WPI MECHANICAL ENGINEERING

ME Seminar

Coupled Sensor Placement and Motion Planning for Autonomous Mobile Vehicles

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Abstract

Motion-planning is the ability of a vehicle to determine, without human intervention, a future trajectory to accomplish a prespecified goal. It is a critical functionality of autonomy in mobile vehicles like unmanned aerial vehicles, wheeled robotic vehicles, and self-driving cars. For highly structured and well-mapped environments, motion-planning may be considered a solved problem. In less structured and uncertain environments, motion-planning poses several challenges.

In the first part of this talk, after a brief review of the state-of-the-art, I discuss motion-planning to achieve high-level tasks beyond the basic ability to move from A to B. I discuss the formulation of such tasks using linear temporal logic (LTL). A fundamental challenge arises because logic models for high-level tasks involve finite-state discrete mathematical structures like graphs or automata, whereas the physical motion of vehicles is best modeled by continuous-state nonlinear dynamical systems. Ad hoc discretization of the vehicle model's state space not only invokes the curse of dimensionality, but also fails to provide guarantees that a high-level plan for task execution will be compatible with the vehicle's kinematic-, dynamic-, or input constraints. To address this challenge, I propose a new method involving so-called lifted graphs. This method relies on discretization of the vehicle's 2D workspace, instead of its state space. Edges of lifted graphs can be associated with certain reachability properties of the vehicle model, which can be precomputed offline.

In the second part of this talk, I discuss the placement of exteroceptive sensors in an unknown or uncertain environment. Sensor placement to maximize environment information metrics is a well-studied topic in the literature. However, the literature addresses motion-planning and sensor placement separately, perhaps as a consequence of the success of the principle of separation in feedback control systems. I propose a coupled approach where sensor placement is driven by the objective of minimizing the cost of the motion plan. Through several examples I demonstrate that this coupled approach can result in orders-of-magnitude reductions in the number of measurements taken, as compared to the traditional decoupled approach. In the future, these striking examples can provide templates for deploying mobile vehicles in applications where data acquisition is expensive (e.g., aerial surveillance) and decisions must be made with as little data as possible.

About the Speaker

Raghvendra V. Cowlagi is an Associate Professor in the Aerospace Engineering Program at Worcester Polytechnic Institute, Worcester, MA. Previously, he obtained a Ph.D. in Aerospace Engineering from Georgia Tech (advisor: P. Tsiotras); worked as a postdoctoral researcher at MIT (sponsor: E. Frazzoli); and worked as a researcher at Aurora Flight Sciences Corp., Cambridge, MA. His research and teaching interests are in planning, optimal control, and estimation for mobile vehicles. He is a recipient of the 2016 AFOSR Young Investigator award, the 2017 Sigma Xi Outstanding Junior Faculty award, and the 2019 Moruzzi Award for Innovation in Undergraduate Education at WPI. He serves as Associate Editor on the IEEE Control Systems Society Conference Editorial Board and is a member of the AIAA Guidance, Navigation, & Control Technical Committee.