Reference List for 15-464 / 15-664 Feb 27, 2017

The first thing we did was talk through MiniProject2. One possible focus of this second project is to explore cloth simulation.

A description of how to do basic spring-mass cloth is given on this page:

http://www.cs.cmu.edu/~15464-s13/assignments/assignment3/assignment%203%20description.htm

Many cloth simulation systems are based on this central idea. If you really want to get a spring mass cloth simulation right, my favorite reference is this one. Features to look into include (1) how collisions (including self collisions) are handled by applying impulses to the cloth particles so that these collisions are never allowed to happen and (2) how impulses are similarly applied for "strain limiting" so that the cloth never stretches beyond a desired amount.

Bridson R, Fedkiw R, Anderson J. Robust treatment of collisions, contact and friction for cloth animation. ACM Transactions on Graphics (ToG). 2002 Jul 1;21(3):594-603. http://dl.acm.org/citation.cfm?id=566623

The integrator you choose can determine cloth behavior, and we talked about a variety of integrators to compare, including Euler, RK4, and various semi-implicit techniques. It is possible to develop a fully implicit integrator for cloth, and that is the subject of this paper:

Baraff D, Witkin A. Large steps in cloth simulation. InProceedings of the 25th annual conference on Computer graphics and interactive techniques 1998 Jul 24 (pp. 43-54). ACM. http://dl.acm.org/citation.cfm?id=280821

If you want cloth to contact the environment, you have a choice of many contact methods. We talked through the penalty based method in this paper, specifically taking a glance at how it handles friction, which is tricky for penalty based methods:

Yamane K, Nakamura Y. Stable penalty-based model of frictional contacts. In Robotics and Automation, 2006. ICRA 2006. Proceedings 2006 IEEE International Conference on 2006 May 15 (pp. 1904-1909). IEEE. http://ieeexplore.ieee.org/abstract/document/1641984/

My favorite paper at the moment for setting up and solving the Linear Complementarity Problem is this one:

Jain S, Liu CK. Controlling physics-based characters using soft contacts. InACM Transactions on Graphics (TOG) 2011 Dec 12 (Vol. 30, No. 6, p. 163). ACM.
http://dl.acm.org/citation.cfm?id=2024197

One problem with spring mass systems is that it can be difficult to set parameters for realistic appearance and to illustrate the different properties of different types of cloth. This paper attempts to set parameters by optimizing to fit measurements taken on actual cloth swatches.

Wang H, O'Brien JF, Ramamoorthi R. Data-driven elastic models for cloth: modeling and measurement. InACM Transactions on Graphics (TOG) 2011 Aug 7 (Vol. 30, No. 4, p. 71). ACM. http://graphics.berkeley.edu/papers/Wang-DDE-2011-08/

I showed a constraint based system to contrast to these various spring mass driven cloth systems. The writeup can be found here: http://www.cs.cmu.edu/~ytoh/stickyfingers.pdf

Videos can be seen here: http://www.kentoh.com/publications/

Another theme of class was to overview some of the simulation engines that are available, especially for rigid bodies.

I showed a comparison of simulators that we did recently, and the writeup can be found in the following paper. One nice thing about this paper is that it shows what simulator parameters we found to work best for our test simulations (to best match an analytical solution for a cube rolling downhill).

Chung SJ, Pollard N. Predictable behavior during contact simulation: a comparison of selected physics engines. Computer Animation and Virtual Worlds. 2016 May 1;27(3-4):262-70.

http://graphics.cs.cmu.edu/nsp/papers/ChungCAVW2016.pdf

http://onlinelibrary.wiley.com/doi/10.1002/cav.1712/full

We talked about:

- Bullet http://bulletphysics.org/wordpress/ and you may find this SIGGRAPH course of interest: http://bulletphysics.org/siggraph2011/michael_siggraph2011.pdf
- Karen Liu's RTQL8 http://www.cc.gatech.edu/~karenliu/RTQL8.html and the valuable writeups available on that web page if you want to learn more about the dynamics of articulated characters and how these simulators are written.
- Karen Liu's DART http://dartsim.github.io/index.html which is a follow-on to RTQL8.
- Emo Todorov's MuJoCo http://www.mujoco.org/ which was developed at least partially with the goal of doing optimization of motions that include many contacts.
- Box2D http://box2d.org/about/ which does very well with 2D simulations
- Gazebo http://gazebosim.org/ which has options for using different simulation engines
- FleX https://developer.nvidia.com/flex which is entirely particle based.
- I also mentioned ARCSim for cloth simulation http://graphics.berkeley.edu/resources/ARCSim/ More on this next time!