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Xinhua Wang

Advanced Sliding Mode Control for Mechanical Systems

Design, Analysis and MATLAB Simulation

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Simulation**

With 165 figures



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Jinkun Liu
Xinhua Wang

机械系统先进滑模变结构控制： 设计、分析及MATLAB仿真

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内 容 简 介

本书从 MATLAB 仿真角度系统地介绍了机械系统先进滑模变结构控制的基本设计方法,是作者多年来从事控制系统教学与科研工作的结晶,同时融入了国内外同行的新近成果。

全书共分 12 章,包括滑模变结构控制基本设计方法、基于名义模型的滑模控制、基于线性矩阵不等式和反演的滑模控制、离散滑模控制、动态滑模控制、自适应滑模控制、终端滑模控制、基于观测器的滑模控制、模糊滑模控制、神经网络滑模控制以及针对机器人和飞行器的滑模控制。每种控制方法都通过 MATLAB 仿真程序进行了仿真分析。

本书适于从事生产过程自动化、计算机应用、机械电子和电气自动化领域工作的工程技术人员阅读,也可作为大专院校相关专业学生的参考教材。

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Preface

In the formulation of any control problem there will be typical discrepancies between the actual plant and the mathematical model developed for the controller design. This mismatch may be due to unmodelled dynamics, variation in system parameters or the approximation of complex plant behavior by a straightforward model. The engineer must ensure the practical applicability of the resulting controller to produce the required performance levels despite such plant /model mismatches. This has led to an intense interest in the development of robust control methods to solve this problem. One particular approach to robust controller design is the sliding mode control methodology.

One of the most intriguing aspects of the sliding mode is the discontinuous nature of the control action. The primary function of each of the feedback channels is to switch between two distinctively different system structures (or components) such that a new type of system motion called the sliding mode exists in a manifold. This peculiar system characteristic is claimed to result in superb system performance which includes insensitivity to parameter variations and complete rejection of disturbances.

Sliding mode control is a specific type of variable structure control. The control systems are designed to drive and then constrain the system state to lie within a neighborhood of the switching function. There are two main advantages to this approach. Firstly, the dynamic behavior of the system may be tailored by the particular choice of switching function. Secondly, the closed-loop response becomes totally insensitive to a particular class of uncertainty. The latter invariance property clearly makes the methodology appropriate for robust control. Additionally, the ability to specify performance directly makes the sliding mode control attractive from the design perspective.

The sliding mode design approach consists of two components. The first involves the design of a switching function so that the sliding motion satisfies design specifications. The second is concerned with the selection of a control law to

make the switching function attractive to the system state. Note that this control law is not necessarily discontinuous.

The chattering phenomenon is generally perceived as a motion which oscillates about the sliding manifold. There are two possible mechanisms which produce such a motion. Firstly, in the absence of switching nonidealities such as delays, i.e., the switching device is switching ideally at an infinite frequency, the presence of a parasitic dynamics in series with the plant causes a small amplitude high-frequency oscillation to appear in the neighborhood of the sliding manifold. These parasitic dynamics represent the fast actuator and sensor dynamics. Secondly, the switching nonidealities alone can cause such high-frequency oscillations.

It is our goal to accomplish these objectives:

- Provide reasonable methods of the chattering phenomenon alleviating;
- Offer a catalog of implementable robust sliding mode control design solutions for engineering applications;
- Provide advanced sliding mode controller design methods and their stability analysis;
- For each sliding mode control algorithm, we offer its simulation example and Matlab program.

This book provides the reader with a thorough grounding in the sliding mode controller design. More advanced theoretical results are developed on the basis. Typical sliding mode controller design is emphasized using Matlab simulation. In this book, concrete case studies, which present the results of sliding mode controller implementations are used to illustrate the successful practical application of the theory.

The book is structured as follows. Chapter 1 introduces the concept of sliding mode control and illustrates the attendant features of robustness and performance specification using a straightforward example and graphical exposition, several typical sliding mode controllers for continuous system are introduced, and concrete stability analysis, simulation examples and Matlab programs are given. Chapter 2 introduces several normal sliding mode controllers design, including sliding mode control based on nominal model, global sliding mode control, sliding mode control based on linearization feedback technology and sliding mode control based on low pass filter. Chapter 3 introduces two kind of advanced sliding mode controllers design, including sliding mode control based on LMI technology and sliding mode control based on backstepping technology. Chapter 4 introduces discrete sliding mode controller design, including discrete sliding mode controller design analysis and a kind of discrete sliding mode controller design based on disturbance observer. Chapter 5 introduces a kind of dynamic sliding mode controller design. Chapter 6 introduces a kind of adaptive sliding mode controller design for mechanical systems. Chapter 7 introduces three kind of terminal sliding mode controllers design, including a typical terminal sliding mode controller design, a nonsingular terminal sliding mode controller design and a fast terminal

sliding mode controller design. Chapter 8 introduces sliding mode control based on several observers; four kinds of observers are used, including high gain observer, extended state observer, integral-chain differentiator, disturbance observer and delayed output observer. Chapter 9 introduces four kinds of fuzzy sliding mode controllers design, including fuzzy sliding mode control based on equivalent control, sliding mode control based on fuzzy switch-gain regulation, sliding mode control based on fuzzy system approximation and adaptive fuzzy control based on fuzzy compensation for manipulator. Chapter 10 introduces two kinds of neural network sliding mode controllers design, including sliding mode controller design based on RBF neural network approximation and adaptive RBF network sliding mode control for manipulator. Chapter 11 introduces three kinds of sliding mode controllers design for robot, including sliding mode controller design based on input-output stability, sliding mode controller design based on computed torque method and adaptive sliding mode controller design for manipulator. Chapter 12 introduces two kinds of sliding mode controllers design for aircraft, which are sliding mode control for helicopter and sliding mode control for an uncertain VTOL aircraft.

Welcome to find and download the simulation programs of the book from <http://ljk.buaa.edu.cn/> or email to ljk@buaa.edu.cn.

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