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Research on the Control Approach of Image Stabilization Platform Oriented to Polarization Information

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Abstract: This paper integrates the mechanical image stabilization into the polarization information acquisition device. On the basis of analyzing the structure of gyro stabilization platform which is used to gain polarization information and the inertial stabilization isolation theory, the factors that affect the precision of gyro stabilization platform are researched. Furthermore, the modeling and simulation of the stabilization control circuit are made. In view of the shortcomings of the classical PID control algorithm, an algorithm is put up with based on the variable parameters PID control and fuzzy PID control. The simulation results demonstrate that the improved algorithm overcomes the shortcomings of classical PID algorithm and effectively solves the problem of information blurring caused by the sight jitter in polarization information acquisition. The steady state precision and response speed have been greatly improved. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Image stabilization, Variable parameters PID, Fuzzy PID control.

1. Introduction

Currently, in order to solve the problem of visual perception in low visibility condition, three-channels of high-quality with synchronous stationary polarization information is needed [1]. Under dynamic environment, the carrier for the polarization information acquisition device includes the different motion modes in yaw, pitch and roll. The self-vibration of the carrier, as well as the interference from external environment to the carrier, can be coupled to the device platform of polarization information acquisition. It would bring about jitter by the visual axis and image blurring, even arise great impact on the image processing in depth and the visual accurate perception. The traditional polarization information acquisition device is generally not integrated with the stationary function [2]. Based on this point, this paper attempts to integrate the mechanical image stabilization into the system of the polarization information acquisition device, so as to meet the demands of obtaining polarization information of high quality.

The stabilized platform for polarization information acquisition device adopts gyro-inertia platform structure, which serves as the sensitive component and platform visual axis of angular motion for space velocity. It regulates the servo torque generated by torque motor and offsets disturbance moment by platform visual axis motion, thus the stability of platform visual axis can be guaranteed. So far, the conventional PID algorithm has still been adopted to most of the control for stable platform [3-6], which aiming at compensating for the obvious delay. With the increasing the high demand for the information acquisition of the modern stable platform, including high dynamic characteristics, fast respond and wide brand, the conventional PID control method can not meet the demands any more. As a consequence, it is great necessary to make an improvement and innovation on the basis of conventional PID control. In resent years, many advanced control algorithms come up [7-10], such as neural network control, fuzzy control, variable structure control.

This paper takes the issue of addressing the problem of visual perception under the low visibility as background, studies on the gyro-stabilized platform used for the polarization information acquisition device. On the basis of exploring the basic structure of gyro-stabilized platform by polarization information acquisition and the theory of inertial stabilization and isolation, this paper attempts to build a mathematical model with stable loop. Then the factor that affects the accuracy of platform stability is analyzed. The PID control algorithm with variable parameter based on fuzzy control for stable control is applied. Meanwhile, the algorithm is verified through the simulation software of Matlab-Simulink. The result proved that the improved control algorithm can work stably with the control system of stable platform.

2. Image Stabilization Control Algorithm

The gyro-stabilized platform structure in this paper is three-axis frame structure. The isolation principle is: by the movement of gyro-sensitive platform relative to the inertia space and driving framework torque motor, the disturbance torque is overcame so as to ensure the polarization information acquisition device won't be affected by carrier movement. The principle is shown as Fig. 1.

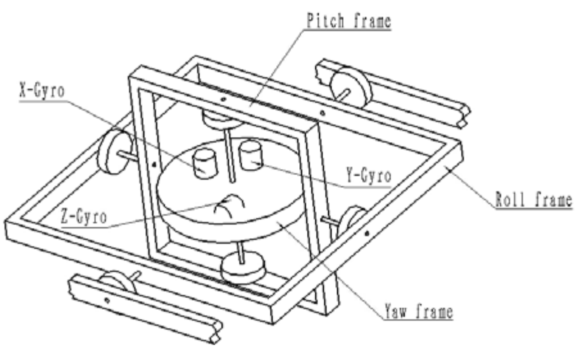


Fig. 1. Principle of stable platform structure.

2.1. Mathematical Model of Stabilization Loop

The polarization information acquisition by stable platform uses gyro with three-degrees of freedom as feedback element, which give the feedback information of the angular deviation relative to inertia space to control system. The motor is controlled by control system stabilize visual axis. The stable loop model of gyro-stable platform is shown as Fig. 1. The stable platform system is made up by the liquid floated integral gyro with single- degree of freedom, DC torque motor, platform body, PWM power amplifier.

