High Performance Computational Motion

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Introduction

- ✓Founded in 1886
- ✓World’s largest female-only college
- ✓First female-only college offering engineering program
- ✓Ranked 1st among Korean universities in 2014 Leiden ranking

Ewha Womans University

Female-only students

- ✓16K undergrad
- ✓6K grad
- ✓1K faculty members
- ✓9 colleges and 16 grad schools

Ewha Womans University

Graphics Lab at Ewha

Faculty, Postdoc 1
Ph.D. 2, MS/Ph.D. 3, M.S. 2
Intern 1, Staff 1

Computational Motion

- Spatial reasoning
- Physically-based animation

  (more on this later by Yun-hyeong)
- Robot motion planning

  (more on this later by Youngeun)

High Performance

- Real-time constraints
- Complicated problems
- Parallel processing

  (more on this later by SeongKi)

Spatial Reasoning

- Collision Detection
- Penetration Depth

(more on this later by Yeojin)

- Distance Calculation
- Distance Fields
- Swept Volume

Cont. Collision Detection

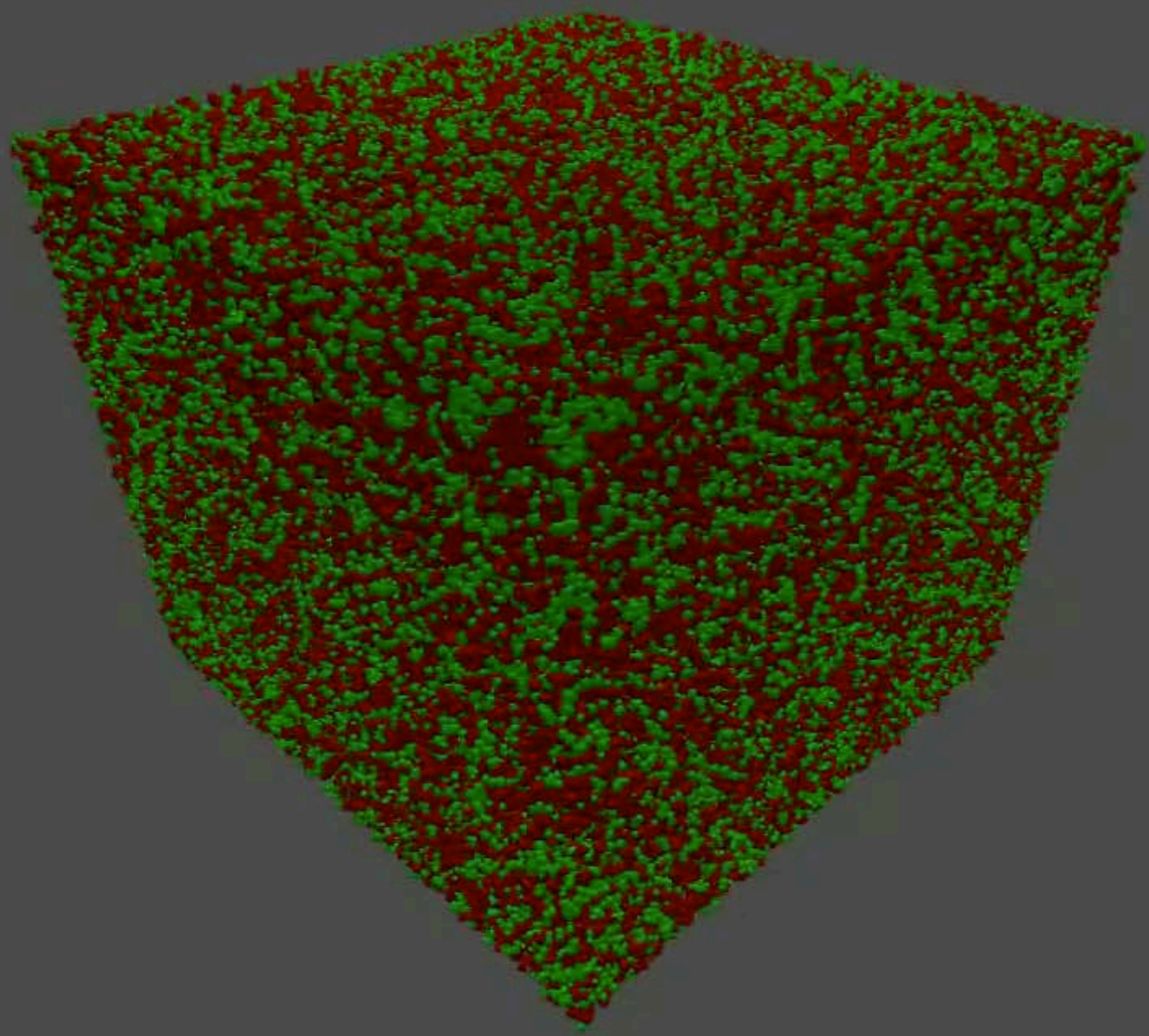
140K Triangles, 110 FPS

68K Triangles, 186 FPS

Articulated Models

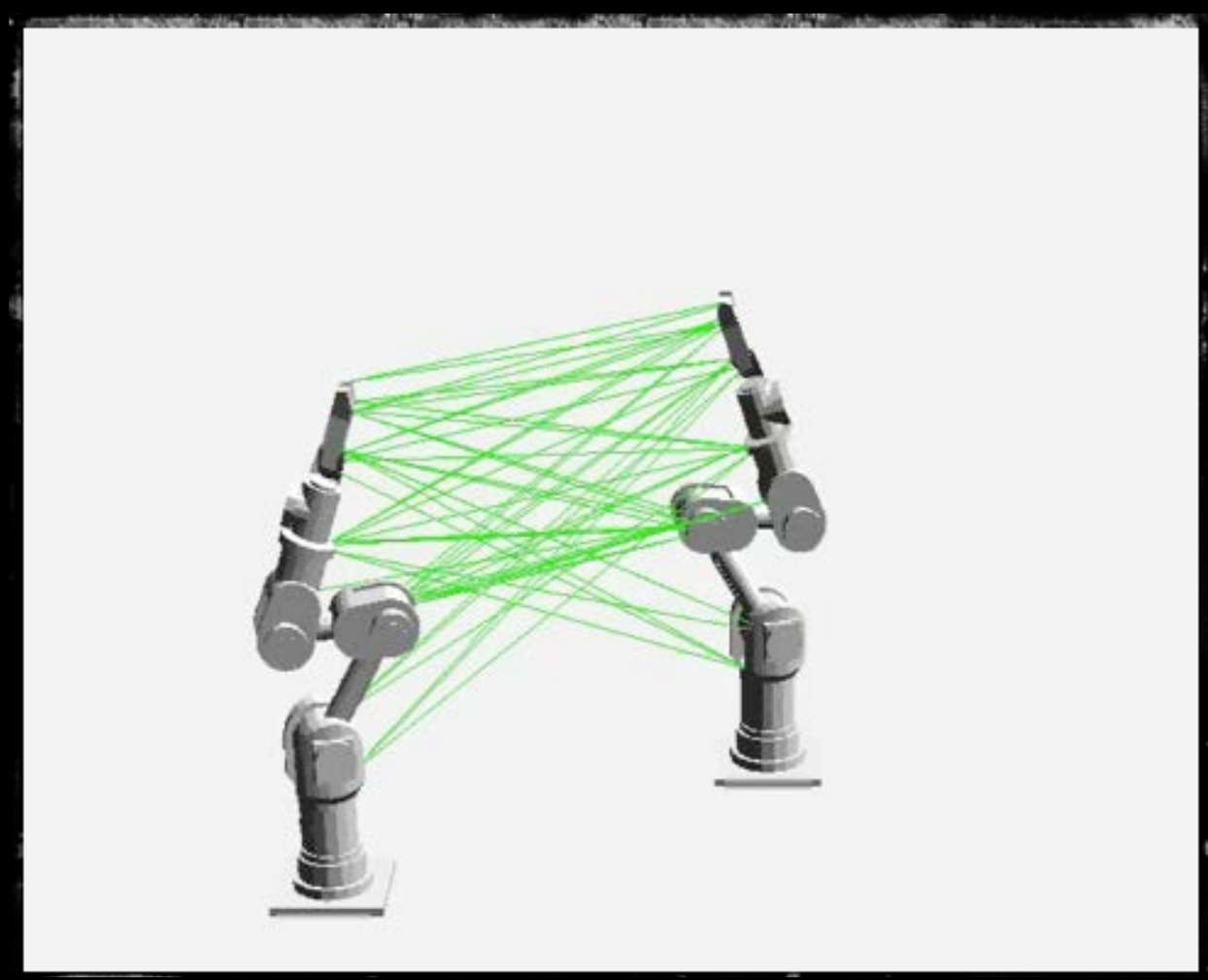
131K Triangles, 1.22ms

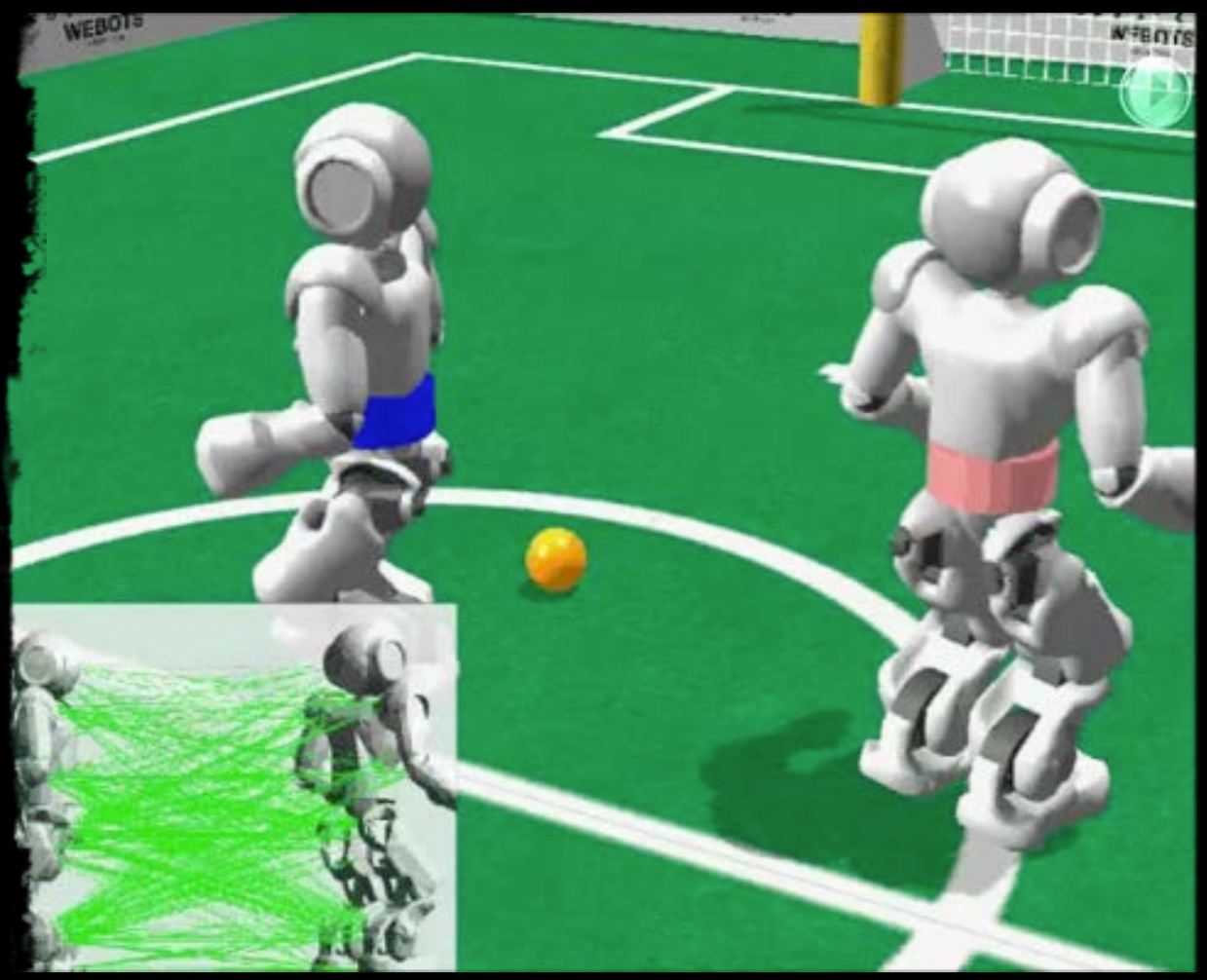
0.9M Triangles, 535 ms



Massive Bodies on GPUs

k-IOS for Proximity Query





Simple and Parallel Proximity Algorithm

Distance Computation

Collision Detection

Scalable Collision Detection on CPU and GPU

Benchmarking Scenarios

We apply our parallel collision detection algorithms to each benchmark and measure their scalability by varying the number of cores and changing the hardware platform on CPUs and GPUs

