

Yue Liu

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Academic Interests

- Modelling of biological systems with partial differential equations (PDEs) and agent-based models
- Numerical analysis, asymptotic analysis, bifurcation and dynamical behaviors of PDEs
- Combining machine learning approaches with mechanistic modelling toward optimal control of biological systems

Technical Skills

- Proficient in: Java, C, C++, Python, Matlab, Julia, Scheme/Racket.
- Intermediate experience with: R, Perl, JavaScript, PHP, Bash scripting, SQL
- Comfortable with version control: Git, SVN, Mercurial

Education

University of Oxford <i>Doctor of Philosophy</i> Mathematics, focus on PDE and statistical modelling of biological systems. Supervised by Prof. Ruth Baker and Prof. Philip Maini	Oxford, UK 2019–2024
University of British Columbia <i>Master of Science</i> Applied Mathematics, focus on mathematical modelling and analysis of biological systems. Graduating average 93.2% (A+). Supervised by Prof. Leah Edelstein-Keshet	Vancouver, BC, Canada 2017–2019
University of Waterloo <i>Bachelor of Mathematics (Honours, Co-op)</i> Double major in Computer Science and Mathematical Physics, minor Pure Mathematics, Graduated with overall average 95.5% and With Distinction – Dean’s Honours List	Waterloo, ON, Canada 2012–2017
Fort Richmond Collegiate <i>High school</i> Graduated with Magna Cum Laude, final average 98%	Winnipeg, MB, Canada 2009–2012

Selected Awards and Scholarships

- Landahl Travel Grant, 2022. Awarded by Society for Mathematical Biology (SMB), \$800
- Canadian Centennial Scholarship, 2021. Awarded by Canadian Centennial Scholarship Fund, £5,000
- Canada Postgraduate Scholarships – Doctoral (PGS-D), 2019. Awarded by Natural Sciences and Engineering Research Council of Canada (NSERC), \$63,000
- Canada Graduate Scholarships-Master’s (CGS-M), 2017. Awarded by NSERC, \$17,500
- R Howard Webster Foundation Fellowship, 2017. University of British Columbia (UBC), \$2,500
- Faculty of Science Graduate Award, 2017-2018. UBC, \$5,500
- Lloyd Switzer Scholarship in Applied Mathematics, 2017. University of Waterloo (UW), \$2,500
- Arthur Beaumont Memorial Scholarship, 2016. UW, \$2,000

- o Frank Goodman Memorial Scholarship, 2015. UW, \$2,000
- o University of Waterloo Descartes National Scholarship, 2012-2016. UW, \$12,000

Publications

Yue Liu, Kevin Suh, Philip K Maini, Daniel J Cohen, and Ruth E Baker. Parameter identifiability and model selection for partial differential equation models of cell invasion. *Journal of the Royal Society Interface*, 21(212):20230607, 2024.

Yue Liu, Philip K. Maini, and Ruth E. Baker. Control of diffusion-driven pattern formation behind a wave of competency. *Physica D: Nonlinear Phenomena*, 438:133297, 2022.

Dario Domingo, Stanislaw Biber, Gabriele Dian, Patrick Dorey, Kays Haddad, Paul Heslop, Ingrid Holm, **Yue Liu**, and Raymond Pang. Trans-national equitable strategies of vaccine distribution during the covid-19 pandemic. *Mathematics in Industry Reports*, 2021.

Yue Liu, Elisabeth G Rens, and Leah Edelstein-Keshet. Spots, stripes, and spiral waves in models for static and motile cells. *Journal of Mathematical Biology*, 82(4):1–38, 2021.

Andreas Buttenschön, **Yue Liu**, and Leah Edelstein-Keshet. Cell size, mechanical tension, and GTPase signaling in the single cell. *Bulletin of Mathematical Biology*, 82(2):28, 2020.

Yue Liu. Analysis of pattern formation in reaction-diffusion models for cell polarization. Master's thesis, University of British Columbia, 2019.

Yue Liu, John Milton, and Sue Ann Campbell. Outgrowing seizures in childhood absence epilepsy: time delays and bistability. *Journal of Computational Neuroscience*, 46(2):197–209, 2019.

Priyank Jaini, Abdullah Rashwan, Han Zhao, **Yue Liu**, Ershad Banijamali, Zhitang Chen, and Pascal Poupart. Online algorithms for sum-product networks with continuous variables. In *Conference on Probabilistic Graphical Models*, pages 228–239, 2016. proceedings.mlr.press/v52/jaini16.pdf.

Research Experience

Purdue University

Postdoctoral Research Associate

Biological pattern formation and agent-based modelling

West Lafayette, IN, USA

September 2024 – Present

University of Waterloo

USRA Undergraduate Researcher

Developed and analyzed delay differential equation models for neuronal systems for explaining the onset and outgrowth of childhood absence epilepsy.

Waterloo, ON, Canada

January–August 2017

Agriculture and Agri-Food Canada

Bioinformatics Software Developer

Developed the Genomics and Transcriptomics Analysis pipeline. Utilized bioinformatics softwares to analyze fungal pathogens on crops.

