

# Game Developers Conference®

February 28 - March 4, 2011  
Moscone Center, San Francisco

[www.GDCConf.com](http://www.GDCConf.com)

The logo for the Game Developers Conference (GDC) 2011. The letters 'GDC' are rendered in a large, bold, 3D font with a yellow-to-white gradient and a multi-colored outline. To the right of the 'C' is a small, colorful cube icon with the number '25' on its top face, indicating the 25th anniversary of the conference.

GDC

# Game Physics Artifacts

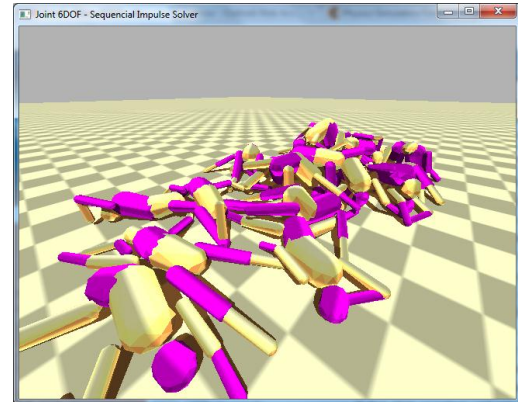
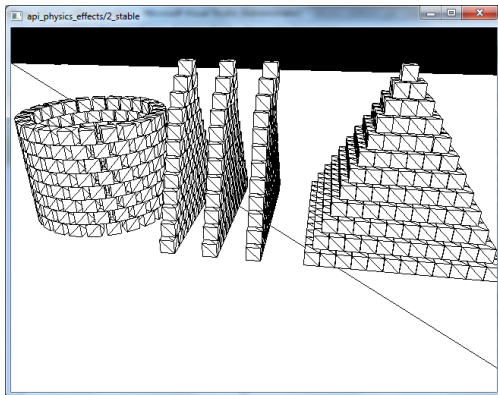
Erwin Coumans, AMD

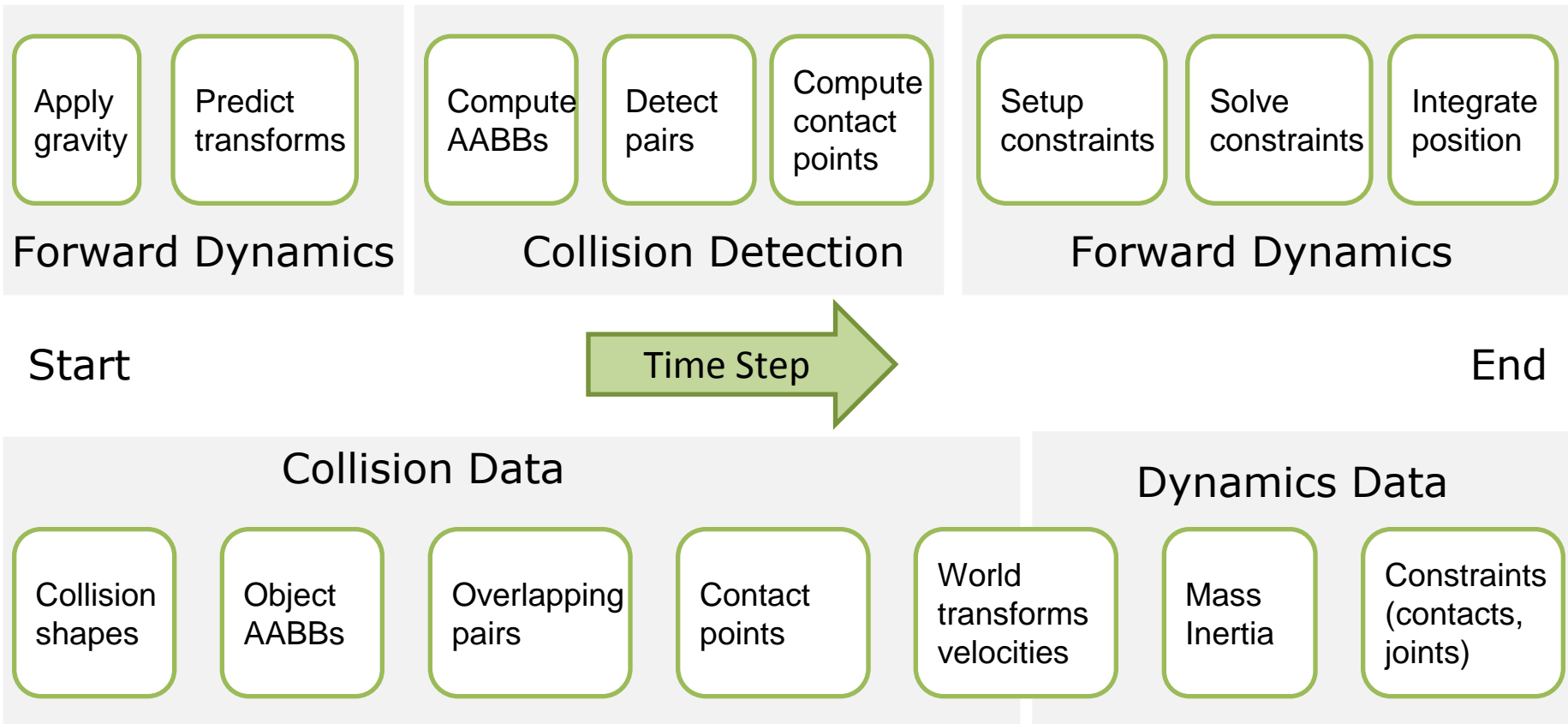
# Intro

- Collision shape and contact artifacts
- Dynamics and constraint solving artifacts

# SCE Physics Effects and Bullet

- <http://bullet.googlecode.com>

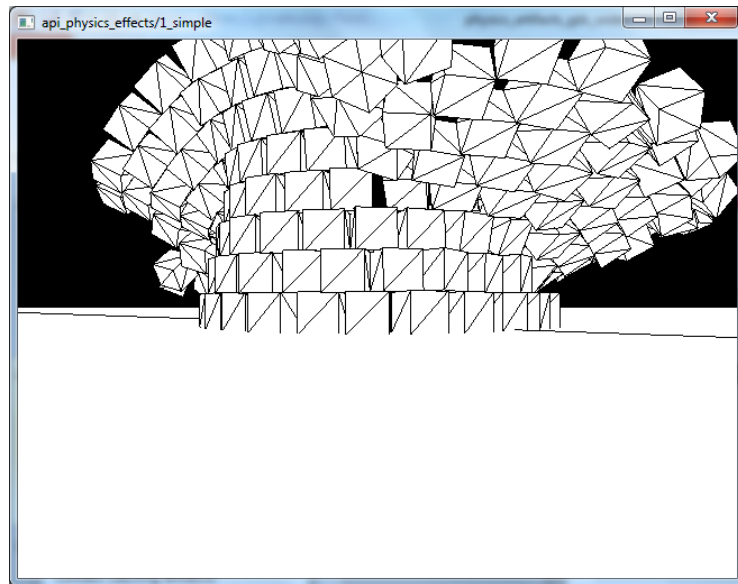
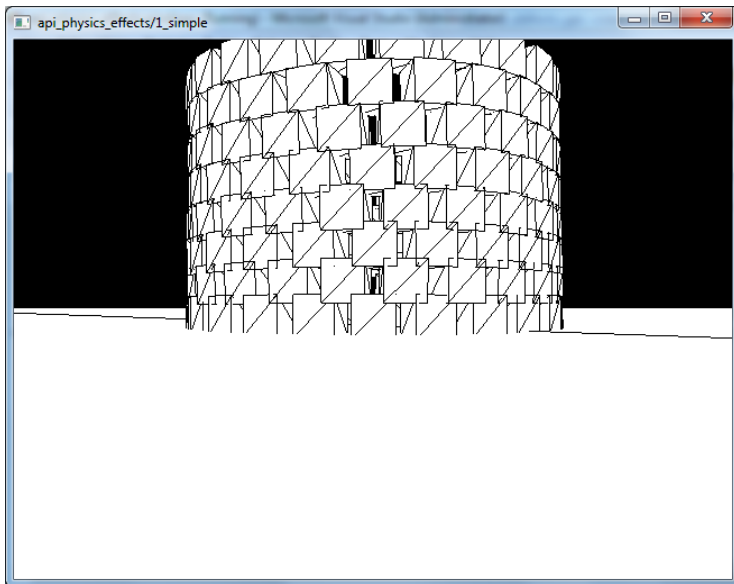




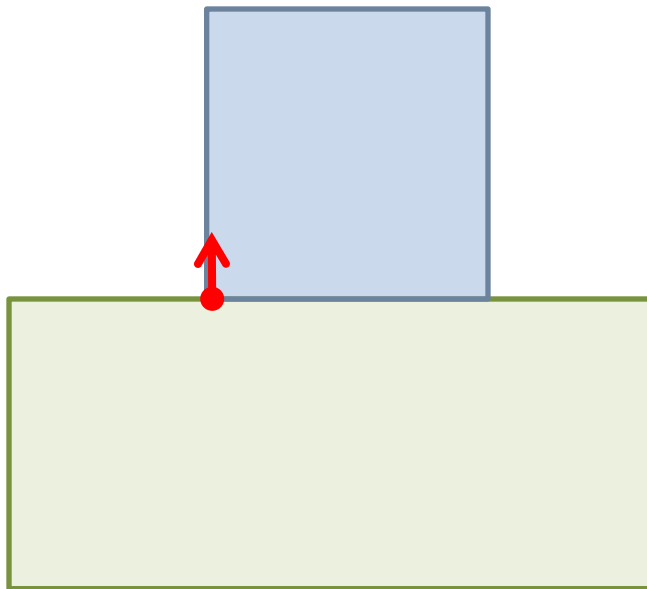
# bounding volume artifacts

- axis aligned bounding boxes (AABB)
- if bounds are too small, you might get shootouts

