computer graphics laboratory

Physically-Based Simulation: Final Presentation

CLOTH SIMULATION

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MILESTONES

BASIC

Working cloth/solid simulation

Basic scene with showcases

DESIRED

Cloth/cloth simulation & friction

Beautifully rendered showcase scenes

BONUS

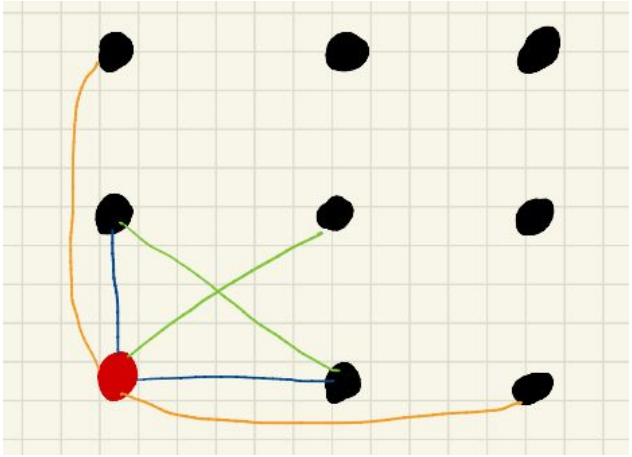
Mesh subdivision scheme

Rendered short film story

FINAL PROGRESS

- 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



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

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

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

$$f_{ij} = -f_{ji}$$

INTEGRATION

- 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?

