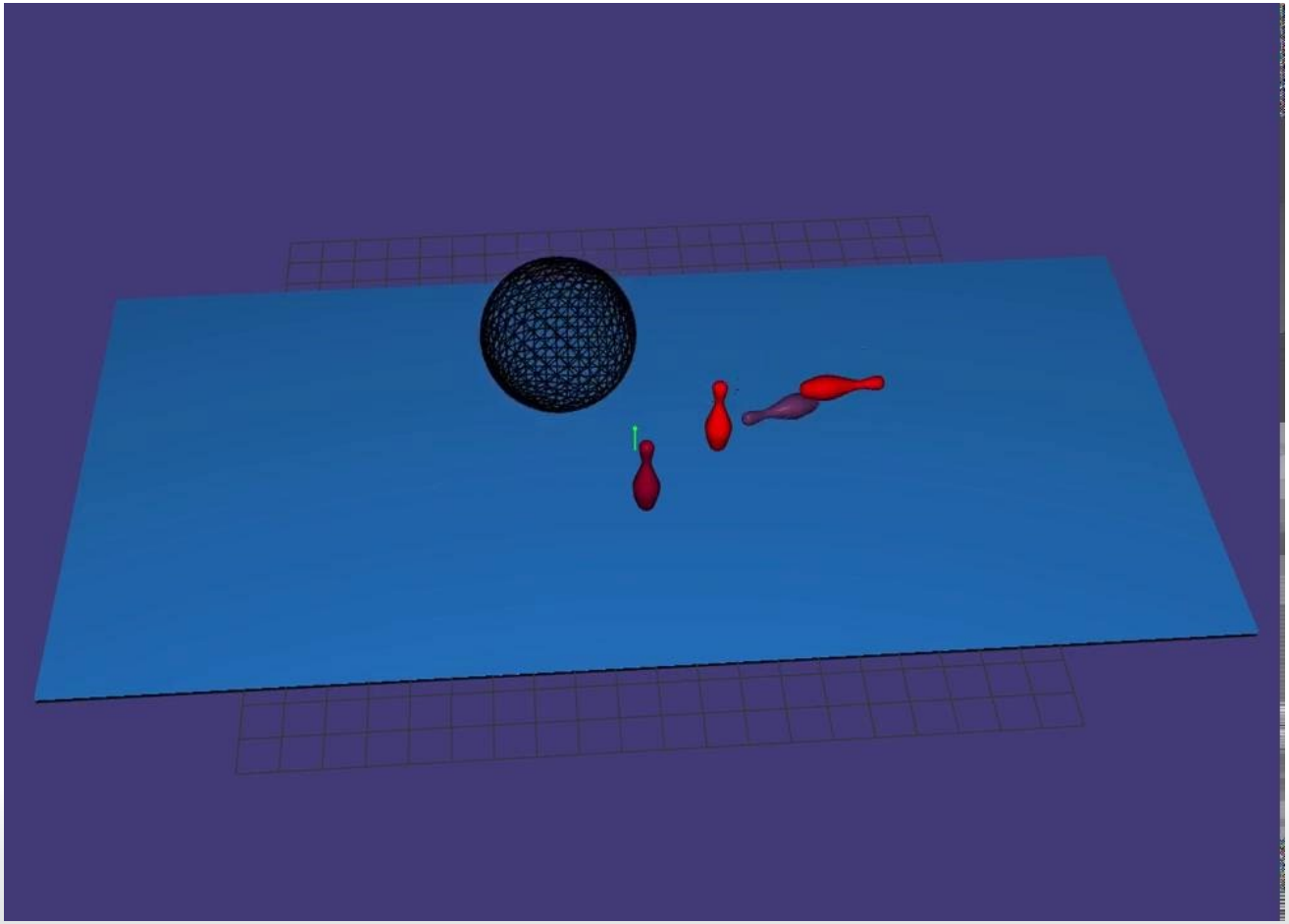
Physically-Based Simulation
Final: Bowling Alley