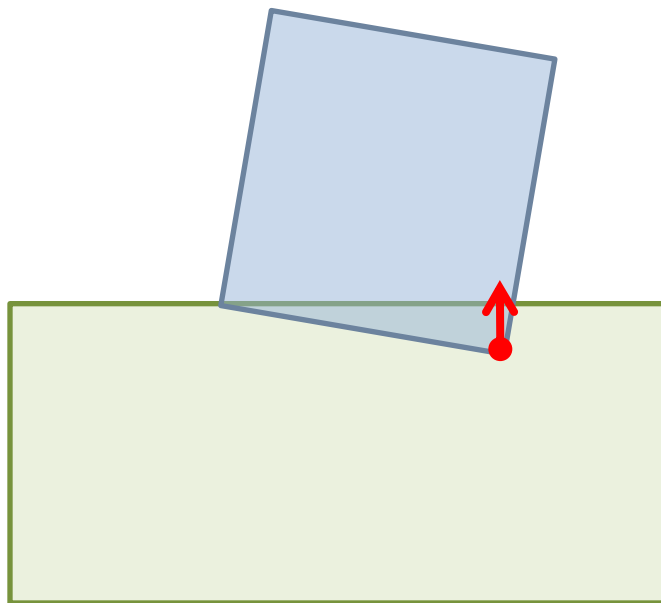
# Single contact point artifacts



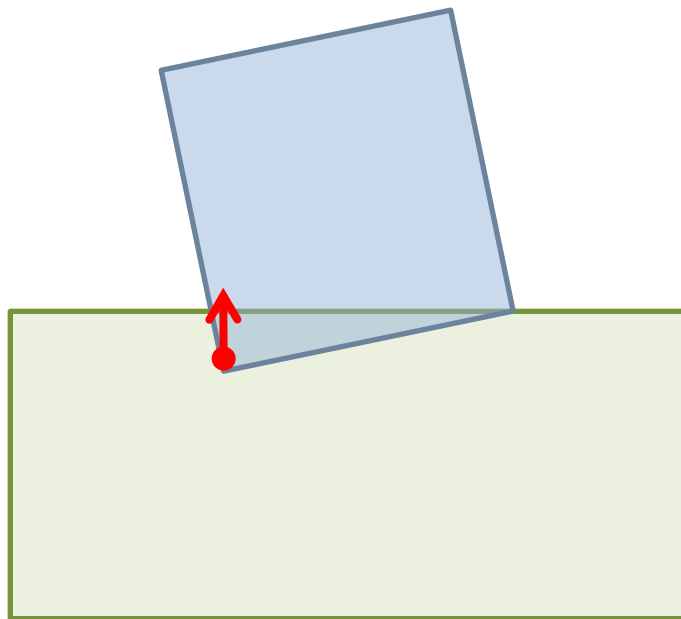
# Single contact point



# Single contact point



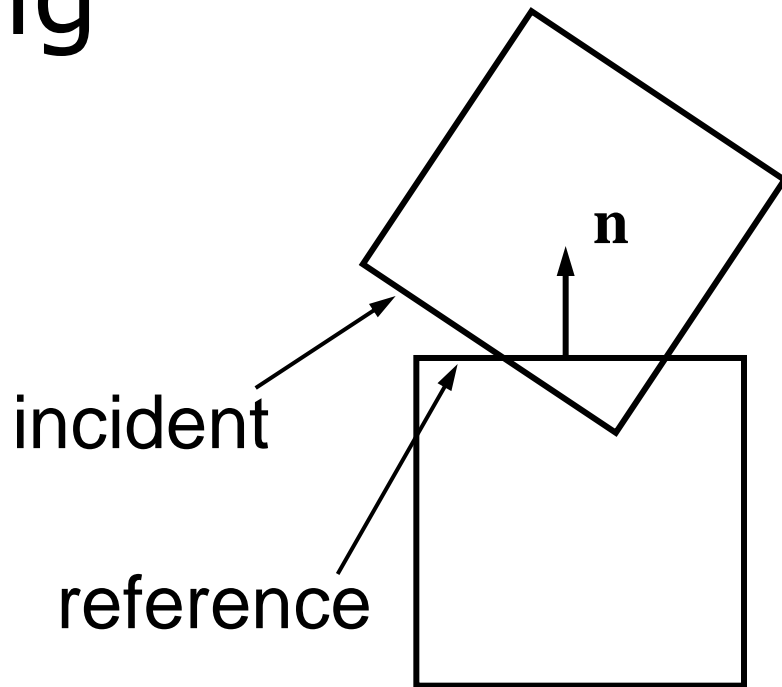
# Single contact point



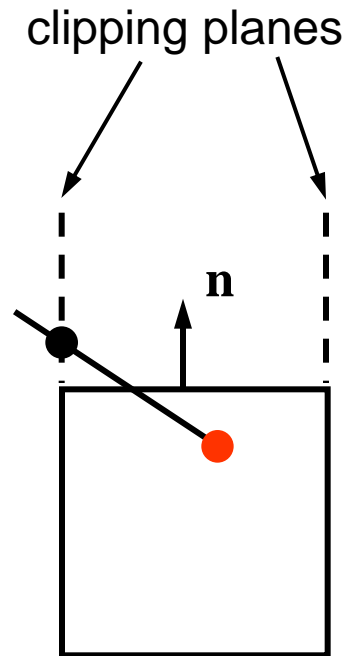
# Multiple contact points

- Feature clipping
- Persistent contact cache
- Perturbation to fill the contact cache

# Feature clipping



# Feature clipping

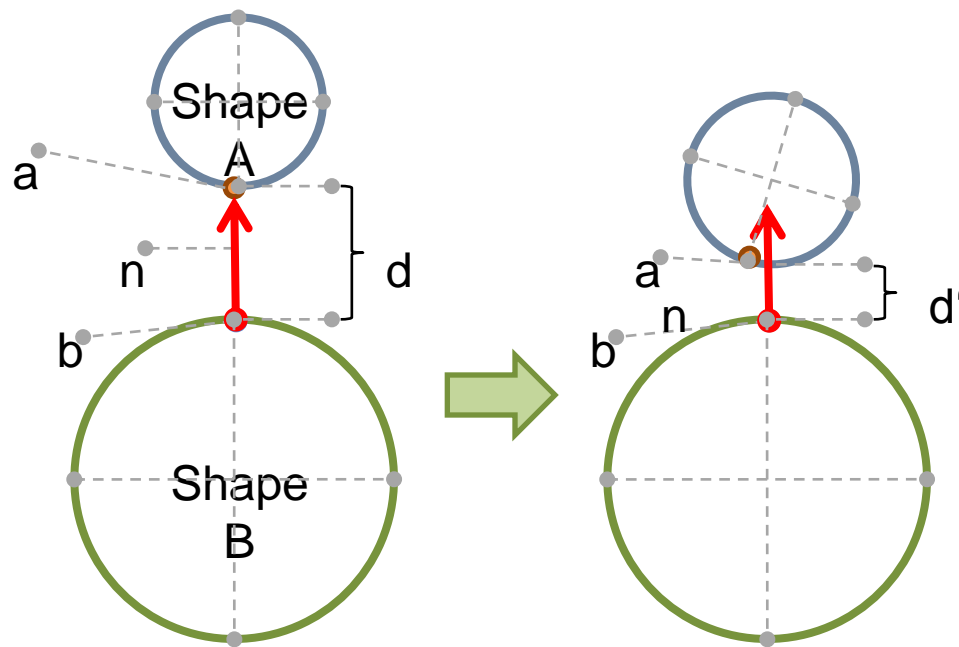


# Shapes without features?

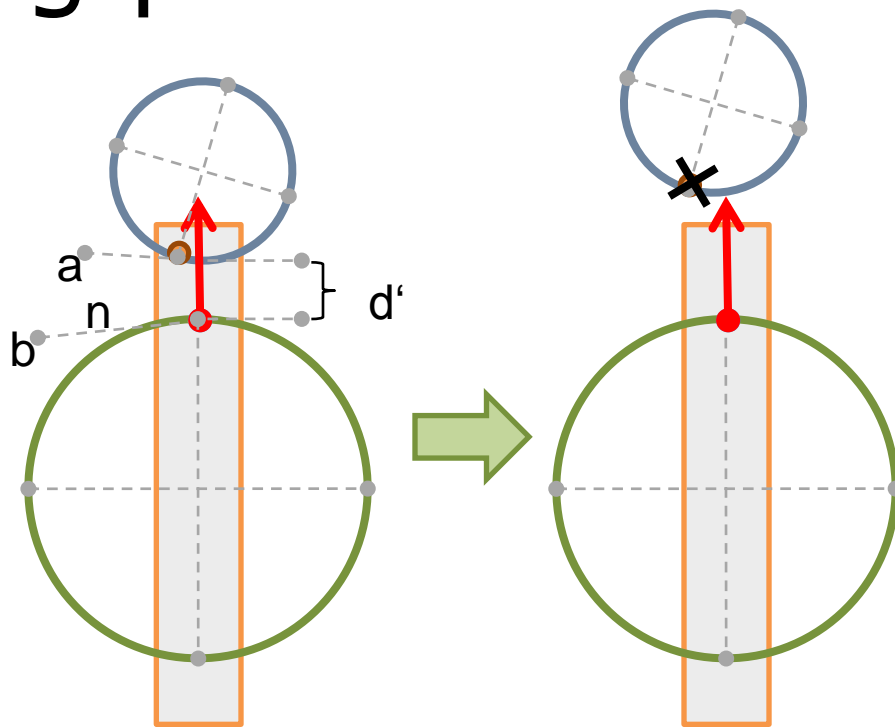
# Persistent Contact Cache

- Add a single point at a time to a cache
- Refresh cache, update or remove points

