Discrete Variable Structure Control for Linear Time-Varying Systems

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Abstract

In this paper, a discrete-time variable structure controller for linear time-varying systems with time-varying disturbances is proposed. The proposed method guarantees that the system state is globally uniformly ultimately bounded (G.U.U.B.) under the existence of external disturbances.

1 Introduction

It has been known that the Variable Structure Control (VSC) has robust and invariant property to parameter uncertainties and external disturbances, and almost all of previous works have been studied in the continuous-time domain [1]-[3].

In the actual systems, however, controllers are implemented in the discrete-time domain since they use microprocessors or computers in general. And it is well known that the control system designed in the continuous-time domain may become unstable after sampling.

Recently, a variable structure control in the discrete-time domain has attracted the attention [4]-[7]. Generally speaking, lots of previous works have used discretized version of continuous-time design schemes for the systems with *no* uncertainty or disturbance: reaching condition, $s(t)\dot{s}(t) < 0$, i.e.,

$$|s(k+1)| < |s(k)|,$$

or Lyapunov approach, $\dot{V}(t) < 0$, i.e.,

$$V(k+1) - V(k) < 0,$$

where $V(k) = s^2(k)/2$. Under the existence of uncertainties and disturbances, however, the discrete-time variable structure control does not guarantee the invariant property. Furthermore, it does not assure the asymptotic convergence of the system state, either.

Thus, in this paper, a discrete-time variable structure control for linear time-varying systems is proposed. The proposed method guarantees that the system state is globally uniformly ultimately bounded (G.U.U.B.) under the existence of time-varying disturbances. It is also shown that the closed-loop system is globally asymptotically stable if the disturbance is time-invariant.

2 Problem Formulation

Consider a discrete-time linear time-varying plant of the following form:

$$x(k+1) = A(k)x(k) + Bu(k) + d(k) \qquad (1)$$

where $x(\cdot) \in \Re^n$ is the state vector, $u(\cdot) \in \Re$ is the scalar input, and $d(\cdot) \in \Re^n$ is the vector of time-varying