

Jiayin (Kay) Lu

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Google scholar

EDUCATION

Harvard University

- Ph.D. Applied Mathematics Expected: Dec 2023
Advisor: **Professor Christopher H. Rycroft**
- M.S. Applied Mathematics Nov 2021

University of Illinois at Urbana-Champaign (UIUC)

Dec 2017

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

RESEARCH INTERESTS

Applied and Computational Geometry, Computer Graphics, Parallel Computation,
Interdisciplinary Mathematical Modeling, Scientific Computing, Numerical Methods,
Data-driven Approach, Multi-scale Modeling, Quantitative Biology, Machine Learning

GRADUATE RESEARCH PROJECTS

I. Computational Geometry, Parallel Computation

Distributed-memory Parallel Computation of the Voronoi Diagrams

Advisor: *Prof. Chris Rycroft*

Fall 2022–Present

Collaborators: *Emanuel Lazar, Deborah Schwarcz*

- Developing distributed-memory parallel computation extension for Voro++, a software library for computing Voronoi diagrams, using OpenMPI
- Exploring optimal code architecture for parallel efficiency and investigate efficient communication strategies among processes

Multi-threaded Parallel Computation of the Voronoi Diagrams and its Applications

Advisor: *Prof. Chris Rycroft*

Fall 2019–Fall 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

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

Numerical Methods on Simulating Quasi-static Elastoplastic Materials

Advisor: Prof. Chris Rycroft

Spring 2020–Present

- 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

III. Quantitative Biology, Statistics, Geometry, Machine Learning

Large-scale 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)

- Digitizing a Field Museum Chicago grasshopper collection of 4000+ species through high-resolution photos (reflected and transmitted light)
- Utilizing machine learning packages (Segment Anything, Cellpose, ML-morph) and computer vision techniques to segment the wings from the images, and further segment the cells inside the wings and obtain a vein network for each wing
- Investigating quasi-conformal techniques for mapping forewings and hindwings to reference wing spaces, considering boundaries and landmarks
- Analyzing vein thickness, vein networks, and cell geometries in common wing spaces for inter-individual and inter-population comparisons

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

The Nash-Shapley Model for Multi-player Games

Fall 2017

Research Scholar, Illinois Geometry Lab, UIUC

Advisor: Prof. A.J. Hildebrand

- Investigated extensions and variations of the famous three-player mathematical poker model proposed by John Nash and Lloyd Shapley, who derived optimal probabilistic strategies for each of the players
- Reproduced the three-player five-round game discussed in the paper with Mathematica coding, and extended the game into two-player version and three-player three-round and four-round versions
- Derived formulas for expected profits for each player using relevant game theory analysis and probabilities calculation
- Wrote Mathematica code to calculate potential equilibrium points for each game and optimal strategies for each player

PUBLICATIONS

Accepted/Published

- [1] [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).
- [2] 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

- [3] [Lu, Jiayin](#), and Rycroft, Chris. *TRIME++: Multi-threaded geometry meshing using the Delaunay Triangulation*.
- [4] [Lu, Jiayin](#), and Rycroft, Chris. *Numerical methods and improvements for simulating quasi-static hypo-elastoplastic materials*.

PRESENTATIONS

SIAM student chapter at the University of Wisconsin-Madison <i>2D Multi-threaded geometry meshing using the Delaunay Triangulation</i>	Nov 2023, Madison Talk
SIAM Conference on Computational Science and Engineering <i>A multithreaded extension to Voro++ for rapid analysis of particle systems and an application in 2D multithreaded geometry meshing</i>	March 2023, Amsterdam Talk
APS March Meeting <i>A multithreaded extension to Voro++ for rapid analysis of particle systems</i>	March 2022, Chicago Talk
Nebraska Conference for Undergraduate Women in Mathematics <i>The Nash-Shapley Model for Multi-player Poker Games</i>	Jan 2018, Lincoln Poster
UIC Undergraduate Mathematics Symposium <i>The Nash-Shapley Model for Multi-player Poker Games</i>	Nov 2017, Chicago Poster

