Ready, Set, Plan! Planning to Goal Sets Using Generalized Bayesian Inference

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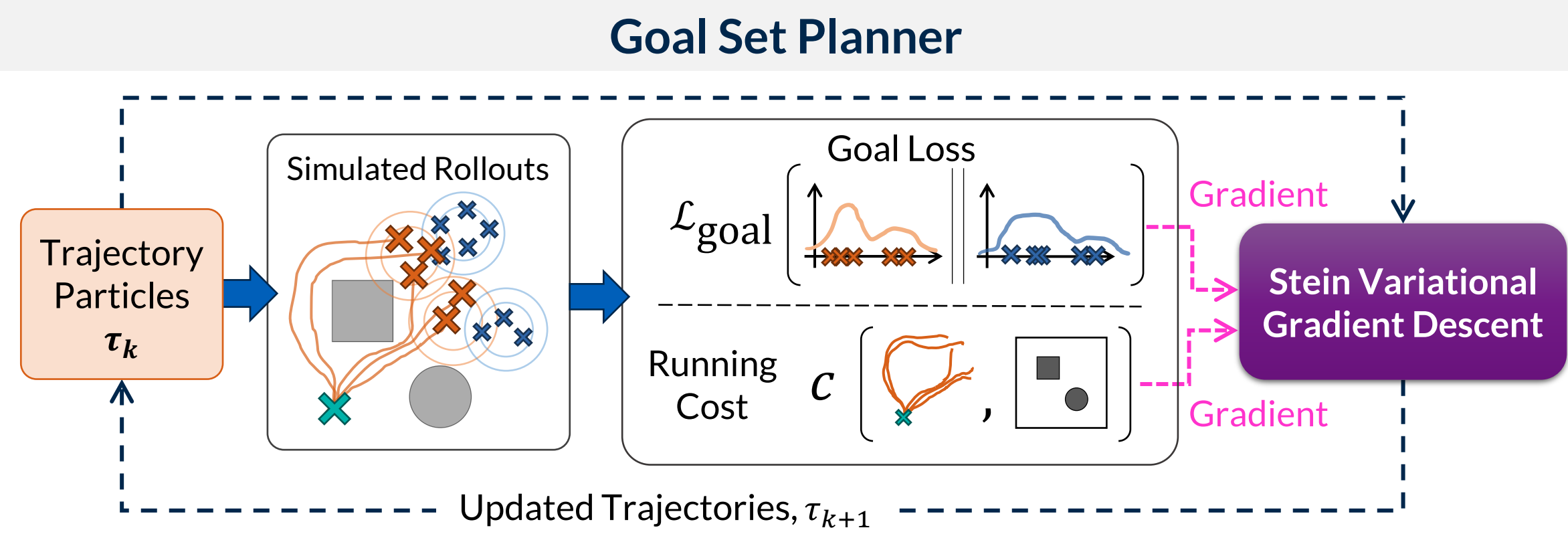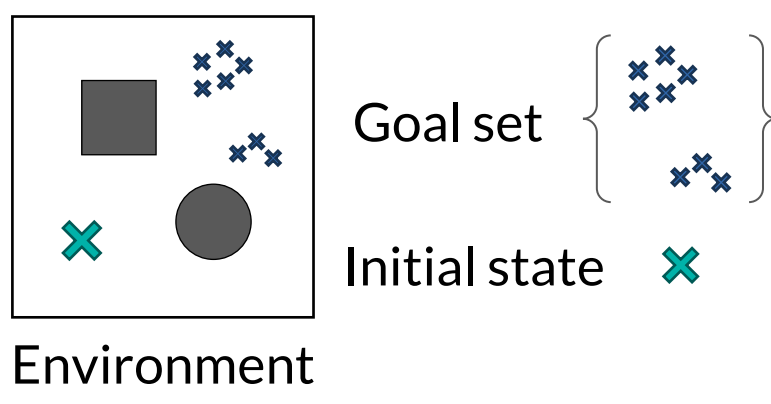
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Summary

Many robotic tasks have multiple and diverse solutions which can be naturally expressed as goal sets. However, some goals are intractable to model, leading to uncertainty over the goal. In this work, we propose a technique for planning directly to a set of sampled goal configurations using a fully differentiable cost which generalizes across a diverse range of objectives.