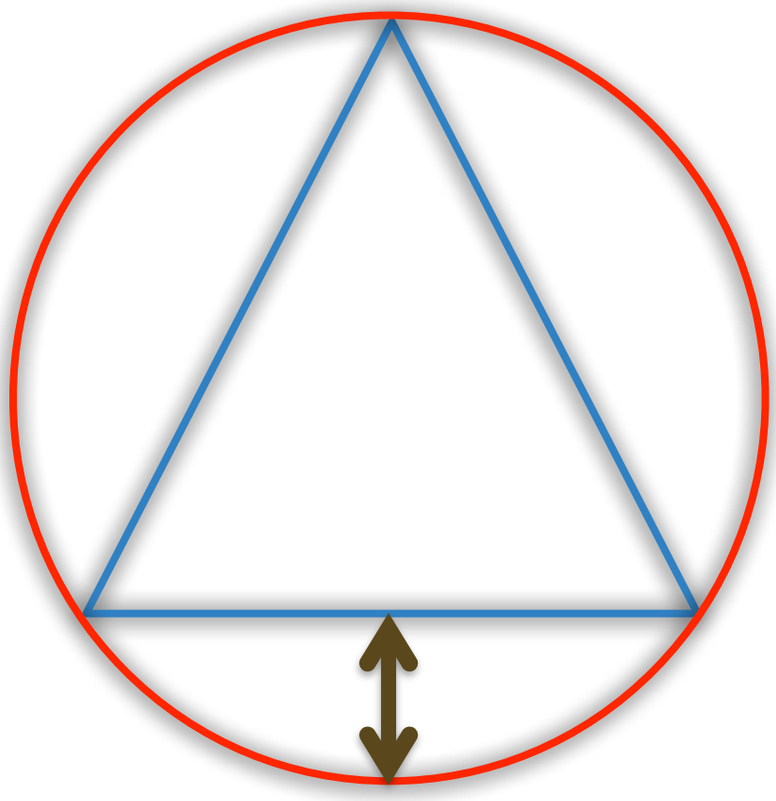
Out-of-Core Proximity Computation for Particle-based Fluid Simulation

Results

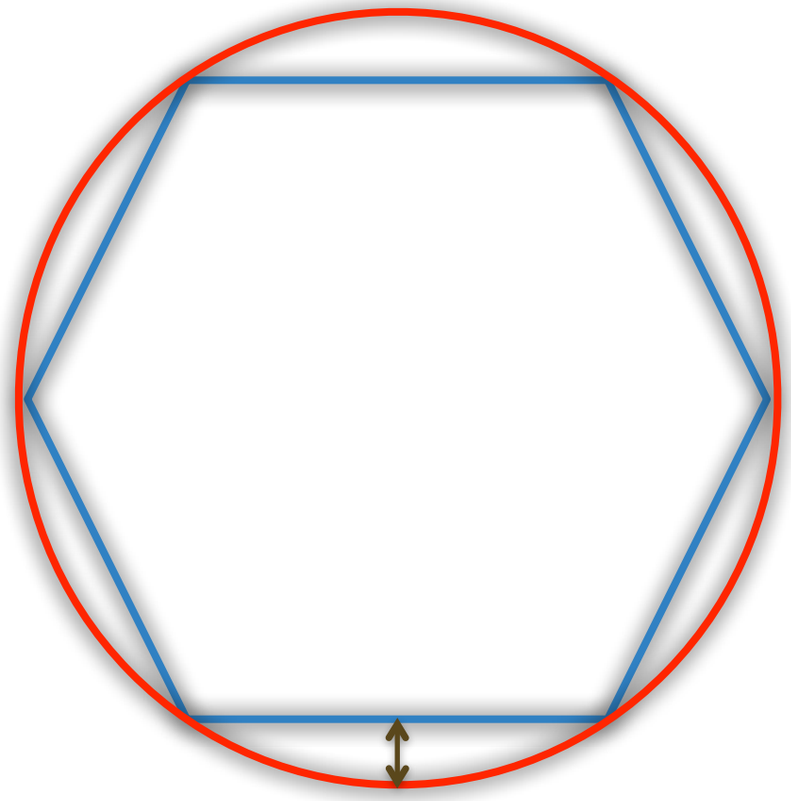
- **Test machine configuration**
  - **Two hexa-core Intel CPUs and a GPU (Geforce GTX780, 3GB video memory)**