Group 10

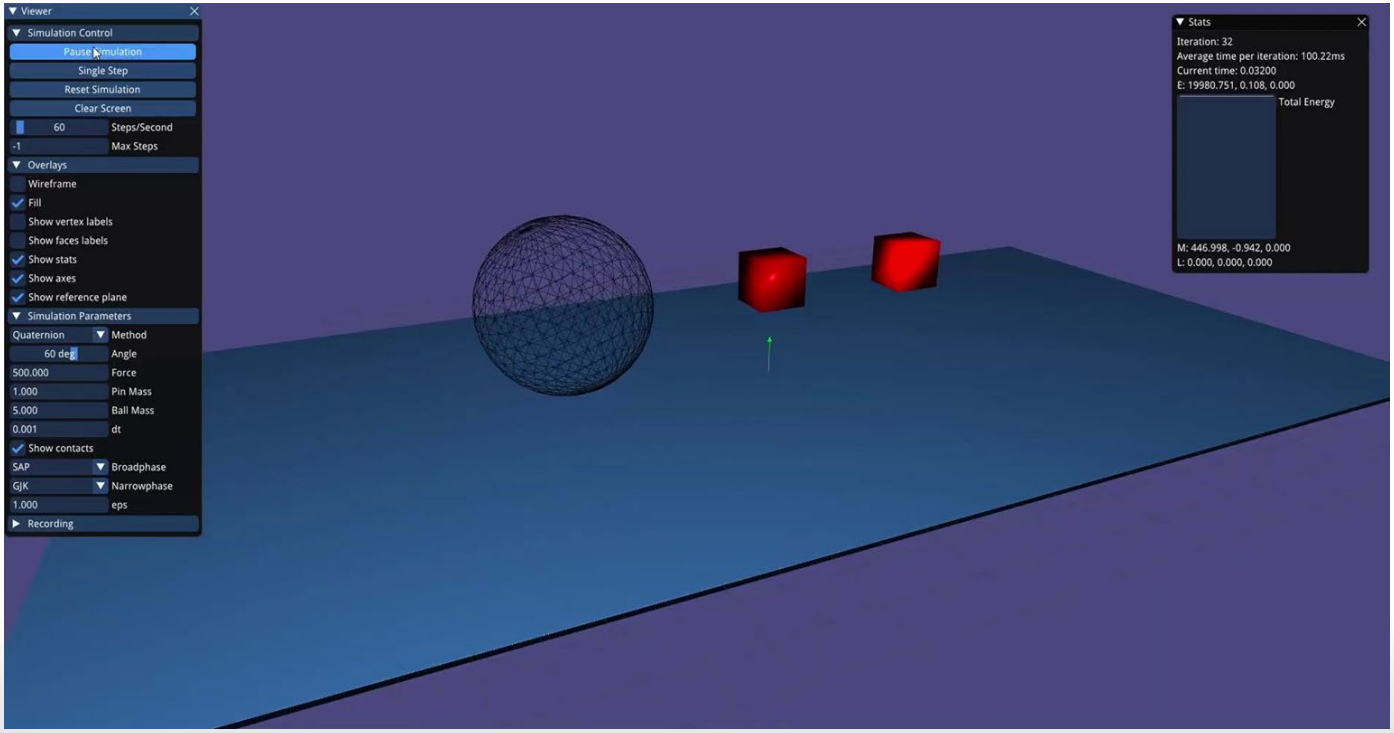
Elham Amin Mansour, Akshay Narayan



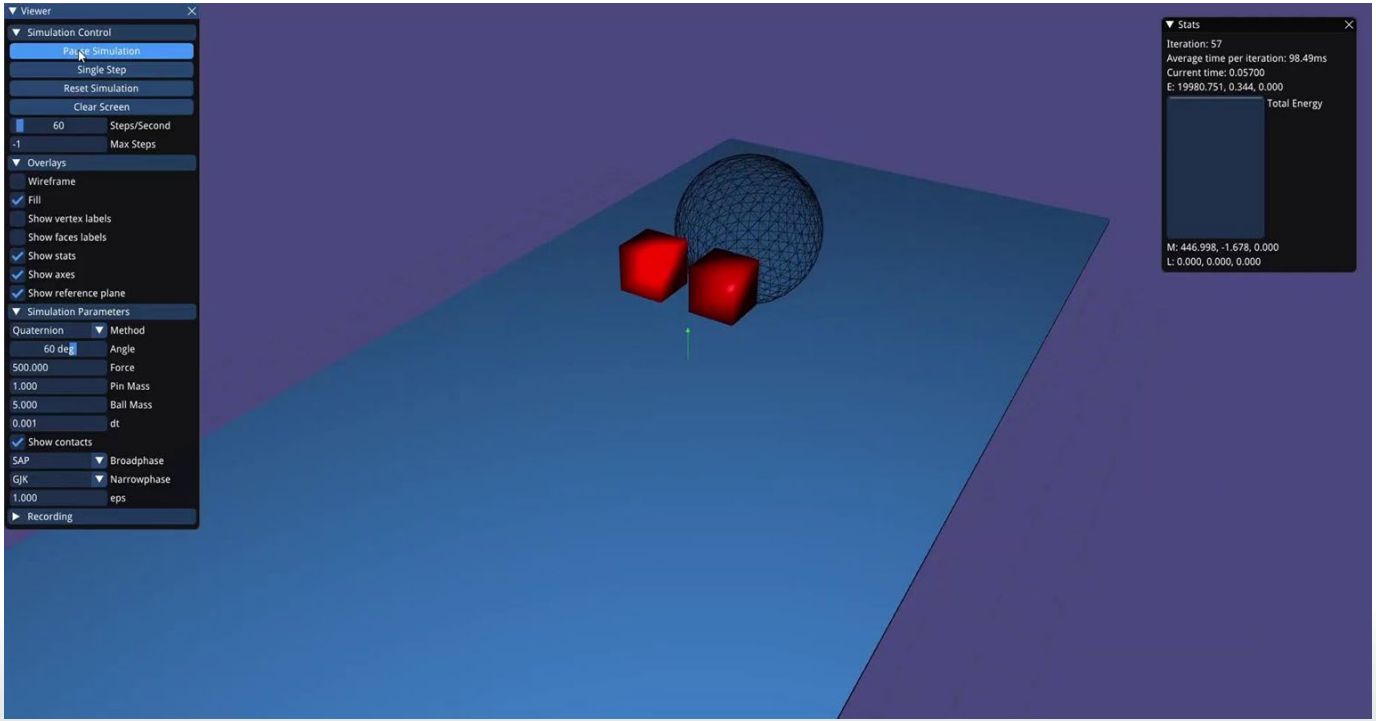
Challenges

- Bowling pin mesh had too many polygons (and was not entirely convex)
- Exhaustive narrow collision detection not responsive
- Vanilla GJK issues; accurate detection but impulses not applied correctly -> extended to use EPA
- Computationally intensive -> modified framework to run on Euler (without GUI)
- Multiple resting contacts

