Research for Control Parameters Optimization of 6-DOF Flight Simulator Based on Particle Swarm Optimization

Yun Lu\(^1,2\), Kai Zhou\(^1\), Weijia Li\(^1\), Wenzhuo Tian\(^3\), Xiao Wang\(^4\)

1. School of Naval Architecture and Ocean Engineering, Huazhong University of Science and Technology, Wuhan, Hubei, China
2. Detachment of Warship Training, Dalian Naval Academy, Dalian, Liaoning, China
3. NO.722 Institute, China Shipbuilding Industry Corporation, Wuhan, Hubei, China
4. Key Laboratory of Naval Architecture and Ocean Engineering Hydrodynamics, Wuhan, Hubei, China

ABSTRACT

Based on a 6-DOF flight simulator driven by electricity, the experiments show that certain parameters of the AC servo driver have a great impact on the stability of the platform. The study of the optimization for controlling parameters of the AC servo drivers is carried out by the continuous change to the controlling parameters, aiming to improve the performances of the platform in stabilization and frequency response by Particle Swarm Optimization. The result shows that the Particle Swarm optimization algorithm is fitted for the system of the controlling parameter optimization.

KEY WORDS: AC servo motor drivers; controlling parameter optimization; particle swarm optimization; Stewart platform; roulette operator.

INTRODUCTION

This study aims at optimize the control parameter of 6-DOF flight simulator by using the particle swarm optimization method. The flight simulator provides realistic flight environment for pilot training by simulating the space 6-DOF motion. Compared with the traditional training, it can save training expenses, and also fully guarantee the safety of pilots. Therefore, the flight simulator is used to train pilots more and more. Electric 6-DOF platform is an important component of the flight simulator. The transient overload feel and the dynamic information of attitude angle changes within a certain range are given by the platform. The stability and frequency response has some strict requirements and the motivation of the platform is provided by the servo motor. The control performance of the AC servo driver which is the kernel control part of the motor system directly affects the performance of the entire platform system. However, there is always a contradiction between the speed of response and stability of the system. So the appropriate controlling parameters are selected to make a compromise between the speed of response and stability. In this paper, the controlling parameter optimization based on Particle Swarm Optimization effectively solves the contradiction between the speed of response and stability of the system.

STRUCTURE OF THE PLATFORM

The research object of this paper is based on the structure of Stewart platform that simulates the space 6-DOF motion. The platform consists of six electric cylinders, the upper platform (motion platform), the lower platform (fixed platform) and cross hinge (connecting the upper and lower platforms with the electric cylinders). It is shown in Fig. 1. The upper and lower platforms are connected in parallel with electric servo cylinders by the cross hinges so that the six electric servo cylinders can flex independently. Through the coordinate flexing of cylinders, the spatial position and attitude on the six freedoms can be achieved. The electric cylinder is driven by the AC servo motor which has a working stroke of 860mm, output force 28KN and achieves the maximum speed of 600mm/s. Each set of the cylinder is driven by a AC servo motor and a corresponding driver. The motor that is the brushless servo motor of Fissler Ultract \(\text{III}\) series has a rated power of 6.7kW. And the driver is LENZE 9400H series.

The motion control of the platform is based on position control. The communication of the input control instruction between host computer and the servo drivers is achieved by the CAN bus. According to the servo driver control instruction and the feedback signal of servo motor encoder, the closed loop control is realized by the internal adjustment of the driver. The measurement for the six freedoms of the 6-DOF platform is achieved by the slave computer which is equipped with the Embedded Linux System. The position and attitude of the platform is returned to the master computer through the network communication. The optimization research of the control system is carried out based on the sinusoidal signal input. The control effect is evaluated through the feedback state information of the control system which is sent by the CAN bus communication. The corresponding control parameters of the driver gotten by the optimization algorithm can be set through RS232 serial port. The control system schematic is illustrated in Fig.2.