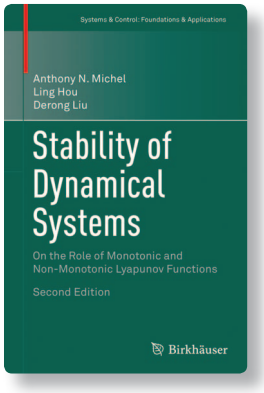
IEEE Control Systems Magazine welcomes suggestions for books to be reviewed in this column. Please contact either Scott R. Ploen, Hong Yue, or Hesuan Hu, the associate editors for book reviews.



Birkhäuser, 2015,
ISBN 978-3-319-15274-5 (Print),
978-3-319-15275-2 (Online),
653 pages, US$149.00.

Stability of Dynamical Systems—On the Role of Monotonic and Non-Monotonic Lyapunov Functions, Second Edition

by ANTHONY N. MICHEL, LING HOU, and DERONG LIU

Reviewed by
N. HARRIS McCLAMROCH

Lyapunov stability concepts are one of the main intellectual pillars in control theory and applications. Formally, these methods address only stability issues, but they have also provided a basis for control design and tools for the analysis of broader classes of performance metrics that depend on the speed of response. Although Lyapunov stability concepts originated in the doctoral dissertation of A.M. Lyapunov in 1907, the basic methods did not become widely adopted until the 1950s. Since that time, they have been a part of the mainstream control methodology and in the toolboxes of most control engineers and scientists. Since the 1950s, the development of Lyapunov stability theory has continued at a steady pace; depth of understanding has been improved, the applicability of the concepts beyond the context of ordinary differential equations has blossomed, and stability problems for broad classes of systems that arise in applications have been solved.

The history of stability theory using Lyapunov functions has many threads that have evolved, expanded, and then become a part of the mainstream tools of control theory. This is especially true of the many developments since 1960. Consequently, the appearance of the second edition of this book is a cause for celebration since it provides a comprehensive overview of many of these intellectual threads. In addition to its sensitivity to the historical developments, the book addresses all three facets of the subject: fundamental aspects of stability theory based on Lyapunov functions; applicability of concepts to a broad class of dynamical systems, including hybrid systems; and illustration of Lyapunov theory to address stability of dynamical systems that arise in applications.

The contents of the book are a review of dynamical systems, the principal stability and boundedness results on metric spaces, specialized stability and boundedness results on metric spaces, applications to discrete-event systems, stability results for finite-dimensional dynamical systems, applications to the stability of finite-dimensional dynamical systems, and stability results for infinite-dimensional systems. Each chapter ends with three final sections: Notes and References, Problems, and Bibliography; these sections are welcome additions that provide insights and perspectives beyond the main content of the chapters.

This second edition provides more emphasis on the stability of discrete-event and hybrid systems than the first edition [1] (see [2] for an earlier review), and it emphasizes the use of non-monotonic Lyapunov functions, which the authors developed in their recent research publications. In the Preface, the authors motivate the introduction of non-monotonic Lyapunov functions; this generalization is used to derive a general form of Lyapunov stability results. Further, in the case that the Lyapunov functions are monotonic, standard Lyapunov stability results are obtained. In practice, this extension is primarily motivated by discrete-event and hybrid dynamical systems. These new features add significant material to the first edition.

In spite of the coverage of important topics, several topics are treated lightly, if at all. In particular, no attention is given to the use of Lyapunov functions to estimate domains of attraction of an equilibrium solution. Further, there is little attention given to Lyapunov functions, viewed as characterizing dynamic performance; the related topic of Lyapunov-based control design is not covered at all. These omissions are indicated to make the scope of the book clear.

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Date of publication: 19 January 2016

This new edition of the book by Michel, Hou, and Liu provides a scholarly and comprehensive view of Lyapunov stability.

This new edition of the book by Michel, Hou, and Liu provides a scholarly and comprehensive view of Lyapunov stability that should be accessible to mathematically inclined graduate students and to many researchers in the control field. It is a welcome addition to the published literature.

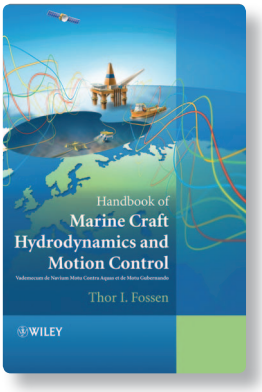
REVIEWER INFORMATION

N. Harris McClamroch has been a faculty member at the University of Michigan since 1967. He was professor and past chair of the Department of Aerospace Engineering. He is currently professor emeritus of aerospace engineering and electrical engineering and computer science. His publications treat theoretical control problems and control applications arising in robotics, manufacturing, buildings and bridges, and aerospace vehicles. He is a Fellow of the IEEE and a recipient of several IEEE awards. He served as editor of *IEEE Transactions on Automatic Control*, and he was the president of the IEEE Control Systems Society in 1998.

REFERENCES

[1] A. N. Michel, L. Hou, and D. Liu, *Stability of Dynamical Systems: Continuous, Discontinuous, and Discrete Systems*. Berlin, Germany: Springer-Verlag, 2008.

[2] A. Astolfi, "Stability of dynamical systems—Continuous, discontinuous, and discrete systems (by A. N. Michel, L. Hou, and D. Liu, 2008)," *IEEE Control Syst.*, vol. 29, no. 1, pp. 126–127, Feb. 2009.



Wiley, 2011,
ISBN: 978-1119991496,
596 pages, US$212.00.

Handbook of Marine Craft Hydrodynamics and Motion Control

by THOR I. FOSSEN

Reviewed by LEIGH McCUE

Handbook of Marine Craft Hydrodynamics and Motion Control by Thor I. Fossen is a comprehensive manuscript encompassing two separable texts on hydrodynamics and control of marine vehicles. In contrast to the aerospace industry, where dynamicists are often control experts as well, in the maritime world (due to the significant effect environmental loads have on the dynamics of the system) the more common pairing is dynamics with hydrodynamics. As such, Fossen is one of few in the maritime industry who could write such a complete treatment of dynamics, hydrodynamics, and control issues related to surface and subsurface marine vehicles. Fossen's earlier text [1] is written from a strong control systems perspective, with nomenclature derived heavily from the aerospace industry. Although [1] is an excellent resource, it has historically been priced so as to be prohibitively expensive for many readers (US$550 per the publisher's website at the time of this writing). Fossen's new text, reviewed here, provides an excellent treatment of the subject matter, written from a more generalist perspective, at a substantially lower cost. There are excellent texts covering marine hydrodynamics [2]–[5], vessel dynamics [6]–[9], and ship motion control [1], [10]. However, for some time a void has existed in the literature covering the intersection of these related fields, with the exception of specialist texts such as the treatment of high-speed craft control [11].

CONTENTS

This book is presented as two volumes. The first volume, "Marine Craft Hydrodynamics," includes eight chapters. Chapter 1 covers the history and challenges of modeling marine vessel dynamics, with emphasis on the differences and similarities between maneuvering and seakeeping models. The second and third chapters describe kinematic modeling and the formulation of equations of motion. The fourth chapter introduces the hydrostatic contribution to the forcing terms. The fifth and sixth chapters then discuss how the equations of motion are treated specifically for seakeeping (Chapter 5) and maneuvering (Chapter 6). Both frequency-domain and time-domain modeling are covered. Chapter 6 also provides explicit discussion on reconciling seakeeping and maneuvering nomenclature. This is an often overlooked topic that, if not treated properly, can lead to erroneous modeling.

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