MOTIVATION

I am captivated by the open challenges in machine learning that biology evolved to solve. Backpropagation can be inefficient due to global error signals while static architectures seem to lack the plasticity to prevent catastrophic forgetting. **I am motivated to research how integrating the principles of computation from biological substrates may reduce these limitations**.

SELECTED RESEARCH EXPERIENCES

My research with Drs. Hanna, Sala, and Berland has resulted in **eight first-author papers: five peer-reviewed publications in NeurIPS** workshops, one in NSF BRAID, and two preprints under review.

World Models for MARL. My research began with exploring bio-inspired multi-agent reinforcement learning (MARL), contributing to my team's **first-place finish at RoboCup**. We found that an emergent strategy, inspired by signaling in simple organisms, collapsed to 12.2% success. Pivoting to a **world-model based** approach improved to 96.5% success, revealing the value of an agent internally simulating the environment.

Active Inference & Structural Plasticity. I addressed the intractability of **active inference** by developing a novel approximation using principles from RL. **Dr. Levin invited me to extend this research under his mentorship**. Without a reward, the model maintained 82% success in Cart Pole, forming a step towards computable active inference.

Visual-Cortex Architecture. I led a team experimenting with primate visual cortex architectures for light field identification. We implemented biological features including **dual-stream processing and predictive coding**. The model achieved 74.4% accuracy, outperforming the next-best by 2.3 percentage points while being 2.5 times smaller, and demonstrated the value of inductive bias.

Industry Embodied AI. I **lead state estimation research** at an industry AI R&D lab. SOTA algorithms proved unsuited for our constrained hardware. This drove me to develop an algorithm reducing dimensionality by disentangling data manifolds. The algorithm achieved over 100x improvement in accuracy over SOTA. It is now deployed on all company robots.

WHY MICHIGAN TECHNOLOGICAL UNIVERSITY

I am fascinated by **Dr. An**'s research on neuromorphic embodied AI. I propose investigating a **social associative learning framework** that extends the single-agent Oja's rule in "Mimicking Associative Learning of Rats" into a distributed, swarm-based model. Drawing on my background in multi-agent reinforcement learning and swarm coordination, I would explore how aversive stimuli, such as the vibration detected by the LIMO platform, can trigger synaptic weight updates that propagate across a multi-agent network. This would allow agents to update their place cell representations and avoid hazards without direct physical exposure. By implementing shared spatial memory protocols on the lab's existing robots, I aim to determine if collaborative mapping can reduce convergence time and power consumption in SWaP-constrained exploration tasks.

Challenge of Isolation

Research neuroscience-inspired intelligent systems, **I overcame academic isolation**. Professors in AI told me researching applications of neuroscience for AI is uncommon. Noting I was the only engineer in his class, a neuroscience professor expressed a wish for research on building AI's neurons into hardware, independently envisioning neuromorphic computing, unheard of in his department.

Research Leadership and Mentoring

To create an interdisciplinary structure for this research at UW-Madison, **I founded and direct the Wisconsin Neuromorphic Computing and NeuroAI Lab**, securing formal funding, dedicated space, support from Dr. Akhilesh Jaiswal as advisor, and partnership with neuroAI startup FinalSpark. My role involves **mentoring 15 undergraduate researchers**, providing advice to over 100 researchers, developing research proposals, organizing biweekly workshops, and lecturing on topics like spike-timing-dependent plasticity drawing audiences of over 100 undergraduates, graduates, and professionals. At MTU, I aim to serve as a mentor in the SURF and URIP programs, guiding undergraduates through the challenges of interdisciplinary research.

How a PhD Fits My Career Goals

Researching in industry, my development process was one of empirical iteration. I realized a deeper understanding of underlying mathematical theory may yield more efficient solutions. While I have strong practical skills, **I am driven to gain the theoretical depth to more rigorously devise novel algorithms**. My long-term objective is conducting **research within a group like DeepMind's neuroscience lab**. Conversations with the current and previous lead, Drs. Kim Stachenfeld and Matthew Botvinick, solidified a PhD as the essential path to gain the theoretical depth and research freedom required. Receiving an **invitation from Dr. Karl Friston** to present my prospective doctoral research at his theoretical neurobiology group reinforced the value of a PhD for engaging with these ideas.