Jiayin (Kay) Lu

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Google scholar

RESEARCH FOCUS

AI/learning-based geometry processing, Computational design & Mathematical art, Computer graphics, Parallel/high-performance computing, Numerical methods, Multi-scale modeling for simulation, Interdisciplinary mathematical modeling

APPOINTMENT & EDUCATION

University of California, Los Angeles (UCLA)

- Hedrick Assistant Adjunct Professor (Postdoc) Applied Mathematics — July 2024–
  Mentor: Professor Chanfanfu Jiang
- Responsibilities: Research, Mentor students, Teaching
- Topics: Artificial intelligence, Computer graphics

University of Wisconsin-Madison (UW-Madison)

- Postdoc Applied Mathematics — Jan 2024–June 2024
  Advisor: Professor Christopher H. Rycroft
- Responsibilities: Research, Mentor students
- Topics: Numerical methods, Materials science, Computational geometry

Harvard University

- Ph.D. Applied Mathematics — Sep 2018–Jan 2024
  Advisor: Professor Christopher H. Rycroft
  Thesis: Numerical Methods and Analysis Tools for Material Mechanics Across Scales
- M.S. Applied Mathematics — Sep 2018–Nov 2021

University of Illinois at Urbana-Champaign (UIUC) — Sep 2013–Dec 2017

- B.S. Mathematics (High Distinction), B.S. Statistics (Highest Distinction), B.S. Finance (Highest Honors)
- *Magna Cum Laude*

PUBLICATIONS

Accepted/Published

[1] Lu, Jiayin, and Rycroft, Chris. (2025). *Numerical methods and improvements for simulating quasi-static elastoplastic materials*. **Journal of Computational Physics**. 525. 113756 (2025).

[2] Lu, Jiayin, and Rycroft, Chris. (2025). TriMe++*: Multi-threaded geometry meshing using the Delaunay Triangulation*. **Computer Physics Communications**. 308. 109442 (2025).

[3] Lazar, Emanuel, and Lu, Jiayin, and Rycroft, Chris, and Schwartz, Deborah. (2024) *Characterizing structural features of two-dimensional particle systems through Voronoi topology*.

Modelling and Simulation in Materials Science and Engineering. 32(8). 085022 (2024).

[4] Lu, Jiayin, and Lazar, Emanuel, and Rycroft, Chris. (2023). *An extension to Voro++ for multithreaded computation of Voronoi cells*. **Computer Physics Communications**. 291. 108832 (2023).

[5] Lazar, Emanuel, and Lu, Jiayin, and Rycroft, Chris. (2022). *Voronoi cell analysis: The shapes of particle systems*. **American Journal of Physics**. 90. 469-480 (2022).

Preprint/Submitted

[6] Lu, Jiayin*, Ying Jiang*, Yin Yang, Chenfanfu Jiang. (2025) *VoroLight*: Learning Quality Volumetric Voronoi Meshes from General Inputs. 2025 (ArXiv link coming soon)

[7] S. Bonfanti, R. Busch, J. Byggmästar, J.C. Dyre, J. Eckert, S. Fajardo, M.L. Falk, I. Gallino, J.J. Kruzic, J. Lu, G. Monaco, M. Ozawa, A.D.S. Parmar, C.H. Rycroft, and S. Sastry. *Recent Advances in Metallic Glasses*. 2025 (Submitted to *Reviews of Modern Physics*.)

[8] B. Xu, and Z. Wu, and J. Lu, and M.D. Shields, and C.H. Rycroft, and F. Bamer, and M.L. Falk. *Stochastic evolution elasto-plastic modeling of a metallic glass*. 2024 (submitted to *PNAS*).

