DEFORMATION GRADIENT CONTROL OF PHYSICALLY SIMULATED AMORPHOUS SOLIDS

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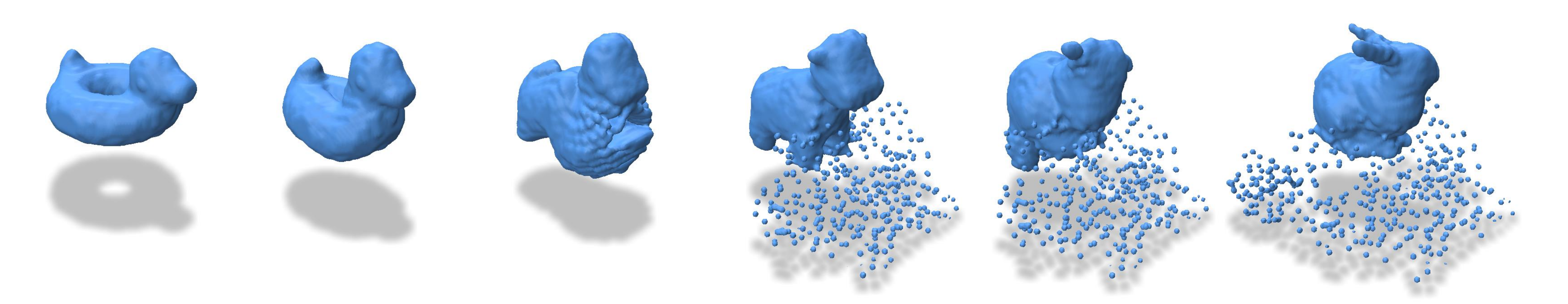
Problem:

The objective is to control a physically simulated amorphous solid to move in a lifelike manner. The solid should also be able to change its topology and shape morph. The ideal artist workflow with this tool is to input initial and target shapes, and then receive as output the physically based animation morphing between the two.

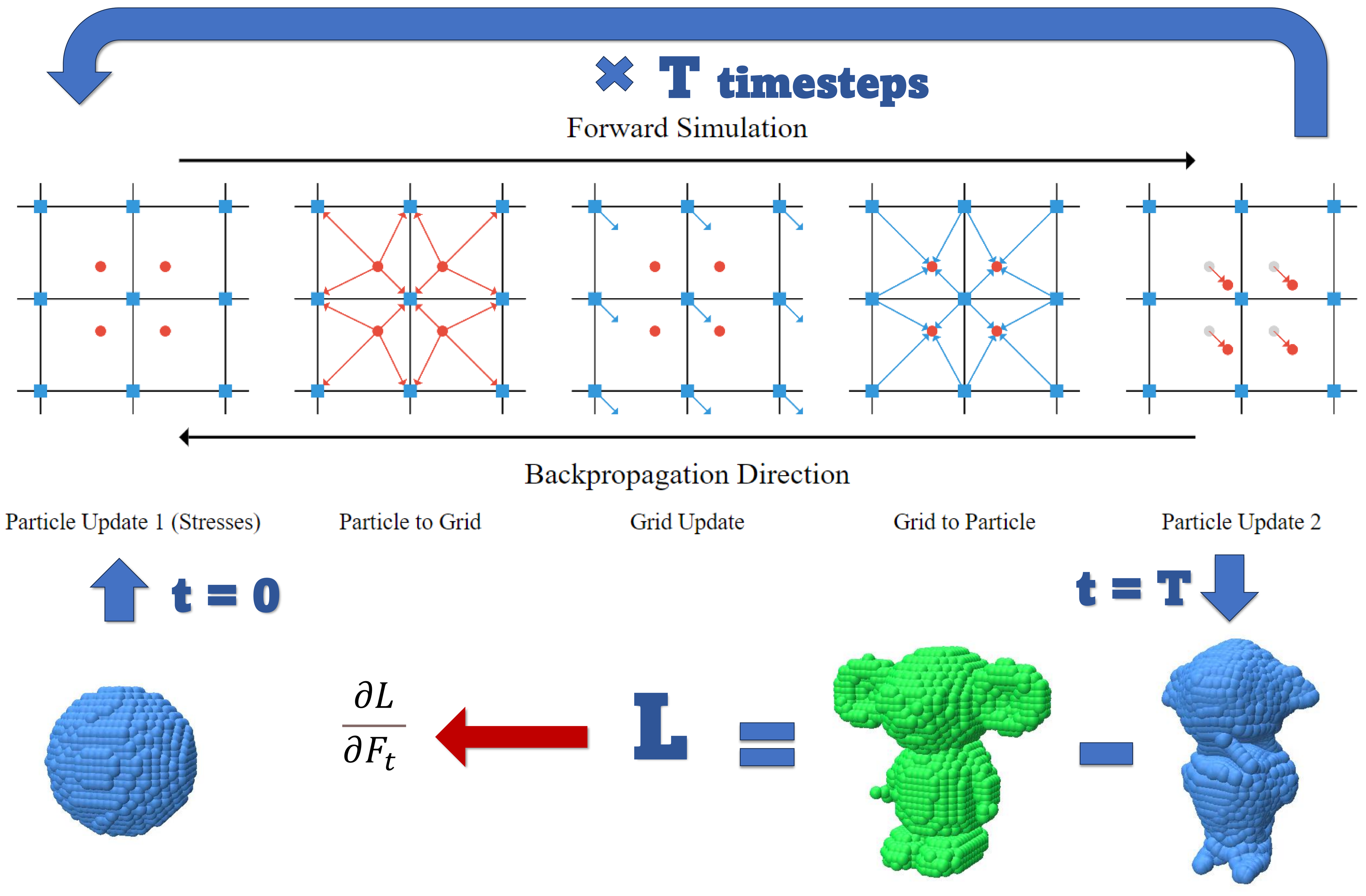
Related Work:

