

Simulation Methods for Multiphysics Phenomena in Visual Computing

Fabian Löschner, Stefan Rhys Jeske, José Antonio Fernández-Fernández, Jan Bender

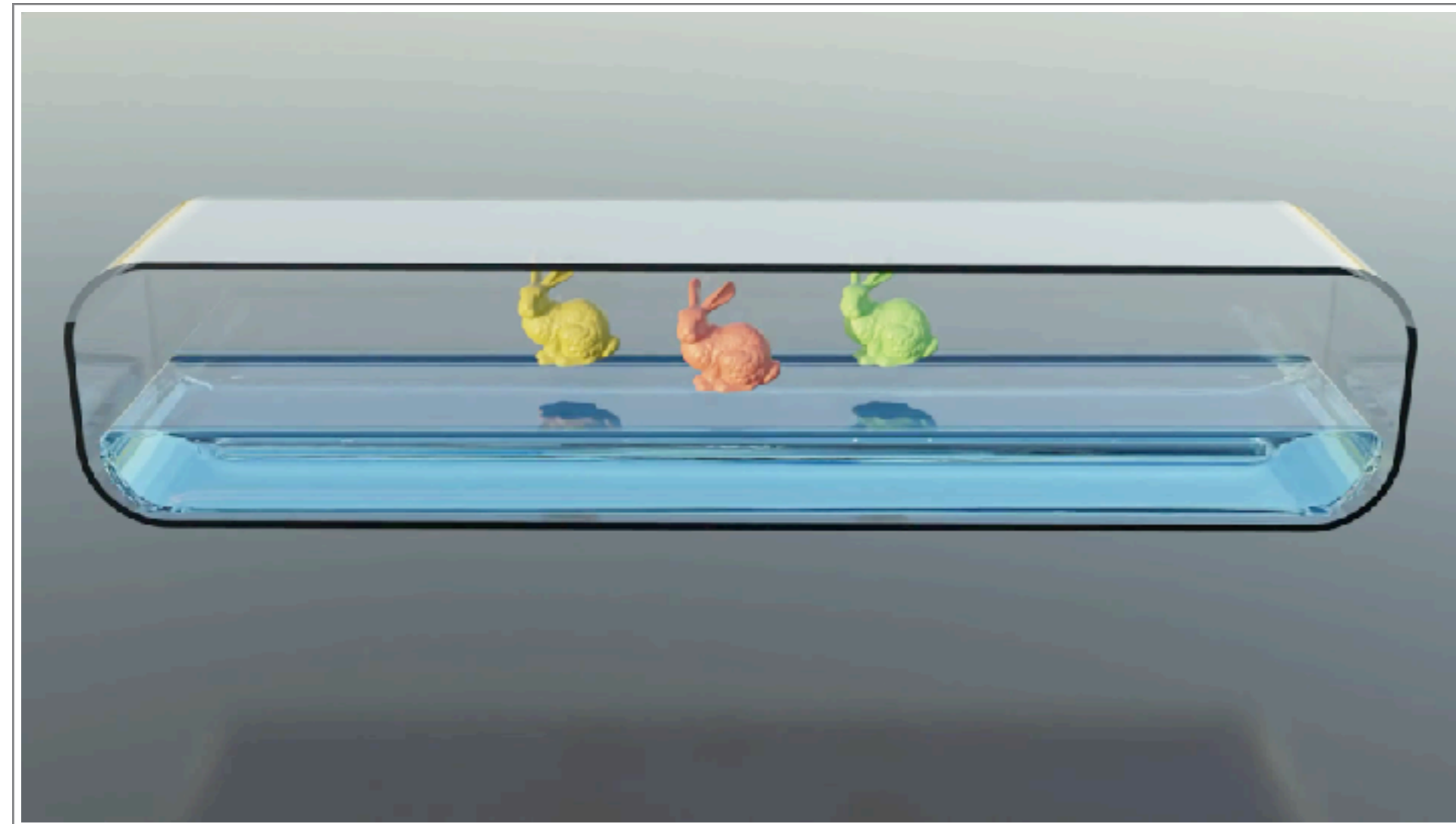
Computer Animation Group, RWTH Aachen University



