements, through researching the existing mode of optoelectronic detection equipment characteristics and the analysis of Z-3 installation space and the vibration characteristics of unmanned helicopter, determining the optoelectronic pod technical indicators. In the end, mechanical structure of the optoelectronic pod use three axis platform.

3 Photoelectric pod principle

The stabilized platform is connected by precision bearing, making the frame can be moved each other. Framework configuration from the outer to the inner framework are roll, pitch and azimuth framework. The stable objects (the camera) fixed installed in a location within the framework of the stable plane, respectively in the three support shaft end equipped with attached directly to the shaft torque motor which is used to drive platform for each frame rotation. In their respective shaft which corresponds to the spin variable used to measure relative stable platform carrier in azimuth, pitch and roll on the direction of the three axial angle deviation of relative to their respective framework; gyro platform used for sensitive in three directions for inertial coordinate system which are angular velocity parameters of the movement. Inertial measurement unit is used to get the platform which relative to the inertial coordinate system rotation matrix or parameters such as rotation quaternion.

According to the mechanical structure of the platform between each frame kinematics principle, configuration and installation in location within the framework of the platform body movement is produced by torque motor bearing frame circuit compensation angle motion and pitching angle motion synthesis framework coupled to the bearing framework. The angular motion of pitching framework is the motion synthesis through the angle of motor sport and pitch frame circuit of compensation angle motion and roll framework coupled to the framework of pitch angle. Roll frame angular motion is produced by roll motor frame circuit compensation angle motion and platform angle motion coupled to the framework of azimuth angle motion synthesis. Above all, the movement of the sensor is made up of roll frame, pitch framework, bearing frame and carrier of the movement which are derived through complex coupling relationship.

To isolate interference angle motion on each frame, needing to set up three platform stable loop: horizontal roller steady servo loop, pitching axis servo loop stability and stable bearing axis servo loop, respectively, using the reverse compensation of motor angular velocity to compensate interference velocity of coupled to the platform.

Inertial measurement unit is sensitive to the carrier’s rate of angle swing, by means of the gyro stabilization loop, keeping optoelectronic pod into the stability of the closed-loop control under swing and vibration conditions of the unmanned helicopter. By the inertial element to calculate theeuler angle, rotating quaternions and rotation matrix, and by the management module to calculate the pod ontology of rotary angle of the shaft system realize the stable position closed loop control, making the image sensor which can get orthographic images. Control message by Z-3 unmanned helicopter control link send command to the pod, controlling platform into the normal operation, and reporting and recording the working stateplat form. Working principle is shown as figure 1.

