

Robert Joseph George

Portfolio: robertj1.com

Google Scholar: scholar.google.ca/robert-joseph

Email: rgeorge@caltech.edu

Github: github.com/Robertboy18

LinkedIn: linkedin.com/robert-joseph-2001

Research Interests

My research interests include Neural Operators, AI4Science, AI4Math, Optimization, Numerical Algorithms, and Large Language Models. More specifically, I am working towards building open-source foundational models for science, efficient scaling, optimization, and theory of Neural operators and their applications in AI4Science. I am also working towards efficient training of LLMs, theorem proving and their intersection in AI4Math.

Education

California Institute of Technology (Caltech)

Ph.D. Mathematics and Computer Science

Pasadena, CA

Sep 2023 - Present

- **Academic Supervisor:** Anima Anandkumar
- **Academic Profile:** GPA: (4.0/4.0)

University of Alberta

B.S.c Honors Applied Mathematics and Computer Science, First Class

Edmonton, AB

Sep 2019 - Jun 2023

- **Honors Thesis 1:** Numerical Analysis for Real-time Nonlinear Model Predictive Control of Ethanol Steam Reformers.
- **Honors Thesis 2:** Hybrid Dealiased Convolutions.
- **Academic Profile:** GPA: (3.9/4.0). Dean's Silver Medal and Dean's Honor Roll.

Work Experience

Caltech

Research Intern, AI + Science Group

Pasadena, CA

Jul 2022 - Aug 2023

- **Deep Learning:** Foundations of Deep Learning; understanding Rank and Spectral Bias in Neural Networks plus applications to solving PDEs using Fourier Neural Operators.
- **Academic advisor:** Anima Anandkumar (Nvidia)

Alberta Machine Intelligence Institute (Amii)

Research Intern, Reinforcement Learning and Artificial Intelligence Lab

Edmonton, AB

Jan 2022 - Jan 2023

- **Reinforcement Learning:** Optimization of RL environments - Decreased training time by around 50% on all environments and proposed a new hyperparameter approach with the team at DeepMind. Released the code as open source on Github. RL researchers use the codebase to test their RL and AI agents.
- **Theoretical Machine Learning:** Comparing the theoretical properties of Implicit vs Explicit Kernel Features.
- **Academic advisor:** Martha White and Adam White (Google DeepMind)

Work Integrated Learning Opportunity

Mar 2022 - Mar 2022

- **Duties:** Created discussion activities centred around introductory Python concepts to various startups and colleges.
- **Impact:** Helped startups and colleges to educate their workspace/students and enabled them to take advanced courses.

University of Alberta

Research Intern, Department of Mathematics and Department of Computer Science

Edmonton, AB

Nov 2020 - August 2023

- **Hybrid Dealiased Convolutions:** Optimization of the Fast Fourier Transform Algorithm using Hybrid Dealiasing.
- **Academic advisor:** John Bowman
- **Climate Forecast:** Led the climate forecast team using Machine learning Techniques to predict the climate over the next year, especially for the Prairies and Global Forecast Team. Analyzed seasonal patterns like ENSO, NAO, SAO etc.
- **Impact:** Part of the \$3 Million project aims to mix artificial intelligence with agriculture to help cattle ranchers.
- **Academic advisor:** David Wishart
- **Data Science:** Enhancing Occupational Health and Safety Performance of companies through data analysis.
- **Academic advisors:** Lianne Lefsrud, Joel Gehman, Heather Eckert

Pacific Institute for the Mathematical Sciences (PIMS)

Research Assistant, Department of Mathematics and Statistics

Toronto, ON

Jan 2022 - Dec 2022

- **Research Projects:** Numerical Analysis for NMPC of Ethanol Steam Reformers and Finding the solution space of a homogeneous linear ODE. The work is was part of my Honors Thesis and Honors ODE course - Github
- **Impact:** Performed simulations, numerical and a rigorous theoretical analysis of first-order quasi-PDEs.
- **Academic advisor:** Xinwei Yu

Canadian Vigour Center (CVC)

Research Assistant, Department of Medicine and Dentistry

Edmonton, AB

Jan 2022 - Jun 2022

- **Research Project:** Prediction of the next clinical event of a patient with a certain disease using Process Mining Tools.
- **Academic advisor:** Russ Greiner

Microsoft

Data Science Intern, Azure Compute

Redmond, WA

Jun 2021 - Aug 2021

- **Azure Dedicated Hosts:** Improved the efficiency of Azure, 0.05% increase in accuracy.
- **Machine Learning and AI:** Worked in Azure alongside Microsoft Research to create Interpretable and Explainable Classifiers (Explainable Boosting, LIME and SHAP Kernel Explainer) and did feature importance using Mutual Information and other statistics. Used AI tools in Power BI to verify the results and create reports.
- **Impact:** Helped lay the foundation for more research and increase in efficiency led to a \$200 Million save for Microsoft.

