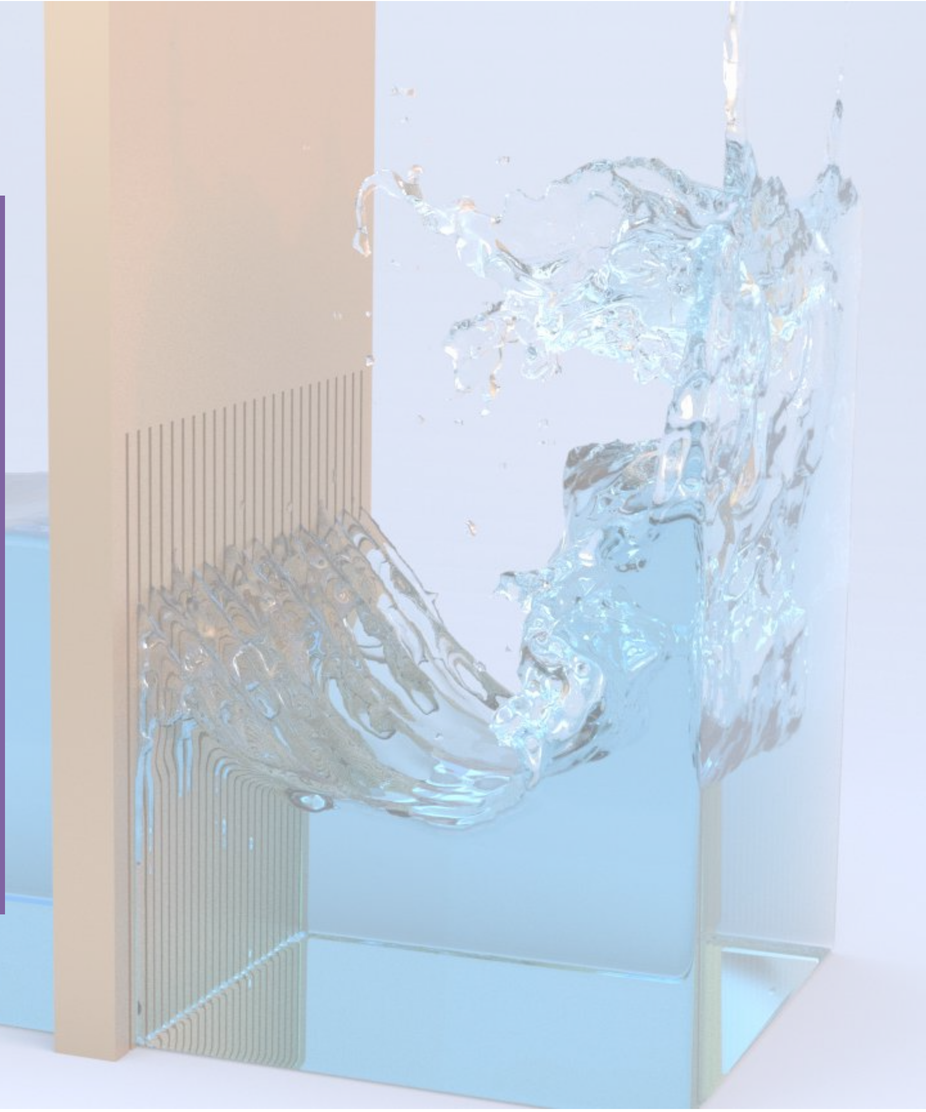
Data driven Fluid Simulation

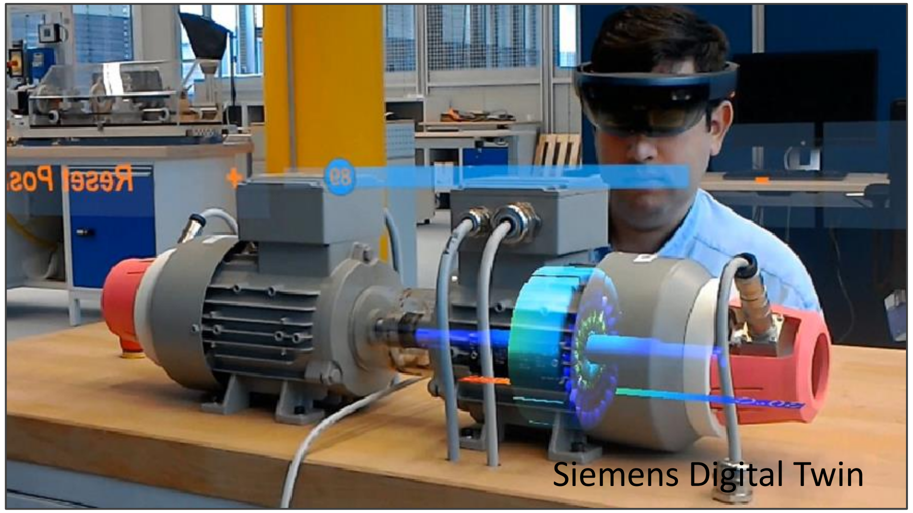
EG22 STAR

Barbara Solenthaler



Persistent Challenges of Fluid Simulations

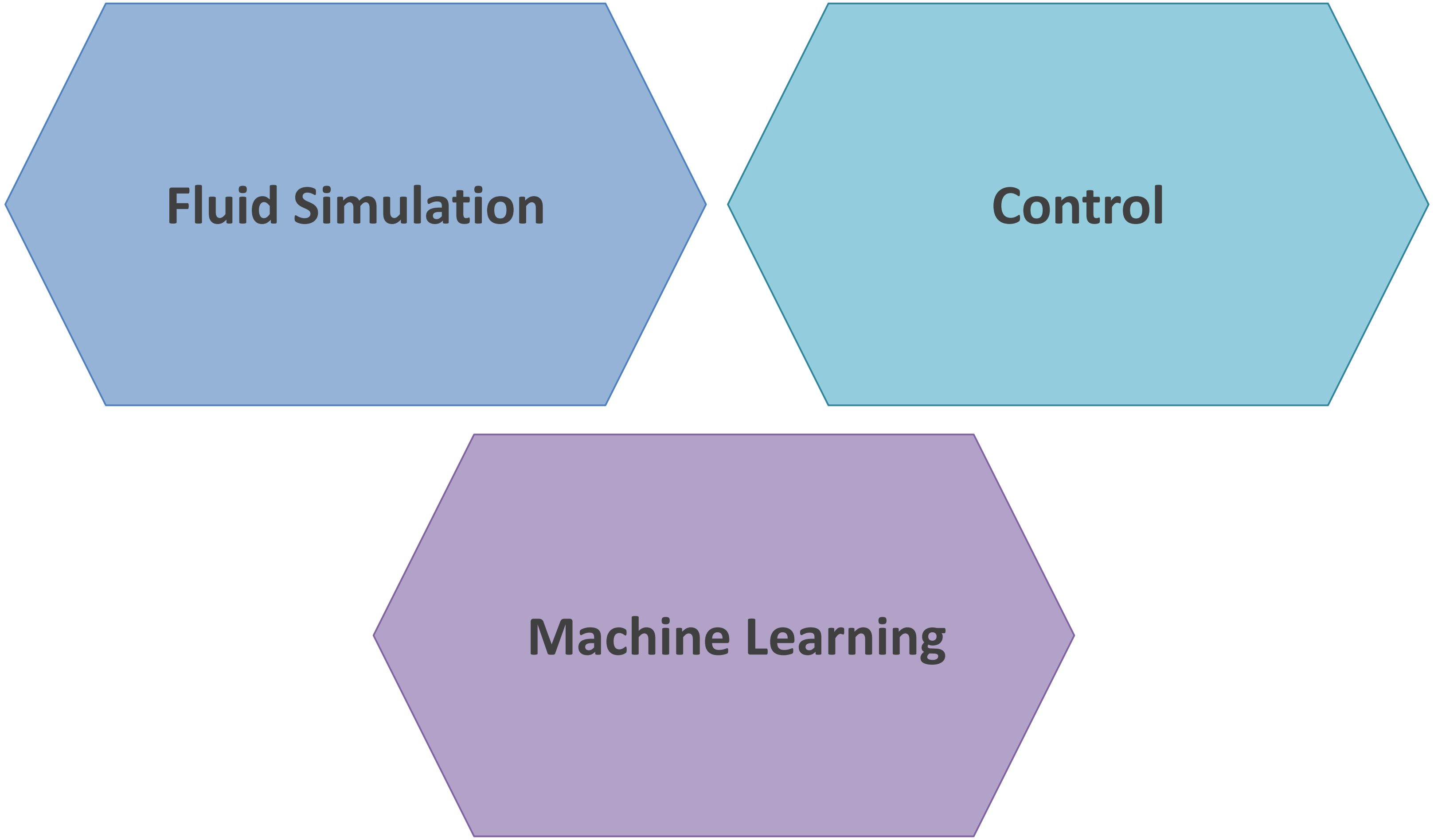
Fluid Simulation



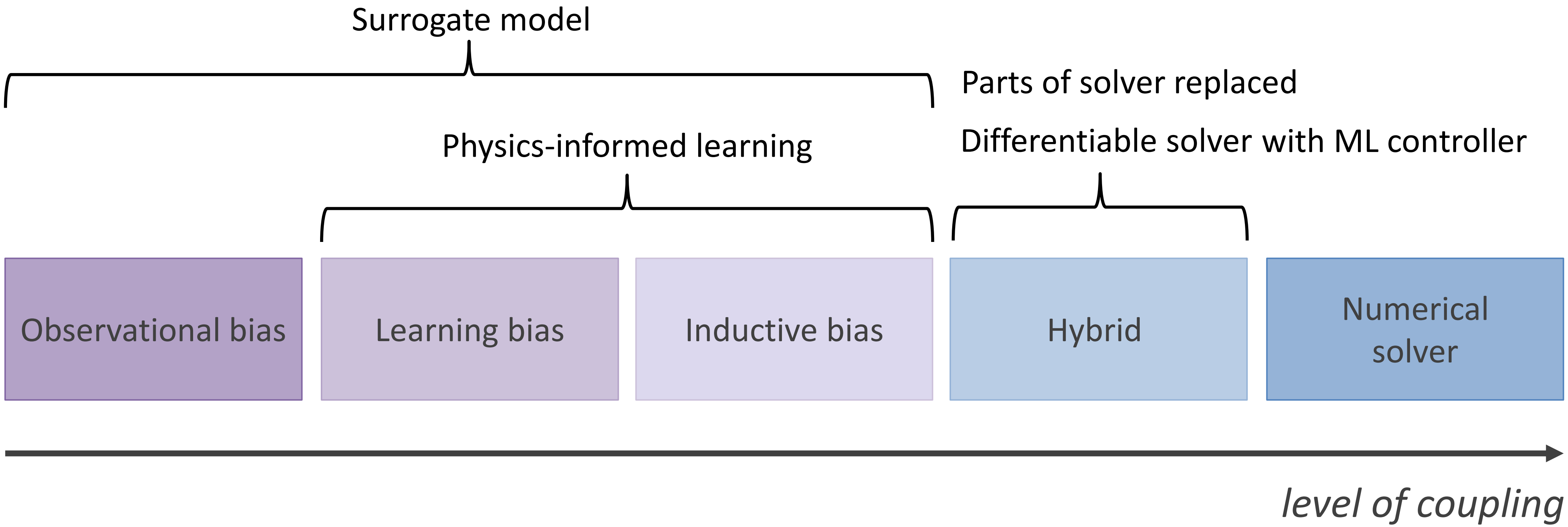
Persistent Challenges of Fluid Simulations

Control

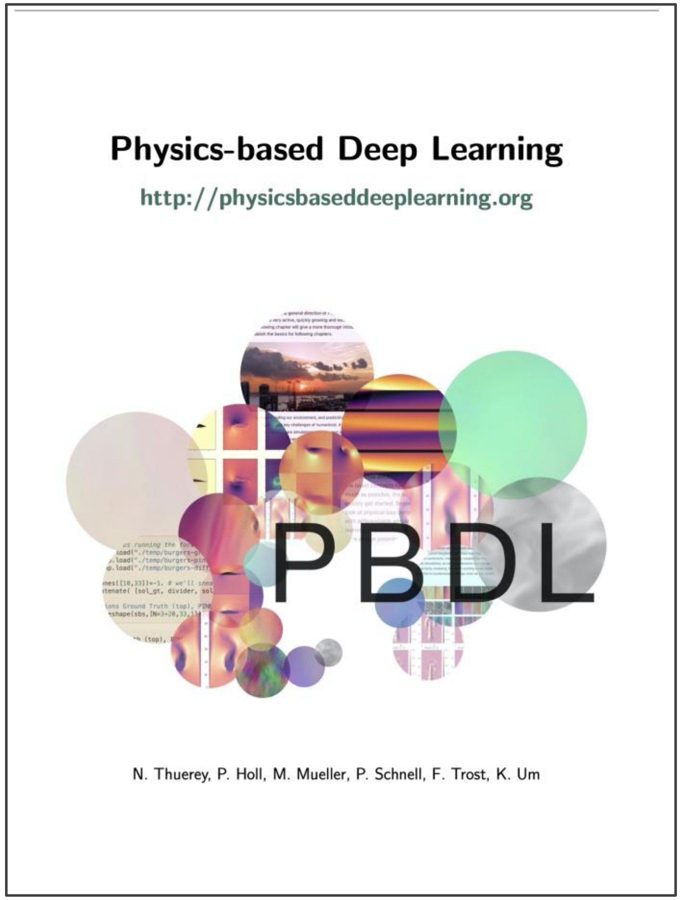
The Rise of Data-driven Modeling and Simulation



