NeuralSVCD for Efficient Swept Volume Collision Detection

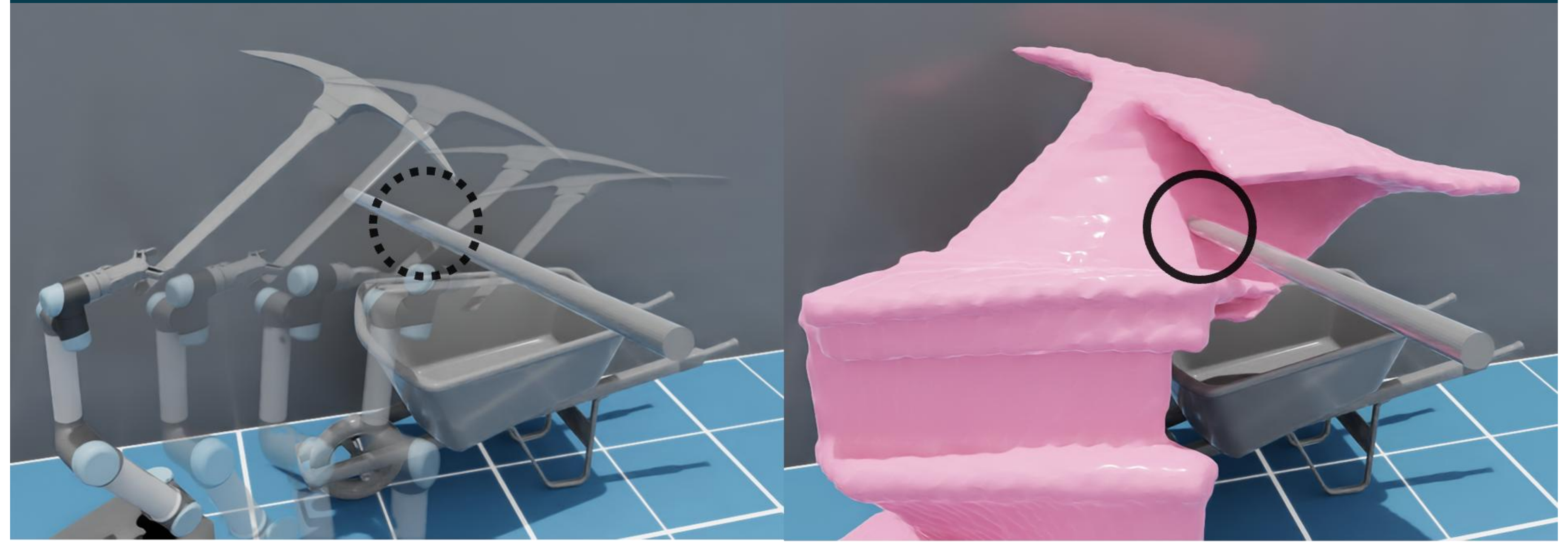
Project Page

Hojin Jung*, Dongwon Son *, Beomjoon Kim

Humanoid Generalization Lab

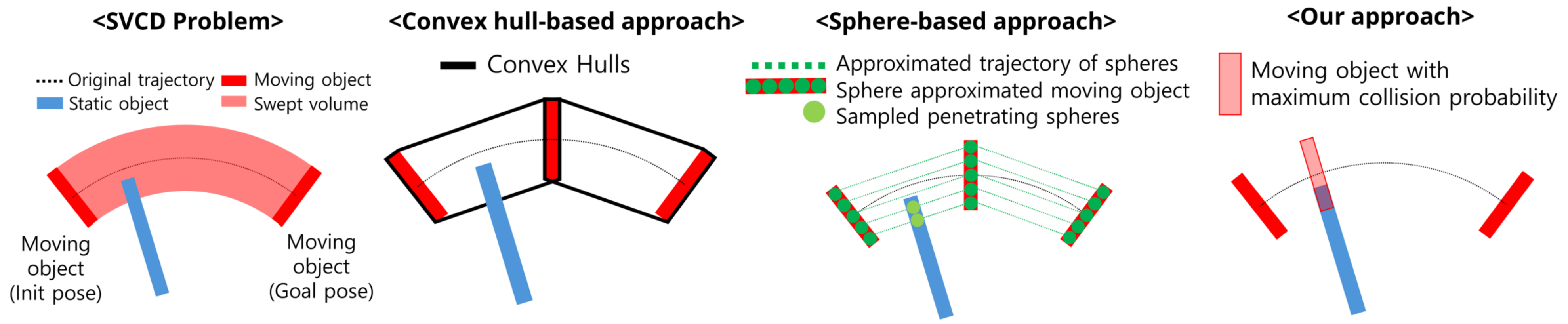
Graduate School of AI, KAIST

Problem (Why another collision detection method?)