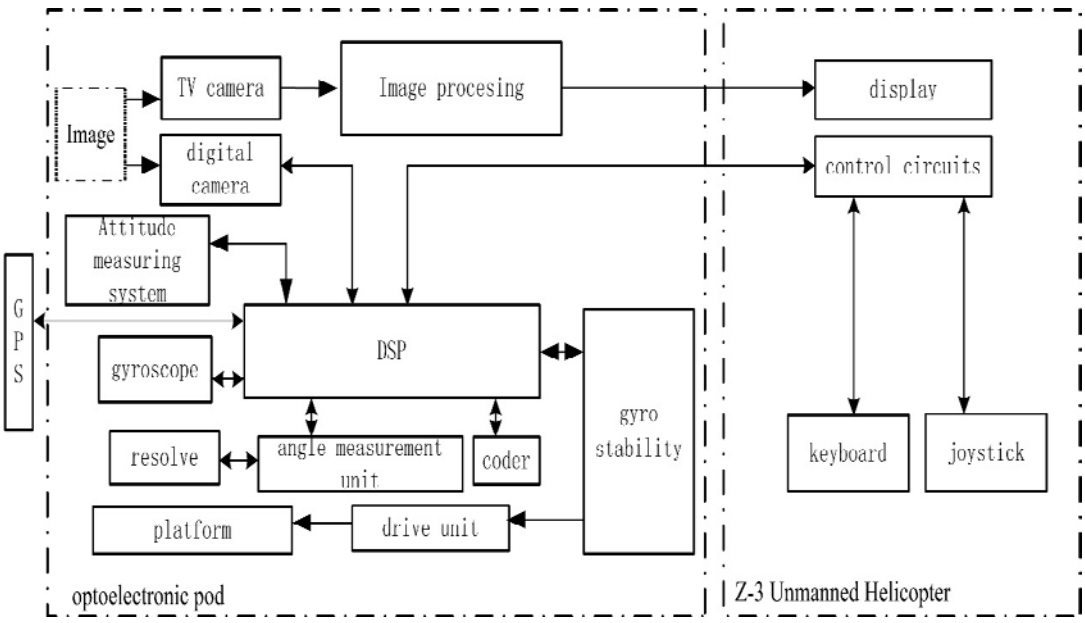

Figure1. Working principle

4 Physical design of optoelectronic pod

The mechanical structure is an important part of the pod. Its performance directly affect the overall performance of the pod. The mechanical structure must have a good rigidity, small volume, light quality, high precision, compact structure and good maintainability. The structure design consider the space, weight and the limitation of working environment. Combined with image sensor and electronic circuit design, select reasonable load structure form, determine the best layout scheme, allocate unit indicators, choose the reasonable structure of components and minimize the weight of the parts of uncertainty. Under ensuring the precision of the shafting, the tensile and stiffness, try to reduce the volume and weight of the shafting.

4.1 Physical design

The optoelectronic pod which is based on Z-3 unmanned helicopter's installing space, considering the vibration, the payload weight and the dismounting way, adopt the mechanical structure of the three-axis platform as shown in figures(Fig.2,Fig.3,Fig.4,Fig.5) . The top with a hemispherical structure as shown in figure 5, reduce the wind resistance, the gyration radius and the moment of inertia.

Figure 2. Pitch axis

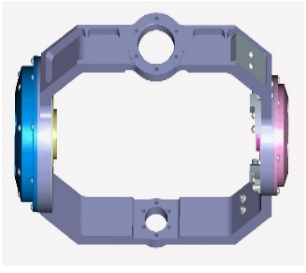

Figure 3. Roll axis

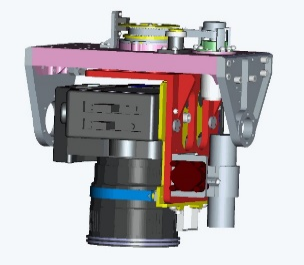

Figure 4. Azimuth axis

Figure 5. Hemispherical structure of pod

4.2 Seismic design

According to the unmanned helicopter's vibration frequency characteristics and the pod overall weight to choose the appropriate absorber, considering the inclement optoelectronic pod working environment and the diversity of flight attitude[3]. Given the unmanned helicopter vibration frequency characteristic, in order to filter more than 10 Hz high frequency in the form of passive vibration reduction of component, absorb 10 Hz low frequency component of vibration the stability of servo control system. From the effect of vibration isolation test, optimal damping ratio is ζ equal to 0.05 to 0.2. Within this range, resonance amplitude is smaller. Within ζ equal to 0.1 to 0.2, considering the weight factors, the most practical way is to use the rubber absorber. It is not only the elastic component but also viscoelastic dampers. According to the above analysis, choosing the three-dimensional absorber which is made up of the central metal core column, umbrella cover metal and rubber connection.

5 Design of electric system

According to the technical requirements, the electric integrated design of optoelectronic pod which combined with structural design develops the miniaturization, low power consumption control board and image processing board. In order to Improve the comprehensive performance of the system, using large scale integrated circuit and high speed digital processor to realize electronic processing unit of modularization and integration and using multiple processors, complete series of parallel processing system integrated control and image acquisition process. Based on integrated control technology, light machine integration technology, electrical system miniaturization, High vibration absorbing technique, high precision gyro platform vibration damping technology and real-time digital image processing technology to improve optoelectronic system[4].

5.1 Management module

The control management of main control module is the main working mode of reception control. The main control module is responsible for the receiving host command at any time or an external device information, and according to the received command or information to control the corresponding equipment, making the system work in a normal condition. The control channel is the electrical and mechanical frame structure, including an inner ring of speed and outer loop of position. The system is essentially a typical servo control system. The main task of testable tracking control system which is composed of receiving channel and control channel is to keep the optical axis perpendicular to the horizontal plane.

Control circuit function is mainly composed of DSP processing and storage unit, D/A expansion units, external bus extension units, asynchronous-serial expansion unit, I/O expansion unit, angle measurement expansion interface unit, FPGA control unit and so on. Compositional controlling management modules is shown in figure 6.

