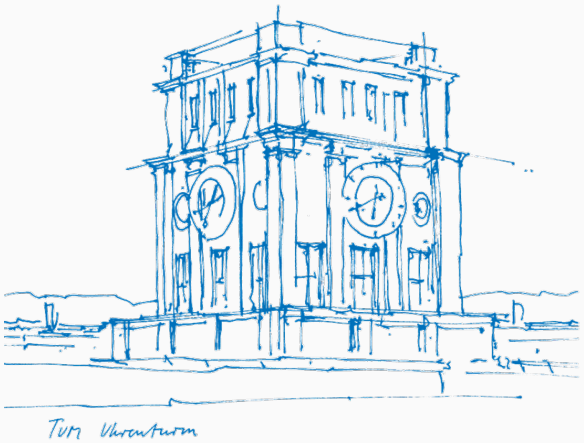
# Dynamical Post-Processing for Manipulation Trajectories

## Internship Report



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# Motivation

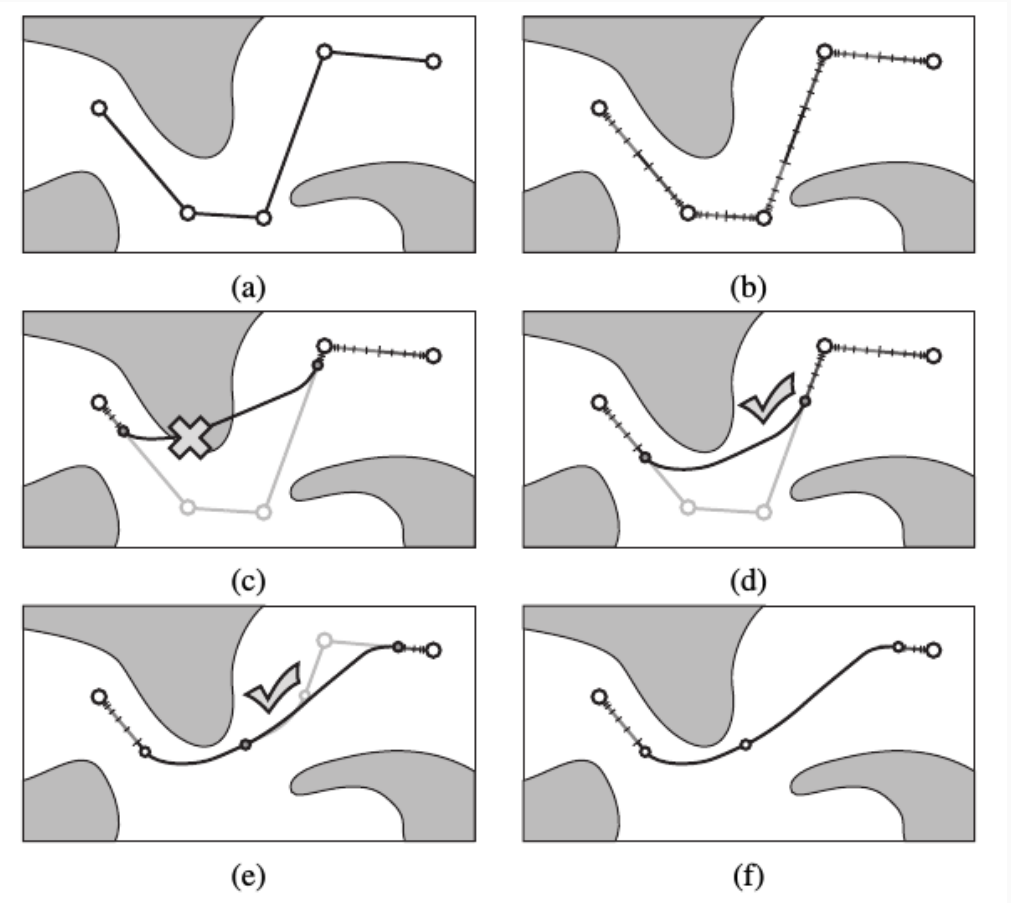
- sampling-based manipulation planners output kinematic path
- dynamics not yet taken into account
- local improvements possible