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Multiphysics in Computer Graphics

Fluids & Deformables



Fast Octree Neighborhood Search for SPH Simulations [Fernández-Fernández, et al. 2022]

Multibody Systems & Frictional Contact



STARK: A Unified Framework for Strongly Coupled Simulation of Rigid and Deformable Bodies with Frictional Contact [Fernández-Fernández, et al. 2024]

Magnetism & Rigid Bodies



Strongly Coupled Simulation of Magnetic Rigid Bodies [Westhofen et al. 2024]

The Tutorial

- Two sessions of 90 minutes, \approx 15 minute break in-between
- Aimed at **beginners** in physics simulation
 - E.g. early PhD students or researchers from other Computer Graphics areas
- **Overview** of prominent methods, **no deep-dives** into specific advanced papers
- Reference material:
 - Tutorial course notes
 - Online slides (*soon*)
 - STAR: “Multiphysics Simulation Methods in Computer Graphics”, 2025 (*Holz, Jeske, Löschner, Bender, Yang, Andrews*)



Authors & Presenters



Fabian Löschner



Stefan Rhys Jeske



José Antonio
Fernández-Fernández



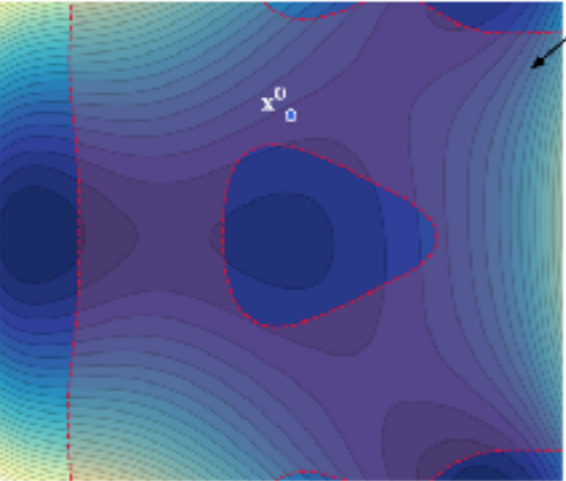
Jan Bender



Tutorial Outline

- Introduction
- **Part I:** Mathematical Foundations
- **Part II:** Energy-based Multiphysics Models
- **Part III:** Lagrangian Point-based Methods
- **Part IV:** Constraint-based Simulation
- Outlook

Descent Directions And Hessian Definiteness






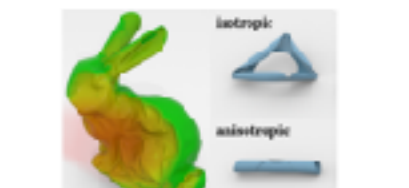


Indefiniteness / Non-convex

We need descent directions: $\Delta \mathbf{x}^T \mathbf{g} < 0$

$$\mathbf{H} \Delta \mathbf{x} = -\mathbf{g} \rightarrow \underbrace{-\Delta \mathbf{x}^T \mathbf{H} \Delta \mathbf{x}}_{>0} = \underbrace{\Delta \mathbf{x}^T \mathbf{g}}_{<0} < 0$$
$$\mathbf{p}^T \mathbf{H} \mathbf{p} > 0, \quad \forall \mathbf{p} \neq \mathbf{0}$$

H is Symmetric Positive (Semi)definite

Contact  <small>Collisionless Incremental Potential Contact [Li et al. 2021]</small>	Rigid Bodies  <small>Interaction-free Rigid Body Dynamics [Ferguson et al. 2021]</small>	Multibody Systems  <small>A Unified Newton-Raphson Method for Multibody Dynamics [Zhou et al. 2022]</small>
Fluids  <small>Contact Proxy Splitting Method for Lagrangian Solid-Fluid Coupling [Wu et al. 2020]</small>	Magnetism  <small>Strongly Coupled Simulation of Magnetic Rigid Bodies [Wacholder et al. 2024]</small>	Heating & Wetting  <small>Physical Simulation of Environmentally Induced Thin-Film Deformation [Zhou et al. 2019]</small>

