ADVANCED REAL-TIME PLANNING AND DECISION MAKING

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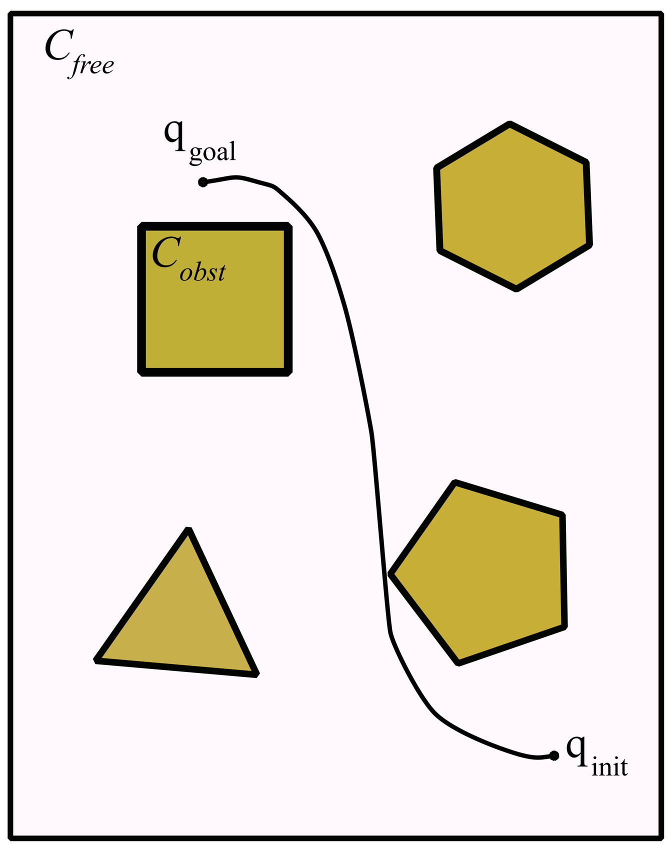
Description:

This project aims at developing state-of-the-art real-time planning and decision making algorithms that we believe will play a key-role of the "intelligence" of future autonomous systems. We would like to, as far as possible, work model based and minimize situation and platform specialization, as well as operator involvement. The algorithms should themselves find solutions, i.e., a sequence of decisions in time, to the given problems formulated in the form of a user-defined mission objective, constraints on behaviors and actions, and a model of relevant parts of the world (updated in real-time from observations and communication) where the platform acts.

Background & Motivation



Small efforts have been spent combining results from the predictive control community with results from the planning community in computer science. We strongly believe that performing such interdisciplinary research aiming at bridging this gap has great potential to result in very interesting and useful results.

Research Goal & Questions

- Draw parallels between optimal control and planning.
- Re-optimization online based on observed states using model predictive control techniques.

- How to handle non-convexity in a structured way?
- How to achieve real-time capabilities?
- How to guarantee stability?
- Is it possible to go beyond optimized planning?
- What can be achieved for these non-convex problems using techniques from global optimization?
- How to extend to multi-agent systems?

