WebGPU Material Point Method

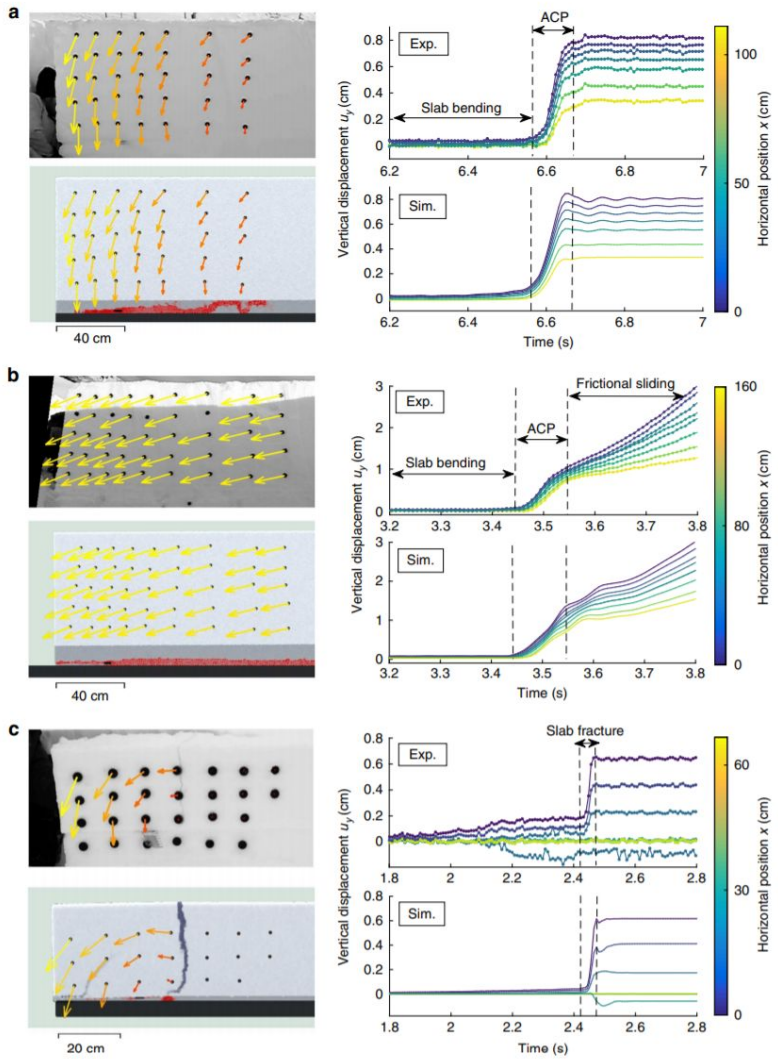
Henry Yang, Chetan Parthiban, Jacky Lu

Joshuah Wolper, Yunuo Chen, Minchen Li, Yu Fang, Ziyin Qu, Jiecong Lu, Meggie Cheng, and Chenfanfu Jiang. 2020. AnisoMPM: Animating Anisotropic Damage Mechanics. ACM Trans. Graph. 39, 4, Article 37 (July 2020), 16 pages. https://doi.org/10.1145/3386569.3392428

Material Point Method

Advantages:

