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SUMMARY OF Ph.D. DISSERTATION

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Title

A Study of Iterative and Adaptive Control Methods for Mechanical Systems with Parametric Uncertainties

Abstract

In industrial applications, system engineers often encounter the daunting task of designing controllers for unknown or uncertain systems. The complexity of this process can be greatly increased by the magnitude of the system and the presence of nonlinear dynamics. Adaptive and iterative control theories have emerged as a powerful tool to design efficient and robust controllers, despite this lack of information. They have been successfully applied throughout a wide range of engineering discipline to achieve desired performance and provide information about parametrically uncertain systems. As a vital component of most industrial processes, the control of mechanical systems has generated immense research interest. While adaptive and iterative control algorithms have been used to resolve many issues, there remain to this day countless topics that must be addressed. It is therefore the objective of this thesis to explore the various issues involved with model-based adaptive and iterative control of parametrically uncertain mechanical systems. This study proposes several novel adaptive and iterative algorithms, and investigates their performance and convergence properties, while clarifying necessary conditions for stability.

Chapter 1 begins with an introduction to the control problem of parametrically uncertain mechanical systems and presents the general scope of this study. This is elaborated in Chapter 2, which provides a literature review of existing control methods, along with mathematical preliminaries that are utilized throughout the thesis. The motivation of this research is presented in detail.

The results of this study are presented in Chapter 3 to 5. First, a linear, two-mass torsional motor system with parametric uncertainties is considered in Chapter 3. A novel iterative feedback tuning method is proposed that yields an optimal controller, while simultaneously identifying unknown system parameters and reducing the number of required experiments per iteration. Chapter 4 investigates the semi-active vibration control of an unknown vehicular suspension system with a hysteretic, nonlinear magnetorheological (MR) damper. It proposes several adaptive algorithms and clarifies necessary conditions for stability. A key advantage of the proposed methods is the ability to achieve adaptive control of a suspension system by using the MR damper when all parameters are unknown. Chapter 5 addresses the issue of nonlinear friction compensation via the use of a generalized Maxwell-slip model. This study proposes an adaptive algorithm that compensates for nonlinear frictional effects and other uncertainties, and evaluates its performance for velocity and position control. It provides an efficient and simplified alternative to existing adaptive methods, while guaranteeing robustness to modeling error and establishing necessary conditions for stability. Finally, Chapter 6 summarizes the main results of this study and concludes with suggestions for future research.