

# Aman Bhargava

Curriculum Vitae

✉ xxxxxxxx@caltech.edu    ☎ (xxx)-xxx-xxxx    📍 Pasadena, California  
🆔 0000-0002-3347-0602    🌐 amanb2000    🌐 <https://aman-bhargava.com>

## Education

Sep 2022 – Ongoing	<b>California Institute of Technology</b> <i>Ph.D., Computation and Neural Systems.</i> Advisor: Matt Thomson
Sep 2018 – May 2022	<b>University of Toronto</b> <i>BASc. with Honours: Engineering Science, Machine Intelligence Option.</i> <u>Relevant Coursework</u> : 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	<b>Trinity College School</b> <i>Secondary School Diploma &amp; AP Capstone Diploma. Governor General's Bronze Medal (#1 ranked student, global top scoring Capstone defense).</i>

## Research Experience

May 2023 – Ongoing	<b>Thomson Lab – California Institute of Technology</b> <i>Ph.D. Student: Computation and Neural Systems</i> <ul style="list-style-type: none"><li>Led efforts on formalizing a <b>control theory for LLMs</b>, demonstrating theoretical and empirical bounds on output reachability [3].</li><li>Led research on <b>Prompt Baking</b> [1], a technique that convert a text prompt for a large language model into an equivalent weight update for the model, offering greater control over language models (extending [3]).</li><li>Proved theorems guaranteeing <b>disentangled representation learning</b> for multi-task evidence aggregating classifier systems in [2], offering a unifying theory for low-dimensional cognitive map learning in spite of potentially high-dimensional and noisy observations.</li><li>Architected and developed a novel high-throughput <b>distributed system of LLMs</b> leveraging PyTorch, HuggingFace's Transformers library, and FastAPI to probe the horizontal scalability of LLM systems.</li><li>Developed interactive web-based data visualizations and demonstrations on <b>LLM representations and control</b> (link)</li><li>Developed frequency domain analysis methods for predicting immune infiltration of tumors based on spatial proteome data [4].</li></ul>
Jan 2023 – Apr 2023	<b>Winfree Lab – California Institute of Technology</b> <i>Rotation Student: Programmable Liquid-Liquid Phase Separation</i> <ul style="list-style-type: none"><li>Developed a <b>differentiably optimizable</b> implementation of the Cahn-Hilliard multicomponent phase separation model in JAX from the ground up.</li><li>Leveraged <b>frequency domain</b> techniques to drastically improve simulation accuracy and throughput.</li><li>Investigated the <b>programmability</b> of multi-component phase separation via computational experiments and theoretical analysis. Developed the connection between phase separation and <b>Hopfield networks</b> and Ising models.</li></ul>

Feb 2021 – Jan 2023	<b>Neural System &amp; Brain Signal Processing Lab – Krembil Research Institute</b> <i>Researcher: Theoretical Neuroscience</i> <ul style="list-style-type: none"> <li>Led investigation on <b>reinforcement learning</b> approaches for reverse-engineering <b>learning rules</b> in neural networks.</li> <li>Designed and optimized large scale neural network simulations in <b>Julia</b>.</li> <li>Generated a <b>robust, biologically feasible synaptic</b> learning policy for rate-based neural networks using novel reinforcement learning approach [5].</li> </ul>
Jun 2021 – Aug 2021	<b>Turaga Lab – HHMI Janelia</b> <i>Research Intern: ML-Based Protein Engineering</i> <ul style="list-style-type: none"> <li>Designed and tested a variety of <b>large scale deep learning</b> models for GCaMP <b>protein functionality prediction</b> task.</li> <li>Leveraged <b>pre-trained</b> transformer (ESM-1b) and RNN-LSTM (UniRep) language models for semantically rich sequence representations.</li> <li>Introduced data <b>transformations</b> and <b>dimensionality reduction</b> techniques to increase final model performance on key prediction targets.</li> </ul>
Oct 2019 – Jan 2021	<b>MannLab – University of Toronto</b> <i>Researcher: ML, BCI, Signal Processing</i> <ul style="list-style-type: none"> <li><b>Collaborated with and lead</b> teams of masters students, undergraduates, and industry professionals to produce a variety of publications on <b>machine learning, signal processing, brain-computer interface, and wearable technology</b> [8, 6, 9, 7].</li> <li>Generated research questions, designed systems and apparatus, performed experiments, and published results in <b>peer-reviewed venues</b>.</li> <li>Rapidly acquired mathematical and scientific skill sets in order to carry out research objectives.</li> </ul>