TALKS & ORGANIZATION

Computational/Applied Mathematics Seminar — Dec 2025
Invited speaker by Prof. Henry Segerman and Prof. Yanwen Luo — Oklahoma State University
"VoroLight: Learning Quality 3D Voronoi Mesh from General Inputs"

Level-Set Seminar — Dec 2025
Speaker: "VoroLight: Learning Quality 3D Voronoi Mesh from General Inputs" — UCLA

TITANE Seminar — July 2025
Speaker: "Voronoi tessellation, Delaunay triangulation: Parallel computation and applications in geometry meshing" — Inria, France

Association for Women in Mathematics Research Symposium — May 2025
Co-organizer & Speaker, special session "Mathematics, Modeling, and Art" — UW-Madison
"Voronoi tessellation, Delaunay triangulation and their applications"

Southern California Applied Math Symposium — April 2025
Session chair & Speaker — UC Riverside
"Voronoi tessellation, Delaunay triangulation and geometry meshing"

Symposium for Women and Gender Minorities in Mathematics in Southern California
Speaker: "Numerical Methods for Simulating Quasi-static Elastoplastic Materials" — Feb 2025, Los Angeles

Level-Set Seminar — Oct 2024
Speaker: "Parallel computation of the Voronoi tessellation and an application on geometry meshing" — UCLA

Graduate Applied Math Seminar at UW-Madison — Feb 2024
Speaker: "Solid Mechanics: Numerical Methods for Simulating — UW-Madison

Quasi-static Elastoplastic Materials"

SIAM Student Chapter Seminar at UW-Madison Nov 2023
Speaker: "Computational Geometry: Voronoi Tessellation, Delaunay Triangulation, and their Fun Applications" UW-Madison

SIAM Conference on Computational Science and Engineering March 2023
Speaker: "A multithreaded extension to Voro++ for rapid analysis of particle systems and an application in 2D multithreaded geometry meshing" Amsterdam

APS March Meeting March 2022
Speaker: "A multithreaded extension to Voro++ for rapid analysis of particle systems" Chicago

MENTORING

Faith Luo, Evelyn Zhu (Undergraduate) UCLA
Co-mentor: Dr. Ying Jiang, Prof. Chenfanfu Jiang Summer 2025–
Topic: *Mesh simplification using deep reinforcement learning*

Mucheng Zhu, Shanmei Wanyan, Peihang Lin (Undergraduates) UCLA
Co-mentor: Prof. Chenfanfu Jiang, Prof. Christopher Rycroft Spring 2025–
Topic: *Multi-threaded Geometry Meshing in 3D*

- Poster presentation at *Southern California Conference for Undergraduate Research* by mentees: "Multi-threaded Generation of Adaptive Geometry Sizing Fields from Input 3D Meshes"

Shanmei Wanyan, Coco Zhang, Junhao Jia, Weimo Zhu (Undergrads)
Tucker Nielson (High school) UCLA
Co-mentor: Dr. Ying Jiang Fall 2025–
Topic: *Developing a new course for UCLA Department of Mathematics, "Math + Code + Art", to be taught in the 2026 academic year.*

Peihang Lin, Mucheng Zhu (Undergraduate) UCLA
Co-mentor: Prof. Christopher Rycroft, Prof. Chenfanfu Jiang Summer 2025–
Topic: *Creating a open-accessed Python binder library for multi-threaded Voro++*

Yumeng He (Master) UCLA
Co-mentor: Dr. Ying Jiang, Prof. Chenfanfu Jiang Summer 2025–
Topic: *Sim-ready Part-level Articulated Reconstruction with VLM Knowledge*

Yusi Sun (PhD) UCLA
Co-mentor: Dr. Ying Jiang, Prof. Chenfanfu Jiang Summer 2025–
Topic: *AR Storytelling/ Tutorial generation*

Zhaolun Luo (Undergraduate) UW–Madison
Co-mentor: Prof. Christopher Rycroft Spring 2024
Topic: *High-order spectral deferred correction framework for simulating elasto-plastic materials*

- Led to *Poster presentation* by mentee in the UW-Madison Undergraduate Research Symposium; Undergraduate thesis of mentee to fulfill graduation requirement; Joint talk by myself and mentee presented to a joint-group meeting at the Department of Mathematics

COLLABORATION & VISITS

TITANE team, Inria Center at Université Côte d'Azur Sophia Antipolis, France
Research Collaborator of Dr. François Protais and Prof. Pierre Alliez Summer 2025

The Institute of Materials Science & Engineering, Washington University in St. Louis
Research Collaborator of Prof. Katharine Flores May 2025

Department of Materials Science & Engineering, Johns Hopkins University
Research Collaborator of Prof. Michael Falk Dec 2023

