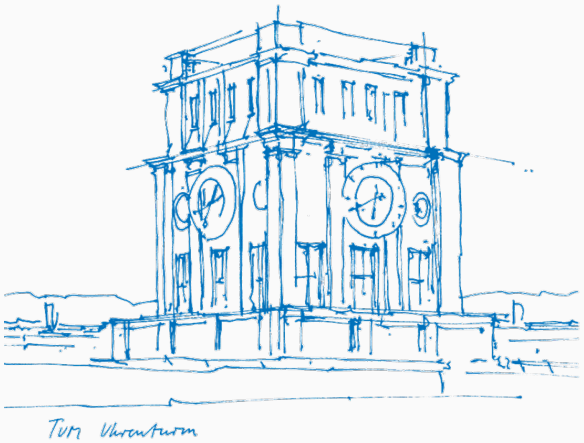
Dynamical Post-Processing for Manipulation Trajectories

Internship Report



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Technische Universität München

Motivation

Classical manipulation planners:

- Sampling-based
- Output *kinematic* path consisting of sequence of robot configurations

$\Rightarrow$ Dynamics not yet taken into account

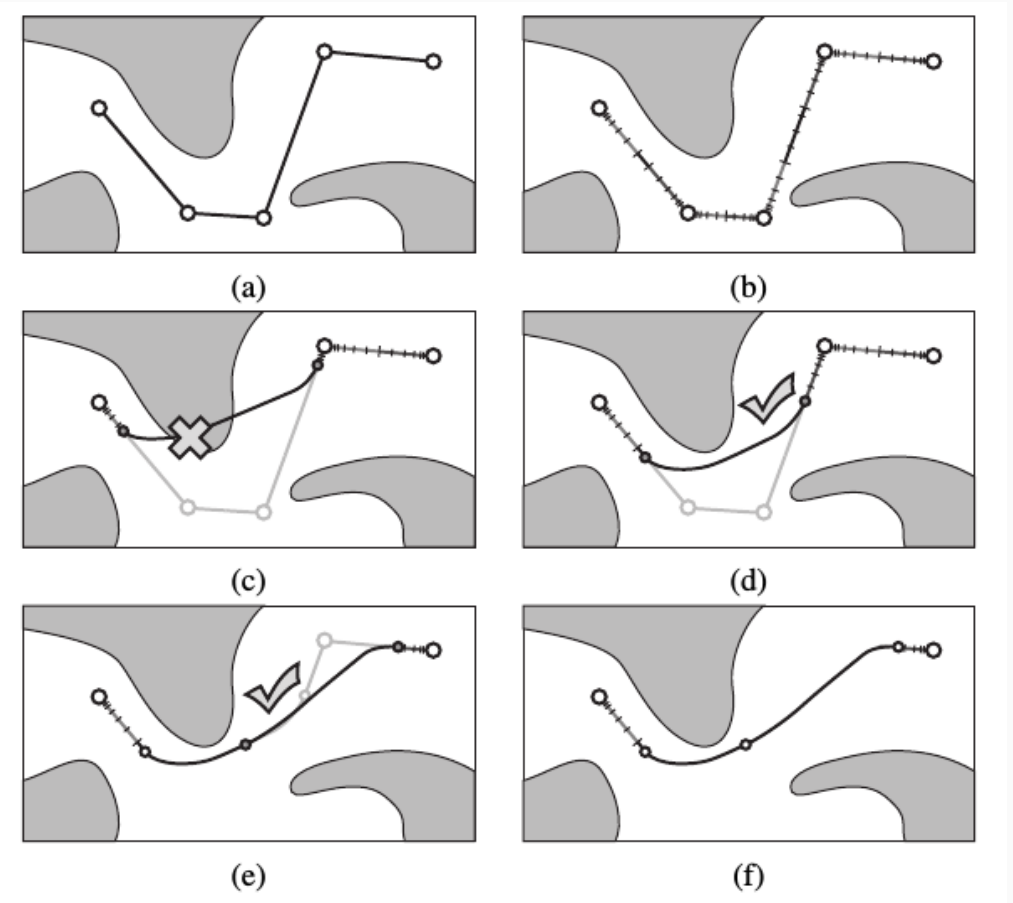
$\Rightarrow$ Local improvements possible

Evaluation of Various Post-Processing Strategies

1. Hauser's shortcutting idea
2. Smooth object interaction
3. Sampling of new transitions
4. Sampling of new grasps and placements

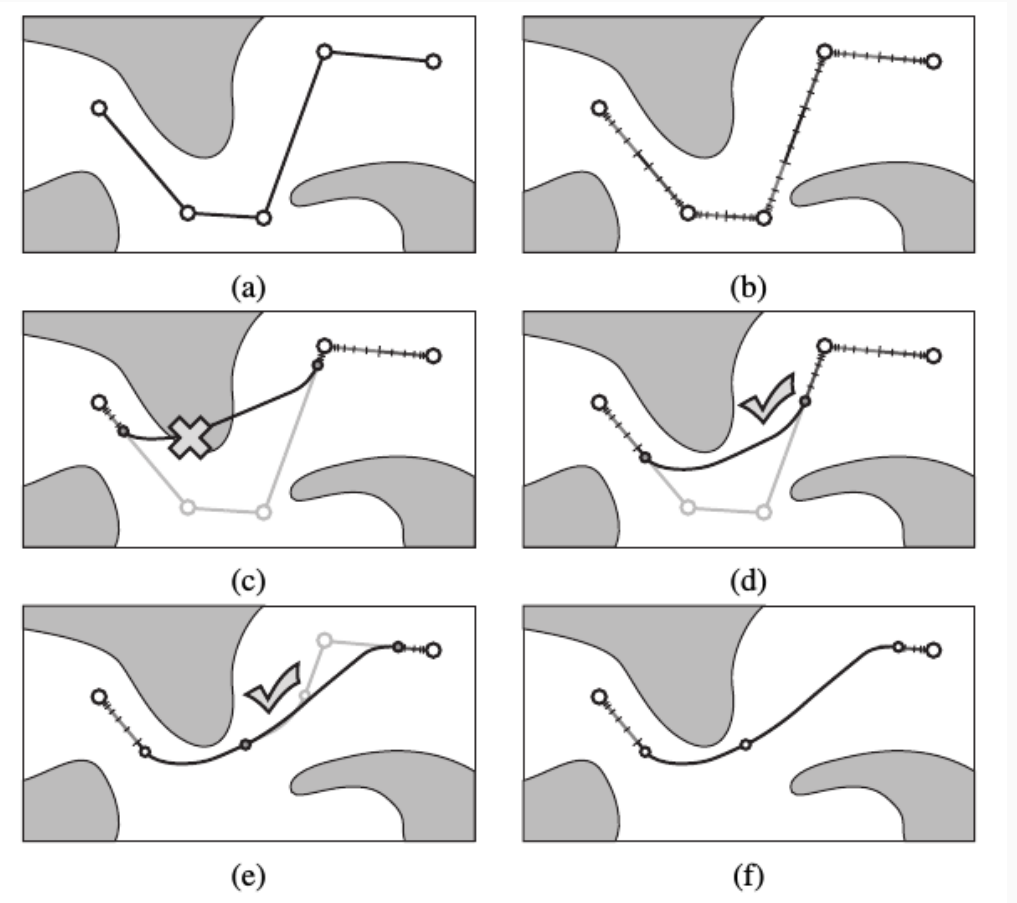
1. Hauser's Shortcutting Idea

- Transform path to start-stop-trajectory
- Shortcut iteratively:
  - sample two points
  - compute shortcut
  - check collisions



1. Hauser's Shortcutting Idea

- Transform path to start-stop-trajectory
- Shortcut iteratively:
  - sample two points
  - **How?** compute shortcut
  - check collisions