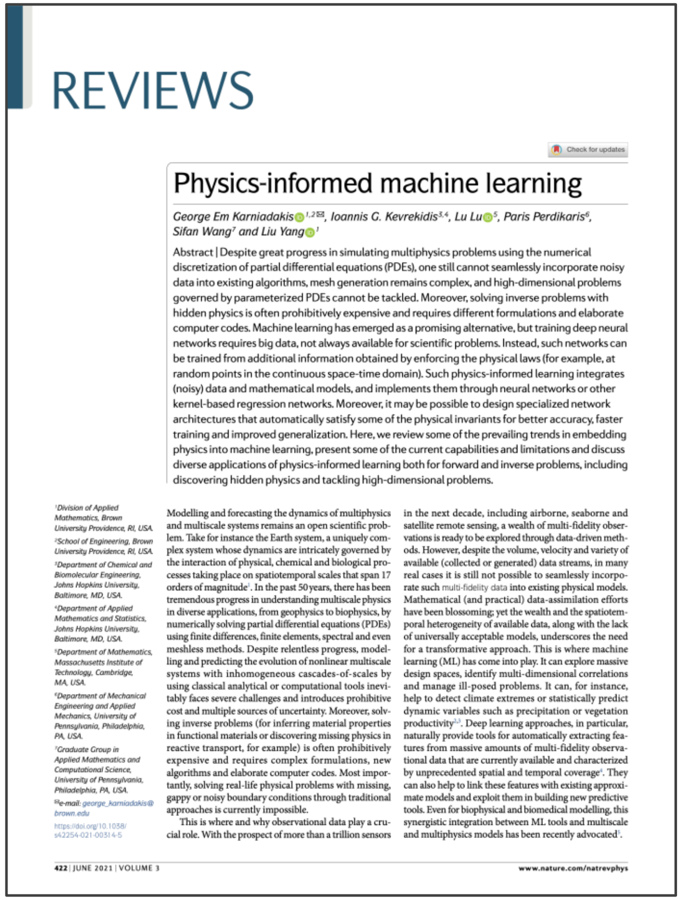
Shifting from First Principles to Data-driven Approaches



