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Stabilization precision control methods of photoelectric aim-stabilized system

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ABSTRACT

To solve the question that photoelectric aim-stabilized system can be controlled with high precision and stability, this paper researches a new photoelectric aim-stabilized control algorithm, analyzes the photoelectric aim-stabilized system architecture, sets up stability control system mathematical model, designs the stability of the photoelectric aim-stabilized LSSVM identification and control system, discusses uncertain factors and calculates the LSSVM parameters by the Chaos theory, gives the predictive controller model by the LSSVM and designs new photoelectric aim-stabilized system. Through the simulation calculation and experimental analysis, new photoelectric aim-stabilized control algorithm was verified; the results show the new photoelectric aim-stabilized control method can meet the demand of high precision control in photoelectric aim-stabilized system. Q2

1. Introduction

The airborne photoelectric stabilized equipments mostly are equipped with the various types of aircrafts in recent years. Its core is the gyro stabilized platforms and it is designed to isolate disturbance yielded by carrier, and stability accuracy is one of the most important and critical indicators in photoelectric aim-stabilized system for photoelectric aim-stabilized system performance evaluation. In current photoelectric aim-stabilized system, there are some contradictions between rapidity and control accuracy. To overcome these contradictions there are some ways as following. In reference [1] has designed a fuzzy classic composite control method, this system has high control accuracy, but with the dimension increase the fuzzy logic control needs to be adjusted to lots of fuzzy variables and parameters. This complex adjustment process will take a lot of time. In reference [2] the synovial variable structure control can better solve the contradiction between precision and rapidity. This is very hard to coordinate in the traditional design method. But it is easy to have a chattering phenomenon because of inertia or delay factors. The active disturbance rejection controller (ADRC) is applied in reference [3]. The simulation results show that it has strong robustness, rapidity, and high precision etc, but it is not very good to adapt to some objects of the large variation parameters.

A certain type of photoelectric stabilized pod is selected as the research object; it has the dynamic seal, high friction characteristics. Photoelectric detection technology and photoelectric precision guidance technology requirements tracking control system has high control precision and fast tracking ability. There will be some contradictions between fast (regulation time) and control accuracy (overshoot) in the traditional servo control algorithm. Least Square Support Vector Machine (LSSVM) is a specialized machine learning theory in small sample situation and it is fast speed. LSSVM has excellent generalization ability, it has a good learn and function approximation ability [4,5]. Rough Sets (RS) can attribute reduction under the condition of classification ability unchanged; it can deal with the large capacity high dimensional information. In order to ensure real-time system, the RS theory is to contract the data attribute values of the sensor measured. It is to eliminate redundant information and reduce LSSVM training data, thus overcome the LSSVM algorithm because of large amount of data, slow processing speed of faults. It is put forward photoelectric stabilized platform stability control method based on the RS-LSSVM methods according to the characteristics of various methods on the advantages and disadvantages of airborne photoelectric aim-stability system stable precision control method. It

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is very meaningful and necessary to research a new method of photoelectric aim-stability system stability and accuracy.

2. The structure and mathematical model of photoelectric aim-stability system

2.1. The structure and principle of photoelectric aim-stability system

The two-ring structure of photoelectric aim-stability system is studied in this paper. They are respectively position outer ring and internal ring, as shown in Fig. 1. Photoelectric sensors and inertial sensors are mounted on the inner pitch rack. The inertial sensor is the rate gyroscope, the position and pitch motor is driven by the sensitive gyro gimbal inertial space relative speed through the position and pitch stabilization controllers, thus it achieved the stability of the photoelectric sensor relative inertia space.

The control loop of photoelectric aim-stability system is shown in Fig. 2. The whole loop includes the current loop, stable loop and position loop. The armature current is strictly followed by the current instruction and as soon as possible by the current loop control; it can improve the dynamic characteristics of current with voltage. They are including overshoot, regulation time, suppress the influence of electronic noise and back electromotive force coefficient etc. Stable ring is the key to the photoelectric aim-stability system. Airborne application of photoelectric detector is directly affected by servo system stable loop performance. Inertia rate gyro is used as the sensitive element in the stabilization loop. It is used to detect the photoelectric stabilized platform position and pitch axis angular velocity. The error voltage is formed between the angular velocity and the speed command signal, and then, it can produce a steady torque on the DC motor shaft through stability controller, so, it can realize the photoelectric stabilized platform in the disturbance rejection and keep relatively stable in inertial space. The external is the position loop; the control deviation is generated by comparing the input signal and feedback signal. It is to control the photoelectric steady ring steady with the aid of position controller compensating output.