Synchronization of Axes

Basic Idea

- find "bottleneck" axis
- synchronize all axes to bottleneck time

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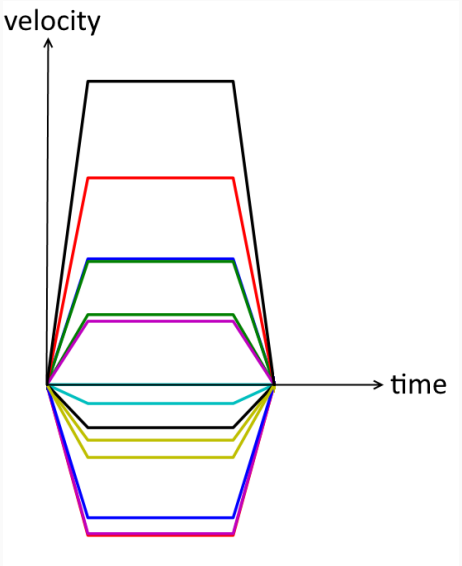
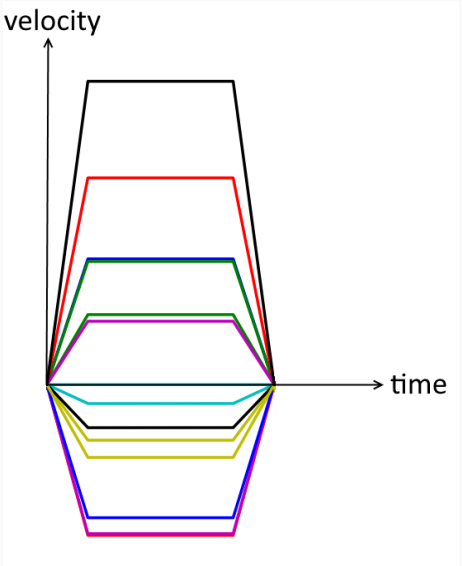


Synchronization of Axes



Basic Idea

- find "bottleneck" axis
- synchronize all axes to bottleneck time

Problem

- synchronization to arbitrary subsequent point in time not always possible
- each axis has inoperative time intervals in which axis cannot be synchronized

Synchronization of Axes

Basic Idea

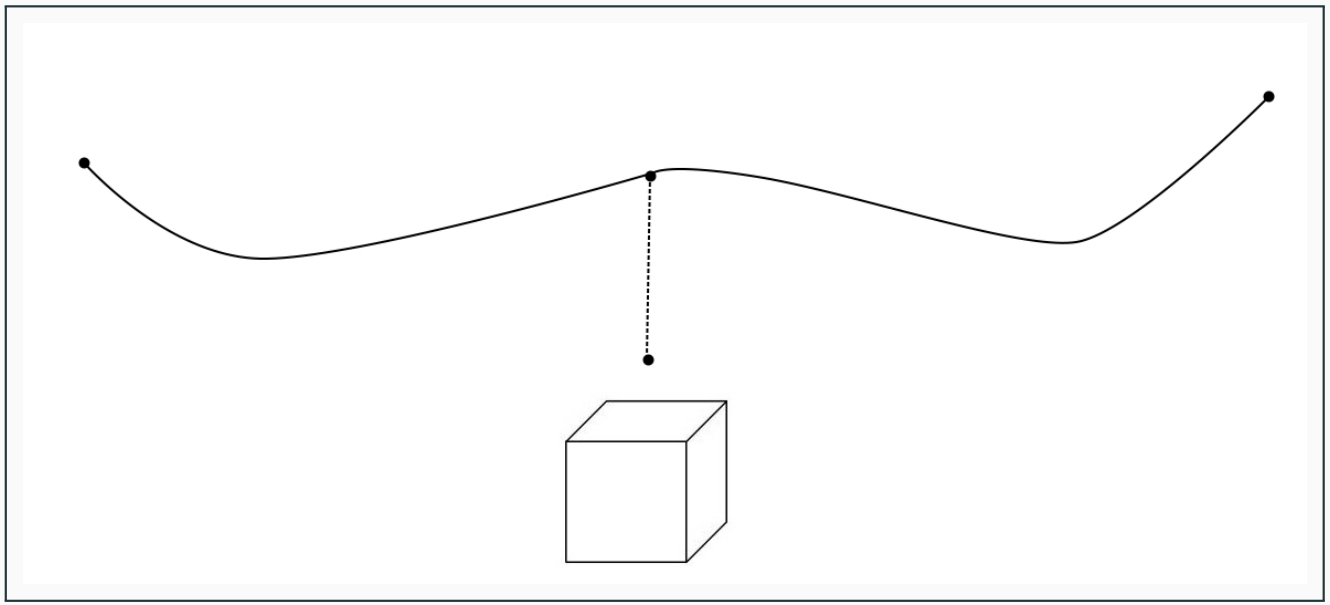
- find "bottleneck" axis
- synchronize all axes to bottleneck time

Reflexxes

- find "bottleneck axis" and inoperative time intervals
- synchronize all axes to earliest possible point in time

2. Smooth Interaction

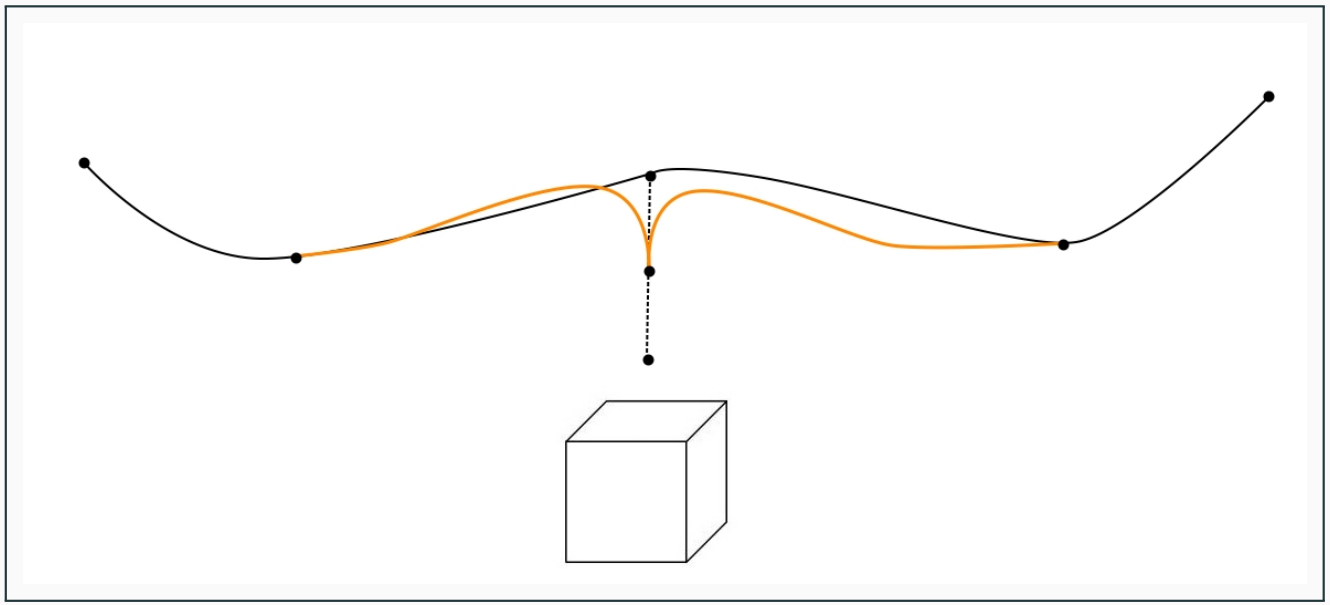
- "interaction" = approaching the object to be gripped



- current solution: stop between motion and grasp
- stopping takes a lot of time

2. Smooth Interaction

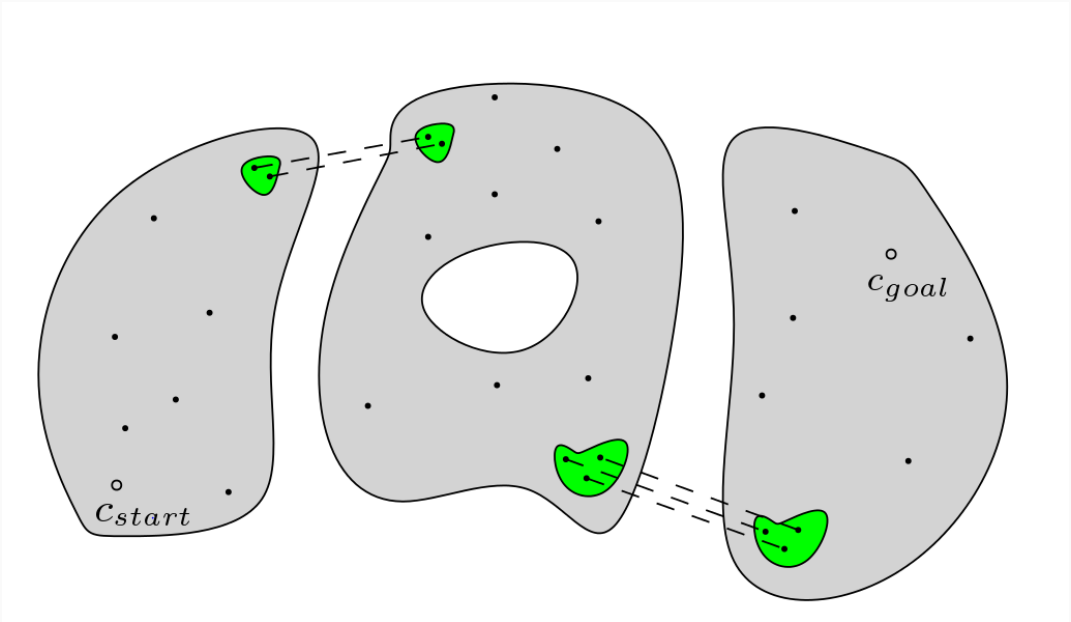
- "interaction" = approaching the object to be gripped



