40 St. George Street Department of Computer Science University of Toronto Toronto, Ontario, Canada

Education

University of Toronto

Ph.D. Computer Science

- Thesis Proposal title: High-order Numerical PDE Methods for Pricing Multi-asset Options on Sparse Grids.
- Committee: Christina C. Christara (supervisor), Kenneth R. Jackson, Maryam Mehri Dehnavi.

M.Sc. Computer Science

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

University of British Columbia

B.Sc. Honours Computer Science and Statistics (Graduated with Distinction)

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

Publications

- P1. **Wu**, R and Christara, C. "The combination method for multidimensional Black-Scholes partial differential equations", Proceedings of The VI AMMCS International Conference, 2023, in press. https://link.springer.com/book/9783031848681 [pdf]
- P2. 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]
- P3. 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]
- P4. 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]
- P5. 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]

Talks

- T1. *Convergence Remedies for Option Pricing on Sparse Grids*, presented at the 2024 Society of Industrial and Applied Mathematics (SIAM) Annual Meeting, July 8-12, 2024, Spokane, WA, USA.
- T2. Convergence Remedies for Option Pricing on Sparse Grids, presented at the Canadian Applied and Industrial Mathematics Society (CAIMS) Annual Meeting, June 24-27, 2024, Queen's University, Kingston, ON, Canada.
- T3. *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, CWI, Amsterdam, the Netherlands.

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2019 – 2021

2021 - present

Vancouver, BC, Canada 2015 – 2018

Toronto, ON, Canada

- T4. *The combination method for multidimensional Black-Scholes partial differential equations*, presented at the VI AMMCS International Conference, August 14-18, 2023, Wilfrid Laurier University, Waterloo, ON, Canada.
- T5. *The combination method for multidimensional Black-Scholes partial differential equations*, presented at the CAIMS Annual Meeting, June 12-15, 2023, University of New Brunswick, Fredericton, NB, Canada.
- T6. *The combination method for multidimensional Black-Scholes partial differential equations*, presented at Southern Ontario Numerical Analysis Day, May 19, 2023, University of Waterloo, Waterloo, ON, Canada.
- T7. *Deep Galerkin Method with Timestepping*, presented at the CAIMS Annual Meeting, June 13-16, 2022, University of British Columbia (Okanagan), Kamloops, BC, Canada.
- T8. *DGMT: A semi-discretization method for solving parabolic PDEs*, presented at Southern Ontario Numerical Analysis Day, May 27, 2022, York University, Toronto, ON, Canada.
- T9. Penalty Methods for Nonlinear PDEs in Finance, presented at CAIMS Annual Meeting, June 21, 2021, online.
- T10. *Penalized PDE and HJB Formulations and Computation for Some Nonlinear Problems in Finance*, presented at the Second Joint SIAM/CAIMS Annual Meeting, July 15, 2020, online.
- T11. *Mutation Testing & Numerical Algorithms*, presented to the Shared Control group at UBC Department of Computer Science, August 22, 2018, Vancouver, BC, Canada.

Awards

Graduate Level

NSERC Postgraduate Scholarship - Doctoral (\$21,000/year for first 2 years, \$40,000 for final	year) 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.	
Department of Computer Science PhD Conference Travel Grant (\$800, declined)	2024
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
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
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

Supervisor: Professor Christina C. Christara

- Working on Sparse Grid methods for multi-dimensional PDEs with a focus on Option Pricing problems.
- Currently interested in high-order methods and their use on sparse grids.
- Previously worked on Neural Network methods for high-dimensional PDEs.

MSc Student, University of Toronto

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

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

Supervisor: Professor Uri M. Ascher

• Worked on different types of solvers for stiff ODEs arising from computer graphics problems.

Summer Student, Barrodale Computing Services

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 2023Taught a section of CSC338 (Numerical Methods, around 80 students). As the sole instructor for this course, I was 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

I have been a Teaching Assistant (TA) at University of Toronto for numerous terms, and my responsibilities involved grading, tutorials, exam invigilation, office hours, and project guidance for the following courses:

- CSCC11 (Introduction to Machine Learning), 2 terms.
- CSC2321 (Graduate level Numerical Linear Algebra), 1 term.
- CSC466/2305 (Graduate level Numerical Methods for Optimization Problems), 1 term.
- CSC336 (Numerical Methods), 8 terms.
- CSC236 (Introduction to Theory of Computation), 1 term.

Feb 2021 – present

Sep 2019 – Jan 2021

Sep 2017 – Apr 2018

May 2018 – Aug 2018

May 2016 – Aug 2016

Sep 2019 – present

Teaching Assistant, University of British Columbia

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

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

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

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

GAAP mentor

I was a mentor for The Toronto Graduate Application Assistance Program (GAAP), which is a student-run, volunteerled effort that aims to ensure that all applicants to higher-degree programs (thesis-based MSc/PhD) in the University of Toronto Department of Computer Science can receive feedback on a draft of their application before final submission. The GAAP program aims to be one step towards a more equitable application process.

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
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Journal Reviewer

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

Mentoring Experience

Graduate Mentor, PRISM Program, University of Toronto.

The Preparation for Research through Immersion, Skills, and Mentorship 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.

2021

2018

2022

2021

2021

Other Work Experience

Intern, RBC Capital Markets Software Developer Intern, SAP Canada Applications Engineering Intern, Broadcom Canada Sep – Dec 2023 Jan – Aug 2019 May – Aug 2017