

Introduction to Nonlinear Control

Stability, control design, and estimation

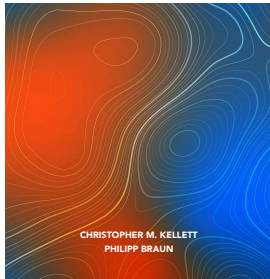
Christopher M. Kellett & Philipp Braun



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STABILITY, CONTROL DESIGN, AND ESTIMATION

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Introduction to Nonlinear Control: Stability, control design, and estimation

Part I: Dynamical Systems

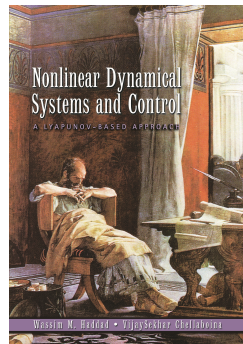
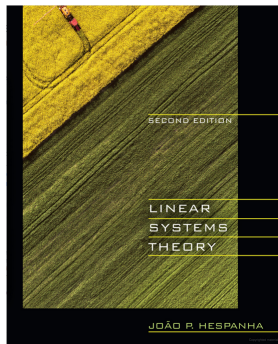
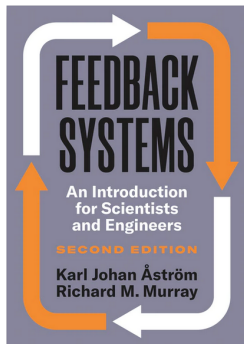
1. Nonlinear Systems - Fundamentals & Examples
2. Nonlinear Systems - Stability Notions
3. Linear Systems and Linearization
4. Frequency Domain Analysis
5. Discrete Time Systems
6. Absolute Stability
7. Input-to-State Stability

Part II: Controller Design

8. LMI Based Controller and Antiwindup Designs
9. Control Lyapunov Functions
10. Sliding Mode Control
11. Adaptive Control
12. Introduction to Differential Geometric Methods
13. Output Regulation
14. Optimal Control
15. Model Predictive Control

Part III: Observer Design & Estimation

16. Observer Design for Linear Systems
17. Extended & Unscented Kalman Filter & Moving Horizon Estimation
18. Observer Design for Nonlinear Systems



Dynamical Systems and the impact of Lyapunov methods

Dynamical Systems (with and without input)

$$\frac{d}{dt}x = \dot{x} = f(x), \quad \frac{d}{dt}x = \dot{x} = f(x, u)$$

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Stability/Convergence analysis:

- Under which conditions is convergence

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guaranteed? (Asymptotic stability)

- How to select a $u(x)$ such that convergence in (1) is guaranteed? (Stabilization)

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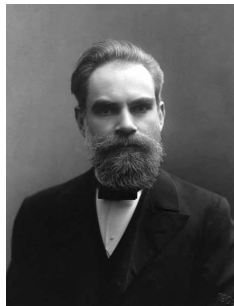
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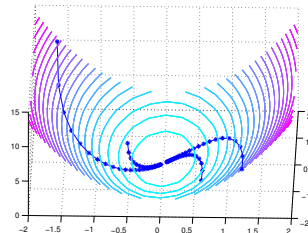
Lyapunov functions: Let $V : \mathbb{R}^n \rightarrow \mathbb{R}_{\geq 0}$ such that

$$\begin{aligned} \frac{d}{dt}V(x(t)) &= \langle \nabla V(x(t)), f(x(t)) \rangle \\ &< 0 \quad \forall \quad x(t) \neq x^*. \end{aligned}$$

Then $x(t) \rightarrow x^*$ can be concluded.



Aleksandr Lyapunov
(1857–1918)



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