Digital Book and Review Articles



Thuerey et al., 2021



Karniadikis et al., 2021

Brunton and Koumoutsakos, 2020

Particles and Learning

level of coupling

SPH with Regression Forests

Lagrangian Fluids with Convolutional Neural Networks

Graph Network-based Simulations

Differentiable Solvers and Neural Networks

Particles and Learning

level of coupling

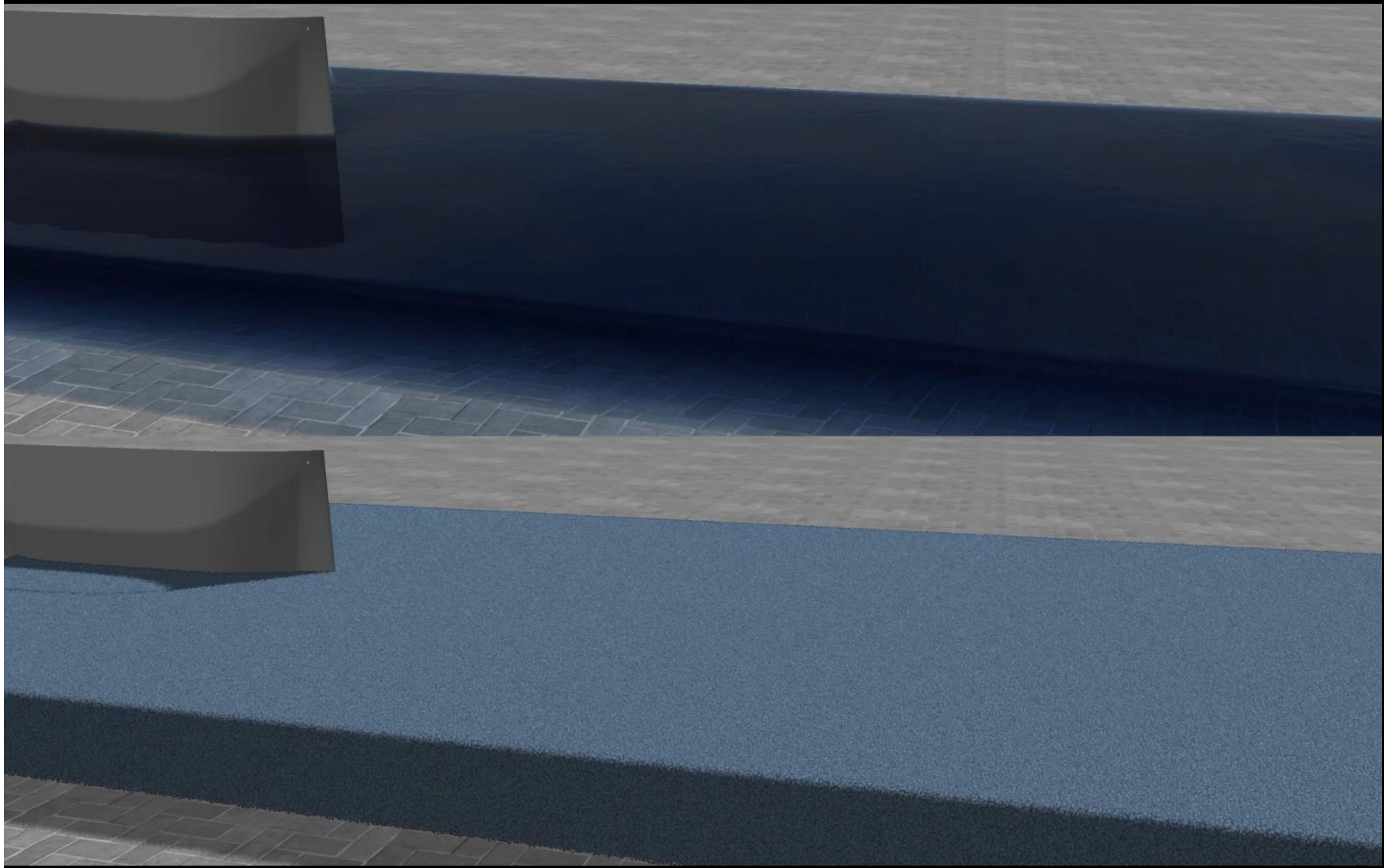
SPH with Regression Forests

Lagrangian Fluids with Convolutional Neural Networks

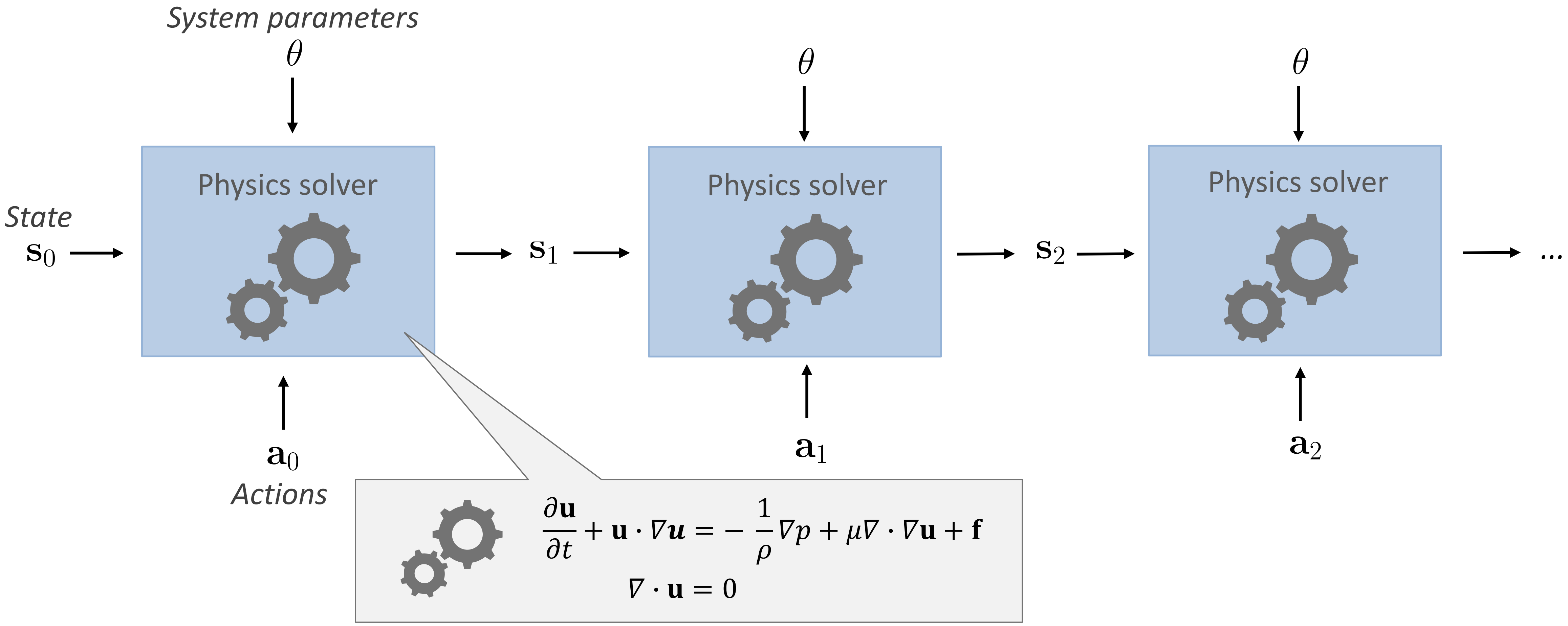
Graph Network-based Simulations

Differentiable Solvers and Neural Networks

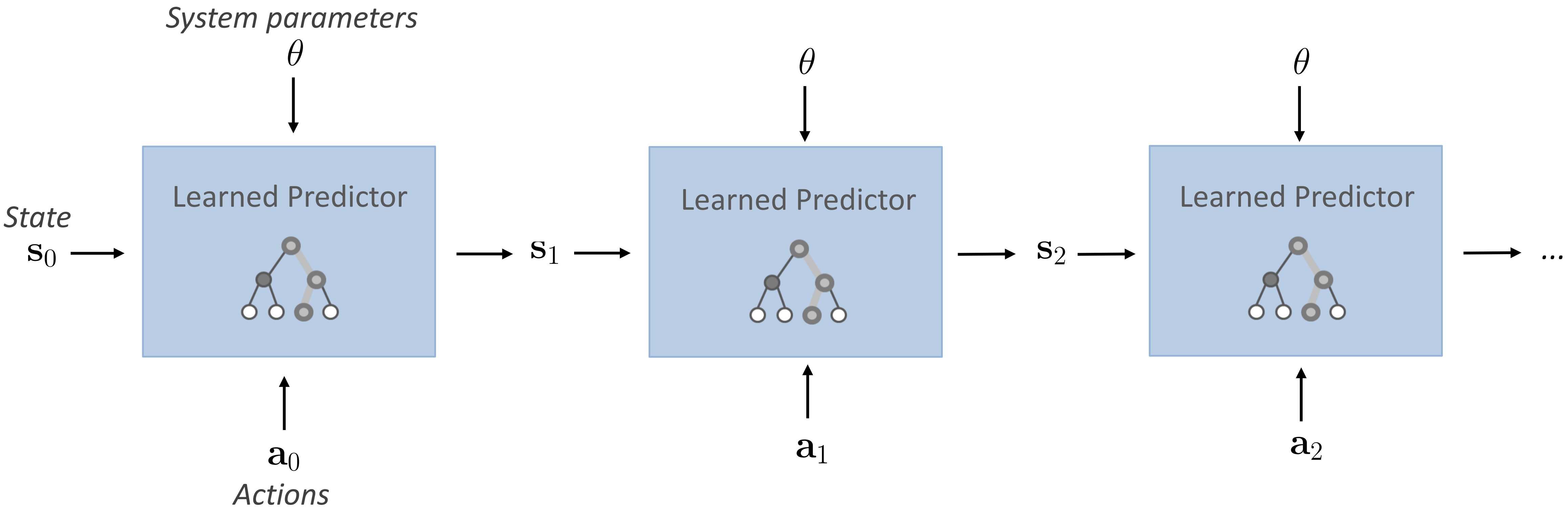
Decision Tree Driven Model



Forward Simulation

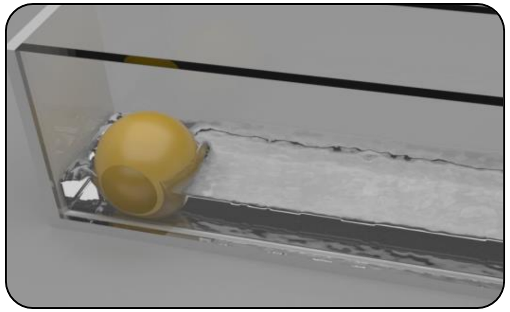


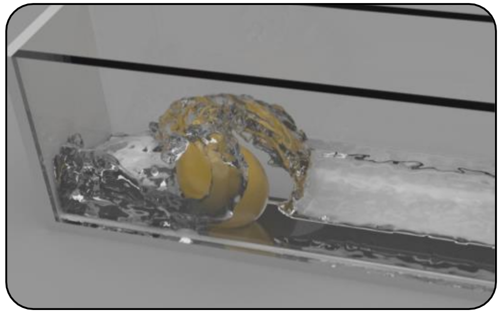
Surrogate Model for Particle Fluids



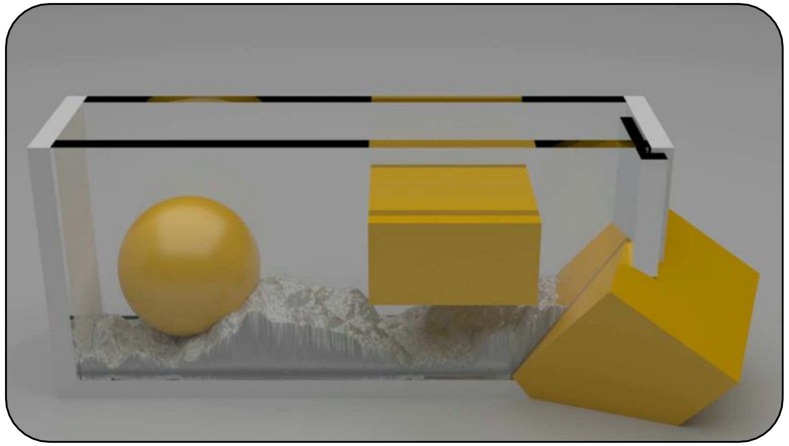
Ladicky et al., SIGGRAPH Asia 2015

SPH with Regression Forests





Current state $\mathbf{s}_i$ $\rightarrow$ $\mathbf{s}_{i+1}$ Next state

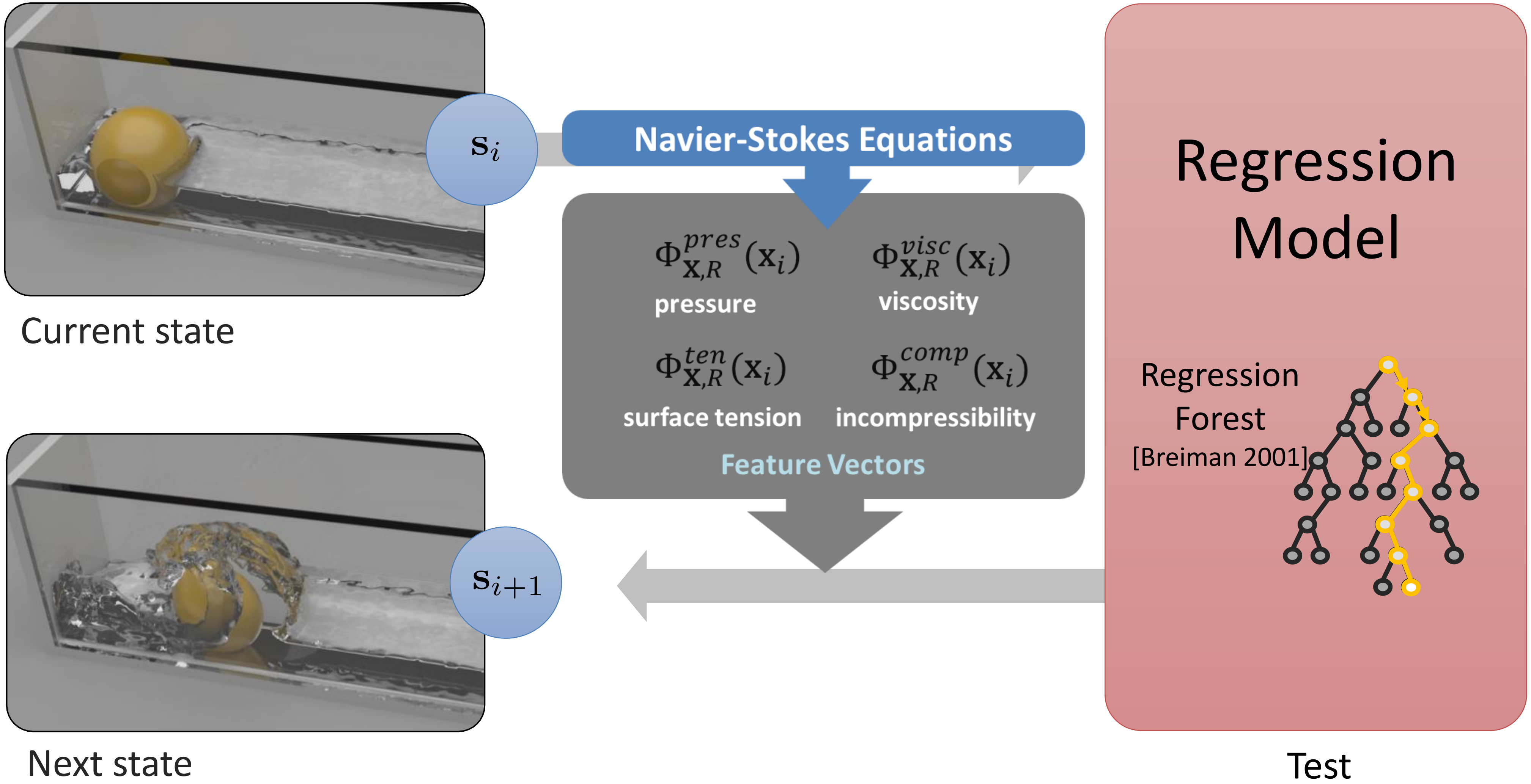


Training data

Regression Model

Training

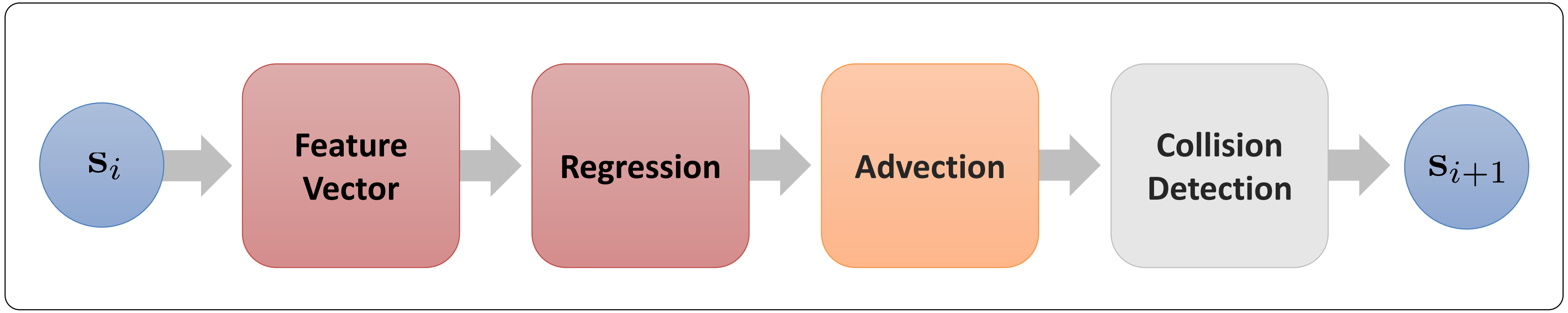
SPH with Regression Forests



Learning Strategies

Standard Regression Pipeline

Naïve approach



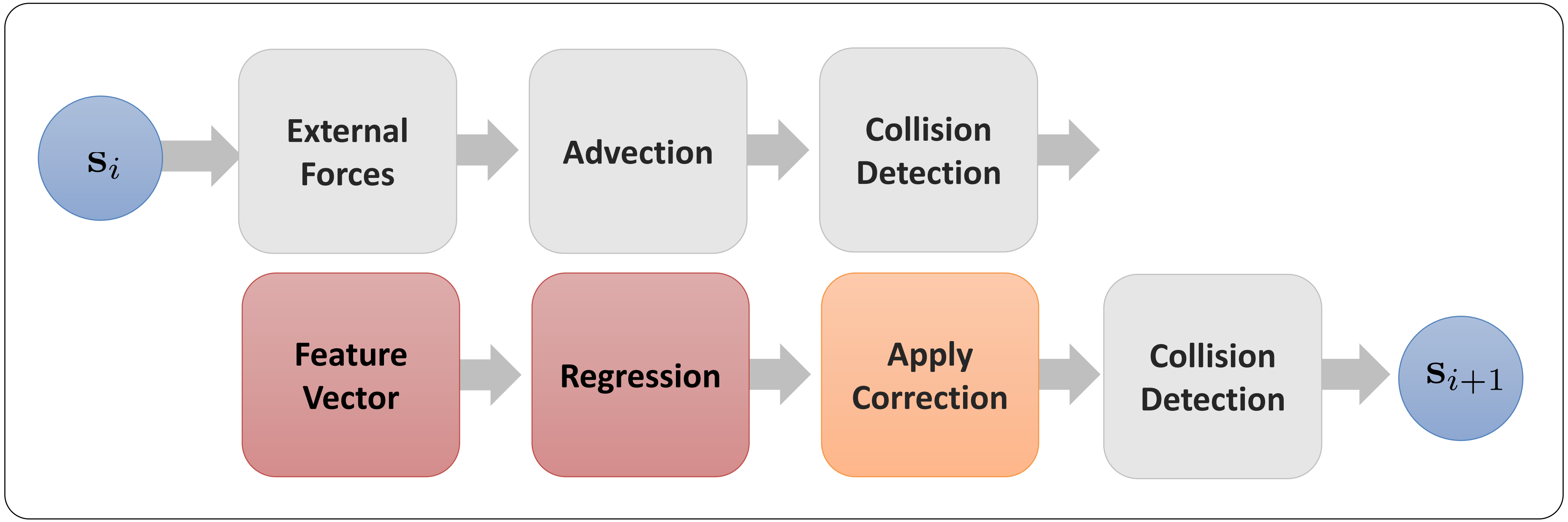
Learn **accelerations**

-> mimics standard SPH (no incompressibility)

Learning Strategies

Correction approach

Correction from Advected States



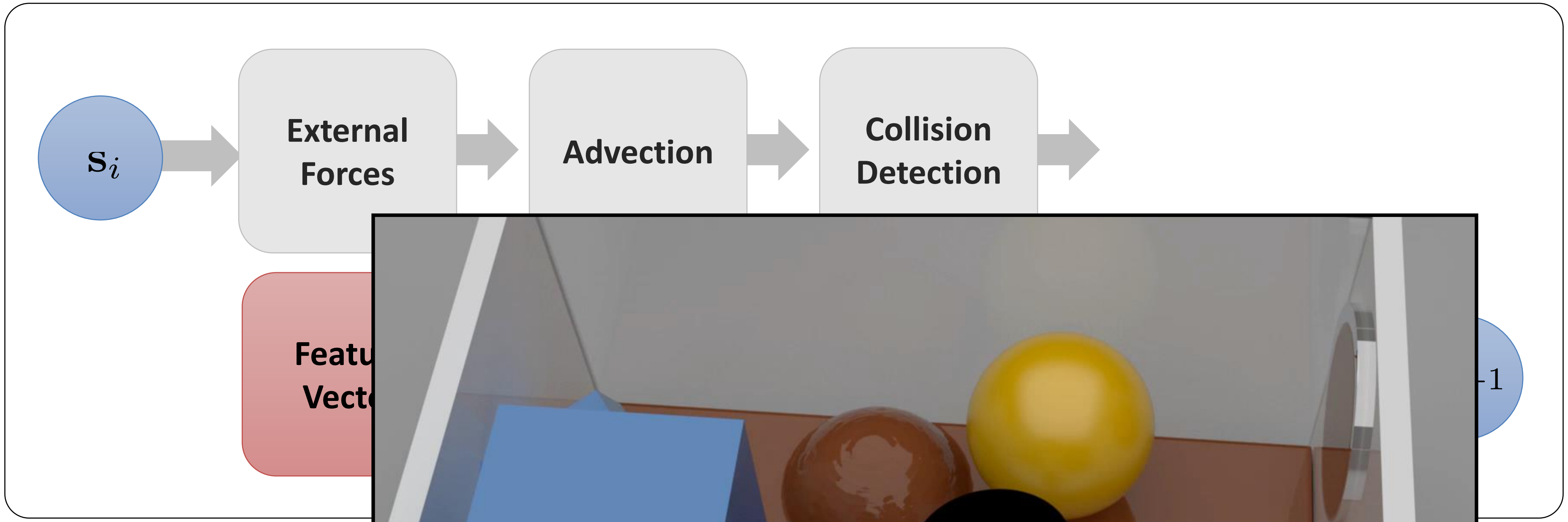
Learn **acceleration corrections**
-> mimics incompressible SPH methods

