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Hauptseminar Computer Graphics and Visualization

Advanced Seminar

Physically-based Rendering and Simulation

Kick-off Meeting

APB E009 / 18th April 2024 / 2. DS

Computer Graphics and Visualization

General Information

- If you haven't already, please **register** in jExam (non-CMS) or Selma (CMS) in order to get accreditation!
- All whole-group meetings will happen in APB E009 Thursdays at 2. DS.
- Regularly check the seminar webpage for updates and important dates.

Objective of the Seminar

- Learn how to conduct high-quality scientific writing.
- The essential aspects of literature study for success in scientific writing.
- The importance of sharing research work in science through publications.
- Nice side-effect: Learn advanced concepts of physically-based rendering and simulation.

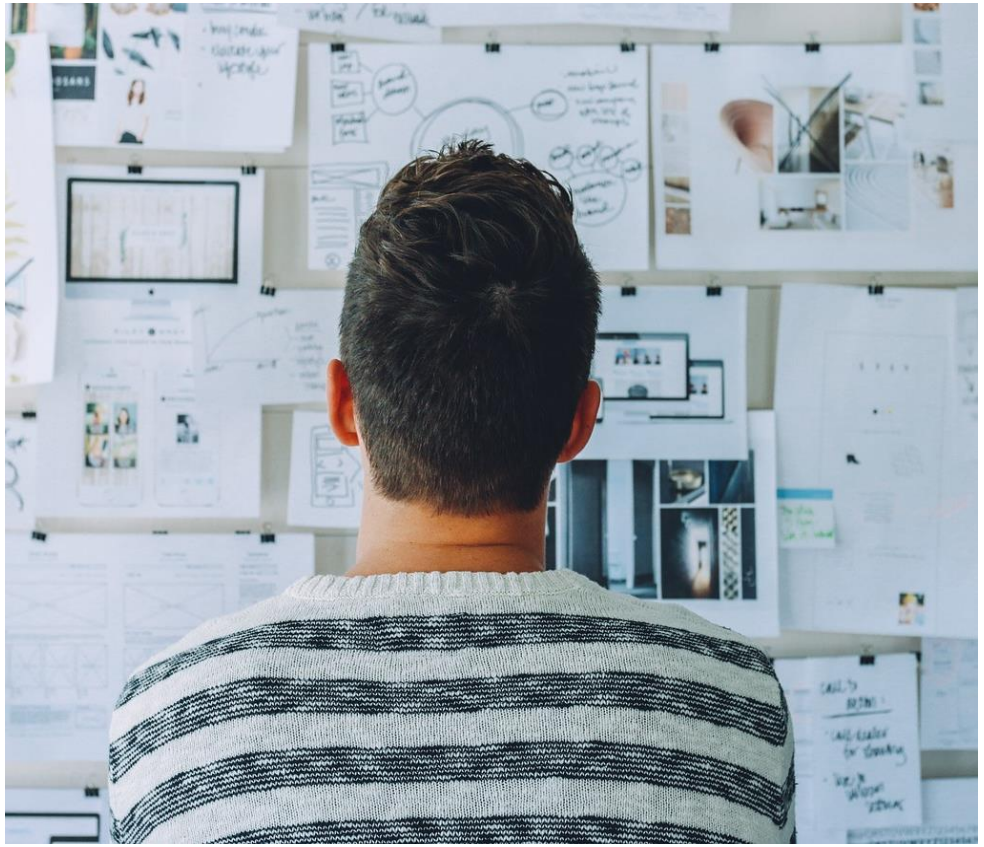

Image source: SlidesAI.io

Teamwork and Grading

- Teams of up to three members can take a topic.
- Grading is done on an individual basis based on the contribution to each milestone. Maintain a work diary!
- Maintain a shared database of papers (e.g. with Zotero).
- Study the papers in depth and collaborate with teammates to share insights.
- Divide your workloads equally.

Image source: SlidesAI.io

Topic Selection and Contact with Supervisor

- A doodle poll for topic selection is available on the course webpage.
- Deadline to select a topic is 20th April.
- The teams should contact their supervisors* after the topics have been assigned.
- Have regular contact with your supervisor for guidance throughout the seminar duration.

Image source: SlidesAI.io

Scientific Writing

- Planned for 25th April: A special lecture to provide you guidance on conducting good scientific research and writing.

Ethical Considerations

- The ethical considerations in scientific writing including plagiarism, conflicts of interest, or falsification.