Methods & Preliminary Results

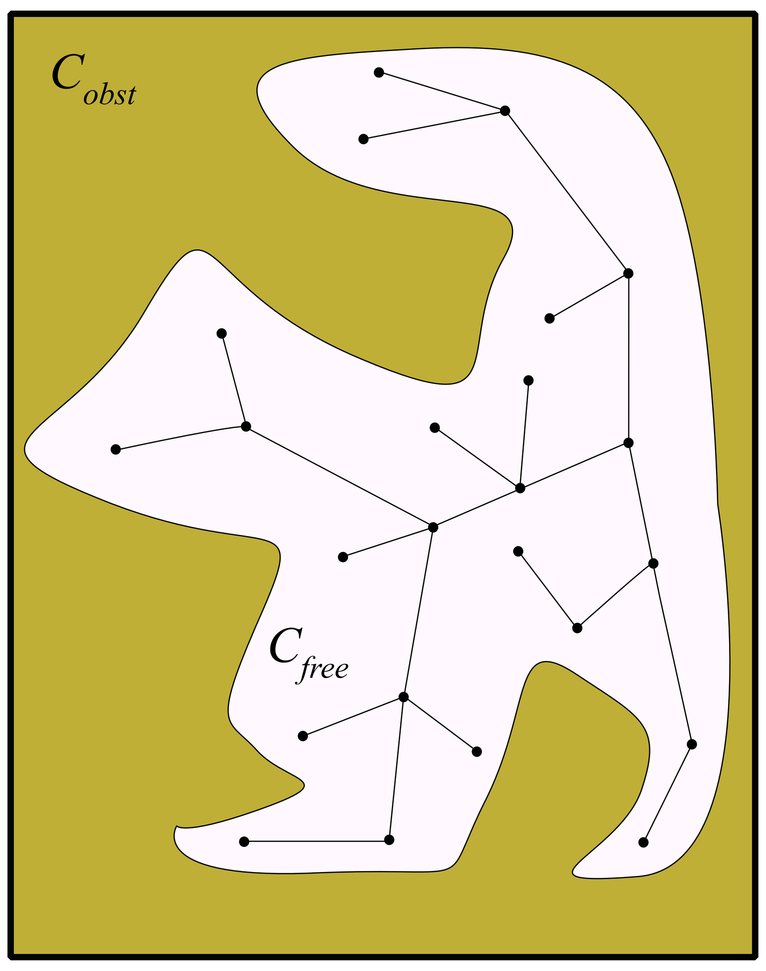
As a first step, a comparison between

- an optimal control method based on numerical optimization in ACADO,
- a sampling based non-optimal method (RRT) and
- a sampling-based near-optimal method (stable sparse RRT)

have been performed on small-scale examples in environments with non-convex obstacles. The Open Motion Planning Library (OMPL) implementations of RRT and SST have been used. The objective for the optimization methods was to produce the shortest path.

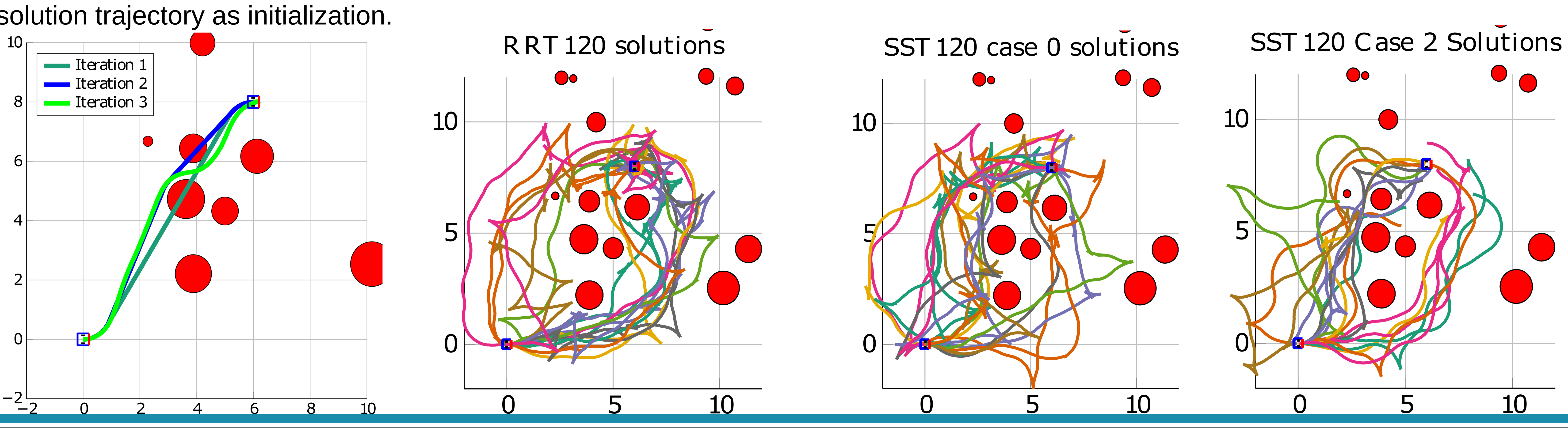
- Numerical optimization efficiently compute a solution that satisfies the endpoint constraint to a predefined accuracy.
- Local numerical optimization sensitive to initialization of the problem.

Roadmap & Milestones



- Investigate if local optimal control methods can be used to reliably generate good feasible solutions.
- Use branch-and-bound for nonlinear optimal control in 2D and 3D environments, with static and moving obstacles.
- What can be handled in a global framework?
  1. Non-convexity from nonlinear dynamics.
  2. Hybrid systems.
- Extend to distributed solutions (multi-agent systems).

The figures show solution paths from numerical optimal control (ACADO), RRT and SST with different parameterizations, for a simple car model in an environment with obstacles. For ACADO, the obstacles that are violated are added successively, with the previous solution trajectory as initialization.



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