# Updating local contact points



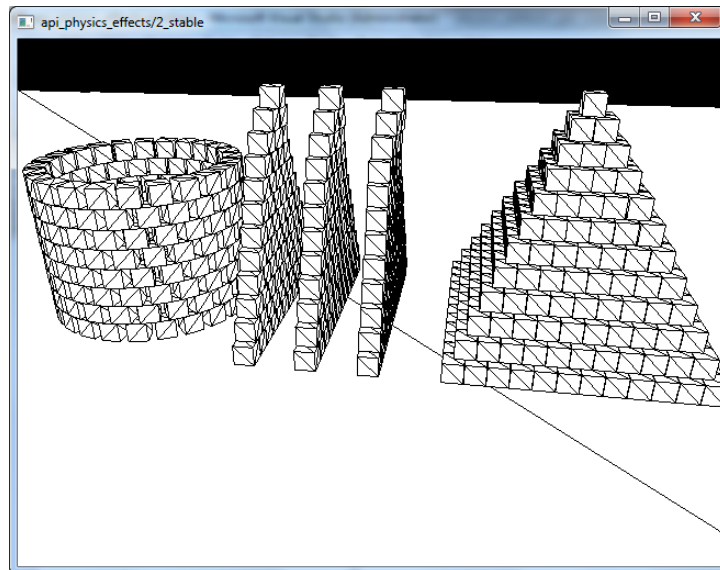
# Removing points



# Contact reduction

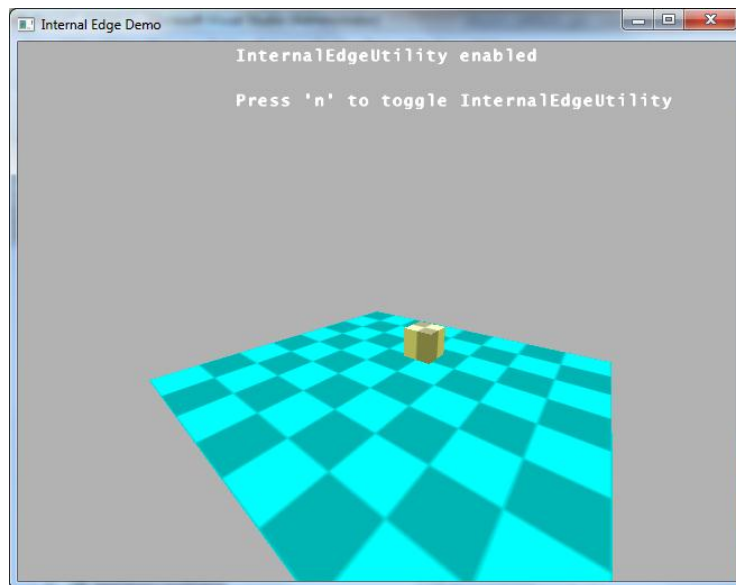
- Keep up to 4 contact points
- keep point with deepest penetration
- maximize area of the points

# Stable stacking

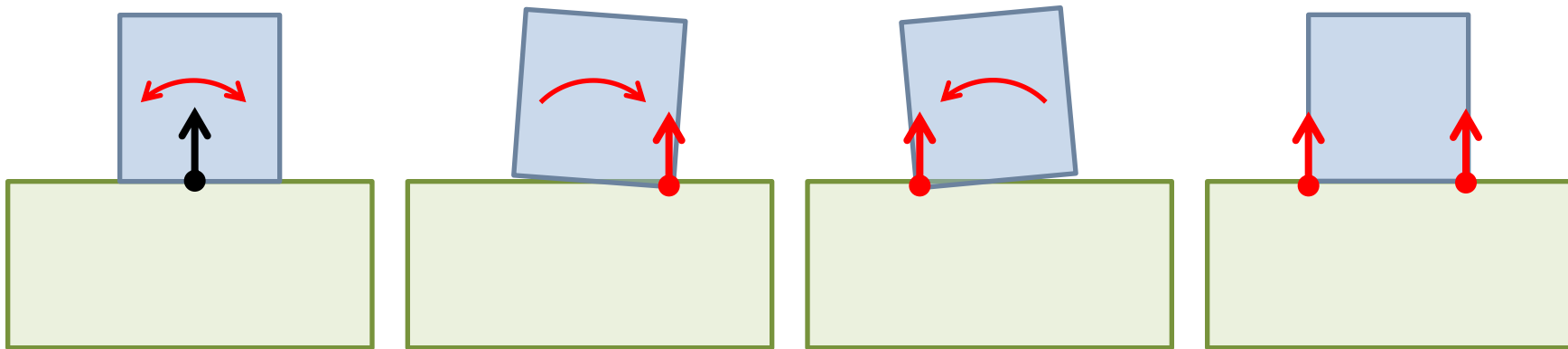


# contact caching artifacts

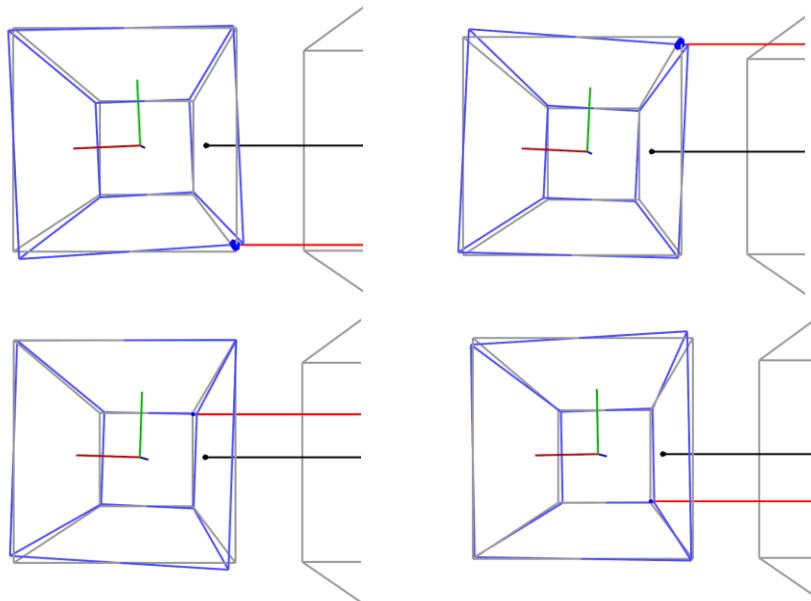
- ③ Sliding clears cache



# Perturbation



# Perturbation in 3D

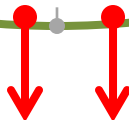


# Hybrid method

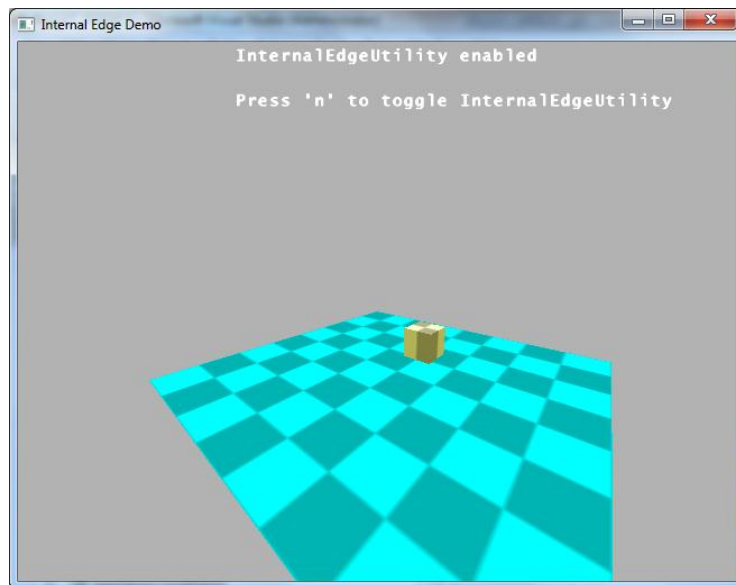
- Single shot manifold to build a full cache
- Only add a single point to a full cache
- Google for `btPersistentManifold`