# 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

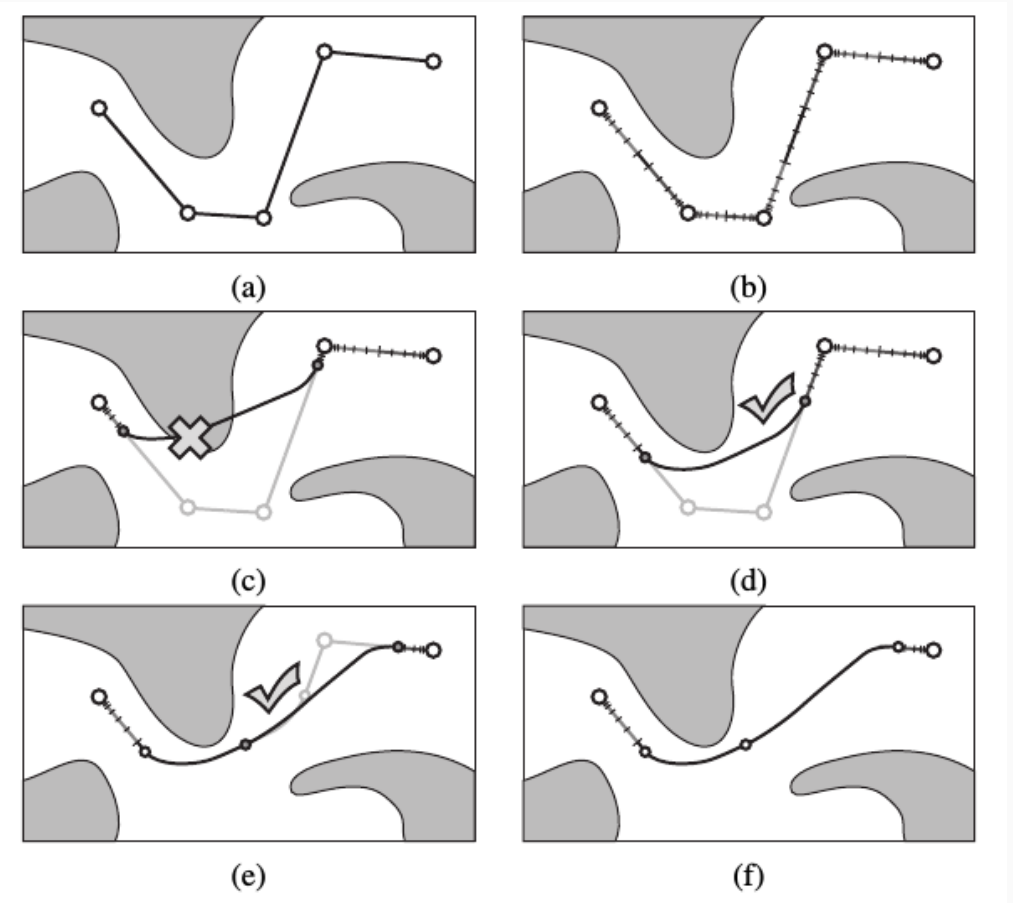
# 1. Hauser's Shortcutting Idea

- sample two points
- compute shortcut
- check collisions



# 1. Hauser's Shortcutting Idea

- sample two points
- compute shortcut How?
- check collisions



# Synchronization of Axes

## Basic Idea

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

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## 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**

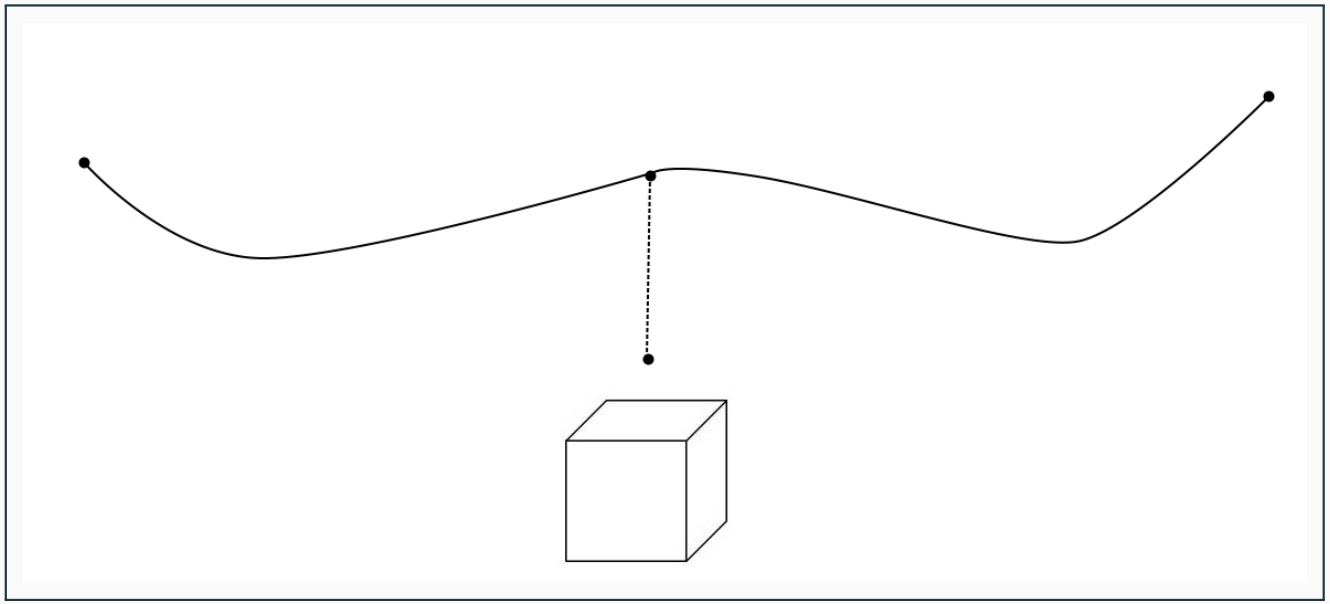
- find "bottleneck" axis
- synchronize all axes to bottleneck time

