Preface

The intent of this book is to present, in a unified and rigorous way, recent results in the control theory of continuous-time Markov Jump Linear Systems (MJLS). This is neither a textbook nor a complete account of the state-of-the-art on the subject. Instead, we attempt to provide a systematic framework for an understanding of the main concepts and tools underpinning the control theory of MJLS, together with some basic relevant results. We follow an approach that combines probability and operator theory, which we have named here as *the analytical point of view*.

It is worth mentioning that the topics treated here represent just a fraction of the several important results nowadays available for MJLS. The limited size of a book, in addition to the continued rapid advance in the theory of MJLS, makes it unfeasible to cover all the aspects in this field. Therefore, some degree of specialization is no doubt inevitable and, perhaps, desirable. For instance, although fitting under the MJLS field, some important topics and different approaches, such as MJLS with delay, adaptive control of MJLS, and hidden Markov chain filtering, are not considered in this book. We apologize for those who find that some of their favorite topics are missing. The analytical point of view, together with our personal affinities, has determined the choice of topics that, to some extent, are related to our previous contributions with coauthors on the subject.

Another important point of view regarding MJLS, which has achieved a considerable degree of success in applications, is known in the specialized literature as *multiple model*. Departing from the multiple model approach and tracing as much as possible a parallel with the control theory for the linear case, the analytical point of view adopted in this book allows us to obtain explicit solutions to some important stochastic control problems. A basic step in this approach, which indeed permeates most of the book, is the fact that the mean square stability results are written in terms of the spectrum of an augmented matrix. On the other hand, it is worth pointing out that the MJLS carry a great deal of subtleties that distinguish them from the linear case. In fact, MJLS have a certain degree of complexity which does not allow one to recast several results from the linear theory and, therefore, cannot be seen as a trivial extension of the linear case.

The motivation for writing this book was at least twofold. Most of the material presented here is scattered throughout a variety of sources, which includes journal articles and conference proceedings papers. Considering that this material constitutes, by now, a coherent body of results, we have felt compelled to write an introductory text putting together systematically these results. In addition, this seemed an opportunity to introduce, as far as possible in a friendly way, a bent of the MJLS theory that we have named here the analytical point of view, contributing to encourage and open up the way for further research on MJLS.

Although the book is mainly intended to be a theoretically oriented text, it contains several illustrative examples that show the level of maturity reached on this field. For those wishing to delve into topics which were not contemplated in this book, a substantial number of references (not meant to be exhaustive) are included. Most of the chapters end with historical remarks, which, we hope, will be both informative and interesting sources for further readings. The notation is mostly standard, although, in some cases, it is tailored to meet specific needs. A glossary of symbols and conventions can be found at the end of the book.

The book is targeted primarily for advanced students and practitioners of control theory. It may be also a valuable reference for those in fields such as communication engineering and economics. In particular, we hope that the book will be a valuable source for experts in linear systems with Markovian jump parameters. For specialists in stochastic control, the book provides one of those few cases of stochastic control problems in which an explicit solution is possible, providing interesting material for a course while introducing the students to an interesting and active research area. Moreover, we believe that the book should be suitable for certain advanced courses or seminars. As background, one needs an acquaintance with the linear control theory and some knowledge of stochastic processes and modern analysis.

A brief description of the book content goes as follows. Chapter 1 motivates the class of MJLS through some application-oriented examples and presents an outline of the problems. Chapter 2 provides some background material needed in the following chapters. Chapter 3 deals with the mean-square stability for MJLS, while Chap. 4 deals with the quadratic optimal control problem with complete observations. In Chap. 5 the infinite horizon quadratic optimal control problem is revisited but now from another point of view, usually known in the literature of linear systems as H_2 control. Chapter 6 deals with the finite-horizon quadratic optimal control problem and the H_2 control problem for continuous-time MJLS under partial observations. In this case the state variable $x(t)$ is not directly accessible to the controller, but, instead, it is assumed that only an output $y(t)$ and the jump process $\theta(t)$ are available. Chapter 7 considers the best linear mean-square estimator for continuous-time MJLS assuming that only an output $y(t)$ is available (no knowledge of $\theta(t)$ is assumed). Chapter 8 is devoted to the H_∞ control of continuous-time MJLS in the infinite horizon setting. Design techniques, expressed as linear matrix inequalities optimization problems, for continuous-time MJLS are presented in Chap. 9. Chapter 10 presents some numerical applications from the theoretical results introduced earlier. Finally, the associated coupled algebraic Riccati equations and some auxiliary results are considered in Appendices A and B.

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