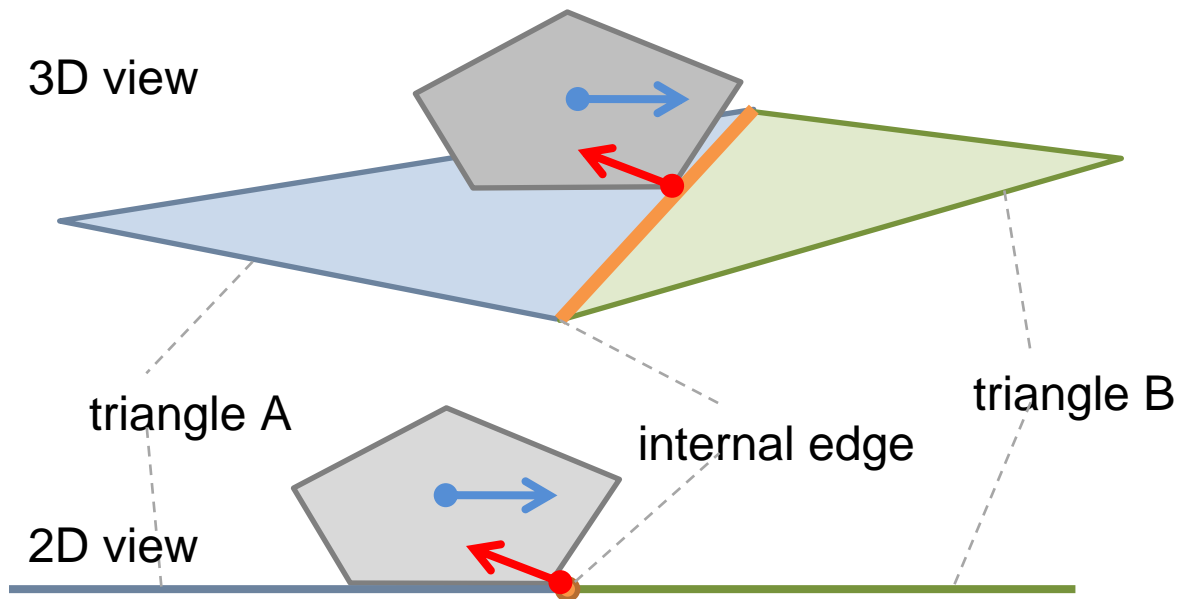
# Perturbation artifact

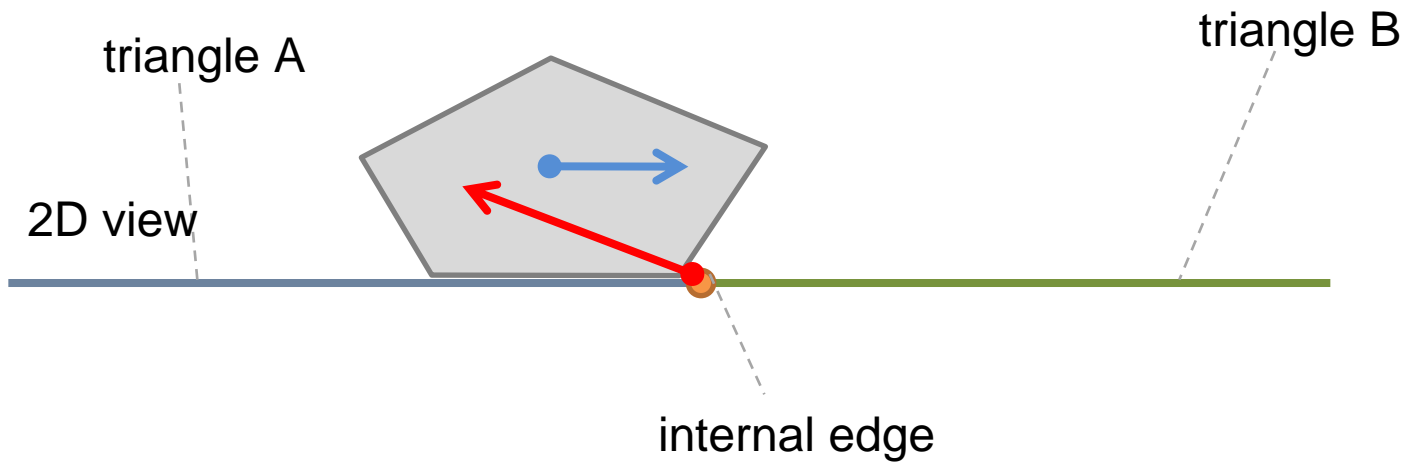
- Curved objects start rolling
- Use damping to prevent it