**Reflexxes**

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

# 2. Smooth Interaction

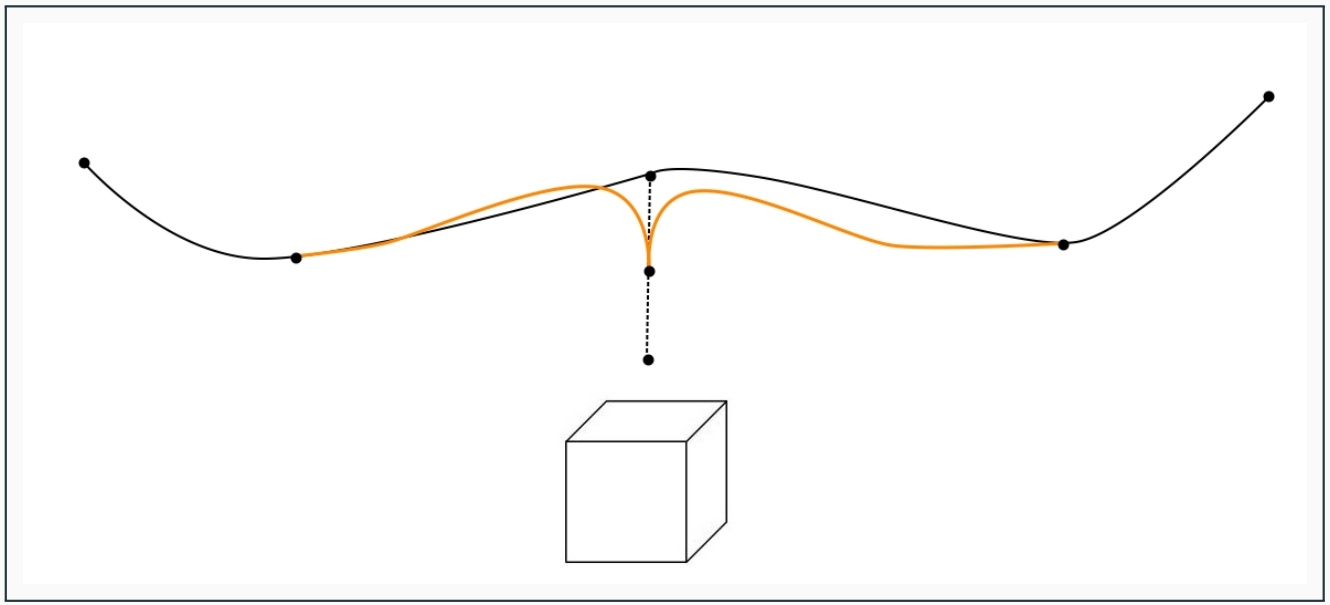
- "interaction" = approaching the object to be gripped



- 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

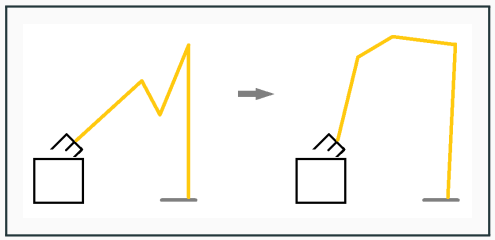
# 3. Sampling of New Transitions - Basic Idea

- Recall: Manipulation Planner
  PHILIPP'S IMAGE
- Idea: Sample new transitions and re-plan trajectories in adjacent modes

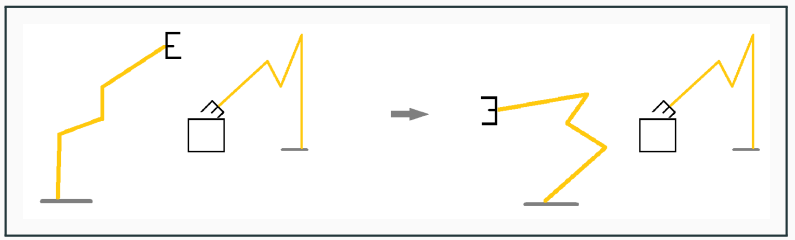
# 3. Sampling of New Transitions - More Details

- new transition is ...

... either new inverse kinematic



... or arbitrary valid configuration




- Replan using Reflexxes:

