

SPRING 2026 SEMINAR SERIES

Responsive & Resilient AI for

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Autonomous Systems Engineering

Physics-Informed Neural Certificates for Stability and Control

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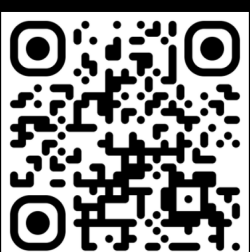
Friday, May 1, 2026, at 12:30 pm
Mechanical Engineering, Rm. 208

Abstract

Neural networks are universal approximators, yet learned models rarely come with rigorous guarantees. Typical statistical learning generalization bounds are often too conservative, and such probabilistic guarantees fail to certify correctness of a specific computed solution. In this talk, we present a formal verification framework that produces a posteriori error estimates for neural network solutions of partial differential equations (PDEs) arising in systems and control. We aim to provide rigorous guarantees for the learned models rather than mere probabilistic guarantees on the PDE residuals. The framework connects machine learning with rigorous control theory by turning physics-informed neural models into certifiable computational tools. More specifically, we study PDE characterizations that arise in stability and contraction analysis, control synthesis, and estimation for nonlinear dynamical systems. By combining formal verification tools with theoretically derived estimates, we rigorously bound approximation errors and translate these bounds into provable guarantees of stability and safety. The resulting neural certificates enable verification of regions of attraction, construction of provably correct stabilizing neural feedback controllers, and design of neural state estimators with provable error bounds.

Speaker Bio

Jun Liu received the B.S. degree in applied mathematics from Shanghai Jiao-Tong University in 2002, the M.S. degree in mathematics from Peking University in 2005, and the Ph.D. degree in applied mathematics from the University of Waterloo in 2011. Following an NSERC Postdoctoral Fellowship in Control and Dynamical Systems at Caltech, he became a Lecturer in Control and Systems Engineering at the University of Sheffield in 2012. He joined the Faculty of Mathematics of the University of Waterloo in 2015, where he is currently a Professor of Applied Mathematics and directs the Hybrid Systems Laboratory. Dr. Liu's main research interests are in the theory and applications of hybrid systems and control, including rigorous computational methods for control design with applications in cyber-physical systems and robotics. He was awarded a Marie-Curie Career Integration Grant from the European Commission in 2013, a Canada Research Chair from the Government of Canada in 2017 and 2022, an Early Researcher Award from the Ontario Ministry of Research, Innovation and Science in 2018, and an Early Career Award from the Canadian Applied and Industrial Mathematics Society and Pacific Institute for the Mathematical Sciences in 2020. His best paper awards include the Zhang Si-Ying Outstanding Youth Paper Award, the Nonlinear Analysis: Hybrid Systems Paper Prize, and the Oded Maler Award. Dr. Liu is a senior member of IEEE, a member of SIAM, and a lifetime member of CAIMS. He has served as the Chair of the IEEE Control Systems Society Technical Committee on Hybrid Systems, as the Vice Chair of the SIAM Control and Systems Theory Activity Group, and on the editorial boards and program committees of several journals and conferences, including *Automatica*, *Systems & Control Letters*, and *Nonlinear Analysis: Hybrid Systems*.



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