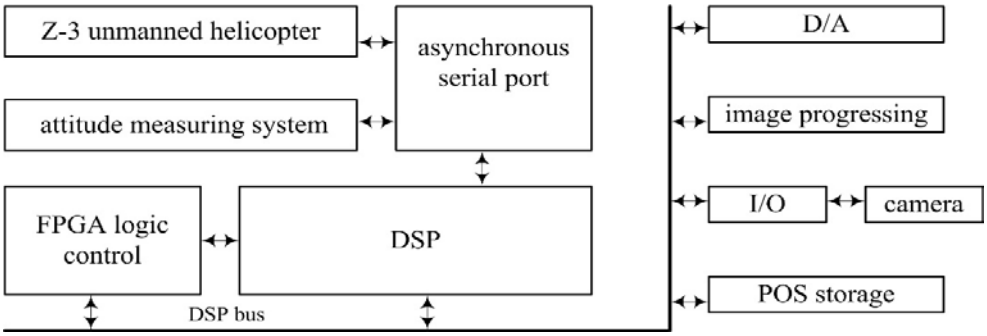

Figure 6. Compositional controlling management module

5.2 Gyro stability and servo control

Gyro stabilization and performed is made of the controller, power amplifier, the motor servo board and so on. The gyro stability, servo board, control board, angle measuring circuit and gyro servo unit constitute the type II speed no difference, spin, roll, pitch servo units, same gyro servo board composition as shown in figure 7, stability and stable servo module according to the size of the speed signal voltage control platform at a certain rate of azimuth and pitching rotation, the implementation of the target area of the detection and tracking.

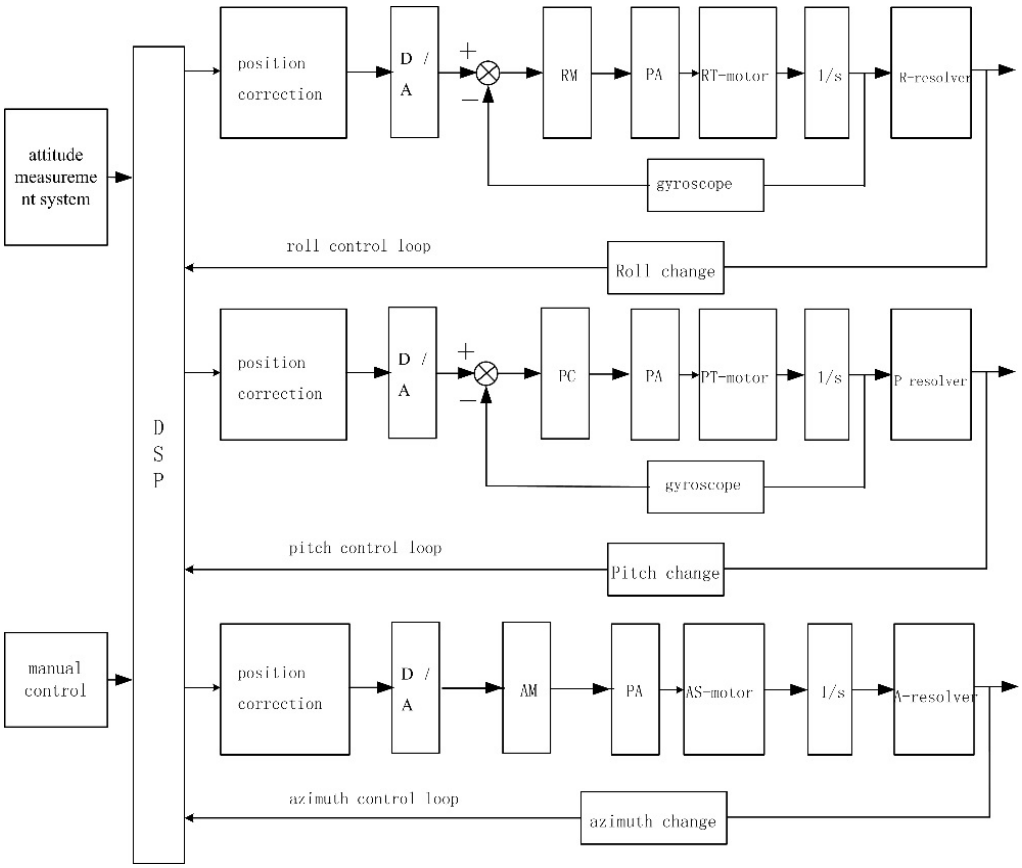

Figure 7. Gyro stability and servo system

6 Control system design of software

Pod software consists of three independent unit of work. Control management software: responsible for the closed-loop control of servo control system, function module, the parameter adjustment and settings of pod and sensor, power management, self-checking, communication between pod and helicopter and so on. Image processing software, responsible for image collection, superposition of characters and symbols, menu display and so on. Control and processing software: responsible for sending control commands and the display of the video signal, running in the display control unit. Automatic control and manual control system realize the control of pod. Optoelectronic pod software flow diagram as shown in figure 8.