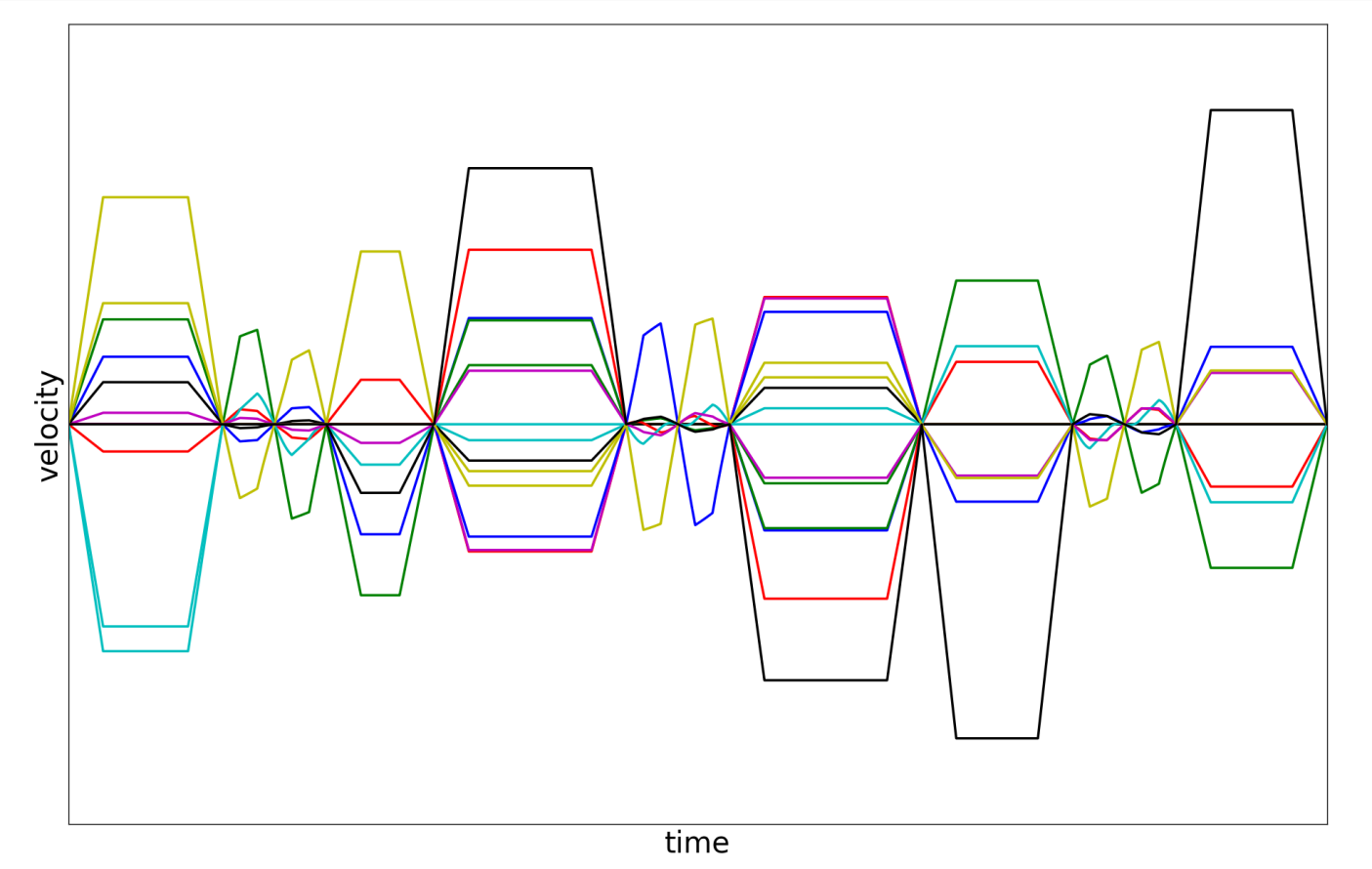
  include picture similar to Philipp's

# 4. Sampling of New Grasps and Placements

- Recall: Within-contact roadmaps for a couple of *fixed* grasps and placements
- Idea: Also sample new grasps and replan
- Difficulties: new grasp changes planning scene for all subsequent modes, expensive updates