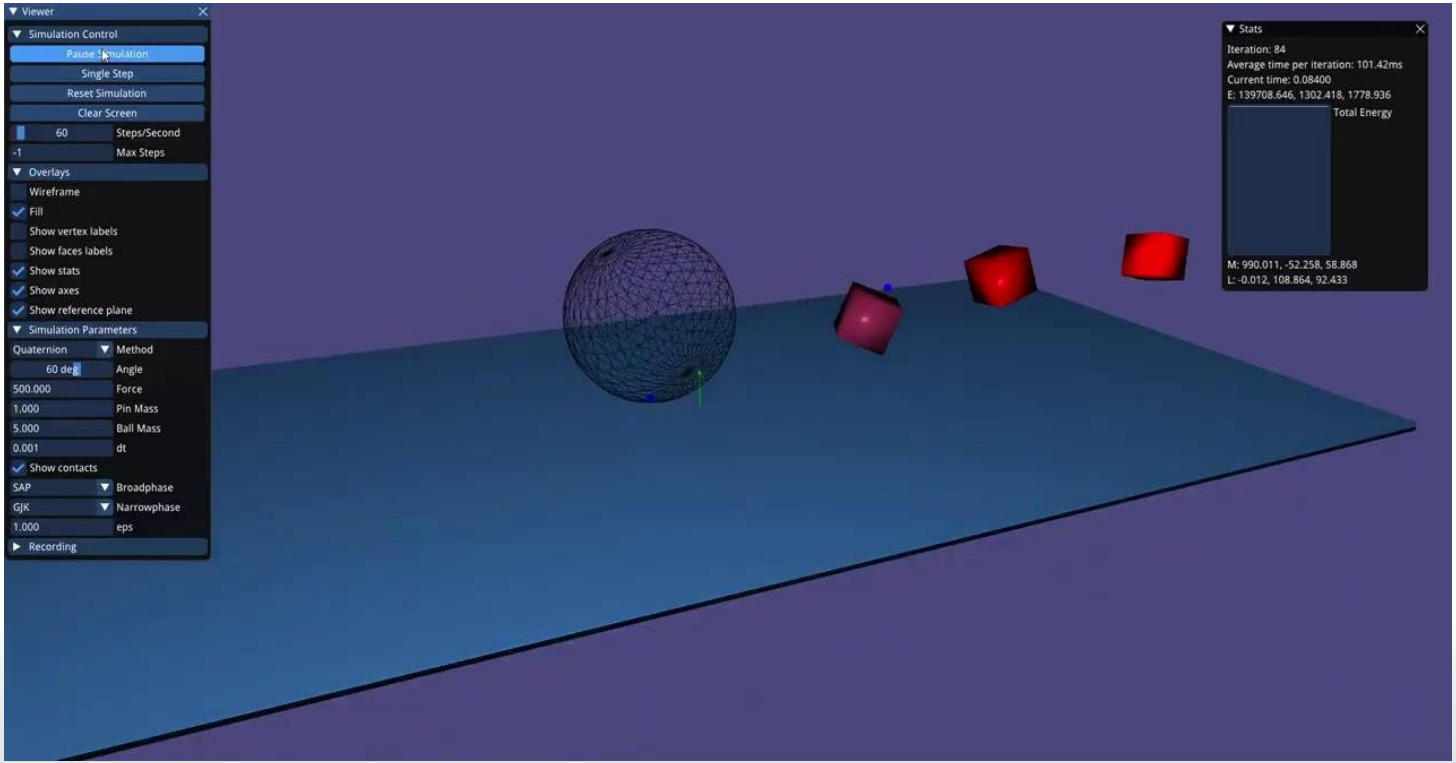
Basic Collision Detection



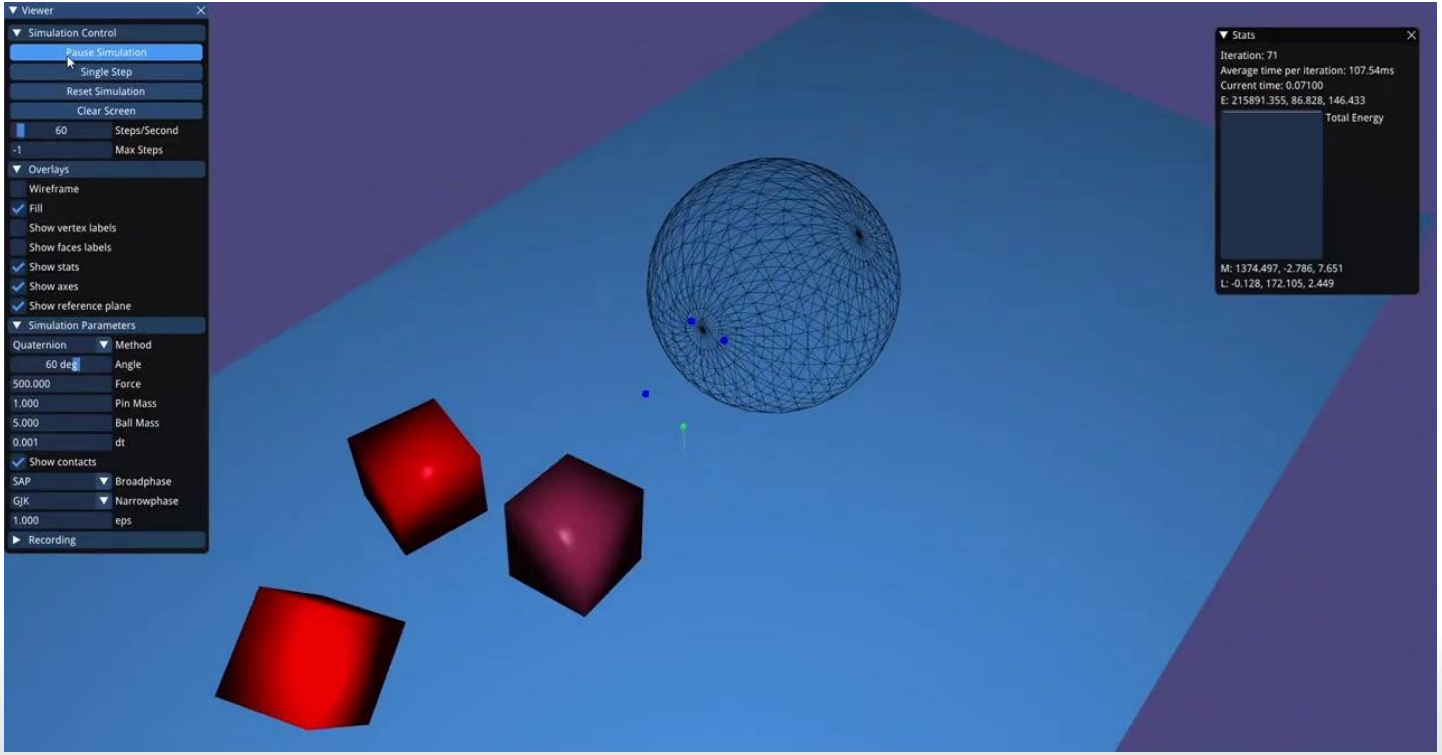
Basic Collision Detection



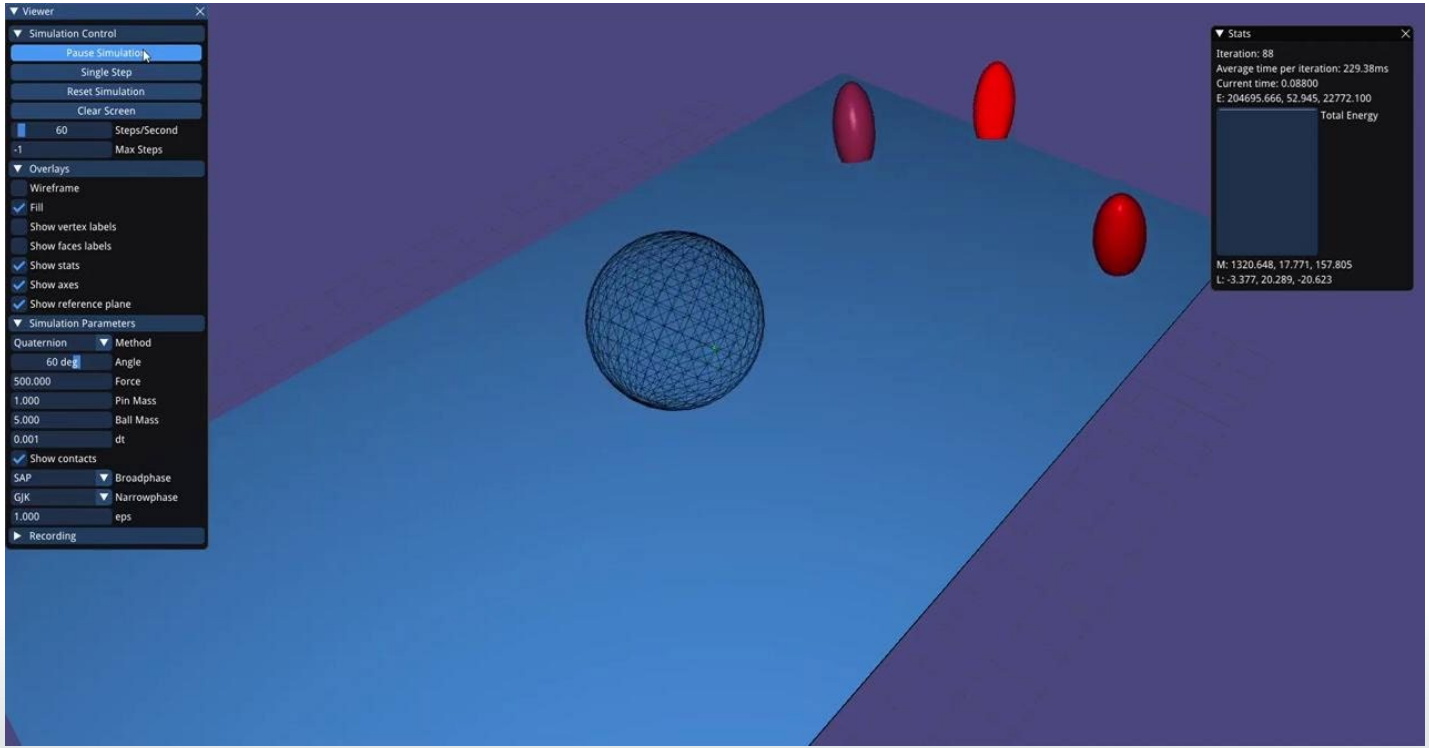
Basic Collision Detection



Basic Collision Detection



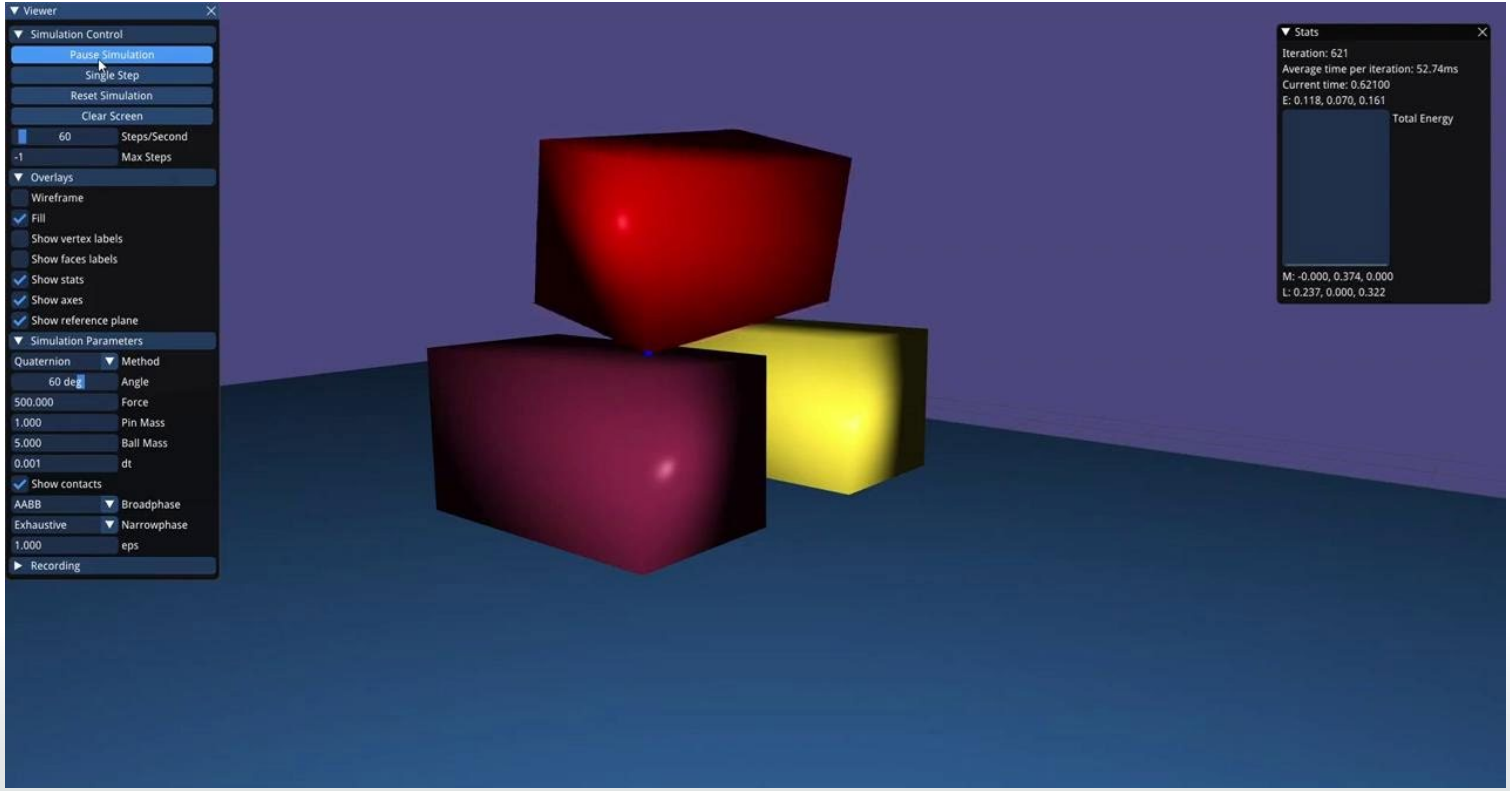
More Complex Meshes



Stability

- Object rotation sometimes speeds up (even with implicit Euler for gyroscopic torque)
