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Presentation Abstract

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Title:	Quantifying and addressing the impact of spike waveform instability on neural prosthetics
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Abstract:

Neural prosthetics is a rapidly growing field with the potential to provide quality of life improvements to patients with a wide range of conditions, as demonstrated in a recent proof of concept system used by human patients (Hochberg et. al., Nature, 2006). These systems decode the user's intent from spike times. Spike times are extracted using spike sorting methods on signals recorded from electrode arrays implanted in cortex. The spike sorting and decoding methods used to date assume that recorded signals characteristics remain constant over time. However, significant changes in waveform shapes have been observed in freely behaving rhesus macaques (Santhanam et. al., IEEE TBME, 2007). These changes can degrade system performance, but the scale of this effect has yet to be quantified.

Towards this end, we trained a rhesus macaque, L, to perform center-out reaches while we record from a 96-channel electrode array (Blackrock Microsystems, Salt Lake City, UT) implanted in dorsal premotor cortex (PMd). This experiment was conducted daily for 7 weeks. Between experiments, 20 channels of wireless neural data were recorded (in 2 week blocks on different subsets of 96 channels) to track waveforms continuously day and night using the head-mounted HermesC system (Chestek et. al., IEEE TNSRE, 2009).

In data from the reaching task, we saw changes in waveform amplitude of 1

μV/min or 0.3%/min on average and up to 5 μV/min. Over the course of an hour, the amplitude of some units remained virtually unchanged, while others changed by over 20% (over 100 μV/hour). Between consecutive days, more dramatic changes were seen with large waveforms disappearing or emerging. To quantify the impact of these changes on prosthetic performance, we fixed spike sorter and decoder parameters on day one, and measured offline decoder performance across 7 weeks. In this analysis we observe a drop in performance for both discrete naïve Bayes decoding of reach end point and continuous linear decoding of reach trajectory. For discrete decoding on a 1 of 7 target selection task, performance on day one is 82% correct. By day 5, performance drops to 68% and for the remaining weeks fluctuates between this value and chance (14.3%).
We have previously reported that a spike sorter that takes into account behavioral information can reduce decode misclassification rates (Gilja et. al., SFN, 2007). In future work we will extend this model to allow for parameter drift and for the addition and deletion of neurons over time. By quantifying and addressing the effects of signal acquisition instability, we hope to increase the clinical viability of neural prosthetics by sustaining performance without frequent recalibration.

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SPIKE SORTING

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