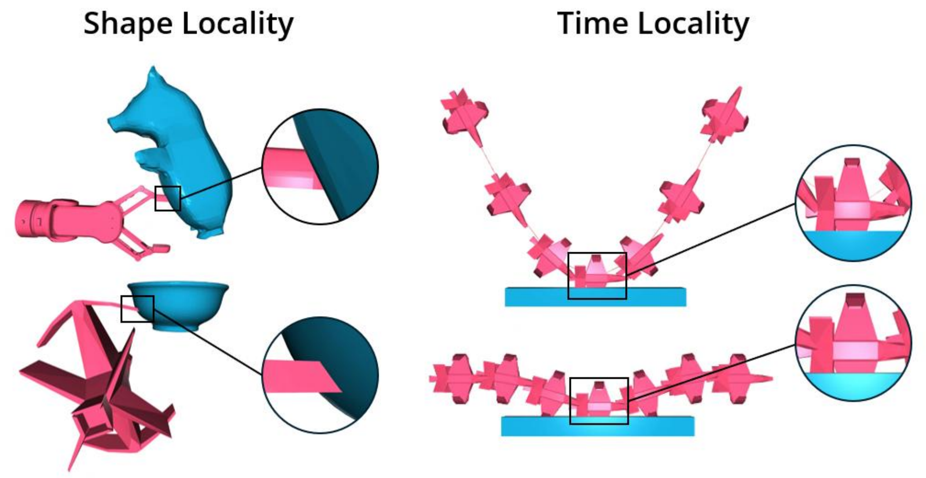
- Conventional collision detection assumes **fixed object pairs.**
- When applied to a moving object, **tunneling** occurs due to discretization.
- Instead, **SVCD (Swept Volume Collision Detection)** computes the swept volume of a moving object and run collision checking → avoids tunneling.

