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Movement decoding: dealing with neural signal drift

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Introduction: Recent BCI hardware advances have enabled long-term implantable devices in humans, allowing extended interaction with the environment and diverse BCI strategies. However, achieving stable decoding with minimal recalibration remains challenging due to the ever-changing nature of neural signals and electrode properties, as well as individual variability. In response, researchers are increasingly adopting advanced deep learning approaches, as they hold promise for meeting these demands.

Material, Methods and Results: We develop and evaluate real-time decoding methods using electrocorticography (ECoG) data collected across multiple subjects over several months. The experiments involve upper-limb motor tasks, focusing on wrist, elbow, and shoulder joint movements in non-human primates. We analyze the drift in the underlying structure of neural signals over time and propose methods to compensate for this drift to improve decoding reliability. Specifically, we leverage manifold alignment techniques via self-supervised learning, employing a generative model to detect the drift in the manifold space and align neural data accordingly. This alignment enables a pretrained decoder to maintain comparable accuracy across time without retraining. We demonstrate the application of our alignment approach in online experiments using a real-time decoding platform, achieving state-of-the-art latency and robust performance.

Conclusion: This study presents a self-supervised manifold alignment approach using ECoG data that effectively compensates for neural signal drift, enabling stable, real-time decoding across time without retraining.

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