Preface

Linear system theory and optimal estimation and control are taught at the graduate level in many universities. This book is written primarily for graduate students in electrical engineering who specialize in control. Yet, the mathematical theory applies not only to feedback control systems but also to communication and signal processing. Indeed, from two decades of my teaching in the advanced digital control class at LSU, I found that whenever I introduced applications to digital communications and signal processing such as equalization and precoding, more graduate students came to attend my class. Teaching of this new application stimulated more interests from students. Control students were eager to learn applications of control theory to communications that had more actions in the high-tech boom time, while students from communication and signal processing saw the new prosect of the mathematical system theory in their specialized area. These observations motivated me to seriously consider expansion of my teaching material to include new applications other than feedback control. However, it is also true that control and communication seldom interact in the last century, in spite of being two of the most successful areas in engineering system design. The two areas are more or less isolated from each other in terms of teaching and research.

Two major technological developments, namely, wireless communications and the Internet, in the last decade have changed the aforementioned isolatory phenomenon. Because of the existence of multipath and fading, the dynamic and random behaviors of the wireless channel cannot be ignored. And because of the multiuser nature for Internet, the communication channel is shared by more than one user. As such, the emergence of the wireless Internet has brought in design issues for dynamic multivariable communication systems. On the other hand, wireless communications and Internet have made remote and networked control systems possible, in which feedback controllers and physical processes are situated in two different locations and connected via wireless channels or Internet. Therefore, communication issues also need be addressed in control system design. It is felt strongly by this author that a unified approach is necessary to design of optimal MIMO dynamic systems in both control and communications. This text provides a platform for graduate students and researchers in these two different areas to study and work together. Such multidisciplinary interactions will greatly benefit each other and further advance the research frontier in engineering system design.

This text is focused on system and control theory with applications to design of feedback control systems and the signal processing aspect of the design issues. It is written for the first or second year graduate students, who are interested in general areas of control, or communications, and signal processing. The readers are assumed to have some basic knowledge on random processes and linear algebra, and have taken some basic undergraduate courses in discrete-time control, or digital communications and digital signal processing from electrical engineering. The appendices provide a quick review for the required mathematical background materials. Students are encouraged to read the related texts to strengthen their background knowledge.

This book consists of two parts. The first part presents linear system theory and theory of optimal estimation and optimal control for linear systems. State space is the main subject that provides not only the mathematical insight into the structure of linear systems but also the computational tool for obtaining the solution to optimal estimation and optimal control. The second part presents the design methodology for linear systems with feedback control and data communications as application areas. The design issues in modeling, system identification, channel estimation, symbol detection in data communications, and disturbance rejection in feedback control are addressed based on the theories from the first part.

It is observed by this author that design has been overlooked for the past two decades in engineering curricula at the graduate level. While courses on advanced research topics are important in training graduate students, the lack of design experience for graduate students may weaken the quality of our research programs. This text represents an effort to teach engineering system design at the graduate level, in hope to bring design into the graduate curriculum. The author welcomes any comments and suggestions regarding the materials in this text.

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