Approach

Input

Goal set

Initial state ✖

Environment
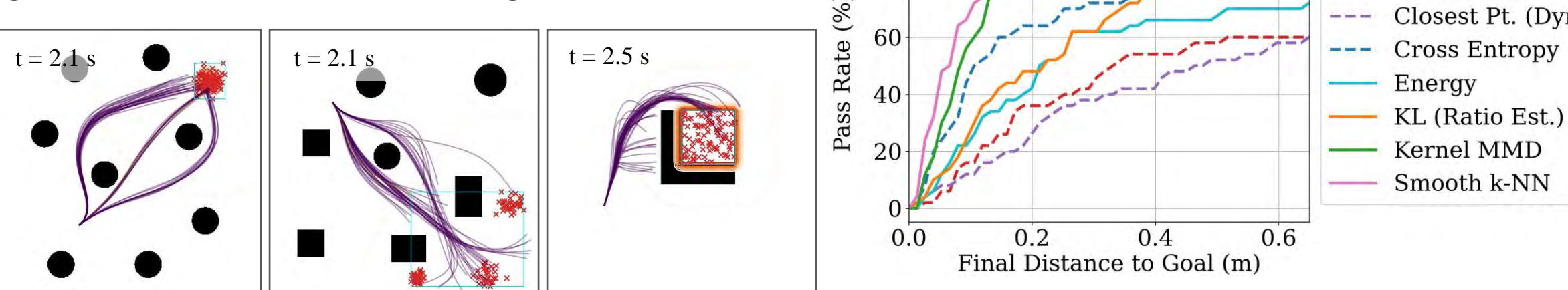
We take a planning as inference approach. **Stein Variational Inference** [1] enables us to formulate a differentiable goal loss over goal samples.

Generalized Bayesian Inference [2] enables the intractable goal likelihood to be approximated with a goal loss.

Goal Set Planner

Trajectory Particles τ_k

Simulated Rollouts

Goal Loss

$\mathcal{L}_{goal}$

Running Cost c

Gradient

Gradient

Stein Variational Gradient Descent

Updated Trajectories, τ_{k+1}

Results

Planar Navigation

We validate multiple possible differentiable goal losses on a planar navigation problem.

t = 2.1 s   t = 2.1 s   t = 2.5 s

- - - Closest Point
- - - Closest Pt. (Dyn.)
— Cross Entropy
— Energy
— KL (Ratio Est.)
— Kernel MMD
— Smooth k-NN

Grasping

Stable grasping is intractable to model, making data-driven approaches popular. We apply the goal set planner where the goal is stable grasp samples from simulation [3].
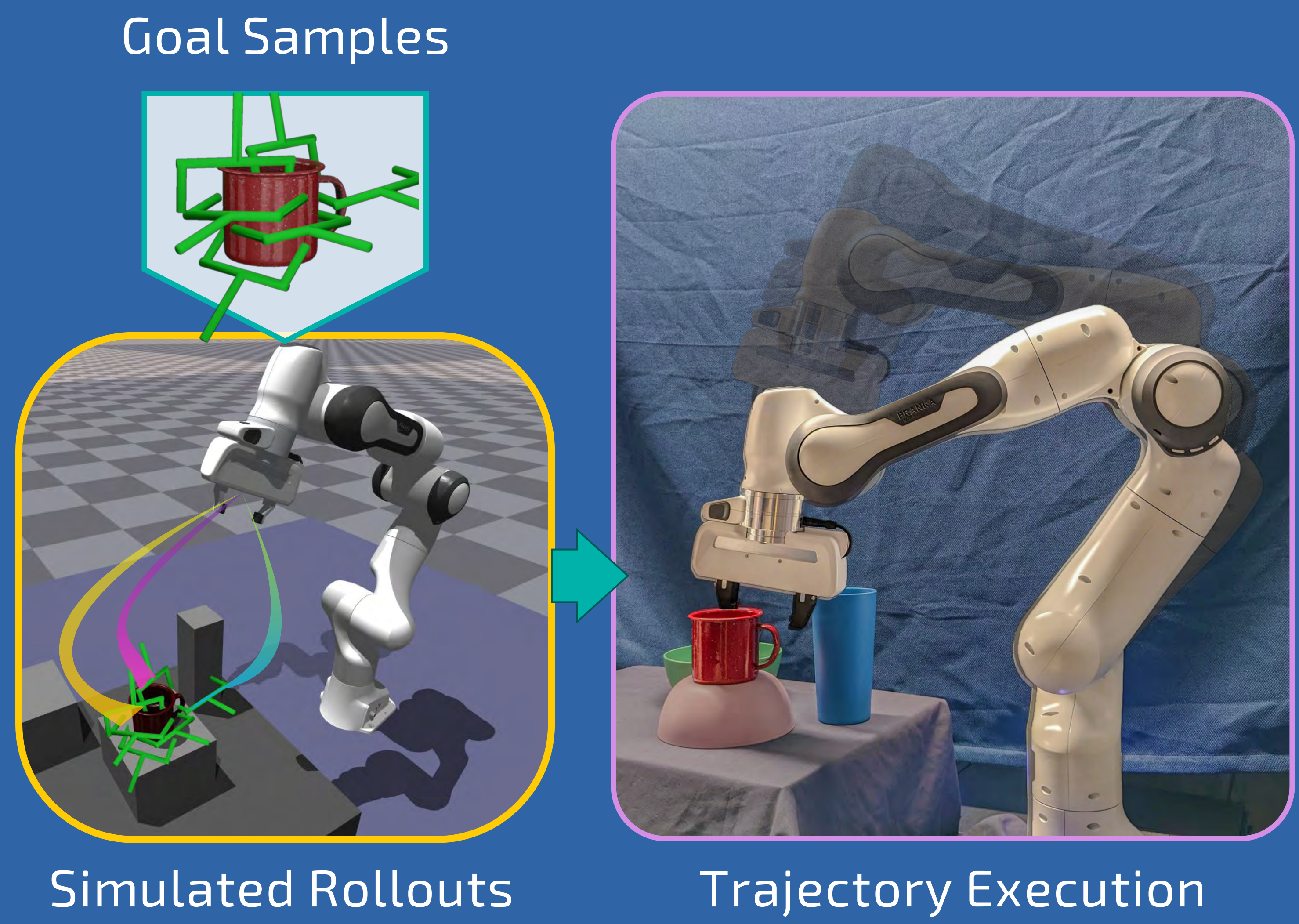
Placement

