a good addition to libraries of academics and researchers working in the field of optimal control theory and its applications. It will also serve as a textbook in graduate courses on applied optimal control theory. Naturally, it will be of interest to financial engineers, industrial engineers, economists, and operational researchers concerned with the application of dynamic optimization theory in their fields.

Modeling and Simulation for Automatic Control, by O. Egeland and T. Gravdahl, Marine Cybernetics, Trondheim, Norway, 2002, 639 pp., US$100, ISBN 82-92356-00-2. *Reviewed by D.S. Bernstein.*

We control engineers share a common view of the world in terms of systems. Simply put, a system has inputs, outputs, and an internal state. Simple systems can be combined through interconnection to model more complicated systems, whereas complicated systems can be decomposed into simpler systems for analysis. The beauty of this worldview is that it applies to virtually all engineering and scientific applications. Interested in modeling the dynamics of a vibrating membrane? The input may be a force applied to the surface, the state is the collection of modal amplitudes, and the output may be the deflection at a point. Want to model the air traffic control system? The input may be the airplanes in the takeoff queue, the state may be the positions and velocities of the planes in flight, and the outputs may be GPS data on current aircraft positions. Need to model the Internet? An automobile engine? A kidney? The Martian atmosphere? The same ideas apply.

Although these systems involve very different phenomena, control engineers use a common language and tools to understand them. If a system is linear, we want to understand the physical meaning of its poles, zeros, and eigenvectors, which determine the transient and steady state response. If the system is nonlinear, we want to understand how the nonlinearities affect its behavior. System concepts allow us to use our understanding of representative systems as the starting point for tackling new systems.

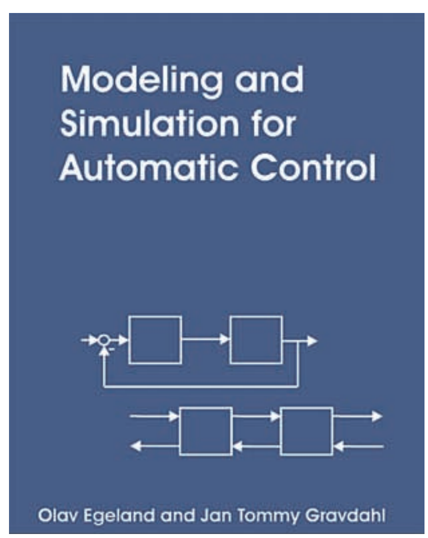
With this systematic and insightful thought process, I have often wondered why we couldn't teach all of engineering from the systems point of view. We could first lay down the main ideas and methods, and then we could teach each subject (circuits, structures, orbital mechanics, or whatever) using these concepts. Wouldn't this approach simplify and streamline the engineering curriculum? The difficulty, unfortunately, is that system concepts are abstract, and abstract concepts need to be made concrete before they can be appreciated. By that time, a student interested in, say, fluid mechanics, may have no interest in concepts that might be useful for modeling the Internet. Abstractions just are not everyone's cup of tea.

But there is a group of students who are swept away by the systems worldview, and these are the control students. In approaching any new area, students of systems are primed to ask questions that will help them understand the relevant features. These are the future engineers who are in a good position to work on interdisciplinary teams, where they can integrate diverse technologies through common language and concepts.

What kind of education should a control engineer have? Is it possible to design a curriculum that gives control engineers a working knowledge of dynamics, structures, fluids, thermodynamics, and all of the basic engineering core areas? In *Modeling and Simulation for Automatic Control*, Egeland and Gravdahl have written a sweeping tome that attempts to do just that.

In this ambitious book, the authors cover a remarkable range of engineering material from a systems point of view. Part I entitled, "Modeling," begins in Chapter 1 with a brief review of state-space models, under the assumption that the reader is familiar with these concepts. Next, in Chapter 2, the authors analyze these models with an emphasis on passivity concepts, including a unified treatment of one- and two-port models for electrical and mechanical systems. Chapter 3, which begins Part II, provides an overview on dc and ac motors, including port-based modeling of electromechanical systems. Likewise, Chapter 4 provides a self-contained presentation on hydraulic systems. Network models as well as irrational transfer functions and their rational (lumped) approximations are presented. Chapter 5 provides an overview of friction models. Chapters 1-5 occupy about 200 pages.

