Seminar in Computer Graphics 186.175, WS 2024/25, 2.0h (3 ECTS)

Stefan Ohrhallinger

Institute of Visual Computing and Human-Centered Technology (E193-02)

TU Wien

http://www.cg.tuwien.ac.at/staff/StefanOhrhallinger.html

Important!

Register to course in TISS and TUWEL: to get news & updates

These slides will on TUWEL and institute website after this meeting

Official registration: by submitting the literature list

Topics are presented and chosen today, assigned tomorrow

Seminar Goals

Practice selecting, reading and understanding

- Search and select papers relevant to your topic
- Summarize them as a state-of-the-art report
- Prepare a talk about your topic in the seminar

This permits in-depth familiarization with the topic

More in-depth/spezialized than Bachelor seminar!

If well done → can continue to master thesis ...

Tasks

- Submit a literature list (chosen with supervisor)
- Attendance of 3 lectures
- Meetings with supervisor: paper selection, discussion of papers, preparing talk slides
- Alternative: evaluate and compare algorithms
- Write a report
- Review a report from a colleague
- Final talk in seminar

Literature List

- Analyze recent papers (select with supervisor)
- Study secondary literature to understand topic
- How to find relevant papers:
- SIGGRAPH Proceedings
- Google Scholar: find the right key words
- Survey papers, often-referenced papers
- Submit a list of 10+ papers to TUWEL → official registration

State-of-the-Art Report (STAR)

- 8 pages per student, must be in English
- Format in the style of a scientific paper
- Use LaTeX template on course website, can use Overleaf
- Provide a way to show changes from mid-term to final report
- Submit the mid-term and final report in PDF format
- Mid-term report has to be complete and minimum 8 pages!

Scientific Review

- You will get a draft of another student to review
- Typical conference review form (Eurographics)
- This helps author to improve the manuscript
- Guides on review writing on course website
- You will receive 2 reviews (student, supervisor)
- Improve final report according to reviews

Seminar Talk

- Prepare slides in advance, using template
- Each student talks for 15 minutes, in english
- 5 minutes discussion after each talk
- Focus is on overview/comparison of methods
- Present so that other students will understand it
- Active discussion is mandatory and is graded
- Slides presentation from seminar PC (ODP, PPTX, PDF)

Grading

- Lecture attendance 5%
- Review: 15%
- Seminar slides+talk: 30%, discussion 5%
- Final report: 45%

- Late submission: 15% off task per day, so no points after 1 week (this also concerns the mid-term report!)

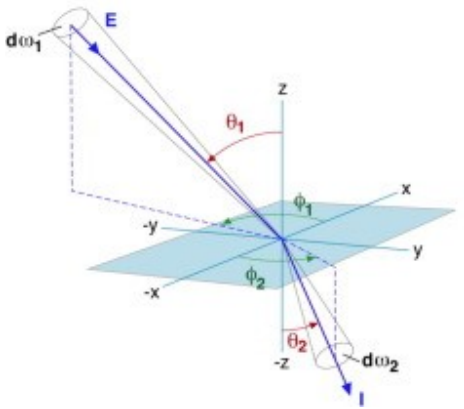
Important Dates

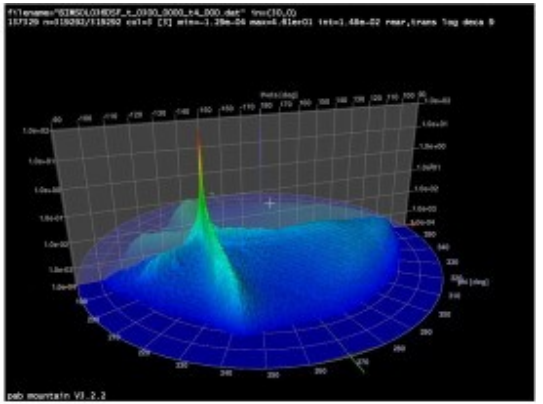
- 21.10. 23:59 Submit literature list (on TUWEL)
- 29.10. 13:00-15:00 Lecture Prof. Gröller
- 11.11. 14:00-16:00 Lecture Prof. Wimmer
- 19.11. 13:00-15:00 Lecture Prof. Kaufmann
- 16.12. 23:59 Submit report draft
- 06.01. 23:59 Submit review
- 27.01. 23:59 Submit slides
- 28.01. 14:00-19:00 Seminar talks
- 28.01. 23:59 Submit final report