- LCP can be unstable depending on the geometries

LCP (unstable)



LCP (more stable)

Framework Modification

- RB simulations are very computationally expensive
  - Difficult to run and record on laptops
  - Modified framework to run on Euler (without GUI)

    :export objs and put together into png frames using blender
  - Only record frames in which computation occurs

More Cubes

Simplified Pins

Cubes colliding

Cube colliding with simplified pin

Accomplished Targets

- Rigid Body Simulation
  - Position & rotation updates
  - Gyroscopic forces
  - SAP (broad phase)
  - GJK-EPA (narrow phase)
  - LCP with Quadratic programming

$$\begin{pmatrix} \ddot{d}_1(t_0) \\ \vdots \\ \ddot{d}_n(t_0) \end{pmatrix} = \mathbf{A} \begin{pmatrix} f_1 \\ \vdots \\ f_n \end{pmatrix} + \begin{pmatrix} b_i \\ \vdots \\ b_n \end{pmatrix}$$

Resources

- https://www.cs.cmu.edu/~baraff/sigcourse/notesd2.pdf
- http://www.dyn4j.org/2010/05/epa-expanding-polytope-algorithm/

Future Features

- Collision detection with concave objects (e.g. bowling pin)
- Soft body bowling ball

Thanks!

Q&A