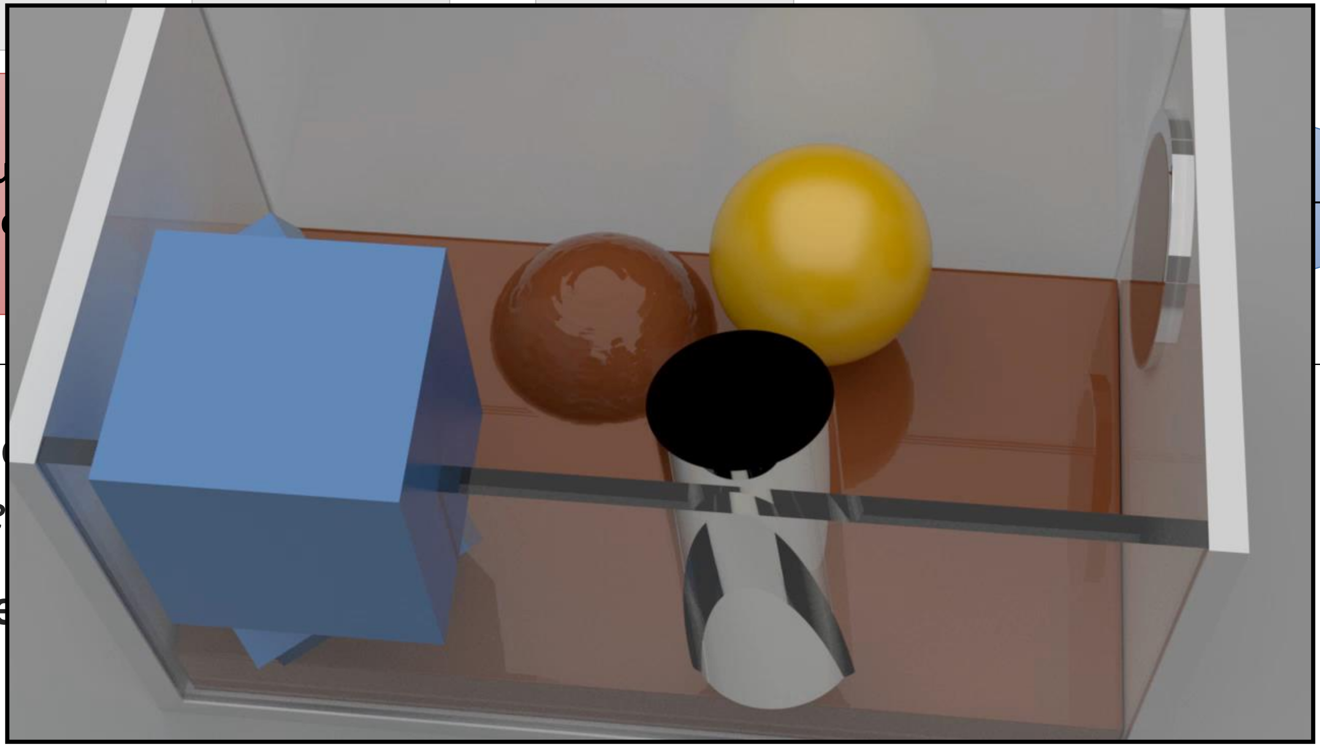
Learn **velocity corrections**
-> mimics PBD

Changing Parameters at Test Time

Correction approach

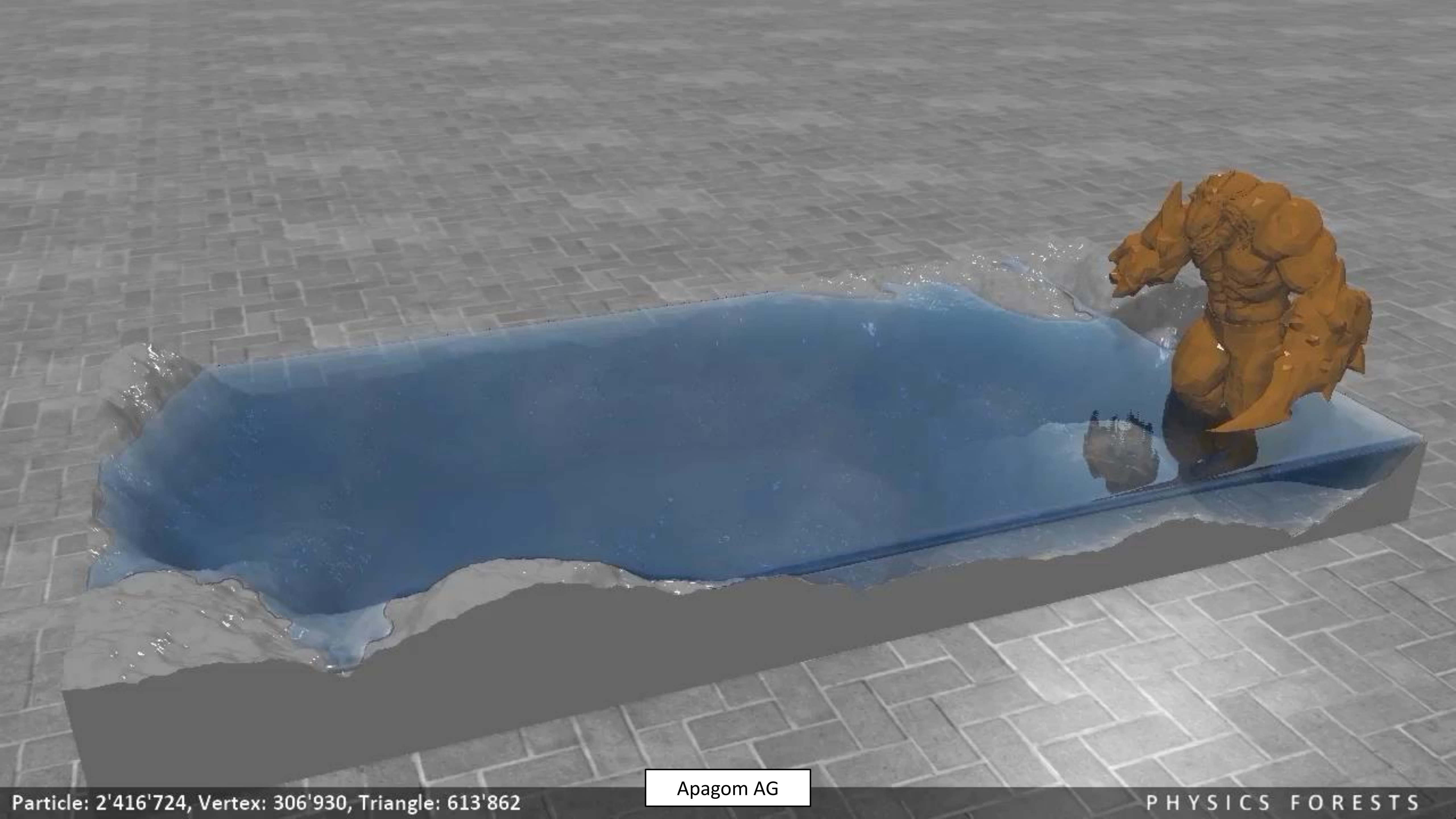
Correction from Advected States



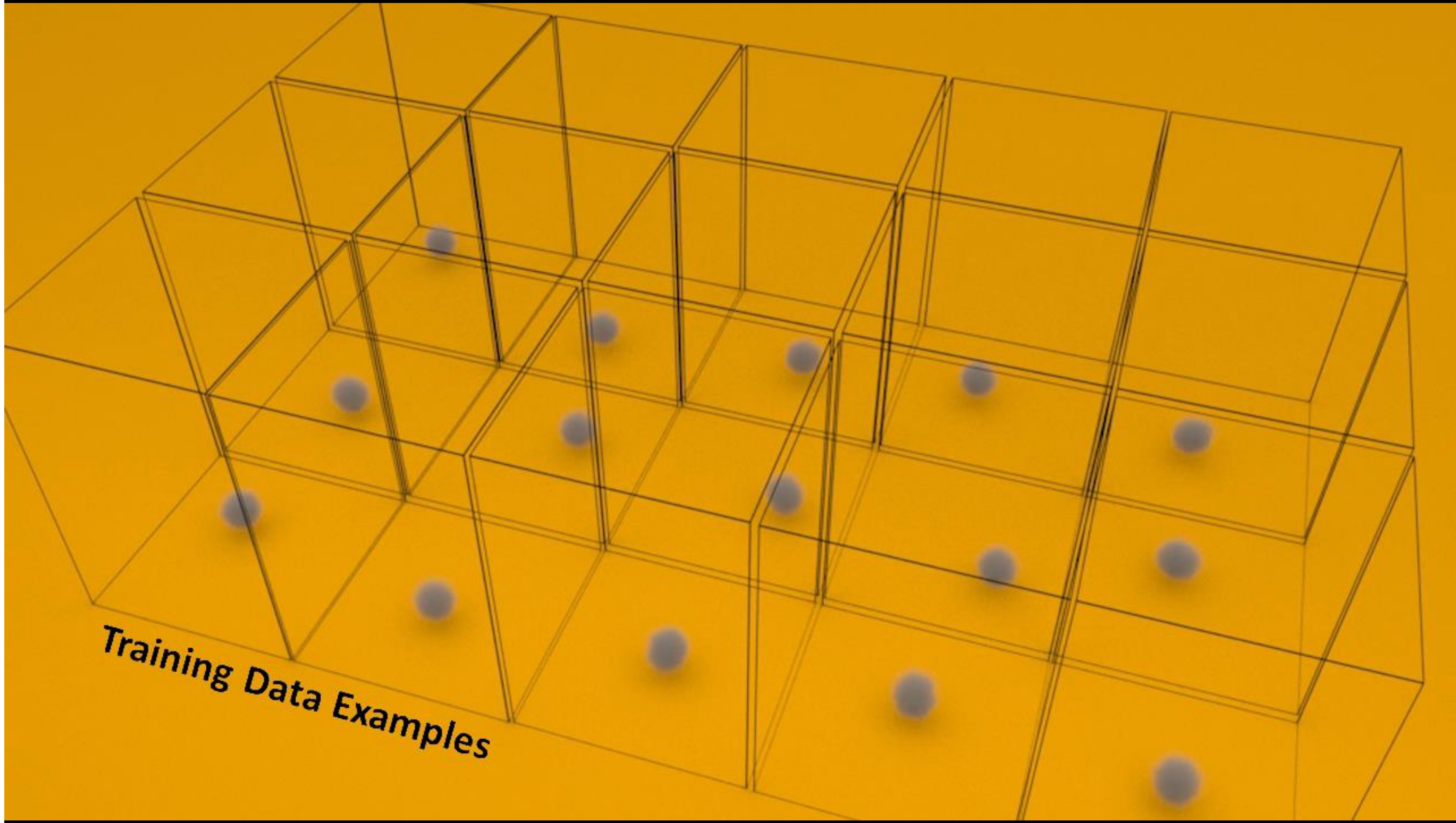


Learn **acceleration**
-> mimics incompre

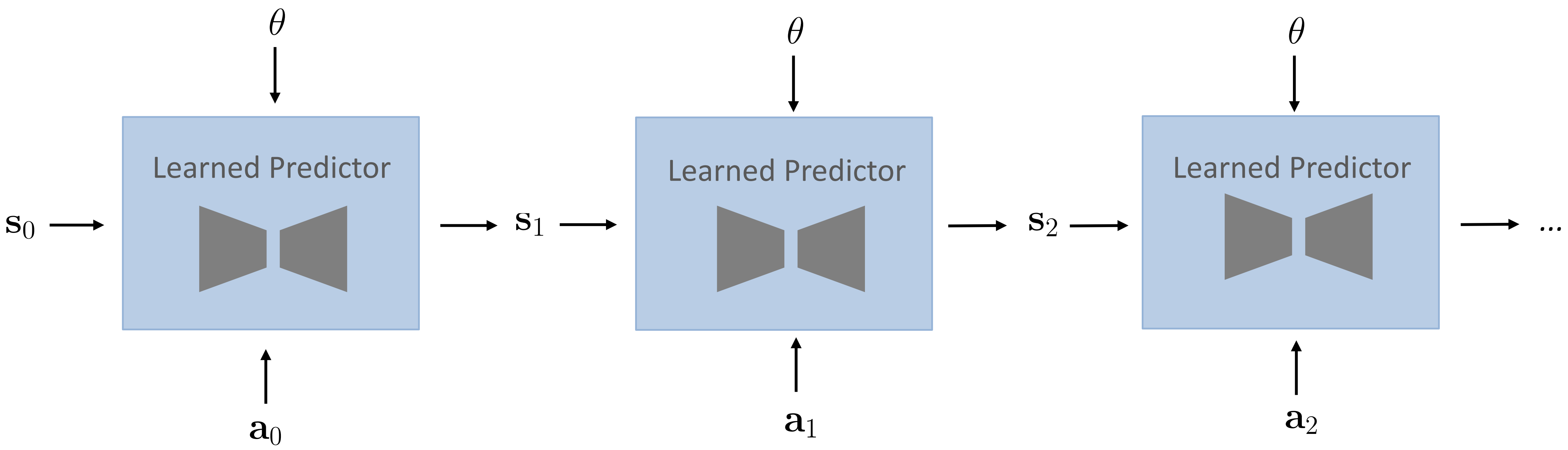
Learn **velocity corre**
-> mimics PBD


Apagom AG
Particle: 2'416'724, Vertex: 306'930, Triangle: 613'862
PHYSICS FORESTS

