Fast But Accurate: A Real-Time Hyperelastic Simulator with Robust Frictional Contact

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1. Problem Statement

Simulating hyperelastic materials with accurate frictional contact in real time is critical for applications in robotics. In the *world model* frameworks, simulation serves as a predictive environment for learning, planning, and decision making. Existing methods struggle to balance accuracy, stability, and speed, especially under large deformations, complex contact patterns, and high-stiffness conditions, limiting their suitability for high-fidelity, closed-loop world models in control and reinforcement learning.

2. Key Innovations

High-Fidelity Simulation Our physics engine is capable of accurately modeling the deformation of the elastic body in real world and contact interactions, capturing frictional behaviors with errors as small as 0.01 in challenging scenarios.

High-Performance Simulation We purpose numerically efficient, parallelizable framework that maintains high accuracy while enabling real-time execution, supporting large-scale and contact-rich simulations essential for robotics applications.

Simulation–Manipulation Integration A unified platform that couples high-fidelity deformable object simulation with robotic manipulation tasks, enabling closed-loop testing, policy learning and benchmarking for contact-rich interactions.

3. Result

Our engine delivers accurate, efficient simulation for contact-rich manipulation of deformable objects. It combines high-fidelity physics with real-time performance, making it ideal for world model–based control and reinforcement learning.

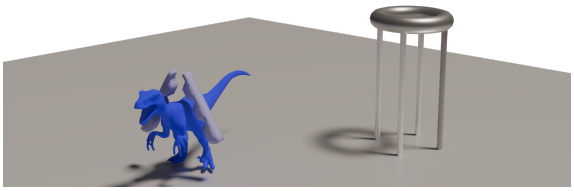

Figure 1. Grabbing Raptor: stable catching of an elastic raptor with a soft gripper actuated by cables. Lifting, rotating, and moving the raptor by the fingers are complex operations where friction constraints are necessary.

4. Relevance to Workshop

Our simulator supports realistic and fast simulation of deformable objects in robotics, benefiting interactive manipulation, soft object handling, and physically realistic training. Its accuracy and efficiency make it well-suited for integration into world model–based control and learning frameworks.

5. Original Publication

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