Topic Presentation

- Now 14 topics will be presented
- After the presentation, please mark down at least 3 in order of preference (1, 2, 3, …), your name and student number and hand them in
- I will try to make a fair assignment of topics in case of conflicts and post them in forum “Announcements” tomorrow

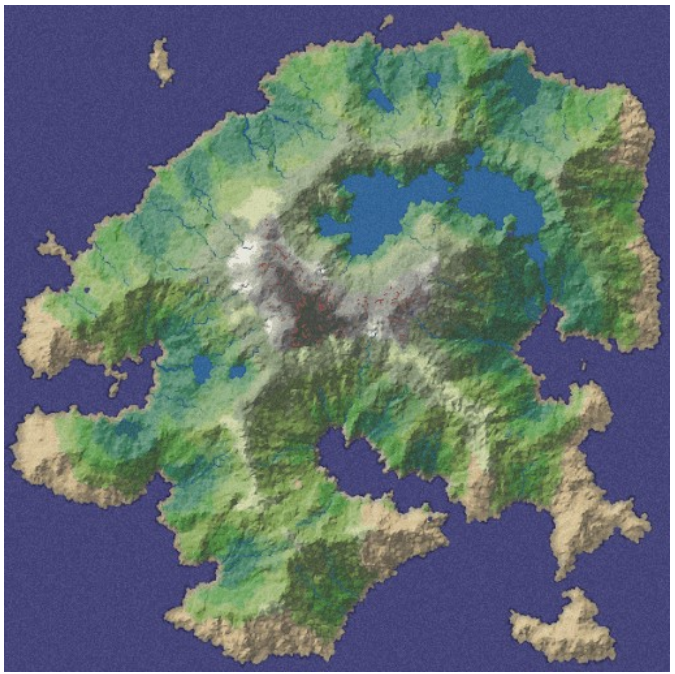
Conduct a survey of recent advances in the representation and application of measured materials

