We will begin with a look at some beautiful recent research on Eulerian solvers for fluids. These papers build on exactly the Eulerian techniques we have been studying, but utilize an interesting trick to minimize dissipation during the projection step. Recall that the projection step is where we modify pressures to make the fluid conserve mass, i.e., to make it divergence free. This step typically has resulted in loss of energy, damping out the fluid and making it less interesting. These papers provide a solution.


In fact, most of the research in fluids over the years has been built around trying to reduce dissipation and preserve fluid detail. This paper asks whether we can see the difference between various methods and which technique may be best in terms of perceptual accuracy. You can see the comparisons that they present to users in the associated video.


We can take a look at the various fluid simulation approaches which they compare.

MP and LS methods are due to Nick Foster’s Eulerian approach, which we explored over the last week, with LS indicating a level set method to smooth out and track the fluid surface. As a reminder, here is the paper we examined last Wednesday that introduced the MP / LS method.


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 will see PIC just introduces more dissipation and smoothing!). These techniques are well discussed in these course notes and slides:


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

https://vimeo.com/159438315

WCSPH and IISPH try to solve the problem of simulating incompressibility in SPH fluid simulations efficiently and are covered in the following papers.


Fluid control

Aside from making fluid more realistic, there are other things we may wish to do. For example, how do we coerce a fluid into going where we want it to go or into taking on keyframes? The go-to references for this topic are the first two, while the third shows an extension by previous 15-464 students.


Fluids Motion Capture

Some researchers have tried to use real-world images or 3D point clouds to help guide a simulation, in a form of motion capture for fluids. Here are some examples:


**SIGGRAPH 2013 course**

You may find this course interesting:


**Heightfields**

Heightfields are an old and standard technique to produce water that is relatively calm (think of pond ripples or an ocean away from the shore).


Here is a good explanation of a heightfield technique: