MEMORANDUM

DATE: October 23, 2020

TO: Faculty and Students

FROM: Professor(s) Sharon Crook
Chair/Co-Chairs of Reuben “Vergil” Haynes
Defense for the PhD in Applied Mathematics
Committee Members Hans Dieter Armbruster
Richard Gerkin
Steven Baer
Yi Zhou

DEFENSE ANNOUNCEMENT

Candidate: Reuben “Vergil” Haynes
Defense Date: 11/04/2020
Defense Time: 10:30 AM
Virtual Meeting Link: https://asu.zoom.us/j/96367860084
Title: Understanding Cortical Neuron Dynamics through Simulation-based Applications of Machine Learning

Please share this information with colleagues and other students, especially those studying in similar fields. Faculty and students are encouraged to attend. The defending candidate will give a 40 minute talk, after which the committee members will ask questions. There may be time for questions from those in attendance. But, guests are primarily invited to attend as observers and will be excused when the committee begins its deliberations or if the committee wishes to question the candidate privately.

ABSTRACT
-See next page-
Abstract

It is increasingly common to see machine learning techniques applied in conjunction with computational modeling for data-driven research in neuroscience. Such applications include using machine learning for model development, particularly for optimization of parameters based on electrophysiological constraints. Alternatively, machine learning can be used to validate and enhance techniques for experimental data analysis or to analyze model simulation data in large-scale modeling studies, which is the approach I apply here.

I use simulations of biophysically-realistic cortical neuron models to supplement a common feature-based technique for analysis of electrophysiological signals. I leverage these simulated electrophysiological signals to perform feature selection that provides an improved method for neuron-type classification. Additionally, I validate an unsupervised approach that extends this improved feature selection to discover signatures associated with neuron morphologies. The result is a simulation-based discovery of the underlying synaptic conditions responsible for patterns of extracellular signatures that can be applied to understand both simulation and experimental data.

I also use unsupervised learning techniques to identify common channel mechanisms underlying electrophysiological behaviors of cortical neuron models. This work relies on an open-source database containing a large number of computational models for cortical neurons. I perform a quantitative data-driven analysis of these previously published ion channel and neuron models that uses information shared across models as opposed to information limited to individual models. The result is simulation-based discovery of model sub-types at two spatial scales which map functional relationships between activation/inactivation properties of channel family model sub-types to electrophysiological properties of cortical neuron model sub-types. Further, the combination of unsupervised learning techniques and parameter visualizations serve to integrate characterizations of model electrophysiological behavior across scales.