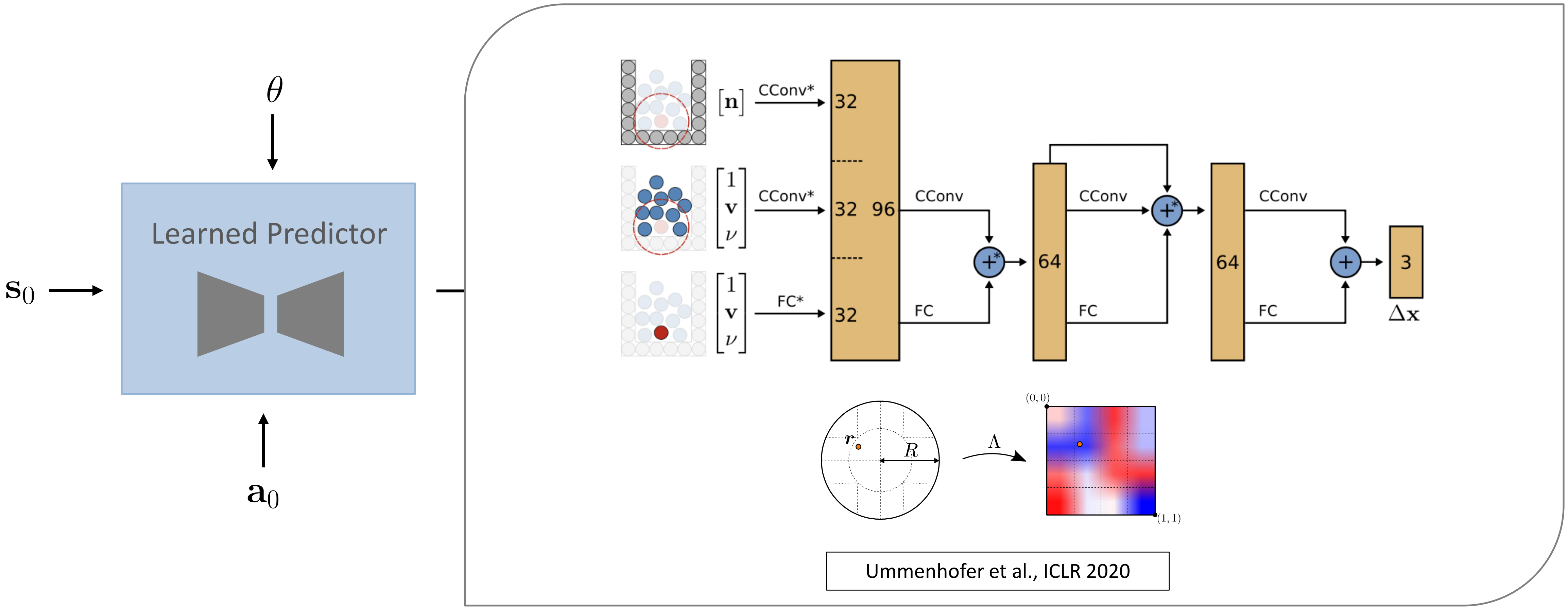
Neural Simulations



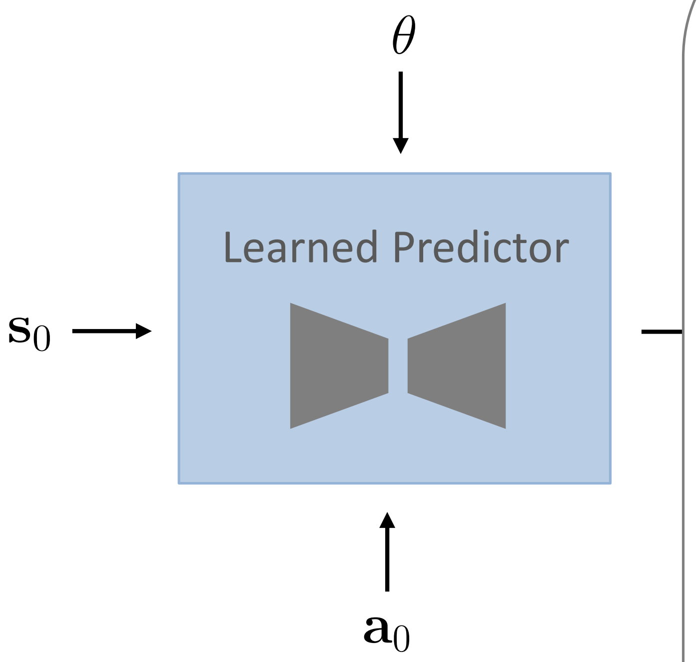
Surrogate Model for Particle Fluids

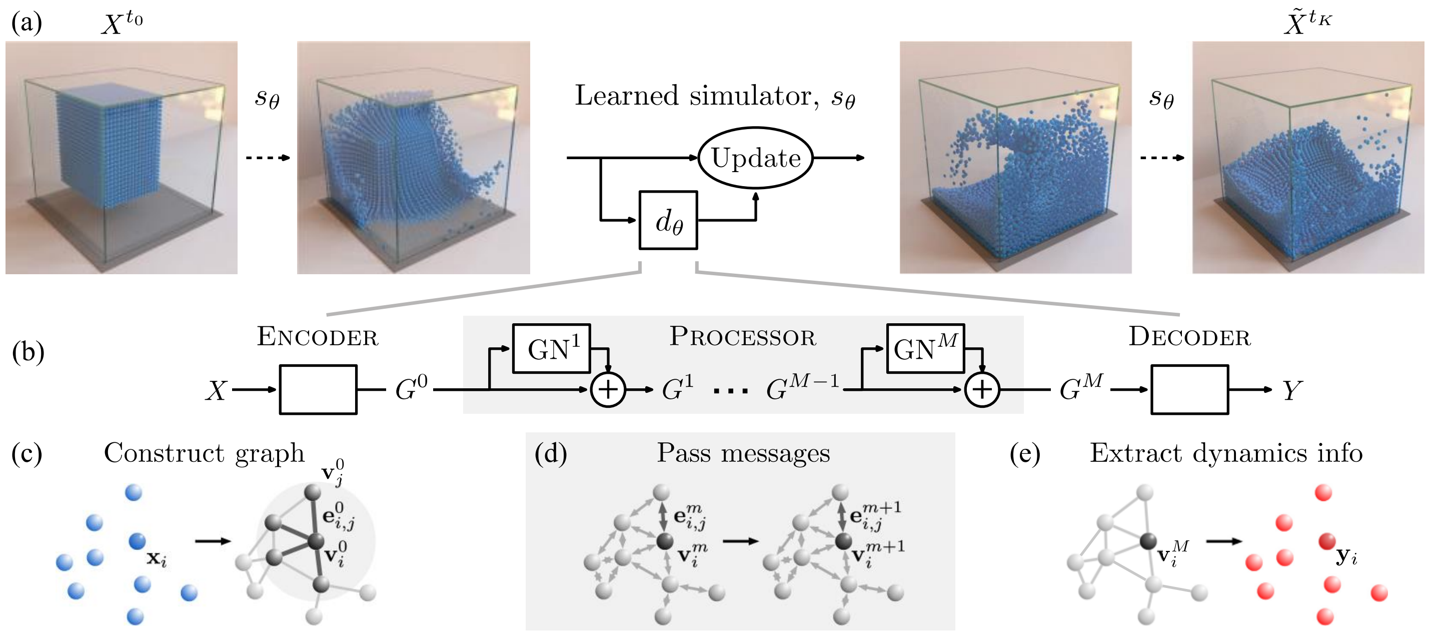


Lagrangian Fluid Simulation with Continuous Convolutions



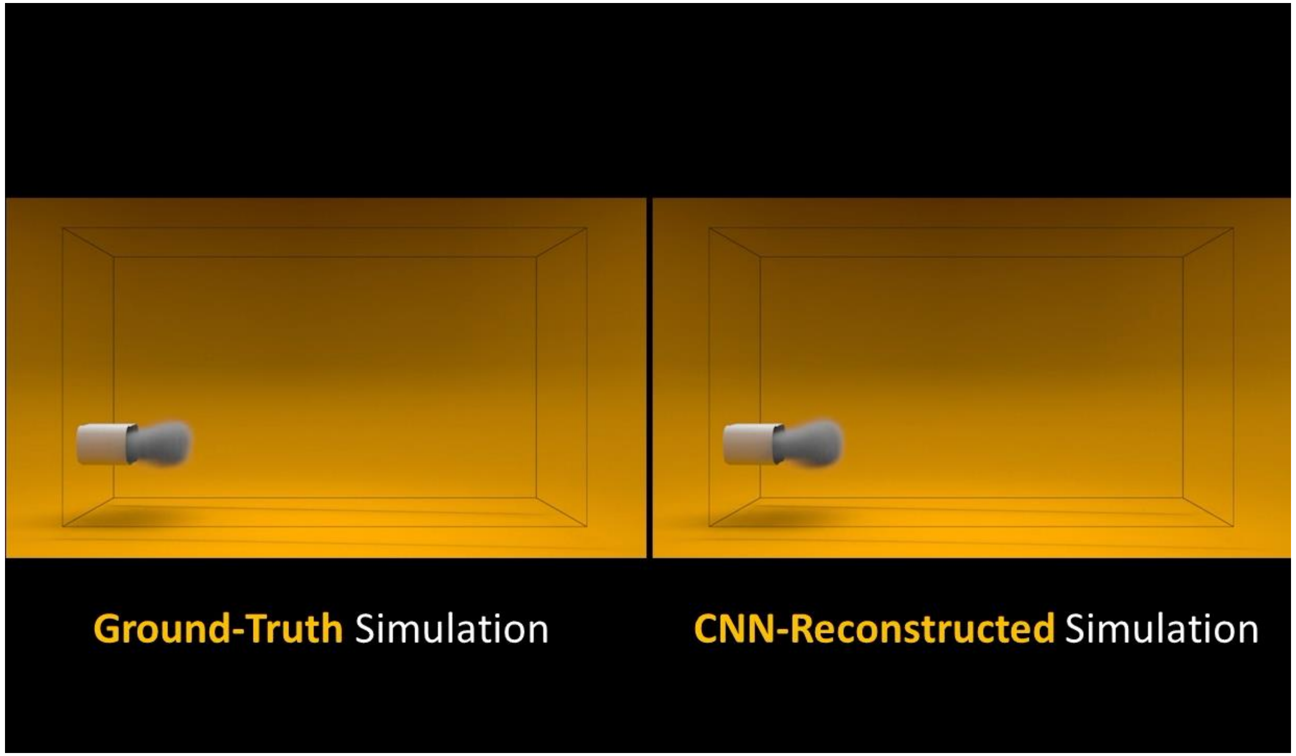
Learning to Simulate Complex Physics with Graph Networks