Related Work

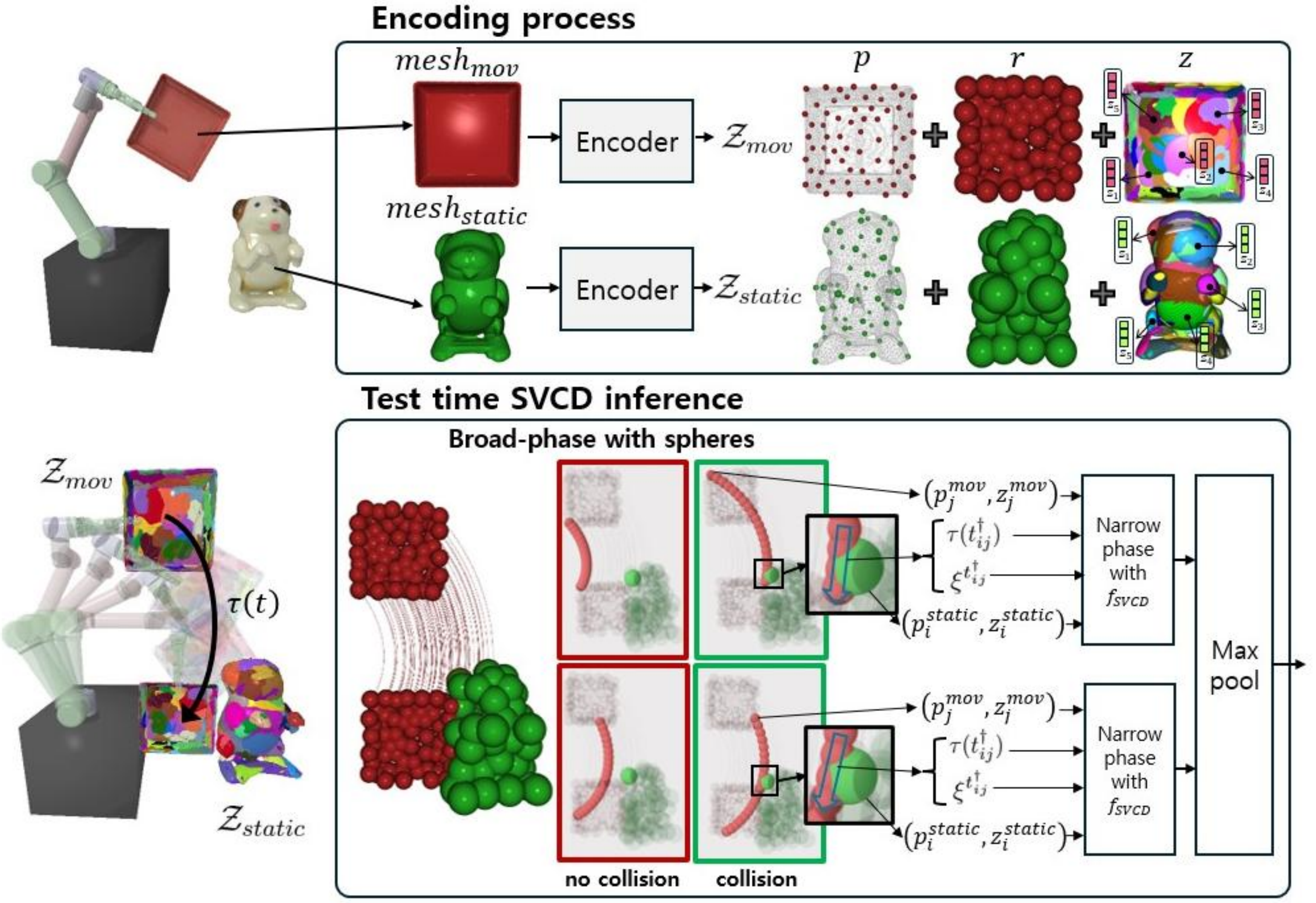


- Convex hull-based methods: branching computation of GJK makes it hard to fully utilize GPU → **inefficient.**
- Sphere-based methods: Can fully utilize GPU, but sacrifices accuracy since approximates mesh into spheres → **inaccurate.**

