

Preface

Overhead cranes are widely used in many places, such as warehouses, disaster sites, nuclear plants, shipyards and construction sites. Overhead crane control has been paid more and more attention in recent years. Concerning the control problem, numerous theoretical studies and practical implementations have been carried out. Accordingly, various control methods have been presented. Among the diversity of control methods, sliding mode control is recognized as one of the most efficient design tools.

Many control designs and applications in the fields of sliding mode control for overhead cranes have been published in various journals and conference proceedings. In spite of these remarkable advances in this field, most of the current researches only focus on some special control applications, rather than a systematic methodology.

The methodology of hierarchical sliding mode control fills the gap between sliding mode control and its applications in overhead cranes. Hierarchical sliding mode control presents several control structures for the sliding mode control applications in overhead cranes. It is a systematic and effective design tool, which has both theoretical and practical significances.

This book provides readers with a comprehensive overview of sliding mode control for overhead crane systems with detailed proofs of the fundamental results. Capturing the structure characteristic of overhead cranes, this is possible to achieve novel control structures by the method of sliding mode control. With the understanding that the physical structure of overhead crane systems is dismantled, some appropriate control structures are constructed and hierarchical sliding mode control is developed.

The key feature of hierarchical sliding mode control architectures is the hierarchical sliding surfaces with the guaranteed stability. By explicitly building the structure specification into the problem formulation, it is possible to construct and analyze novel sliding surface structures. With hierarchical sliding mode control architectures, sliding motion can be depicted by phase plane and this appears to be beneficial both for scientific researches and studies.

The book has six chapters. Each chapter concludes with appendices about simulation programs.

Chapter 1 starts with a brief introduction of overhead crane systems. It proceeds with a brief historical overview of sliding mode control. A review about overhead crane control is considered next. This chapter proceeds with analysis of some typical control problems associated with sliding mode control for overhead cranes.

Chapter 2 investigates modeling of overhead crane systems. First, equations of motion for single-pendulum-type overhead cranes are presented. Then, dynamics of double-pendulum-type overhead cranes are described. Uncertainties of the two models are considered next. The chapter proceeds with analysis of oscillations for pendulum-type motions according to the linearized models of the two types of overhead cranes.

Chapter 3 introduces several typical design methods of sliding mode control. The chapter proceeds with applications of these design methods for overhead cranes. Some simulation results are demonstrated. MATLAB codes about the simulations are also available in the appendix part.

Chapter 4 presents hierarchical sliding mode control for overhead cranes. Three hierarchical structures are designed for single-pendulum-type overhead cranes and one hierarchical structure is considered for double-pendulum-type overhead cranes. For each hierarchical structure, it is proved that both the hierarchical sliding surfaces and the whole control system are of asymptotically stability in the sense of Lyapunov. Numerical simulations illustrate the feasibility of these designed hierarchical structures. MATLAB codes about the simulations are also attached in the appendix part.

Chapter 5 extends the method of hierarchical sliding mode control to accommodate unmatched uncertainties. It starts with compensator design for the unmatched uncertainties of overhead cranes. The compensator and the controller work together to realize the robust overhead crane control. Since the compensator design needs a strict assumption, this chapter proceeds with the design of intelligent compensator based on the hierarchical structure. Some simulations are conducted to verify the effectiveness of the presented control scheme. MATLAB codes about the simulations are also presented.

Chapter 6 summarizes some of the further extensions not captured within this book, states the open problems, and the challenges for future thinking.

The book can be used for teaching a graduate-level special-topics course in sliding mode control.

In this book, all the control algorithms and their programs are described separately and classified by the chapter name, which can be run successfully in MATLAB 7.5.0.342 version or in other more advanced versions. If you have questions about algorithms and simulation programs, please feel free to contact Dianwei Qian by E-mail: dianwei.qian@gmail.com.

Hierarchical Sliding Mode Control for Under-actuated
Cranes

Design, Analysis and Simulation

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2015, XIV, 199 p. 93 illus., 38 illus. in color., Hardcover

ISBN: 978-3-662-48415-9