CPS:Medium: Tightly Integrated Perception and Planning in Intelligent Robotics

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Abstract

The objective of this research is to develop truly intelligent, automated driving through a new paradigm that tightly integrates probabilistic perception and deterministic planning in a formal, verifiable framework. The interdisciplinary approach utilizes three interlinked tasks. *Representations* develops new techniques for constructing and maintaining representations of a dynamic environment to facilitate higher-level planning. *Anticipation and Motion Planning* develops methods to anticipate changes in the environment and use them as part of the planning process. *Verifiable Task Planning* develops theory and techniques for providing probabilistic guarantees for high-level behaviors. Ingrained in the approach is the synergy between theory and experiment using an in house, fully equipped vehicle.

The recent Urban Challenge showed the current brittleness of autonomous driving, where small perception mistakes would propagate into planners, causing near misses and small accidents. Fundamentally, there is a mismatch between probabilistic perception and deterministic planning, leading to `reactive' rather than `intelligent' behaviors. The proposed research directly addresses this by developing a single, unified theory of perception and planning for intelligent cyber-physical systems.

Our group is developing algorithms that use vision and depth information in order to aid in 3D perception of a dynamic and complex environment. We have also developed and validated an approach for probabilistic anticipation of objects in a dynamic and complex environment using a Gauss-mixture representation; validation has occurred on a dataset with multiple cars and intersections. We have also developed a probabilistic, verifiable task planning paradigm using a set of task specifications as inputs. The approach provides guarantees in the presence of uncertainties, while also automatically synthesizing, analyzing and optimizing complex controllers. Our group is currently validating our approaches experimentally using Skynet, our autonomous driving vehicle.