Position-based Fluid Simulations

CS-116B Computer Graphics Algorithms

Position-based Dynamics

- “Position Based Dynamics provides a method for simulating dynamics in games based on Verlet integration” (p. 2).
- “Position based dynamics is popular for simulating deformable objects such as cloth. We have prototyped two-way interaction between position based cloth and fluid with promising results” (p. 4).
- The authors implemented their parallel algorithm in CUDA (p. 4).
- Using a GTX-680, they were able to achieve real-time fluid simulations using particles (p. 4).

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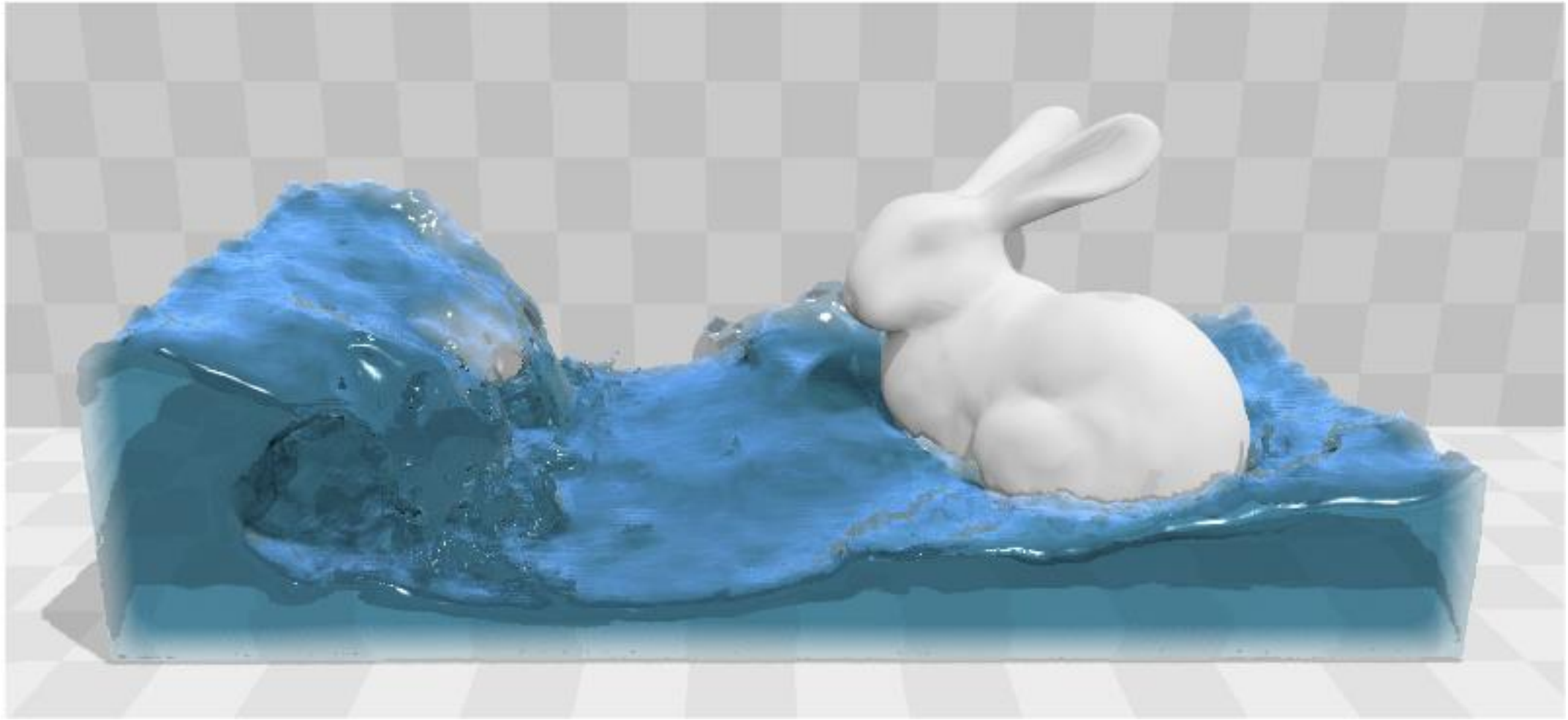
Position-based Dynamics