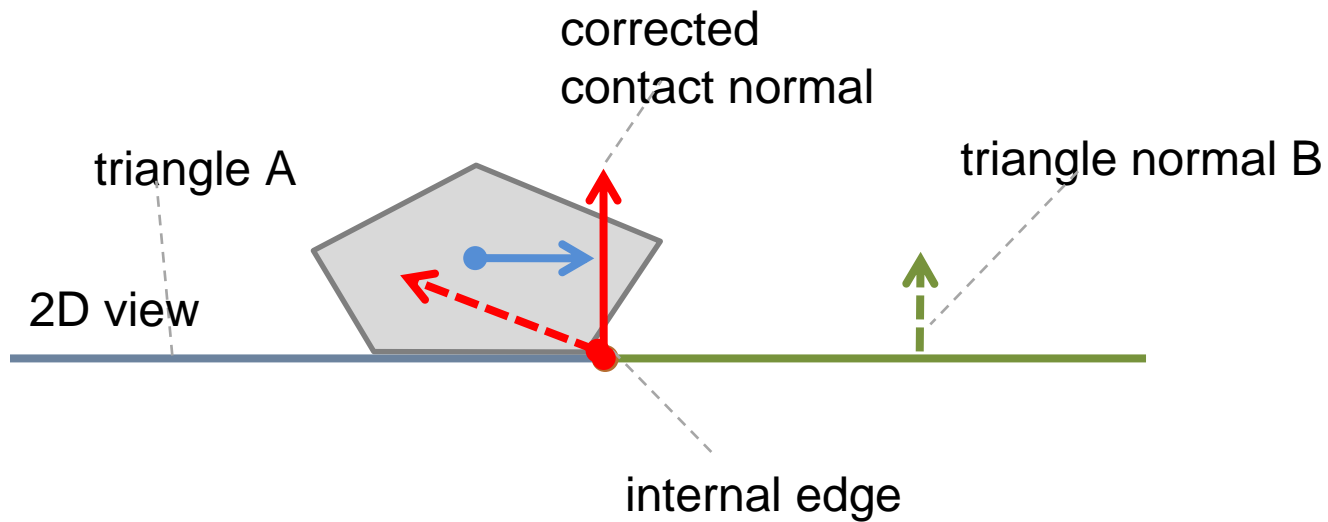


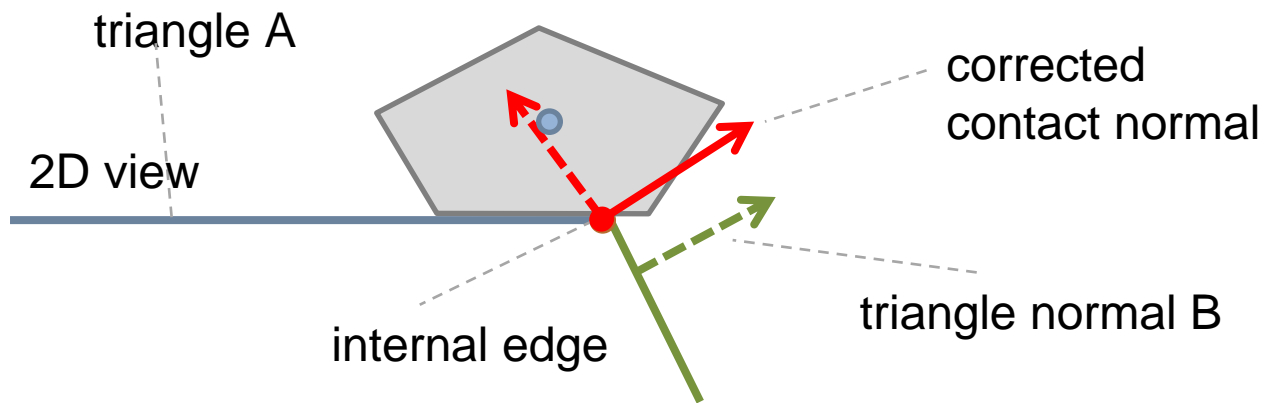
# internal edge artifacts

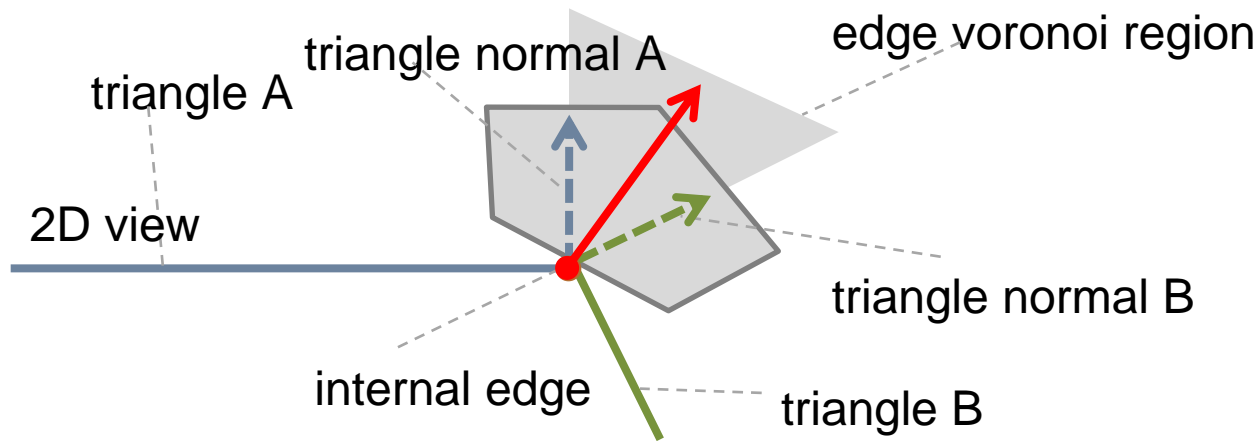


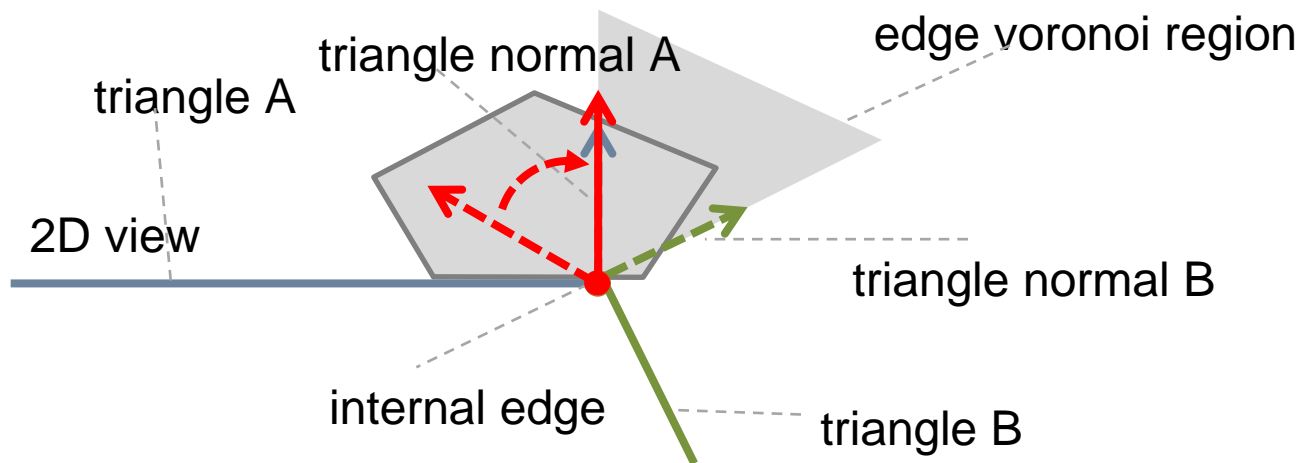








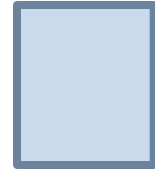
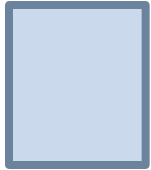




# Internal edges

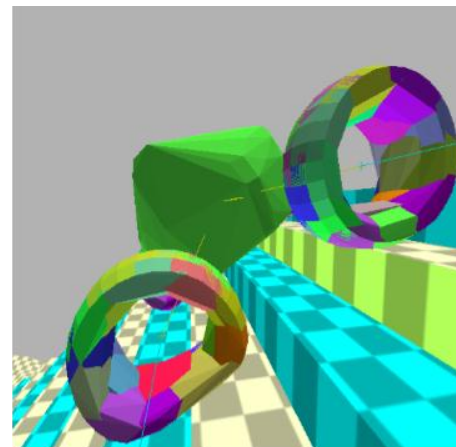
- Need to solve some more corner cases

# tunneling artifacts



# collision shape artifacts

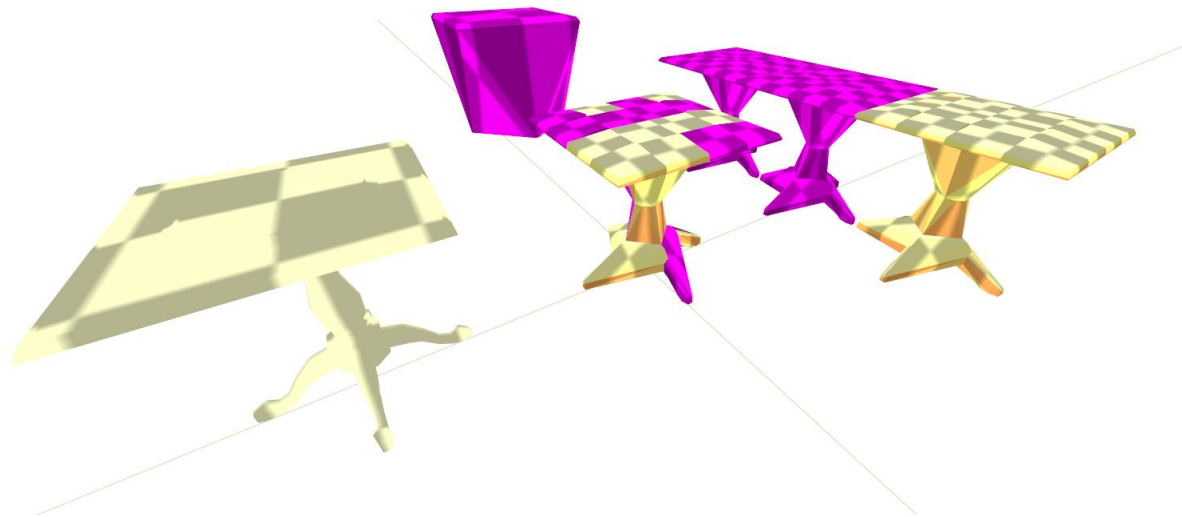
- Avoid concave triangle meshes
- Use visual debugging tools



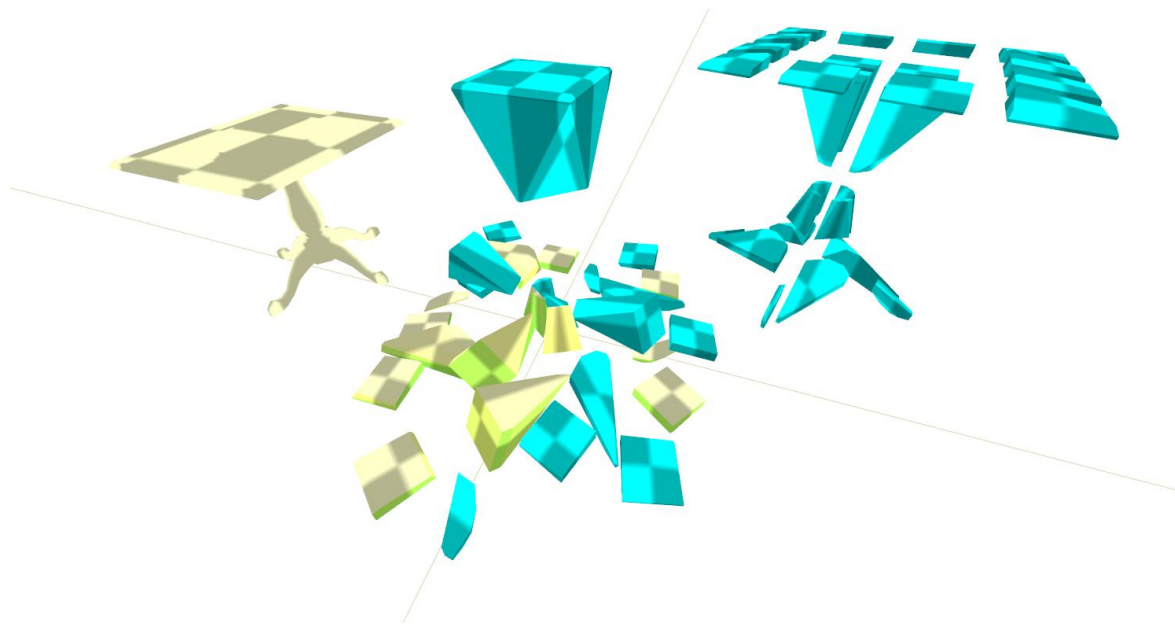
# shape scale artifacts

- large scale appears as slow motion
- avoid scaling, skew, shear in rigid transforms
- Use local scaling instead of global scaling