Our method is most inspired by Deformable Objects Alive [Coros et al. 2012], which used rest-state adaptation to control mesh based elastic objects. We apply a similar approach to meshless objects in a differential material point method simulator based on ChainQueen [Hu et al. 2018].



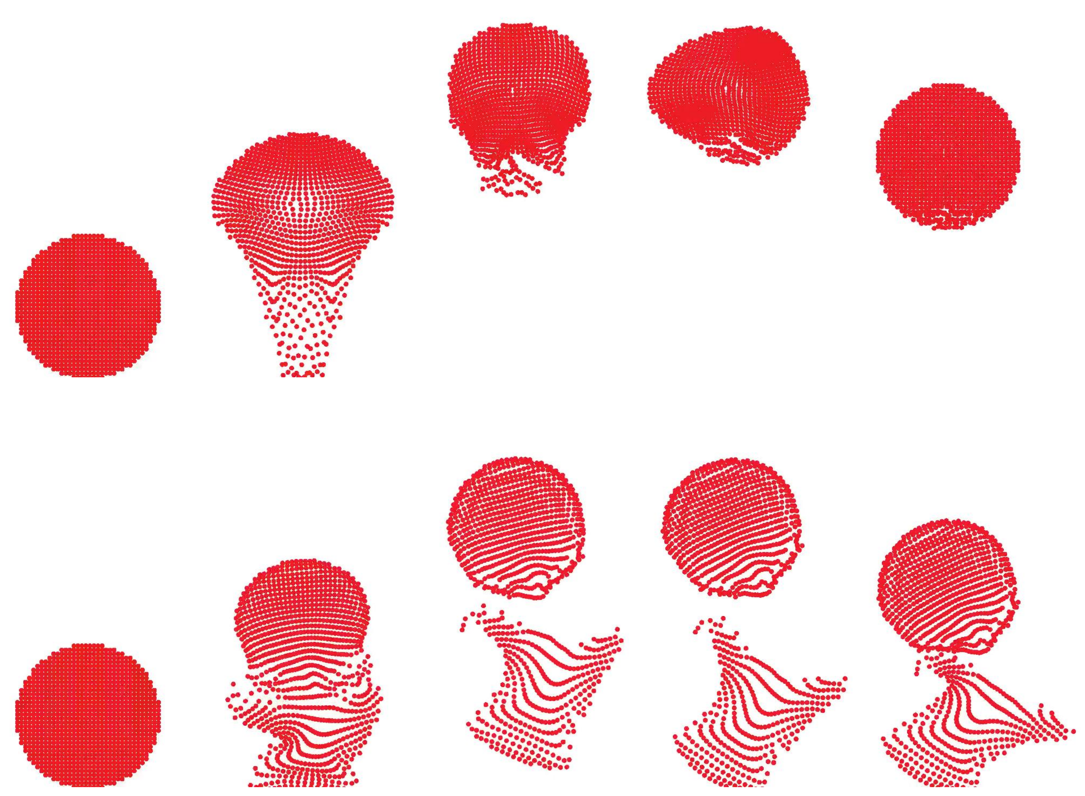
Method:

Our method is based on the minimization of a loss function at the end of a simulation network produced by the forward pass of a differentiable MPM simulator. We model our material's constitutive properties using fixed co-rotated elasticity [Jiang et al . 2016; Stomakhin et al. 2012]. A key property of elasticity is a material's return to their rest shape after stresses are removed. Since we are controlling deformation gradients and hence changing rest shapes, our simulated objects are elastoplastic despite using an elastic material. The loss function we use is the squared distance between projected particle grid mass, and target grid mass.



Deformation Gradient Control:

Deformation gradients can be controlled by optimizing with respect to a position loss function. However, this type of loss function is difficult to use since it requires a point-to-point mapping between the target and input point cloud. To circumvent this, we use optimize with respect to a grid loss function, where particle masses are projected to a background grid like in MPM. The sequence to the right show the difference between using a position loss function (top) versus a grid loss function (bottom) for a circle jumping optimization.



Limitations and Future Work:

- *Mass ejection*. Optimizing the grid loss function often leads to mass ejection, where the object propels itself towards certain morphs by ejecting its own mass.
- *Parallelization*. The working implementation is CPU-based. The computation can be sped up with a parallel CPU implementation or GPU implementation.
- *Learned Model*. The particle-to-grid step of MPM is difficult to parallelize, and so a learned model of the particle-to-grid step may enhance speed significantly. On the other hand, we could use a fully learned simulator.

YOUTUBE DEMO PLAYLIST

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