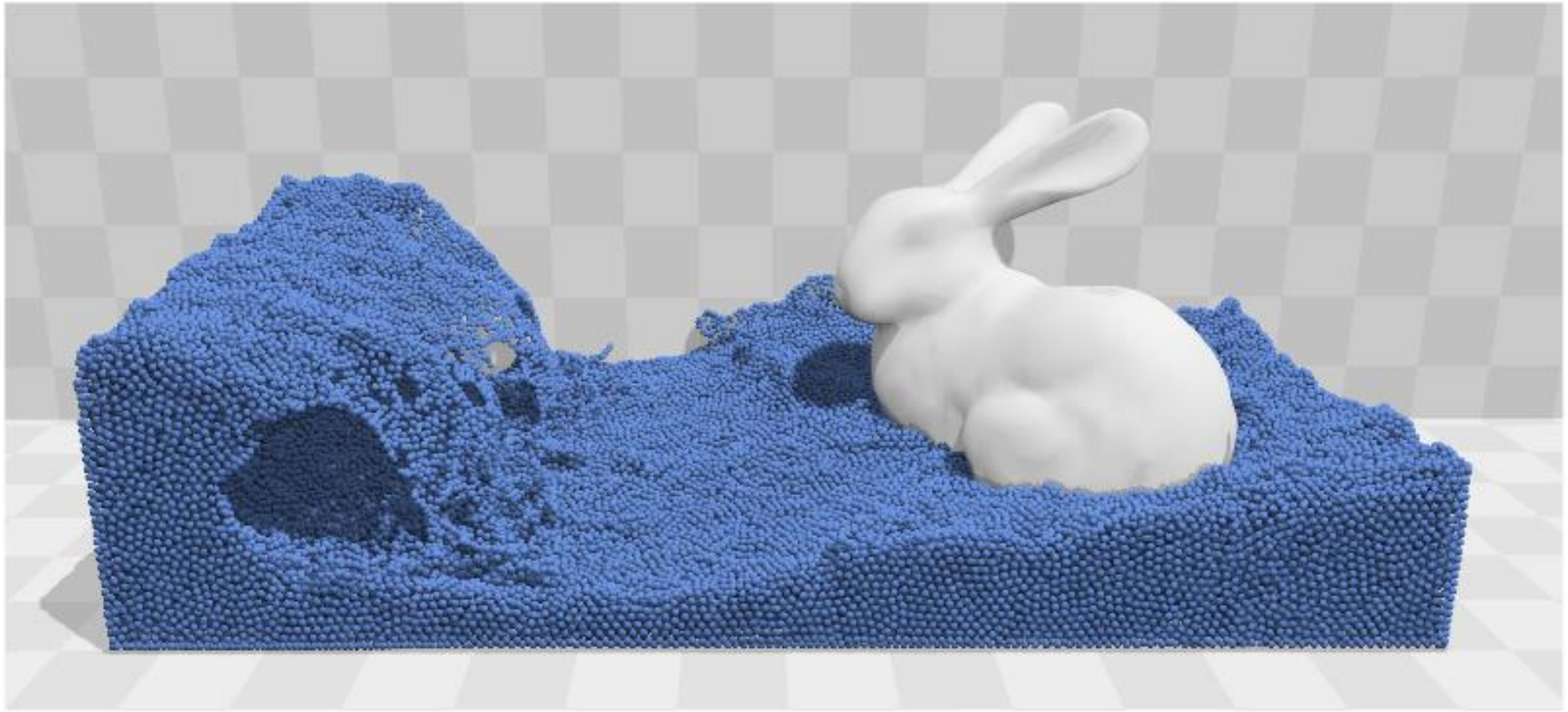
- Here is a video demonstration of position-based dynamics: https://www.youtube.com/watch?v=F5KuP6qEuew