Department of Mathematics, UW-Madison
Research Intern Spring & Fall of 2023

Department of Mathematics, Bar-Ilan University, Israel
Research Collaborator of Prof. Emanuel Lazar Jan 2020

Mathematics Group, Lawrence Berkeley National Laboratory
Research Affiliate Summers of 2019, 2023

AWARDS

- UCLA Institute for Digital Research and Education (IDRE) Postdoc Fellowship Fall 2025
- Mentor Travel Grant, Association for Women in Mathematics Summer 2025
- Travel Grant from workshop *Discrete and Computational Geometry, Shape Analysis and Applications*, Rutgers University Spring 2023
- Professional Development Fund, Harvard Spring 2023
- Certificate of Distinction in Teaching, Harvard Bok Center for Teaching Fall 2020

SERVICE

- Reviewer, *IEEE Transactions on Visualization and Computer Graphics* since Fall 2025
- Reviewer, *The 33rd Pacific Conference on Computer Graphics and Applications* Summer 2025
- Reviewer, *The Journal of Supercomputing* by Springer Nature since April 2025
- Reviewer, *Methematics* by MDPI since March 2025
- Reviewer, *Geometry* by MDPI since January 2025

ONGOING PROJECTS

I. Computational Geometry, AI/Learning, Parallel Computation, Mathematical Art

Learning Mesh Generation Policies from Point Clouds

Advisor: Prof. Pierre Alliez, Prof. Chenfanfu Jiang Summer 2025–Present
*Collaborators: Dr. François Protais** (*Equal contribution)

- Developing a reinforcement learning framework that learns local policies to place and connect mesh vertices directly from point clouds, guided by the Quadric Error Metric (QEM).
- Designing a single policy network capable of adapting to shape features, scaling across resolutions, and generalizing to unseen geometries.
- Aims to bridge feature-preserving reconstruction and scalable adaptive meshing for efficient shape generation.

VoroLight: Learning Quality 3D Voronoi Mesh from General Inputs

Advisor: Prof. Chenfanfu Jiang Fall 2024–Present
*Collaborators: Dr. Ying Jiang** (*Equal contribution)

- Developed a learning-based Voronoi meshing framework for reconstructing watertight, topology-consistent 3D shapes from diverse inputs (e.g., images, point clouds, SDFs, and meshes).
- Integrated differentiable Voronoi diagrams with a sphere-based surface optimization (inspired by *VoroCrust*) to achieve high-quality surface reconstruction and eliminate small-cell artifacts.
- Implemented a three-phase training pipeline: (1) initialize a differentiable Voronoi surface, (2) optimize boundary spheres for surface refinement, and (3) introduce interior points to generate volumetric Voronoi meshes.
- Designed a unified shape regularization loss with modality-specific shape terms, enabling consistent learning across different input types.
- Demonstrate applications in artistic Voronoi lamp design and single-image 3D shape generation.

Multi-threaded 3D Geometry Meshing using Delaunay Tetrahedralization

Advisors: Prof. Christopher Rycroft, Prof. Chenfanfu Jiang Fall 2024–Present
Collaborators (Undergrad Mentees): Mucheng Zhu, Shanmei Wanyan*, Peihang Lin** (*Equal contribution)

- Extending the *TriMe++* framework for 2D multi-threaded meshing to 3D Delaunay tetrahedralization, enabling scalable generation of high-quality volumetric meshes.
- Building upon the parallel design principles of *Voro++* and *TriMe++* to achieve efficient shared-memory parallelism for large-scale geometric models.

II. Continuum Mechanics, Numerical Methods, Data-driven Approach

Multi-scale Modeling of the Bulk Metallic Glasses (BMG)

Advisor: Prof. Chris Rycroft Fall 2021–Present
Collaborators: Bin Xu, Zhao Wu, Michael Falk, Franz Bamer, Michael Shields

- Collaborating with Professor Falk's group and Professor Bamer's group, who specialize in microscopic molecular dynamics (MD) simulation to study the plastic deformation of BMG
- Investigating ways to model realistic stochastic plastic deformation behaviors of BMG in the macroscopic continuum model, by incorporating a mesoscopic data-driven model of a representative element developed by Professor Falk's group
- Bridging the scale gap between the two models, ensuring a physically sound combination
- Developing a multi-scale data-driven continuum model of BMG, using the mesoscopic model to describe local plasticity deformation