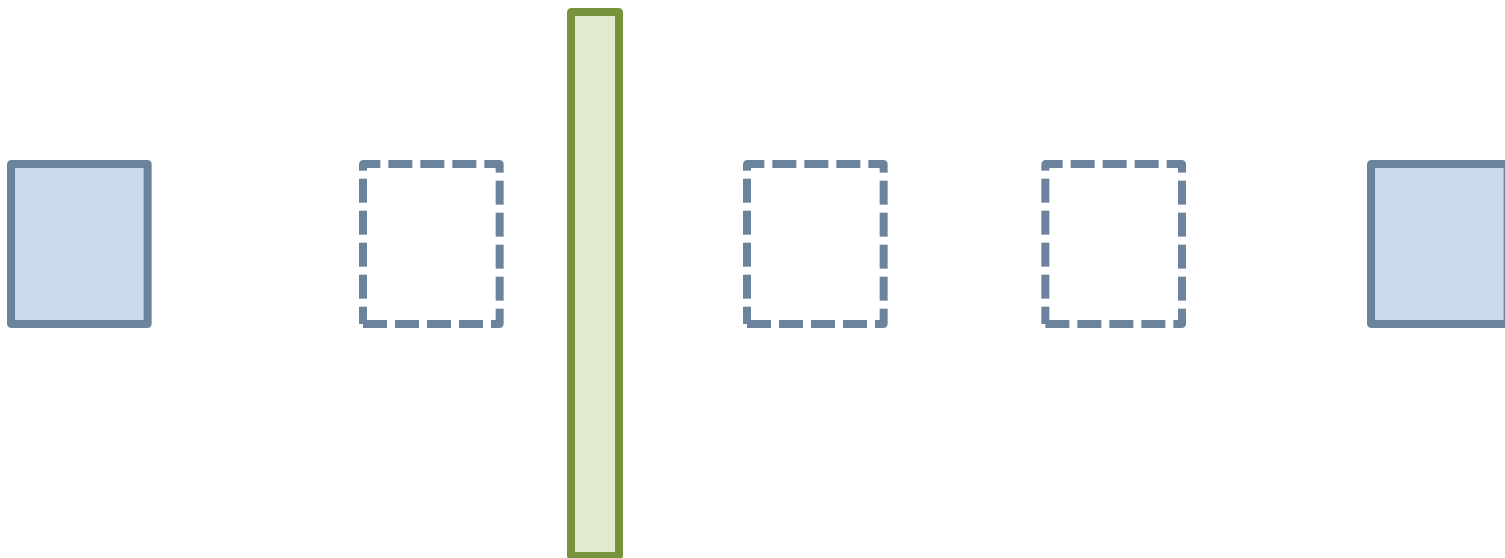
# Convex decomposition



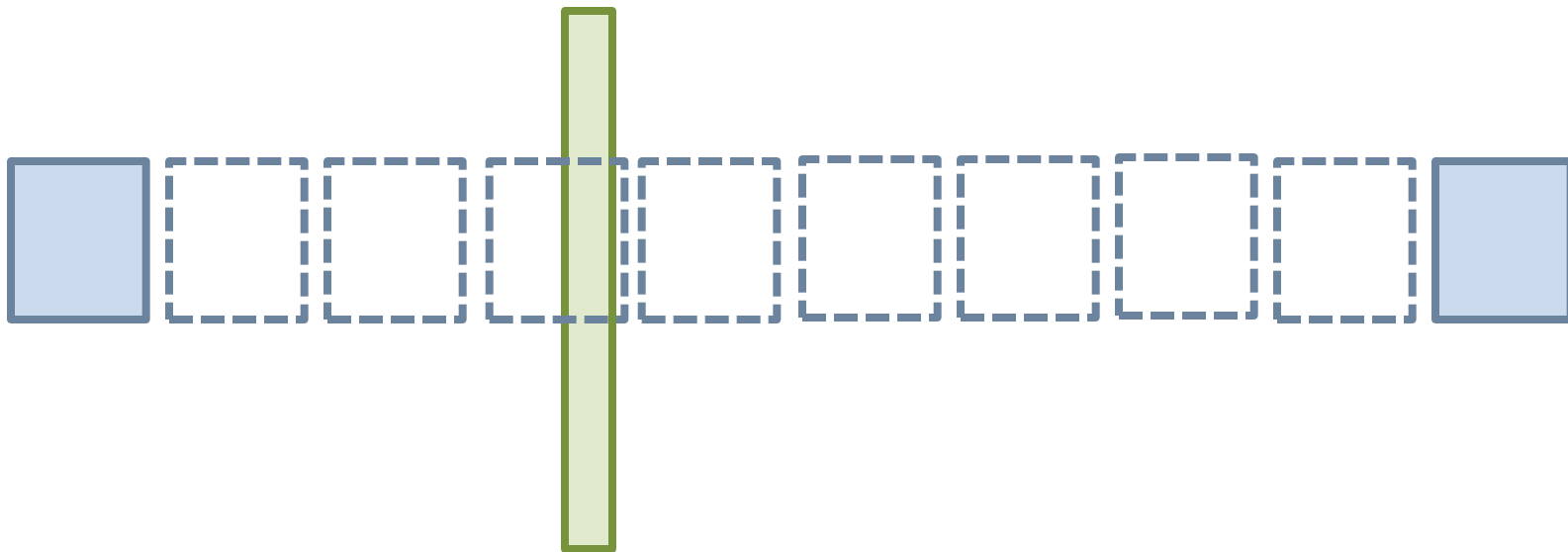
# Convex Decomposition



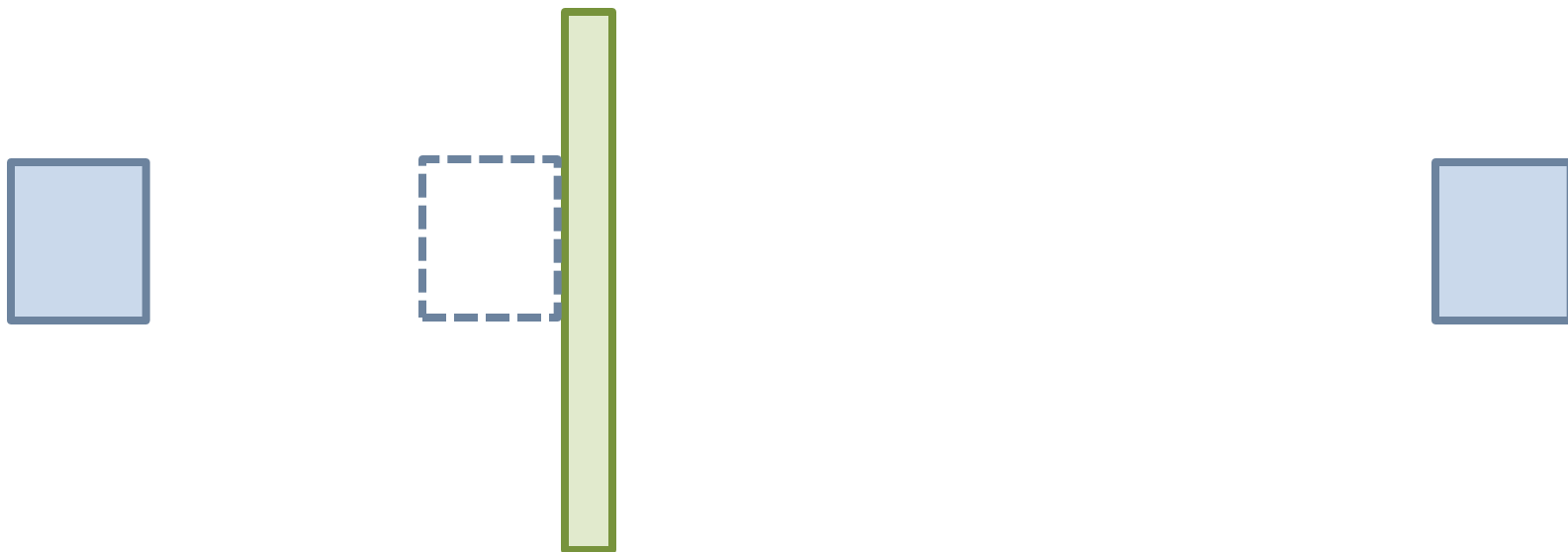
# Subdividing the time step



# Even smaller time steps

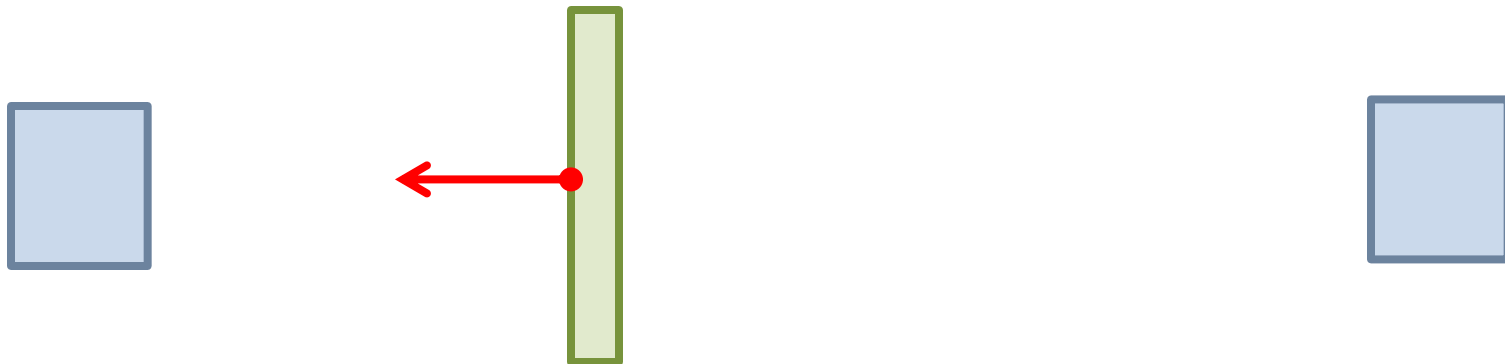


# Conservative Advancement



# Predictive contact constraints

- Add contact constraints using closest distance/points computation



# Predictive contact constraints

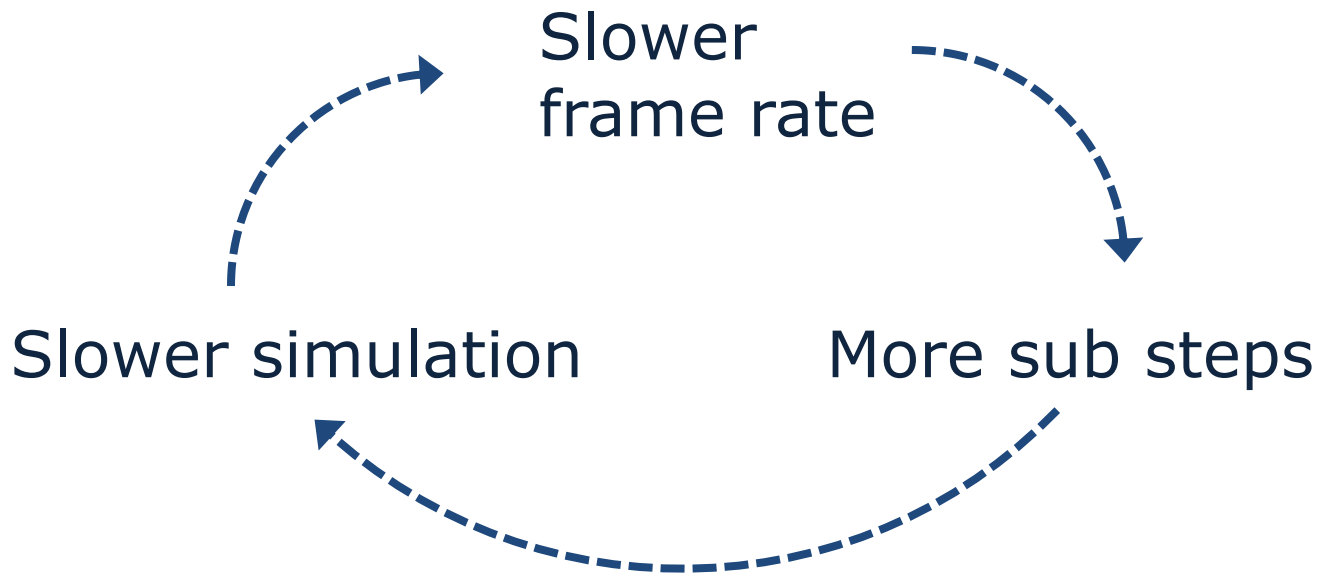
- The constraint solver will allow the object to move up to the given distance



# Fix your time step

- fixed time step versus variable timestep
- clamping causes slow-motion

# Well of despair



# mass ratio artifacts

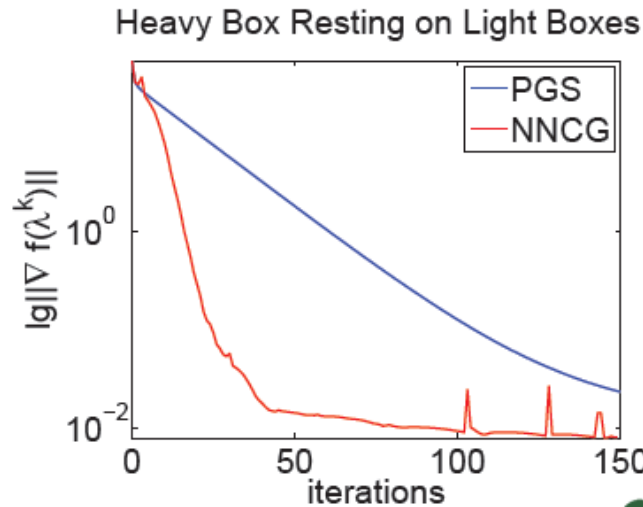
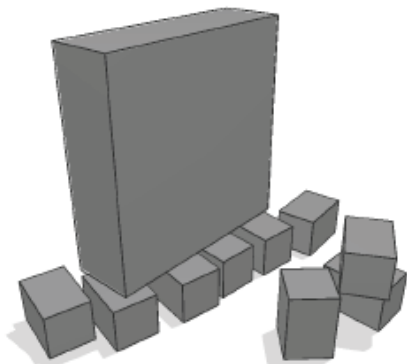
