USC Viterbi
School of Engineering
Ming Hsieh Department of Electrical and Computer Engineering

Ming Hsieh Institute **Seminar Series**

Center for Systems and Control – CommNetS

The safe gradient flow: a system-theoretic approach to anytime constrained optimization through control barrier functions

Jorge Cortes
Professor and Cymer Corporation Endowed Chair
High Performance Dynamic Systems Modeling and Control
Department of Mechanical and Aerospace Engineering
University of California, San Diego

Monday, October 28, 2024 | 2:00pm | EEB 132

Abstract: Problems where the solution to a constrained optimization problem is used to regulate a physical process modeled as a dynamically evolving plant arise in multiple application areas, including safety-critical control, power networks, traffic networks, and network congestion. This may take the form of providing setpoints, specifying optimization-based controllers, or steering the system toward an optimal steady state. A paradigmatic example is the use of CBF-based quadratic programs for controller synthesis in robotics. In this talk, we are motivated by situations where the problem incorporates constraints which, when violated, threaten the safe operation of the physical system. In such cases, the algorithm that solves the optimization must be anytime, meaning that it is guaranteed to return a feasible point even when terminated before it has converged to a solution. We introduce a class of novel system-theoretic algorithms for solving constrained nonlinear programs that combine continuous-time gradient flows to optimize the objective function with techniques from control barrier functions to maintain forward invariance of the feasible set. We refer to the resulting closed-loop system as the safe gradient flow. We draw on the alternative interpretation of the safe gradient flow as a projected dynamical system to characterize its dynamical properties regarding regularity, stability, convergence, contractivity, and invariance. We also show how the proposed framework is conducive to the extension of the proposed designs to monotone variational inequalities and discrete-time settings.

Bio: Jorge Cortes is a Professor and Cymer Corporation Endowed Chair in High Performance Dynamic Systems Modeling and Control in the Department of Mechanical and Aerospace Engineering, University of California, San Diego. He is the author of "Geometric, Control and Numerical Aspects of Nonholonomic Systems" (New York: Springer-Verlag, 2002) and co-author of "Distributed Control of Robotic Networks" (Princeton: Princeton University Press, 2009). He is a Fellow of IEEE, SIAM, and IFAC. He has co-authored papers that have won the 2008 and the 2021 IEEE Control Systems Outstanding Paper Award, the 2009 SIAM Review SIGEST selection from the SIAM Journal on Control and Optimization, the 2012 O. Hugo Schuck Best Paper Award in the Theory category, and the 2019 and 2023 IEEE Transactions on Control of Network Systems Outstanding Paper Award. At the IEEE Control Systems Society, he has been a Distinguished Lecturer (2010-2014), an elected member (2018-2020) of the Board of Governors, and Director of Operations (2019-2022) of its Executive Committee. His research interests include distributed control and optimization, network science and complex systems, resource-aware control and coordination, distributed decision making and autonomy, network neuroscience, and multi-agent coordination in robotic, power, and transportation networks.

Host: Dr. Lars Lindemann, llindema@usc.edu

The CSC/CommNetS-MHI Seminar Series is supported by the Ming Hsieh Institute and Quanser.