Applications of Statistical Modeling in Cognitive Neuroscience

Kensuke Arai

Department of Mathematics and Statistics, Boston University

February 19, 2019

Abstract: The brain is made up of billions of neurons connected to each other through trillions of synapses that transmit spikes from one neuron to another. Brain function arises from the coordinated activity of a large number of neurons. Attempts to understand the neural code requires the analysis of spike trains - the discrete, sparse, stereotyped pulses emitted by neurons from the brains of awake, behaving and learning animals. However, the properties of spike trains dynamically change during an experiment, and brain signals are noisy and often more variable than expected given the controlled conditions in experiments, likely reflecting uncontrollable dynamic internal processes like changing motivation or learning. Statistical models that capture the various components of variability allow study of the dynamics of cognition and learning, and have wide applicability not only in neuroscience, but generally to signals arising from complex systems with uncontrolled and unobserved degrees of freedom. The universe is composed almost entirely of ionized gas a.k.a. plasma, where the dynamics of space plasmas is governed by the interaction between the plasma and magnetic fields in space. Developing computer models to study plasma dynamics is challenging since plasma dynamics involves extremely complicated physics, which includes many physical processes operating together, and a strong coupling between large and small scales. I will briefly describe the basics of computational plasma physics and its applications to solar and space physics, astrophysics, and extrasolar planets.