15-464/15-664 Reference List for April 3 2023

PIC, FLIP, and APIC

Today we began to talk about modern fluid simulation techniques that mix Eulerian and Lagrangian approaches. PIC and FLIP methods involve switching between grid based and particle based representations to try to combat dissipation that occurs due to using a grid for advection (although as we saw, PIC introduces even more dissipation and smoothing!). These techniques are well discussed in these course notes and slides:

SIGGRAPH 2007 course: Robert Bridson and Matthias Müller-Fischer, "Fluid Simulation for Computer Animation" http://www.cs.ubc.ca/~rbridson/fluidsimulation/

In particular, take a look at this short slide deck on combatting dissipation:
https://www.cs.ubc.ca/~rbridson/fluidsimulation/CombatingDissipation.ppt

The APIC method attempts to conserve affine transformations in the mapping to and from particles and is covered in this paper:

Jiang, Chenfanfu, Craig Schroeder, Andrew Selle, Joseph Teran, and Alexey Stomakhin. "The affine particle-in-cell method." *ACM Transactions on Graphics (TOG)* 34, no. 4 (2015): 51.
https://dl.acm.org/citation.cfm?id=2766996
https://vimeo.com/159438315

This website contains an APIC course project that may be of interest. (There may be more recent versions of it -- I did not do a complete search.)
http://graphics.stanford.edu/courses/cs348c/PA3_APIC2017/index.html

Material Point Method

That brought us to the material point method, which were initially designed as an extension of the PIC/FLIP type solvers to handle not only fluids, but solids – famously introduced to Computer Graphics in the following Material Point Snow paper.

Stomakhin, Alexey, Craig Schroeder, Lawrence Chai, Joseph Teran, and Andrew Selle. "A material point method for snow simulation." *ACM Transactions on Graphics (TOG)* 32, no. 4 (2013): 1-10.
https://disneyanimation.com/publications/a-material-point-method-for-snow-simulation/
https://vimeo.com/160322962

MPM has since then been applied with success to simulate many and varied effects. This tutorial provides an advanced introduction, along with links to the famous 88-line Taichi code for MPM:

Hu, Yuanming, Xinxin Zhang, Ming Gao, and Chenfanfu Jiang. "On hybrid lagrangian-eulerian simulation methods: practical notes and high-performance aspects." In *ACM SIGGRAPH 2019 Courses*, pp. 1-246. 2019. https://yuanming.taichi.graphics/publication/2019-mpm-tutorial/

There is also an earlier course that you may find useful:

Jiang, Chenfanfu, Craig Schroeder, Joseph Teran, Alexey Stomakhin, and Andrew Selle. "The material point method for simulating continuum materials." In *Acm siggraph 2016 courses*, pp. 1-52. 2016. https://www.math.ucla.edu/~cffjiang/research/mpmcourse/mpmcourse.pdf