Alec Bunn

abunn2@uw.edu | 509-279-4044

EDUCATION

Bachelor of Science in Computer Science
Bachelor of Science in Mathematics
University of Washington, Seattle, WA
Expected Graduation: May 2025

- **Cumulative GPA:** 3.76
- **Honors:** University of Washington Honor Society, Dean's List

Related Coursework:
Machine Learning, Deep Learning, Natural Language Processing, Autonomous Robotics, Artificial Intelligence, Algorithms, Hardware-Software Interface, Data Structures and Parallelism, Data Visualization, Theory of Computations, Software Design & Implementation

RESEARCH EXPERIENCE

Research Project on Supportive Data for In-Context Learning
Dr. Hannah Hajishirzi's H2 Lab, University of Washington (January 2024 – Current)

- Collaborating with Dr. Ben Bogin and Dr. Sarah Wiegreffe to investigate training data properties that enable large language models (LLMs) to learn in-context using data attribution techniques such as TRAK (Tracing with the Randomly-projected After Kernel)

Machine Learning Research Internship
Music Information Retrieval Lab, Harvey Mudd College (Summer 2023-Spring 2024)

- Conducted research on music and audio processing with Dr. Timothy J. Tsai, Associate Professor of Engineering and peers. Joint first author on a paper published in Transactions of the International Society for Music Information Retrieval (TISMIR).
- Paper citation: **Jain, A., Bunn, A., Pham, A., & Tsai, T. (2024).** PBSCR: The Piano Bootleg Score Composer Recognition Dataset. *arXiv*. https://arxiv.org/abs/2401.16803
- Presented findings at an international conference on the intersection of music and artificial intelligence at International Audio Laboratories in Erlangen, Germany. Our group then collaborated with Dr. Meinard Muller, and his PhD students on the findings.

I2 (Interactive Intelligence) Club
University of Washington (January 2022 - Present)

- Active member of a project-driven community focused on reinforcement learning, embodied AI, and neuroscience.
- Collaborated with different members on multiple AI research projects. One project explored the possibility of getting two independent models to communicate with each other using their own de novo language. Another involved developing a model to meta-learn a novel learning algorithm.
- Poster presentation of the results of first project at UW Research Symposium, Spring, 2022. Presentation was titled, *"Emergent Language: Independent AI Development of a Language-like Syntax."*

PROFESSIONAL EXPERIENCE

Teaching Assistant for Mathematics Department
University of Washington Mathematics Department (Fall 2024-Current)

- Instruct and help students in Ordinary Differential Equations Class. Assist professor as needed.

Software Engineering Internship
Engage, Health Information Technology Company (Summer 2020)

- Developed a Python program employing machine learning techniques, primarily matrix math applied to multivariate regression, to forecast hospital wait times.
- Link to actual hospital wait times my algorithm predicts: https://waittimes.inhs.org/Home?orgId=d175f125-360d-4321-a7b4-cbe0c27a706b_

Advanced Robotics at the University of Washington (ARUW)
(October 2021 - January 2022)

- Engaged in robot design, CAD modeling (SolidWorks), manufacturing, and 3D printing.

PROJECTS

In-Context Learning
(Current, H2 lab)

- Currently, investigating training data properties that enable large language models (LLMs) to learn in-context using data attribution techniques such as TRAK (Tracing with the Randomly-projected After Kernel).
- Identifying key characteristics in samples that are important to the development of ICL that could be illuminating for its mechanism. For instance, soft-copying (corresponding to the induction heads paper), parallel structure, burstiness, etc.
- Performing pretraining on models without this data to identify how important these samples are.

Emergent Language
(I2 Club Project)

- Co-designed and coded (Python) an AI system that develops a de novo symbolic language to communicate about a cooperative task. This project explores AI's potential for developing linguistic skills that are grounded to objects in an environment.

Neural Graphs
(2023)

- Invented and implemented Neural Graphs, a machine learning approach using Graph Neural Networks (GNNs) to implement a meta-learning algorithm. This approach can acquire and optimize novel learning algorithms, including well-known techniques such as backpropagation.

Music and Audio Processing Projects
(Summer 2023)

- Researched and completed two AI projects during Harvey Mudd College summer internship. The first project was creating a new dataset for a composer classification task. Various encoding schemes and architectures were tested, and their performances compared. These included: transformers with various levels of pretraining, vision transformers, CNNs, and RNNs.
- The second project involved cross-verifying audio clips of the same event to prevent tampering. We created a novel algorithm to do this based around the Hidden State Time Warping (HSTW) algorithm.

Reinforcement Learning Neural Graphs
(2023)

- A partner and I applied Neural Graphs project to a Reinforcement Learning (RL) context. Specifically, the Multi-Armed Bandit problem. We implemented a Neural Graph that learns a novel RL algorithm for this problem for a specific time horizon. It beat all

baselines for a given time horizon including epsilon greedy, UCB-1 and UCB-2. Was completed for final project in Deep Learning class.

Large Language Model Chess Project
(2023)

- A partner and I set out to determine the extent to which a LLM creates a "world model" when trained autoregressively. We trained an LLM autoregressively on PGN chess notation strings. We then probed the model to see if we could reconstruct the chess board given the model state. We found that we could not, which offers evidence that LLMs don't implicitly construct a "world model". This was completed for a final project in a Natural Language Processing course.

