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Presentation Abstract

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Title:	Generalization and robustness of a continuous cortically-controlled prosthesis enabled by feedback control design
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Abstract: Brain-machine interfaces (BMIs) translate neural signals into useful control signals. Using the algorithmic advances discussed in Gilja et al. (SFN 2010), we describe here our attempt to systematically test the performance and robustness of this BMI on two rhesus macaques, as well as to generalize the behavioral tasks beyond the center-out task. Monkeys were implanted with 96 channel electrode arrays, and experiments were carried out 19-27 (4-8) months post implantation for monkey L (monkey J). To control for inter-day variations in array or monkey performance, experiments were carried out intra-day in an A-B-A block design, thereby directly assessing the difference between various algorithms and modes of control. All decodes were performed with one 96 channel electrode array per animal (PMd in monkey L; M1 in monkey J), using neural threshold crossings set

at -4.5×RMS without spike sorting at the beginning of each experimental day. Using a standard Kalman filter without any of the new algorithmic advances, when monkey L was first switched into BMI control, two weeks of training were required before 4 cm targets could be acquired and held for 500 ms on an 8 cm center-out task. However, using our algorithmic advances, training appears considerably streamlined and high performance was achieved on the first day with monkey J.
Using this BMI on the same center-out task, monkey L had a mean target acquire time (and success rate) of 671 ms (96%) vs 543 ms (100%) for hand. Enforcing a maximum 1000 ms acquire time during BMI control improved mean target acquire time (618 ms) but decreased success rate (87%). This was 86% the performance of hand control and was repeatable with similar results over a span of six months.
On a more generalized "pinball" task, 4 cm targets appeared randomly in a 16x16 cm workspace with a 500 ms hold time. Using the BMI, monkey L achieved 54% the performance of hand control, the BMI at 722 ms (99%) vs hand at 496 ms (98%). This performance could be maintained for nearly two hours under BMI control, matching the duration of the longest hand-controlled sessions.
On a more complex, obstacle avoidance task, monkey J was trained to acquire 6 cm targets while avoiding an intervening visual barrier. Monkey J successfully navigated around the obstacle by instructing a curved trajectory and acquired targets 60% of the time with the BMI vs 62% of the time with hand control. BMI performance was 63% that of hand, the acquire time of BMI at 1219 ms vs hand at 889 ms.
We believe this new feedback-control design substantially increases the performance, robustness, and generalization of BMIs and may help bring BMIs closer to clinical viability.

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