Method

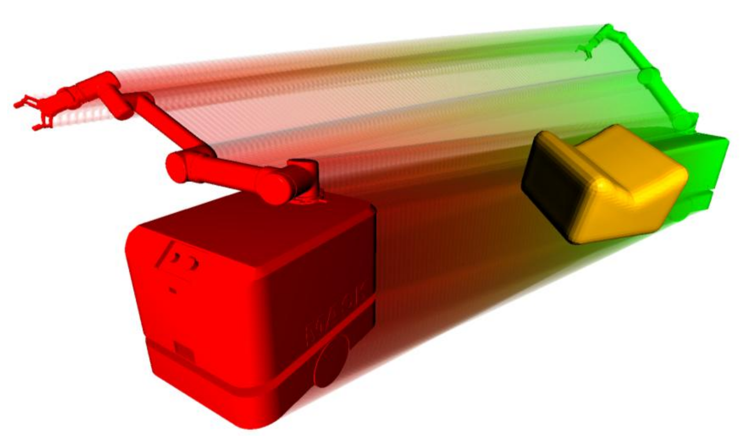


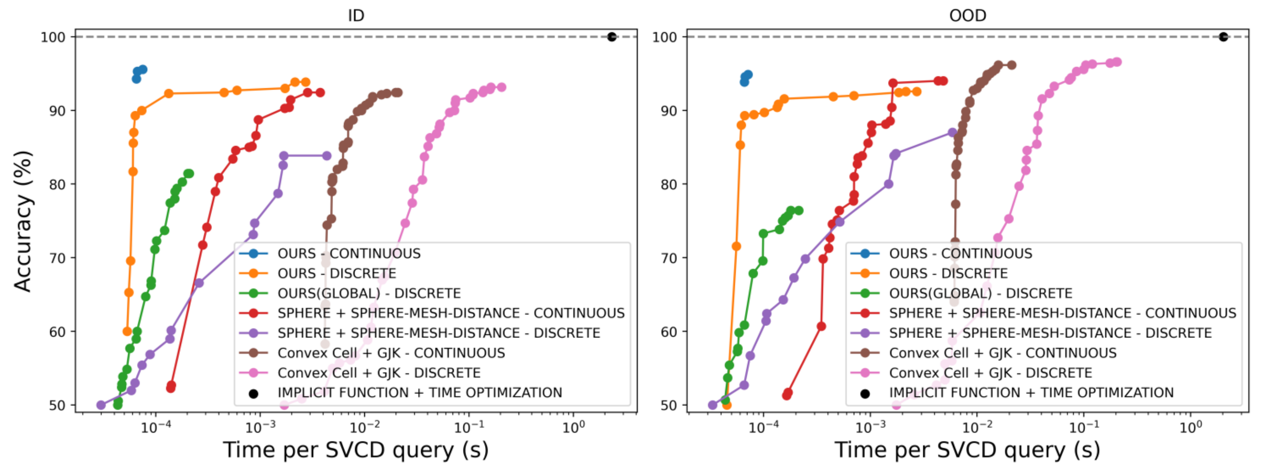
- **NeuralSVCD** is an encoder-decoder based neural network.
- Because 3d assets are limited, we exploit **shape & temporal locality** to improve the network's generalization.
- NeuralSVCD consists of three stages: 1) Encoding 2) Broad-phase 3) Narrow-phase.