- The importance of adhering to ethical standards for the credibility and reproducibility of research.

https://handmadewriting.com/blog/guides/scientific-paper/

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Milestones

Computer Graphics and Visualization

1st Milestone - 1 Page Review

- The team will submit a 1 page review of publications that are highly important for the selected topic.
- It is advisable to send the 1 page draft to your supervisor before final submission.
- Submission Deadline: 16th May

Image source: SlidesAI.io

2nd Milestone - Detailed Scientific Report

- After the submission of the 1 page review, the team will study relevant publications in detail.
- The team will write a detailed scientific report of 15-20 pages following ethical and scientific standards.
- It is encouraged to collaborate with teammates and find solutions to open problems.
- Have regular meetings with your supervisor to seek guidance.
- Submission Deadline: 20th June

Image source: SlidesAI.io

3rd Milestone – Final Presentation

- The team will discuss their work with a PowerPoint style presentation.
- Importance of clear and effective communication in scientific presentations.
- The final presentation will also be conducted purely onsite.
- Tentative Schedule: mid to end of July

Image Source: DALL-E

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Topics

Computer Graphics and Visualization

Rendering 01 – Solutions to the rendering equation

- Light propagation can be expressed in mathematical terms using a single formula – the rendering equation.
- However, no closed form solution is available
- Several solutions to this equation have been proposed, each with their advantages and disadvantages.

Source: Metropolis light transport

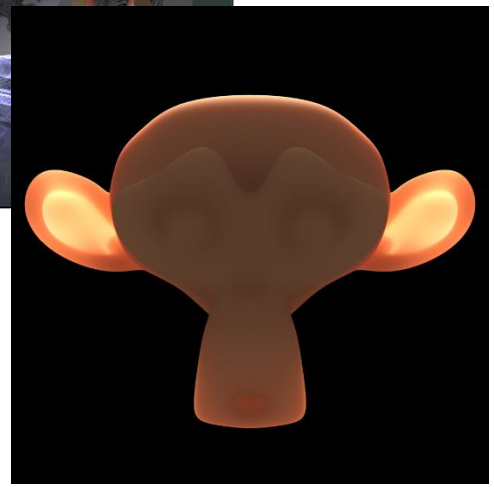
Relevant papers:

[1] Kajiya: The rendering equation.
[2] Veach and Guibas: Metropolis Light Transport.
[3] Jensen: Global Illumination using Photon Maps.

Rendering 02 – Advanced light transport effects

- Some effects like caustics, dispersion and volumetrics are hard to render.
- However, they might be key to realistic image synthesis.
- Specialized additions to existing algorithms tackle these problems.

Source: Zeltner et al.



Source: Wikipedia

Relevant papers:

[1] Zeltner et al.: Specular Manifold Sampling for Rendering High-Frequency Caustics and Glints
[2] Jensen: A Practical Model for Subsurface Light Transport

Rendering 03 – Real-time global illumination effects

- Complete solutions to the rendering equation are computationally expensive. So far just offline rendering.
- Recent hardware trends have show the industry is shifting towards including global illumination into real-time applciations.
- Specialized methods provide fast high-quality approximations.

Source: NVIDIA

Relevant papers:

[1] Thiedemann: Voxel-based Global Illumination
[2] Crassin: Interactive Indirect Illumination Using Voxel Cone Tracing
[3] Lin et al.: Generalized Resampled Importance Sampling: Foundations of ReSTIR

Rendering 04 – Radiance fields

- Recent developments have been producing new forms of scene representations.
- Input is typically a series of images.
- Some training process will fit a model to represent the scene.
- Rendering of novel views is possible.

Source: Kerbl et al.

Relevant papers:

[1] Müller et al.: Instant Neural Graphics Primitives with a Multiresolution Hash Encoding
[2] Kerbl et al.: 3D Gaussian Splatting for Real-Time Radiance Field Rendering

Simulation 01 – Rigid (+ soft) bodies

- Rigid body simulations are used in many fields in science but also consumer applications
- Problems: stability, coupling between individual parts, reliable collision detection

Source: Müller et al.

Relevant papers:

[1] Müller et al.: Detailed Rigid Body Simulation with Extended Position Based Dynamics
[3] Wolper et al.: Continuum Damage Material Point Methods for Dynamic Fracture Animation

Simulation 02 – Cloth simulation

- Cloth simulations suffer from the complexity arising from the material parameters and possible self-intersections.
- Often times cloths are applied on top of animated characters where they need to accurately collide with the base mesh.

