Optimized Task and Motion Planning

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Finding optimized solutions to joint task and motion planning problems by using optimal control

1. Introduction

Autonomous systems must perform

- **Task planning** (discrete, high-level) – *what* actions to take to achieve an abstract goal
- **Motion planning** (continuous, lower-level) – *how* to move the system in order to execute actions

We aim to **find optimized solutions to the joint task and motion planning problem** (TAMP) by solving it jointly and using optimal control

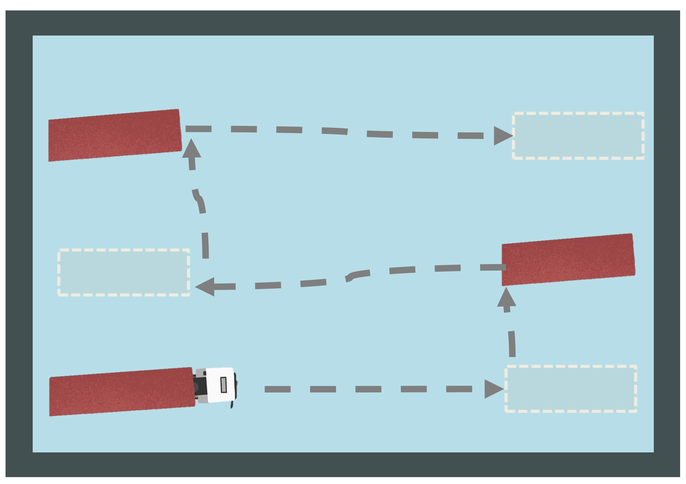
2. Problem

Given: the current and desired positions of a tractor and a number of trailers, obstacle locations

Goal: find the solution consisting of

- Task plan indicating what actions (connect/disconnect trailer, move tractor) to perform
- Feasible and collision-free motion plans for each move action

that **minimize the total cost** (path length)

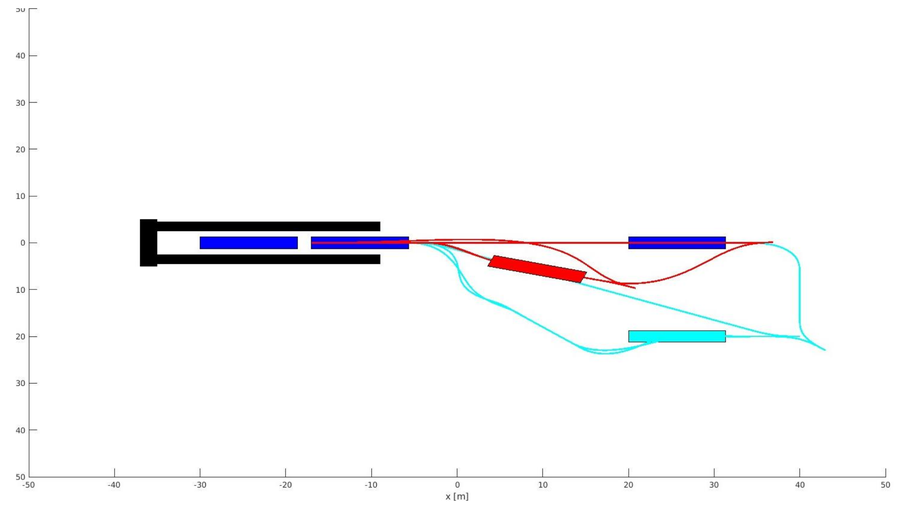


3. Results

We have proposed a two-stage framework for optimized TAMP with applications to tractor-trailers [1-3]

1. Discretize and solve TAMP problem to resolution optimality

2. Improve found plan using local optimization



Example of solution plans. Solution after Step 1 shown in cyan. Optimized solution after Step 2 shown in red.

TAMP solution step

- Proposed a **resolution optimal TAMP planner** [1]
- Idea: repeatedly find an optimal task plan using LPA* and estimated action costs. Compute the true action costs by calling the motion planner (expensive) only for actions of interest
- Using upper bounds, it is possible to **abort or pause the motion planner** in advance to **save time**
- Proposed several **strategies to reduce the number of calls to the motion planner** and improve efficiency [3]

Improvement step

- **Warm-start** numerical solver with solution from previous step
- **Solve a sequence of finite-horizon optimal control problems** that improve upon one part of the solution [2]
- **Reduces discretization artefacts**

References

1. Hellander, A., Bergman, K., Axehill, D., *On Integrated Optimal Task and Motion Planning for a Tractor-Trailer Rearrangement Problem*, **CDC**, 2023
2. Hellander, A., Bergman, K., Axehill, D., *Improved Task and Motion Planning for Rearrangement Problems using Optimal Control*, Intelligent Vehicles Symposium (**IV**), 2024
3. Hellander, A., Axehill, D., *On Methods for Improved Efficiency of Optimal Task and Motion Planning*, **CDC**, 2024