CARNEGIE MELLON UNIVERSITY
BME 2023 SPRING SEMINAR SERIES

Taming machine learning models of neural dynamics with anatomical and behavioral contraints

PRESENTED BY

Shreya Saxena
Assistant Professor
Electrical & Computer Engineering
University of Florida

SCHEDULE

Hall of Arts (HOA) 160

Tuesday,
February 21, 2023
(11:00AM-12:00PM)

Our ability to record large-scale neural and behavioral data has substantially improved in the last decade. However, the inference of quantitative dynamical models remains challenging due to their unconstrained nature. Here, we incorporate constraints from anatomy and physiology to tame machine learning models of neural activity and behavior. I will show that these constraints-based modeling approaches allow us to predictively understand the relationship between neural activity and behavior.

How does the motor cortex achieve generalizable and purposeful movements from the complex, nonlinear musculoskeletal system? I will present a deep reinforcement learning framework for training recurrent neural network controllers that act on anatomically accurate limb models such that they achieve desired movements. We apply this framework to kinematic and neural recordings made in macaques as they perform movements at different speeds. This framework for the control of the musculoskeletal system mimics biologically observed neural strategies and enables hypothesis generation for prediction and analysis of novel movements and neural strategies.

Modeling neural activity and behavior across different subjects and in a naturalistic setting remains a significant challenge. Widefield calcium imaging enable recordings of large-scale neural activity across the mouse dorsal cortex. Here, it is critical to demix the recordings into meaningful spatial and temporal components that can be mapped onto well-defined brain regions. To this end, we developed Localized semi-Nonnegative Matrix Factorization (LocaNMF) to extract and model the activity of different brain regions in individual mice. The decomposition obtained by LocaNMF results in interpretable components which are robust across subjects and experimental conditions. Moreover, we develop novel explainable AI methods for modeling continuously varying differences in behavior, which successfully represent distinct features of multi-subject and social behavior in an unsupervised manner. These methods are also successful at uncovering the relationships between recorded neural data and the ensuing behavior.

BIOMEDICAL
ENGINEERING
Carnegie Mellon University