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

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

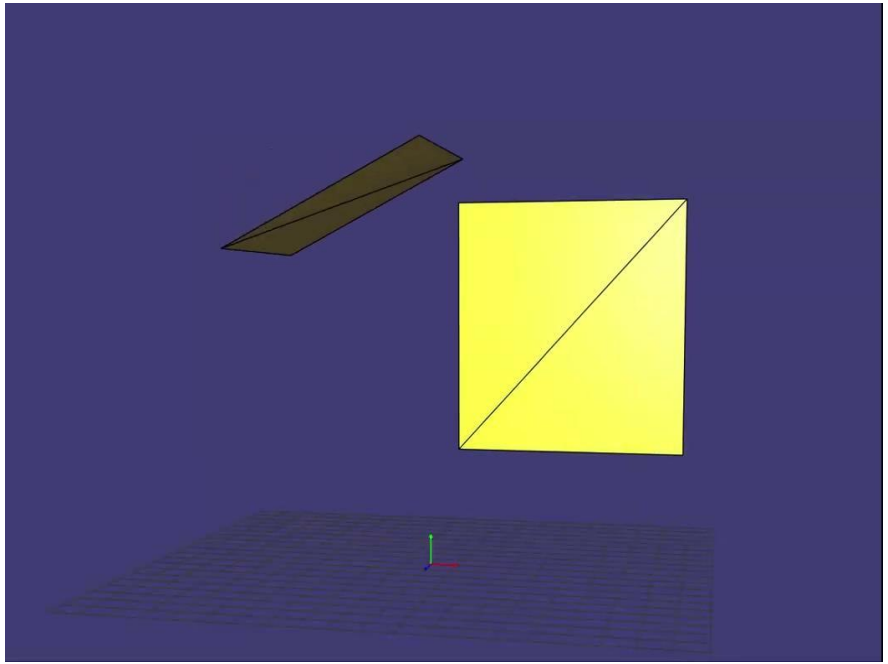
FROM LAST TIME

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

COLLISION DETECTION

Vertex-face collisions

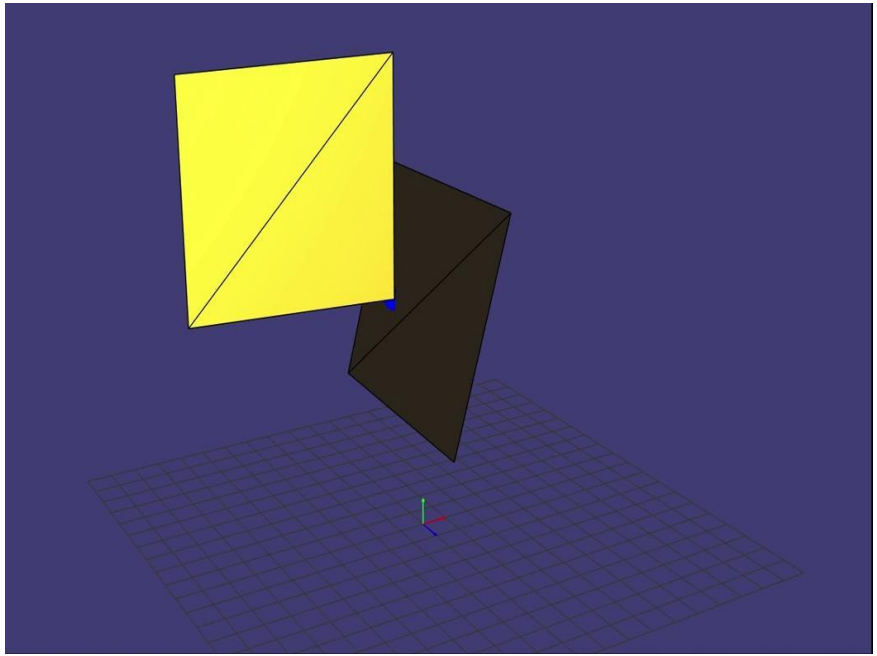
Edge-edge collisions



COLLISION DETECTION ISSUE

Before fix, backfaces were ignored

