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Toward Human Cortical Prostheses: Addressing the Performance Barrier to Clinical Reality

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INTRODUCTION: Proof-of-concept systems exist for direct brain-controlled prosthetic systems that could assist paralyzed patients. However, no existing system yet demonstrates the performance, durability, and safety needed for a practical system. Unless these are addressed, we believe it is unclear whether such systems will become a clinical reality. We present our latest data for intracortical electrode array-based prosthetic systems that demonstrate considerably increased performance, a better understanding of prosthetic system design principles, and longer term usability of neural signals.

METHODS: Two Rhesus monkeys were implanted with 96-electrode silicon microarrays in the dorsal premotor cortex (PMd). They were trained to reach in 2-D space to presented targets for reward. Neural activity was simultaneously recorded and mapped to inferences of the animal's movement intention, using a new feedback control perspective, generating decode algorithms. These algorithms were then used to predict arm reaches based on neural activity alone.

RESULTS: With the latest algorithm (Kalman filter modified with a feedback-control perspective), we are able to demonstrate the highest level of prosthetic decode speed and accuracy, to our knowledge, across any source of neural information. This performance is on par with that of a human controlled computer mouse. Importantly, in one of the two monkeys, the array had been implanted for over 2 years when these experiments were performed (using threshold crossings); this indicates that multi-year high-performance prostheses are possible with intracortical arrays.

CONCLUSION: Our latest intracortical electrode array-based prosthetic systems demonstrate performance far beyond any other currently reported prosthetic system. With newer algorithms and a better understanding of real world design issues, this performance suggests translation to a useful prostheses may yet be a tangible possibility.