Teaching Experience

University of Alberta

Department of Mathematics and Statistics, Department of Computer Science

Edmonton, AB

Apr 2021 - May 2023

- **MATH 117/127**: Honors Calculus I (Real Analysis)/ Honors Linear Algebra
- **Mathematics help center**: Honors Calculus II (Multivariable Real Analysis and Topology)
- **CS 474**: Formal Languages, Automata, and Computability Theory
- **CS 304**: Algorithms II (Complexity Theory, Advanced, Random and Approximation algorithms)
- **CS 204**: Algorithms I (Basic Algorithms)
- **CS 267**: Basics of Machine Learning

Honors and Awards

- Caltech Institute Fellowship 2024
- Dean's Silver Medal in Science 2023
- Google Computer Science Research Program Scholar 2022
- The Harry E. Balfour Scholarship in Mathematics 2022
- University of Alberta Undergraduate Leadership Award (International) 2022
- Dr. Clement W Bowman Scholarship in Honors Applied Mathematics (Twice) 2022
- Mathematical and Statistical Sciences Undergraduate Student Research Award (USRA, Twice) 2022
- The Mathematical Contest in Modeling (Successful Participant Award) 2022
- International Undergraduate Summer Enrichment Program - Excellence Award (Top 5 students) 2021
- Morgan Stanley (Code For Good Hackathon Winner) 2021
- Mathematical and Statistical Department Excellence Scholarship 2021
- Merit List Holder (7 Years) - Bronze Medal 2019
- Gulf Mathematics Olympiad - Bronze Medal 2018
- Prime Ministers Foundation Award for Academic Excellence and Leadership 2018

Preprints

- Md Ashiqur Rahman, **George, Robert Joseph**, Anima Anandkumar, et. al.. "Pretraining Multiphysics PDEs with Codomain Attention Neural Operators", *under review*, 2024.
- **George, Robert Joseph**, Jiawei Zhao, Jean Kossaiji, Zongyi Li and Anima Anandkumar. "Incremental Spatial and Spectral Learning of Neural Operators for Solving Large-Scale PDEs", *under review*, 2024.

Conference Proceedings

- **George, Robert Joseph**. "EDCDE - Extended Discovery of Closed-Form Differential Equations", *International Conference of Learning Representations Tiny Paper*, 2023

Workshops

- Jiawei Zhao, **George, Robert Joseph**, Yifei Zhang, Zongyi Li and Anima Anandkumar "Incremental Fourier Neural Operator" *NeurIPS 2022 Workshop AI4Science*, 2022.
- **George, Robert Joseph**, Martha White, Adam White and Samuel Neumann. "Making Reinforcement Learning Experiments More Reproducible and Computationally Efficient." *Undergraduate Research Symposium* (Also at Alberta Machine Intelligence Institute Reverse Expo) , 2022, pp. 15–16.

Undergraduate Honors Thesis

- **George, Robert Joseph**, and Xinwei Yu. "Numerical Analysis for real-time Nonlinear Model Predictive Control of Ethanol Steam Reformers." *Canadian Undergraduate Mathematics Conference*, 2022.
- **George, Robert Joseph**, Noel Murasko and John Bowman. "Hybrid Dealiasing Convolutions." *Joint Mathematics Meetings*, 2023.

Talks/Presentations

- *Foundational Models for PDEs*, Scientific Foundation Models, University of Michigan. 2024
- *CoDomain Attention Neural Operator*, AI+Science, University of Chicago. 2024
- *Summer School in Logic and Formal Epistemology*, Carnegie Mellon University. 2022
- *International Undergraduate Summer Enrichment Program*, University of Alberta. 2021
- *Alberta Number Theory Days*, Banff International Research Station for Mathematical Innovation and Discovery. 2021
- *Riemann $\zeta(2k)$ using Fourier Analysis*, Number Theory Society, University of Alberta. 2020
- *Western Summer School in Algebra*, University of Alberta. 2020

Leadership Experience

Caltech Y

Vice President Internal

Pasadena, CA

May 2024 - Present

- **Activities:** In charge of organizing various events such as helping out at homeless shelters, cultural cuisines, concerts etc.

