Merging and Unmerging in Multi-Body Simulations

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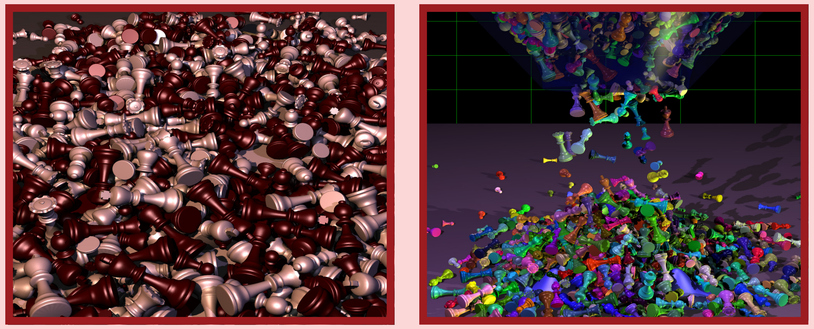
Problem: Too Many Contacts!



[Fast Frictional Dynamics, Kaufmen et. al., 2005]

>Collision Detection
- For each body!

>Collision Resolution
- For each contact!

Becomes slow for large number of contacting bodies...

Observation: Relative Motion

Sometimes, static friction makes two bodies move as one...

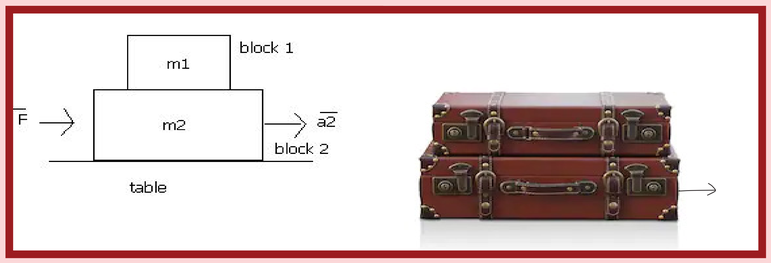


Figure 1: Contacting objects, when in motion, may sometimes predictably have near-zero relative velocity

Merging

If two bodies have:

> been in contact for N timesteps
> relative kin. energy/mass < threshold
> relative kin. energy monotonically decreasing

Bodies can be merged into “Rigid Collection”

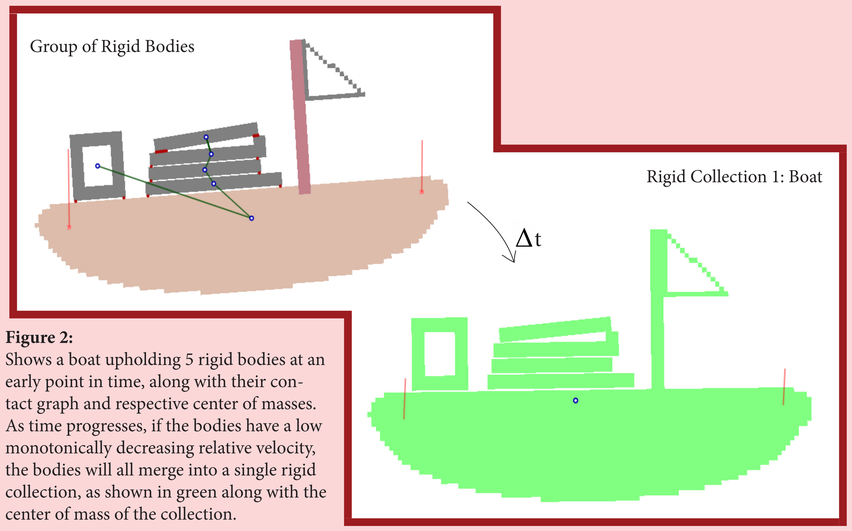


Figure 2:
Shows a boat upholding 5 rigid bodies at an early point in time, along with their contact graph and respective center of masses. As time progresses, if the bodies have a low monotonically decreasing relative velocity, the bodies will all merge into a single rigid collection, as shown in green along with the center of mass of the collection.

In a “Rigid Collection”:
> No need for collision detection b.w. sub-bodies
> Sub-bodies have the same speed
> Memory of contact locations
- And last N forces at each contact

Can Rigid Collections Exist Forever ?

Unmerging

Bodies could unmerge from Collections when:

> Applied external forces > threshold
- Causes stickiness/premature unmerging

> Opposing contact force required for immobility lies outside of static friction cone
- Requires quick solver to be useful

> Large change between old contact forces and current ones
-Needs quick solver + extra memory

> Neighboring body unmerges
- Recurse

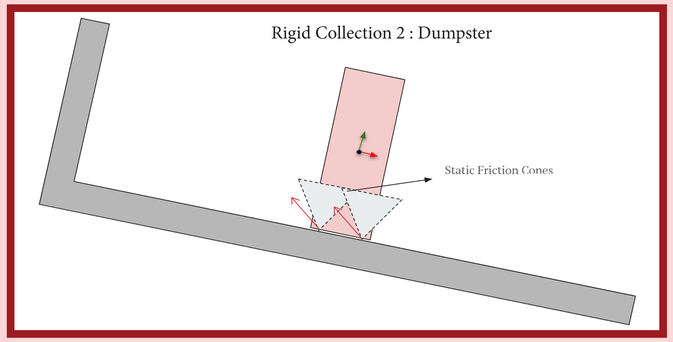


Figure 3: Shows a 2D representation of a dumpster. Assuming the two bodies are merged, because the contact force required for staticity (red arrows) lie outside of the friction cone, the red body should unmerge

Figure 4:
Shows 2 of our unmerging criteria.

Before the magnet activates, all bodies are immobile as one Rigid Collection. When the magnet activates on the first square body, we should determine that the new contact force lies outside of the friction cone (like in Figure 3), breaking the contact and unmerging the body.

Once that occurs, we should check all neighbors of the unmerged square to find the rectangular body who’s contact criteria is no longer met and should therefore also unmerge.