PennState College of Engineering

Systems, Controls, and Robotics Seminar Series

A Correct-by-Construction Paradigm for Designing Autonomous Systems

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Seminar: Friday, March 15
2:00 – 3:00 PM, 125 Reber

ABSTRACT

Correct-by-construction synthesis is increasingly recognized as a critical approach at the intersection of formal methods and control theory, particularly for the design of safety-critical systems. This method marks a departure from the traditional, labor-intensive redesign-verify-validate loop, promoting instead an iterative process of refining formal requirements linked through formal proof chains. Such an approach inherently integrates system correctness within the design phase itself. Over the past two decades, there has been notable progress in expanding the horizons of correct-by-construction synthesis, with a focus on cyber-physical systems that meld discrete-event control with continuous-space environments. The advancement in this field has been propelled by integrating symbolic techniques with state-space reduction methods, thus extending the practicality of correct-by-construction synthesis to large-scale autonomous systems. Moreover, recent developments have introduced novel directions utilizing barrier certificates and data-driven approaches, particularly when system models are not known. This presentation will outline the recent advances we have made, laying a robust groundwork for the correct-by-construction synthesis of cyber-physical systems. Time permitting, we will also delve into our most recent explorations in secure-by-construction synthesis, focusing on the integration of safety and security considerations into the system design process, alongside the transfer of assured autonomy between related systems.

BIOGRAPHY

Majid Zamani is an associate professor in the Computer Science Department at University of Colorado Boulder. Between May 2014 and January 2019, he was an assistant professor in the Department of Electrical Engineering at Technical University of Munich where he led the Hybrid Control Systems Group. He received a Ph.D. degree in Electrical Engineering and an MA degree in Mathematics both from University of California, Los Angeles in 2012, an M.Sc. degree in Electrical Engineering from Sharif University of Technology in 2007, and a B.Sc. degree in Electrical Engineering from Isfahan University of Technology in 2005. He received the George S. Axelby Outstanding Paper Award from the IEEE Control Systems Society in 2023, the NSF Career award in 2022 and ERC starting grant and ERC Proof of Concept grant from the European Research Council in 2018 and 2023, respectively. His research interests include verification and control of cyber-physical systems, secure-by-construction synthesis, and compositional analysis and synthesis of interconnected systems.