Automatica 68 (2016) 397–398

Contents lists available at ScienceDirect

Automatica

journal homepage: www.elsevier.com/locate/automatica

Book review

Analysis and Design of Networked Control Systems, K. You, N. Xiao, L. Xie. Springer, London (2015).
ISBN: 978-1-4471-6614-6

Broadly speaking, networked control systems are systems in which spatially distributed feedback loops are closed via a communication network. From the control theory perspective, this scenario imposes constraints on the information exchange between different parts of the control system. These constraints give rise to signal quantization, scheduled transmission of nodes, time delays, noise, and so on. Addressing all of these issues pertinent to networked control systems would be a daunting task, and the present book does not attempt this. Instead, it focuses mainly on stabilization and estimation of linear systems over communication channels. In other words, it studies a single feedback loop, represented by a linear discrete-time plant, in which information between the plant and the controller flows through a limited-capacity channel. Scheduling protocols that govern signal transmission for several nodes in the system are not addressed except in the last two chapters of the book. This still leaves plenty of material to be covered, as several groups of researchers (including the authors of this book) have been developing results on estimation and control under different models of the channel in the loop.

The book starts with a nice introduction to networked control systems in Chapter 1. Then in Chapter 2 it gives a definition of topological entropy for linear time-invariant systems, followed by a useful overview of recent research on control and estimation over noiseless and noisy channels. It should be noted that the entropy definition given in the book is the "operational" one expressed in terms of system eigenvalues, and not an intrinsic definition of topological entropy as developed, e.g., in Katok and Hasselblatt (1995). Chapter 2 ends with a list of open problems.

Chapters 3–6 develop variants of the so-called "data rate theorem" for different channel models, all for the case of a discrete-time LTI plant. First, Chapter 3 assumes a noiseless channel and characterizes the smallest data rate necessary and sufficient for stabilization. Then, Chapter 4 allows random packet losses (erasure channel) and derives the additional data rate needed to compensate for this. In Chapter 5 this result is generalized to the case when packet losses are governed by a Markov chain. Finally, in Chapter 6 fading channels are considered.

In Chapters 7–9 the authors turn their attention to stabilization under logarithmic quantizers. In Chapter 7, infinite-level logarithmic quantizers are analyzed using a robust control approach. Then, Chapter 8 considers dynamic finite-level quantizers. In Chapter 9, mean-square stabilization of Markov jump linear systems with logarithmic quantization is studied.

The remaining chapters deal mainly with Kalman filtering. Chapter 10 discusses Kalman filtering with quantized innovations, followed by quantized LQG control for a symmetric channel in Chapter 11. Chapters 12 and 13 study Kalman filtering over fading channels and erasure channels, respectively. Chapters 14 and 15 turn to the networked scheduling issue: first Kalman filtering with scheduled measurements is presented in Chapter 14, and then parameter estimation is addressed in the last chapter. A typical scheduling algorithm considered here is one in which a node's innovation is sent over the network when it exceeds a certain threshold. We note that other scheduling protocols, such as Round Robin and Try-Once-Discard, have been considered in the networked control literature (see, e.g., Nešić & Teel, 2004 and the references therein), but in the last two chapters of this book the focus is on estimation.

This book is a serious attempt at presenting in a unified way the various results on estimation and control over communication channels obtained by several research groups under different channel models. The authors could have done more to unify their presentation; for example, they could have chosen to avoid repeated quantizer definitions and system architecture descriptions in each chapter and instead develop all necessary background at the beginning of the book. But on the other hand, the current choice makes the individual chapters more self-contained, which has some advantages. The chapters are still quite compact, about 20 pages on average. Proofs of most results are included, and these tend to get quite technical, especially for more advanced channel models such as fading and erasure channels. But even without following the proofs, the reader would be able to get a flavor of the current research in the area by reading this book.

In closing, the book is recommended to graduate students and researchers who are interested in mastering basic results in networked control systems. As explained at the beginning of this review, the scope of the book is somewhat more limited than what the title might suggest, but this is not to say that it is narrow. To go beyond stabilization and estimation problems for a single linear discrete-time system over a communication channel, the reader

http://dx.doi.org/10.1016/j.automatica.2016.01.034
0005-1098/

will find the references listed in the book (especially at the end of Chapter 2) quite helpful.

References

Katok, A., & Hasselblatt, B. (1995). *Introduction to the modern theory of dynamical systems*. Cambridge University Press.

Nešić, D., & Teel, A. R. (2004). Input-output stability properties of networked control systems. *Transactions on Automatic Control*, *49*, 1650–1667.

Daniel Liberzon
Coordinated Science Laboratory,
University of Illinois at Urbana–Champaign,
Urbana, IL 61801, USA
E-mail address: liberzon@uiuc.edu.

10 November 2015
Available online 19 March 2016