Preface

Robust Control of Uncertain Dynamic Systems has been an active area of research in the last two decades within the control systems community. During the 1980s and 1990s, it even occupied a central role among many areas of control systems research with impressive and significant contributions from many researchers. It has reached a stage of maturity with many universities now offering graduate-level courses in robust control, resulting in authorship of many textbooks from various viewpoints. Essentially, these research results can be broadly categorized as frequency domain transfer function based results and time domain state space based results. Majority of the textbooks in the current literature focus on topics such as $\mu$ synthesis, $H_\infty$ control, LQG/LTR, mixed $H_2/H_\infty$ theory, quantitative feedback theory, polynomial methods (inspired by Kharitonov theorem), and quadratic stability. Textbooks that emphasize methods specifically addressing real parameter variations as the modeling error have been relatively scarce. This book intends to fill that gap. This book thus emphasizes time domain state space methods with uncertainty characterized as real parameter variations. It is intended as a textbook for first-year graduate-level students in the area of multivariable robust control.

This book is an outgrowth of my sustained interest and contributions to the robust control field which resulted in the coeditorship of an IEEE monograph (with an esteemed colleague and mentor late Prof. Peter Dorato) as well as a short course given in IEEE CDC in 1992 (with another respected senior colleague and friend Prof. George Leitmann). Over the years, the class notes prepared for a series of courses on robust control offered at the Ohio State University helped pave the way for embarking on this task of preparing a textbook on this subject. The prerequisite for understanding the material covered in this book is some basic knowledge of linear control systems, especially linear state space theory and good background of some fundamental matrix theory. The material covered in this book is suitable for a one-semester course or a two-quarter course sequence. Some selected topics from the chapters can be suitable for a single-quarter course. The first chapter, Introduction and Perspective, covers some basic notions of uncertainty characterization and various robustness concepts. The second chapter is one of the main chapters of the book, thoroughly covering the topic of perturbation bounds for robust stability of linear state space models (i.e., stability robustness analysis). Chapter 3 covers the aspect of performance robustness analysis by casting the problem as a robust root clustering (or robust D-stability) problem, thereby
addressing the robust stability of discrete-time systems. Chapter 4 addresses the aspect of robust control design (i.e., synthesis of controllers for robust stability). In this chapter on robust stabilization issue, control design methods using various approaches such as design by perturbation bound analysis, quadratic stabilization under matching and mismatched conditions, robust microstructure assignment, and guaranteed cost control are discussed. In Chap. 5, few application examples which use the methods discussed before are presented. Finally Chap. 6 presents an overview of some related topics such as simultaneous stabilization and some new directions of research using ecological sign (qualitative) stability. An Appendix covers a brief summary of some fundamental matrix theory concepts and results used in the chapters.

It is interesting and important to realize that, in this internet (Google) age, the proliferation of research articles on a single topic is simply overwhelming. Thus, it is almost impossible to acknowledge all the possible references in any given subject. Hence, it is inevitable that the literature citation is based on a complicated mixture of author’s familiarity, the impact of an article, and the relevance of it to the scope of this particular book, among many other things. As such, every effort is made to highlight the early, impacting articles with all others acknowledged indirectly through the references within the references of this book. I, at the very outset, apologize for any omission or oversight of some important articles and their authors. It is appreciated if this is taken in the right spirit. It is also essential to keep in mind that this book is aimed at budding future researchers at the level of a first-year graduate student, and as such only the most critical and fundamental content is presented with as much exposure to the various aspects of state space based robust control theory as possible, leaving most proofs and other details for further reading.

I would like to take this opportunity to express my sincere thanks to my many professional peers with whose association I benefitted immensely in understanding and exploring this exciting area of research. In particular, colleagues such as Bob Barmish, Shankar Bhattacharyya, Bob Skelton, Drago Siljak, Peter Dorato, George Leitmann, Kris Holllot, Mohammed Mansour, Lee Keel, Ian Petersen, Minyue Fu, Roberto Tempo, Rajni Patel, Li Qiu, Bahram Shafai, Martin Corless, Dennis Bernstein, Kemin Zhou, Pramod Khargonekar, Faryar Jabbari, and Mathukumalli Vidyasagar deserve special mention. It was a pleasure to interact with and learn from them.

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