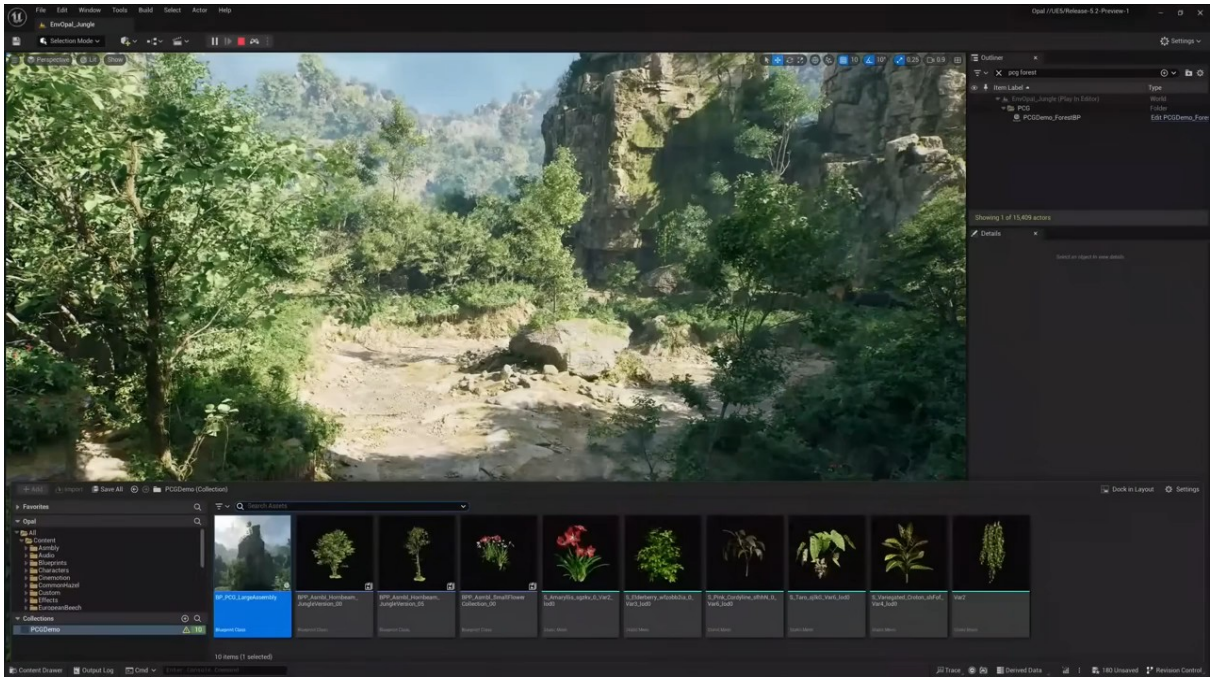




2 Procedural Content Generation

- 3D Scenes, maps, assets
- 2D Maps,
- UE5: Drop an asset, procedurally integrate it to surrounding





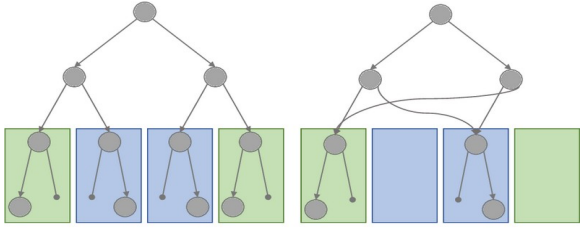
3 Compression Algorithms for the GPU

- Compression for meshes, meshlets, textures, …
- Approaches that decode once vs decode every frame during rendering

Texture Compression

Uncompressed BC1

Voxel Compression via Directed Acyclic Graphics

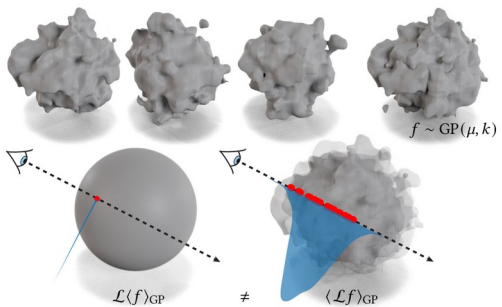


(a) Original SVO. **(b)** Transformed to DAG.

4 Unified Representations: From Surfaces To Volumes

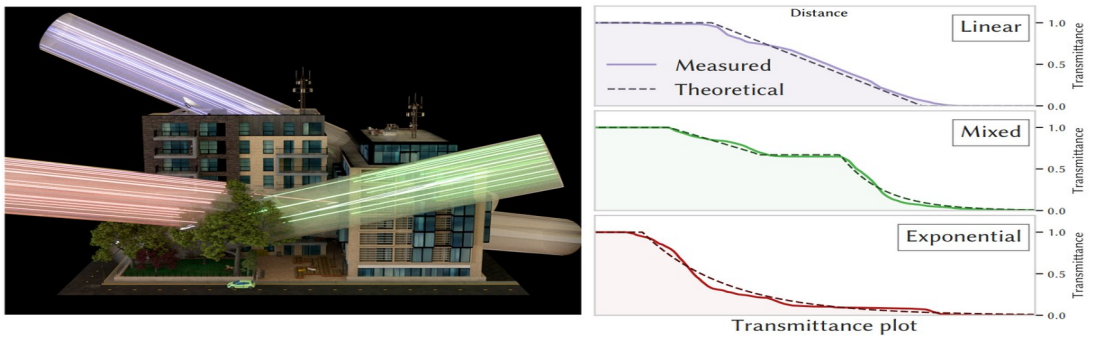
Representing Surfaces and Volumes in one Unified Model

