

Discrete Element Modeling

Possibilities in Open Source

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Overview:

- Bullet on CPU/GPU
- DualSPHysics – SPH on CPU/GPU
- Yade DEM
- Blender

Bullet

- Physics engine for computer graphics
- Developed by Erwin Coumans – currently at Google
- Example
 - Real-time simulation
 - Run on GPU
- <http://bulletphysics.org/wordpress/>

Bullet

- Modular extensible C++ design
- Library only, not software package
- Optimized backends for pthreads/Win32 Threads (CPU)
- The entire collision detection and rigid body dynamics can be executed on the GPU (OpenCL)

DualSPHysics

- Collaborative effort
 - University of Vigo
 - University of Manchester
 - Johns Hopkins University (SPHysics)
- Examples
 - Visualization with Paraview
 - GPU runs ~6x faster than parallel CPU, ~45x Serial
 - <https://www.youtube.com/watch?v=pnLTWUk6wPc>
- <http://www.dual.sphysics.org/>

DualSPHysics

- Complete package, but can modify and rebuild
- SPH formulation to solve Navier-Stokes equations
- Same particle structure for DEM, but use non-linear Hertzian model for interactions
- Code can be run either on CPU or GPU
 - OpenMP CPU implementation
 - CUDA GPU implementation
- Visualization/post-processing in Paraview, but can make it shiny in Blender

Yade

(Yet Another Dynamic Engine)

- Developed at the University of Grenoble
- Has been coupled with FEM, PFV, LBM
- Examples
 - <https://www.youtube.com/watch?v=TWDIf0RINCU>
 - <https://www.youtube.com/watch?v=mBjnNnKskhg>
 - <https://www.youtube.com/watch?v=gH585XaQEcY&feature=youtu.be>
- <https://yade-dem.org/doc/>

Yade

(Yet Another Dynamic Engine)

- Complete package, but can modify and rebuild
- Extensible framework focused on DEM
- Computational portions in C++ using flexible object model
 - Independent implementation of new algorithms and interfaces
- Python interface to scene construction, simulation control, post-processing & debugging
- Parallel implementation using OpenMP

Blender

- 3-D animation suite
- Primarily for rendering and some preprocessing (DualSPHysics)
- Examples
 - <https://www.youtube.com/watch?v=OBzBfhrjx5s>
 - https://www.youtube.com/watch?v=anEv_1DN2dk
- <http://www.blender.org/>

Blender

- 3-D Animation Suite
- Already uses Bullet to do rigid body interactions
 - Would need to expand complexity of element interactions
- Models can be imported to DualSPHysics
 - Complex geometry can be constructed quickly

Overview

	Parallel Capability	Modeling Framework	Documentation
Bullet	CPU/GPU	DEM	Minimal
Dual-SPHysics	CPU/GPU	DEM & SPH	Best
Yade	CPU	DEM, FEM*, PFV*, LBM*	Best
Blender	CPU*	DEM*	Excellent

Next Steps?

- Expand capabilities of current open source packages
 - Yade and DualSPHysics are better options
- Develop own open source package?
 - Framework
 - Apache Spark?

Thank you
Questions?