Research project offer
CHU Sainte-Justine Research Center

Project title	Dendritic learning algorithms of the neocortex
Study level(s)	☒ MSc ☒ PhD
Principal investigator(s)	Eilif B. Muller, Ph.D.
Project duration	2 years (renewable)
Start date	As soon as possible

Date of posting: 2022-11-15

Research laboratory presentation

The research program being pursued by the Architectures of Biological Learning Lab (ABL-Lab) is an interdisciplinary one, aiming to expand the symbiotic relationship between state-of-the-art neuroscience and Artificial Intelligence (AI) theories to solve a fundamental mystery at the intersection of these two disciplines: How sensory perception is learned in the neocortex. Integrating the latest empirical advances in our understanding of the synaptic, dendritic and circuit physiology of the neocortex, the ABL-Lab leverages a synergy of biophysical simulations of neocortical circuits and functional deep convolutional networks to explore a radically new dendritic perspective on the processes of neocortical learning. The aim is to provide new inspiration to solve open problems in the field of deep learning, and a new conceptual foundation for understanding learning function and dysfunction in mammalian brains.

Research project description

This project, which is at the interface of Neuroscience and AI, will explore the hypothesis that dendritic non-linearities endow neurons with a powerful learning algorithm. We will employ simulations of neocortical pyramidal neurons with a calcium-based model of synaptic plasticity (see Chindemi et al., 2020) to characterize the rules governing plasticity outcomes under various correlated input conditions relevant for perceptual learning *in vivo*. In parallel, the hypothesized rules will be abstracted to their algorithmic essence and implemented in deep convolutional networks to explore their capacity to implement representation learning.

Required training and profile

The ideal candidate is a constructive team player with a keen interest and motivation to pursue research in the direction of the proposed topic, and excellent written and oral communication skills. Specific profile requirements include:

- Academic requirements, depending on the candidate's level :
  - <u>Master project</u>: undergraduate degree (BSc or equivalent) in neuroscience, computational neuroscience, computer science, mathematics, physics or related discipline for admission as a MSc student, with possibility for an accelerated transition to a PhD program (see respective program admission guidelines for details);
  - <u>PhD project</u>: master's degree (MSc or equivalent) in the above disciplines for admission as a PhD student (see respective program admission guidelines for details);

- One or more of the following expertise:
  - mathematical modeling of neurons, ion channels, and synapses;
  - convolutional networks, deep learning algorithms, self- and unsupervised learning;

- Two or more of the following experience:
  - Experience in scientific programming with Python (numpy, pandas, matplotlib);
  - Experience with the NEURON simulation environment;
  - Experience with a deep learning framework such as pytorch or tensorflow;
  - Experience with version control (git), Linux, shell scripting and use of high-performance computing resources.

Conditions

MSc or PhD candidates must apply for, and be admitted to the Université de Montréal in the MSc or PhD program (respectively) of either the Department of Neuroscience or the Department of Computer Science and Operations Research (DIRO).

Funding will be provided from Dr. Muller's research funds for one year, with a possibility for renewal. Trainees will be expected to apply for scholarships through CHU Sainte-Justine and the Université de Montréal, as well as from external sources.

The duration of the research project is conditional to:

- The availability of research funds;
- The progress of the project;
- The candidate's eligibility to maintain a status at the university (MSc or PhD).

Submit your application

Candidates should send the required documents to **Dr. Eilif Muller** at **eilif.muller@umontreal.ca**. Applications will be accepted until the position is filled.

Please provide:

√ *Curriculum vitæ*

√ Most recent official transcripts

√ Cover letter

√ References

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Equity, diversity and inclusion
The masculine gender is used without discrimination and for the sole purpose to facilitate reading. The CHU Sainte-Justine subscribes to the principle of equal access to opportunities and invites women, members of visible and ethnic minorities, persons with disabilities and Indigenous people to apply. We would appreciate it if you could inform us of any disabilities that would require technical and physical accommodation adapted to your situation during the selection process. Please be assured that we will treat this information as confidential.

Studies at the CHU Sainte-Justine Research Center
Pursue your graduate or postdoctoral studies at the **CHU Sainte-Justine Research Center**, and be one of the 500 students, fellows and interns involved in accelerating the development of knowledge in the field of maternal, child and adolescent health, whether in basic or clinical research. Under the supervision of prominent scientists, especially in leukemia, rare pediatric diseases, genetics, perinatology, obesity, neuropsychology and cognition, scoliosis and rehabilitation, you will have the opportunity to work with multidisciplinary scientific teams and collaborators from all over the world.

About the CHU Sainte-Justine Research Center
CHU Sainte-Justine Research Center is a leading mother-child research institution affiliated with Université de Montréal. It brings together more than 200 research investigators, including over 90 clinician-scientists, as well as 500 graduate and postgraduate students focused on finding innovative prevention means, faster and less invasive treatments, as well as personalized approaches to medicine. The Center is part of CHU Sainte-Justine, which is the largest mother-child center in Canada and the second most important pediatric center in North America. More on research.chusj.org