Material Point Methods in the Browser

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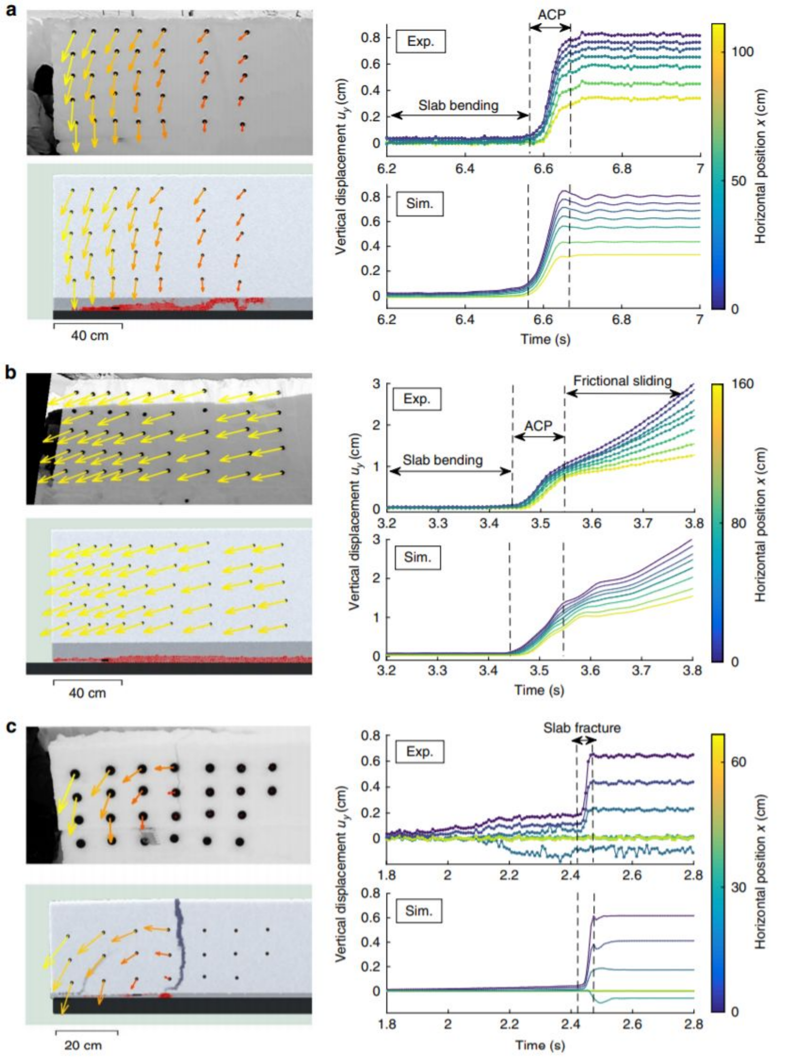
see this presentation with gifs at: https://docs.google.com/presentation/d/1AmkR8h1SU_69glhijSGEYvMLTdvV20eTBSlzSBuYG60/edit?usp=sharing

Material Point Method

A Hybrid Lagrangian-Eulerian Method

Advantages:

- *Physically Accurate*
- *Multi-Phase Interactions*
- *Large Deformation Handling*
- *Automatic Collision Handling*



Gaume, J., Gast, T., Teran, J. *et al.* Dynamic anticrack propagation in snow. *Nat Commun* 9, 3047 (2018). https://doi.org/10.1038/s41467-018-05181-w

