Toward High-Performance Cortically-Controlled Motor Prostheses

In recent years, cortically-controlled prostheses – which translate action potentials from neurons in the motor cortices into control signals for guiding computer cursors and robotic arms – have demonstrated considerable potential through a series of proof-of-concept laboratory animal experiments as well as an initial human clinical trial. While encouraging, several potential barriers remain which, if left unaddressed, may hamper the translation of these systems into widespread clinical use. First, an array of electrodes implanted in cortex (of rhesus monkeys, or humans) typically provides action potentials from highly-distinguishable single neurons for just a year or two, and even while working well the recorded signals grow and shrink on both slow (e.g., diurnal cycle) and fast (e.g., head movement) timescales. Second, the speed and accuracy of cortically-controlled computer cursor and robotic arm movements is much slower and less accurate than that of the natural arm. Third, the performance of cortically-controlled prosthetic devices has yet to achieve a level of robustness – the capability of running for hours straight, working seamlessly across days, and working across multiple behavioral contexts without human technical intervention – necessary for widespread clinical use. To address these three potential barriers, we conducted experiments with two rhesus monkeys with a 96-electrode array implanted in PMd/M1 and found that (1) threshold crossing detection provides high signal quality for many years, and with low fluctuation, (2) a continuous-decode algorithm redesigned (using a feedback control perspective) can provide cortical-cursor control on par with typical computer-mouse control, and (3) multi-hour, multi-day, and multi-context operation is readily possible.