- better: slide smoothly into linear movement
- use Reflexxes for computation of orange motion

3. Sampling of New Transitions - Basic Idea

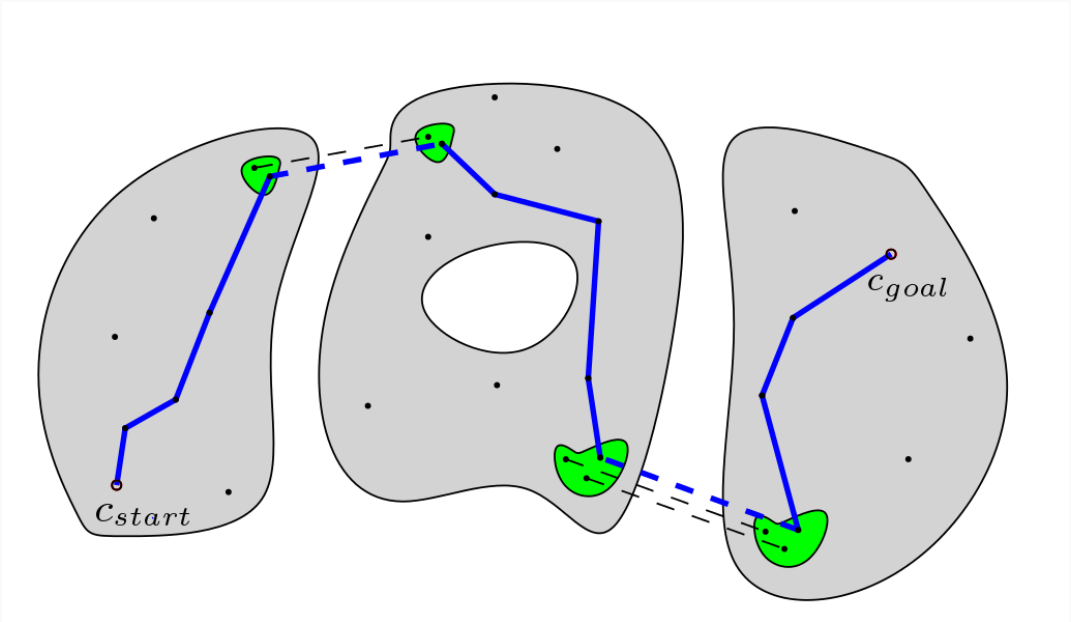
- Recall: Manipulation Planner



- Idea: Sample new transitions and re-plan preceeding and succeeding trajectories

3. Sampling of New Transitions - Basic Idea

- Recall: Manipulation Planner

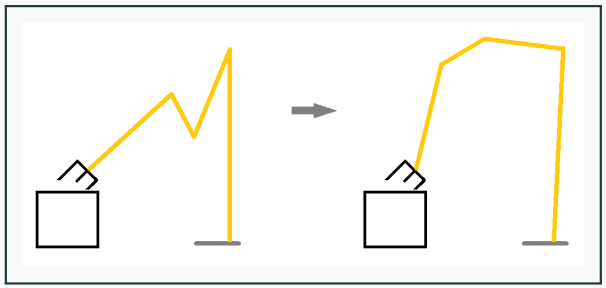


- Idea: Sample new transitions and re-plan preceeding and succeeding trajectories

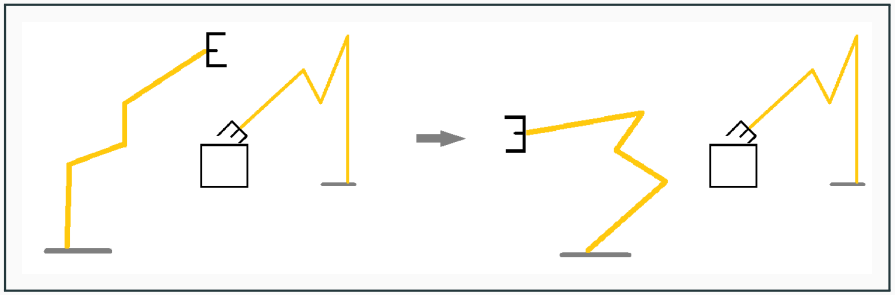
3. Sampling of New Transitions - More Details

New transition is ...

... either new inverse kinematic (for active arms)

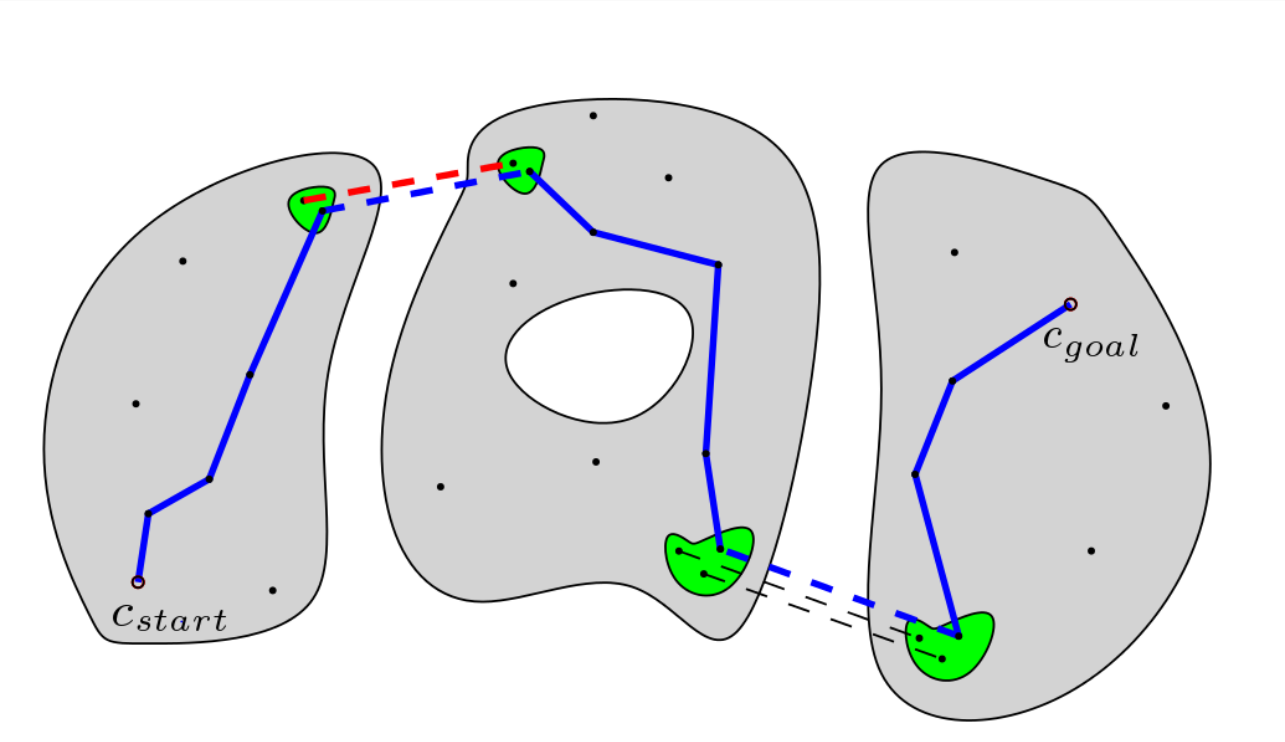


... or arbitrary valid configuration (for passive arms)