- pgs constraint solver doesn't handle it well
- heavy of top of light

# mass ratio artifacts

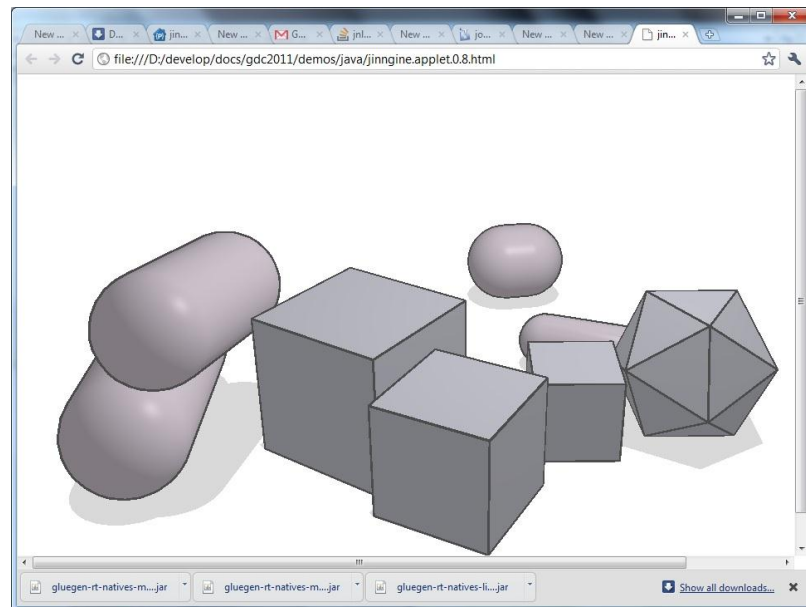
- Keep masses all very similar
- Promising research in NNCG method (quadratic convergence)

See <http://iphys.wordpress.com/> and <http://jinngine.googlecode.com>

# Non-smooth Non-linear Conjugate Gradient Method



# Jinngine NNCG java applet



# warm starting artifacts

- applied impulses are similar each frame, cache them
- full warm starting can add energy so scale it down
- assume that the configuration hardly change
- this assumption doesn't always hold, joint limits etc.

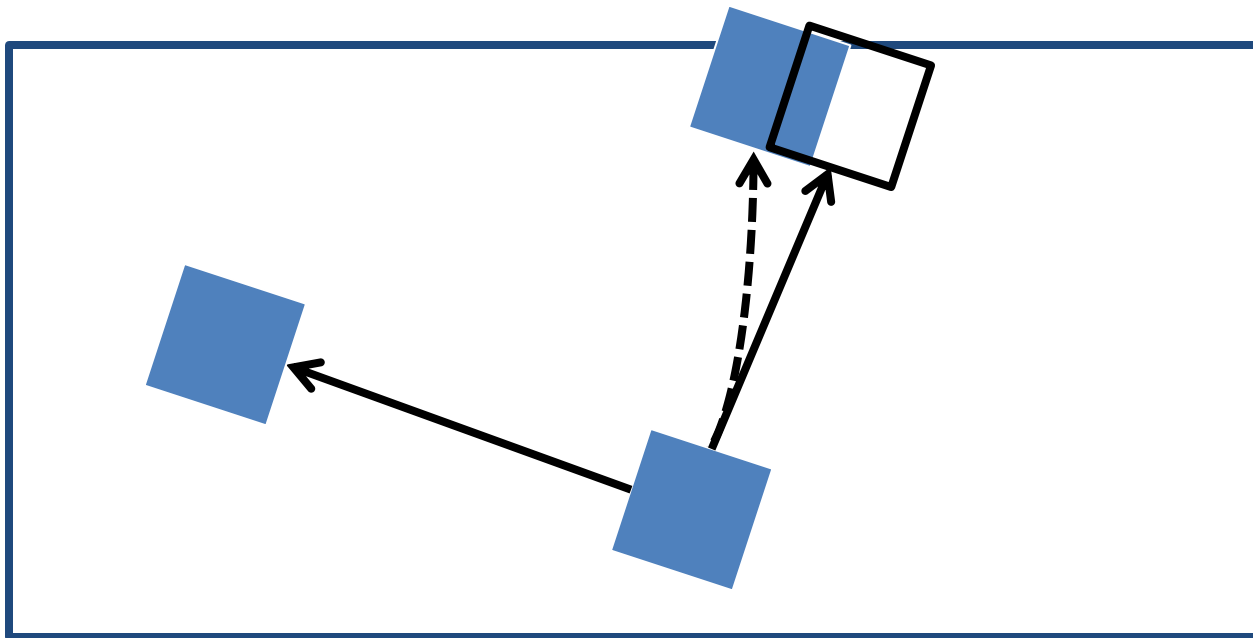
# constraint solving order artifacts

- complex interaction between various constraints
- randomizing can help convergence

