Aman Bhargava

Curriculum Vitae

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Education

Sep 2022 – Ongoing
California Institute of Technology
Ph.D., Computation and Neural Systems.
Advisor: Matt Thomson

Sep 2018 – May 2022
University of Toronto
BASc. with Honours: Engineering Science, Machine Intelligence Option.
Relevant Coursework: Decision Support Systems (#1 ranked student), Matrix Algebra and Optimization, Neural Bioelectricity, Probabilistic Reasoning, Systems Software, Artificial Intelligence, Control Theory I-II, Digital & Computer Systems, Distributed Systems, Optimization in Machine Learning.

Sep 2014 – June 2018
Trinity College School
Secondary School Diploma & AP Capstone Diploma. Governor General's Bronze Medal (#1 ranked student).

Research Experience

May 2023 – Ongoing
Thomson Lab – California Institute of Technology
Ph.D. Student: Deep Learning, Collective Intelligence, Large Language Models (LLMs)
- Led efforts on formalizing a **control theory for LLMs**, demonstrating theoretical and empirical bounds on output reachability [1].
- Architected and developed a novel high-throughput **distributed system of LLMs** leveraging PyTorch, HuggingFace's Transformers library, and FastAPI to probe the horizontal scalability of LLM systems.
- Developed interactive web-based data visualizations and demonstrations on **LLM representations and control** (link)

Jan 2023 – Apr 2023
Winfree Lab – California Institute of Technology
Rotation Student: Programmable Liquid-Liquid Phase Separation
- Developed a **differentiably optimizable** implementation of the Cahn-Hilliard multicomponent phase separation model in JAX from the ground up.
- Leveraged **frequency domain** techniques to drastically improve simulation accuracy and throughput.
- Investigated the **programmability** of multi-component phase separation via computational experiments and theoretical analysis. Developed the connection between phase separation and **Hopfield networks** and Ising models.

Feb 2021 – Jan 2023
Neural System & Brain Signal Processing Lab – Krembil Research Institute
Researcher: Theoretical Neuroscience
- Led investigation on **reinforcement learning** approaches for revserse-engineering **learning rules** in neural networks.
- Designed and optimized large scale neural network simulations in **Julia**.
- Generated a **robust, biologically feasible synaptic** learning policy for rate-based neural networks using novel reinforcement learning approach [2].

Jun 2021 – Aug 2021

Turaga Lab – HHMI Janelia

Research Intern: ML-Based Protein Engineering

- Designed and tested a variety of **large scale deep learning** models for GCaMP **protein functionality prediction** task.
- Leveraged **pre-trained** transformer (ESM-1b) and RNN-LSTM (UniRep) language models for semantically rich sequence representations.
- Introduced data **transformations** and **dimensionality reduction** techniques to increase final model performance on key prediction targets.

Oct 2019 – Jan 2021

MannLab – University of Toronto

Researcher: ML, BCI, Signal Processing

- **Collaborated with and lead** teams of masters students, undergraduates, and industry professionals to produce a variety of publications on **machine learning, signal processing, brain-computer interface**, and **wearable technology** [5, 3, 6, 4].
- Generated research questions, designed systems and apparatus, performed experiments, and published results in **peer-reviewed venues.**
- Rapidly acquired mathematical and scientific skill sets in order to carry out research objectives.

Awards and Honors

- 2022: **Chen Fellowship**, California Institute of Technology.
- 2022: **Predoctoral Training in Quantitative Neuroscience**, National Institutes of Health (NIH).
- 2021: **Janelia Undergraduate Scholars Fellowship**, Howard Hughes Medical Institute.
- 2020: **Undergraduate Student Research Award**, Natural Sciences and Enginenering Research Council of Canada (NSERC USRA).
- 2020: **Shaw Design Scholarship**, University of Toronto Faculty of Engineering Science.
- 2019: **Engineering Alumni Network Scholarship**, University of Toronto Faculty of Applied Science and Engineering.
- 2018: **President's Scholarship**, University of Toronto.
- 2018: **Global Top Scoring Thesis Paper & Presentation**, AP Capstone Diploma.

Publications

2023

1. **Bhargava, A.**, Witkowski, C., Shah, M. & Thomson, M. *What's the Magic Word? A Control Theory of LLM Prompting* 2023. arXiv: 2310.04444 [cs.CL].

2022

2. **Bhargava, A.**, Rezaei, M. R. & Lankarany, M. Gradient-Free Neural Network Training via Synaptic-Level Reinforcement Learning. *AppliedMath* **2,** 185–195 (2022).

2021

3. **Bhargava, A.** & Mann, S. *Adaptive Chirplet Transform-Based Machine Learning for P300 Brainwave Classification* in *2020 IEEE-EMBS Conference on Biomedical Engineering and Sciences (IECBES)* (2021), 62–67.
4. **Bhargava, A.**, Zhou, A. X., Carnaffan, A. & Mann, S. Deep Learning for Enhanced Scratch Input. arXiv: 2111.15053 [cs.HC] (2021).

2020

5. **Bhargava, A.**, O'Shaughnessy, K. & Mann, S. *A Novel Approach to EEG Neurofeedback via Reinforcement Learning* in *2020 IEEE SENSORS* (2020), 1–4.
6. Mann, S. *et al. Sensing of the Self, Society, and the Environment* in *2020 IEEE SENSORS* (2020), 1–4.

Skills

- **Programming**: Python, Julia, MATLAB, C, JavaScript, Java, HTML5/CSS3, ARM Assembly, Verilog.
- **Software**: PyTorch, Tensorflow, JAX, NumPy, Pandas, SciKit Learn, OpenCV, HTMX, FastAPI, Firebase, Git, Arduino,

ESP32, PlatformIO.

- **Techniques**: Large Language Models, Supervised ML, Unsupervised ML, Statistical Machine Learning, Deep Learning, Reinforcement Learning, Supercomputing, Object-Oriented Programming.

Professional and Leadership Experience

Apr 2020 – Apr 2022 | **University of Toronto Consulting Association**
Consulting Group Director

- Recruited & onboarded a group of 90 University of Toronto students (undergraduate, Masters, and Ph.D.) over 2 years to solve management consulting problems for local **non-profits and startups** at UofT's largest consulting club.
- Worked with client organizations to understand issues in their operations and draft **problem statements.**
- Mentored 15 independent teams working to solve problems for real-world clients.

Jul 2019 – Ongoing | **CareTrack**
Co-Founder & CEO

- Designed and implemented a full-stack web-based **medical data entry & analytics platform** for assisted living facilities.
- Leverages modern UI, data visualization, and predictive algorithms to improve patient outcomes and nurse, doctor, and administrator productivity. Currently in **private beta** for data collection.
- Utilizes Angular, Firebase, Chart.js, Python/Flask.

Jun 2019 – Aug 2019 | **Venture13**
Software Developer

- Conceptualized and developed **full-stack web applications** using Angular and Firebase incorporating Google Calendar, Maps, Directions API's for **TheWeekendRoute, Venture13**, and the **Cobourg Police Force.**
- Created **robotics software suite** for CrossWing Solutions using OpenCV, Python, and JavaScript.
- Performed **microprocessor programming**, implementing low power machine learning and signal processing with Nordic Semiconductor's SDK for wearable personal security device.