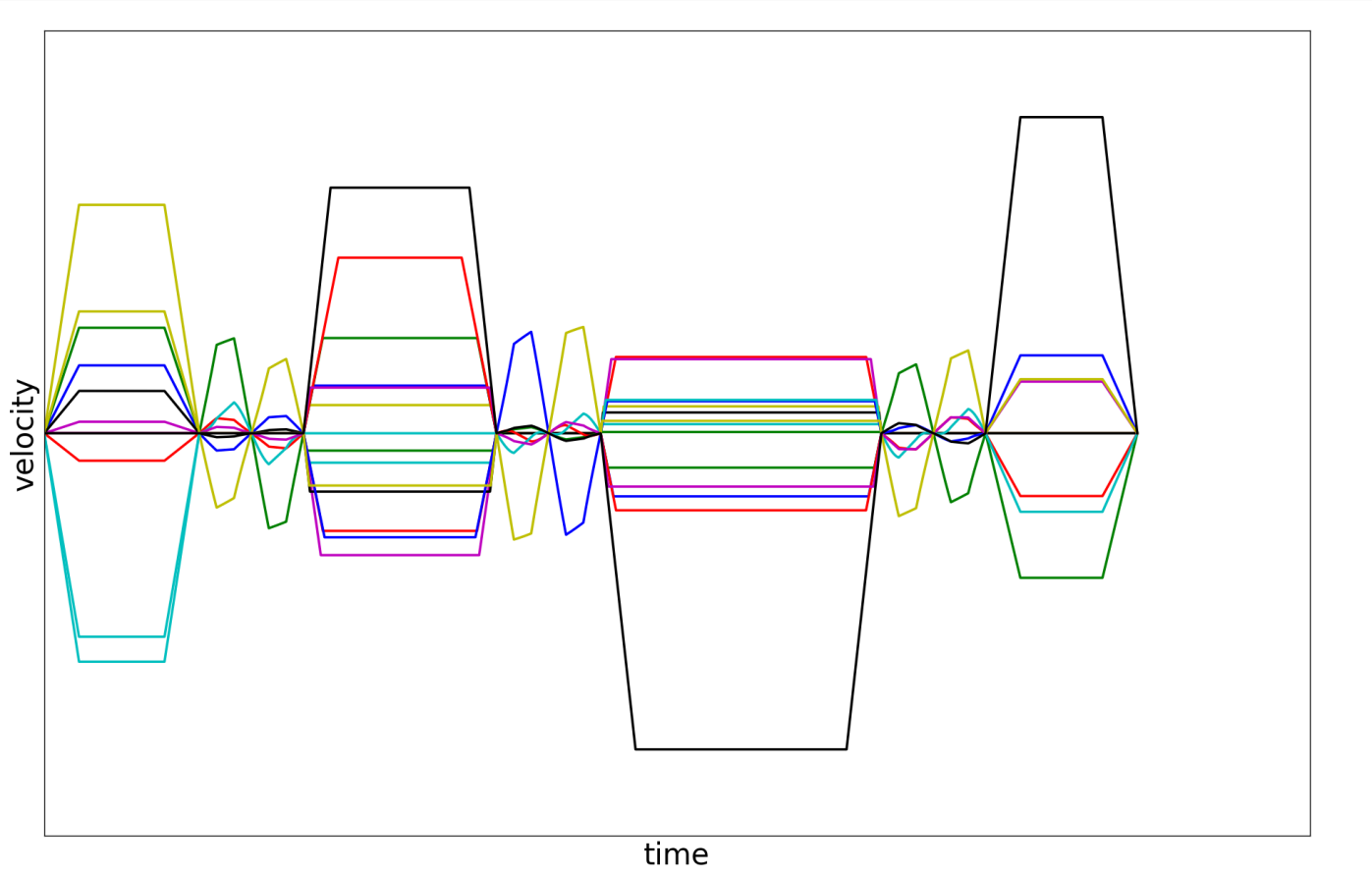
# Evaluation

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



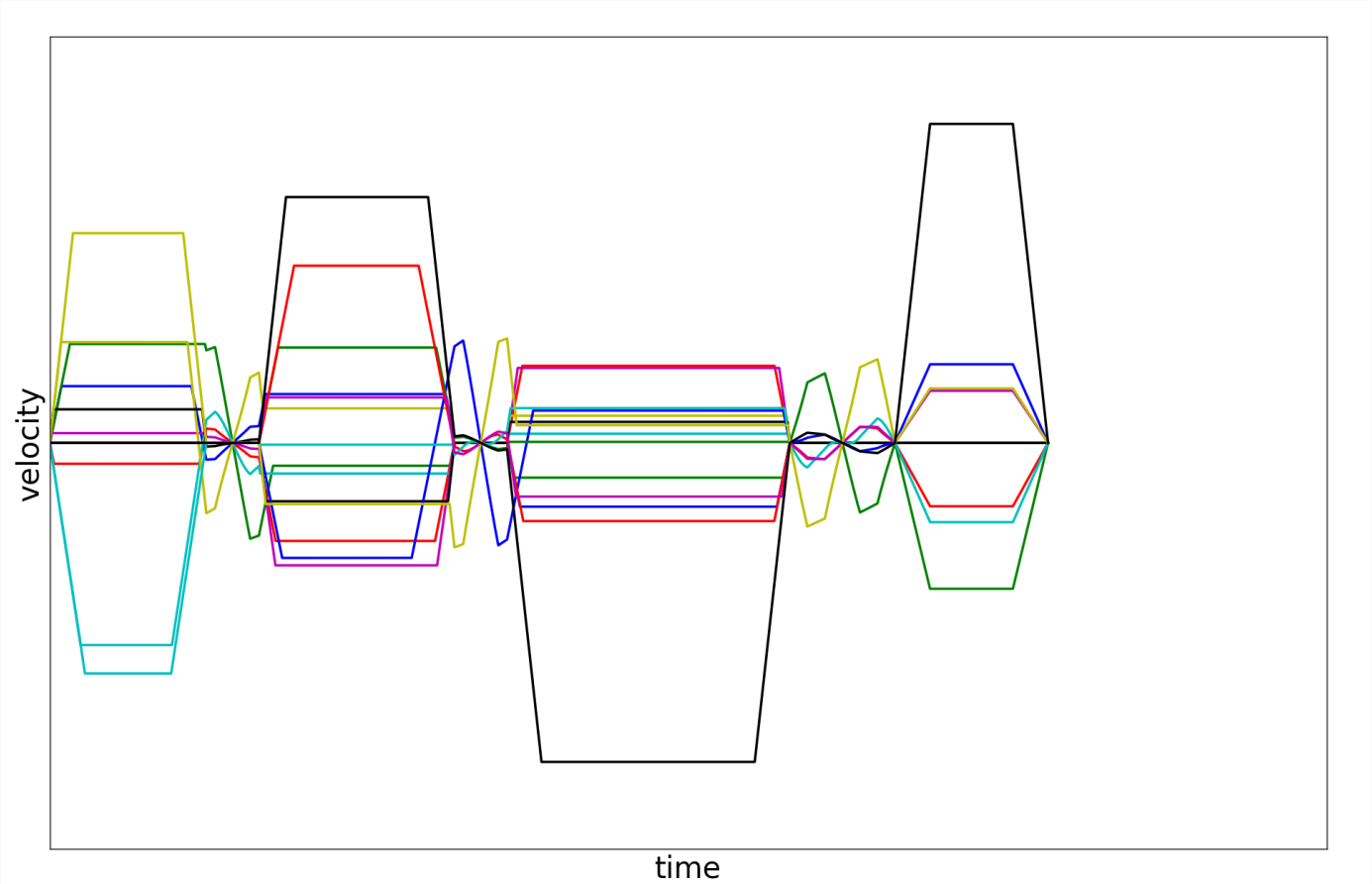
# Evaluation

... after Hauser's Shortcutting



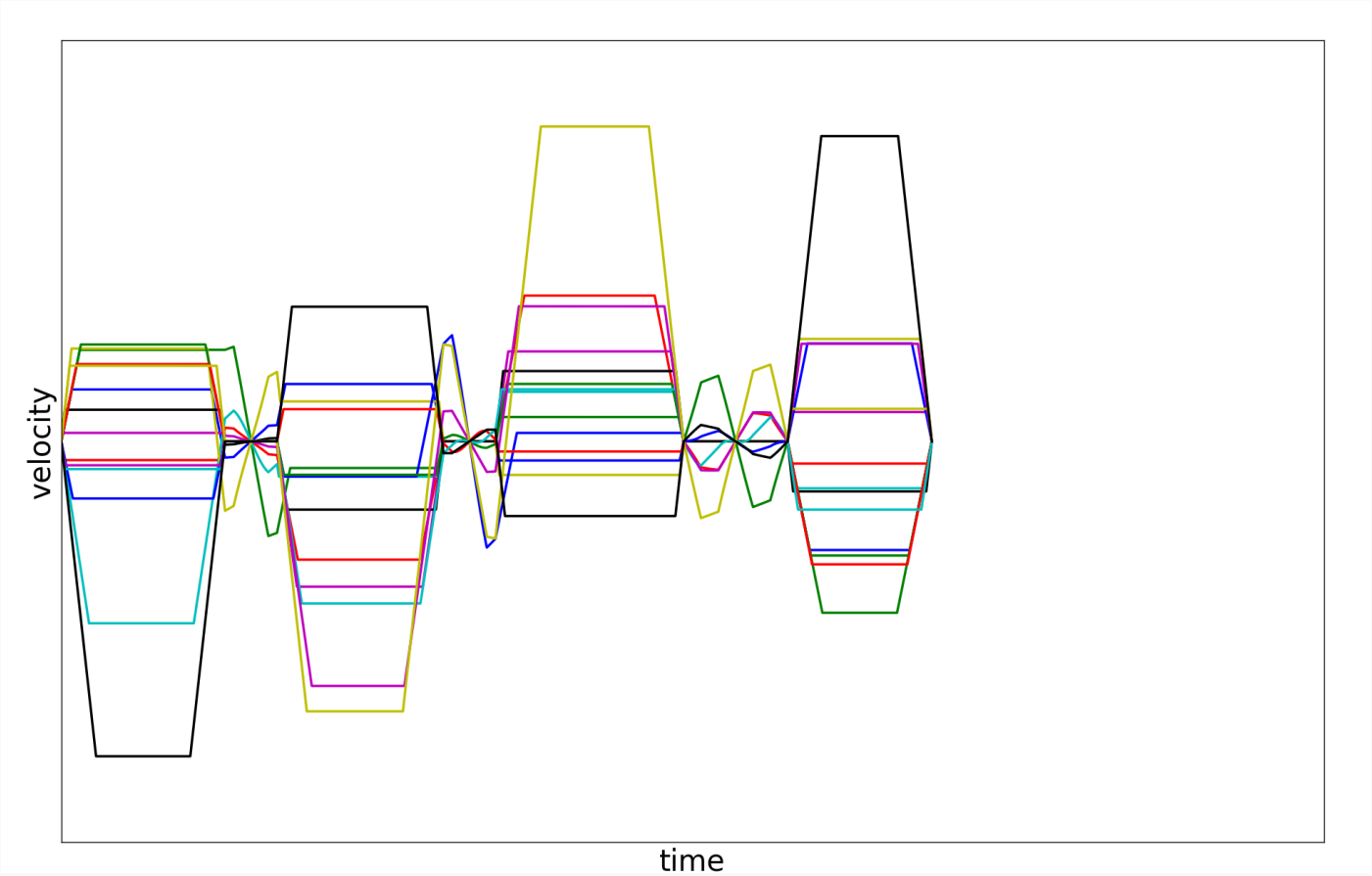