# friction artifacts

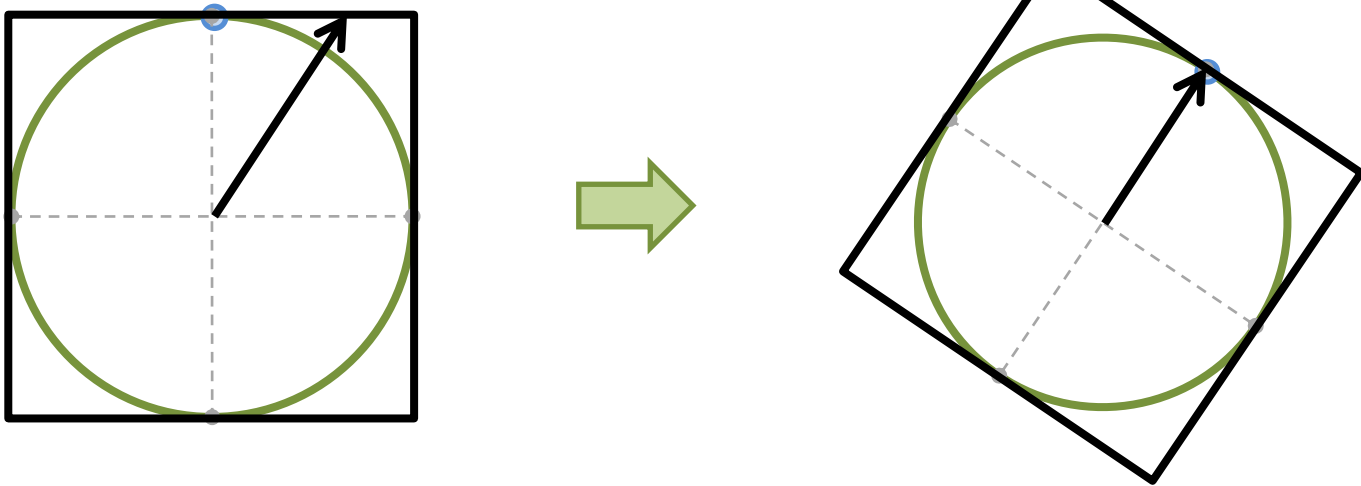
- coupled versus decoupled friction
- friction pyramid approximation
- clamping of friction directions
- friction and warm starting

# friction artifacts

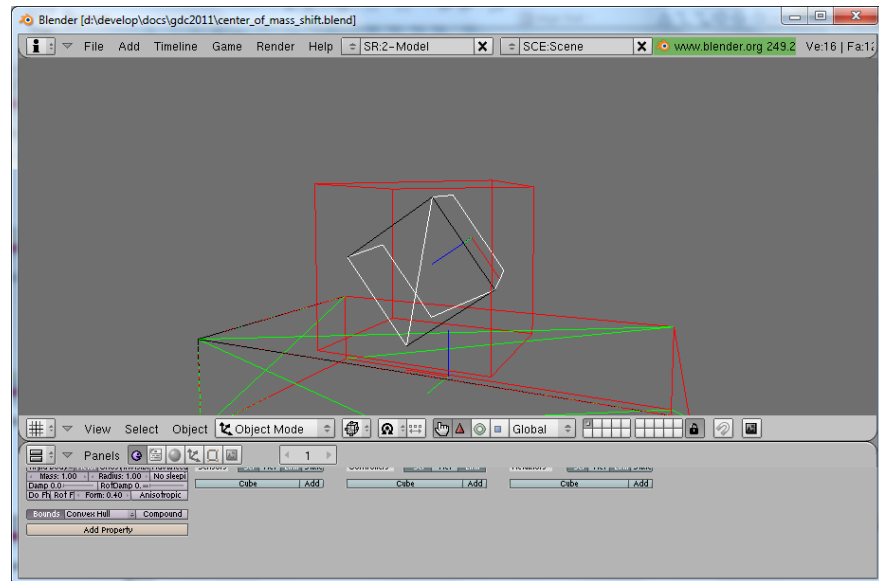


# Friction clamping artifact

- Use velocity direction as clamping axis



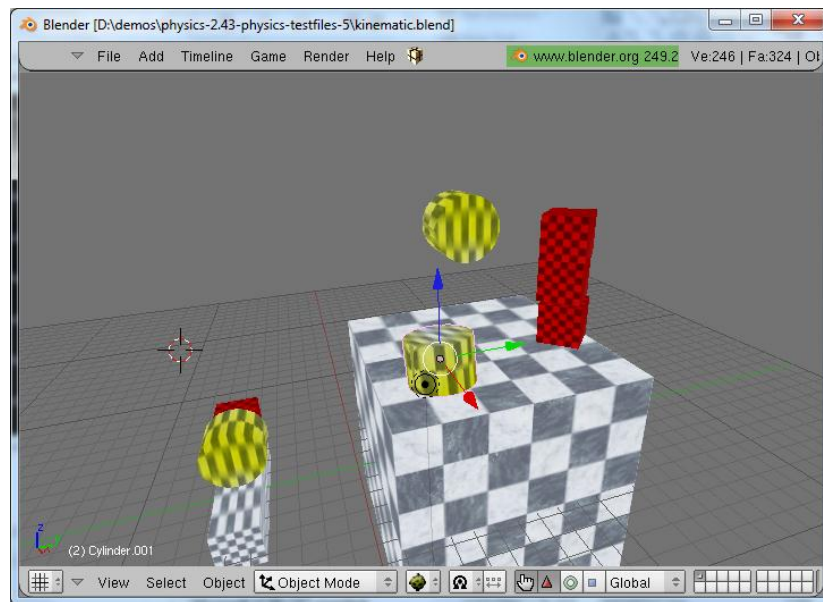
# center of mass artifacts



# Animated (kinematic) objects

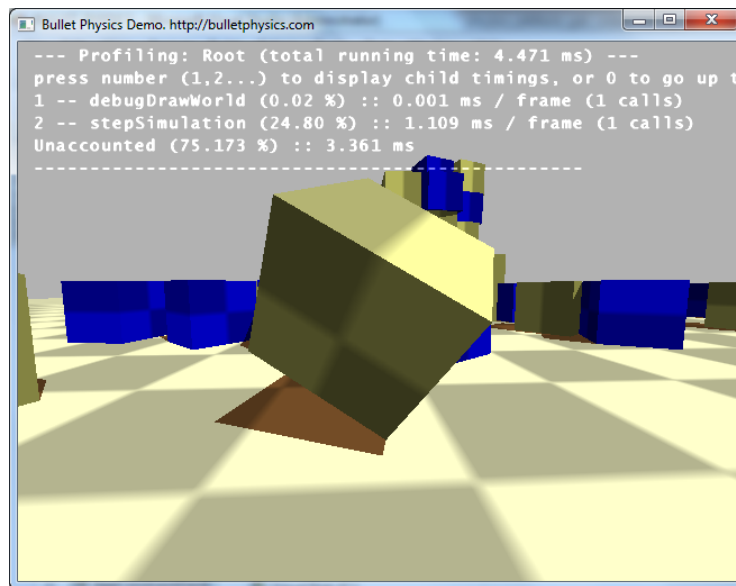
- also known as kinematic objects
- use infinite mass and inertia
- update the linear and angular velocity

# Animated (kinematic) objects



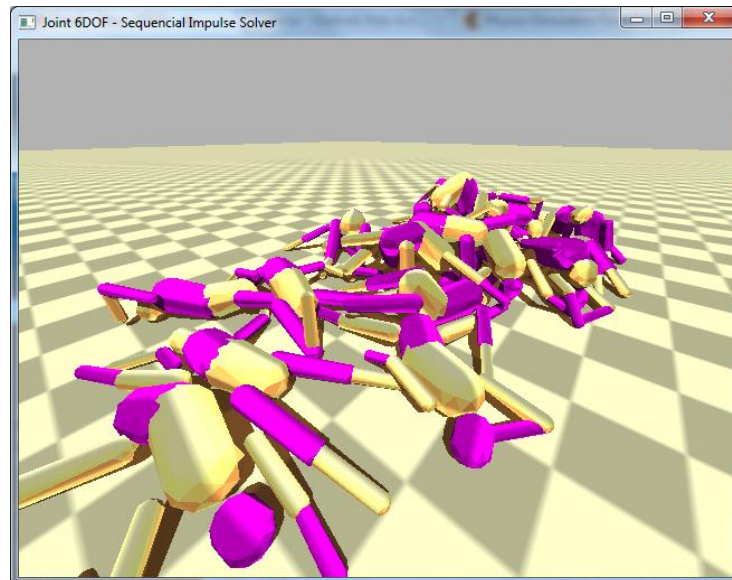
# inertia tensor artifacts

- objects don't rotate



# inertia tensor artifacts

- angular motion causing instability and jitter
- Shaking ragdoll limbs
- Increase inertia tensor
- Or aggressive deactivation



# References

- Game Physics Pearls, book by AK Peters (2010)
- <http://bulletphysics.org>
- <http://iphys.wordpress.com/>