## Honors and Talks

---

- 2024: **Machine Learning Street Talk**, on LLM Control Theory with Cameron Witkowski (recording link).
- 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 Engineering 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 (defense recording link).

## Publications

---

- |      |   |
|------|---|
| 2024 | 1. <b>Bhargava, A.</b> , Witkowski, C., Detkov, A. & Thomson, M. Prompt Baking. <i>arXiv preprint arXiv:2409.13697</i> (2024).  |
| 2024 | 2. Vafidis, P., <b>Bhargava, A.</b> & Rangel, A. Disentangling Representations in RNNs through Multi-task Learning. <i>arXiv preprint arXiv:2407.11249</i> (2024).  |
| 2023 | 3. <b>Bhargava, A.</b> , Witkowski, C., Shah, M. & Thomson, M. <i>What's the Magic Word? A Control Theory of LLM Prompting</i> 2023. arXiv: 2310.04444 [cs.CL].   |
| 2023 | 4. Wang, Z. J., Xu, A. M., <b>Bhargava, A.</b> & Thomson, M. Generating counterfactual explanations of tumor spatial proteomes to discover effective strategies for enhancing immune infiltration. <i>bioRxiv</i> , 2023–10 (2023). |
| 2022 | 5. <b>Bhargava, A.</b> , Rezaei, M. R. & Lankarany, M. Gradient-Free Neural Network Training via Synaptic-Level Reinforcement Learning. <i>AppliedMath</i> <b>2</b> , 185–195 (2022).   |
| 2021 | 6. <b>Bhargava, A.</b> & Mann, S. <i>Adaptive Chirplet Transform-Based Machine Learning for P300 Brainwave Classification in 2020 IEEE-EMBS Conference on Biomedical Engineering and Sciences (IECBES)</i> (2021), 62–67.           |
| 2021 | 7. <b>Bhargava, A.</b> , Zhou, A. X., Carnaffan, A. & Mann, S. Deep Learning for Enhanced Scratch Input. arXiv: 2111.15053 [cs.HC] (2021).  |
| 2020 | 8. <b>Bhargava, A.</b> , O'Shaughnessy, K. & Mann, S. <i>A Novel Approach to EEG Neurofeedback via Reinforcement Learning in 2020 IEEE SENSORS</i> (2020), 1–4.   |
| 2020 | 9. Mann, S. <i>et al. Sensing of the Self, Society, and the Environment in 2020 IEEE SENSORS</i> (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 | <b>University of Toronto Consulting Association</b><br><i>Consulting Group Director</i> <ul style="list-style-type: none"><li>• Recruited &amp; onboarded a group of 90 University of Toronto students (undergraduate, Masters, and Ph.D.) over 2 years to solve management consulting problems for local <b>non-profits and startups</b> at UofT's largest consulting club.</li><li>• Worked with client organizations to understand issues in their operations and draft <b>problem statements</b>.</li><li>• Mentored 15 independent teams working to solve problems for real-world clients.</li></ul> |
| Jul 2019 – Ongoing  | <b>CareTrack</b><br><i>Co-Founder &amp; CEO</i> <ul style="list-style-type: none"><li>• Designed and implemented a full-stack web-based <b>medical data entry &amp; analytics platform</b> for assisted living facilities.</li><li>• Leverages modern UI, data visualization, and predictive algorithms to improve patient outcomes and nurse, doctor, and administrator productivity. Currently in <b>private beta</b> for data collection.</li><li>• Utilizes Angular, Firebase, Chart.js, Python/Flask.</li></ul>  |

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.