Position-based Dynamics



Source: http://mmacklin.com/pbf_sig_preprint.pdf

Position-based Dynamics



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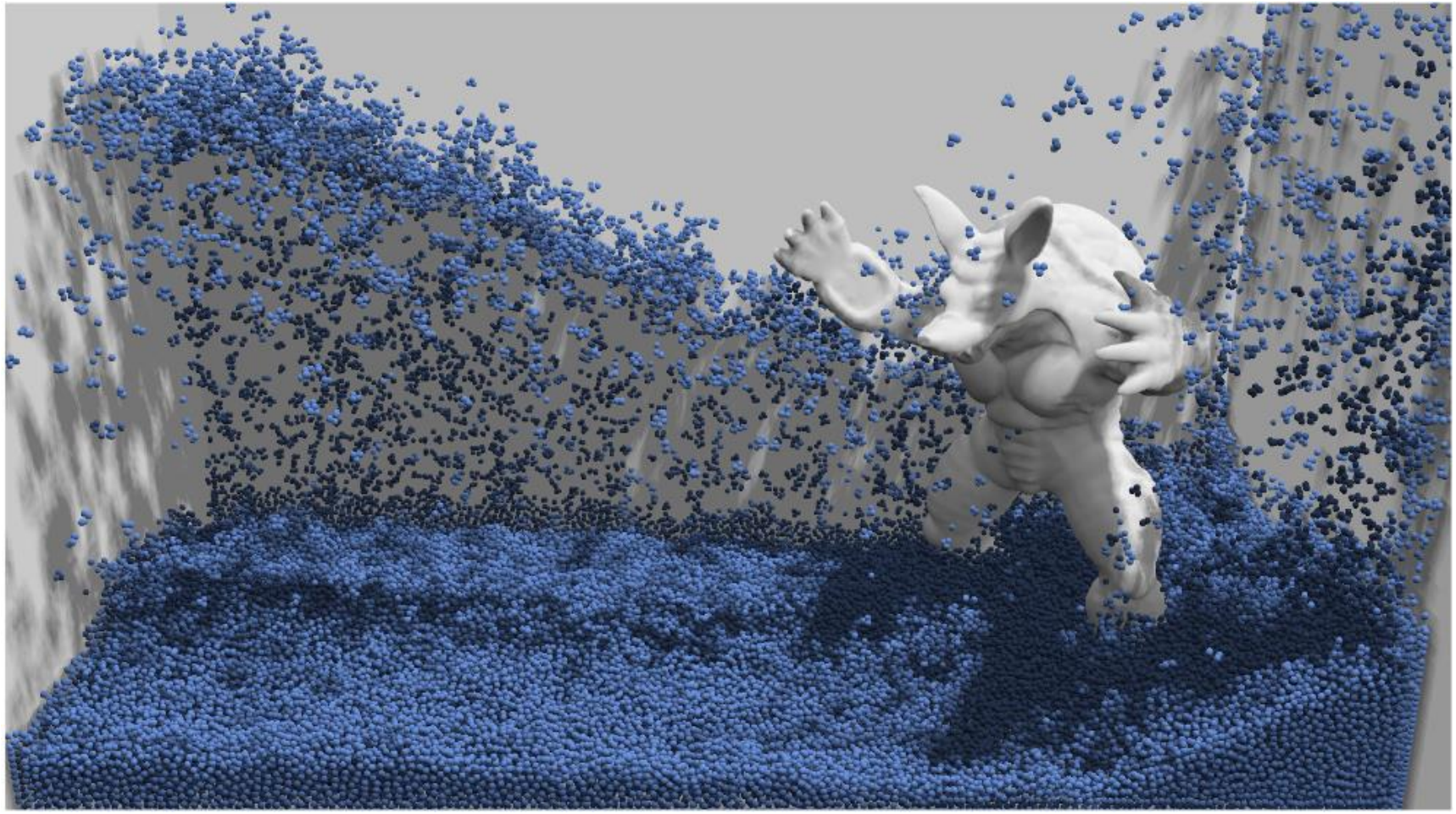
Particle clumping (undesirable)