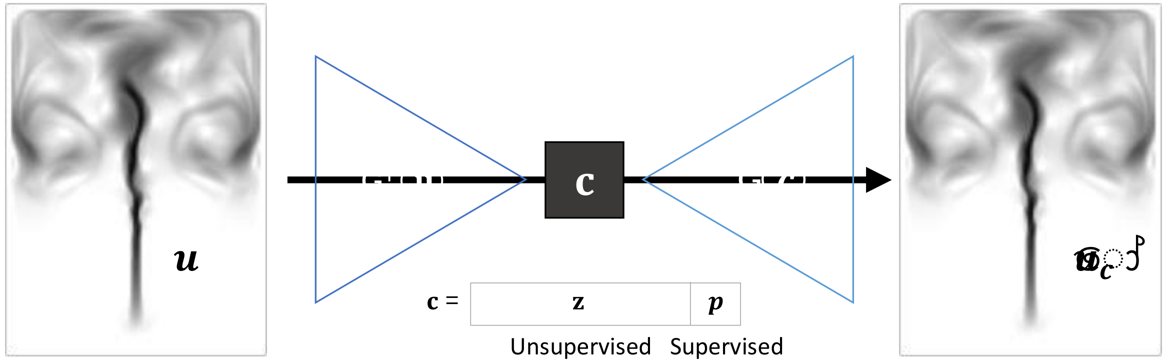




Sanchez-Gonzalez et al., ICML 2020

Digression: Neural Eulerian Simulations

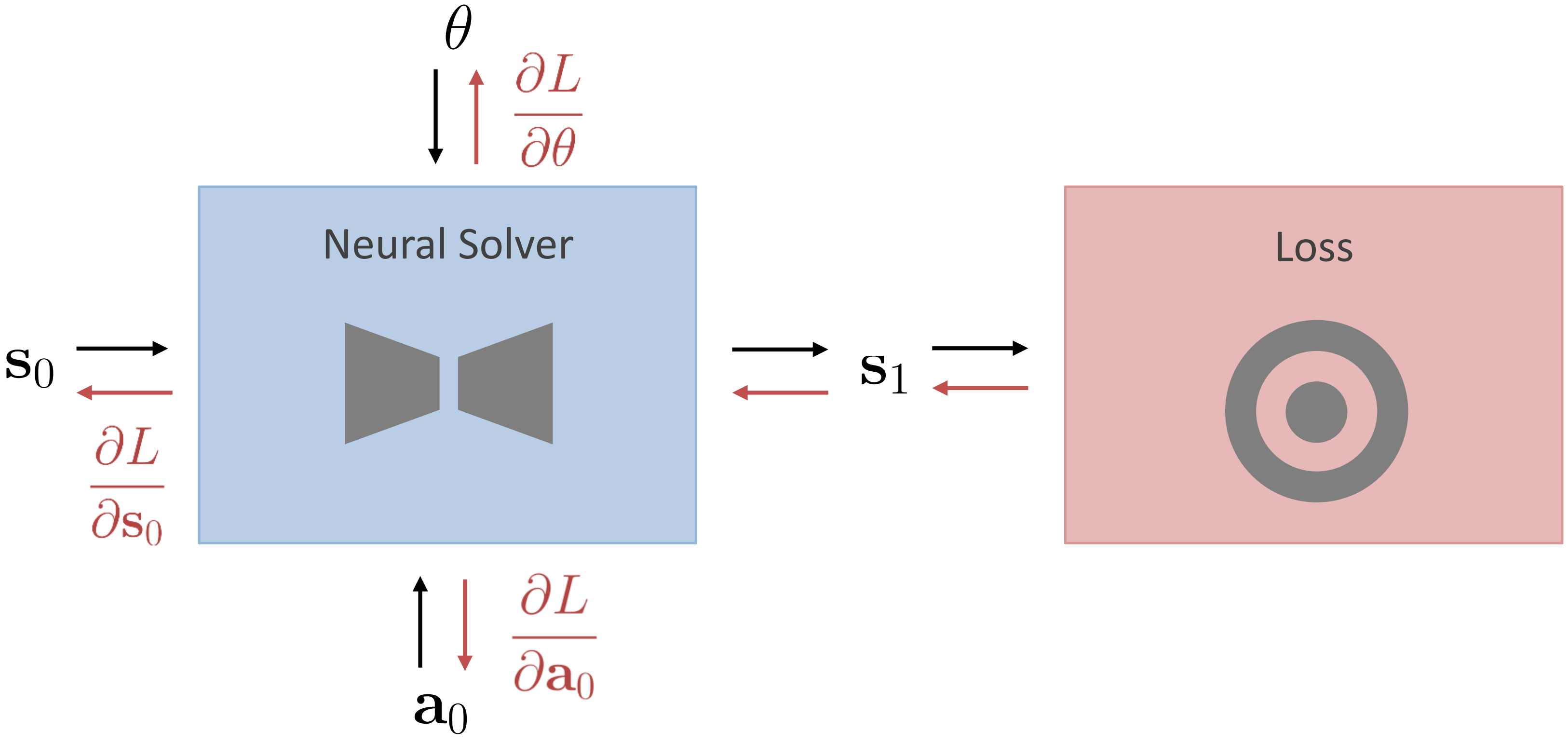




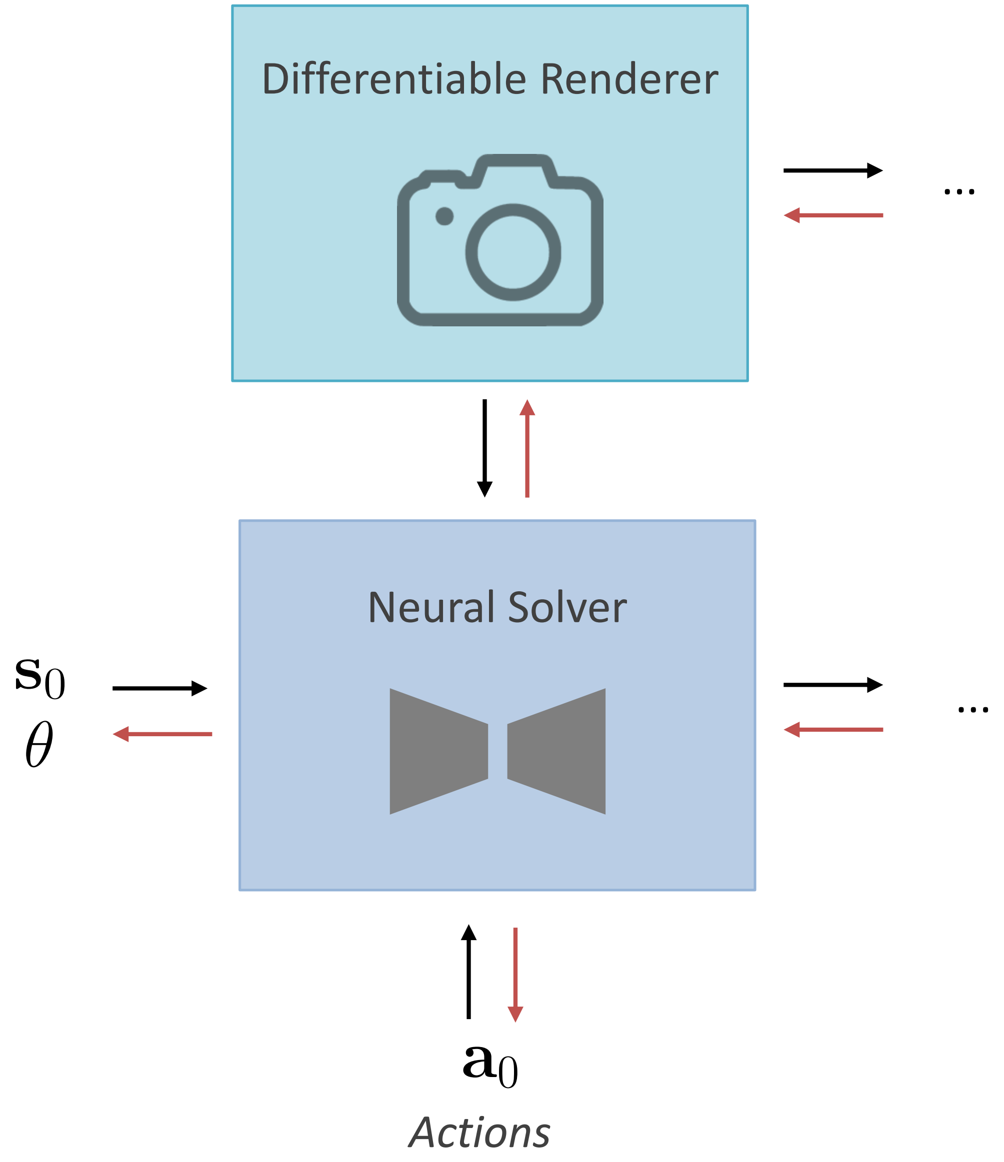
Kim et al., Eurographics 2019

Differentiable Physics for Fluid Control

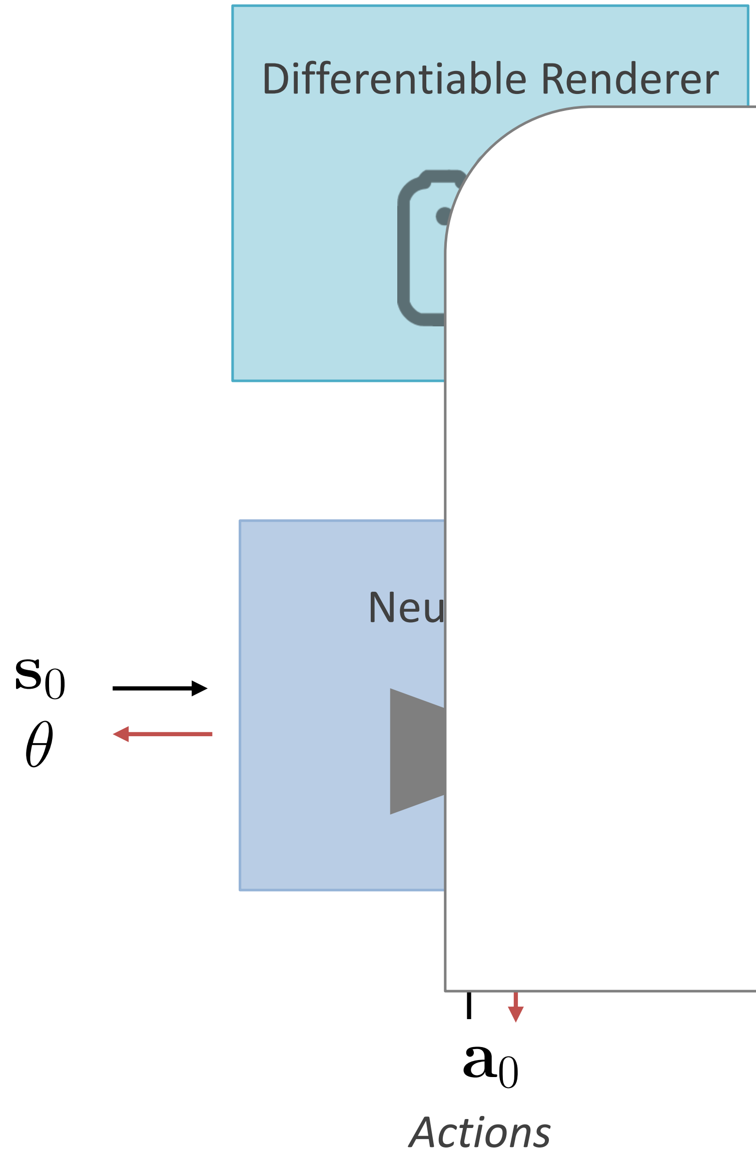
The Key Player for Control: Differentiable Simulation

