

Ontological robustness for certification of autonomous systems

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Abstract: Learning-based control paradigms have seen many successes in autonomous systems in recent years. A typical architecture in these systems involves layers for perception, planning and control, wherein each of these layers uses different tools and metrics for assessing robustness and performance. For example, the planners – that use vision-based sensors to update navigation and motion planning – operate largely by relying on distributionally robust stochastic optimal control, whereas the low-level controller can be deterministic, with its conventional gain and phase (time-delay) margin. We present a new analysis framework to address this ontology challenge inherent in autonomous systems. We derive distributional robustness guarantees for deterministic L_1 adaptive controllers that can be used by any stochastic planner without facing a language barrier. The combined planner-controller framework can serve as a foundation for developing certificates for V&V of learning-enabled systems. An overview of projects at our lab that build on this framework will be presented to demonstrate its applications.

Bio: Naira Hovakimyan received her MS degree in Applied Mathematics from Yerevan State University in Armenia. She got her Ph.D. in Physics and Mathematics from the Institute of Applied Mathematics of the Russian Academy of Sciences in Moscow. She is currently W. Grafton and Lillian B. Wilkins Professor of Mechanical Science and Engineering and the Director of AVIATE Center of UIUC. She has co-authored two books, thirteen patents, and more than 500 refereed publications. She is the 2011 recipient of AIAA Mechanics and Control of Flight Award, the 2015 recipient of SWE Achievement Award, the 2017 recipient of IEEE CSS Award for Technical Excellence in Aerospace Controls, and the 2019 recipient of AIAA Pendray Aerospace Literature Award. In 2014 she was awarded the Humboldt prize for her lifetime achievements. In 2015 and 2023 she was awarded the UIUC Engineering Council Award for Excellence in Advising. In 2024, she was recognized as the winner of the College Award for Excellence in Translational Research, and in 2025, she was recognized for Excellence in Graduate Student Mentoring. She is a Fellow of AIAA, IEEE, ASME, IFAC, and a senior member of the National Academy of Inventors. She has been named a Distinguished Lecturer for IEEE CSS for 2026-2028. She is a co-founder and chief scientist of Intelinair. Her work in robotics for elderly care was featured in the New York Times, on Fox TV, and on CNBC, and her recent NASA ULI award for flying cars led to a live interview on Cheddar Innovates and many other media platforms. Her research interests are in control and optimization, autonomous systems, machine learning, neural networks, game theory, and their applications in aerospace, robotics, mechanical, agricultural, electrical, petroleum, biomedical, and elderly care engineering.