Skills

- **Programming Languages:** Python, Java
- **Frameworks/Tools:** TensorFlow, PyTorch
- **Technical Skills:** Data analysis, machine learning algorithms, CAD modeling, audio analysis
- **Mathematics:** Experience in problem solving, proofs, high-level mathematics areas such as linear algebra, linear optimization, real and complex analysis, topology, abstract algebra
- **Teaching:** Experience tutoring and teaching mathematics on college level

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Research Interests

Currently focused on understanding and improving machine reasoning capabilities and exploring how these insights can enhance individual lives and contribute to the greater good of humanity.

Statement of Purpose

Alec Bunn

In my exploration of the complexities of artificial intelligence, I am driven by fundamental questions: Can we understand how machines reason? If so, can we enhance their learning capabilities to make this process more efficient? If machines can fully develop these abilities, how can we best leverage these models for the benefit of humanity? Inspired by these inquiries, I have actively pursued research from multiple perspectives. I believe that meta-learning holds significant promise for developing more efficient learners, a concept I have explored through various course projects particularly in the context of Reinforcement Learning. I have a strong desire to continue to contribute to this exciting frontier of Artificial Intelligence (AI), where I aim to develop systems that can reason and learn with greater accuracy and efficiency. It is with this goal in mind that I am pursuing a PhD.

Research Projects. My curiosity and inquiry with Artificial Intelligence was fueled early in my collegiate career when I joined ***Interactive Intelligence*** (***I2)***, University of Washington's AI club. Soon after, a fellow club member and I began meeting and developing questions and ideas we wanted to explore together. Some of these questions revolved around our desire to have two independent models communicate with their own de novo language to solve a cooperative task. Despite challenges and setbacks, we persisted and succeeded in producing a focused example where two models successfully communicated with each other in a new language. We were then able to present this work in a poster presentation at the UW Research Symposium and from that we got ideas on ways to build on our work. More recently, we have been exploring meta-learning and are working on a project to develop a model to meta-learn a novel learning algorithm. This pursuit of efficient data learning remains a central theme to me, and one I hope to continue to pursue further in graduate school.

In the summer of 2023, I had the privilege of joining the ***Music Information Retrieval (MIR) Lab*** at Harvey Mudd College. As a research intern under Dr. Timothy Tsai, I joined a research team to study the impact of AI in the field of music. During the summer, I made significant contributions on projects involving music and audio processing. One of the projects focused on predicting the composer of a piece

of music based on its compositional style. Working with a team of 3 other students, we constructed a dataset of classical music data and trained CNN, RNN, and Transformer-based models using modern pretraining and fine-tuning practices. The project continued after the summer and well into the school year with testing new ideas and weekly virtual meetings with Professor Tsai to discuss and refine our work. We ended up producing a dataset that can be used for other music-related tasks such as training models for music classification or generation. I was a joint first author on the subsequent article that we published in *Transactions of the International Society for Music Information Retrieval (TISMIR)*. Dr. Tsai and his lab will continue to build on the work we accomplished. Near the end of the summer our research team visited and presented our research and results at the International Audio Laboratories in Erlangen, Germany, where we collaborated with Dr. Meinard Müller and his team of PhD students. It was a great experience to be able to present at the conference and collaborate with other researchers. Furthermore, this experience helped me realize my absolute passion for research. I loved working and collaborating with a team and grinding through the challenges of a problem and coming up with creative solutions. This experience solidified my desire to pursue further research goals and be involved in an academic environment.

Last year I began a research project with Dr. Ben Bogin and Dr. Sarah Wiegreffe, part of Dr. Hanna Hajishirzi's ***H2Lab***, at the University of Washington, investigating the aspects of training data that allow large language models (LLMs) to perform In-Context Learning (ICL). I am still working on the project and my work primarily involves using data attribution techniques, such as Tracing with the Randomly projected After Kernel (TRAK), to explore how specific data characteristics influence the acquisition of ICL. A few ideas for the mechanism of ICL have been proposed, however, the specific aspects of the data that cause ICL to develop in a model are not as well studied. In other words, the "how" is well understood but less so the "why" which is what intrigues me. I am interested in the specifics of ICL which is essentially another meta-learned algorithm, and I want to analyze what sort of algorithm it implements and if that idea can be generalized.

Future Work. All of my research opportunities as well as countless personally inspired projects have led me to the conclusion that graduate school is for me. I am an innately curious person and have

spent many hours trying to solve problems that I have encountered both on my own and through collaborating with friends and colleagues. I have a hunger to dive deeper into the field of AI and discover what exactly makes a machine able to reason and how these ideas and concepts can be applied to improve our individual lives as well as humanity as a whole. I am excited about the possibility of continuing my studies at Columbia. The work of Professor Daniel Hsu in the area of statistical machine learning and Professor Christos Papadimitriou on the mathematical foundations of machine learning align closely with my interests in machine reasoning. Additionally, the research environment at Columbia, with its strong emphasis on interdisciplinary collaboration, is the ideal setting for me to pursue my research goals. I am eager to embark on this journey into graduate study, where I can contribute to the advancement of machine reasoning and meta-learning.