Computational Tasks

~200,000 *Particles*

~130,000 *Grid Nodes*

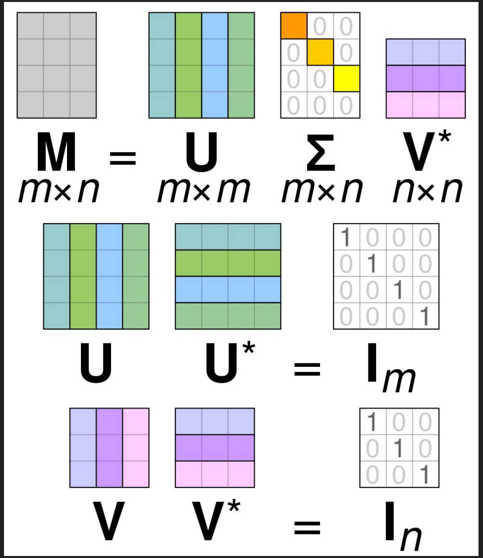
2X Particle & Grid Information Transfers

Physically Accurate Force Computation

Physically Accurate Material Attribute Update

40X Iterations Per 24Hz Frame For EVERYTHING!

4 Million Triangles!

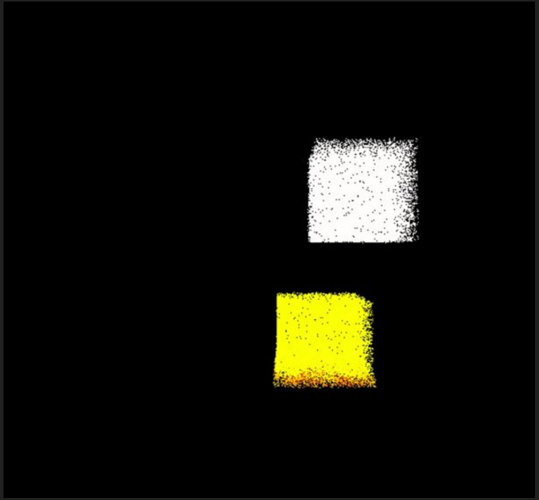


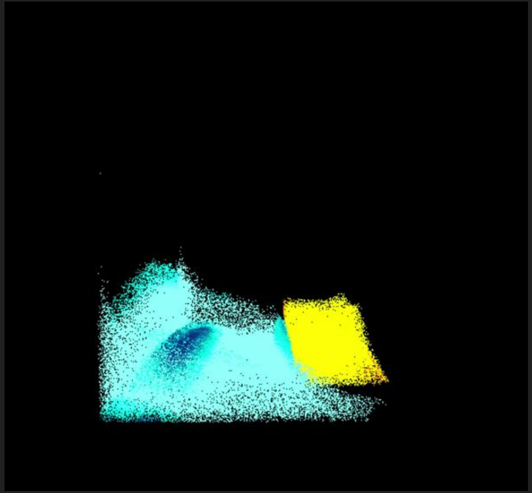
$\underset{m\times n}{\mathbf{M}} = \underset{m\times m}{\mathbf{U}} \ \underset{m\times n}{\mathbf{\Sigma}} \ \underset{n\times n}{\mathbf{V}^*}$
$\mathbf{U} \ \mathbf{U}^* = \mathbf{I}_m$
$\mathbf{V} \ \mathbf{V}^* = \mathbf{I}_n$

WebGL™ → WebGPU

Simulator Features

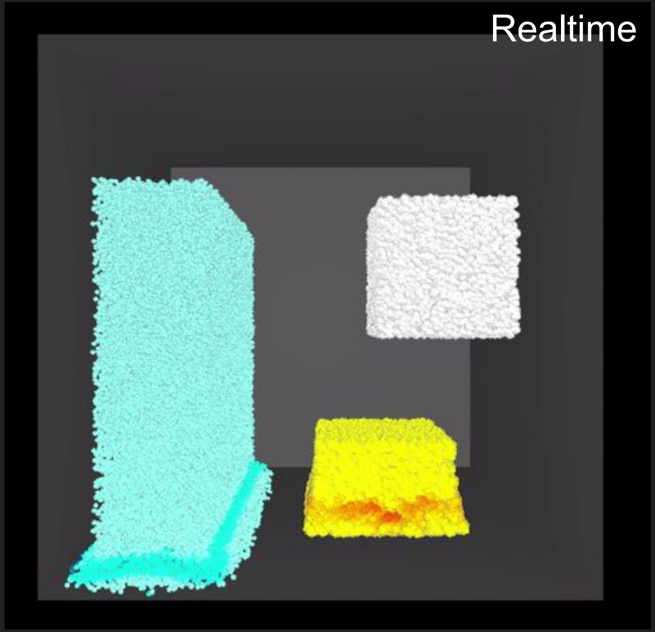
- Runs in the browser in near real-time w/ 200k particles
  - Of course this requires a suitable powerful GPU on the device
- Handles 3 different materials (Snow, Jello, Fluid)