Shape Deviation Measure

- Hausdorff distance quantifies deviation between two geometric models

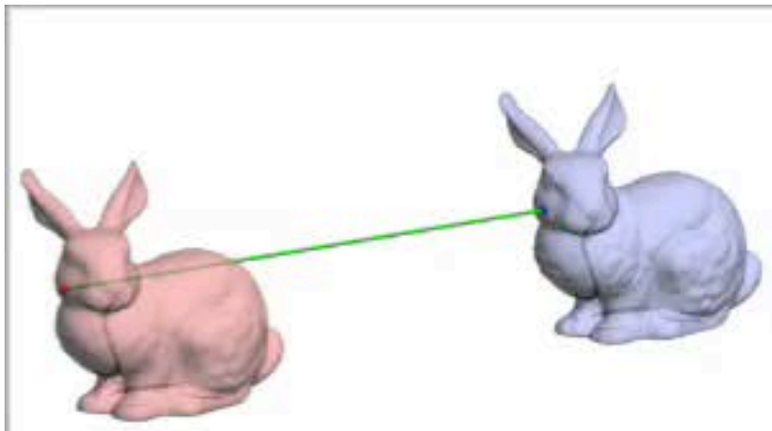


Large Hausdorff Distance Value

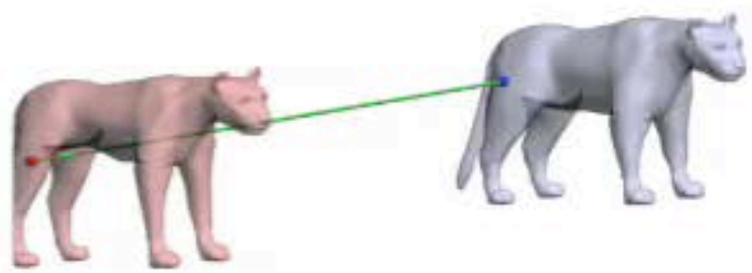


Small Hausdorff Distance Value

Hausdorff Distance Computation

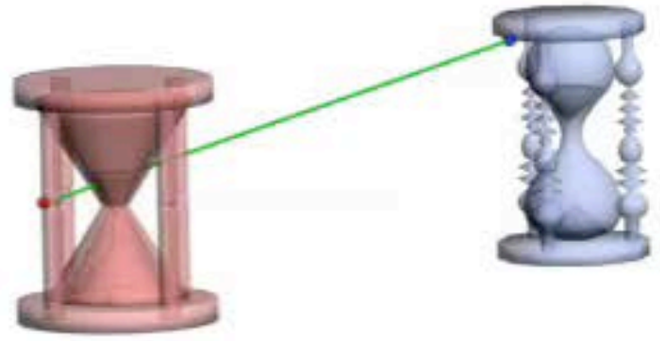


21.95 msec



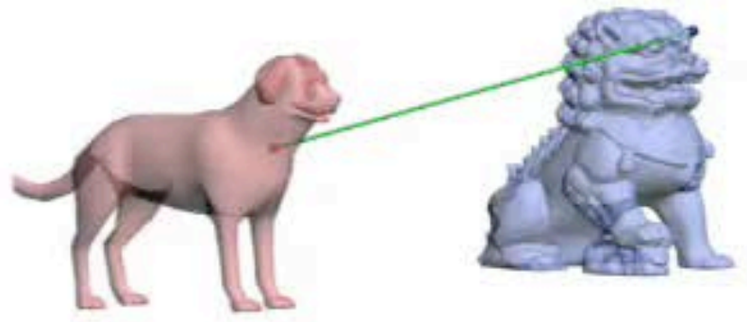
6.10 msec

2.57 msec



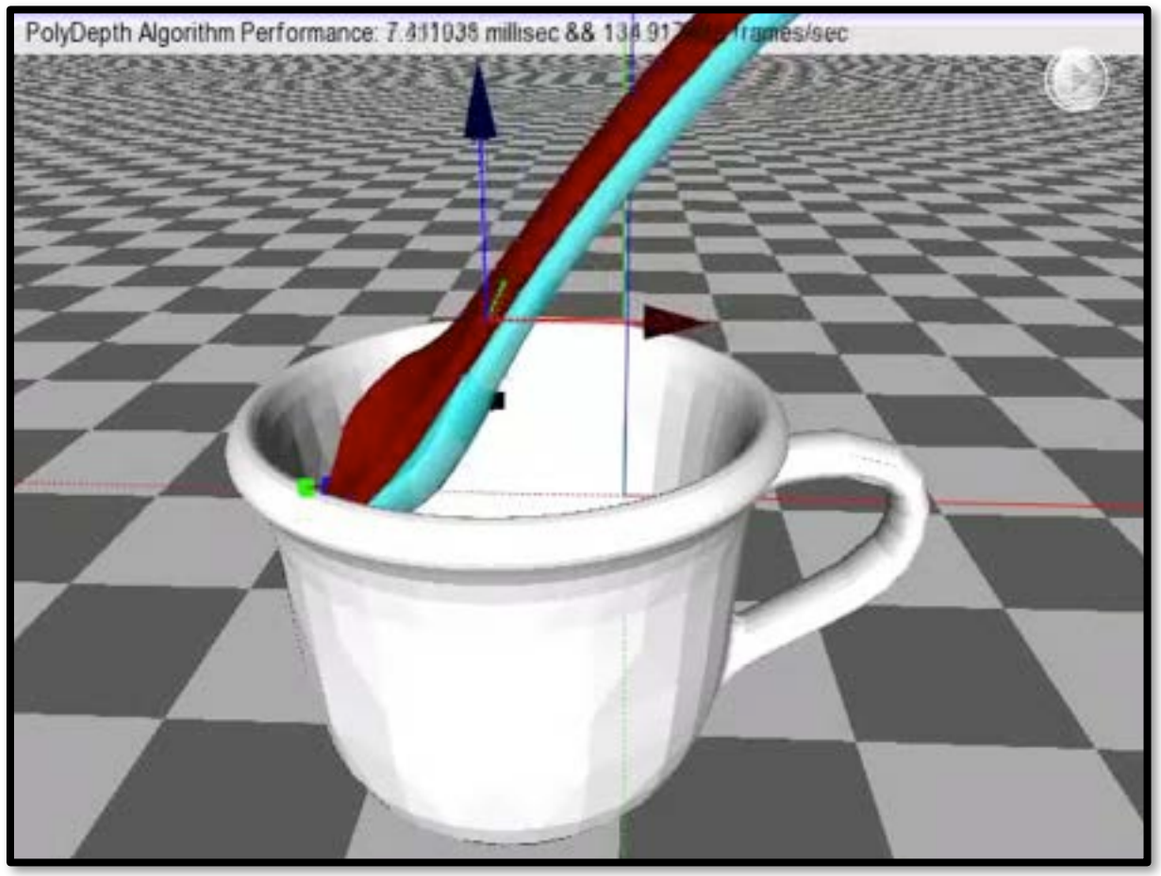
6.92 msec

18.77 msec



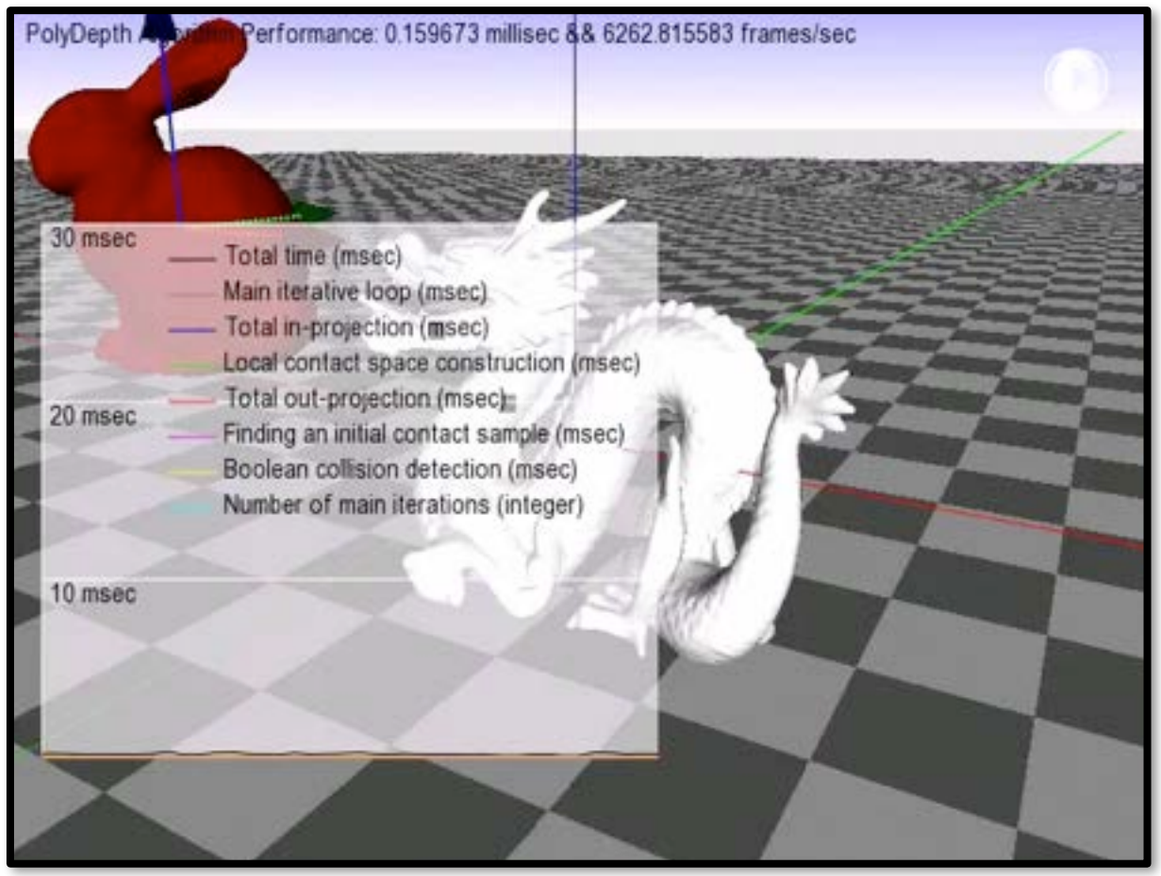
84.31 msec

Penetration Depth



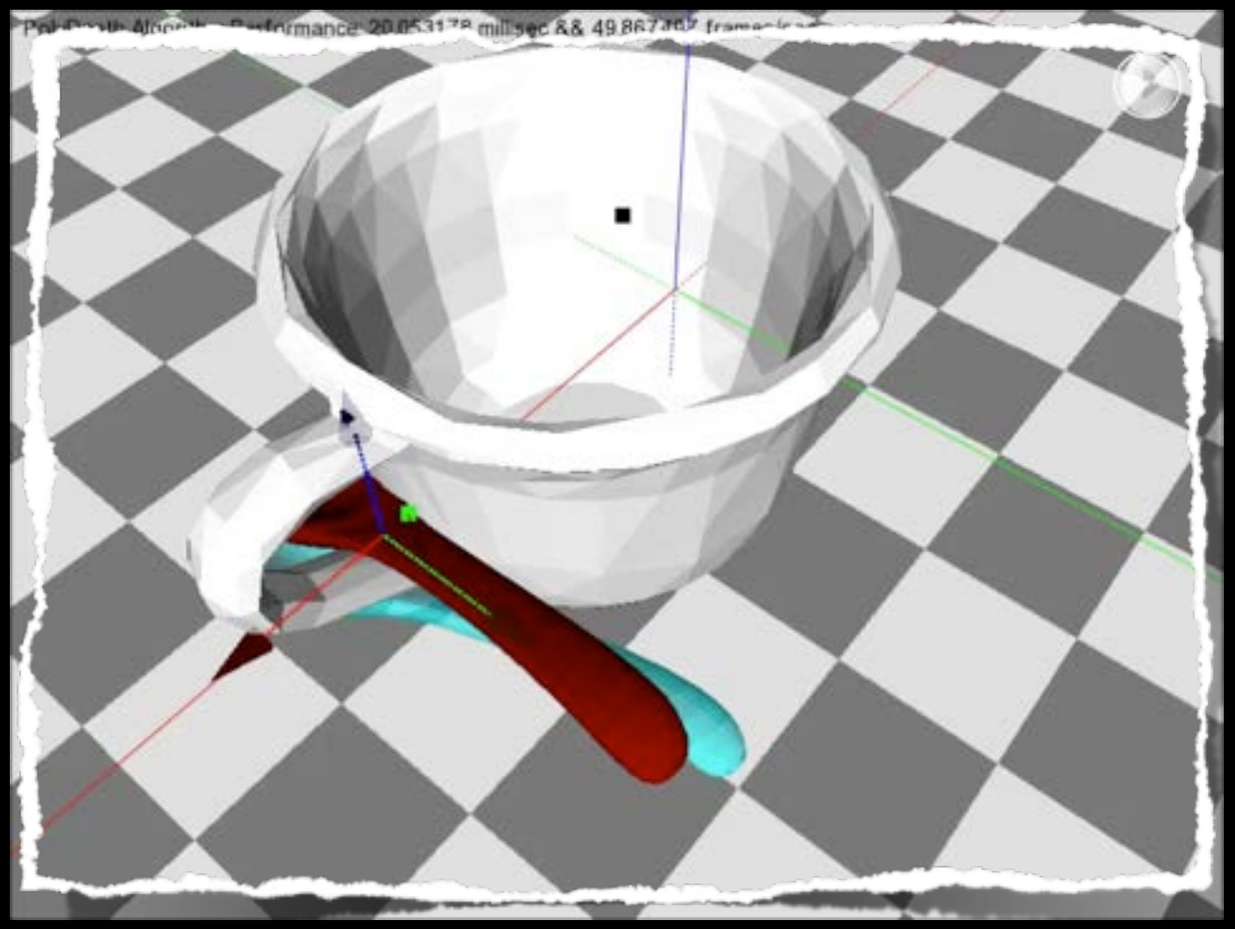
- Spoon: 1.3K triangles
- Cup: 8.4K triangles
- Time: 1~7 msec

