Chapter 6
Sliding–Mode Control of Large–Scale Fuzzy Interconnected Systems

ABSTRACT
This chapter will study the decentralized SMC for large-scale fuzzy interconnected systems. The design result on the decentralized sliding mode control of the continuous-time systems is derived in terms of LMIs. We also extend the result to discrete-time systems. Two simulation examples are provided to validate the advantage of the proposed methods.

6.1 INTRODUCTION
In recent years, many research and engineering societies have focused on the sliding mode control (SMC) design due to its simplicity and robustness against parameter variations and disturbances (Utkin, 1992). The idea of SMC is that for a predesigned switching manifold, the desirable controller drives the state trajectories toward in a vicinity of the switching manifold. Such motion is performed by imposing discontinuous control actions (Bartoszewicz & Żuk, 2010; Yu & Kaynak, 2009). More recently, the SMC technique has been developed for large-scale interconnected systems. In Yan, Edwards, and Spurgeon (2004), a decentralized static output feedback control scheme for nonlinear large-scale systems is proposed using SMC technique. The work in Yan (2003), Shyu, Liu, and Hsu (2005), Chou and

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Cheng 2003) considered a special large-scale nonlinear system that all the system state variables are available and the interconnection terms are linear, and proposed a decentralized SMC strategy. A decentralized sliding mode control for discrete-time large-scale linear interconnected systems with time delay using only output information is considered in (Mahmoud & Qureshi, 2012).

This chapter will study the decentralized SMC for large-scale T-S fuzzy interconnected systems. The design result on the decentralized SMC is derived in terms of LMIs. We also extend the result to discrete-time systems. Two simulation examples are provided to validate the advantage of the proposed methods.

6.2 DECENTRALIZED SLIDING-MODE CONTROL

In this section, we will study the problem of decentralized SMC for large-scale T-S fuzzy interconnected system.

6.2.1 Problem Formulation

Consider a continuous-time large-scale fuzzy interconnected system, which consists of \( N \) subsystems as below,

\[
\dot{x}_i(t) = A_i(\mu_i)x_i(t) + B_iu(t) + \sum_{j=1,j\neq i}^{N} \tilde{A}_j(\mu_i)x_j(t).
\]

Here, we make the following assumptions (Yan, Edwards & Spurgeon 2004):

1. \( \text{rank}(B_i) = m_i \);
2. All the pairs \( (A_i', B_i) \) are completely controllable;
3. There exists a matrix \( T_i \in \mathbb{R}^{n_i \times m_i} \) such that

\[
T_iB_i = \begin{bmatrix} 0 \\ B_i \end{bmatrix}
\]

(2)
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