INTEGRATED NEURAL SYSTEMS AND ALGORITHMS FOR ANALYSIS OF POPULATION ACTIVITY DURING DEXTEROUS HAND MOVEMENTS

by

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Abstract

Everyday hand movements require the collective activation of thousands of neurons in the motor cortex. Understanding how the brain encodes these movements can hold tremendous implications for neural control of external devices as well as for treating motor disabilities. Traditionally, motor movement studies have been performed by recording spiking activity from a small motor cortical area from an animal subject confined in a small workspace. Consequently, this thesis is partly aimed at understanding the information content of all neural signals during dexterous hand movements over a large M1 territory, and partly aimed at developing technology needed to enable such studies in freely moving animals.

I studied the modulation of neural activity over a large volume in M1 during hand movements. I showed that spiking and 100-170 Hz LFP power from shallow recording sites in M1 could decode reach to grasp movements better than deeper sites. On the other hand, I showed that LFP amplitude and LFP power in the 1-4 Hz band have similar grasp type information across M1 volume. Consequently, I built models to predict the hand kinematics from neural data in motor cortex. Most joint angles and few of the principal components (PC) of joint movements could be predicted with correlations as high as 0.8 using spike or 100-170 Hz LFP power features. I also observed that prediction of PCs was not a direct function of PC variance. It was also possible to reliably reconstruct the hand kinematic data from only the first seven PCs of the movements.

As mentioned earlier, true studies of motor movements require neural recording from freelymoving animals. Hence, I developed a wirelessmultichannel headmounted recording system to answer this unmet need. I first designed a multichannel CMOS circuit with programmable bandwidth, gain and ADC resolution settings, for recording multiple neural

signal modalities. I showed that system has better noise versus power performance relative to its predecessors, achieving a NEF of less than 3. Finally, I developed a head-mounted neural recording system using the VLSI circuit and showed that we can wirelessly record electrocorticographic signals in a primate performing motor movements.