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Title:	Multiscale compressed sensing of neuronal response properties for brain machine interfaces
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Estimation of the response properties of cortical neurons from within a recorded population is an essential component in a cortically-controlled brain machine interface application. The response properties of interest typically include precise spike timing, mean firing rate and any inherent correlation in the activity of the recorded ensemble. The notion of multiscale neuronal response properties results from the timing precision being the encoding of information on a very short timescale, for e.g. when synchrony in the population plays an active role in the encoding process, while firing rate estimation takes place on a significantly larger timescale to assess individual cells' tuning properties. It is believed that these properties constitute the fundamental elements of cortical population coding.
We have previously demonstrated the effectiveness of multiscale wavelet-based methods at performing the high levels of compression necessary to overcome communication bandwidth limitations of an intra-cortical implanted device. In this thesis, we demonstrate the utility of the multiscale representation in estimating both spike precise timing and instantaneous firing rate directly from the recorded non-binary spike waveforms (i.e. pre spike sorting). Furthermore, we demonstrate our ability to identify clusters of functionally interdependent neurons from their spike trains (i.e. post spike sorting). The later is an important step in recognizing the topology of neural circuits distributed across multiple motor areas that are momentarily configured to process and store information during movement planning and execution.
The performance is assessed with data synthesized using a probabilistic point process model mimicking cortical population encoding of a 2D arm trajectory. The firing probability of each neuron is based on its own spiking history and those of other neurons connected to it in which auto-inhibition, cross-inhibition, and excitatory synaptic interactions are considered. Maximum accuracy is achieved with neuronal elements and at time scales matching the simulated network spatiotemporal properties. We demonstrate the performance under two types of cortical plasticity (structural and functional) typically encountered during learning and behavior. In a neuro-motor prosthesis, the approach can be very useful to first identify functional connectivity between neuronal elements exhibiting variable response latencies and degrees of participation in encoding movement parameters before actual decoding takes place. Current work aims at applying the algorithm to experimental recordings in two motor areas of awake behaving rats.

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