Math 583 Topics in Applied Mathematics:
Modern brain-inspired computing with neural dynamics

M/W/F, 2:10-3:00pm
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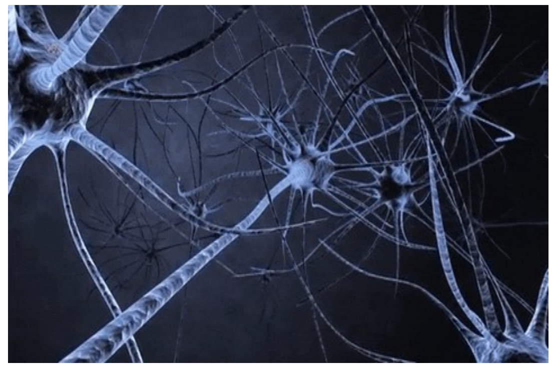

We are at the crossroads of powerful currents in science and technology, spurred by recent advances in both neuroscience research, and neuromorphic engineering. A recent focus on brain studies has produced a wealth of new, multi-modal structural and functional neural data. At the same time, advances in electronics and the search for unconventional computational paradigms led to the creation of neuromorphic systems like Intel's *Loihi*, IBM's TrueNorth, and the European SpiNNaker and BrainScaleS. There is a natural match between *in silico* realizations of data-based neuronal models produced by the neuroscience research endeavor, and the neuromorphic hardware abstractions forming the foundation of current and future neuromorphic chips. There is also a new paradigm in computing abstractions, possibly advancing beyond the von Neumann paradigm, and through Moore's scaling growth law. As with the original development of computing in the 1940-s and 50-s, tools from Applied Mathematics will play central role in this research program.

This course has two goals. First, for students to learn some of the mathematical and computational tools used for the modeling of biological neural systems. We will focus in particular on spiking neurons and neural networks. Second, for students will gain experience with modern applications of engineered neuromorphic systems based on such neural models to Machine Learning and Artificial Intelligence. As part of those goals, students will also learn some of the basic properties of biological neural systems, from single neurons to learning networks, and mathematical tools for analysis and neuromorphic programming.

Computational neuroscience applies multiple aspects of mathematics and computing to the modeling of a really complex system: the brain. As such it allows for students with different backgrounds to engage successfully in it, typically in small teams. Currently there are two main tracks through which students can be successful in this course. A math-intensive track for students with deeper math background (math, physics, some EE, ME and CS), who will engage deeper with the math analysis, and gain some programming expertise through the course. Alternatively, a solid foundation in CS, with interest in Machine Learning (majors in CS, some EE, some stat) can provide a successful path through this course, with a bigger focus on coding, both in simulators and in neuromorphic hardware. *Note that we will not be doing much with deep nets, except as a tool.* Basic experience in biology (e.g. Biol 107, or Neuro 138) and the physics of electricity (e.g. Phys 202) is recommended. As is willingness to learn more in domains where you have less experience (math, CS, neuroscience, pick what is missing). If unsure whether your background would help you succeed in this course, contact the instructor.