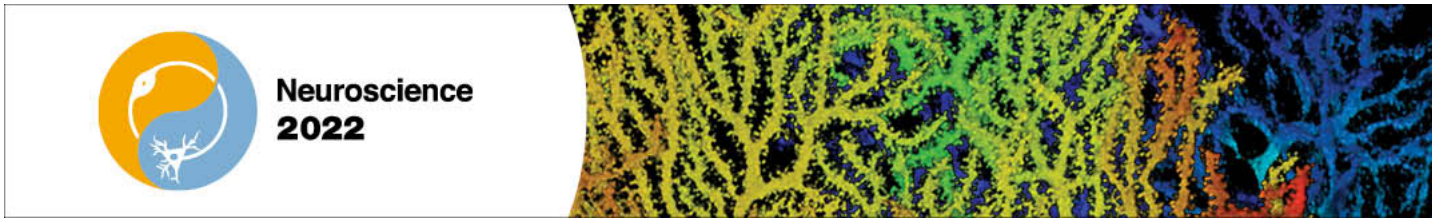

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Tracking Nonstationarity in Multi-Day Intracortical Neural Recordings During iBCI Cursor Control by a Person with Tetraplegia

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Abstract:
Intracortical brain-computer interfaces (iBCIs) have enabled individuals with tetraplegia to control external devices via decoding movement intentions from neural recordings. However, neural activity underlying consistent motor intentions varies over time due to changes in recording conditions, individuals' cognitive states, etc.. There is within- and across-day nonstationarity in the relationship between neural activity and intended movements that can lead to a drop in performance if the decoder is not robust against such changes. To study nonstationarity, a fixed robust online long-short term memory (LSTM) decoder was used for human iBCI cursor control for 142 days. We propose a statistical method to detect when the decoder should be updated solely based on neural activities and decoder outputs, agnostic to the decoder performance.
Neural activity was recorded with two Blackrock Utah microelectrode arrays from the hand-arm area of the precentral gyrus of a participant, T11, who is a 37-year-old male with C4 AIS-B spinal cord injury (enrolled in BrainGate2 pilot clinical trial). Raw neural data were processed in real time into threshold crossing events and power in the spike band (250-5kHz). We trained a LSTM model with recordings from 20 prior sessions of T11 completing point-and-select tasks (trial days 576-646). We analyzed 1832 trials in a closed-loop radial-8 task in 15 sessions (trial days 658-800). The same decoder achieved a mean 93.8% success rate in the first 11 sessions without parameter updates, but subsequently declined to 33.1% in later sessions. We use Kullback-Leibler divergence to measure changes in the distribution of sampled neural features and decoder outputs. This metric highly correlated with the online cursor angular error (r=0.94, Pearson's, $p<0.01$). The same approach also tracked with offline performance in random target Fitts task (794 trials in 4 out of 15 sessions; r=0.94, Pearson's, $p<0.01$). This suggests that KL divergence metric is sensitive to nonstationarities that affect decoder performance. Towards translating iBCIs for practical everyday use, this metric may be effective to track nonstationarity online and be useful for triggering either a user-engaged or background update of the decoder as it begins to degrade.

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