Stochastic Geometry



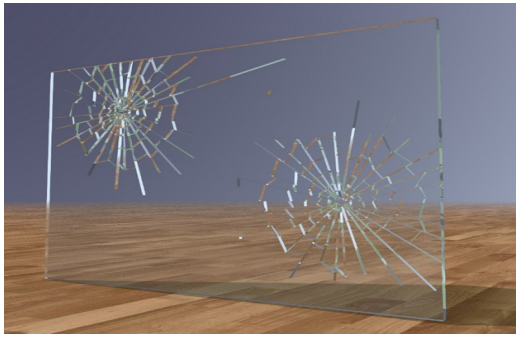
Seyb, et al. "From microfacets to participating media: A unified theory of light transport with stochastic geometry." *ACM Transactions on Graphics (Proceedings of SIGGRAPH)*. Vol. 43. No. 4. ACM, 2024.

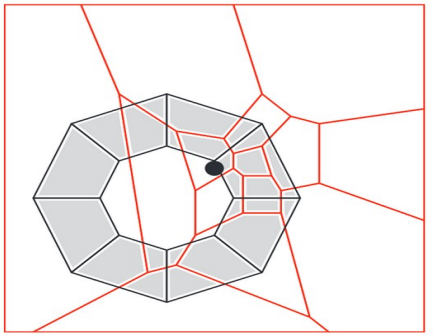
Non-Exponential Transmittance Model

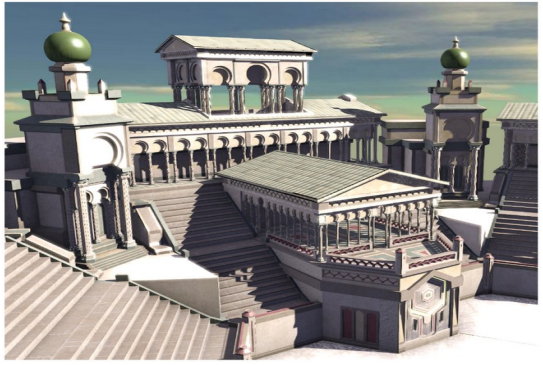


Vicini, et al. "A Non-Exponential Transmittance Model for Volumetric Scene Representations." *ACM Transactions on Graphics (Proceedings of SIGGRAPH)*. Vol. 40. No. 4. ACM, 2021.

5 Real-Time Fracturing

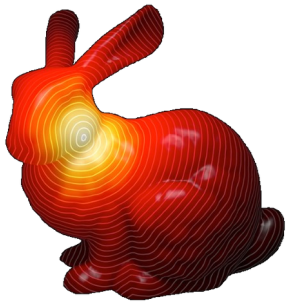




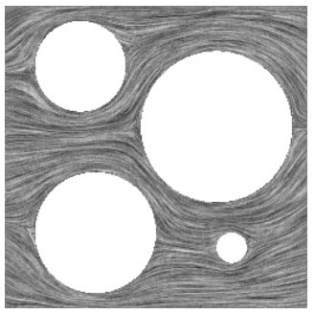


https://youtu.be/eB2iBY-HjYU?si=9iOPYFHqcmUXVOjA&t=166

6 Solving PDEs with Monte Carlo Methods



$$\begin{aligned} \nabla \cdot (\alpha \nabla u) + \vec{\omega} \cdot \nabla u - \sigma u &= -f \quad \text{on } \Omega, \\ u &= g \quad \text{on } \partial\Omega. \end{aligned}$$