3. Sampling of New Transitions - More Details

Re-plan using Reflexxes:



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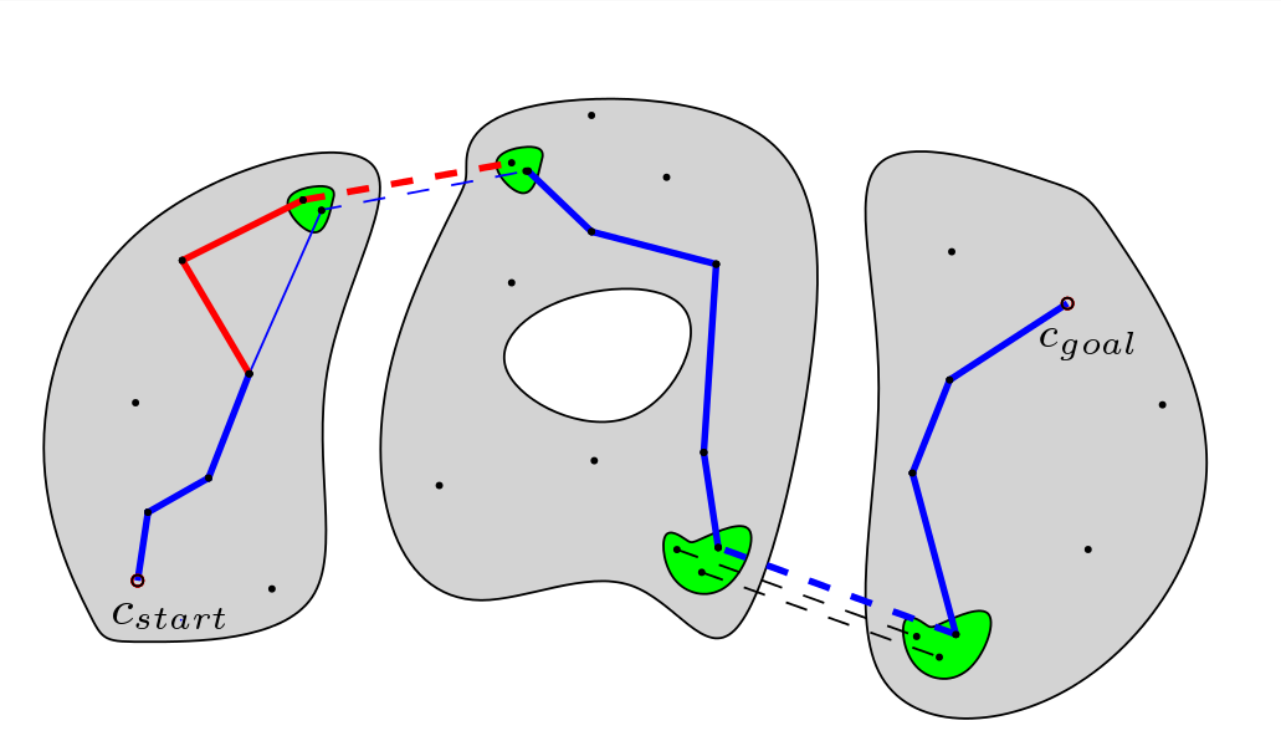

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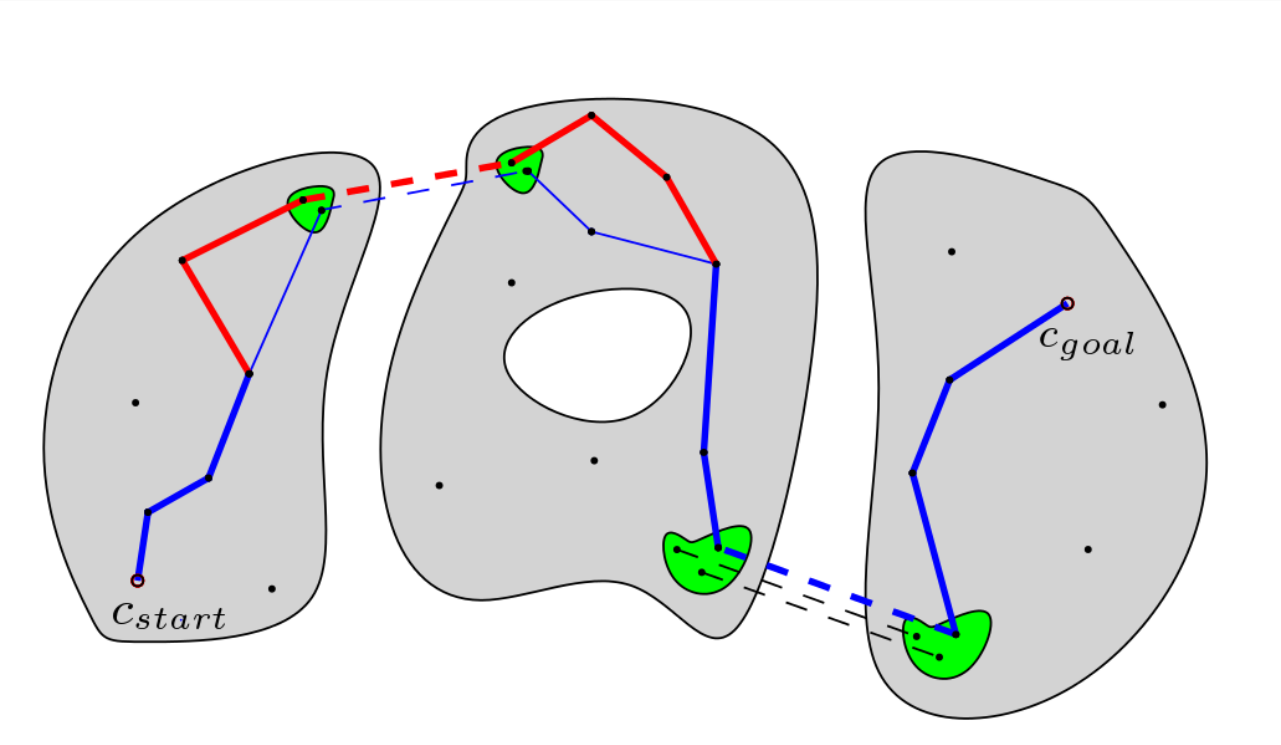


4. Sampling of New Grasps and Placements

- Recall: Manipulation Planner
  - Sample a set of *fixed* grasps
  - For these, sample configuration roadmaps
- Post-Processing so far: Stick to these grasps

4. Sampling of New Grasps and Placements

- Recall: Manipulation Planner
  - Sample a set of *fixed* grasps
  - For these, sample configuration roadmaps
- Post-Processing so far: Stick to these grasps
- Idea: Also sample new grasps and re-plan
- But: New grasp changes collision checks for all subsequent action