Cohere For AI

Machine Learning Theory Learning Group Lead

Toronto, ON

Oct 2022 - Present

- **Activities:** In charge of co-organizing the ML Theory Learning Group and holding discussions with researchers on advances in the field. Topics include Optimization, Generalization theory, Computational Learning Theory, Domain Generalization etc.
- **Impact:** Helping researchers learn various topics in theoretical ML and RL.

Mathematical Sciences Society (MSS)

Treasurer and Member

Edmonton, AB

Aug 2019 - Aug 2023

- **Activities:** Promoted the MSS during club fairs and our love for math through various events and wrote the Math Integration Bee contest problems. The club was perfect for me to debate, interact, have fun, and engage in activities.
- **Impact:** Responsible for keeping track of the funds, restocking, buying new merch managing the entire community.

Google

Developer Student Founder and Leader

Edmonton, AB

Jul 2020 - Apr 2022

- **Google Developer Technologies:** Developer Student Lead/Founder for The University of Alberta DSC Chapter
- **Impact:** Helped organized events and promoted the usage of Google developer technologies. Collaborated with startups, Google Developer Experts etc. Grew the club to around 1,000 members. Got promoted to lead the whole of Alberta province and have been advising various GDSC clubs in North America for 2 years.

Undergraduate Research Initiative (URI)

Peer Undergraduate Research Liaison (PURL) and Reviewer

Edmonton, AB

Aug 2021 - Apr 2022

- **PURL:** Helped support the URI through involvement in promotion and outreach activities, event logistics and peer-advising.
- **Impact:** Promoted related research opportunities. Assisted with the coordination of the Mentor Award, Research Crawls, and High school programs. Helped guide undergrads especially underrepresented students find research-related jobs.

Association for Computing Machinery (ACM)

Founder and Chair

Edmonton, AB

Aug 2020 - Apr 2022

- **Activities:** Founder the University of Alberta ACM Chapter. Hosted hackathons, workshops and other events.
- **Impact:** Organized various club meetings and collaborated with different clubs facilitating effective knowledge of CS. Improved student access to important resources in CS such as Machine Learning, Artificial Intelligence etc.

University of Alberta

Science Mentor and Service Learning Volunteer

Edmonton, AB

Nov 2019 - Apr 2022

- **Activities:** Mentor for the Faculty of Science and Identified social issues in the Edmonton community.
- **Impact:** Mentoring 20 Mentees and helped them gain awareness of the campus and resources available to them as well as shared relevant experiences. I also connected with the different organizations such as Hope mission, operation friendship, Edmonton food bank to support the homeless and give back to the community.

Open source software/Projects

- **Neural Operators:** Implementing various Neural Operator architectures. [Github]
- **MinAtar - Faster:** MinAtar Faster is an optimized testbed for AI agents which implements miniaturized versions of several Atari 2600 games. We also provide benchmarks for standard RL agents on the various environments. [Github]
- **Theoretical Algorithms Implementation:** Implementation of Algorithms from CLRS book - [Github]
- **Fillactive Community App:** The app uses incentives and gamification to promote exercise for self worth and build a community among students, teachers and Fillactive - Acquired by **Morgan Stanley**
- **The Mathematical Contest in Modeling:** Water and Hydroelectric Power Sharing among the river basin (Problem B in the MCM) using Flow Algorithms - Published (Drought and Rain Magazine)

Professional Affiliations

- Institute of Mathematical Statistics (IMS)
- Association for Computing Machinery (ACM)
- Pacific Institute for the Mathematical Sciences (PIMS)

Reviewer

- International Conference of Representation Learning (ICLR) 2023 - Present
- International Conference of Machine Learning (ICML) 2023 - Present
- Neural Information Processing Systems (NeurIPS) 2023 - Present
- Journal of Machine Learning Research 2022 - Present
- Canadian Journal of Undergraduate Research 2021 - 2022