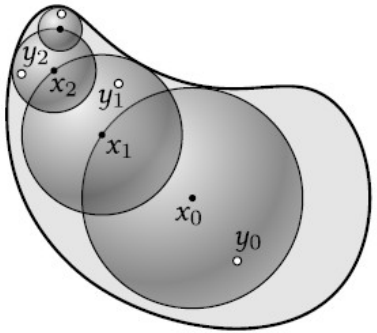


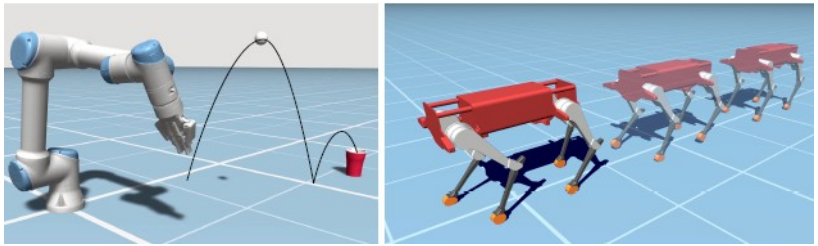
Fig. 5. A source term f can be approximated via a single random sample y_i at each step.

Rohan Sawhney and Keenan Crane. 2020. Monte Carlo Geometry Processing: A Grid-Free Approach to PDE-Based Methods on Volumetric Domains. *Proc. SIGGRAPH* 39, 4 (2020).

Rohan Sawhney, Bailey Miller, Ioannis Gkioulekas, and Keenan Crane. 2023. Walk on Stars: A Grid-Free Monte Carlo Method for PDEs with Neumann Boundary Conditions. *ACM Trans. Graph.* 42, 4, Article 1 (August 2023),

Ryusuke Sugimoto, Terry Chen, Yiti Jiang, Christopher Batty, and Toshiya Hachisuka. 2023. A Practical Walk-on-Boundary Method for Boundary Value Problems. *ACM Trans. Graph.* 42, 4 (August 2023), 16 pages. https://doi.org/10.1145/3592109

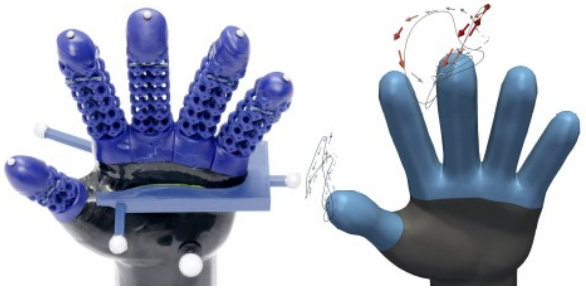
7 Non-linear Optimization in Computer Graphics



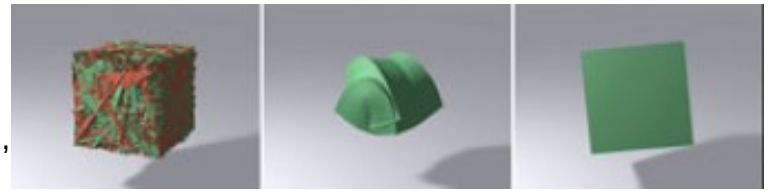
ADD: Analytically Differentiable Dynamics for Multi-Body Systems with Frictional Contact, Geilinger et al., SIGGRAPH Asia 2020

Computational Design of Planar Multistable Compliant Structures, Zhang et al., SIGGRAPH Asia 2021

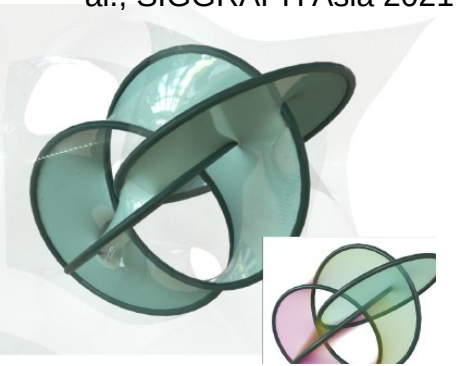
$$\min \quad f(\mathbf{x})$$
$$\text{s. t.} \quad \mathbf{g}(\mathbf{x}) = 0$$