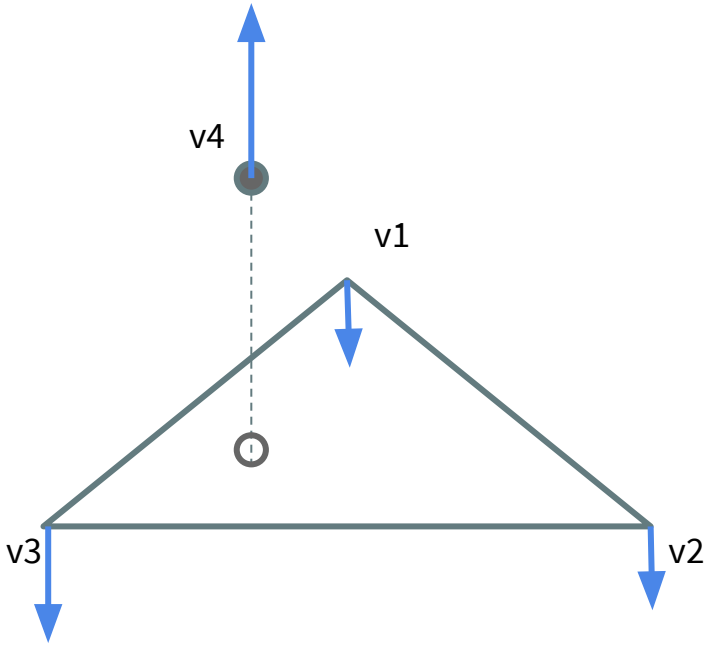
After fix

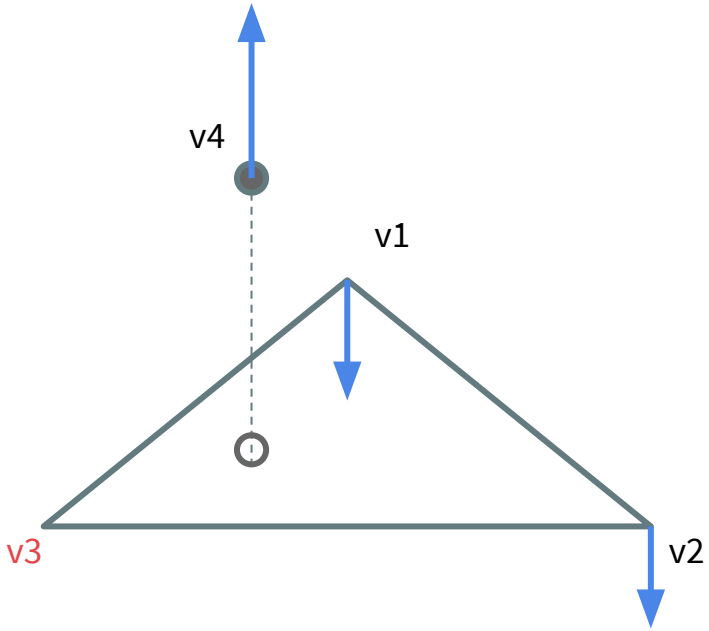


COLLISION RESPONSE DEBUGGING

- 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

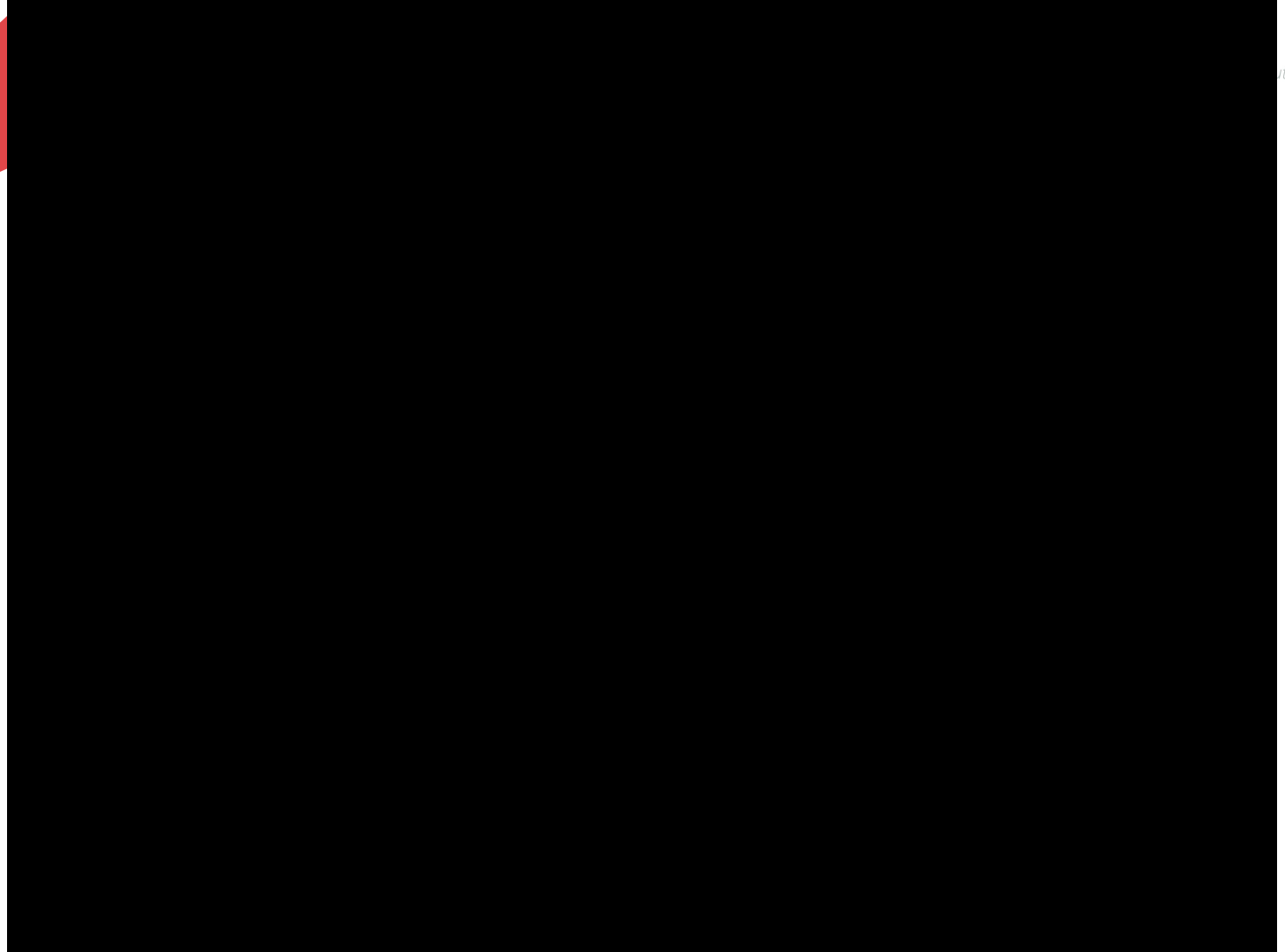
COLLISION RESPONSE DEBUGGING





CONCLUSION

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.



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THANK YOU