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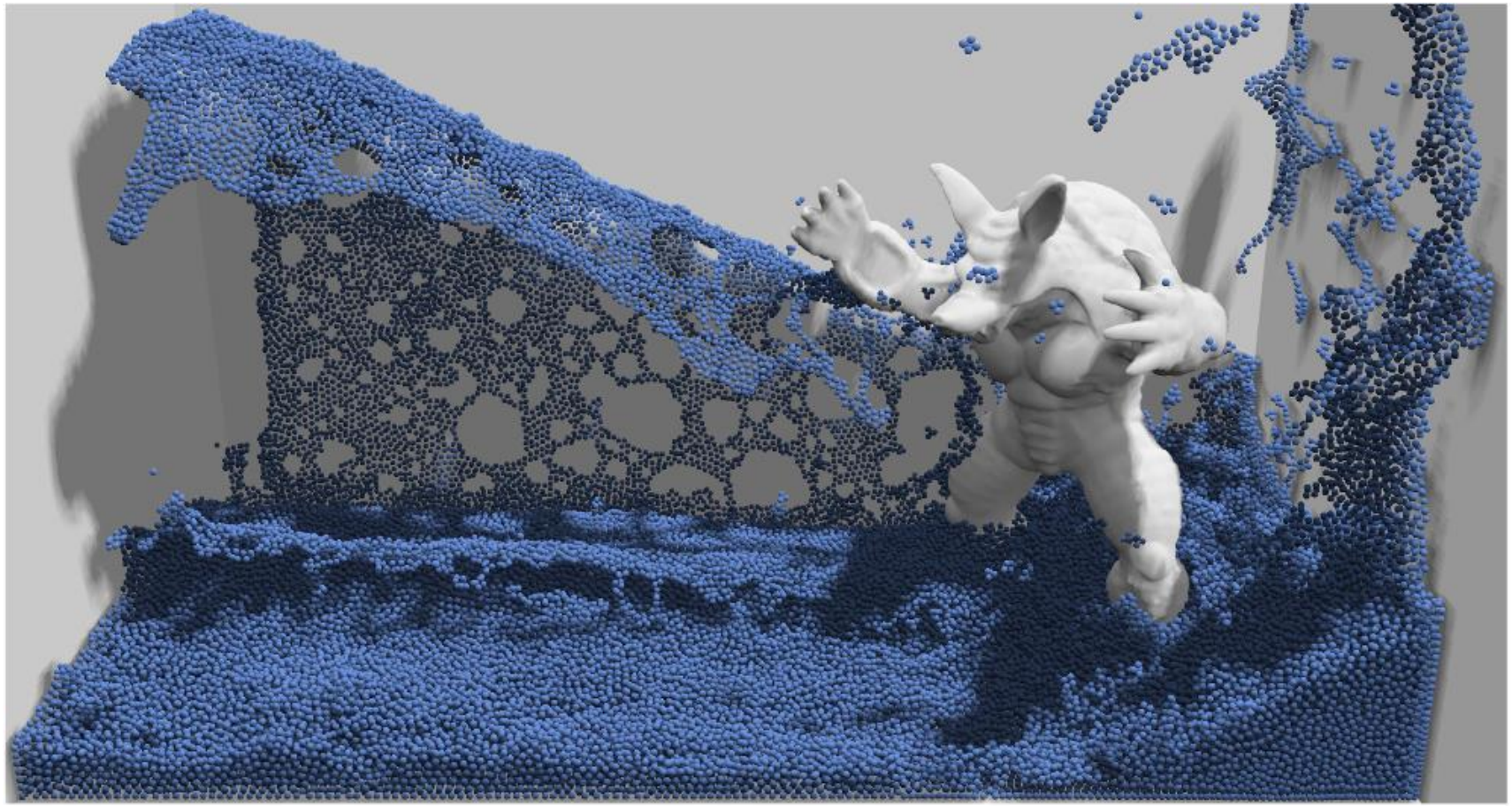
Reduced Particle clumping with improved surface tension



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Position-based Dynamics: Simulation loop algorithm

Algorithm 1 Simulation Loop

for all particles i **do**
  apply forces $\mathbf{v}_i \Leftarrow \mathbf{v}_i + \Delta t \mathbf{f}_{ext}(\mathbf{x}_i)$
  predict position $\mathbf{x}_i^* \Leftarrow \mathbf{x}_i + \Delta t \mathbf{v}_i$
end for
for all particles i **do**
  find neighboring particles $N_i(\mathbf{x}_i^*)$
end for
while $iter < solverIterations$ **do**
  for all particles i **do**
    calculate λ_i
  end for
  for all particles i **do**
    calculate $\Delta \mathbf{p}_i$
    perform collision detection and response
  end for
  for all particles i **do**
    update position $\mathbf{x}_i^* \Leftarrow \mathbf{x}_i^* + \Delta \mathbf{p}_i$
  end for
end while
for all particles i **do**
  update velocity $\mathbf{v}_i \Leftarrow \frac{1}{\Delta t}\left(\mathbf{x}_i^* - \mathbf{x}_i\right)$
  apply vorticity confinement and XSPH viscosity
  update position $\mathbf{x}_i \Leftarrow \mathbf{x}_i^*$
end for

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For Further Reading

Macklin, M. & Muller, M. (n.d.). Position based fluids. Retrieved from: http://mmacklin.com/pbf_sig_preprint.pdf

NVIDIA FleX [computer software]. (n.d.). https://developer.nvidia.com/flex