Real2Sim: Visco-elastic parameter estimation from dynamic motion, Hahn et al., SIGGRAPH Asia 2019



Optimization Integrator for Large Time Steps, Gast et al., TVCG 2015

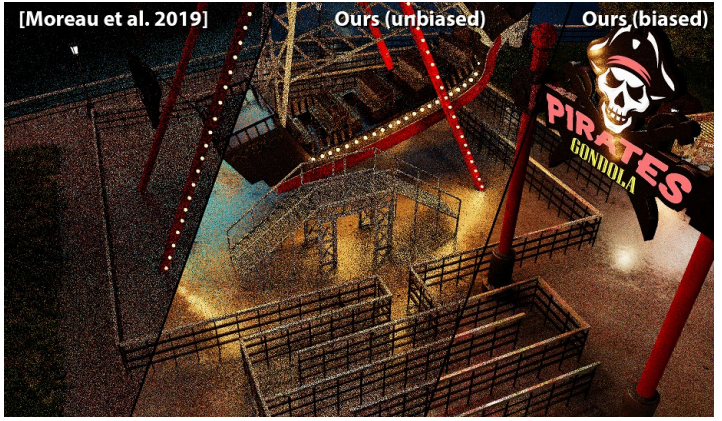


Computing Minimal Surfaces with Differential Forms, Wang and Chern, SIGGRAPH 2021

8 Real-Time Ray Tracing in Video Games

- Denoising
- Super Sampling
- Acceleration Structures

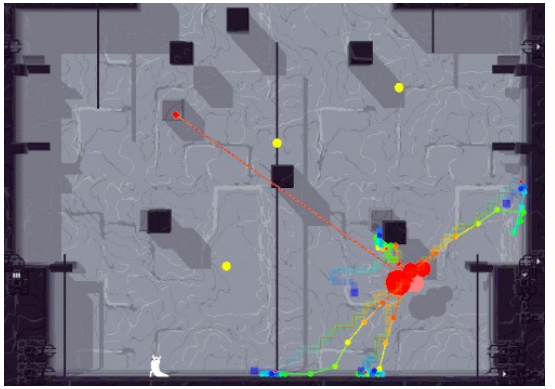
https://developer.nvidia.com/rtx/ray-tracing/rt-denoisers



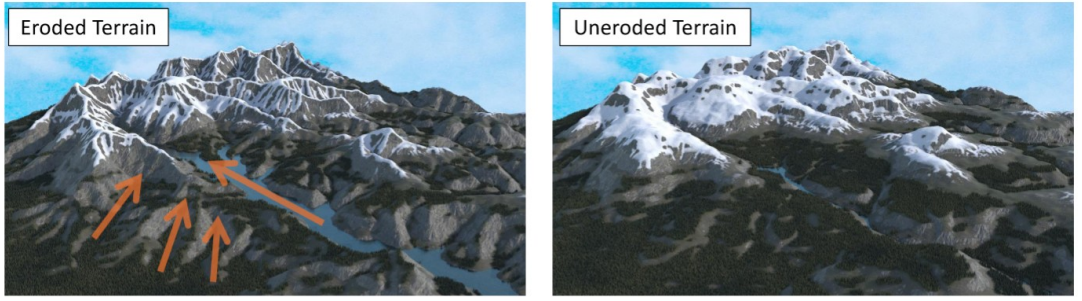
https://research.nvidia.com/publication/2020-07_spatiotemporal-reservoir-resampling-real-time-ray-tracing-dynamic-direct