The next part of the book, entitled simply "Dynamics," comprises a 200-page text on rigid body kinematics (Chapter 6), Newton-Euler equations (Chapter 7), analytical mechanics (Chapter 8), and mechanical vibrations (Chapter 9). The chapter on rigid body kinematics provides a detailed presentation of transformations among various three-dimensional attitude representations, including Euler angles,



quaternions, and Euler-Rodrigues parameters. In keeping with the systems perspective, passivity aspects are included. Using Newton's laws, Chapter 7 includes systems that are dear to control engineers, namely, the ball and beam, the inverted pendulum on a cart, and the Furuta pendulum. These systems are modeled with external inputs that can be used for control system analysis and design. Chapter 8 introduces Lagrangian dynamics and Hamilton's equations, again from a control perspective. Chapter 9 gives a short but sweet discussion of control models for the vibrating string and Euler-Bernoulli beam. These chapters complete Part III and the first 400 pages of the book.

Part IV, entitled, "Balance Equations," begins with Chapter 10, a short overview of the kinematics of flow, followed by Chapter 11 on momentum and energy relations. Incompressible flow is considered in both the inviscid and viscous cases. Chapter 12 on gas dynamics is devoted to compressible flow, including transonic effects. Chapter 13 focuses on compressor dynamics and surge models.

Part V, entitled, "Simulation," includes a substantial discussion of numerical integration algorithms followed by Chapter 15, which is a mini-tutorial on computational fluid dynamics.

There is no question that this is an ambitious book, and it is hard to believe that there are only two authors. The vast number of topics that are covered is impressive, as is the level of detail. The book is unique, and I know of no other control-oriented book that can match the breadth of topics.

I was delighted to see many application-specific topics discussed in systems and control language, making them accessible to control engineers and advanced students seeking to broaden their knowledge of particular applications. In this regard, the book can serve as a reference.

The authors use this book as a graduate-level text in the unique Engineering Cybernetics Department of the University of Trondheim, where the students have already had courses in classical control and linear systems theory. It is not obvious how this book might be used in a traditional electrical, mechanical, or aeronautical engineering department. One might conceive of a graduate course on modeling and simulation with a control-system flavor. As a textbook, the book excels in covering a broad range of topics, and numerous examples are given. Although the book has no exercises, problem sets and solutions are available on the Web, albeit in Norwegian.

I found a fair number of typographical errors in the book, although there is a Web-available errata sheet. More basically, some of the explanations are just too short, with details relegated to other books and papers, and I found myself wishing for more detailed explanations. Nevertheless, this observation does not detract from the service that the authors have provided in covering a large range of topics from a control engineering perspective. The book cannot be purchased from commercial booksellers, but it can be ordered at http://www.marinecybernetics.com.

In summary, this unique book covers a broad range of engineering modeling topics from a systems perspective; it should provide a useful reference for control engineers seeking to learn about mechanically oriented disciplines; and it may be useful in a traditional engineering program for an innovative graduate course on modeling and simulation with a control-oriented perspective.

Looking for Reviewers

The following books are available for review.

- *Evolving Rule-Based Mode*, by Plamen P. Angelov, Physica-Verlag, 2002, 213 pp., ISBN 3-7908-1457-1.
- *Modeling, Identification and Control of Robots*, by W. Khalil and E. Dombre, Hermes Penton Ltd, 2002, 480 pp., ISBN 1 9039 9613 9, www.hermespenton.com.
- *Foundations of Deterministic and Stochastic Control*, by Jon H Davis, Birkhäuser, 2002, 440 pp., ISBN 0-8176-4257-9, www.birkhauser.com.
- *Robust Control, The Parameter Space Approach*, by Jürgen Ackermann in cooperation with Paul Blue, Tilman Bünte, Levent Güvenc, Dieter Kaesbauer, Michael Kordt, Michael Muhler, and Dirk Odenhal, Springer-Verlag London Ltd, 2002, 483 pp., ISBN 1-85233-514-9, www. springer-ny.com.
- *Discrete-Time Stochastic Systems*, by T. Söderström, Springer-Verlag London Ltd, 2002, 375 pp., ISBN 1-85233-649-8, www.springer-ny.com.
- *Relay Feedback Analysis, Identification and Control*, by Qing-Guo Wang, Tong Heng Lee, and Chong Lin, Springer-Verlag London Ltd, 2003, 385 pp., ISBN 1-85233-650-1, www.springer-ny .com.
- *People in Control: Human Factors in Control Room Design*, by Jan Noyes and Matthew Bransby, The Institution of Electrical Engineers, 2001, 315 pp., ISBN-0-85296-978-3.
- *UML for Systems Engineering Watching the Wheels*, by Jon Holt, The Institution of Electrical Engineers, 2001, 287 pp., ISBN-0-85296-105-7.
- *Active Sound and Vibration Control Theory and Applications*, by Osman Tokhi and Sandor Veres, The Institution of Electrical Engineers, 2002, 426 pp., ISBN-0-85296-038-7.