Adaptive Decoding of Eye Movements with Simple Recurrent Artificial Neural Networks

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Abstract

A primary concern for brain-machine interfaces (BMI) is the development of adaptive online decoding algorithms that account for co-learning between the brain and the machine. As the brain learns a task, neural plasticity alters activity patterns; concurrently, decoding algorithms must both adapt to the new patterns and improve performance. We used a simple recurrent artificial neural network (RANN) to test the feasibility of online, adaptive decoding of eye movements from prefrontal cortex (PFC), frontal eye field (FEF), and supplementary eye field (SEF) recordings of a macaque during a 6-choice delayed saccade task. Three consecutive days of data were used for this offline analysis. Whole day training was performed separately on the 1st and 2nd days to create models of the RANN, which were then used on the 2nd and 3rd days, respectively, as bases for online learning. Two days of adaptive online decoding were then simulated by updating the RANN models after each sequential trial of the test data. Late online performance of the RANN models was qualitatively similar to the results obtained from linear discriminant analysis (LDA; 75-80% correct). Asymptotic performance during online learning was achieved within ~100 trials—significantly fewer than the 500 training trials required to build the daily LDA model. We found that use of the RANN: 1) could feasibly be used in online, adaptive decoding, 2) potentially reduces or eliminates the need for training trials in brain-machine interfaces, and 3) may reduce the need for an onsite expert for BMI calibration.