Simulator Features

- Utilizes instancing to allow for lambertian shading of materials
- Easy to create and customize scenes

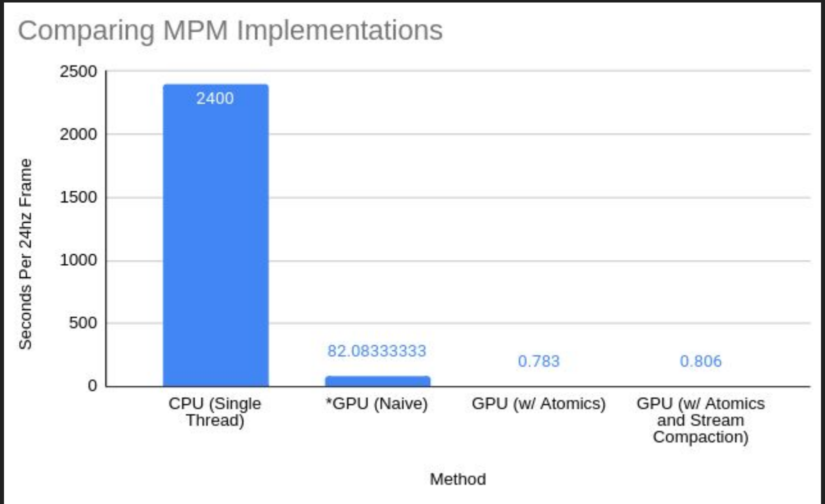


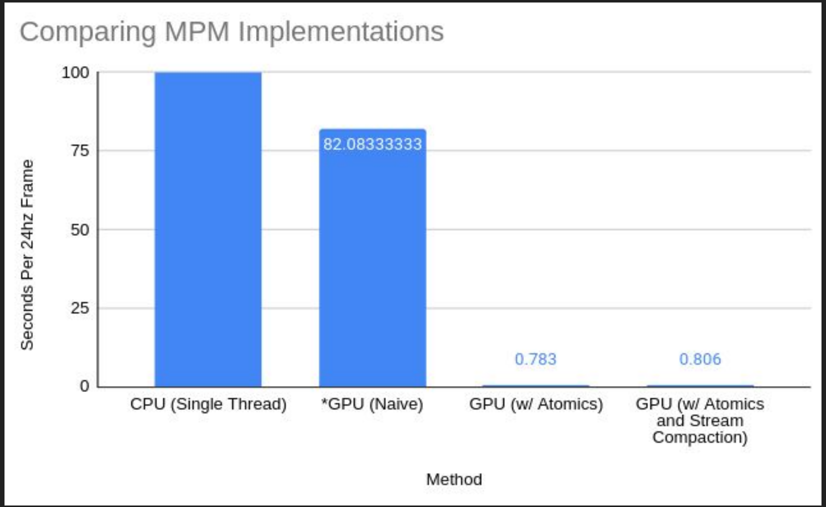
GIFs

GIFs

LIVE DEMO!!!!!!

