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Contraction Theory for Optimization, Control, and Neural Networks

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ABSTRACT:

I survey recent advances on contraction theory for dynamical systems, as a robust, computationally-friendly and modular stability theory. Starting from basic notions, I will present novel theoretical properties and examples of contracting dynamics, including gradient systems, constrained optimization solvers, and multiplayer games. As first application I will discuss online feedback optimization, where a dynamic plant is interconnected with a controller based on first-order optimization methods. Second, I will discuss the contractivity properties of recurrent neural networks and briefly review applications to unsupervised representation learning, implicit learning models, and reservoir computing.

BIOGRAPHY:

Francesco Bullo is a Distinguished Professor of Mechanical Engineering at the University of California, Santa Barbara, CA, USA. He was previously with the University of Padova (Laurea degree, 1994), Italy, the California Institute of Technology (Ph.D. degree, 1998), Pasadena, CA, and the University of Illinois at Urbana-Champaign, IL, USA. His research interests include contraction theory, network systems, and distributed control. He is the author or coauthor of Geometric Control of Mechanical Systems (Springer, 2004), Distributed Control of Robotic Networks (Princeton, 2009), Lectures on Network Systems (KDP, 2022), and Contraction Theory for Dynamical Systems (KDP, 2023). He served as IEEE CSS President and SIAG CST Chair. He is a Fellow of ASME, IEEE, IFAC, and SIAM.