Physically-Based Simulation
Final: Bowling Alley

Group 10

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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)
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

\[
\begin{pmatrix}
\ddot{d}_1(t_0) \\
\vdots \\
\ddot{d}_n(t_0)
\end{pmatrix} = A \begin{pmatrix}
f_1 \\
\vdots \\
f_n
\end{pmatrix} + \begin{pmatrix}
b_1 \\
\vdots \\
b_n
\end{pmatrix}
\]
Resources

- 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