ACG Project Midterm Report

Changxun Pan*
pancx24@mails.tsinghua.edu.cn
2024011323, Yao Class 43, IIIS
Beijing, China

Liming Wang*
xxx@mails.tsinghua.edu.cn
00000000, Yao Class 42, IIIS
Beijing, China

Abstract

We chose the topic of **collision simulation**.

1 Project Goal

In this course project, we aim to implement solid–solid collision and solid–fluid collision with realistic physical behavior. All solids are modeled as rigid bodies.
We use SPH-based liquid simulation.

2 Technical Details

We plan to implement (or have implemented) the following:

- Base types:
  (1) Rigid body (basic; implemented by Changxun Pan)
  (2) Fluid (basic; implemented by Liming Wang)
- Customizable scene configuration (3 pts; implemented by Liming Wang and Changxun Pan)
- Coupling:
  (1) Solid–solid collision and friction effects (3 pts; implemented by Changxun Pan)
  (2) Fluid–solid collision, including fluid vs. static rigid and fluid vs. free rigid (4 pts; implemented by Liming Wang)
- Geometry:
  (1) Simple geometry (basic; implemented by Changxun Pan)
  (2) Complex geometry (mesh-based; e.g., nailong collision with more than 100k triangles) (2 pts; implemented by Changxun Pan)
- Acceleration structures (to be implemented)
- Industrial renderer integration to produce high-quality videos (up to 4 pts; implemented by Changxun Pan): custom materials and lighting.

3 Important Functions Implemented

- Rigid Body Dynamics: (Changxun Pan)
  (1) Free-space updates using linear and angular velocity.
  (2) Damping effect to reduce energy over time.
  (3) Collision detection based on complex mesh rigid bodies.
  (4) Complex mesh rigid-body response including sudden velocity changes and continuous friction when bodies remain in long-term contact and sliding.
  (5) Two types of rigid bodies: static and free (fixed, non-movable bodies and unfixed, fully dynamic bodies).
- SPH Fluid Simulation: Implement Smoothed Particle Hydrodynamics (SPH) for fluid simulation. (Based on WCSPH) (Liming Wang)
  (1) Classical SPH formulation for fluid dynamics (including viscosity, surface tension forces, etc.).
  (2) Fluid–static-rigid collision based on ghost particles.
  (3) Fluid–free-rigid collision (to be fully implemented).
- Scene configuration: (Changxun Pan and Liming Wang)
  (1) Custom scene configuration including mesh-based rigid bodies and fluids.
- Industrial Renderer Integration: (Changxun Pan)
  (1) Custom materials including a principled BSDF.
  (2) Custom lighting including area lights.
  (3) Custom texture mapping and camera animation (to be fully implemented).

4 Some Simulation Results

We have the following figures for our current results:

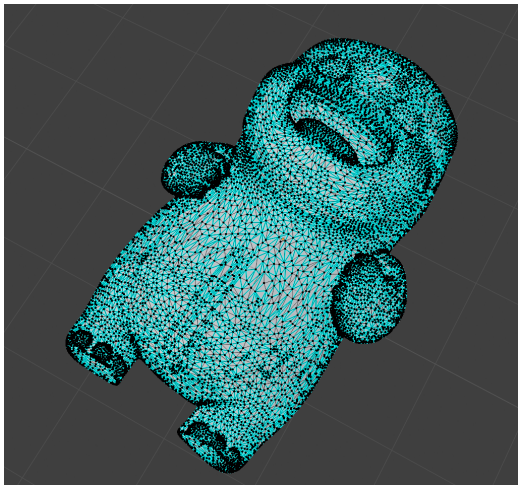

Figure 1: A complex mesh rigid-body example

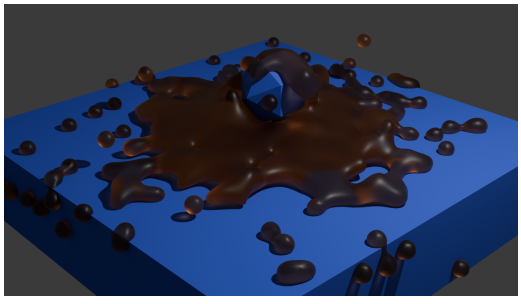

Figure 2: Liquid sphere collision

*Both authors contributed equally to this project.

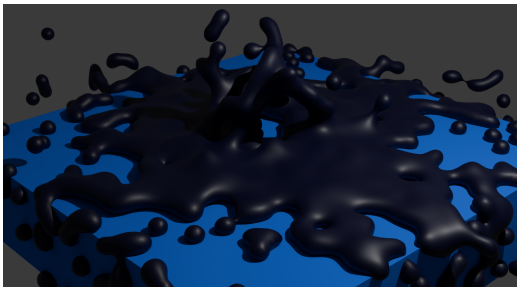

Figure 3: Liquid splashing on the ground

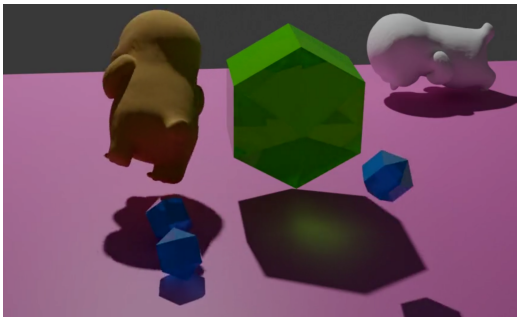

Figure 4: Rigid-body collision

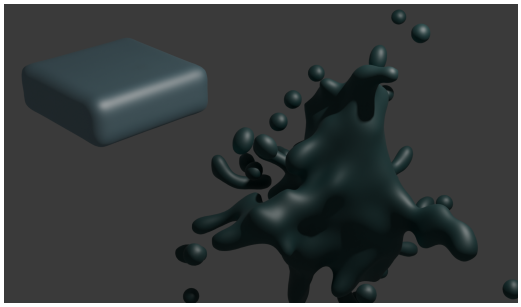

Figure 5: Liquid drop in free space: the left shows the initial state and the right shows an intermediate state.

5 Acknowledgement