A table setting task demonstrates the applicability of the goal set planner when the goal is multi-modal.

- 🔴 Mug Positions
- ✕ Goal Samples
- ⬜ Tabletop
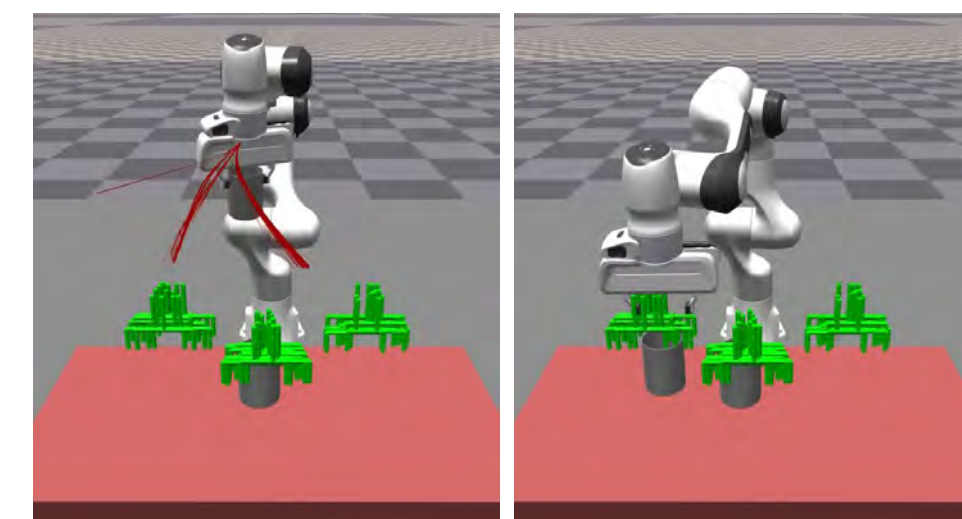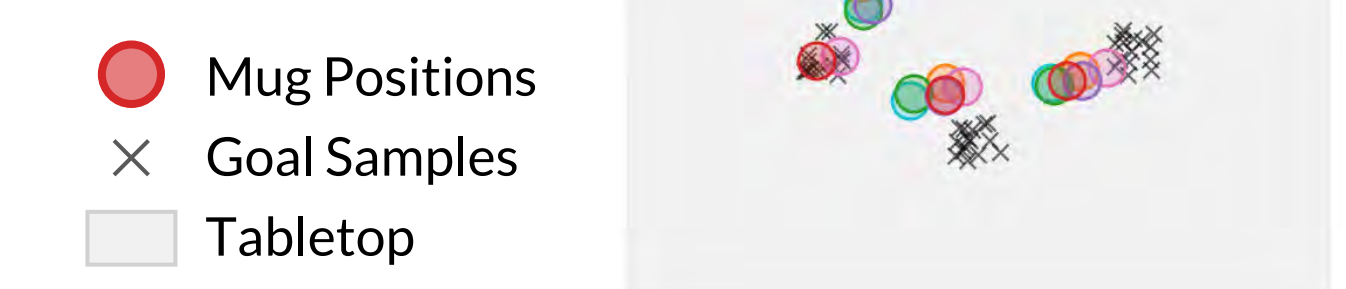
References

[1] Q. Liu and D. Wang, "Stein variational gradient descent: A general purpose Bayesian inference algorithm," NeurIPS, 2016.
[2] T. Matsubara, J. Knoblauch, F.-X. Briol, and C. J. Oates. Robust generalised Bayesian inference for intractable likelihoods. Journal of the Royal Statistical Society Series B: Statistical Methodology, 2022.
[3] C. Eppner, A. Mousavian, and D. Fox. ACRONYM: A large-scale grasp dataset based on simulation. ICRA, 2020.

We address planning to **goal regions** that are **intractable to model** by **planning to goal samples**.

Goal Samples

Simulated Rollouts

Trajectory Execution

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