The stable precision of photoelectric aim-stabilization system is related to many factors such as electromechanical devices, the working environment, complex nonlinear interaction between the various photoelectric related sensors etc. Gyro output signal as a major factor in the multitude of factors that affect the stability of the precision, it can represent stability and accuracy of the magnitude, so, the steady precision of test solution can be found according to the principle of aim-stabilization system stability. The photoelectric aim-stabilization system uses whole platform manner, the carrier platform angular rate of movement is sensed by the gyro of external stable position loop when the system is driven by an external carrier platform vibration disturbance load movement. Gyro output signal is sent to the platform torque motor after correction and amplification. It makes the platform keep stable when the reverse control torque is produced. It is available to the system stability and accuracy after the gyro output signal by the corresponding mathematical operations and it is the basic principle of photoelectric aim-stabilization system.

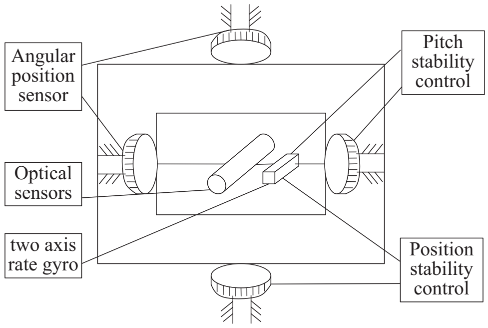

Fig. 1. The structure of photoelectric aim-stability system.

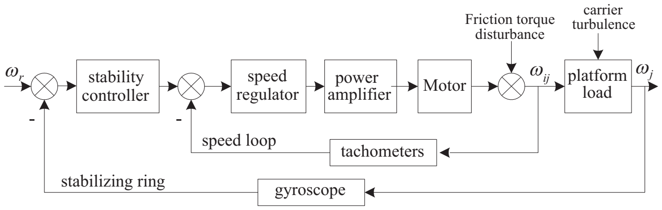

Fig. 2. Stabilization precision control block of photoelectric aim-stabilization system.

2.2. The mathematical model of photoelectric aim-stability system

From Fig. 2, we know motor drive and photoelectric turret is the stability control member. The current closed-loop PWM is dived by the motor driver. Its linear system control block diagram is shown in Fig. 3, the derivation process can refer to reference [6]. The comprehensive amplification coefficient in the feedback channel is $kr=0.45$. $K_{PWM}=12$ is the *PWM* amplification coefficient. $R=4.4\ \Omega$ indicates the circuit loop resistance. $L=3.6$ mH is the loop inductance. K_T and K_e are all equal to 0.93. They are moment coefficient and back electromotive force coefficient, respectively. $J=0.5\ \mathrm{kg\cdot m^2}$ represents the moment of inertia. b is a system of linear damping coefficient, the value of 0.001. T_d is the disturbing moment. The u is the given control, the u' is the control volume by the current closed-loop *PWM*. It includes the nonlinear friction, unbalanced torque, etc.

(1) The gyroscope mathematical model
The photoelectric system requires servo control system that can isolate carrier motion and vibration; it can realize the image stabilization in inertial space. The rate gyro is used in the photoelectric aim-stabilization system and it can be described using first and second order link [7], the model can be expressed by formula (1).

$$G_H = k_g \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2} \tag{1}$$

In (1), G_H is gyroscope mathematical model, k_g is the gyro gain, the value of k_g is 10; ω_n is the gyro inherent frequency, $\omega_n=100$ Hz; ξ is the damping ratio, $\xi=0.707$.

(2) The nonlinear friction model

Friction is a typical nonlinear link in photoelectric stabilized platform. It is an important factor affecting system performance. At present the project general reference Stribeck model.

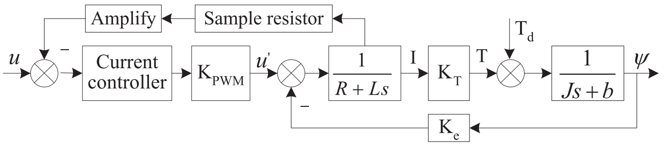

Fig. 3. The mathematical model block diagram of photoelectric aim-stability system.

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