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Robust Guarantees for Perception-Based Control

Motivated by vision-based control of autonomous vehicles, we consider the problem of controlling a known linear dynamical system for which partial state information, such as vehicle position, can only be extracted from high-dimensional data, such as an image. Our approach is to learn a perception map from high-dimensional data to partial-state observation, and its corresponding error profile, and then design a robust controller. We show that under suitable smoothness assumptions on the perception map and generative model relating state to high-dimensional data, an affine error model is sufficiently rich to capture all possible error profiles, and can further be learned via a robust regression problem. We then show how to integrate the learned perception map and error model into a novel robust control synthesis procedure, and prove that the resulting perception and control loop has favorable generalization properties. Finally, we illustrate the usefulness of our approach on a synthetic example and on the self-driving car simulation platform CARLA.