Penetration Depth

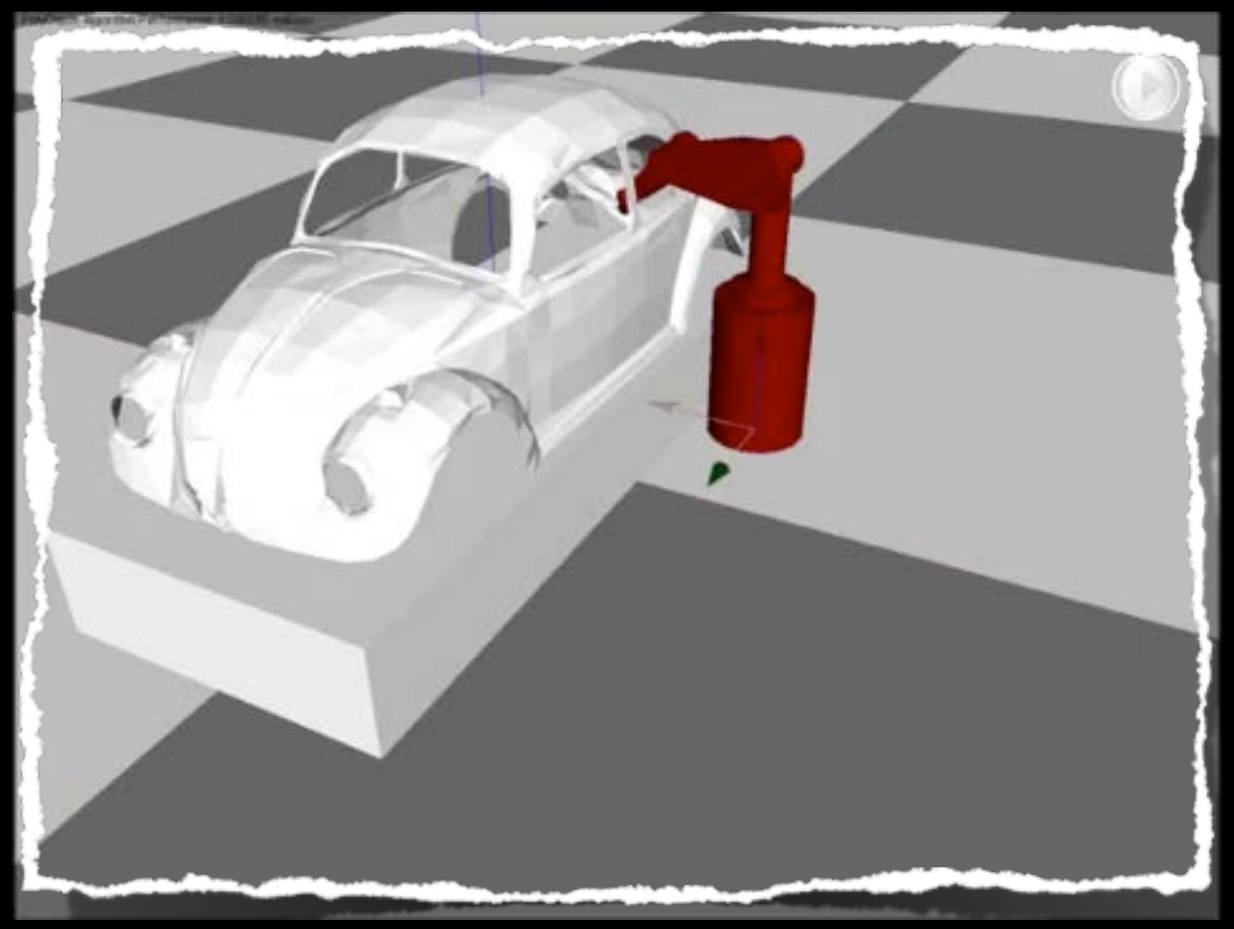


- Bunny: 40K triangles
- Dragon: 174K triangles
- Time: 2~15 msec

Generalized Penetration Depth

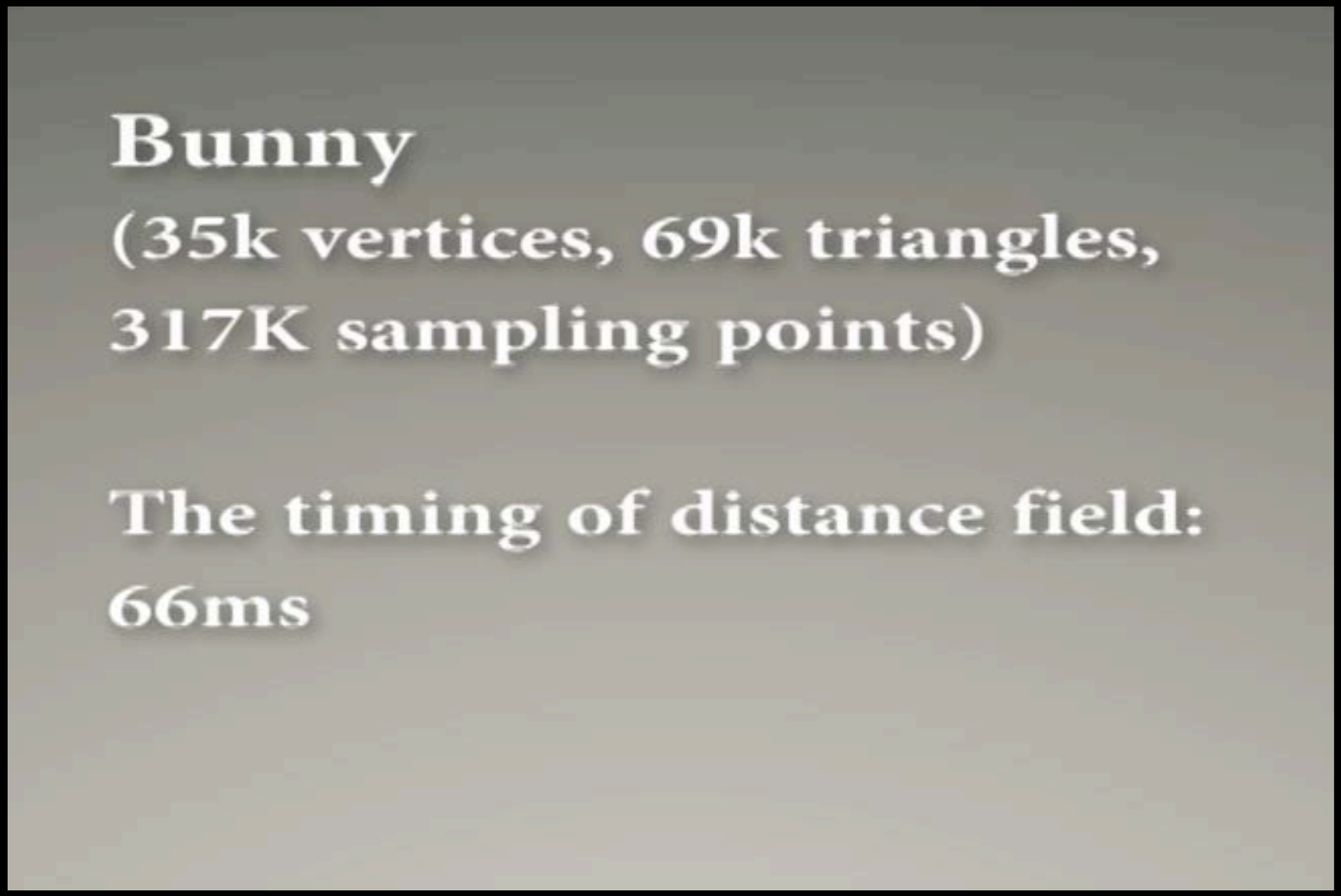


Rigid



Articulated

Distance Fields



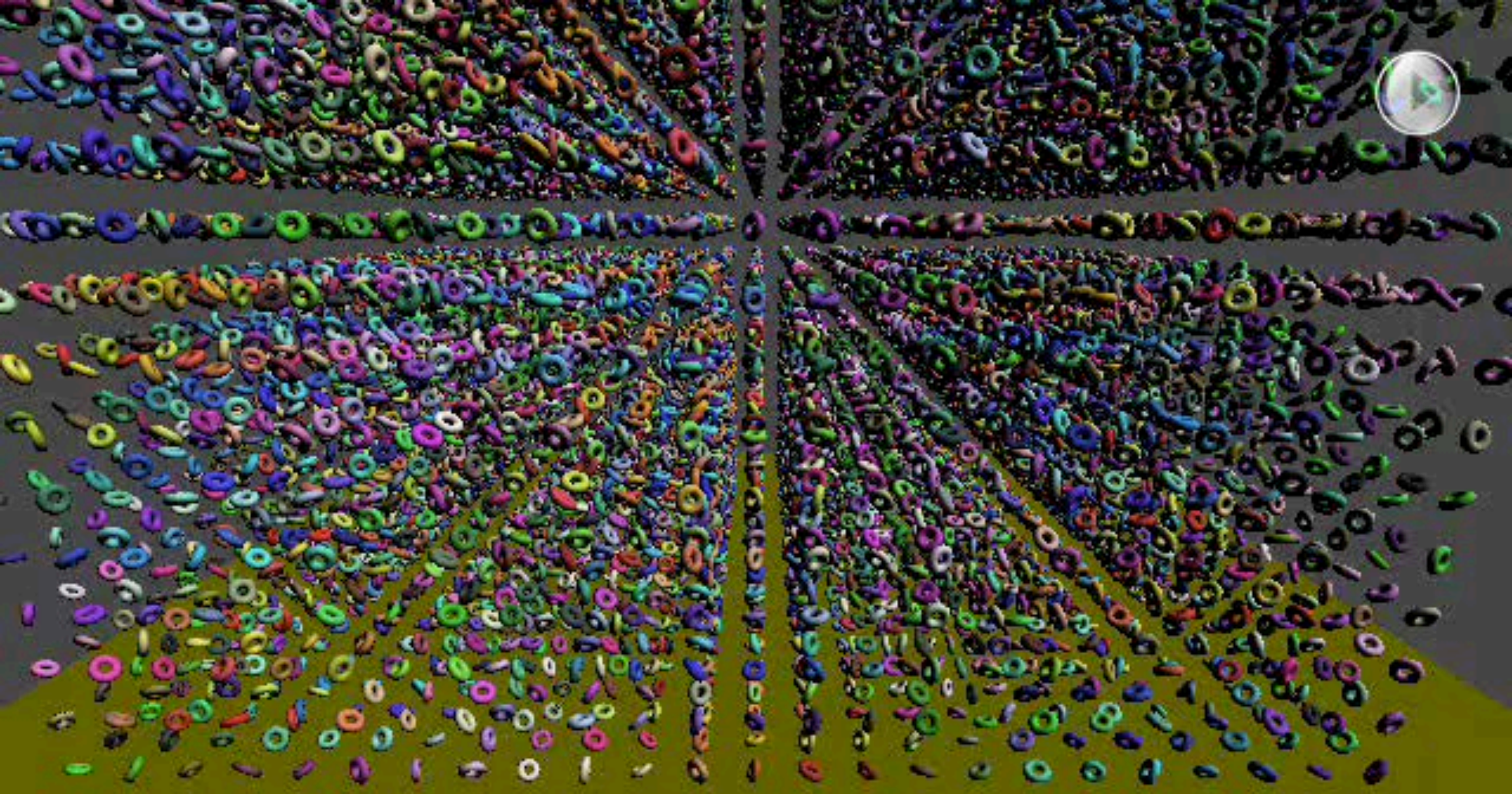
Swept Volume

Solid Modeling

A swept volume is created when
a polyhedral model sweeps in space.