After modeling to every aspect, the unregulated open-loop transfer function is as follow:

$$G(s) = \frac{523500}{s^3 + 100.56s^2 + 10470s}, \tag{1}$$

After the series correction for the stable loop, here is the designed calculation series compensator:

$$F(s) = \frac{5(0.15s+1)(0.012s+1)}{(0.00157s+1)(0.001s+1)}, \tag{2}$$

Under the condition of the accurate model for controlled object, the algorithms to be carried out by the controller based on classic PID control method can guarantee the good stability of the system. However, in consideration of the actual model changes that exist in the system and the non-linearity disturbance factor, the simulation reveals that it cannot always ensure the proper control accuracy of the system. The performance of all components in the control system would vary because of the changes in external environment, the disturbance of the friction and the carrier vibration, the changed carrier status. Therefore, the conventional PID control algorithms based on the fixed correction link cannot guarantee the system equipped with the best performance all the time. The performance of the control system will be improved greatly if we can adopt some adjustable measures on the basis of regular PID design to make the controlling parameters adapt to the change of the controlled object.

2.2. PID Control Algorithms with Variable Parameter Based on Fuzzy Control

The fuzzy control is based on the experience of human operation. It transforms the control strategy of human's natural language expression into the data or mathematical function by the fuzzy logic inference. So as to realize its determined control by the controller, a two-input-three-output fuzzy controller can realize the regulation of coefficient *KP*, *KI*, *KD* for PID controller. The two inputs are deviation E and deviation variation EC, and the three outputs are ratio coefficient variation *P*, integration coefficient variation *I*, and differential coefficient variation *D*. A rule chart of fuzzy regulation is built up on ratio, integration and differential coefficient in order to make the controller parameters realize the online-self-turning. The core control theory as follows: taking the present deviation E and deviation variation EC as the input of the fuzzy controller; then after a series operation of the fuzzification, the logical deduction and the ambiguity resolution, the regulating variables of the present PID controller parameters are obtained; according to the analysis of the influence of the deviation E and the deviation variation EC on PID coefficients, we can get the rule chart of fuzzy regulation for PID parameter, as shown in the Table 1.

According to the rule chart of PID fuzzy regulation in Table 1, we can establish the control rule chart of fuzzy controller. When the system runs, the fuzzy controller can check the control rule chart according to deviation E and deviation variation EC of the system, and get PID parameter variation, then the actual PID controller parameter *KP*, *KI*, *KD* are:

Table 1. Fuzzy control rules table.

E \ EC (P/I/D)	NB	NM	NS	ZO	PS	PM	PB
NB	PB/NB/PS	PB/NB/NS	PM/NM/NB	PM/NM/NB	PS/NS/NB	ZO/ZO/NS	ZO/ZO/NS
NM	PB/NB/PS	PB/NB/NS	PM/NM/NB	PS/NS/NM	ZO/ZO/NS	NS//ZO/ZO	NS/ZO//ZO
NS	PM/NB/ZO	PM/NM/NS	PM/NS/NM	PS/NS/NM	ZO/ZO/NS	NS/PS/NS	NS/PS/ZO
ZO	PM/NM/ZO	PM/NM/NS	PS/NS/NS	ZO/ZO/NS	NS/PS/NS	NM/PS/NS	NM/PB/ZO
PS	PS/ZO/PB	PS/NS/ZO	ZO/ZO/ZO	NS/PS/ZO	NS/PS/ZO	NM/PB/ZO	NM/PB/ZO
PM	PS/ZO/PB	ZO/ZO/PS	NS/PS/PS	NM/PS/PS	NM/PM/PS	NM/PB/PS	NB/PB/PB
PB	ZO/ZO/PB	ZO/ZO/PM	NM/PS/PM	NM/PM/PM	NM/PM/PS	NB/PB/PS	NB/PB/PB

$$\begin{cases} KP = P_0 + P \\ KI = I_0 + I \\ KD = D_0 + D \end{cases}, \tag{3}$$

where P_0, I_0, D_0 serve as the initial parameters of the fuzzy PID controller. The general parameters to be set by PID controller are selected to realize the online-self-regulation of the PID parameter according to the error and error change ratio.

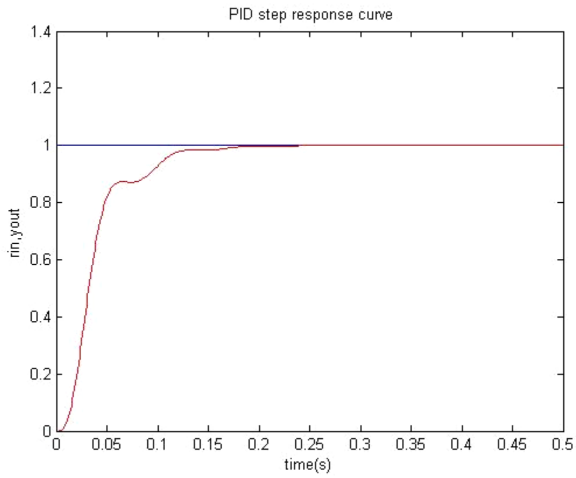
3. Simulation Analysis by MATLAB

Fig. 2 shows that the unit step response curve (a) and sinusoidal error tracking curve of the PID controller algorithms with the variable parameter based on fuzzy control.

