Report on Thesis entitled "Sliding Mode Control: Advanced Design Techniques" by Duy-Ky Nguyen

The thesis is on the subject of advanced design techniques for sliding mode control (SMC). Various important aspects of SMC, including hyperplane design, chattering problem and robustness are addressed. Some novel design techniques are proposed in a unified framework for both continuous and discrete-time systems. A technical assessment of the thesis is given in the next paragraph.

Chapter 1 provides the background to sliding mode control. In Chapter 2, hyperplane design methods are proposed based on direct allocation and optimal sliding dynamics, with simplifications obtained through normalization. In Chapter 3, a simple stability criterion for SMC is obtained and a design rule is proposed to ensure that the reaching mode terminates in finite time for the sliding mode to exist. A unified framework for the chattering problem is proposed and integral VSS control is considered. In Chapter 4, the VSS design of Chapter 3 is extended to deal with uncertain systems using a control function with three components, namely equivalent control, reaching control and perturbation control. Novel linear SMC and robust sliding-mode observer design for both matched and unmatched uncertainties are proposed in this chapter. The simulation studies suggest that the linear SMC has similar performance as the tanH-SMC. The sliding-mode control methods for continuous-time systems developed in Chapters 3 and 4 are extended to discrete-time systems in Chapter 5. The design techniques developed for discrete-time systems which parallel the proposed methods for continuous-time systems are themselves new. Extensive simulation results are provided to illustrate the robust discrete SMC designs. In Chapter 6, sliding-mode control design for both SISO and MIMO nonlinear systems are considered for the general case where the output may be a nonlinear function of all system states. A hosts of examples are given to address issues such as tracking control for nonlinear systems, decoupling of a MIMO system into multiple SISO subsystems and robust MIMO SMC design. In Chapter 7, the theory developed in the previous chapters is applied to a ball-hoop systems. A robust sliding-mode observer is designed. Various robust SMC controllers are designed and verified experimentally. It is pleasing to see that the experimental results agree with the theory.

In my view, the thesis represents a comprehensive treatment of the design problem for sliding-mode control. The candidate has shown in-depth knowledge of the subject. As indicated in the above assessment, the basic results in Chapter 3, the robust SMC design methods for continuous-time systems presented in Chapters 4 and 5, as well as the extensions of the methods to the case of discrete-time systems presented in Chapter 6, are new and are contributions to knowledge by original investigation. These results are suitable for publication. Despite some typos and necessary amendments listed on a separate page, the material is presented in a structured and well-organized manner. I find the thesis is one of a high standard and would recommend acceptance of the thesis subject to minor amendments.