Ruining (Ray) Wu – *Curriculum Vitae*

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Department of Computer Science
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Education

University of Toronto *Toronto, ON, Canada*

Ph.D. Computer Science *2021 – present*

- Research topic: Sparse Grid methods for multidimensional Black-Scholes PDEs.
- Committee: Christina C. Christara (advisor), Kenneth R. Jackson, Maryam Mehri Dehnavi.

M.Sc. Computer Science *2019 – 2021*

- Thesis: Penalty Methods for Nonlinear Problems in Financial Option Pricing
- Advisor: Christina C. Christara. Second reader: Kenneth R. Jackson.

University of British Columbia *Vancouver, BC, Canada*

B.Sc. Honours Computer Science and Statistics (Graduated with Distinction) *2015 – 2018*

- Thesis: Analysis of Generalized-alpha vs theta-methods in Physics-based Computer Simulation of Soft Body materials
- Supervisor: Uri M. Ascher

Awards

Graduate Level

CAIMS 2024 HQP Travel Award ($100) *2024*
School of Graduate Studies (SGS) Conference Grant ($860) *2024*
SIAM 2024 Annual Meeting Student Travel Award ($650 USD) *2024*
Department of Computer Science PhD Conference Travel Grant ($1,000) *2024*
AMMCS 2023 Student Travel Award ($500) *2023*
CAIMS 2023 HQP Travel Award ($500) *2023*
Department of Computer Science PhD Conference Travel Grant ($1,200) *2023*
NSERC Postgraduate Scholarship - Doctoral ($21,000/year for 3 years) *2022 – 2025*
Ontario Graduate Scholarship (Ph.D. level) ($15,000, declined) *2022 – 2023*
Ontario Graduate Scholarship (Ph.D. level) ($15,000) *2021 – 2022*
Ontario Graduate Scholarship (M.Sc. level) ($15,000) *2019 – 2020*
University of Toronto Graduate Entrance Award ($10,000) *2019*

- Awarded to less than 1% of applicants to the Department of Computer Science.

Undergraduate Level

NSERC Undergraduate Student Research Award ($4500) *2018*
UBC Rick Sample Research Award ($1500) *2018*
UBC Trek Excellence Scholarship ($1500) *2016 – 2017*
NSERC Experience Award ($4500) *2016*
UBC Charles and Jane Banks Scholarship ($150) *2016*
UBC J Fred Muir Memorial Scholarship in Science ($150) *2016*
BC Government Pacific Leaders Scholarship ($2500) *2015*

Publications

1. **Wu**, R and Christara, C. "The combination method for multidimensional Black-Scholes partial differential equations", submitted to Proceedings of The VI AMMCS International Conference, 2023.
2. Christara, C and **Wu**, R. "Penalty and Penalty-Like Methods for HJB PDEs", Applied Mathematics and Computation, Volume 425, 19 pages, 2022. ISSN 0096-3003. [pdf]
3. **Wu**, R. "Penalty Methods for Nonlinear Problems in Financial Option Pricing", Master's Thesis, Department of Computer Science, University of Toronto, 2021, 106 pages. [pdf]
4. **Wu**, R and Mitchell, I. "Mutant Accuracy Testing for Assessing the Implementation of Numerical Algorithms", In: Zamani M., Zufferey D. (eds), Numerical Software Verification, proceedings of the 12th International Workshop, NSV 2019, Pages 128-144. New York City, NY, USA, July 13-14, 2019, Lecture Notes in Computer Science, Volume 11652, Springer. [pdf]
5. **Wu**, R. "Analysis of Generalized-alpha vs theta-methods in Physics-based Computer Simulation of Soft Body materials", Undergraduate Honours Thesis, Department of Computer Science, University of British Columbia, April 2018, 30 pages [pdf]

Presentations

1. *Convergence Remedies for Option Pricing on Sparse Grids*, presented at 2024 Society of Industrial and Applied Mathematics (SIAM) Annual Meeting, July 8-12, 2024.
2. *Convergence Remedies for Option Pricing on Sparse Grids*, presented at Canadian Applied and Industrial Mathematics Society (CAIMS) Annual Meeting, June 24-27, 2024.
3. *The sparse grid combination method for multidimensional Black-Scholes partial differential equations*, presented at the International Conference on Computational Finance (ICCF24), April 2-5, 2024.
4. *The combination method for multidimensional Black-Scholes partial differential equations*, presented at The VI AMMCS International Conference, August 14-18, 2023.
5. *The combination method for multidimensional Black-Scholes partial differential equations*, presented at CAIMS Annual Meeting, June 12-15, 2023.
6. *The combination method for multidimensional Black-Scholes partial differential equations*, presented at Southern Ontario Numerical Analysis Day, May 19, 2023.
7. *Deep Galerkin Method with Timestepping*, presented at CAIMS Annual Meeting, June 13-16, 2022.
8. *DGMT: A semi-discretization method for solving parabolic PDEs*, presented at Southern Ontario Numerical Analysis Day, May 27, 2022.
9. *Penalty Methods for Nonlinear PDEs in Finance*, presented at CAIMS Annual Meeting, June 21, 2021.
10. *Penalized PDE and HJB Formulations and Computation for Some Nonlinear Problems in Finance*, presented at Second Joint SIAM/CAIMS Annual Meeting, July 15, 2020.
11. *Mutation Testing & Numerical Algorithms*, presented to the Shared Control group at UBC Department of Computer Science, 2018.

