

Reference List for 15-464 / 15-664 Feb 18, 2019

These course notes are an excellent introduction to writing a physically based simulator:

Andrew Witkin and David Baraff, "Physically Based Modeling: Principles and Practice," Siggraph '97 Course notes. <http://www.cs.cmu.edu/~baraff/sigcourse/>

We talked about how to simulate particles and how to extend a particle simulation into a spring/mass cloth simulation. 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. In Proceedings 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>

This paper has a good practical discussion about different integrators and discusses the design decisions behind Maya nCloth, nParticle, etc.

Stam, Jos. "Nucleus: Towards a unified dynamics solver for computer graphics." In *Computer-Aided Design and Computer Graphics, 2009. CAD/Graphics' 09. 11th IEEE International Conference on*, pp. 1-11. IEEE, 2009. <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5246818>

You can find a clear writeup about the spring mass system's behavior and a reminder for how to solve those differential equations here. Reading this paper may help you to set damping parameters in a correct proportion to how you set stiffnesses.

Allen, Brian F., and Petros Faloutsos. "Misconceptions of PD control in animation." In *Proceedings of the ACM SIGGRAPH/Eurographics Symposium on Computer Animation*, pp. 231-234. Eurographics Association, 2012. <http://dl.acm.org/citation.cfm?id=2422389>

We talked about techniques for resolving contact and collisions. I mentioned a paper on how to do penalty method forces "right." This is the paper:

Xu, Hongyi, Yili Zhao, and Jernej Barbič. "Implicit multibody penalty-based distributed contact." *IEEE transactions on visualization and computer graphics* 20, no. 9 (2014): 1266-1279.
<http://ieeexplore.ieee.org/document/6767148>

We talked about this paper, which talks about particle simulation with constraints and Verlet integration in the context of simulating rag doll characters for the game Hitman.

Jakobsen, Thomas. "Advanced character physics." In Game Developers Conference, pp. 383-401. 2001.
<http://www.gotoandplay.it/articles/2005/08/advCharPhysics.php>

I also showed some videos from a constraint based cloth simulation system written by a CMU MS student. The writeup can be found here: <http://www.cs.cmu.edu/~ytoh/stickyfingers.pdf>

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

Check out the following paper for an overview of point based methods in general for simulation.

Macklin, Miles, Matthias Müller, Nuttapong Chentanez, and Tae-Yong Kim. "Unified particle physics for real-time applications." *ACM Transactions on Graphics (TOG)* 33, no. 4 (2014): 153.
<https://dl.acm.org/citation.cfm?id=2601152>

Some Simulation References

Fortunately, there are many good simulation engines out there. You do not have to write your own! Here are some references to get you started.

Open Dynamics Engine <http://www.ode.org/>

Bullet Physics Library <http://bulletphysics.org/wordpress/>

Also check out this SIGGRAPH 2011 course: <http://bulletphysics.org/siggraph2011/>

Karen Liu's RTQL8 <http://www.cc.gatech.edu/~karenliu/RTQL8.html>

Karen Liu's DART <http://dartsim.github.io/>

Emanuel Todorov's MuJoCo has apparently not yet been released? <http://www.mujoco.org/>

Box2D <http://box2d.org/>

Gazebo <http://gazebo-sim.org/>