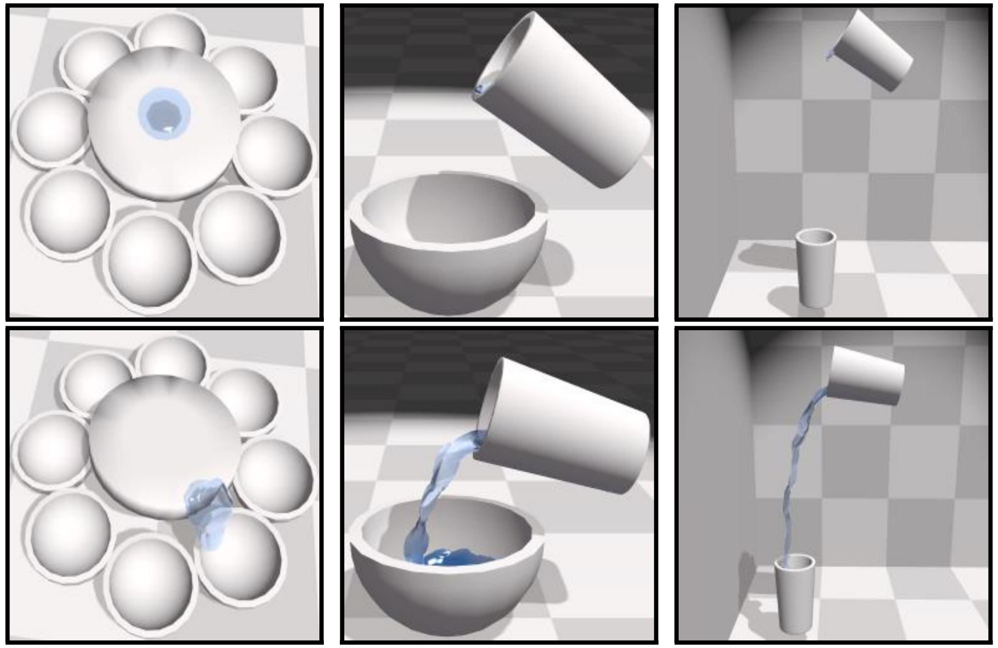


The Key Player for Control: Differentiable Simulation



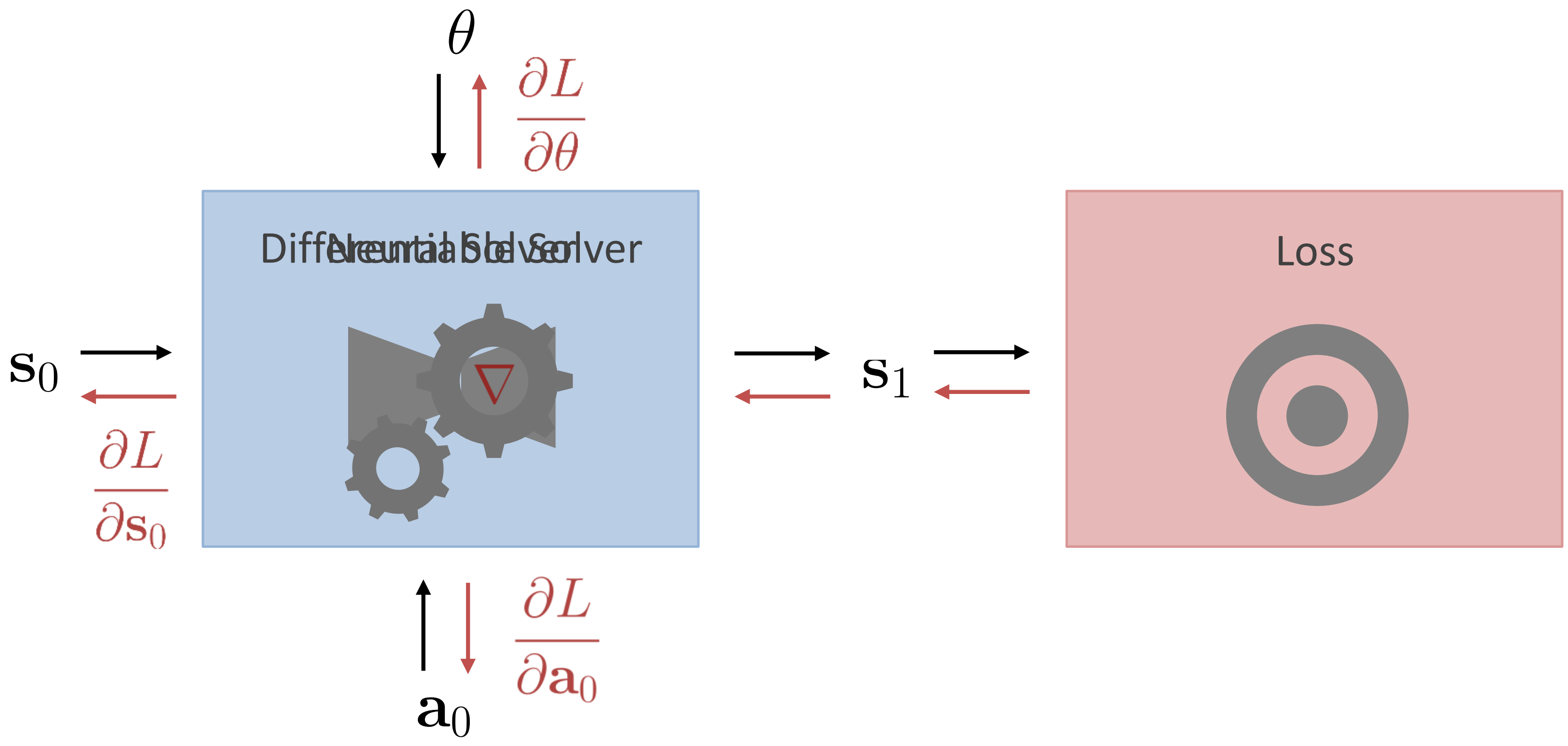
SPNets: Differentiable Fluid Dynamics for Deep Neural Networks





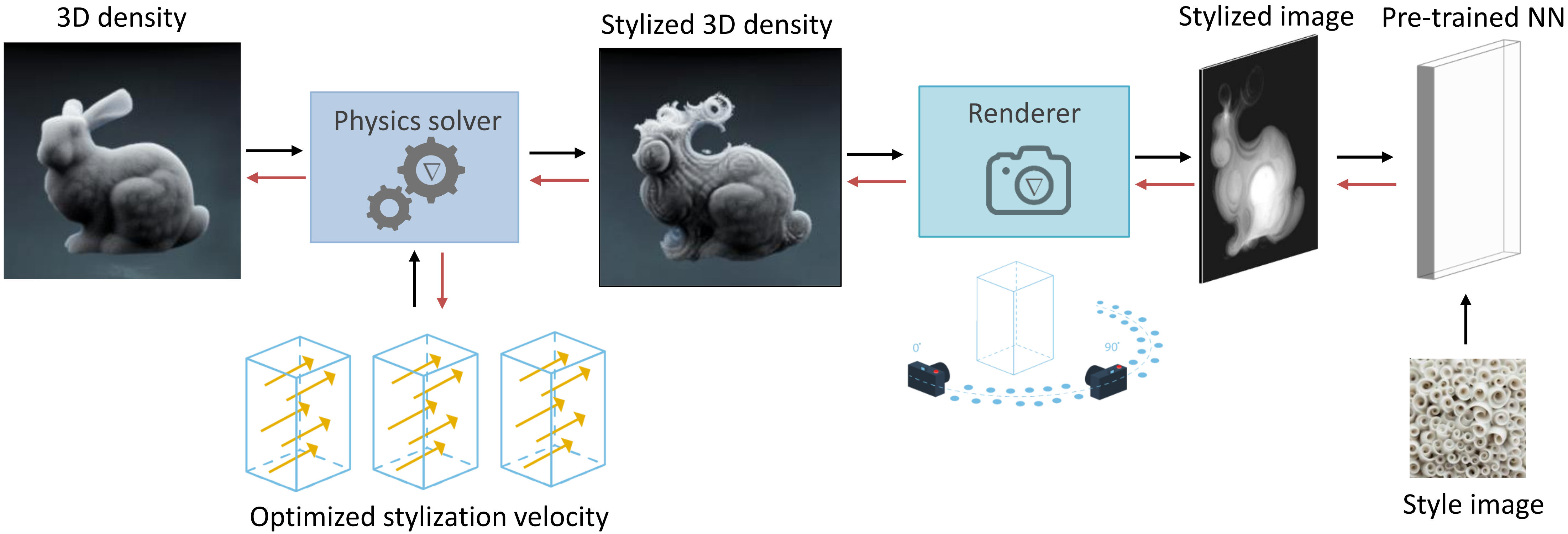
Schenk & Fox, CoRL 2018

The Key Player for Control: Differentiable Simulation

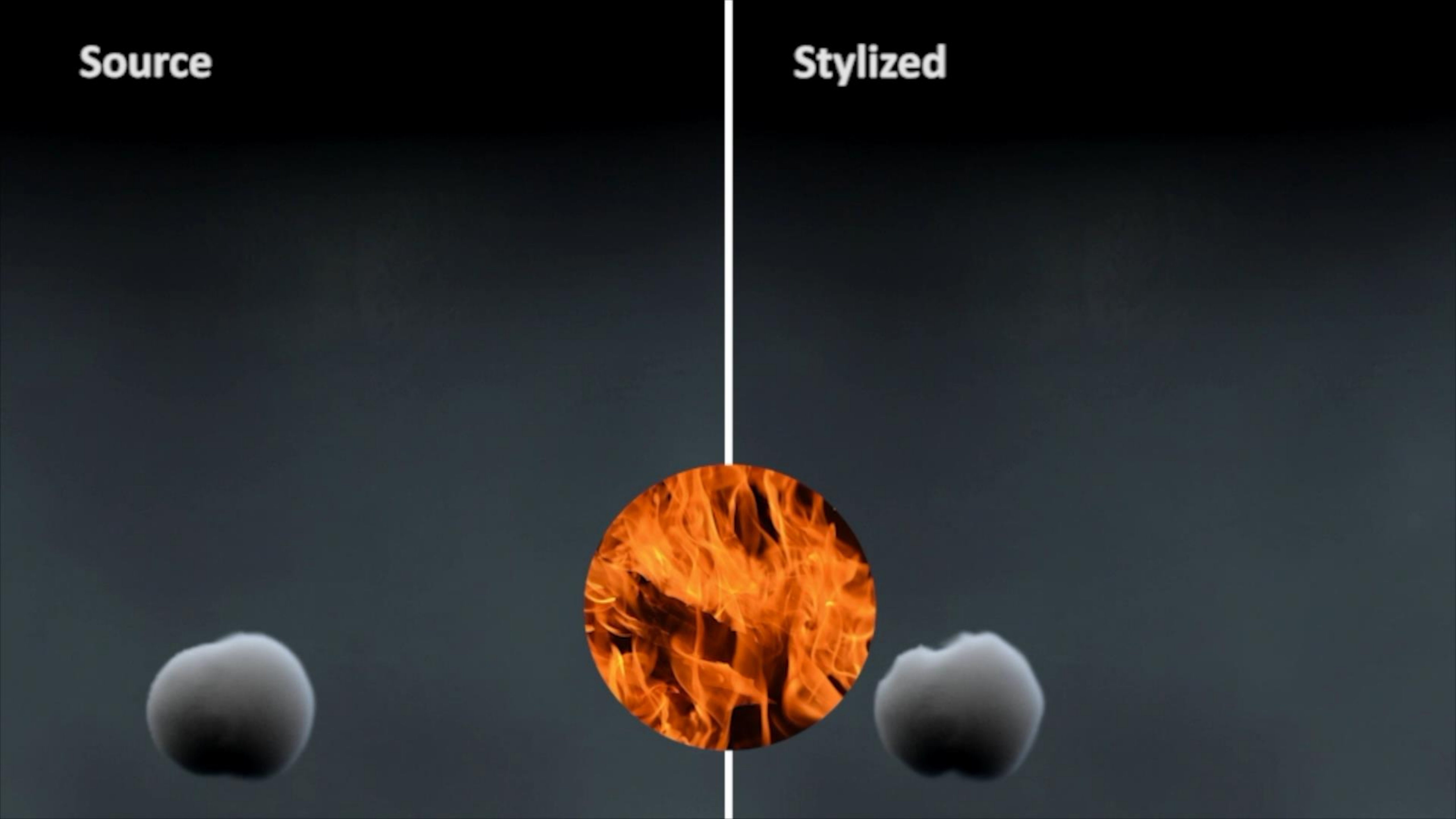


Lagrangian Neural Style Transfer for Fluids

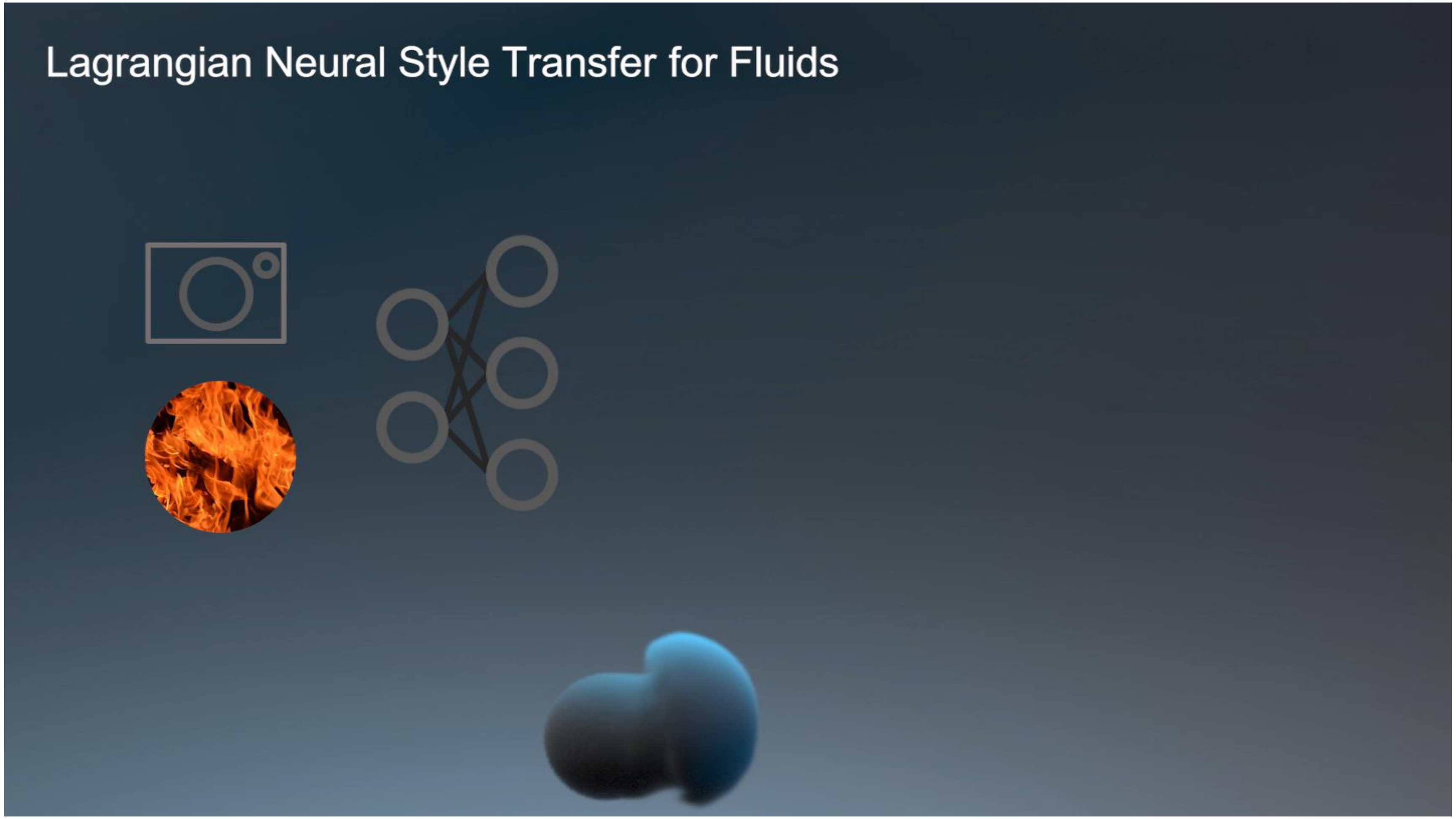
Transport-based Stylization (Eulerian)