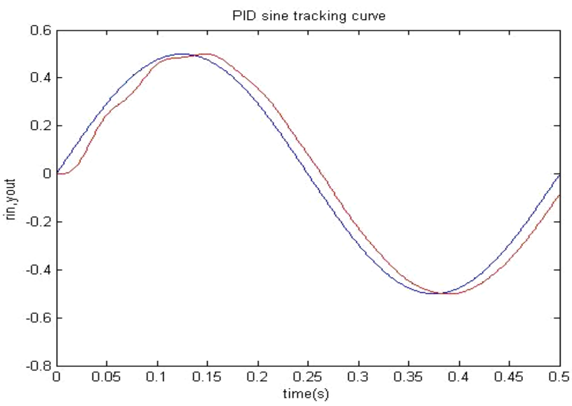
According to Fig. 2(a), the unit step response doesn't overshoot based on fuzzy PID control algorithms with variable parameter, while rising time and adjusting time decrease a little comparing with conventional PID algorithms, response speed increases and steady state error decreases. Fig. 2(b) shows that the PID control algorithms with variable parameter based on fuzzy control basically meets the demands of technique requests of stable platform.

According to the analysis of the parameter in online-self-regulation and unit-step-response curve in Fig. 3, we can see that PID control algorithms with variable parameter based on fuzzy control can stabilize the platform and make response promptly even in different working condition, which is very important to the polarization information acquisition.

Learned from the Fourier series expansion theory, any single signal can be expanded into the sum of one base-wave signal and more than one harmonic signal. Therefore, only the typical step signal and sinusoidal signal would be applied to verify the capability of the algorithms in the simulation process, while the other arbitrary signals would just be the linear combination of the step signal and sinusoidal signal. So the PID control algorithms based on variable parameter has good static performance and dynamic performance to other arbitrary signals.

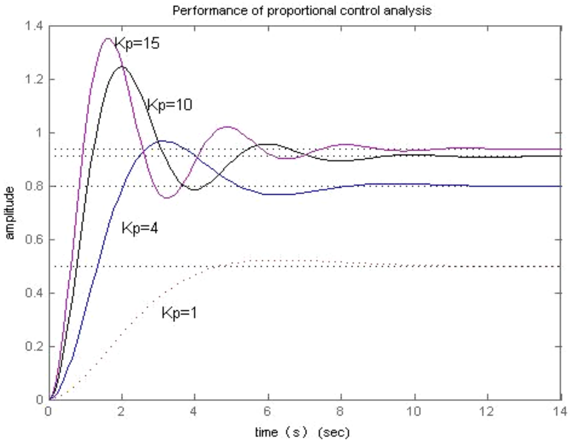


(a)

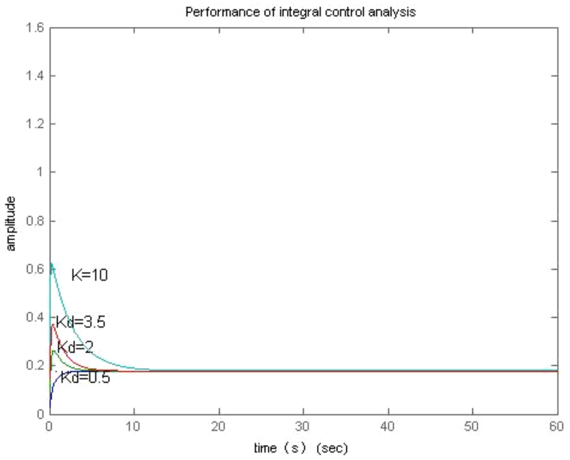


(b)

Fig. 2. Error tracking curve.



(a)



(b)

Fig. 3. Online-self-regulation and unit-step-response curve of variable parameter based on fuzzy control.

4. Conclusions

This paper sets to solve the problem of visual perception in low visibility, and takes the gyro-stable platform for polarization information acquisition as the research object. It explored the basic structural of this gyro stabilized platform and inertial stabilization isolation theory. Emphasized on stability control algorithms, the stable control loop is modeled and simulated. And then, the factor that influences the accuracy of the gyro-stable platform is analyzed. Regarding to the deficiency in conventional PID control algorithms, this paper carries out the PID control algorithms with variable parameters based on fuzzy control. The simulation result proved that the improved algorithms can meet the demands of the stability in polarization information acquisition. It also has strong robustness to the uncertainty of the model and the nonlinear disturbance.

Acknowledgements

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