Designing Hybrid Control with Coarse Observations: Indistinguishability, Rendering, and Lexicographic Reachability

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Abstract

This talk explores certifiable control with coarse observations—for example, a robot detecting a landmark only when it enters a field of view, or an aerial vehicle receiving pixelated images or keypoints from a camera. Such limited information induces perceptual "modes", indistinguishable subspaces, and naturally leads to hybrid system models. I will present recent results addressing the design and verification of such systems. First, a method shows how an agent can localize itself with respect to an unknown landmark, even under unstable dynamics, using only coarse landmark observations. Second, lexicographic reachability, which leverages lexicographic differentiation to avoid explicit boundary computations and enables scalable analysis of nonsmooth and hybrid systems such as ReLU Neural ODEs. Third, abstract rendering, which computes sets of all images produced from uncertain camera poses in NeRF or Gaussian Splat scenes, thereby enabling certification of downstream classifiers and controllers. Together, these approaches form the foundation of a computational library that enables rigorous design and analysis of hybrid control systems.