RESEARCH VISITS

Department of Mathematics, University of Wisconsin-Madison <i>Research Intern</i>	Spring & Fall of 2023
Department of Mathematics, Bar-Ilan University, Israel <i>Research Collaborator of Prof. Emanuel Lazar</i>	Jan 2020
Mathematics Group, Lawrence Berkeley National Laboratory <i>Research Affiliate</i>	Summers of 2019, 2023

AWARDS

• Travel Grant from workshop <i>Discrete and Computational Geometry, Shape Analysis and Applications</i> , Rutgers University	Spring 2023
• Professional Development Fund, Harvard	Spring 2023
• Certificate of Distinction in Teaching, Harvard Bok Center for Teaching	Fall 2020
• Illinois Leadership Certificate, Illinois Leadership Center	Fall 2017
• NetMath Mentor Excellence Award, UIUC Department of Mathematics	Spring 2017
• Edmund J. James Scholar, UIUC College Honor	2013-2017
• Dean's List, UIUC Top 20%	2013-2017

SKILLS

Proficient in C++, Python, OpenMP, Linux Operating System, LaTeX, R.
Experienced with Mathematica, Java, OpenMPI.
Fluent in English and Chinese (Mandarin, Cantonese, Teochew).

TEACHING

Harvard School of Engineering and Applied Sciences (SEAS)

Introduction to Generative Art and Scientific Visualization

Jan 2023

Instructor for January@GSAS Mini Course

Hybrid: In-person/Online

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

Fully in-person

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

Fully online

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

From in-person to online

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

UIUC Department of Mathematics

Applied Linear Algebra

NetMath Course Leader

Fall 2017

- Supervised fellow mentors; conducted monthly mentor grading reviews

NetMath Course Mentor

Summer 2016–Fall 2017

- Taught online with Wolfram Mathematica; communicated weekly to monitor student progresses
- Guided students step-by-step on questions; delivered detailed feedback on homework
- Awarded the *NetMath Mentor Excellence Award* in Spring 2017

Calculus I

Spring 2015

Head Classroom Assistant

- Managed a database of work schedules of Classroom Assistants; handled substitute requests

Calculus I, II, College Algebra

Fall 2014–Fall 2015

Classroom Assistant

- Offered students course and homework support in lab sessions; graded worksheets and quizzes

Illinois Maker Lab, UIUC College of Business

Coursera 3D Printing Specialization series

Fall 2016–Spring 2017

Teaching Assistant

- Contributed to content development; addressed student inquiries; oversaw course progression

UIUC School of Information Sciences

Champaign–Urbana Community Fab Lab

Summer 2015–Fall 2017

Instructional Assistant and Lab Assistant

- Offered assistance during lab open hours
- Contributed to curriculum development and teaching of summer camps
- Led workshops on diverse topics, such as 3D printing and laser cutting

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

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

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

Cambridge School Volunteers, Cambridge, MA

Volunteer Mathematics Tutor

Fall 2019

- Tutored high school students weekly in Mathematics

FIRST Robotics Competition, Newton, MA

Volunteer Judge

Fall 2019

- Evaluated teams using core values: Discovery, Innovation, Impact, Inclusion, Teamwork, Fun

Alternative Seasonal Break, UIUC

Trip Facilitator Trainer

Fall 2014–Spring 2015

- Participated in weekly board meetings; coordinated on volunteer trip planning
- Recruited Trip Facilitator through application review and interviews
- Trained and supported Trip Facilitators in trip planning and group dynamics

Trip Facilitator

Fall 2013–Spring 2015

- Led two volunteering trips, on animal welfare and environment conservation, respectively
- Planned trip logistics; held weekly group meetings
- Organized fundraising events for donations to the volunteering sites

Illini Art Therapy Association, UIUC

Social Chair

Fall 2014–Spring 2015

- Organized social events for board members and group participants; managed Facebook group

Facilitator

Fall 2013–Spring 2015

- Facilitated workshops; explored impactful themes; guided art creation, sharing and discussion

Volunteer Illini Project, UIUC

Active Member

Fall 2013–Spring 2015

- Volunteered monthly in soup kitchen and food pantry for *Hunger & Homelessness* program