Poster Presentation

Gaussian-process factor analysis for low-d single-trial analysis of neural population activity

Byron Yu, John Cunningham, Gopal Santhanam, Stephen Ryu, Krishna Shenoy and Maneesh Sahani

Neural responses are typically studied by averaging noisy spiking activity across multiple trials to obtain firing rates that vary smoothly over time. However, particularly in cognitive tasks (such as decision making or motor planning), the timecourse of the neural responses may differ on nominally identical trials. In such settings, it is critical that the neural data not be averaged across trials, but instead be analyzed on a trial-by-trial basis (Churchland et al., Curr Opin Neurobiol, 2007). With the ability to record simultaneously from a neural population (currently tens to hundreds of neurons in awake behaving primates), we consider techniques for extracting a smooth low-dimensional "neural trajectory" summarizing the recorded activity on a single trial. Beyond the benefit of visualizing the high-dimensional noisy spiking activity in a compact denoised form, such trajectories can offer insight into the dynamics of the underlying neural circuitry.

One way to extract a neural trajectory is to first estimate a smooth firing rate profile for each neuron on a single trial (e.g., by convolving each spike train with a Gaussian kernel), then apply a static dimensionality reduction technique (e.g., principal components analysis, PCA, or factor analysis, FA). We developed a novel alternative approach, Gaussian process factor analysis (GPFA), which performs the smoothing and dimensionality reduction operations simultaneously rather than serially. This allows the degree of smoothness and the relationship between the low-dimensional "neural trajectory" and high-dimensional recorded activity to be jointly optimized.

We applied these techniques to the activity of 61 neurons recorded simultaneously in macaque premotor cortex during a center-out delayed reaching task. To evaluate model goodness-of-fit, we left out one unit at a time and asked how well each technique could predict the activity of that unit, given the activity of all other recorded units. Our findings are as follows: (1) GPFA yielded the lowest prediction error, followed by FA and PCA. (2) The dimensionality of the linear subspace within which the recorded neural activity evolved during reach planning and execution for a single target ranged from 8 to 12. (3) For each of the 14 reach targets, the extracted low-dimensional neural trajectories converged during the delay period, an effect which previously could only be inferred indirectly (Churchland et al., J Neurosci, 2006). By studying trials with outlying reaction times, we

also find that such methods can be a powerful tool for relating the spiking activity across a neural population to the subject's behavior on a single-trial basis.

Conference: Computational and systems neuroscience. Salt Lake City, UT, USA, February 26 - March 03, 2009.

Citation: Yu B, Cunningham J, Santhanam G, Ryu S, Shenoy K and Sahani M (2009). Gaussian-process factor analysis for low-d single-trial analysis of neural population activity. *Frontiers in Systems Neuroscience. Conference Abstract: Computational and systems neuroscience*. doi: 10.3389/conf.neuro.06.2009.03.153

***Correspondence:** Byron Yu, byronyu@stanford.edu

Prev Next