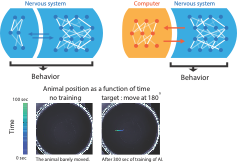
**Integrating Artificial Intelligence into Neural networks**

We ask how artificial intelligence (AI) systems can be integrated into the animal’s nervous system so as to open new avenues to gain a fundamental understanding of both neural and AI networks.

Replacing or augmenting neural circuits within an animal with A.I will allow us to explore the range of computational algorithms that AI employs to solve a behavioral task, directly compare biological and AI algorithms to solve the same behavioral task, determine whether AI networks trained on one animal can be transplanted into another to determine variability in the algorithms biological networks employ and learn how the artificial and biological networks interact with and adapt to each other to guide animal behavior.

Making AI networks function together with the animal’s nervous system to take over the function of a neural subcircuit is challenging. A key challenge is to determine the best suited unsupervised learning algorithms and the AI network architectures to rapidly learn from and integrate with neural circuits in an animal. This proposal aims to address this challenge using a combination of cutting-edge AI and control theory methods (in collaboration with Professor Na Li in SEAS) and neurobiology.

**Approach** We will employ the soil dwelling nematode C. elegans, with its small nervous system, as a test bed in which to validate our ideas. *C. elegans* is highly amenable to genetic modification and optical manipulation. With just 300 neurons and 6000 synapses the animal can execute sophisticated search programs to locate bacteria or mates, associatively learn to avoid or pursue biochemical targets, and trigger stress-resistant long-lived states in dire conditions.

We will develop autonomous AI networks which communicate with the nervous system of this animal’s through an optogenetics setup we have previously established. This set up will allow the AI network to directly control neural activity in the genetically modified animal with light. We will design a closed-loop system where artificial networks receive inputs from the animal in the form of images. Based on these images, the AI network will autonomously learn to control the spatiotemporal pattern of light to excite the nervous system of the animal. By doing so, the AI system will learn to replace damaged subcircuits within the nervous system of the animal and augment the nervous system to more efficiently drive animal behavior.

**(Top Left)** Nervous system of the animal **(top right)** where a subcircuit has been replaced by an AI network. **(Bottom Left)** Position of an animal as a function of time (time pseudo colored in blue) with an untrained AI network **(Bottom Right)** with a trained integrated AI network with a goal of making the animal move left (180 degrees)

**Impact** We will achieve (i) a fundamental understanding of how AI and real neural networks adapt and work with each other, (ii) by comparing the algorithms the AI network converges to with that of the biological network, we will understand how these two networks compare when required to perform the same task, (iii) Determine whether algorithms learned from one animal can be implemented in another, (iv) in the long term, help repair damaged nervous systems.