Evaluation

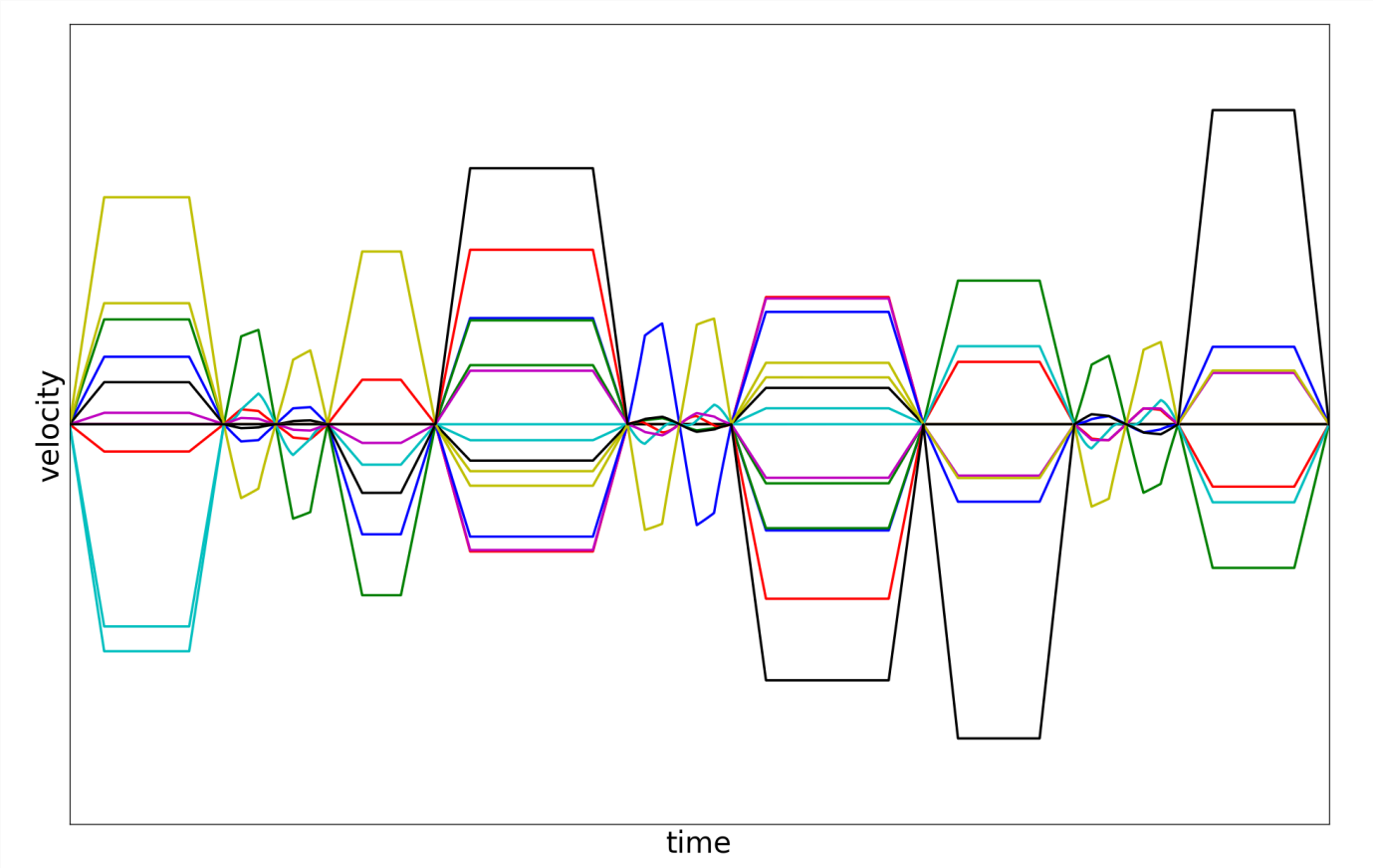
Simple pick-and-place task ... without Post-Processing

Evaluation

Simple pick-and-place task ... after Post-Processing

Evaluation

Simple pick-and-place task ... without Post-Processing



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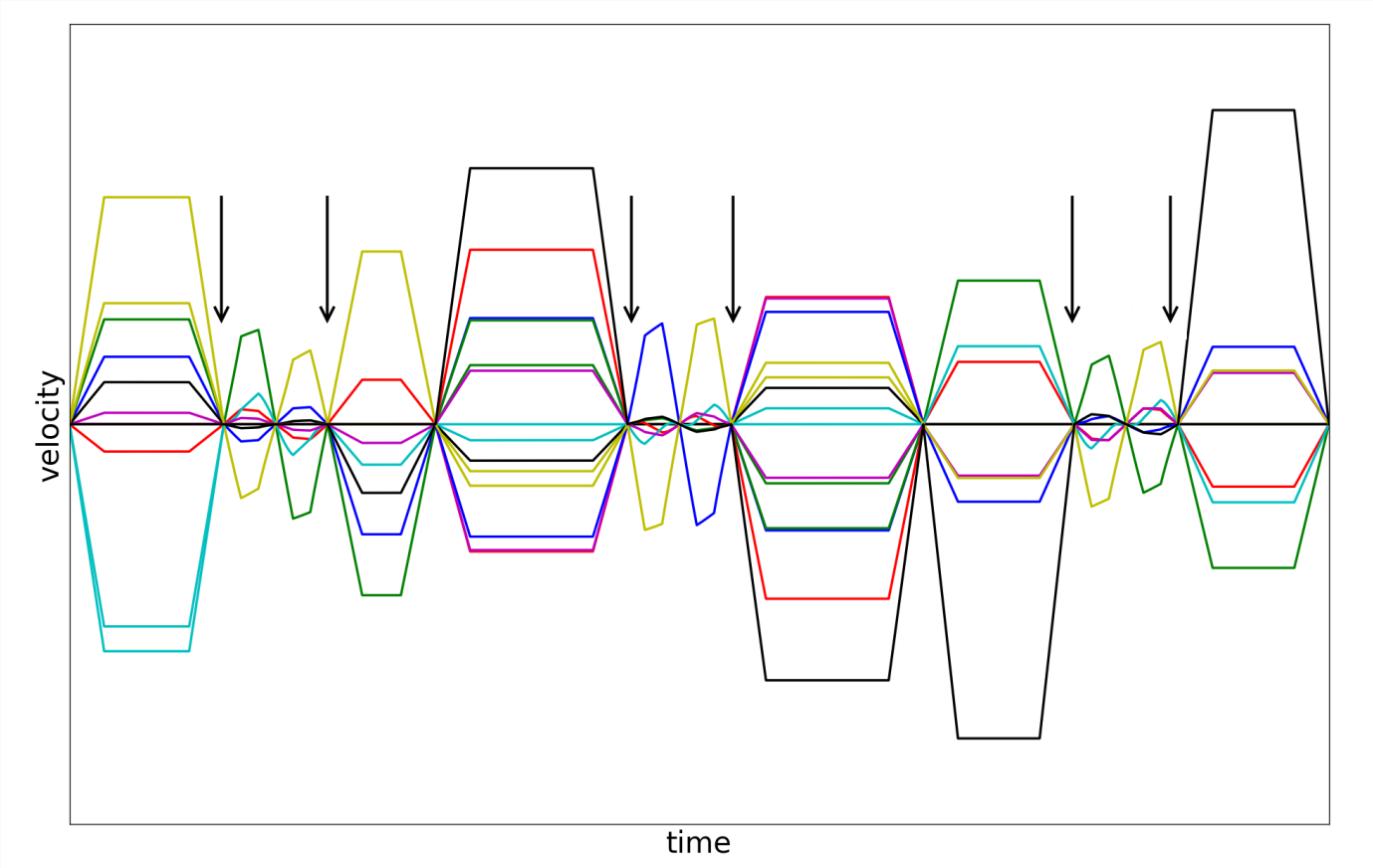

