

SUMMARY OF Ph.D. DISSERTATION

School Science for Open and Environmental Systems	Student Identification Number	SURNAME, First name USHIJIMA, Yumiko
Title Study on Nonstationary Sliding Mode Control with Time-varying Switching Hyperplane Based on Optimal Control Theory and Its Applications		
Abstract In this dissertation, firstly, a new design method of time-varying switching hyperplanes for nonstationary sliding mode control is proposed based on the optimal control theory. Secondly, an approach to shorten the reaching time to the switching hyperplane is proposed by allowing the hyperplane to be changed with time. Finally, the effectiveness and feasibility of the proposed nonstationary sliding mode control is verified through applications to the practical systems. The existing method using time-varying switching hyperplanes based on the optimal control theory is only applicable to a system in a regular form. In the proposed method, a time-varying feedback gain derived from the optimal control theory is adopted as a gradient of time-varying switching hyperplane. This method can be applied to the complicated systems because the transformation into the regular form is unnecessary in the design process. The proposed controller is applied to the vibration control of the elevator rope as a time-varying system to verify its effectiveness. In addition, an approach to shorten the reaching time by using the time-varying switching hyperplane is proposed. By shortening the reaching time, the sliding mode controller could be more robust. In an existing method, the reaching time could be zero under the condition that the information of initial states is available. In other words, the reaching time could not be eliminated or shortened without the information of initial states. In contrast, using the proposed method, we are able to provide the method to shorten the reaching time without knowing the initial conditions. Furthermore, the nonstationary sliding mode control is applied to the positioning control problem to verify its effectiveness for the practical system through the numerical calculation and experiment. The contents of this dissertation are summarized as follows. The first chapter describes the background and purpose of this study. The second chapter presents a new design method of nonstationary sliding mode control with time-varying switching hyperplane based on the optimal control theory. Then the proof of stability of the proposed control system is given. The performance of the proposed method is examined by applying to the vibration control for an example of time-varying system and an elevator-rope through the numerical calculation. The third chapter presents the approach for shortening the reaching time by using the nonstationary sliding mode control. This part shows an approach to design the time-varying switching hyperplane for shortening the reaching time, and its performance is verified by numerical calculation with the positioning control problem of second-order system. In chapter 4, the nonstationary sliding mode control method is applied to the positioning problem of a practical conveyance system. The mathematical model of the control object and the control system is designed in consideration of necessary constraints. The effectiveness of the controller is verified by the numerical calculation, and is demonstrated by the experiment. Finally, chapter 5 presents the conclusion of this study.		