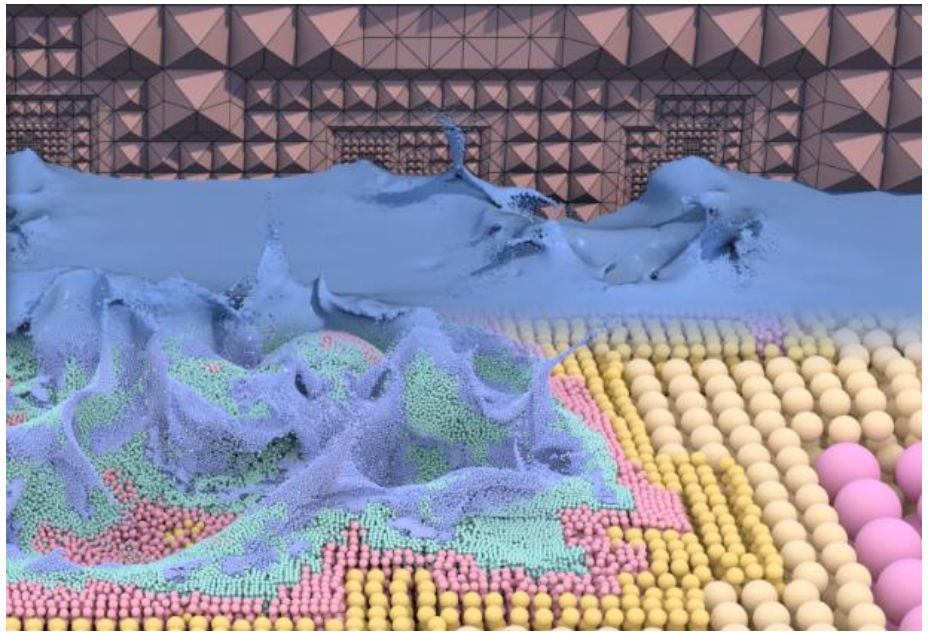
Source: Narain et al.

Relevant papers:

[1] Narain et al.: Adaptive Anisotropic Remeshing for Cloth Simulation
[2] Sperl et al.: Homogenized Yarn-Level Cloth

Simulation 03 – Fluid simulation

- Accurate fluid simulation involves complex computations of large amounts of data.
- Many methods have been proposed to efficiently solve this task.
- Some integrate advanced behaviour of fluid phenomena, like viscosity, multiple phases or two-way coupling.



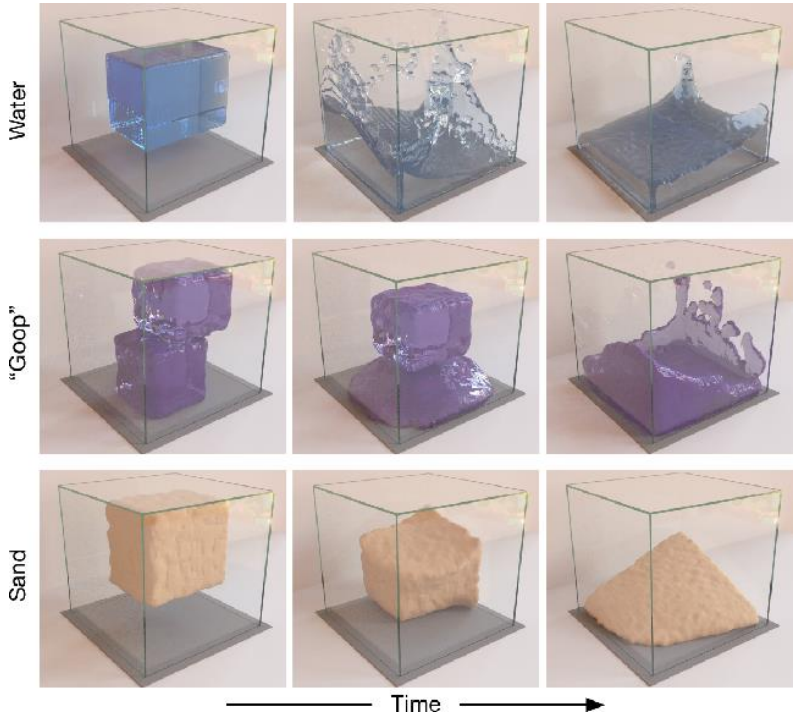
Source: Ando et al.

Relevant papers:

[1] Shao et al.: A Fast Unsmoothed Aggregation Algebraic Multigrid Framework for the Large-Scale Simulation of Incompressible Flow
[2] Ando et al.: Highly Adaptive Liquid Simulations on Tetrahedral Meshes

Simulation 04 – Machine learning in simulation

- The advancement of machine learning methods has quickly gained traction in many fields of computer science.
- Specialized methods have been developed to allow ML being used to drive simulations.
- Other applications include physics-based learning for rigged characters.



Source: Sanchez-Gonzales et al.

Relevant papers:

[1] Sanchez-Gonzales et al.: Learning to Simulate Complex Physics with Graph Networks
[2] Bergamin et al.: DReCon: Data-Driven responsive Control of Physics-Based Characters

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Thank you. Please feel free to ask any questions.