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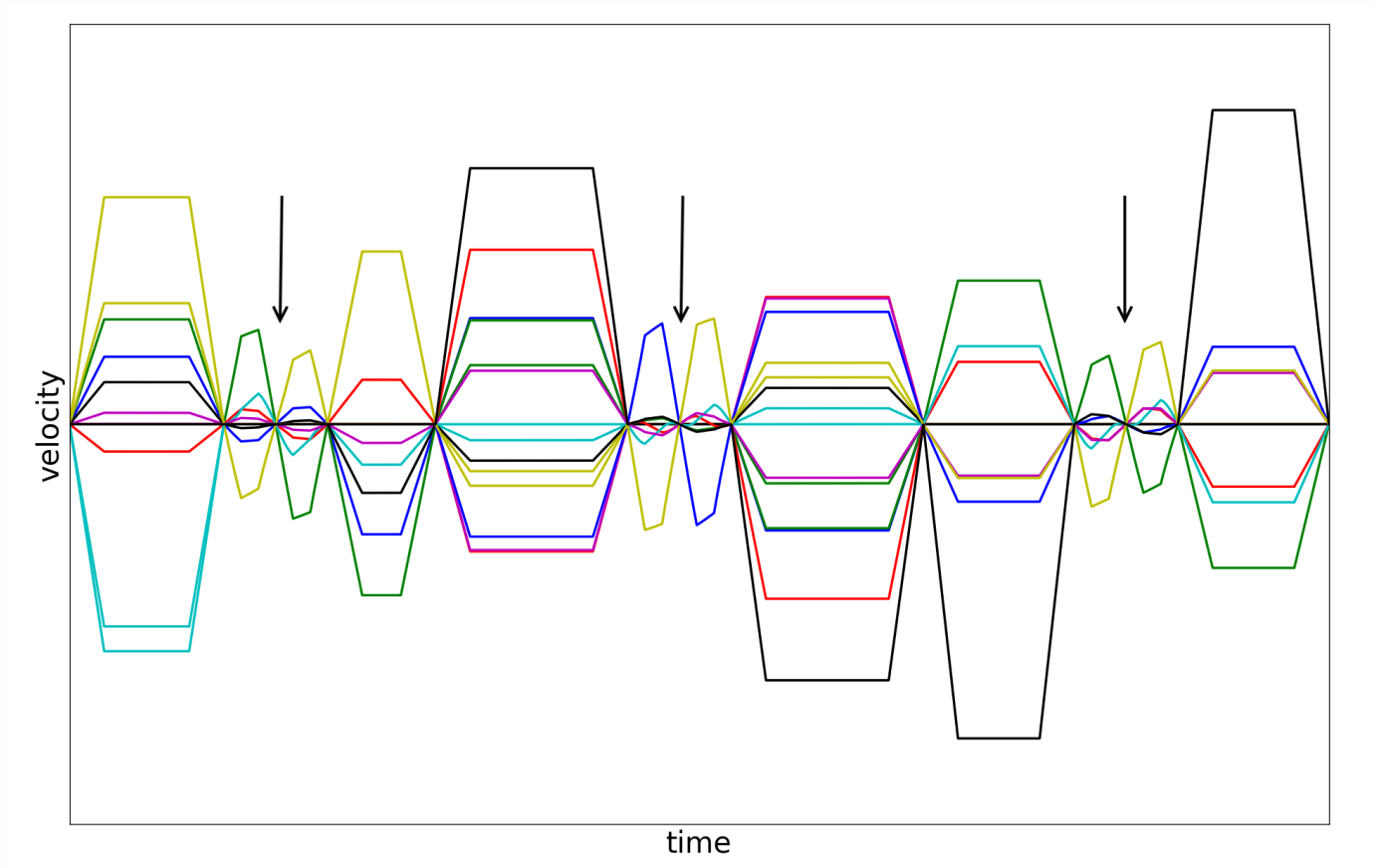

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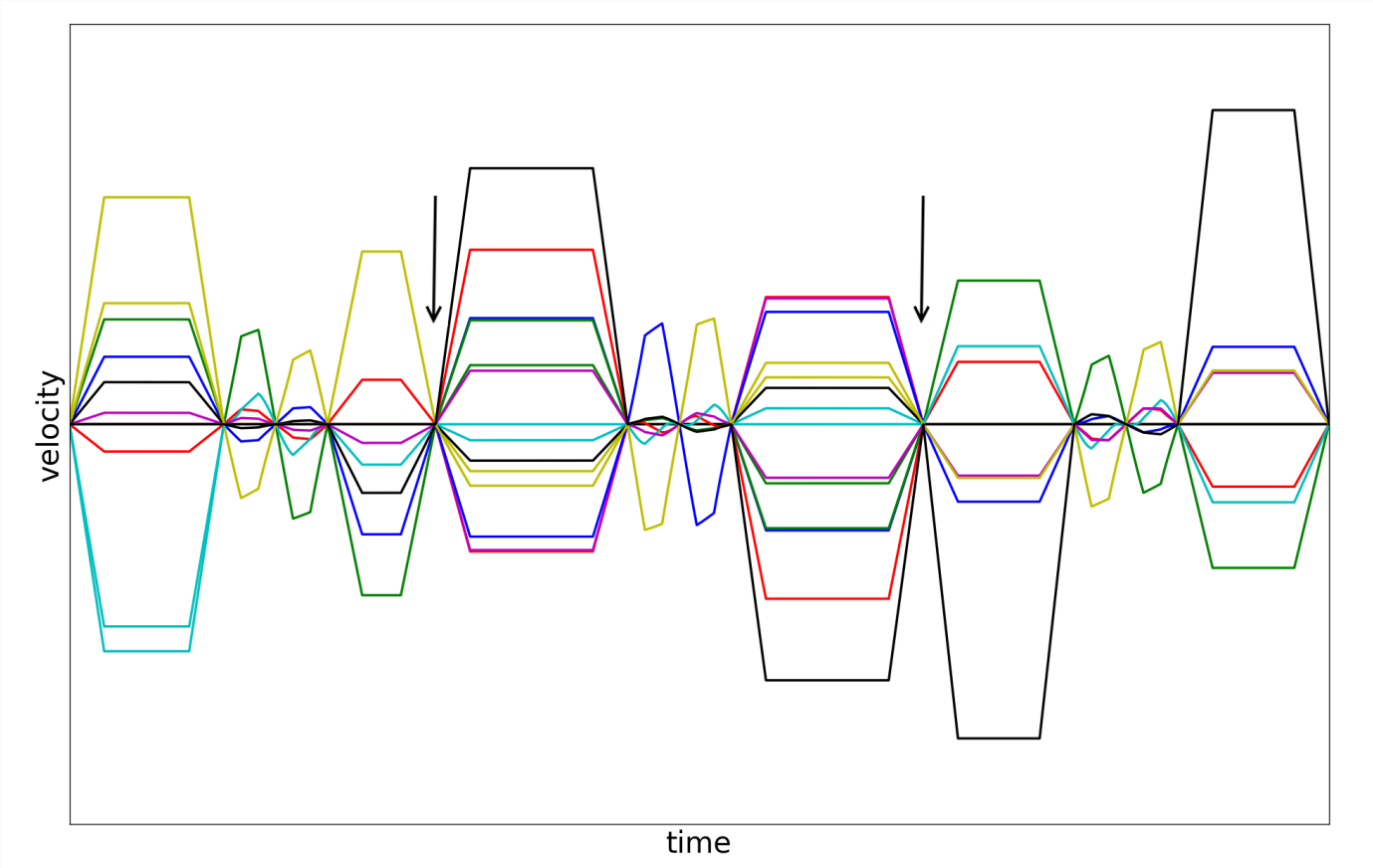
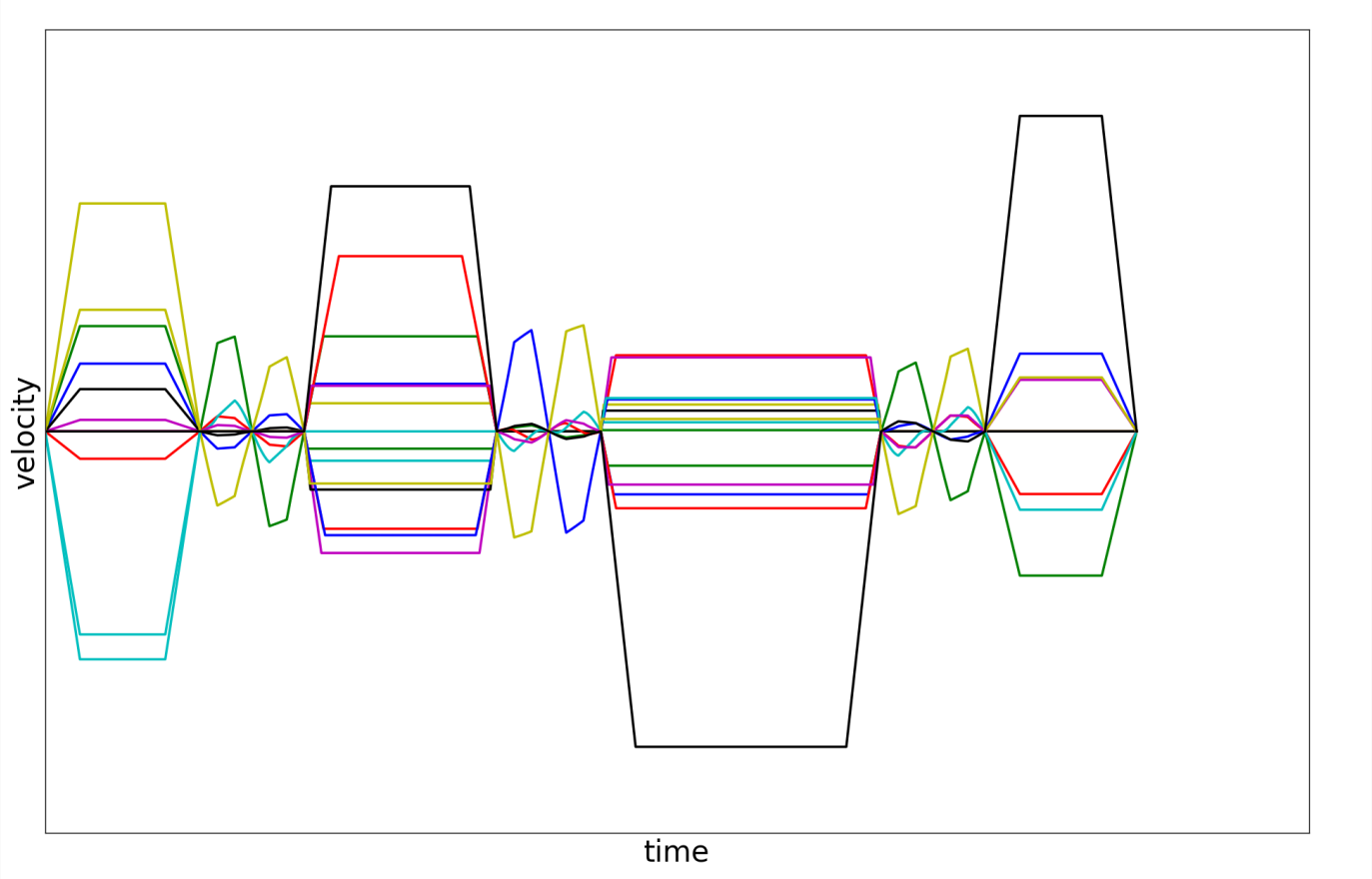


