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Presentation Abstract

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| Title: | A high-performance continuous cortically-controlled prosthesis enabled by feedback control design |
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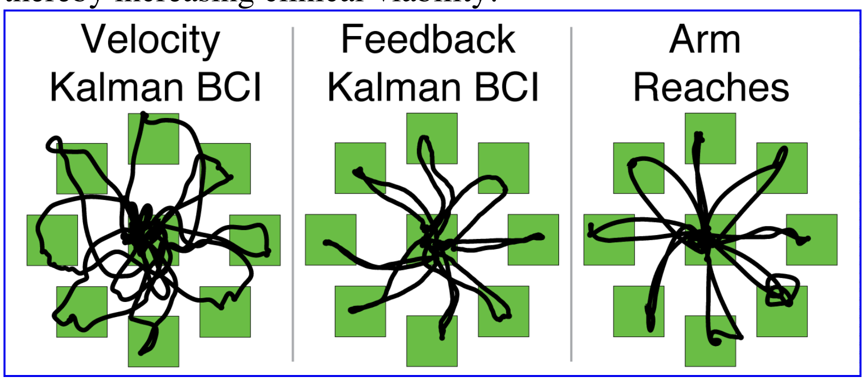
Authors: ***V. GILJA**[1], P. NUYUJUKIAN[2,3], C. A. CHESTEK[4], J. P. CUNNINGHAM[4,6], B. M. YU[4,7,5,8], S. I. RYU[4,9], K. V. SHENOY[4,2,5];
[1]Computer Sci. Dept., [2]Biomed. Engin. Dept., [3]Med. Sch., [4]Electrical Engin. Dept., [5]Neurosci. Program, Stanford Univ., Stanford, CA; [6]Engin. Dept., Cambridge Univ., Cambridge, United Kingdom; [7]ECE Dept. and BME Dept., Carnegie Mellon Univ., Pittsburgh, PA; [8]Gatsby Computat. Neurosci. Unit, Univ. Col. London, London, United Kingdom; [9]Palo Alto Med. Fndn., Palo Alto, CA

Abstract: Neural prostheses, or brain-machine interfaces (BMIs), translate neural signals to guide an actuator or computer cursor. Although current demonstrations provide a compelling proof-of-concept, limited performance impedes clinical viability. BMIs can be viewed from a feedback control perspective (see Cunningham et al, SFN 2010): the brain is the controller of a new plant defined by the BMI. This perspective leads us to two advances that significantly improve qualitative & quantitative performance.
We modify the Kalman filter commonly used in BMI literature (e.g. Kim et al, 2008). In the first advance, during training, we fit neural data to a presumption of the desired volitional control signal, instead of observed or instructed kinematics. In the second advance, we develop the feedback Kalman filter, whose observation model incorporates cursor position as feedback.

Performance was tested in closed loop with two rhesus macaques. On each trial, the monkey acquired a 2D target in an allotted time period with a cursor, controlled by the native contralateral limb or BMI. Neural data were recorded from a 96-electrode array (Blackrock) spanning PMd & M1. All experiments used spike counts found by -4.5×RMS threshold detection without spike sorting (see Chestek et al, SFN 2010). Such a system has clinical appeal, particularly for arrays with potentially decreased SNR (monkeys L & J were 19-27 & 4-8 months post-implantation, respectively).

During online tests, the new BMI appears more controllable, producing straighter reaches & crisper stops, as shown in the figure of monkey L's continuous cursor traces. Relative to a standard Kalman filter, mean time to target (& failure rate) is reduced from 1323 ± 686ms (20%) to 993 ± 364ms (1%) in the same center out & back session. Further bin width & model training optimizations reduce this time to 600-700ms for both L & J, approaching arm reach times of 550-650ms. These innovations, supported by extensive experimental verification & design studies (see Nuyujukian et al, SFN 2010), offer a significant performance advance, thereby increasing clinical viability.

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