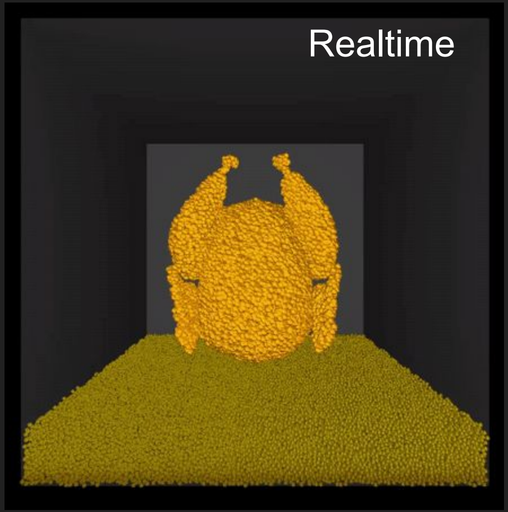
Comparing Implementation Performance





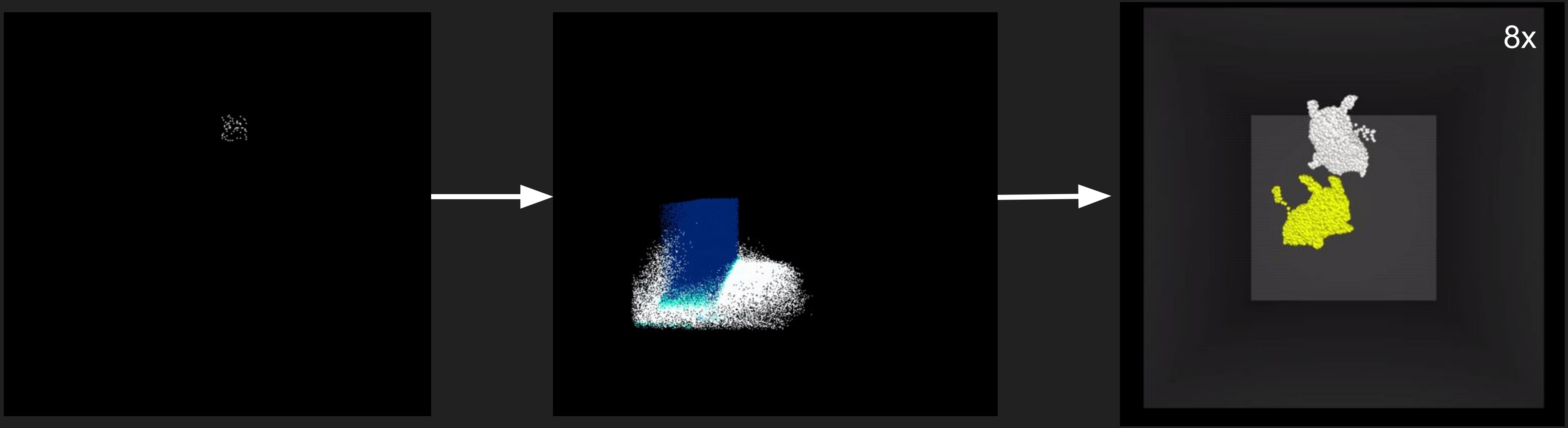
Shortcomings

- Because we utilize atomics, our program is slowed down significantly due to write conflicts
- Creating models for objects with “thin” geometry does not work well
- Limited to lower number of particles due to timeout safety features



Special Thanks To Kai, Austin, Dr. Jiang, and the WebGPU Team!!!

Thanks for watching… Questions?



You can try our demo out right now using Chrome Canary at these webpages:

chetanp.io/WebGPUMPM
jackylu0124.github.io/WebGPUMPM

Do you have more questions?

Here's how you can contact us!

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Credits

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8. Chenfanfu Jiang, Craig Schroeder, Joseph Teran, Alexey Stomakhin, and Andrew Selle. 2016. The material point method for simulating continuum materials. In ACM SIGGRAPH 2016 Courses (SIGGRAPH '16). Association for Computing Machinery, New York, NY, USA, Article 24, 1–52.
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