Sand Simulation

COMP 768 Project Proposal

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Motivation

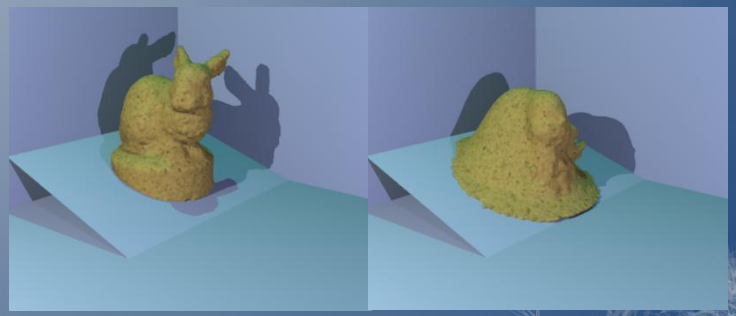
- Simulation of granular materials like sand
- Per-particle simulation expensive – Billions to trillions of particles in medium sized scenes
- Complex behavior – between solids, liquids and gases due to multi particle interaction
- Applicability to multiple types of natural scenarios
  - Sand
  - Avalanches
  - Granular materials

The Mummy

NSIDC

State-of-the-art

- Particle-Based Simulation of Granular Materials – Bell et al. (2005)
  - Approximate all objects as sphere agglomerates
  - Visually accurate behavior
  - Few hundred thousand particles only for at least 3min/frame
- Animating Sand as a Fluid – Zhu & Bridson (2005)
  - Modify commodity fluid simulator for sand
  - Macro-level behavior – no concept of separate grains, approximation
  - 6 seconds per frame for 100^3 grid



Desired Tasks

- Short term
  - Accurate physical model for sand simulation
    - Model all behavior – Pressure capped to a maxima
  - Hybrid model with multiple LOD
    - Fluid
    - Particles
  - Rendering improvements
- Long Term
  - Generalization to Granular material simulation w. multiple particle sizes

Ideas

- Use fluid model to begin with
- Better stress model
  - Handle pressure capping
- Look at unilateral incompressibility and LCP for modeling various behaviors $\rho \leq \rho_{\max}$
  - Sparse sand
  - Solid contact

Timeline

- April 7, 2009
  - Complete physical simulator with unilaterally incompressible sand and stress/friction model
  - Basic renderer (OpenGL/Blender/POVRAY/Renderman)
- May 6, 2009
  - Add LCP based contact handling
  - LOD for sand – Hybrid between fluids and particles
  - Improved renderer with better lighting

References

- Animating Sand as a Fluid, Zhu et al. (SIGGRAPH 2005)
- Particle Based Simulation of Granular Materials, Bell et al. (Eurographics 2005)
- Granular solids, liquids, and gases, Jaeger & Nagel (Reviews of Modern Physics, '96)
- Instability in the Evolution Equations Describing Granular Flow, Schaeffer (1985)
- The Material Point Method for Granular Materials, Bardenhagen et al. (Comput. Methods Appl. Mech. Engrg, 2000)
- Two dimensional Lagrangian particle finite-difference method for modeling large soil deformations, Konagai & Johannson (Structural Eng./Earthquake Eng, 2001)
- Mechanics of Materials, Third Edition, Gere & Timoshenko (For basic physics reference)