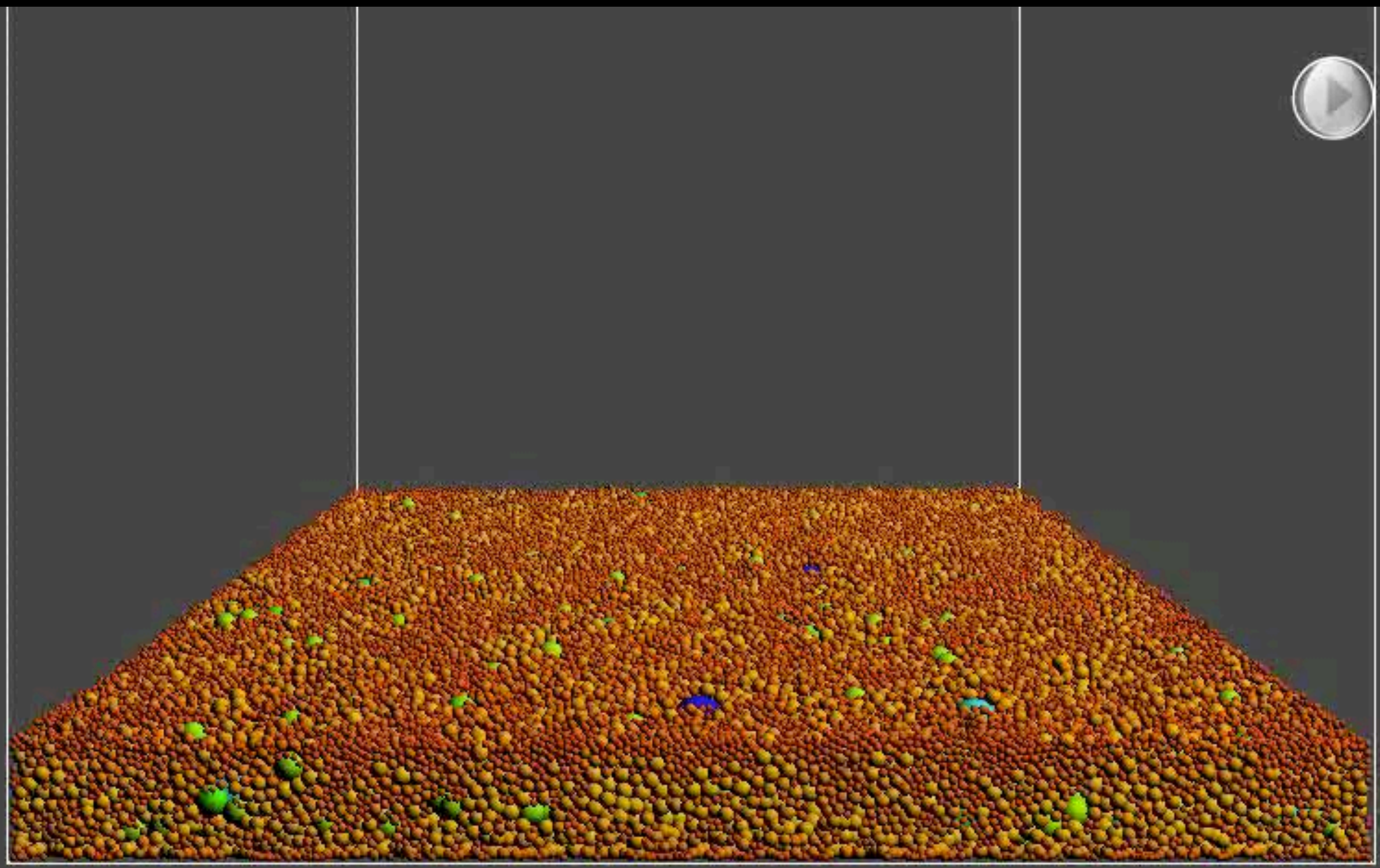
Physically-based Animation

VirtualPhysics

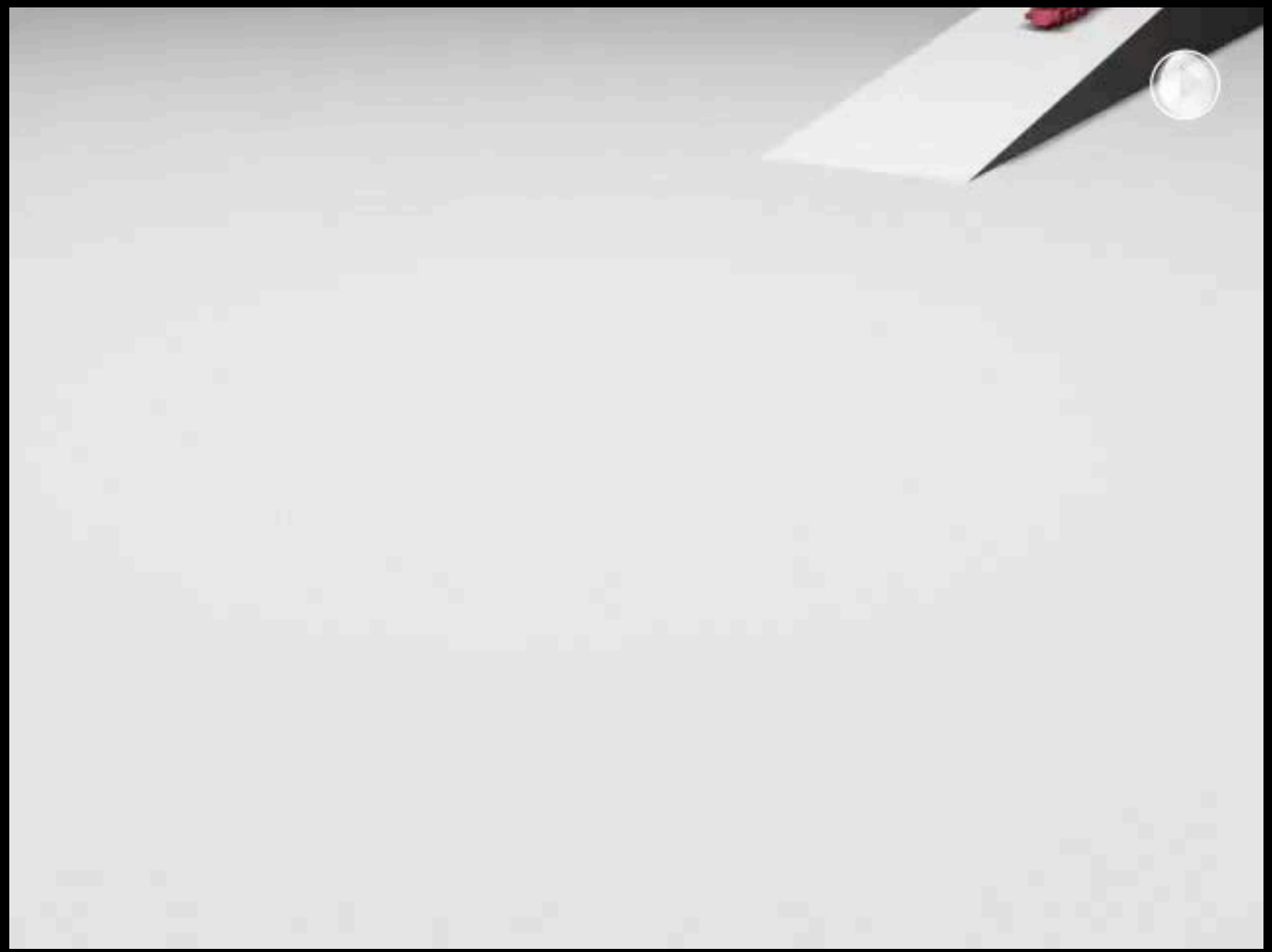


Rigid Body Dynamics

Real-time Particle Dynamics



Articulated Body Dynamics

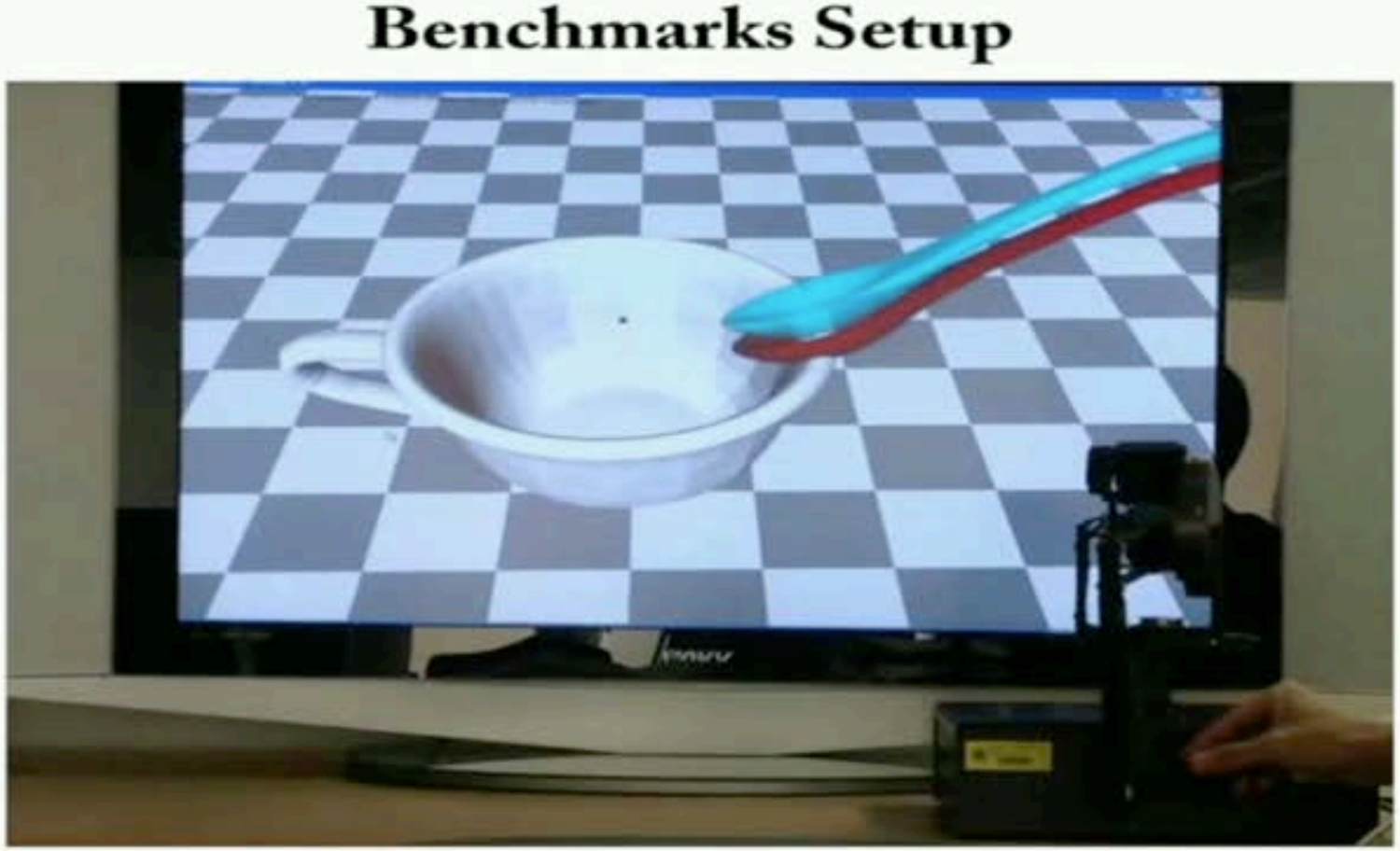


Physics-based Game

Space Foosball

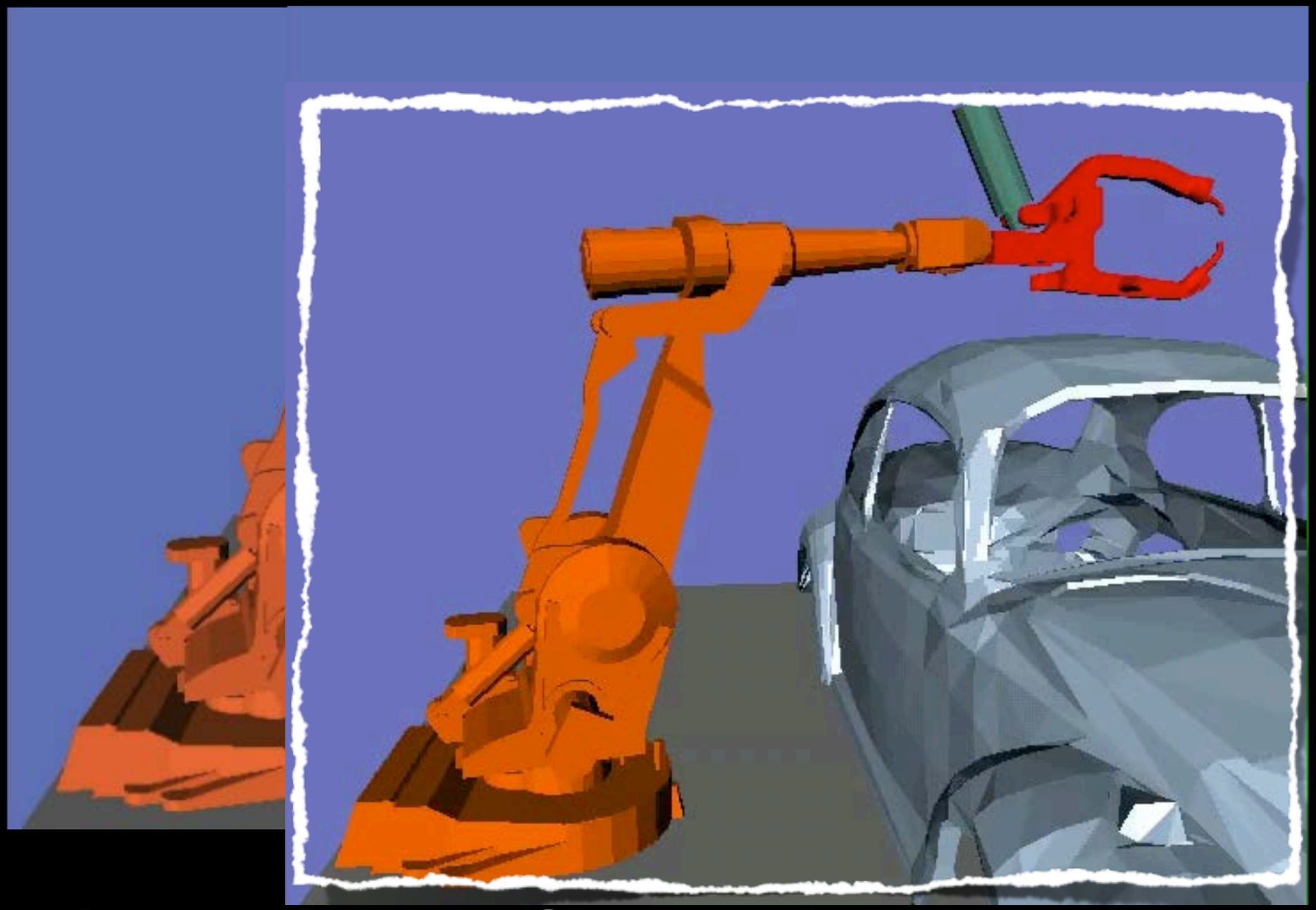
Junkyard Foosball

6DoF Haptics



6DoF PHANToM Premium 1.5

