Nicole Sandra-Yaffa Dumont

Ph.D. Student

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Education

Ph.D in Computer Science

University of Waterloo

Sept 2019 – Present Waterloo, Canada

- Research in computational neuroscience (specifically, spatial cognition and reinforcement learning) under the supervisor of Chris Eliasmith (2019-2021) and Jeff Orchard (2021-present).
- Research into the neuroscience foundation of vector symbolic architectures (VSAs), a class of models that bridges the symbolic and neural/sub-symbolic levels of describing cognitive processes. My work draws inspiration from grid cells (specialized neurons used for memory and navigation) to represent continuous features using Spatial Semantic Pointers (SSPs), a novel VSA. A key feature of this approach is that SSPs can be bound with other features – both continuous and discrete – to create structured, hierarchical representations containing information from multiple domains (e.g. spatial, temporal, visual, conceptual).
- Building spiking neural network models of path integration and SLAM using SSPs.
- Developing biologically plausible, online learning rules for reinforcement learning in continuous time and space using SSPs and Legendre Memory Units (LMUs).
- Using SSPs & successor features for spatial navigation tasks in RL.
- Collaborating on a project to implement SSP Mutual Information Sampling, an algorithm for Bayesian Optimization.

Computational Mathematics (Masters of Mathematics – Co-operative Program)

University of Waterloo

Sept 2017 – April 2019 Waterloo, Canada

- Research on robust optimization of an asset pricing model used to price carbon emissions.

Honours Mathematics and Physics (Bachelors of Science)

McMaster University

Sept 2012 – April 2017 Hamilton, Canada

Research

Publications

- **Dumont, N.S.** & Eliasmith, C. *Accurate representation for spatial cognition using grid cells* in *42nd Annual Meeting of the Cognitive Science Society* (Cognitive Science Society, Toronto, ON, 2020), 2367–2373
- **Dumont, N.S.**, Stewart, T. C. & Eliasmith, C. *Spiking neural network model of simultaneous localization and mapping with Spatial Semantic Pointers* in *Computational and Systems Neuroscience (Cosyne) 2021* (Online, Feb. 2021)
- Voelker, A. R., Blouw, P., Choo, X., **Dumont, N.S.**, Stewart, T. C. & Eliasmith, C. Simulating and Predicting Dynamical Systems With Spatial Semantic Pointers. *Neural Computation* **33,** 2033–2067 (2021)
- Coleman, T. F., **Dumont, N.S.**, Li, W., Liu, W. & Rubtsov, A. Optimal Pricing of Climate Risk. *Computational Economics*, 1–34 (2021)
- **Dumont, N.S.**, Orchard, J. & Eliasmith, C. *A model of path integration that connects neural and symbolic representation* in *Proceedings of the Annual Meeting of the Cognitive Science Society* **44** (Cognitive Science Society, Toronto, ON, 2022)

Teaching

- **CS 371: Introduction to Computational Mathematics** is a rigorous introduction to numerical methods, covering Fourier methods to interpolation and more. I was the sole instructor for this course of over 120 students in Spring 2022. This involved preparing in-person and video lectures, assignments, and tests.

- **CS 245: Logic and Computation** introduces students to mathematical logic. I was a graduate Teaching Assistant and Instructional Apprentice for this course in 2019 and 2020. I prepared and led tutorials, graded assignments, and helped students during office hours.

Scholarships & Awards

- Go-Bell Scholarship (2019, 2020)
- Provost Doctoral Entrance Award for Women (2019)
- Keith & Debbie Geddes Graduate Scholarship (2019)
- The Emanuel Williams Scholarship in Physics (2014)

Professional experience

Research Associate

Cayuga Research

May 2018 – Aug 2019 | Waterloo, Canada

- Consulting work focused on the development and implementation of optimization methods and data driven solutions to industrial problems.
- Projects included development of a global optimization toolbox in Matlab, prototype flight path optimization software, and modelling for chiller plant optimization.

Summer Research Assistant

Ayers Research Group, Department of Chemistry & Chemical Biology, McMaster University

May 2015 – Aug 2015 | Hamilton, Canada

- Implemented a semi-definite optimization algorithm for constraining a density matrix to represent a quantum system.

Skills

Programming languages: Python, Matlab, and C++
DL and neuro-engineering frameworks: Nengo, Nengo SPA, PyTorch, Tensorflow

Academic Projects

Spiking neural network model of simultaneous localization and mapping with Spatial Semantic Pointers

Poster presentation; Cosyne 2021

- Proposed a biological-plausible SLAM model called SSP-SLAM that uses a hybrid oscillatory interference/ continuous attractor network of grid cells for path integration.

Successor Features for Transfer Learning in an Advantage Actor-Critic Framework

Course Project; CS 885: Reinforcement Learning

- Implemented an A2C model for reinforcement learning in pytorch that uses a new method for learning successor features called Generalized Successor Estimation.

Constructing Textual Artificial Conversational Entities using Deep Learning

Course Project; STAT 841: Statistical Learning - Classification

- Built a chatbot using a sequence-to-sequence model with long short-term memory (LSTM) units and an attention mechanism.

Dirichlet Mixture Model Library

Course Project; STAT 840: Computational Inference

- Developed a library in Julia (and an R package wrapper) using Dirichlet process mixture models to perform unsupervised, non-parametric clustering.

Hobbies and Interests

In my spare time, I enjoy getting creative with photography and painting, and camping on the Canadian shield.