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Decoding Neural Population Dynamics Through Latent Factor Models

The human brain contains some hundred billion nerve cells (a.k.a. neurons) which communicate through electrochemical waves called spikes. A sequence of consecutive spikes from a neuron is called a spike train, which encode information about firing rates. Over the past few decades, mathematical and statistical models for neuronal activities have played an important role in helping neuroscientists shed light on neuroscientific phenomena such as the interactions among multiple neurons over time. However, scalability and interpretability of these models are still a challenge in computational/theoretical neuroscience. We present a novel latent factor model for studying the spike train interactions of multiple neurons recorded simultaneously. In the proposed model, the activities of the neuron population are described by correlated Wiener processes, which themselves depend on a small number of latent factors determining the neuronal clustering. We demonstrate how to tackle the computational challenges of high dimensional integration of latent variables and large matrix inversions. We show that our model is highly scalable and can accurately recover neuronal clusters when applied on simulated data. Finally, we apply our model to a set of experimental data obtained from rats' medial prefrontal cortex.