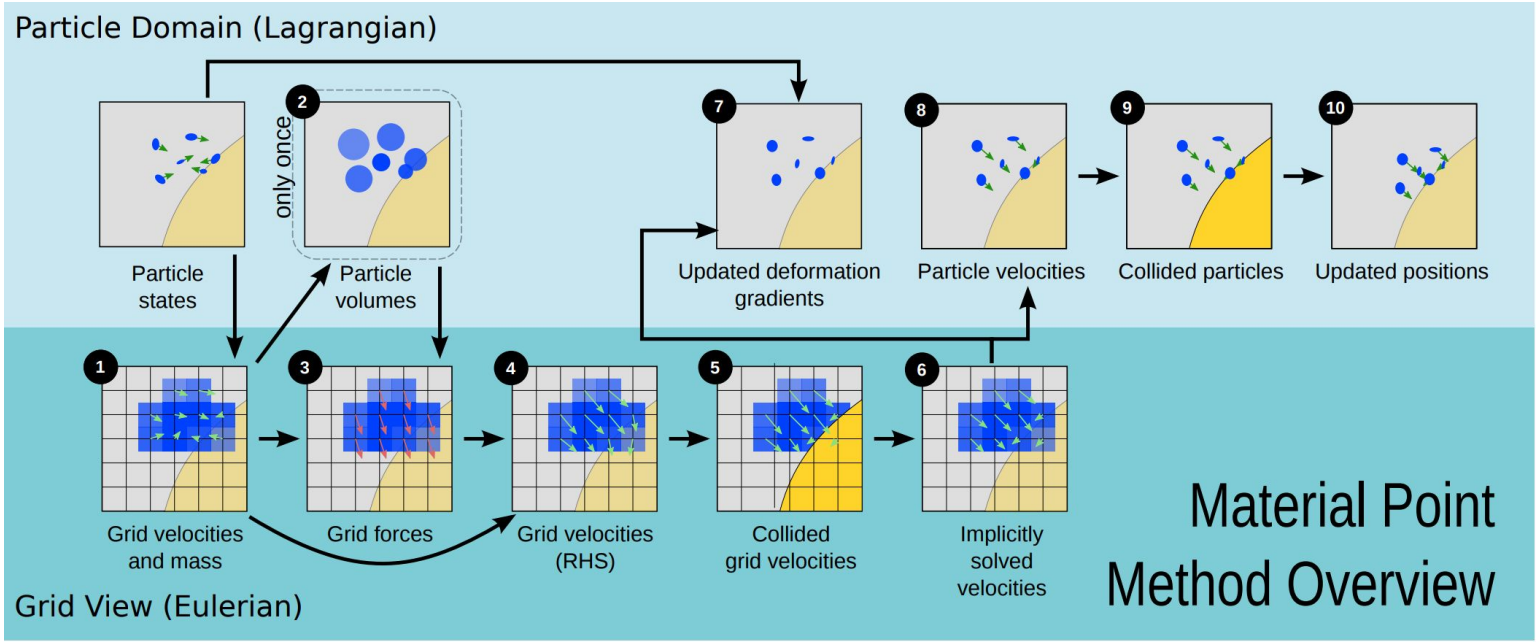
- Physically Accurate
- Multi-Phase Interactions
- Large Deformation Handling
- Automatic Collision Handling



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

Material Point Method

Hybrid Lagrangian-Eulerian Method



Stomakhin, A., Schroeder, C., Chai, L., Teran, J., Selle, A. 2013. A Material Point Method for Snow Simulation. ACM Trans. Graph. 32, 4, Article 102 (July 2013), 12 pages. DOI = 10.1145/2461912.2461948 http://doi.acm.org/10.1145/2461912.2461948.

WebGPU - A modern graphics API for the web

- Better separation of concerns -> cleaner to scale to more complex programs
- More direct control over shaders and how they interact with the hardware
- Better support for compute workloads
- Less browser overhead

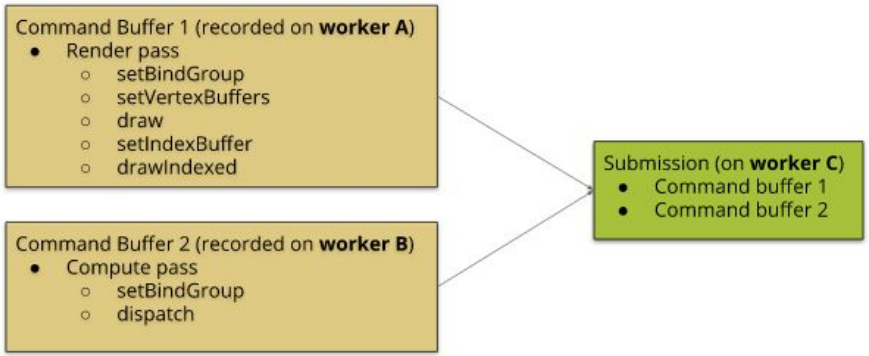


image from https://hacks.mozilla.org/2020/04/experimental-webgpu-in-firefox/

Why WebGPU + MPM?

