Physically-Based Simulation: Final Presentation

CLOTH SIMULATION

Group 23 - Marko Nikic, Pascal Chang
MILESTONES

BASIC
- Working cloth/solid simulation
- Basic scene with showcases

DESIRED
- Cloth/cloth simulation & friction
- Beautifully rendered showcase scenes

BONUS
- Mesh subdivision scheme
- Rendered short film story
Soft Object and Cloth Object class implementation
MSS for the internal cloth dynamics
AABB hierarchy, broad- and narrow-phase collision detection
Penalty forces and impulse based collision response (cloth/cloth + cloth/solid)
Gui-less version for running simulations and exporting recordings on Euler
Lots of debugging tools
MSS + FORCES

\[ f_{ij}^{(\text{int})} = k \cdot (\|x_j - x_i\| - L) \cdot \frac{x_j - x_i}{\|x_j - x_i\|} \]

\[ f_{ij}^{(\text{damp})} = \gamma \cdot (v_j - v_i) \cdot (x_j - x_i) \cdot \frac{x_j - x_i}{\|x_j - x_i\|^2} \]

\[ f_{ij}^{(\text{ext})} = [0, -g, 0]^T \]

\[ f_{ij} = -f_{ji} \]
● Symplectic Euler works fine
● Implicit Euler only partially successful
  ○ On first sight it actually looks correct
  ○ Debugging and convergence tests say otherwise
  ○ Error term linear instead of quadratic
  ○ Not unconditionally stable (if dt too large)
● Debugging tools
  ○ Plot kinetic energy of system
  ○ Convergence test
DEBUGGING IMPLICIT EULER

- How to know if the Jacobian inside a Newton step is correct?

\[ g(x_{n+1} + a_i \cdot \Delta x) \approx g(x_{n+1}) + \frac{\partial g}{\partial x} a_i \Delta x + \mathcal{O}((a_i \Delta x)^2) \]

\[ a_{i+1} = \frac{a_i}{2} \Rightarrow \frac{\text{error}[i+1]}{\text{error}[i]} = \frac{1}{4} \]
FROM LAST TIME

- Basic MSS
- AABB Hierarchy
- Collision visualization
- Buggy collision detection & handling
COLLISION DETECTION

Vertex-face collisions

Edge-edge collisions
COLLISION DETECTION ISSUE

Before fix, backfaces were ignored

After fix
Tedious (edge-edge/vertex-face times cloth-cloth/cloth-solid/solid-cloth/solid-solid)

We assumed rigid bodies to be static and of infinite mass, so needed to change the impulse expression from the paper

Allowed to debug collision detection as well
COLLISION RESPONSE DEBUGGING
1. **STABILITY:** not 100% robust (why?), but was implemented and debugged methodically. Collision handling is overall correct.

2. **COMPLEXITY:** 3d, cloth simulation is hard in itself

3. **PERFORMANCE:** was not parallelized, but wrote a gui-less version to run on Euler cluster.

4. **RENDERING:** export OBJs, render results in Blender using add-on.
Physically-Based Simulation: Final Presentation

THANK YOU