Brain Machine Interfaces—The Era of Avatar

Yiwen Wang

Departments of Electronic and Computer Engineering, and Chemical and Biological Engineering

Email: eewangyw@ust.hk

Abstract:

A fundamental aspect of biological behavior is the ability to learn and to adapt to the environment. The brain has developed remarkable mechanisms to achieve this ability. As part of the overall effort to permit the brain to control neuroprosthetic devices via brain-machine interfaces (BMI), it is critical to model and or recreate such adaptive mechanisms. Classic BMI approaches 'decode' patterns of neural signals from the brain responsible for achieving specific motor movements; these 'codes' are subsequently used to command similar movements in prosthetic devices (e.g. a prosthetic limb). However, such approaches (static neural tuning models) have been limited by fixed codes, resulting in a decay of decoding performance over the course of the trials and across days and subsequent instability in motor performance.

To achieve stable performance, reinforcement learning based technique is developed to cope with the day-to-day neural population variability with more efficiency in exploring the high dimensional neural-state action space. To further model and shape the plasticity of individual neural tuning, we propose to decode the non-stationary tuning property (either gradually-changing or abruptly changing) directly from the spike timing structure in a computational manner, which consequently contributes to the stable BMI performance.

To test this approach, we used multi-channel neural spike trains from the primary motor cortex of adult monkeys trained to perform movement tasks using a joystick. Our results show that our computational approach successfully tracks neural tuning curves over time with better goodness-of-fit than classic static neural tuning models. Our estimation of kinematics results in smaller errors between desired kinematics and in vivo data. Our novel decoding approach suggests that the brain may employ such strategies to achieve stable motor output and that plasticity of neural tuning is essential for non-stationary, adaptive neural systems. Moreover, BMI users may benefit from this adaptive algorithm to achieve more complex and controlled movement outcomes.