Switching Control using Second Order and Fast Terminal Sliding Modes for a Positioning System under Large Disturbances

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Abstract
Control of a positioning system installed on a moving vehicle requires robustness against large external disturbances since the motion of the vehicle continuously changes due to the ground irregularities. In this paper, a two-axis aiming system with yaw and pitch joints is considered for the position control for aiming at a given target. The system has significant nonlinear characteristics because of the requirement of fast reaction and is under a stream of disturbances. Sliding mode control (SMC) is useful for this kind of systems with nonlinearity, modelling uncertainty, and external disturbances. However, ordinary SMC has a problem of severe chattering in the torque input despite of its features of disturbance rejection and guaranteed finite-time convergence [1].

We adopted two advanced SMCs, second-order SMC (SOSMC) and fast terminal SMC (FTSMC) for control of the two-axis positioning system. The former has reduced chattering while the latter has a faster settling time. We propose a switching control which exploits the advantage of each of SOSMC and FTSMC.

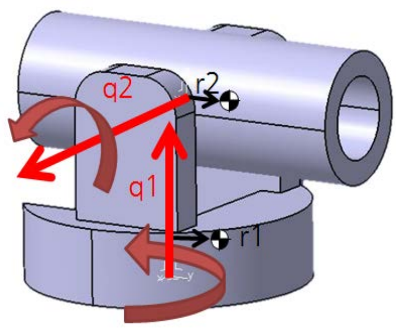

Figure 1: Schematics of the positioning system

The controlled system is a positioning system whose schematic is shown in Figure 1. Through Lagrangean dynamic modeling, the following equations of motion are derived.

$$\begin{bmatrix}\tau_1\\ \tau_2\end{bmatrix} = \begin{bmatrix}H_{11} & H_{12}\\ H_{21} & H_{22}\end{bmatrix}\begin{bmatrix}\ddot{q}_1\\ \ddot{q}_2\end{bmatrix} + \begin{bmatrix}h_1\\ h_2\end{bmatrix} + \begin{bmatrix}g_1\\ g_2\end{bmatrix} \tag{1}$$

Instead of the typical linear sliding surface, the following nonlinear sliding surface (shown in Figure 2) is defined based on the terminal sliding mode control [2,3].

$$s = \dot{e} + c|e|^{1/2}\, sgn(e) \tag{2}$$

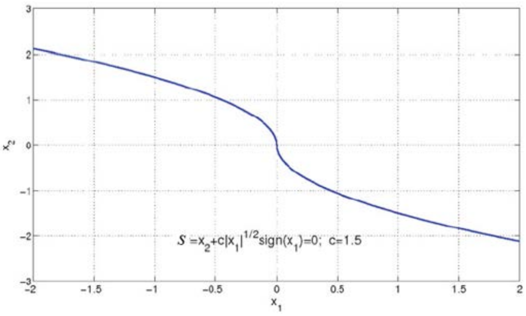

Figure 2: Nonlinear sliding manifold

In order to obtain a finite time settling time, the fast terminal sliding mode control is designed [4,5] and its sliding surface is given by

$$s = \dot{e} + \alpha e + \beta |e|^{a/b}\, sgn(e) \tag{3}$$

Combination of the above mentioned sliding mode control is tried using switching to achieve both reduced chattering and faster convergence. During the transient period, the SOSMC is used and then control is switched to FTSMC after the position reaches near the goal. The effectiveness of the combined control scheme is verified through simulation. The results show that chattering is reduced while fast settling time is obtained.

References

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