Ottawa, ON, Canada

May–August 2014

Teaching Experience

St Hugh's College, Oxford

Stipendiary Lecturer

Taught tutorials for first and second year applied mathematics modules. Conducted interviews for undergraduate admissions.

Oxford, UK

January 2020–2024

University of Oxford

Teaching Assistant (2019–2020), Tutor (2020–)

Responsible for grading and assisting tutorials for Theory of Deep Learning, Mathematical Physiology and Stochastic Analysis and PDEs. Taught classes for Mathematical Biology.

Oxford, UK

October 2019–2024

University of British Columbia

EDUCE Teaching Assistant

Responsible for developing curriculum and delivering data science workshops for the Experiential Data science for Undergraduate Cross-disciplinary Education (EDUCE) program.

Vancouver, BC Canada

September 2018–April 2019

University of British Columbia

Math Graduate Teaching Assistant

Taught workshop sessions for MATH 180 (Calculus 1). Graded assignments and exams for courses MATH 256 (Calculus 3), 221 (Linear algebra). Tutored students in the Math Learning Center.

Vancouver, BC Canada

September 2017–December 2018

Industry Experience

Fairwater Capital, Inc.

Qualitative Analyst (intern)

Developed and implemented pricing models for credit derivatives, and improved collection and storage of financial data.

London, UK

June–Sept 2021

Facebook, Inc.

Software Engineer (intern)

Implemented new database schema and interface for efficient storage of records. Developed new machine learning model for messaging inactive users, which significantly improved user retention.

Menlo Park, CA, USA

May–August 2016

Amazon Web Services

Software Development Engineering (intern)

Developed automated testing framework for Amazon API Gateway.

Seattle, WA, USA

September–December 2015

NexJ Systems Inc.

Quality Assurance Analyst (intern)

Identified bugs in software products and helped fixing them. Created test plans for new software features. Proposed new features and their high level implementation.

Toronto, ON, Canada

May–August 2013

Selected Projects

- **Postdoc Project:** *'Pattern formation and agent-based modelling'*

To be updated

- **PhD Project:** *'Challenges in modelling and control of biological systems'*

The inherent complexity of biological systems presents numerous challenges in their study through mathematical models. My thesis addresses a number of challenges, from model selection, parameter inference, model exploration, to the application of optimal control.

- **ESGI Workshop 2021:** *'Trans-National Equitable Strategies of Vaccine Distribution during the COVID-19 Pandemic'*

We propose a modelling framework to analyse and optimise worldwide vaccine allocation strategies, with reference to the current COVID-19 pandemic, and analyze the strategies for national and global vaccine distribution from a game-theoretic perspective.

- **Masters Project:** *'Extensions of the wave-pinning model and applications to cellular mobility'*

Cellular polarization is essential for a variety of cell behaviors. This project studies two extensions to the wave-pinning model proposed by Mori et al (2008), which describes the dynamics of regulatory proteins in a cell. The model is analyzed numerically, and its bifurcation and asymptotic properties are explored. Finally, I relate the results to experimental observations and interpret its biological significance in real cells.

- **Perturbation Methods for PDEs course project:** *'Stability analysis for spikes solutions to the Gierer-Meinhardt model'*

This project follows the analysis of Iron, Ward & Wei (2001) and analyze the existence and stability of multi-spike solutions to the Gierer-Meinhardt model using perturbation methods and non-local eigenvalue analysis.

- **Advanced Dynamical Systems course project:** *'Dynamical systems description of the Wave Pinning model'*

This project uses local perturbation analysis to examine the wave-pinning model by Mori et al (2008), and focuses on the analysis of codimension-two bifurcations.

- **BC Data Science Workshop 2018 project:** *'A Deep Look into Cytokines and Septic Shock'*

We analyzed genetic and cytokine data from patient records from the VASST study. We identified the relationship between SNPs (single nucleotide polymorphisms), cytokines and sepsis survival with statistical and machine learning techniques. Collaboration with St. Paul's hospital, Vancouver.

- **PIMS Industrial Problem Solving Workshop 2018 project:** *'AI for Tactical Asset Allocation'*

We were interested in the relation between certain economic indicators and relatively return of different types of financial assets. I adapted several standard machine learning techniques to finance application. We found it is difficult to beat relatively simple strategies, however ensemble learning can yield strategies with lower volatility. Collaboration with Responsive Capital Management.

- **Mathematical Biology course project:** *'Dynamics of Evolutionary Game Theory and Application Toward Animal Conflict Behaviors'*

The project extends the work done by Smith & Price (1973) on explaining why animals do not always use the most effective combat strategies during mating competitions. My work extends the model by considering the fitness of strategies in a more realistic environment, with non-equilibrium dynamics and stochastic effects.