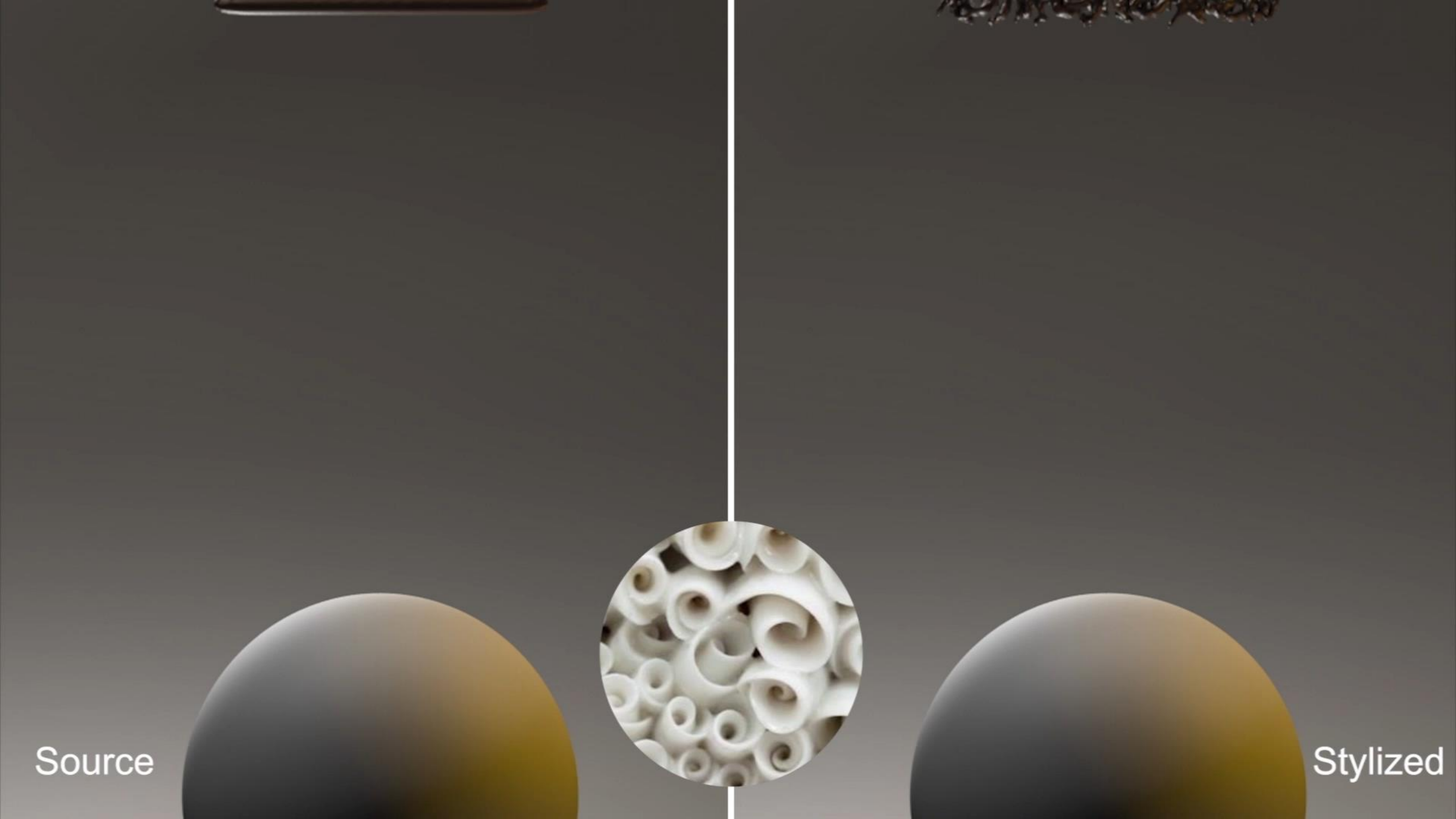
Kim et al., SIGGRAPH Asia 2019


Source
Stylized

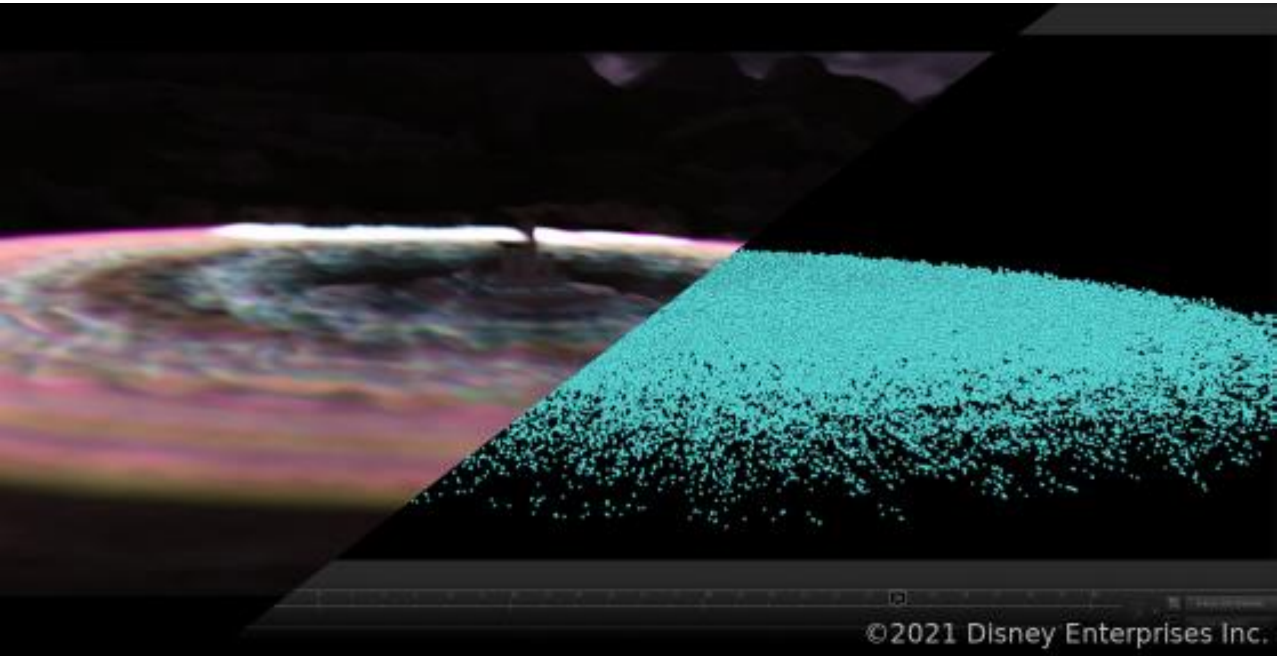
Particles to the Rescue!

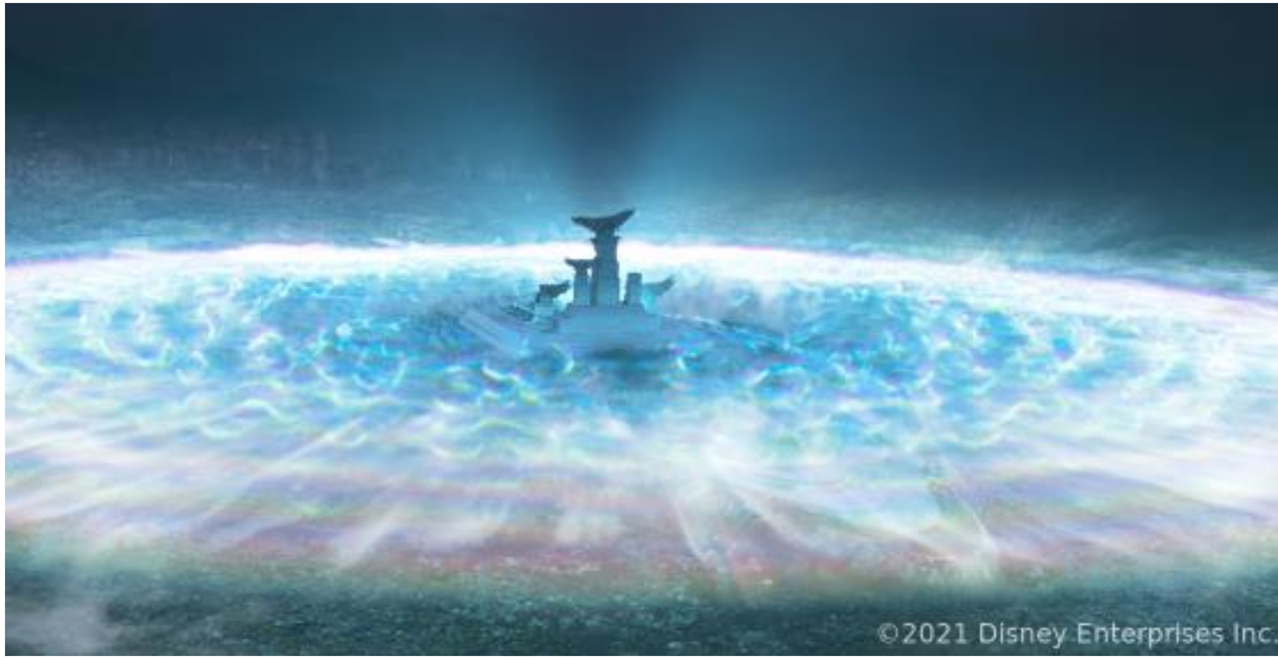


Kim et al., SIGGRAPH 2020


Source
Stylized

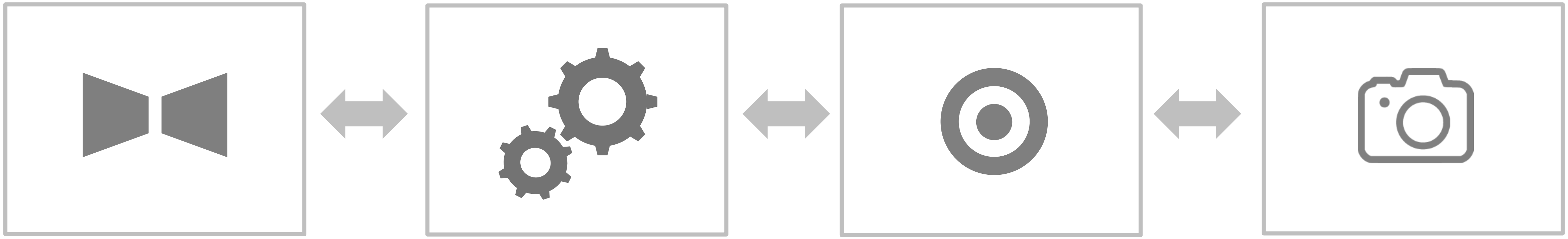
Lagrangian Flow Stylization used in Practice

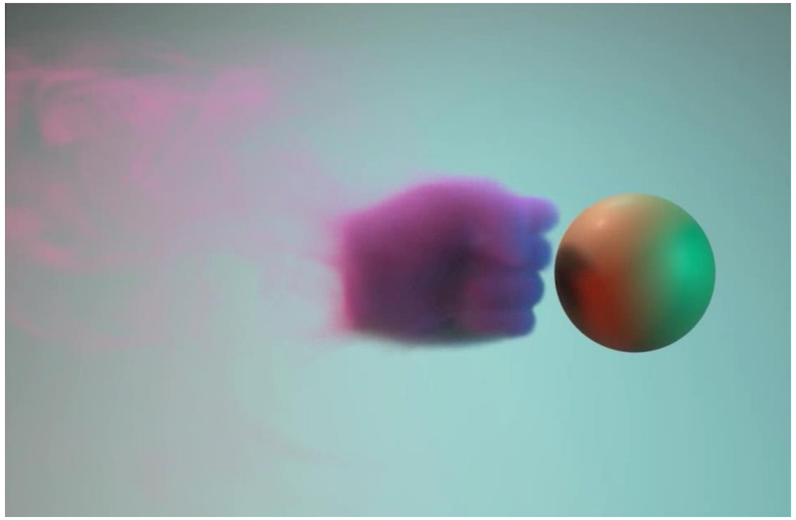




Navarro & Rice, SIGGRAPH Talks 2021

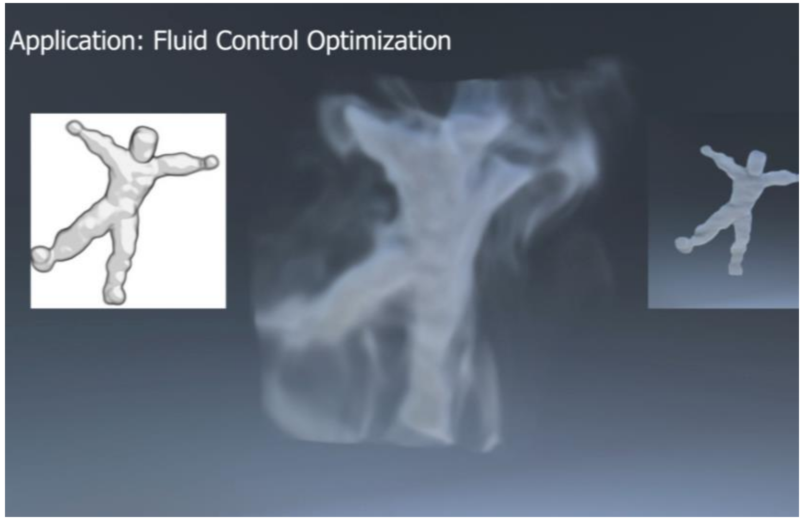
AI Revolution for Fluid Simulation and Animation?





Tang et al., Eurographics 2021

Franz et al., CVPR 2021



Kim et al., Eurographics 2022