# Evaluation

... after Shortcutting + Smooth Interaction



# Evaluation

... after Transition Sampling



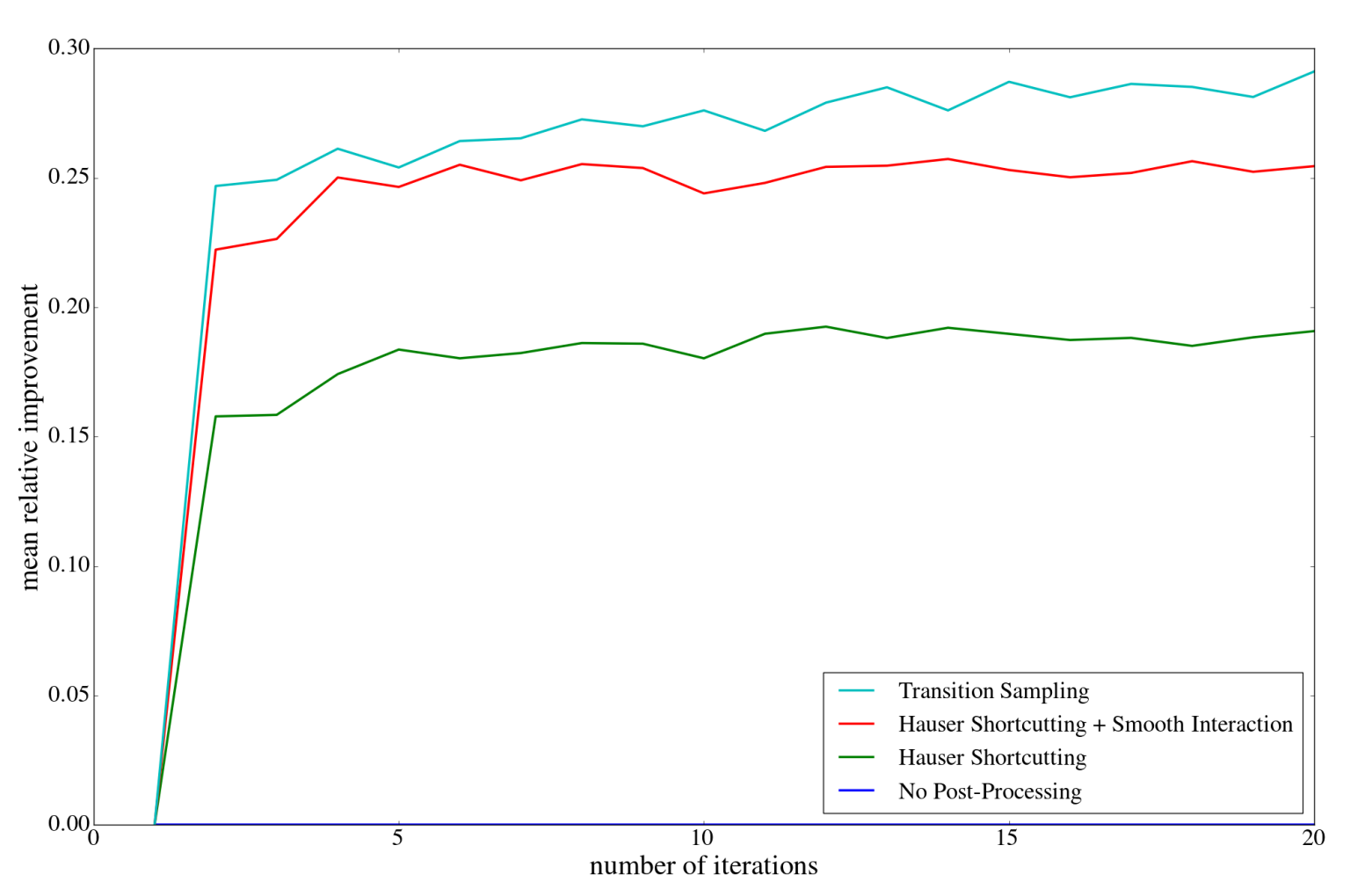
# Evaluation

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

# Evaluation

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