Motion Planning

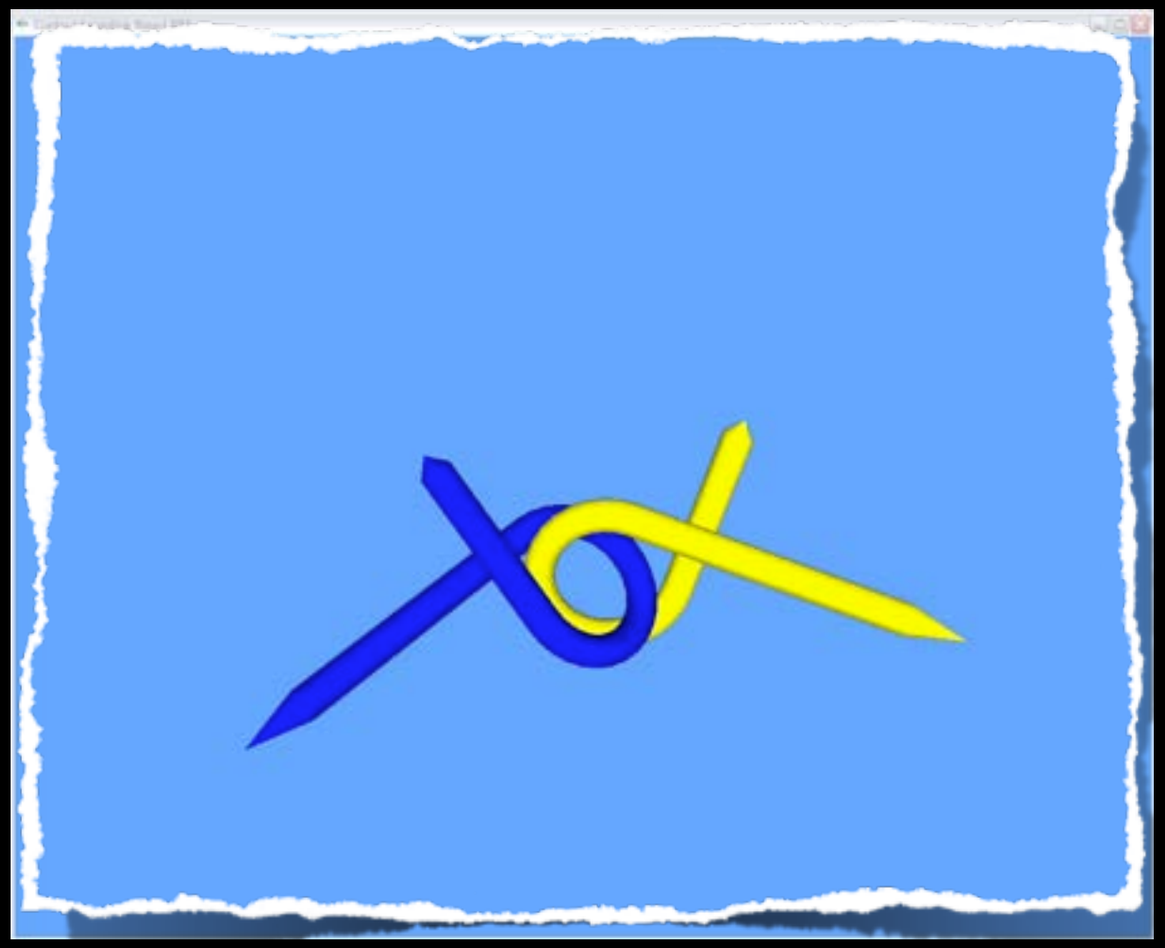


Initial configuration

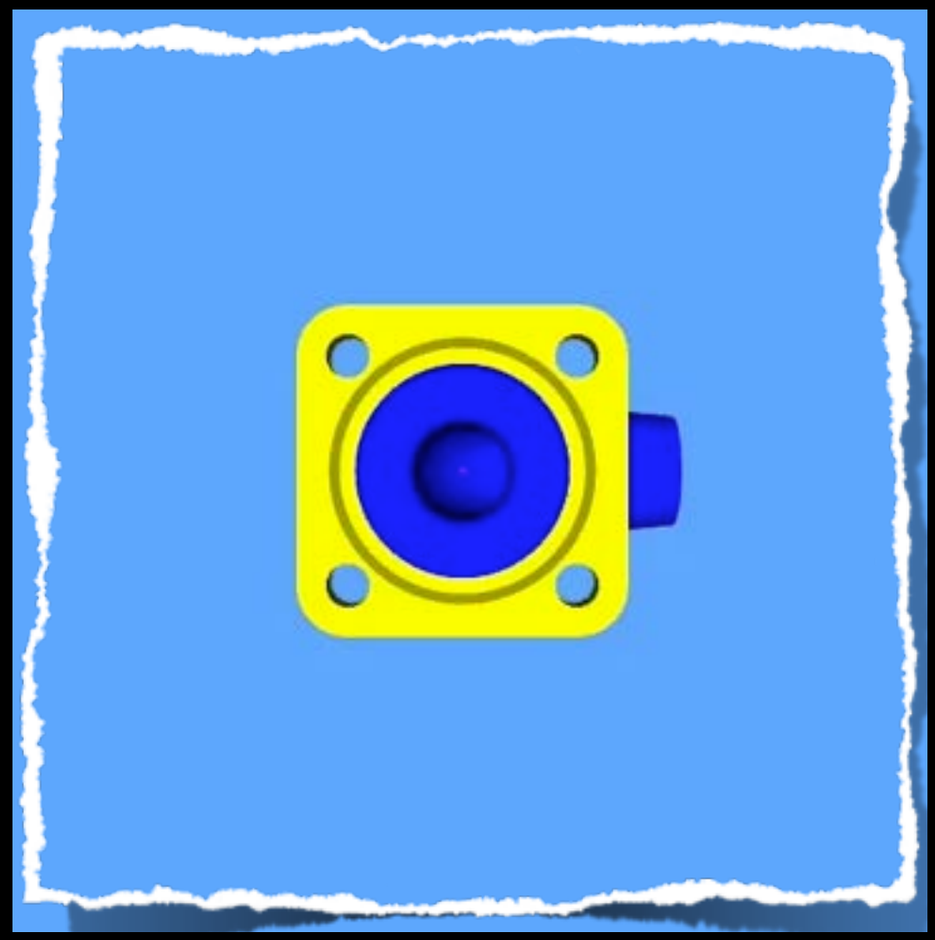
Final configuration

Collision-free Motion

Motion Planning Results



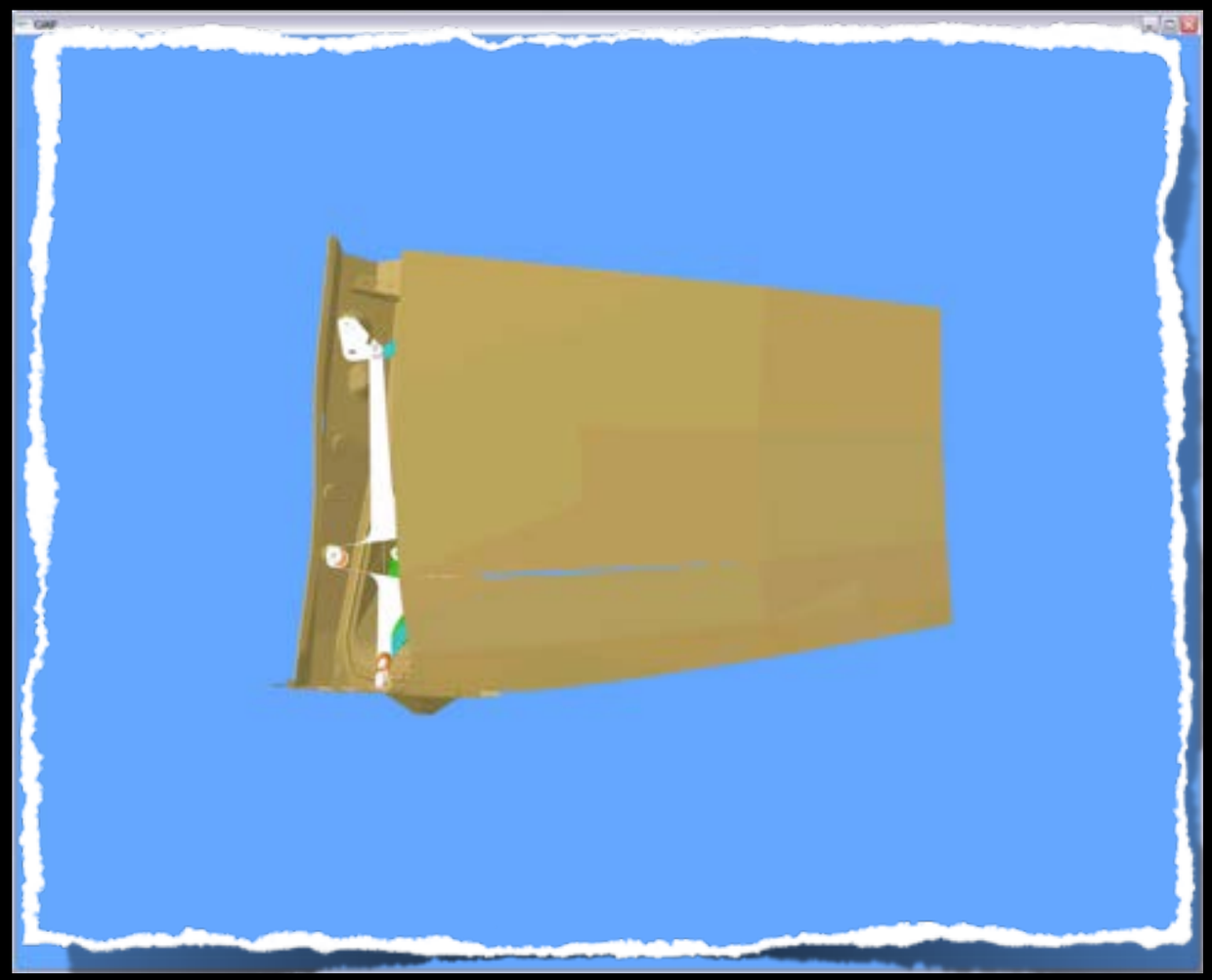
Alpha Puzzle
(18 minutes)



Flange
(42.9 secs)

Car Seat Removal

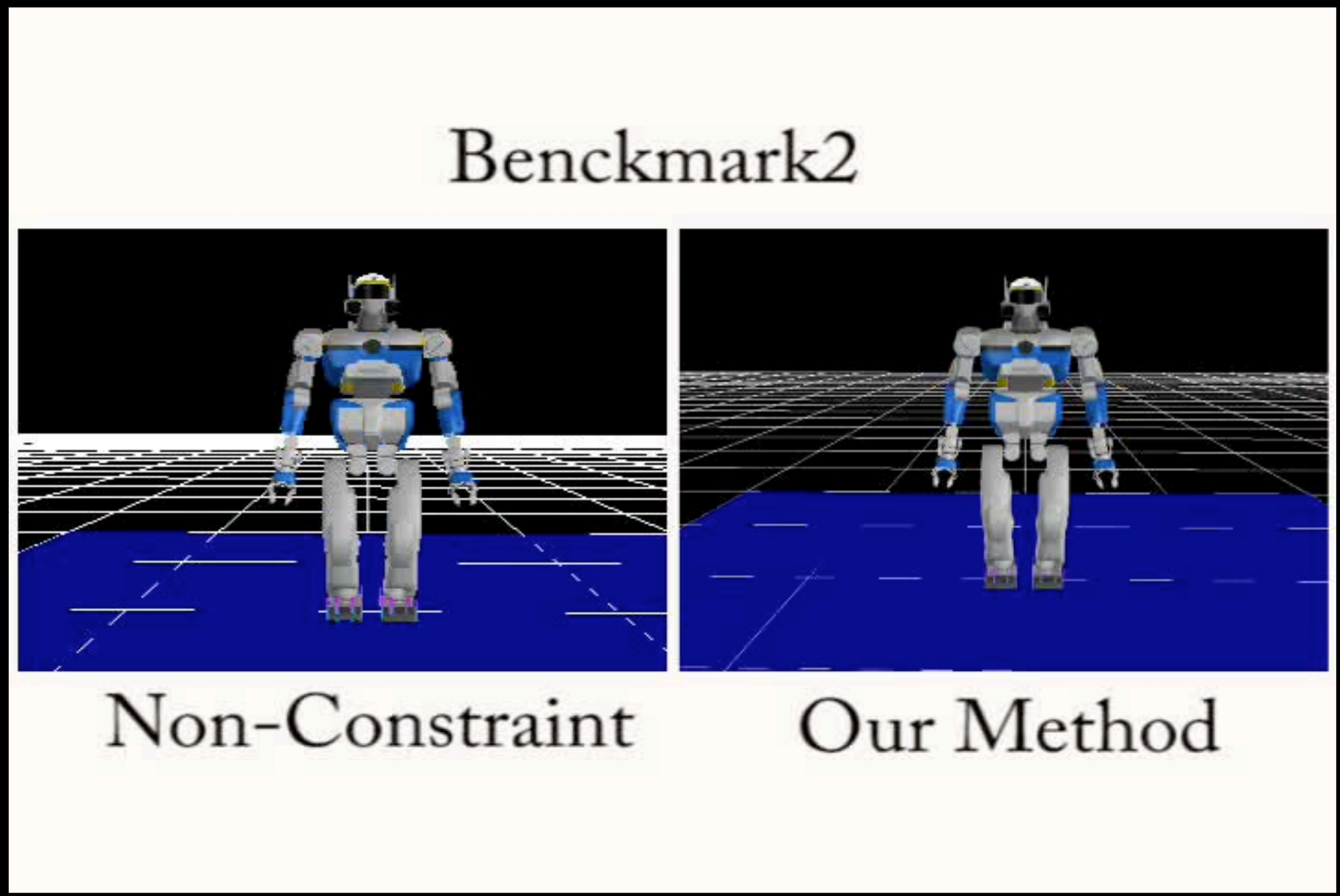
(245K triangles, 3 mins)