- **Industrial Mathematics course project:** *'Examining behaviors of periodically-forced predator-prey system with Floquet theory'*

This project follows the work of Moghadas & Alexander (2005). I examined the dynamics of a predator-prey model with seasonally-varying forcing term. A rich variety of behaviors, including bifurcations, period doubling cascade and emergence of chaos were analyzed with Floquet theory and Poincaré maps.

- **Advanced Machine Learning course project:** *'Solving Partial Differential Equations with Artificial Neural Networks'*

We were interested in evaluating various proposed artificial neural network-based PDE solvers against traditional solvers, and how they compare to their theoretical optimal performance. We implemented one

such solver in Julia, and found that while it works satisfactorily, it has higher errors than both FDM, FEM solvers and theoretical optimum. Despite this, it has advantages such as highly parallelizable, and provides an analytical solution.

- **USRA research project:** *'Examining Childhood Absence Epilepsy Through Conductance-based Delay Differential Equation Models'*

We modelled a small neuron network with a conductance-based model and delay differential equations. We numerically explored its behaviors and found bistability that occur only in certain parameter regimes. We associate bistability with epileptic seizure, and explain the role of neural conductance delay and genetic defect on the onset and recovery of childhood absence epilepsy.

- **Fluid Dynamics course project:** *'Analysis of Tsunami waves with shallow water equations'*

I analyzed the shoaling of Tsunami waves (the phenomenon that the waves grow drastically in height) with shallow water equations and obtain analytical solutions for the case of straight slope using "hodograph transformation" proposed by Aydin & Kanoglu (2012). I then numerically simulate the Tsunami and provide a physical explanation by analyzing energy. Finally, I use wave tank experiments to reveal shortcomings of the theoretical results.

- **Undergrad research project:** *'Empirical Evaluation of Stacked Restricted Boltzmann Machine'*

In this project, I implemented stacked-restricted Boltzmann machine (SRBM) and applied it to several datasets from the UCI machine learning repository in order to evaluate its performances. This was a part of a larger project to propose an online algorithm for training sum-product networks.

- **Quantum Computing course project:** *'Quantum Adversary Method for Proving Lower Bound of Quantum Query Complexity'*

This project studied the quantum adversary method proposed by Ambainis (2000), its application toward proving lower bounds for the unordered search problem, and its consequences.

Presented Seminars

- Modelling the dynamics of GTPase activity. Mathematical Biology Seminar, Pacific Institute for the Mathematical Sciences, Vancouver, Canada, 2018/11/07
- Mathematical Modelling in Biology. Member's Series, Green College, UBC, Vancouver, Canada, 2018/12/03

Selected Conferences and Workshop participation

Delivered oral and/or poster presentations on various topics:

- **Data-driven mechanistic mathematical modelling for life-science applications**, Gothenburg, Sweden, October 2023
- **International Congress on Industrial and Applied Mathematics (ICIAM)**, Tokyo (virtual), Japan, August 2023
- **Workshop on Collective Behaviour**, Isaac Newton Institute, Cambridge, UK, August 2023
- **SIAM UKIE National Student Chapter Conference** (Best Presentation Award), Oxford, UK, June 2023
- **British Applied Mathematics Colloquium (BAMC)**, Bristol, UK, April 2023
- **European Conference on Mathematical and Theoretical Biology (ECMTB)**, Heidelberg, Germany, September 2022
- **SIAM Conference on the Life Sciences (LS22)**, Pittsburgh, USA, July 2022

- **European Study Group with Industry (ESGI 167)**, U of Kent, UK, July 2022
- **Inference in Mathematical Biology Conference**, Oxford, UK, May 2022
- **British Applied Mathematics Colloquium (BAMC)**, Loughborough, UK, April 2022
- **Society for Mathematical Biology Annual Conference (SMB)**, Virtual, June 2021
- **SIAM UK Student Chapter Conference**, Virtual, June 2021
- **European Study Group with Industry (ESGI 165)**, Virtual, Apr 2021
- **Society for Mathematical Biology Annual Conference (SMB)**, Virtual, Aug 2020
- **SIAM/CAIMS Annual Meeting (AN20)**, Virtual, July 2020
- **Canadian Applied and Industrial Mathematics Society Annual Meeting (CAIMS)**, Whistler, Canada, June 2019
- **SIAM Conference on Applications of Dynamical Systems (DS19)**, Snowbird, Utah, USA, May 2019
- **Canadian Mathematical Society Winter Meeting**, Vancouver, Canada, Dec.2018
- **PIMS Workshop on Stochastic and Deterministic Modelling in Biology**, Jasper, Canada, Sept.2018
- **PIMS Industrial Problem Solving Workshop**, U of Calgary, Canada, August 2018
- **Mechanobiology Symposium: The Mechanome in Action**, UC Irvine, USA, July 2018
- **BC Data Science Workshop**, UBC, Canada, June 2018
- **Biophysical Society of Canada Annual Meeting**, Simon Fraser University, Canada, May 2018
- **Canadian Undergraduate Mathematics Conference**, Montreal, Canada, July 2017
- **Undergraduate Applied Mathematics Conference**, University of Western Ontario, Canada, March 2017