III. Quantitative & Evolutionary Biology, Statistics

Large-scale Dataset on Geometric Patterns and Vein Networks of Grasshopper Wings
Advisor: Prof. Chris Rycroft Spring 2023–Present
Collaborators: Danyun He, Alissa Doucet, Bruno de Medeiros, Seth Donoughe* (*Equal contribution)

- Digitized over 4,000 grasshopper specimens from the Field Museum of Natural History (Chicago) using high-resolution reflected and transmitted light imaging.
- Applied machine learning and computer vision methods—`Segment Anything`, `Cellpose`, and `ML-morph`—to segment wings and extract intra-wing cellular and vein network structures.
- Developing an open-access dataset and reproducible analysis pipeline for quantitative and evolutionary studies of wing morphology.

Statistical Study on Geometric Patterns and Vein Networks of Grasshopper Wings
Advisor: Prof. Chris Rycroft Spring 2023–Present
Collaborators: Danyun He, Alissa Doucet, Bruno de Medeiros, Seth Donoughe* (*Equal contribution)

- Conducting large-scale statistical analysis on a high-resolution image dataset of over 4,000 grasshopper species across multiple populations.
- Developed mapping techniques to register individual forewings and hindwings onto reference wing spaces, incorporating boundary and landmark alignment.
- Quantifying vein thickness, network topology, and cell geometry in common coordinate spaces for inter-individual and inter-population comparisons.

COMPLETED PROJECTS

I. Computational Geometry, Parallel Computation

Multi-threaded Parallel Computation of the Voronoi Diagrams and its Applications
Advisor: Prof. Chris Rycroft Fall 2019–Spring 2023
Collaborators: Emanuel Lazar, Deborah Schwarcz

- Created multi-threaded parallel computation extension for Voro++ using OpenMP.
- Conducted performance analysis on various particle distribution systems, identifying optimal load balancing strategies
- Achieved near-perfect parallel efficiency across different particle systems
- Enabled parallelization of another popular software, VoroTop, for rapid analysis of large scale atomistic systems

Multi-threaded Geometry Meshing using the Delaunay Triangulation
Advisor: Prof. Chris Rycroft Fall 2019–Fall 2023

- Utilizing multi-threaded Voro++, developed a multi-threaded parallel meshing software, for large-scale adaptive meshing of complicated shapes in 2D
- Implemented the DistMesh meshing algorithm, the Centroidal Voronoi Diagram (CVD) meshing algorithm, and developed a hybrid algorithm combining the two
- Showed high-quality mesh generation and significant speed-up with parallel computing
- Optimized data, code and algorithm designs for computational efficiency

II. Continuum Mechanics, Numerical Methods, Data-driven Approach

Numerical Methods on Simulating Quasi-static Elastoplastic Materials
Advisor: Prof. Chris Rycroft Spring 2020–Fall 2023

- Reviewed existing works on modeling and simulating quasi-static elastoplastic materials with

interesting mathematical connection to the incompressible fluid dynamics
- Developed a fully second-order temporal accuracy numerical scheme, using two-stage predictor-corrector steps with an incremental-velocity term, drawing inspiration from second-order projection methods for incompressible Navier-Stokes equations
- Developed a FEM solver for the elliptic PDE in the projection step
- Devised an adaptive global time-stepping procedure, by bounding the projection step-sizes, allowing the simulation to reach high order of accuracy efficiently in much fewer time-steps

SELECTED OTHER PROJECTS

Mathematical Art Independent Project (Demo) Spring 2015–Present

Explorer and Designer

- Explored creative and expressive ways to combine my interests in Mathematics and Art together
- Designed and created mathematical art with 3D printing and laser cutting
- Visualized the complexity and symmetry of beautiful mathematical shapes