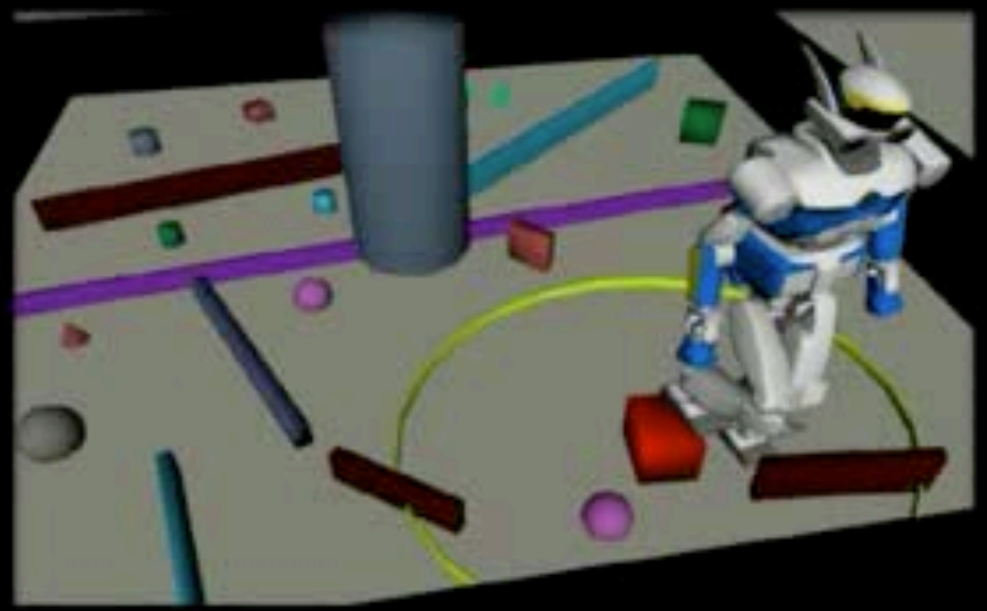
Wiper Removal

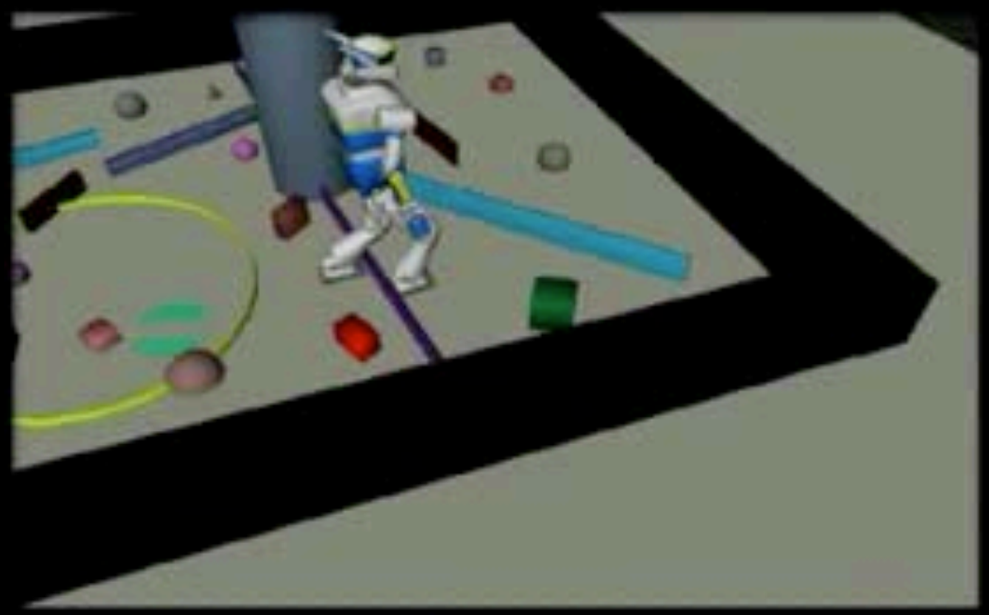
(27K triangles, 20 mins)

