an approximation of the full dynamics which becomes exact in the limit of small population activity and/or weak refractoriness. This approximation allows us to derive an expression for encoding and decoding time-dependent stimulus in the population activity. In like manner, we derive an expression for the linear filter which shows how high-pass and band-pass properties can arise from distinct shapes of the spike after-potential. In all cases the approximation matches very well with direct simulations of large neuronal populations. An analytical expression can shed light onto previously obscure processes. Here we discover that the decoding of a population of weakly active neurons only requires two quantities: i) the instantaneous population activity and ii) an accumulation of the past history weighted by a factor that relates to the effective spike after-potential. The results presented here can be used to make mean-field theory models of neuron networks closer to experimental observations.

III-39. Improving neural control of a simulated arm by decoding intended future movement

Francis R Willett[1] FWILLETT@UCHICAGO.EDU
Aaron Suminski[1] ASUMINSKI@UCHICAGO.EDU
Andrew Fagg[2] FAGG@CS.OU.EDU
Nicholas Hatsopoulos[1] NICHO@UCHICAGO.EDU

[1]University of Chicago
[2]University of Oklahoma

A brain-machine interface (BMI) records neural signals in real time from a subject's brain, interprets them as motor commands, and reroutes them to a device (e.g., a computer cursor or prosthetic arm) in order to restore the subject's lost motor function. Typically, a BMI that enables the control of a prosthetic arm decodes an intended hand position or velocity from the subject and uses a controller to generate joint torques to drive the arm accordingly. Previous studies taking this approach have chosen to decode the subject's desired arm state in the present moment and to use it as the command signal. However, this approach causes the prosthetic arm to lag behind the state desired by the user, as the dynamics of the arm constrain how quickly the controller can bring the arm's state in accordance with the commanded state. If the command signal is smoothed, by filtering the neural data or the signal itself, the arm will lag further behind the user's intent. To compensate for delay introduced by the controller and/or smoothing, we used a regularized Weiner filter to decode a subject's intended hand position in the future at a time lead equal to the known system delay, and used this value as the command signal. In our experiment, a monkey (Macaca mulatta) used a BMI implementing this approach to control a simulated arm to hit targets on a screen. Results from experiments with two BMIs with different system delays (100 and 200 milliseconds) show that the monkey can make significantly straighter and faster movements when the decoder predictively compensates for the delay. By varying the time by which we decode into the future, we also show that performance peaks near the time of the known system delay and degrades otherwise.

III-40. Long-term Decoding Stability without Retraining for Intracortical Brain Computer Interface

William Bishop[1] WBISHOP@CS.CMU.EDU
Cynthia A Chestek[2] CINDYC@STANFORD.EDU
Vikash Gilja[2] GILJA@STANFORD.EDU
Paul Nuyujukian[2] PAUL@NPL.STANFORD.EDU
Stephen Ryu[2] SEOULMAN@STANFORD.EDU
Krishna Shenoy[2] SHENOY@STANFORD.EDU
Byron Yu[1] BYRONYU@CMU.EDU

[1]Carnegie Mellon University
[2]Stanford University

Most current intracortical brain computer interface (BCI) systems rely on daily retraining. While this is feasible in a lab, it is not clear the burden of daily retraining will be viable in the clinic. We therefore sought to investigate the long-term stability of an intracortical BCI system without retraining. We recorded neural activity using a 96-electrode array implanted in the motor cortex of a rhesus macaque performing center-out reaches in 7 directions over 41 sessions spanning 48 days. One simple way to avoid retraining is to hold the decoder static from day to day. As expected, we found that when decoding reach direction based on threshold crossings collected during arm movement, the performance of such a static decoder was diminished compared to one which was retrained daily. However, we found no significant decline in performance across time for this decoder, though variability (standard deviation) from day to day was large. We then considered a second static model which allowed for a greater dispersion of spike counts than the standard method. Mean decoding performance increased from 59.4% to 70.0% while the standard deviation of day-to-day performance decreased from 12.1% to 7.9%. While these results must be reproduced in a closed-loop setting, we believe such insights into the role of decoder training will be important for the clinical translation of BCI systems.

III-41. An objective approach to learning movement-related features from local field potentials

Kelvin So SOKELVIN@EECS.BERKELEY.EDU
Michael Gastpar GASTPAR@EECS.BERKELEY.EDU
Jose Carmena CARMENA@EECS.BERKELEY.EDU
University of California, Berkeley

Past studies have shown that local field potentials (LFP) in the primary motor cortex (M1) encode information related to movement, enabling the possibility of using LFP as a control signal for brain-machine interfaces (BMI). A recent approach to incorporating LFP for BMI focused on the power of specific low frequency bands (0-10Hz and 20-40Hz), which are known to be modulated during movement execution. Conversely, Rickert et al. found multiple other frequency bands ($<$4, 6-13, 63-200Hz) that contain direction related information. Given the wide range of frequencies that appear to contain movement information, it is unclear how to determine the features most relevant to movement from all these frequency bands. Here, we present a novel approach to extracting features from LFP that are well modulated by movement. Specifically, this method searches for an optimal projection of the LFP that maximizes the variance of the activity across different movement directions, while minimizing the variance of the activity during movements in the same direction. This method objectively determines features in the LFP that differentiate between movement directions, instead of relying on a priori assumptions about particular LFP frequency bands. The learned features capture the aspect of the LFP that changes with movement direction but is consistent during movements in the same direction. Our results obtained from LFP recordings in M1 of macaque monkeys performing center-out reaching indicate that these features reflect contributions from the 0-40Hz and 120-200Hz bands of the LFP. Lastly, we demonstrate that these features can provide high accuracy in predicting hand position during movement with a correlation coefficient of 0.7.

III-42. Synaptic input correlations and membrane potential decorrelation in spontaneous cortical activity

Michael Graupner MICHAEL.GRAUPNER@NYU.EDU
Alex D Reyes REYES@CNS.NYU.EDU
New York University

Spiking correlations between neurons have been found in many regions of the cortex and under multiple ex-