1. We could not find any web implementations of MPM

2. MPM on the GPU requires many features (compute shaders, careful memory management, atomics, warp level operations)

3. WebGPU is the only truly cross-platform, modern and low-level graphics API

Milestones & Goals

Milestone 1:

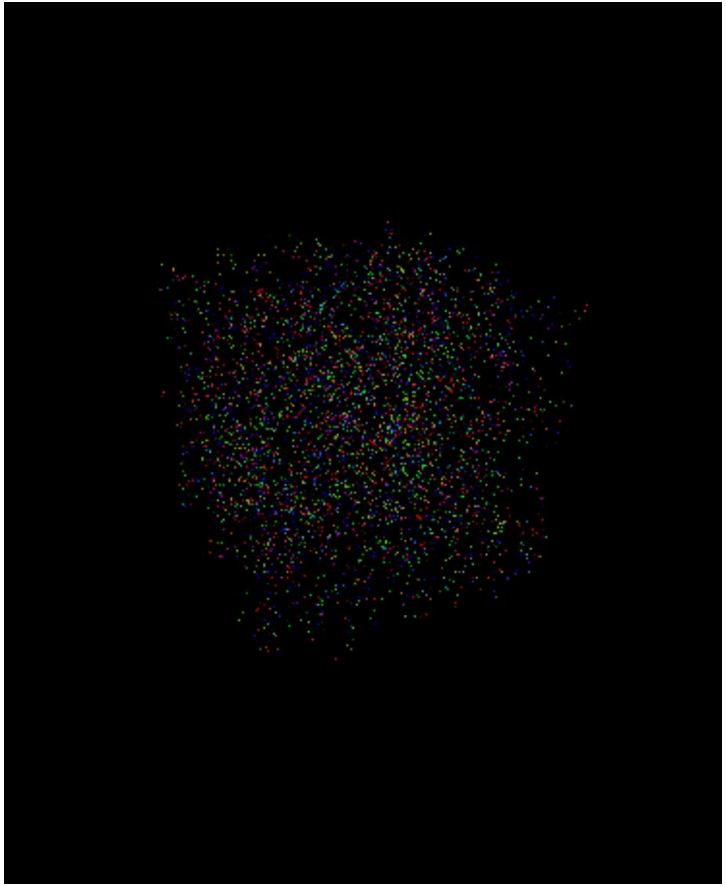
Modify WebGPU example of boids into 3D version as a basis for MPM. Implement camera in order to observe and debug 3D scene.

Milestone 2:

Complete naively parallelized MPM, then implement more GPU optimizations.

Milestone 3:

Utilize WebGPU to optimize MPM and push performance.



Sources

1. Joshuah Wolper, Yunuo Chen, Minchen Li, Yu Fang, Ziyin Qu, Jiecong Lu, Meggie Cheng, and Chenfanfu Jiang. 2020. AnisoMPM: Animating Anisotropic Damage Mechanics. ACM Trans. Graph. 39, 4, Article 37 (July 2020), 16 pages. https://doi.org/10.1145/3386569.3392428
2. 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
3. Stomakhin, A., Schroeder, C., Chai, L., Teran, J., Selle, A. 2013. A Material Point Method for Snow Simulation. ACM Trans. Graph. 32, 4, Article 102 (July 2013), 12 pages. DOI = 10.1145/2461912.2461948 http://doi.acm.org/10.1145/2461912.2461948.
4. https://en.wikipedia.org/wiki/Material_point_method
5. 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)