XU Peiyu

Computer Science, UIUC, IL, US

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EDUCATION

Computer Science, University of Illinois, Urbana-Champaign, US Sept. 2025 – Present

Ph.D. of Computer Science, Supervisor: Prof. Shuang Zhao

ICS, University of California, Irvine, US Sept. 2022 – June. 2025

Department of Computer Science and Technology, HKUST, Hong Kong, China Aug. 2018 – Sept. 2022

B.Eng. in Computer Science, Supervisor: Prof. Pedro Sander

Core Courses: Honors Design and Analysis of Algorithms / Advanced Computer Graphics / Advanced Deep Learning Architectures / Combinatorial Analysis / Advanced Numerical Methods for PDE I&II

WORK EXPERIENCES

Research Scientist Intern | **Adobe Research**, San Jose, US June. 2025 – Sept. 2025

Advisor: Xin Sun & Iliyan Georgiev; Manager: Kalyan Sunkavalli

Research Scientist Intern | **Nvidia Real-time Rendering Research**, Redmond, US June. 2024 – Sept. 2024

Advisor: Benedikt Bitterli & Lifan Wu; Manager: Aaron Lefohn

Research Assistant | **UCSD**, San Diego, US June. 2021 – Sept. 2021

Advisor: Tzu-mao Li

RESEARCH EXPERIENCES

Stochastic Ray Tracing for 3D Gaussian Splatting | Ph.D at UIUC / Research Intern at Adobe June. 2025- Present

Collaborators: Shuang Zhao (UIUC), Xin Sun & Iliyan Georgiev (Adobe)

- Developed the **first fully differentiable, sorting-free stochastic ray-tracing framework** for 3D Gaussian Splatting, enabling end-to-end reconstruction and relighting without depth sorting.
- Generalized the method to **relightable 3DGS**, introducing per-Gaussian Monte Carlo shading with exact shadow rays under all typed of emitters, **surpassing SOTA baselines** in speed, reconstruction accuracy and shadow fidelity.
- Engineered a highly efficient **per-ray tiny-state GPU implementation** using OptiX any-hit traversal, and **in-shader neural material training** using CoopVec.
- Achieved performance comparable to rasterization-based 3DGS and **1.5-2× faster training** than prior ray-tracing baselines (3DGRT), with superior visual quality on NRHints and MipNeRF-360 benchmarks.

Robust and Efficient Differentiable Rendering Through Kernel Density Estimation | Research Intern at Nvidia Feb. 2025- May. 2025

Collaborators: Shuang Zhao, UCI; Ravi Ramamoorthi, UCSD; Benedikt Bitterli, NVIDIA; Lifan WU, NVIDIA

- Introduced **the first kernel-density–based formulation** for boundary path integrals in differentiable rendering.
- Designed an **efficient and GPU-friendly** algorithm for evaluating visibility-boundary, dramatically **reducing variance** and **improving efficiency** for mesh optimizations.
- Achieved state-of-the-art performance on geometry-, lighting-, and material-differentiation tasks, delivering significantly smoother gradients and faster convergence in inverse-rendering pipelines.

Langevin Monte Carlo Based Sampling of Visibility Boundaries | May. 2023- May. 2024

Collaborators: Shuang Zhao, UCI; Tzu-mao Li,UCSD; Sai Bangaru, NVIDIA/MIT;

- Designed a boundary-aware MCMC sampler that efficiently explores discontinuous visibility manifolds by operating directly in primary sample space.
- Integrated Langevin Monte Carlo updates with adaptive step-size control derived from boundary Jacobians, substantially reducing variance in geometry gradients.
- Proposed a local perturbation scheme for **manifold walk on meshes**, enabling reliable traversal of highly fragmented visibility boundaries without kd-trees or global guiding structures.
- Published at **SIGGRAPH Asia 2024**

Unbiased Path-Space Warped Area Sampling for Differentiable BDPT | June. 2022-May. 2023

Collaborators: Shuang Zhao, UCI; Tzu-mao Li,UCSD; Sai Bangaru, MIT | https://shuangz.com/projects/psdr-was-sa23/

- Proposed a general reparameterization of **differential path integrals** that removes the need for explicit visibility-boundary sampling by applying warped-area reparameterization directly in path space.

- Designed **divergence-theorem-based interior estimators** that convert boundary integrals into smooth surface integrals using continuous velocity fields constructed from convolved boundary velocities.
- Developed efficient unidirectional and bidirectional Monte Carlo estimators achieving low-variance geometry gradients and stable inverse-rendering performance across complex scenes.
- Received **SIGGRAPH Asia 2023 Best Paper Award**.

Reprojection-based Frame Reuse for Accelerating Real-Time Rendering | Research Assistant Sept. 2020- Feb. 2021

Collaborators: Pedro Sander, HKUST

- Proposed re-shading scheduling algorithm for reprojection and object-based selective shading.
- Developed an improved algorithm for error estimation with known camera matrix and model motion, and demonstrated the effectiveness when applied on re-shading scheduling.
- Implemented a lightweighted renderer with frame-reprojection support, leveraging **temporal-reuse** for **rasterization-based rendering.**

SELECTED PROJECTS

SPH Fluid Simulator | Project Sep – Oct. 2020

- Designed and implemented a fluid simulator with complete shading pipeline, written in WebGL. Adopted the Position Based Dynamics algorithm.
- Implemented viscosity and boundary particles, which guarantees fidelity to reality and system stability.

Point Cloud Completion | Project Sep – Oct. 2020

- Developed a deep learning model for point cloud completion with PyTorch.
- Applied GAN architecture with an encoder-decoder structured generator, and trained the model on a modified dataset.
- Achieved results comparable with baseline with only **0.17x parameters**.

Multi-Person Motion Transfer | Graduation Thesis Jan – May. 2022.

- Applied **transformer** for **motion transfer** in scenes with multiple people for **video generation**.
- Developed **tracking** algorithm to achieve identity consistency.

AWARDS

Siggraph Asia 2023 Best Paper Awards

SKILLS

- **C++ / Python / Pytorch**
- **GPU Programming: Slang.D / CUDA / OptiX / Vulkan**