- Animation (Inverse Kinematics)
- Terrain (Erosion Simulation, Fractals)
- Levels, Assets
- Audio

https://www.youtube.com/watch?v=lctXaT9pxA0



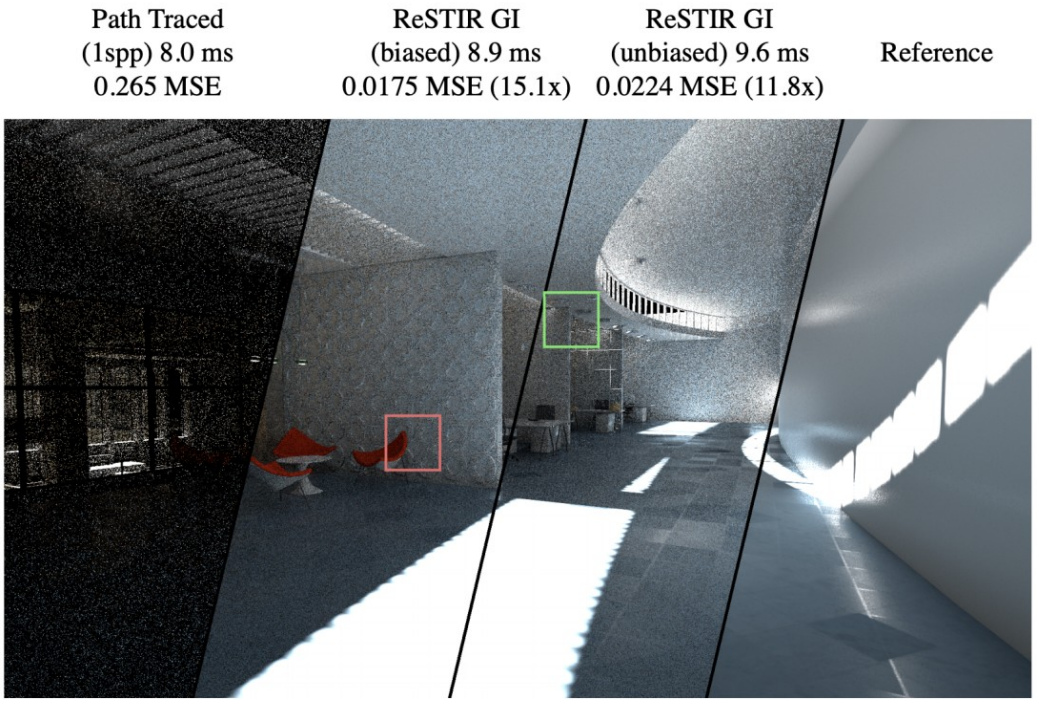
GDC Talk on Procedural Animations in "*Rain World*"
https://www.youtube.com/watch?v=sVntwsriNe4



https://diglib.eg.org/items/32a95921-aabd-48ea-acb0-e72f70264260

10 State of the Art in ReSTIR

- ReSTIR is a new and highly effective variance-reduction technique with great impact in rendering
- Provide an overview of the current state of the art (two students possible)



Hiroyuki Sakai

11 3D Gaussian Splatting

State of the Art report with focus on

- Surface reconstruction (e.g. 2D Gaussian splatting)
- Alignment (e.g. SuGaR: Surface-Aligned Gaussian Splatting)
- Relighting and Material models (e.g. BiGS: Bidirectional Gaussian Primitives for Relightable
- 3D Gaussian Splatting)

3D Gaussian Splatting for Real-Time Radiance Field Rendering

BERNHARD KERBL*, Inria, Université Côte d'Azur, France
GEORGIOS KOPANAS*, Inria, Université Côte d'Azur, France
THOMAS LEIMKÜHLER, Max-Planck-Institut für Informatik, Germany
GEORGE DRETTAKIS, Inria, Université Côte d'Azur, France

12 Simplifying Textured Meshes

- Simplifying Triangle meshes can be done by removing vertices, but this can cause distortions in UV-maps.
- Additional problems when texture-atlases are used
- State of the Art report or preferably project with implementation and comparison of different approaches.