# 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

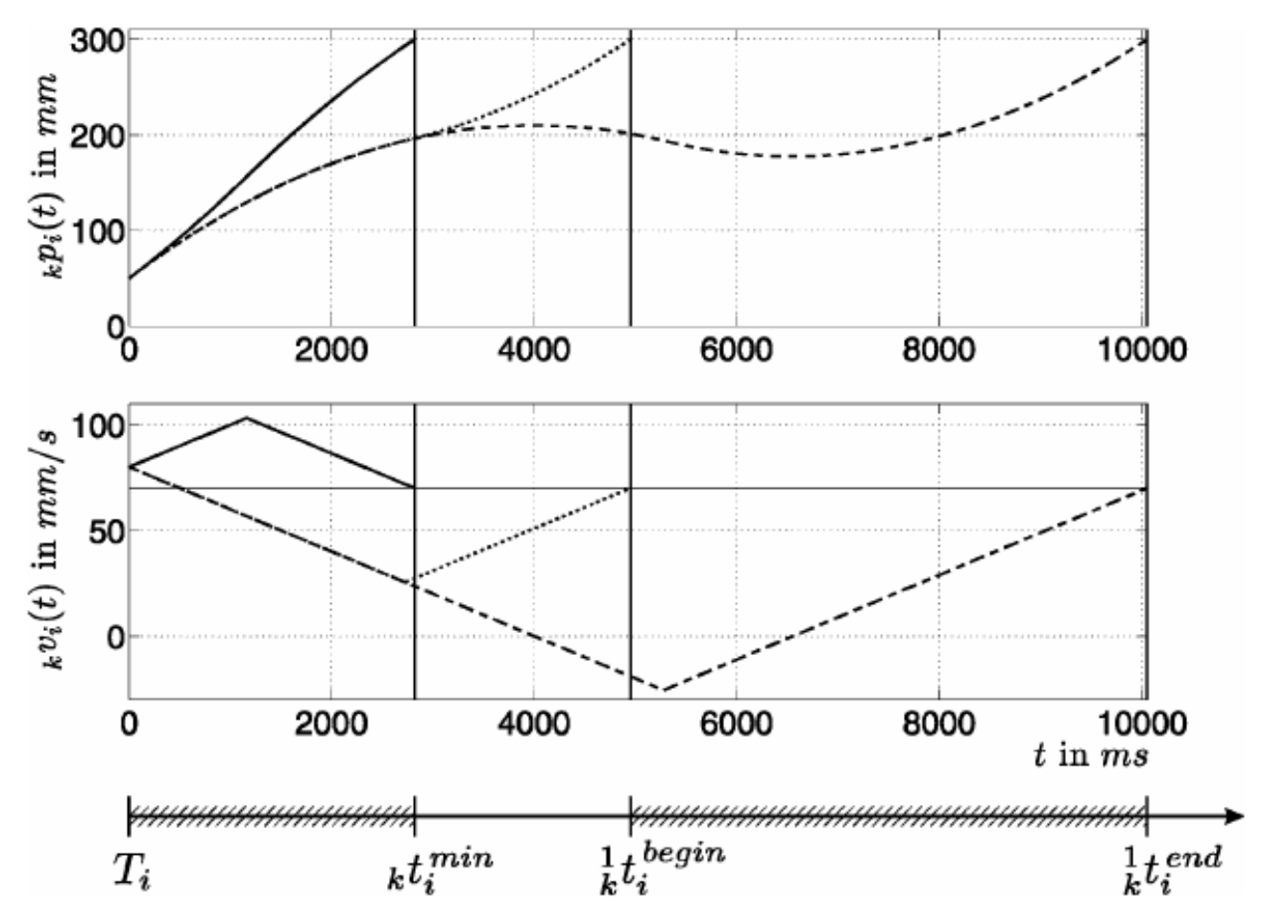
$\Rightarrow$ Time-optimal offline solutions

- Idea: Heuristic for informed search in sampling-based manipulation planner

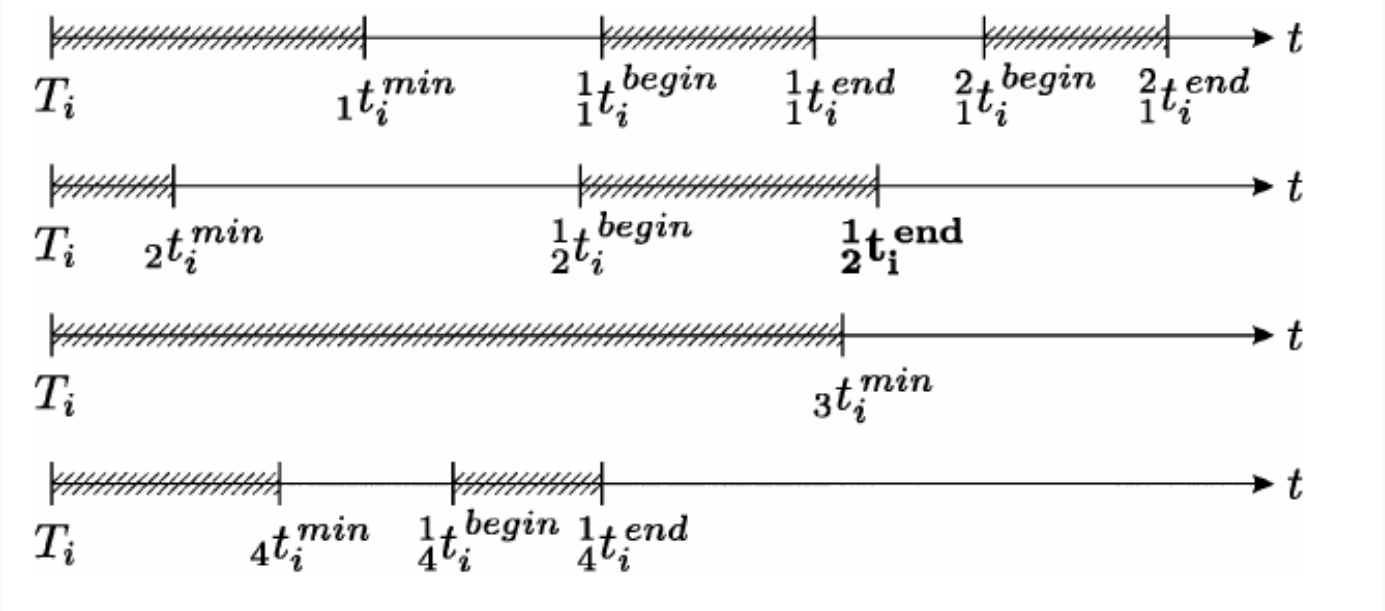
$\Rightarrow$ More effective sampling strategies

# Backup

# Synchronization not always possible



# Synchronization not always possible



# No Post-Processing

Plot

# Hauser's Shortcutting

Plot

# Shortcutting plus Smooth Interaction

Plot

# Sampling of New Transitions

Plot