Research Experience

Intern, Royal Bank of Canada (RBC) Capital Markets *Sep 2023 – Dec 2023*
Supervisor: Dr. Meng Han, Dr. Fenghao Yang

- Worked on model calibration of interest rate derivatives and pricing.

PhD Student, University of Toronto *Feb 2021 – present*
Supervisor: Professor Christina C. Christara

- Working on Sparse Grid methods for high-dimensional PDEs.

MSc Student, University of Toronto *Sep 2019 – Jan 2021*
Supervisor: Professor Christina C. Christara

- Worked on the valuation of various nonlinear financial problems under the Black-Scholes PDE model and Hamilton-Jacobi-Bellman (HJB) type PDEs.
- Formulated optimal control (HJB) problems as penalty PDE problems and studied the efficiency of penalty and penalty-like discretizations vs. policy iteration arising from the HJB formulation.
- Proved theoretical results such as diagonal dominance and monotonicity of discretization matrices and monotonicity of penalty iteration algorithm where applicable.
- Used MATLAB's profiler to optimize code implemented for experiments.

Summer Student, University of British Columbia *May 2018 – Aug 2018*
Supervisor: Professor Ian M. Mitchell
- Worked on mutation testing as a method to test numerical software for bugs.
- Published research findings in Numerical Software Verification (2019).

BSc Student, University of British Columbia *Sep 2017 – Apr 2018*
Supervisor: Professor Uri M. Ascher
- Worked on different types of solvers for stiff ODEs arising from computer graphics problems.

Summer Student, Barrodale Computing Services *May 2016 – Aug 2016*
Supervisor: Dr. Ian Barrodale
- Worked on implementing a linear programming solver for ℓ_1 regression problems.

Teaching Experience

Instructor & Course Coordinator, University of Toronto (Missisauga Campus) *Jan – Apr 2023*
Taught a section of CSC338 (Numerical Methods, around 80 students). As the sole instructor for this course, I am also the course coordinator responsible for managing the employment of TAs and the creation of assignments, tutorials, and exams.
The course website can be found at http://www.cs.toronto.edu/~rwu/csc338/2301/

Graduate Teaching Assistant, University of Toronto *Sep 2019 – present*
I have been a Teaching Assistant (TA) at University of Toronto for nine (9) terms, and my responsibilities involved grading, tutorials, exam invigilation, and project guidance for the following courses:
- CSC2321 (Graduate level Numerical Linear Algebra), 1 term.
- CSC446/2305 (Numerical Methods for Optimization Problems), 1 term.
- CSC336 (Numerical Methods), 7 terms
- CSC236 (Introduction to Theory of Computation), 1 term.

Teaching Assistant, University of British Columbia *2018*
I have been a Teaching Assistant (TA) at University of British Columbia for two (2) terms, and my responsibilities involved grading, invigilation, and office hours for the following courses:
- CS 420 (Advanced Algorithms), Sep - Dec 2018.
- STAT 200 (Introduction to Statistics), Jan - Apr 2018.

Projects

DGMT: A semi-discretization method for solving parabolic PDEs *2022*
Combined time-discretization of numerical analysis with neural networks to solve parabolic PDEs and improve on existing algorithms. Primarily used python/Tensorflow. [pdf]

Alternating Direction Implicit methods for Black-Scholes Equations *2021*
Implemented an efficient Craig-Sneyd ADI solver for two- and three-dimensional Black-Scholes Equations (both European and American options). Primarily used MATLAB. [pdf]

FEPR for computer graphics *2021*
Implemented a projection-based algorithm to keep energy levels of simulated bodies constant to avoid damping and increase stability. Primarily used Eigen and C++. [pdf]

Service and Outreach

Session Chair

Chair for the session CP10 Numerical Analysis++ at SIAM AN24.

Admissions Committee

I reviewed graduate student applications to the Department of Computer Science. *2022*

Journal Reviewer

Reviewer for the journal "Applied Mathematics and Computation" (Elsevier) *2021 – 2022*

Mentoring Experience

Graduate Mentor, PRISM Program, University of Toronto. *2021*
The **P**reparation for **R**esearch through **I**mmersion, **S**kills, and **M**entorship program helps introduce second-year undergraduate students studying Computer Science to research. Mentees are encouraged to be "from members of groups which have been historically underrepresented in computer science research". My specific responsibilities involved leading breakout groups over zoom and describing obstacles that I have solved in my own research and encouraging students to brainstorm ideas that overcome these problems.

Other Work Experience

Software Developer Intern, SAP Canada *Jan – Aug 2019*
Applications Engineering Intern, Broadcom Canada *May – Aug 2017*