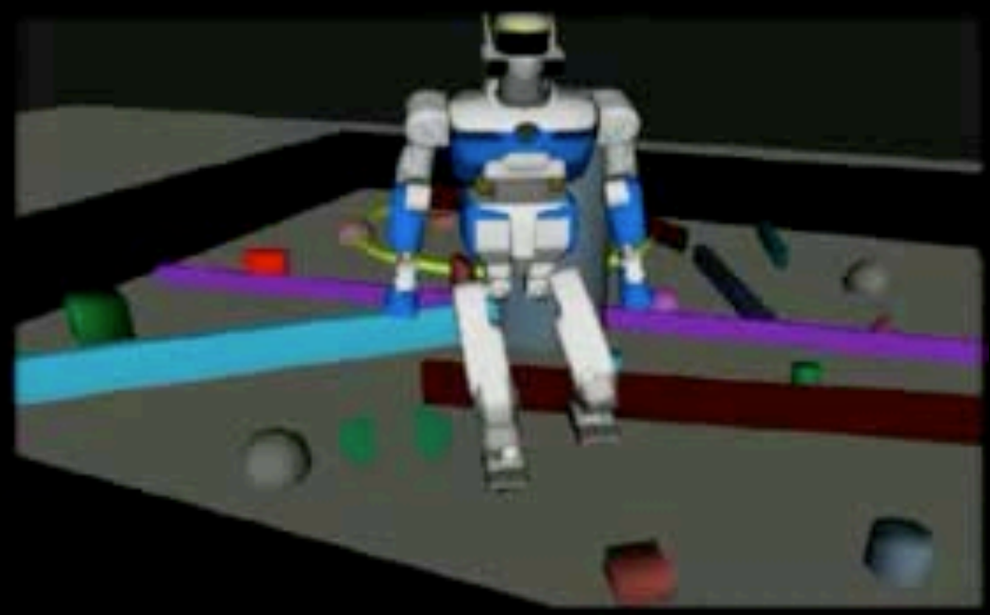
Optimization-based Collision Avoidance



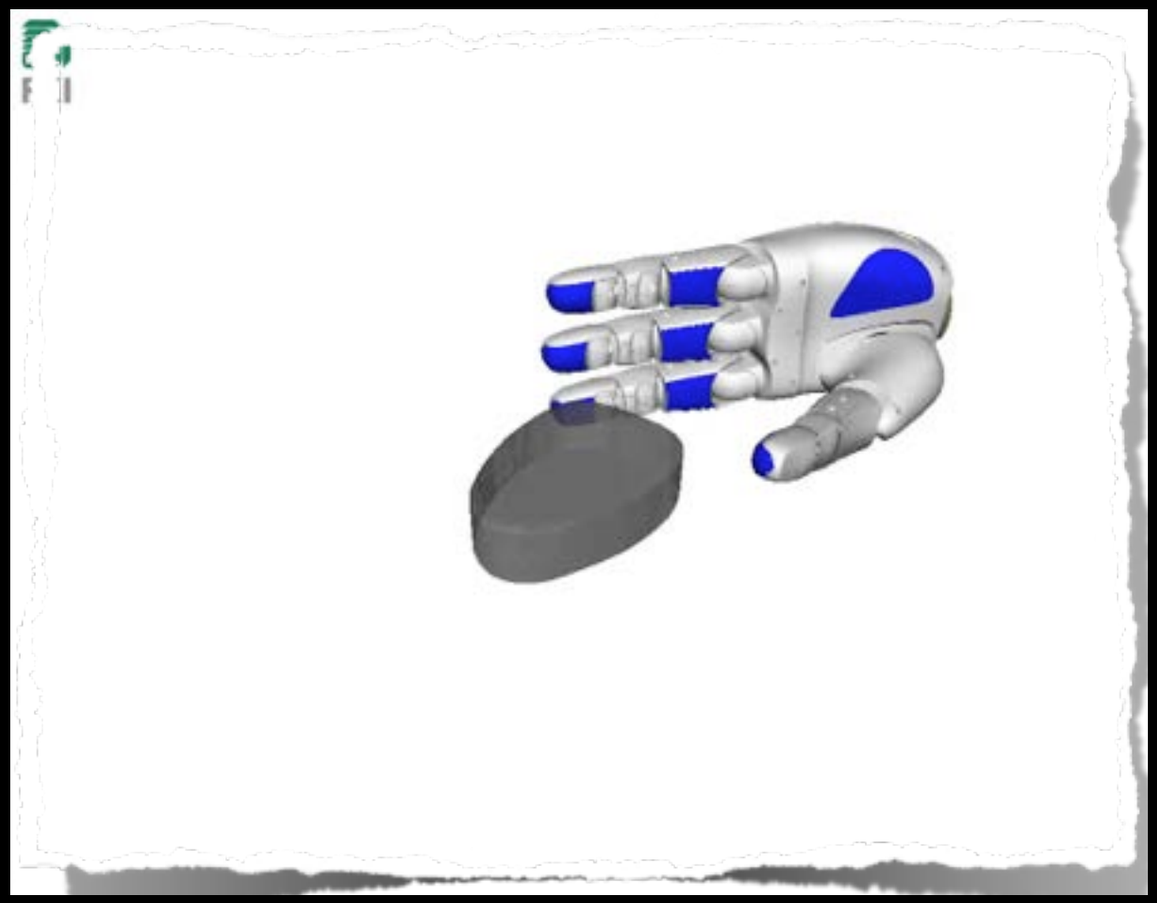
Real-time Footstep Planning

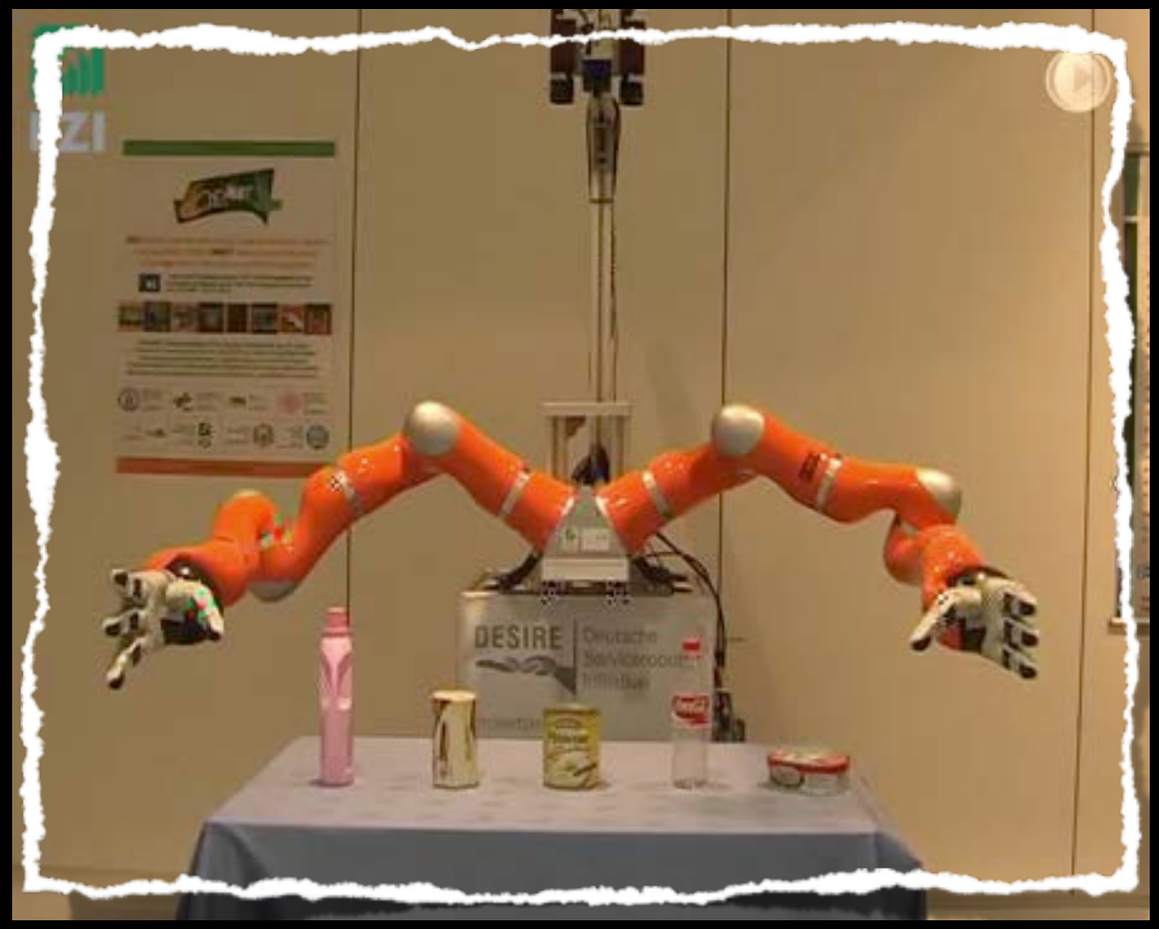




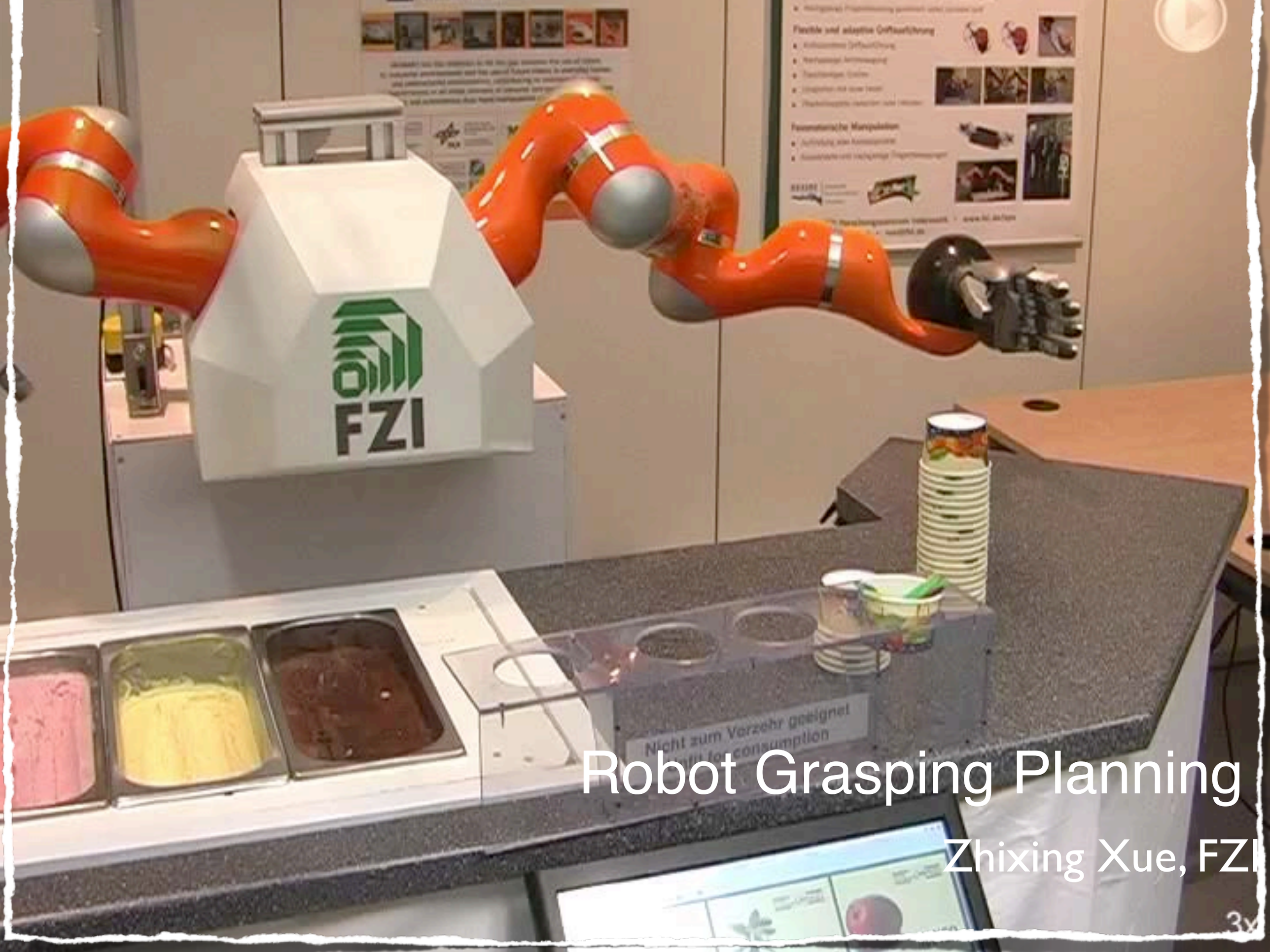


Robot Grasping Planning





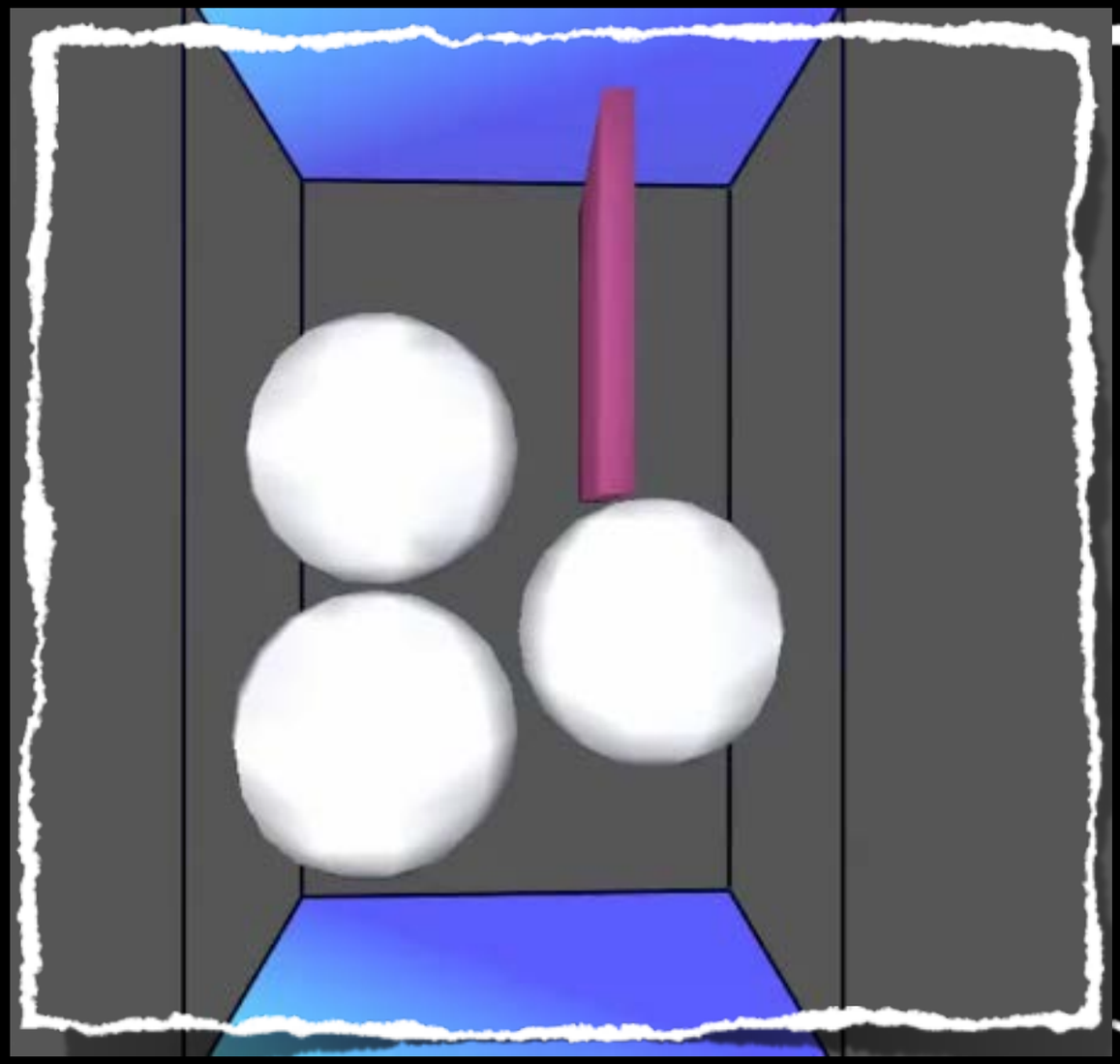
Courtesy of Zhixing Xue, FZI



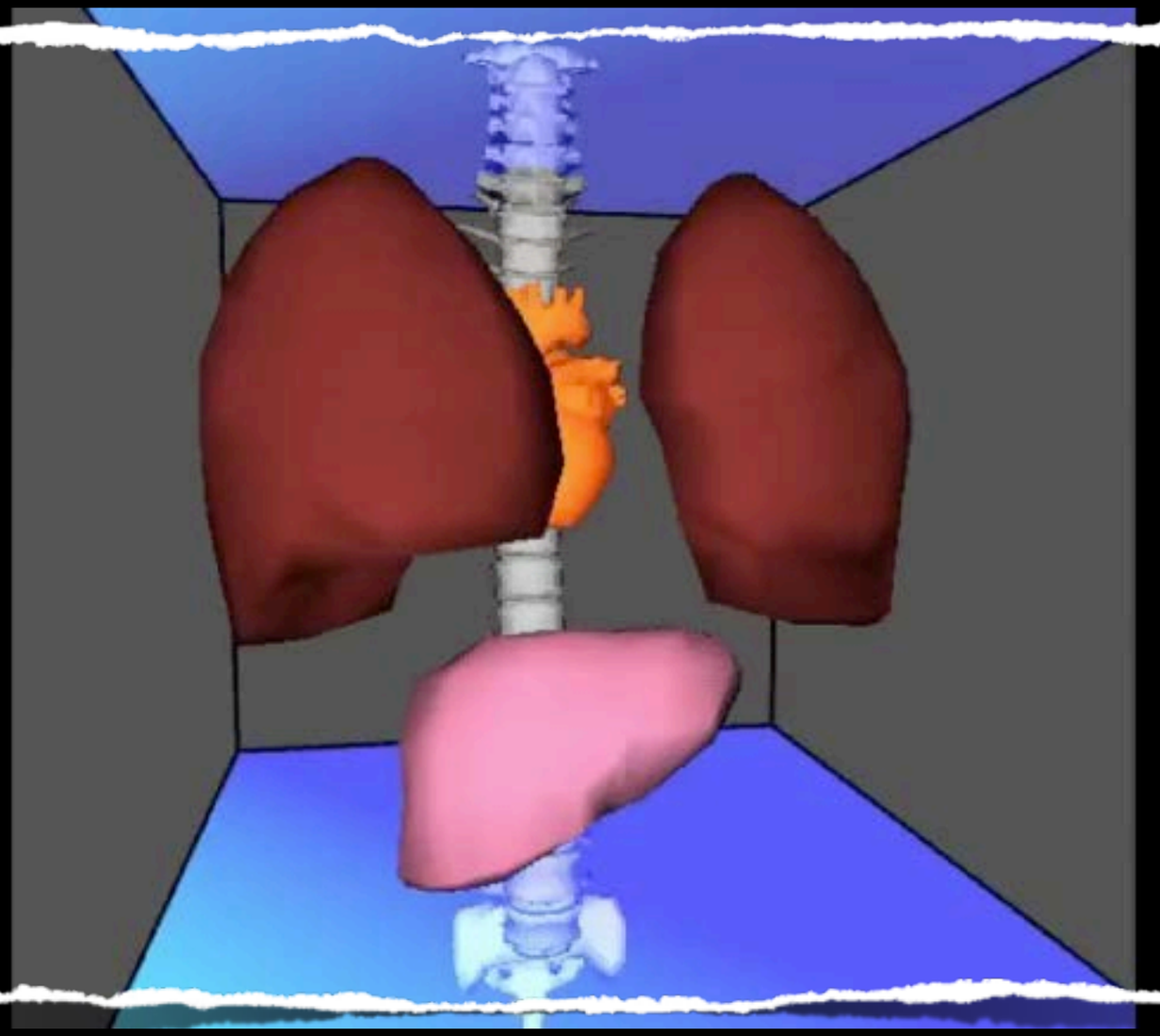
Robot Grasping Planning

Zhixing Xue, FZI

Deformable Motion Planning



Bar/Sphere
(636 triangles)



Human Organs
(14K triangles)

Summary

- Spatial Reasoning
- High Performance
- Applications to Graphics, Robotics, CAD, Haptics

Acknowledgements

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Thank you for listening!

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