Accurate Simplification of Multi-Chart Textured Models (N. Coll, T. Paradinas)

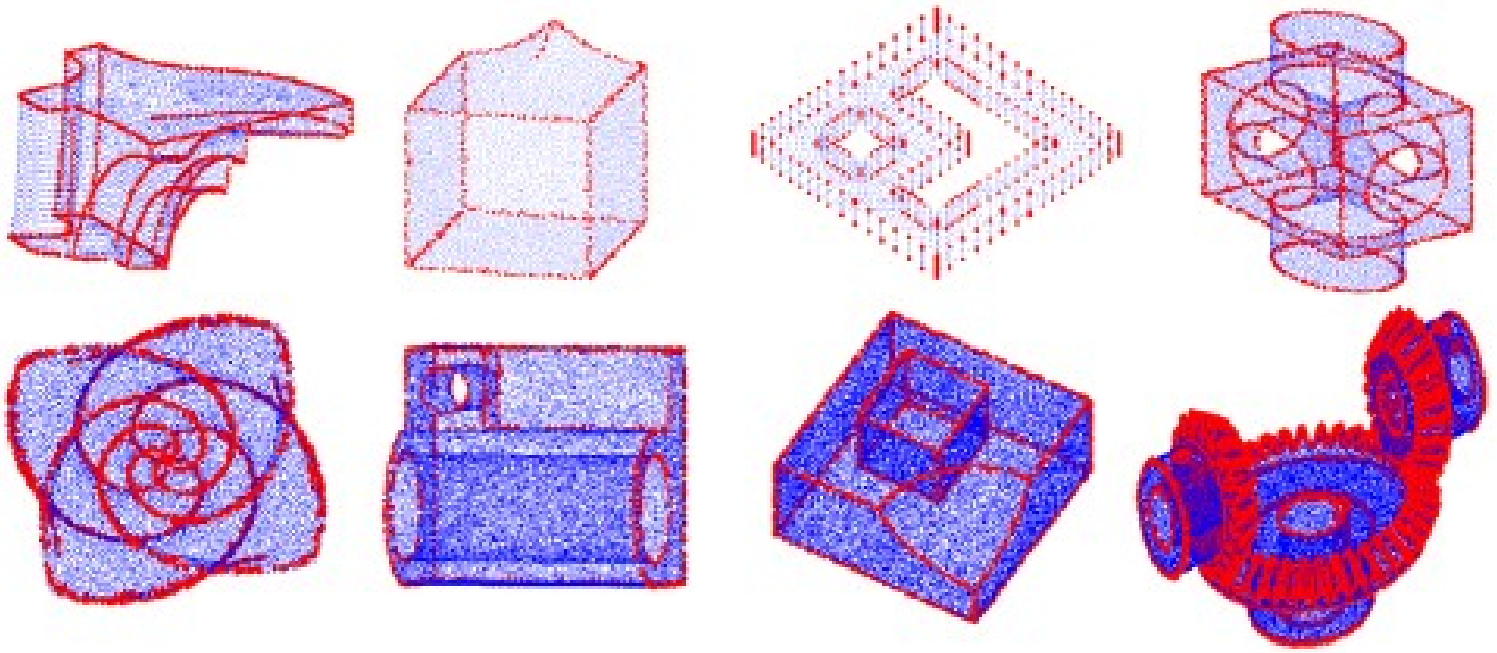
13 Surface Reconstruction from Neural Representations

- Reconstruction from photos via 3D Gaussians or NeRFs
- How to handle artifacts (not well-aligned splats) without over-smoothing the surface

14 Sharp Feature Reconstruction from Scans

Information about sharp or non-sharp is missing in point cloud

- either learn from existing models
- or utilize additional inputs from high-quality 3d scanners



Topic Assignment

- Please please mark down at least 3 topics in order of preference (1, 2, 3, …), your name and student number and hand them in
- I will try to make a fair assignment of topics and post them in forum “Announcements” tomorrow

Questions?

- Get in contact with your supervisor ASAP
- Discuss literature list with your supervisor
- Submit the list to TUWEL by 21.10.