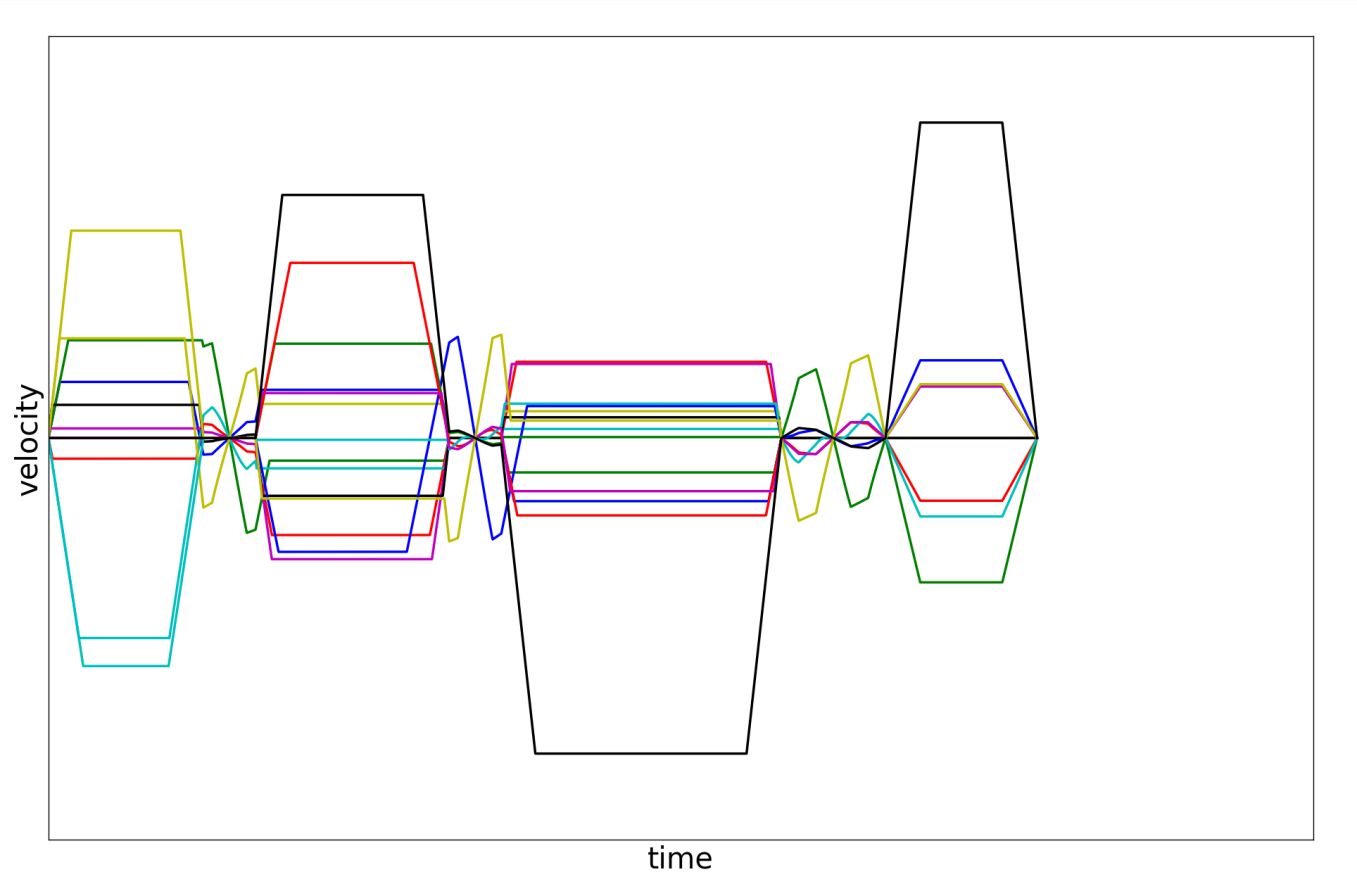
Evaluation

... after Hauser's Shortcutting



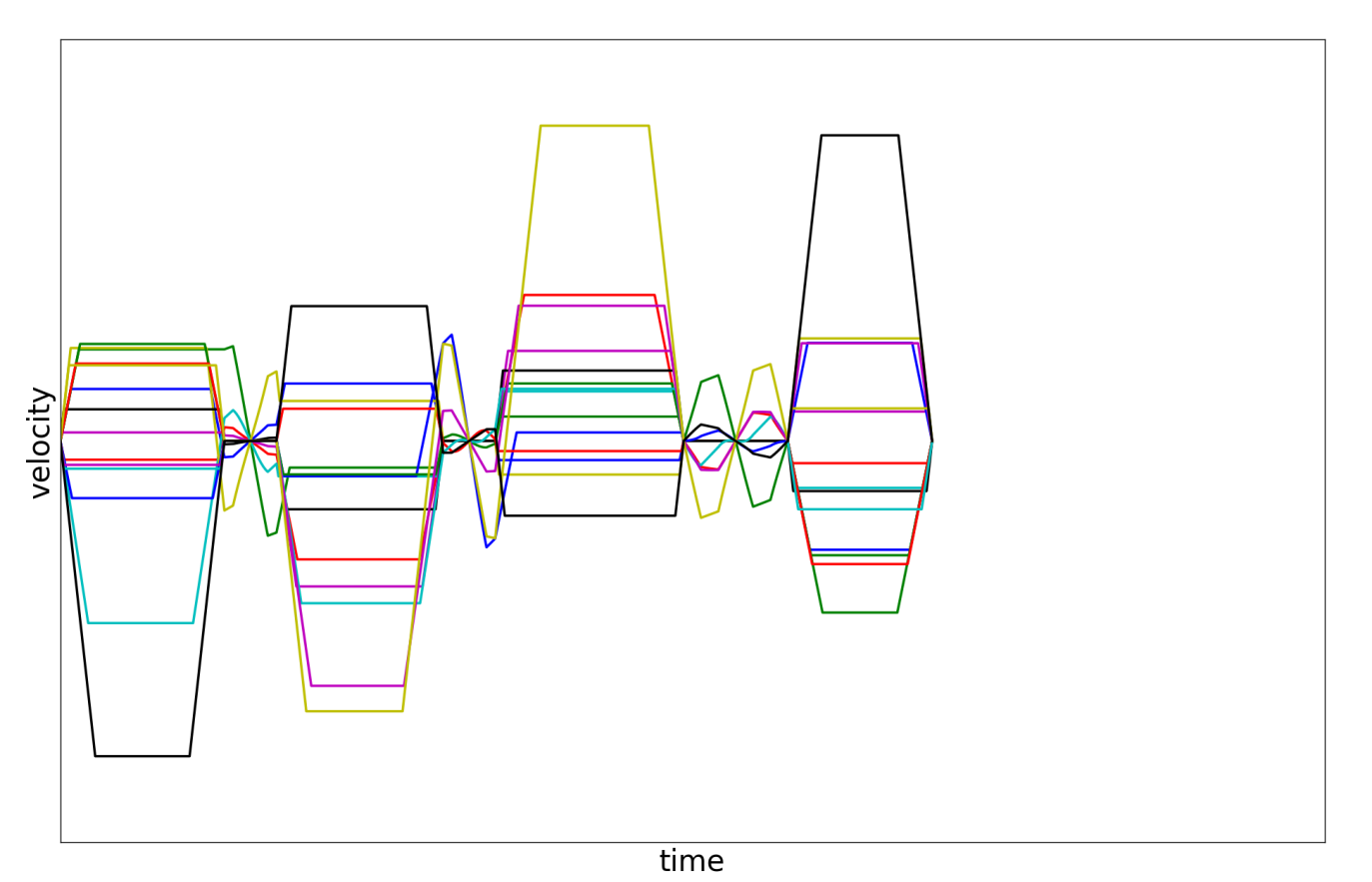
Evaluation

... after Shortcutting + Smooth Interaction

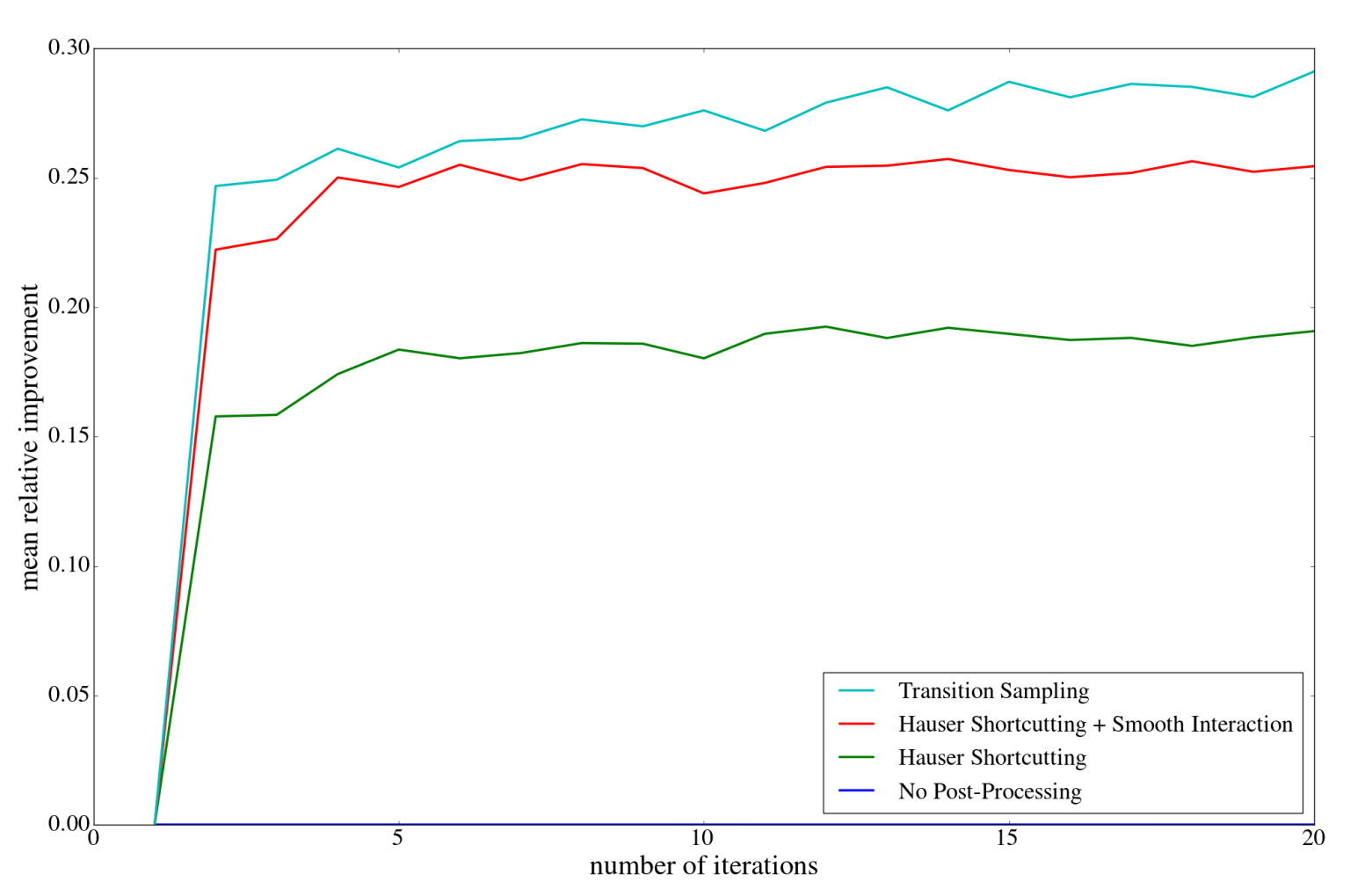


Evaluation

... after Transition Sampling



Comparison of the Post-Processing Steps



Outlook Master's Thesis

- Task: Modeling of a dynamic manipulation task as a MINLP
- MINLP = **M**ixed **I**nteger **N**onlinear **P**rogram
- Include dynamic constraints into optimization
- Idea: Informed search in sampling-based manipulation planner