Experiments

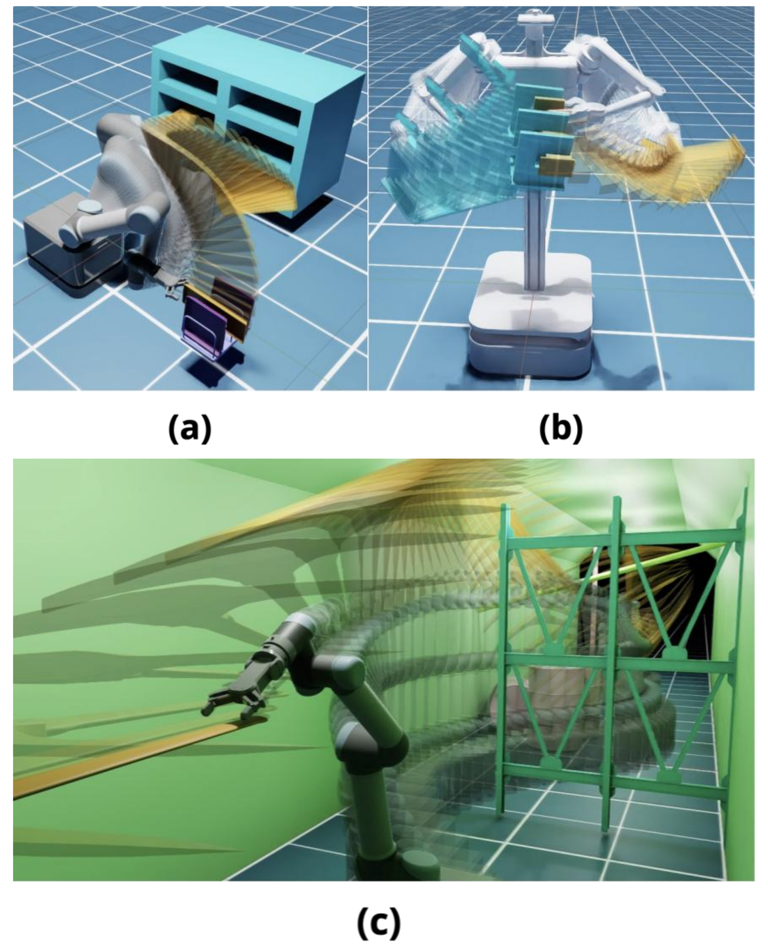
1. SVCD Benchmark

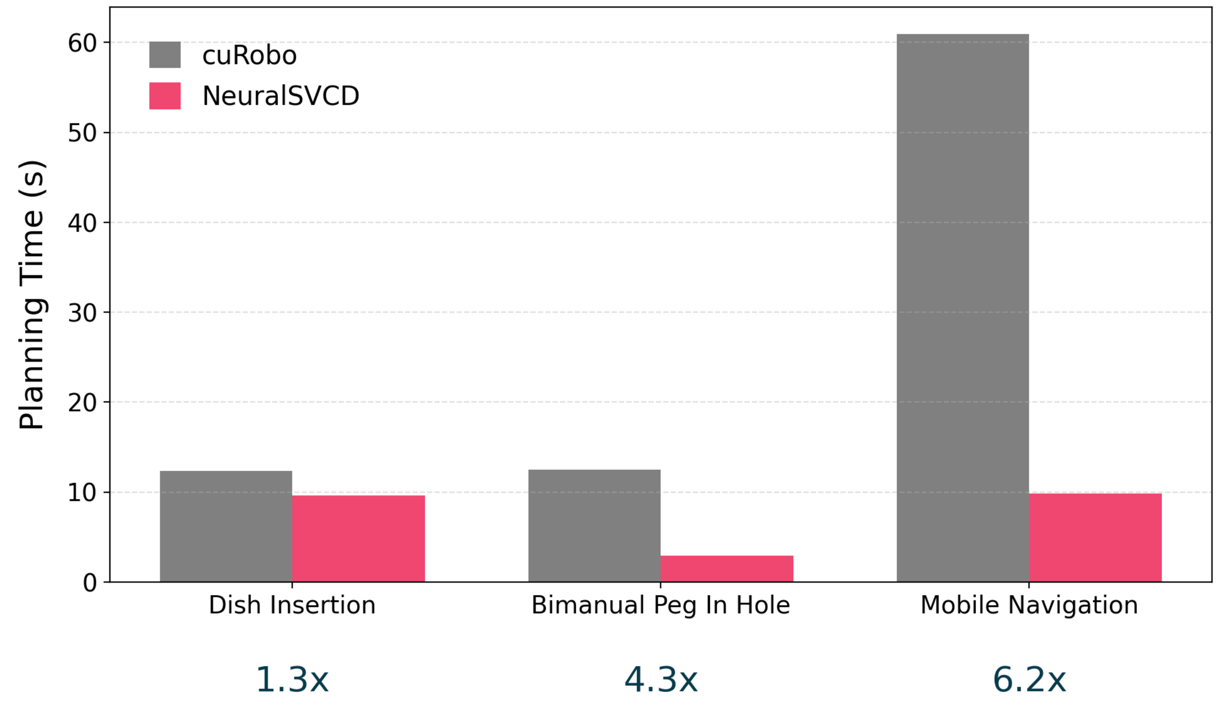




- At the same 90% accuracy, NeuralSVCD is **120x faster** than convex-cell/GJK and **24x faster** than sphere-mesh methods.
- Shows **strong out-of-distribution (OOD) generalization**.

2. Motion planning experiment





State of the art trajectory optimizer, 6x faster than cuRobo!