The Study of Gain Optimization of Sliding Mode Controller with Sliding Perturbation Observer by using of Genetic Algorithm

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Abstract

The Stewart platform manipulator is a closed-kinematics chain robot manipulator that is capable of providing high structural rigidity and positional accuracy. However, this is a complex structure, so controllability of the system is not so good. In this paper, it introduces a new robust motion control algorithm using partial state feedback for a class of nonlinear systems in the presence of modelling uncertainties and external disturbances. The major contribution of this work introduces the development and design of robust observer for the state and the perturbation which is integrated into a variable structure controller(VSC) structure. The combination of controller/observer gives rise to the robust routine called sliding mode control with sliding perturbation observer(SMCSPO). The optimal gains of SMCSPO are easily obtained by genetic algorithm. Simulation and experiment are presented in order to apply to the stewart platform manipulator. There results show highly accuracy and performance.

1. Introduction

The stewart platform manipulator is the manipulator that has the closed-loop structure with a upper plate of end-effector and a lower plate of base frame[1]. The Stewart platform manipulator has the merit with highly working accuracy and rigidly stiffness compared with a serial manipulator. However, this has a complex structure, so controllability of the system is not so good. The major contribution of the design of robust controller for Stewart platform manipulator introduces the development and design of robust observer for the state and the perturbation which is integrated into a variable structure controller structure. The combination of controller /observer gives rise to the robust routine called sliding mode control with sliding perturbation observer. Sliding observer is a high performance state estimator well suited for nonlinear uncertain systems with partial state feedback. Then system is not required additional sensor. The sliding function of this observer is the estimation error of the available output. This observer uses as a tool to eliminate the requirement of a full state feedback in the perturbation estimation, reducing the implementation costs. The resulting observer is able to provide much better state estimation accuracy and is named sliding perturbation observer(SPO). We show that the further combination of this SPO and SMC results in a high performance algorithm that is robust against perturbations, utilizes only partial state feedback[2~3]. In this paper, a new robust motion control algorithm using partial state feedback for a class of nonlinear systems in the presence of modelling uncertainties and external disturbances is applied to Stewart platform. Also, The optimal gains of the motion control algorithm are easily obtained by genetic algorithm. The Stewart platform for the driving simulator is shown as Fig. 1.

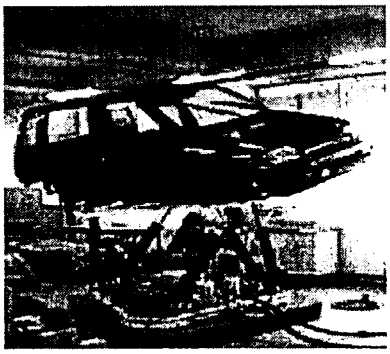

Fig. 1 The Stewart platform for the driving simulator

2. Design of Sliding Perturbation Observer

This section describes the proposed perturbation observer without considering the closed-loop control.

System Modeling and Perturbation Concept

Generally, the governing equation for second order dynamics with 6-degree of freedom is Eq. (1).

$$\ddot{x}_j = f_j(X) + \Delta f_j(X) + \sum_{i=1}^{6}[(b_{ji}(X) + \Delta b_{ji}(X))u_i] + d_j(t) \qquad j=1,\cdots,6 \tag{1}$$

where,

$x \equiv [X_1, \cdots, X_n]^T$: State vector

$X_i \equiv [x_i \ \dot{x}_i]^T$: State variable

$\Delta f_j(X)$: Uncertainties of nonlinear driving terms

$\Delta b_{ji}(X)$: Uncertainties of the control gain matrix

d_i : Disturbance

u_i: Control input