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$\Rightarrow$ Potential new approach for global solutions

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⇒ Systematic approach for local, time-optimal solutions

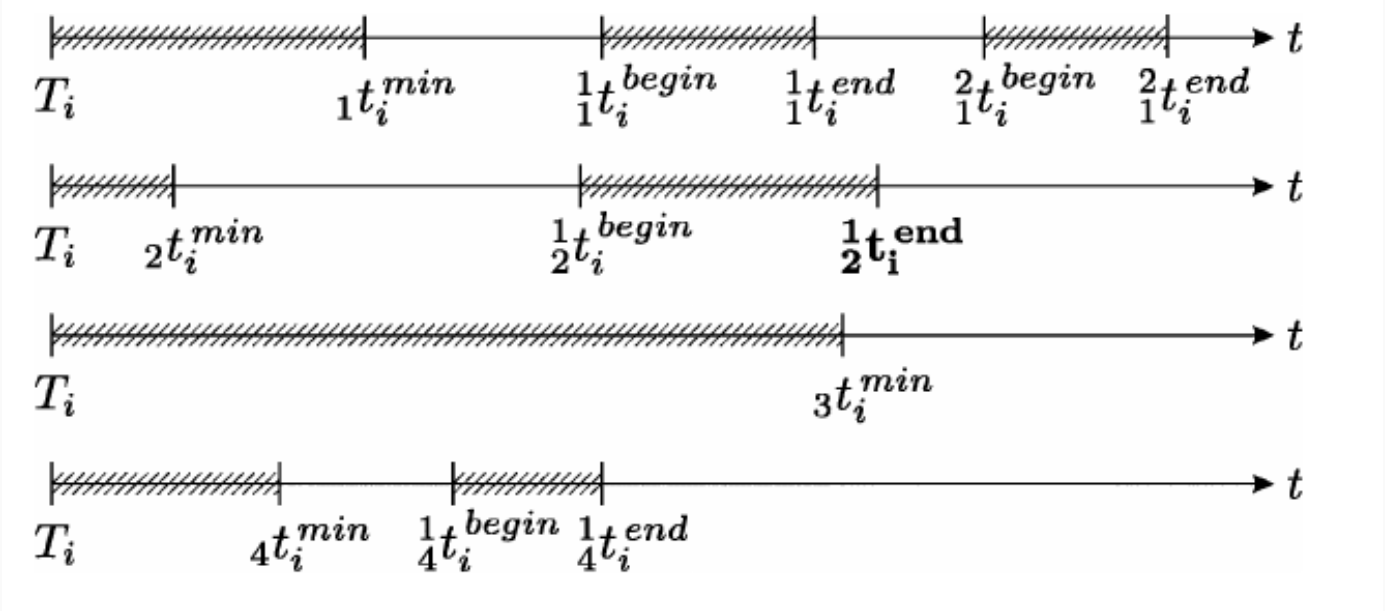
⇒ Potential new approach for global solutions

- Idea: Informed search in sampling-based manipulation planner

⇒ More effective sampling strategies

Backup

Synchronization not always possible



No Post-Processing

Plot

Hauser's Shortcutting

Plot

Shortcutting plus Smooth Interaction

Plot

Sampling of New Transitions

Plot