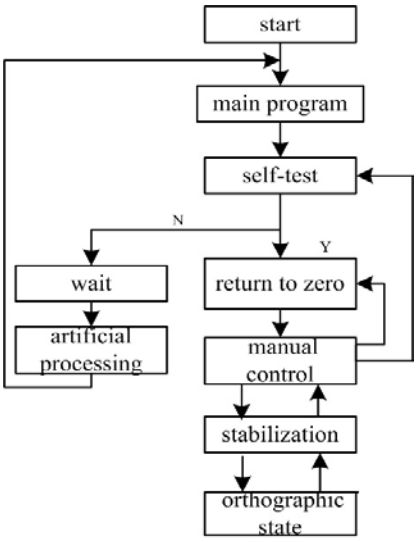

Figure 8. Optoelectronic pod software flow diagram

7 Field demonstration flight

At the Mingguang airport, Z-3unmanned helicopter mount optoelectronic pod to carry out the demonstration flight as shown in figure 9. The flight design the four airlines, flight altitude 300 m, forward over lapis 80%,side overlap is 50% and acquires174 images. Choosing Pixel Grid-UAV software as the data processing analysis. Remote sensing image data processing flow chart is shown in figure 10. Through the data preprocessing, automatical aerial triangulation, control points and transform images[5], generating Mingguang airport digital orthophoto map as shown in figure 11. The result of demonstration flight indicate that the attitude angle of image POS data range between±3 °, meeting the design performance requirements.

Figure 9. Demonstration flight

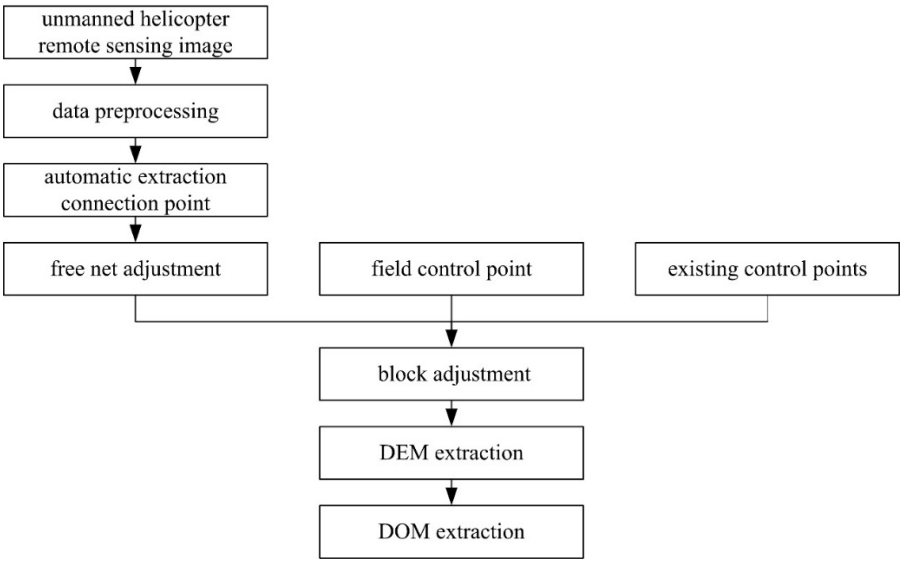

Figure 10. Remote sensing image data processing flow chart

Figure 11. Digital orthophoto map

8 Conclusions

Optoelectronic pod system that is based on TMS320f2812 as the core controller, adopting the closed-loop control system, possessing the three-axis stabilized orthographic function and isolate vibration, is not affected by the swing and vibration of unmanned helicopter. Keeping the payload optical axis perpendicular is to the horizontal plane. Optoelectronic pod system have the following characteristics: light weight, low power, high integration, stable performance, etc. The results of field demonstration flight show that the optoelectronic pod compensates the attitude angle change due to the unmanned helicopter attitude and vibration. Its communication and working is in good condition. The high quality images which were obtained by demonstration flight satisfy low-altitude digital aerophotogrammetry. It has the very good application prospects.

Acknowledgement

This research was financially supported by Geological Survey Project of China No.1212011220164, No.121201012000150016 and No. 121201012000150014; The special public welfare industry

research of The Ministry of land and resources in China No.201011020-8.

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