Computational Design: Series of Perforated Lamps (Demo) Fall 2019

Course project: SCI 6338, Introduction to Computational Design, Harvard

- Implemented a C++ code to create 3D models of perforated lamps, where the lamps can take any shapes, and can project light on surrounding walls with pre-designed patterns
- Investigated computer graphics techniques in creation of the code, such as voxelization, ray tracing, boolean operations, and the marching cube algorithm
- Designed example demo models, 3D printed them and prepared a setup with LED lights and cut-out foams, to showcase in the final project demo day in class

TEACHING

UCLA Department of Mathematics

Developing "Math + Code + Art" course Fall 2025 –
Co-instructor: Dr. Ying Jiang
Co-developers (Mentees): Shanmei Wanyan, Coco Zhang, Junhao Jia, Weimo Zhu (Undergrads) Tucker Nielson (High school)

- Designing a new interdisciplinary course, "Math + Code + Art", to be offered in 2026, integrating mathematical concepts, creative coding, and digital art.
- Planned topics include: spirograph and fractal generation, translating music data into visual art, training neural networks to map sound to color, style transfer for paintings, Voronoi-based generative art, algorithmic image collages, 3D mathematical modeling and printing.

Python with Applications I Spring, Fall 2025
Lecturer, applied mathematics

- Give lectures on in-depth introduction to Python programming language, covering core Python language constructs, useful Python libraries (NumPy, Pandas, Matplotlib, scikit-learn), and applications, such as image processing, text processing, data visualization, and machine learning.

Introduction to Programming Fall 2024, Winter 2025
Lecturer, applied mathematics

- Give lectures teaching principles of programming using C++, covering variables, control flows, functions, classes, arrays and pointers, memory management, algorithmic and procedural problem solving, program design and development

Harvard School of Engineering and Applied Sciences (SEAS)

Introduction to Generative Art and Scientific Visualization Jan 2023
Instructor for January@GSAS Mini Course
Co-instructors: Yue Sun, Jovana Andrejevic, Nina Andrejevic

- Taught a course at the intersection of computation, mathematics, and art
- Collaborated with co-instructors to formulate course objectives and curriculum
- Developed teaching materials and led workshops on "Voronoi art" and "3D printing art"

Physics as a Foundation for Science and Engineering, Part I Fall 2022
Teaching Fellow
Supervisor: Professor Eric Mazur

- Developed tutorials and quizzes; supported in-class activities; provided weekly office hours; graded assignments

Introduction to Numerical methods Fall 2020
Teaching Fellow
Supervisor: Professor Christopher Rycroft

- Developed materials and led sessions on supplementary topics: "**Introduction to POV-Ray**" and "**Further optimization methods**"
- Provided weekly office hours; graded assignments
- Awarded *Certificate of Distinction in Teaching* from the Harvard Bok Center for Teaching

Introduction to Applied Mathematics Spring 2020
Teaching Fellow

Supervisor: Professor Doeke Hekstra

- Supported students during the transition from in-person to online learning due to COVID-19
- Conducted review sessions; assisted in class discussions; provided weekly office hours; graded assignments

OUTREACH

Student Event Photography, Harvard (Portfolio)

CS 50 Photographer Fall 2022

- Maintained a 48-hour turnaround for photos, covering lectures, sections, and course activities
- Collaborated with professional photographers, adhering to their editing preferences

GSAS Communications Photographer Fall 2021–Fall 2022

- Photographed diverse GSAS student events in intellectual, social, and cultural contexts
- Documented all event elements, from food to attendees, fostering community connections

SEAS Communications Photographer Fall 2019

- Photographed student technology related workshops, competitions and events
- Collaborated with student news reporters to provide visuals for online articles

Others Fall 2019

- Photographed symposium for Harvard Medical School
- Conducted professional and graduation photoshoots for graduate students

GSAS Photography Society, Harvard

Vice President Fall 2019–Fall 2022

- Organized club social activities; managed semesterly GSAS Photo Contests; coordinated and facilitated annual Student Family Photoshoot
- Arranged talks by professional photographers for the GSAS community
- Connected student photographers with freelance photography opportunities

Active Member Fall 2018–Fall 2022

- Engaged in club events; Volunteered as photographer for student events

Academic Resource Center, Harvard

Peer Mentor Fall 2021

- Mentored undergraduate students weekly in applied mathematics courses
- Enhanced students' Python coding skills through tutorials and debugging guidance