Incremental-resolution Symbolic Perception-aware Planning

LEHIGH UNIVERSITY | AIRLab Autonomous and Intelligent Robotics Laboratory

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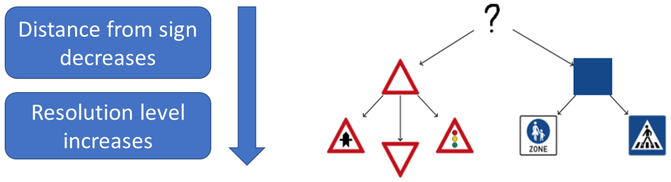
ERL EXPLAINABLE ROBOTICS LAB

Introduction

Sequential perception-planning frameworks compromise safety due to delays, mislabeling. To mitigate this, our overarching goal is to address the problem of symbolic perception-aware planning.

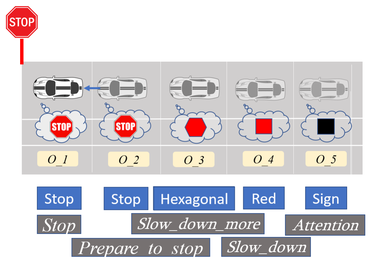
The proposed approach leads to

- Improved decision-making towards satisfying temporal logic rules and locally sensed events.
- Quantification of the risk associated with potential misperception.

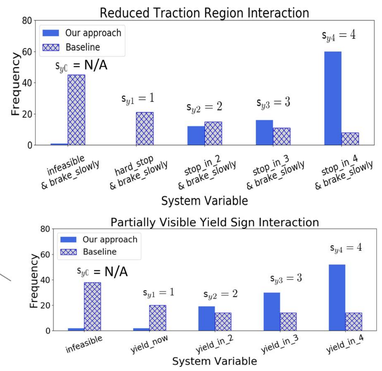


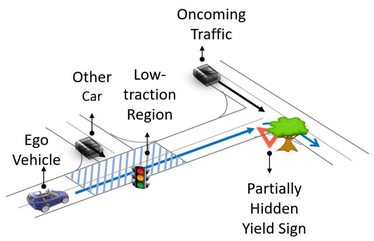
The relationship between symbolic variables represented as a hierarchy.

Correct-by-construction Reactive Control Synthesis



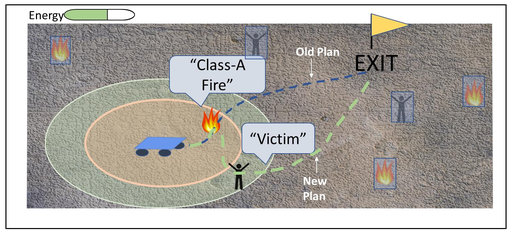
- Solved as a 2-player game between robot and environment.
- The winning control plan is safe for all admissible behaviors of the environment.





Active Exploration Under Energy Constraints

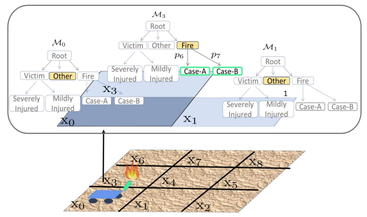
Energy-constrained sequential decision-making with incremental-resolution perception.



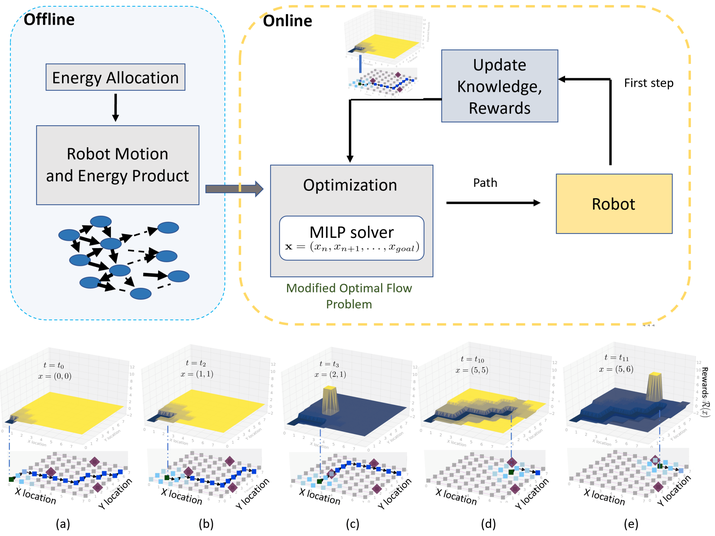
Unknown : location and # targets

Energy-constrained Reward Maximization Problem

$$\max_{\mathbf{x}\in Runs(T)} R_{path}(\mathbf{x})$$
$$\text{s.t. } x_0 = x_0^T$$
$$x_T = x_{goal}, T = |\mathbf{x}|$$
$$w_T(\mathbf{x}) + \sum_{x\in Vis(\mathbf{x})} \mathbf{e}(h(x)) \le \mathbf{E}$$

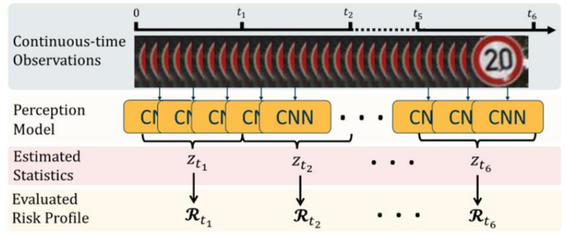


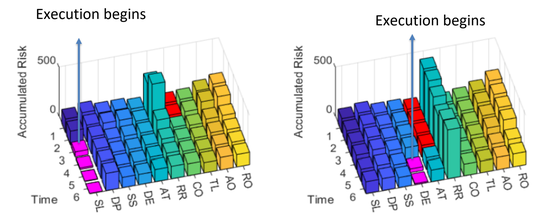
Proposed Approach



Risk of Misperception

- Not all mistakes are equivalent; The severity of potential misperception needs to be quantified for safety critical systems.
- Conditional Value-at-Risk (CVaR) measure to quantify the risk associated with a noisy belief output.





(a) True label: Speed-limit (SL) $\varphi(SL) = Slow\_down$

(b) True label: Do not enter (DE) $\varphi(DE) = Slow\_down \ \& \ Change\_direction$

Scientific Impact

- A step towards safe planning and decision-making with incremental-resolution symbolic perception.
- Novel decision-theoretic frameworks that utilize the automata-based and optimization-based methods.

Broader Impact

- Planning methodologies for safety critical, complex applications, inter alia, autonomous driving, exploration missions.

Collaborators

- Dr. Sofie Haesaert, Eindhoven University of Technology, Netherlands
- Dr. Nader Motee, Lehigh University, USA

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