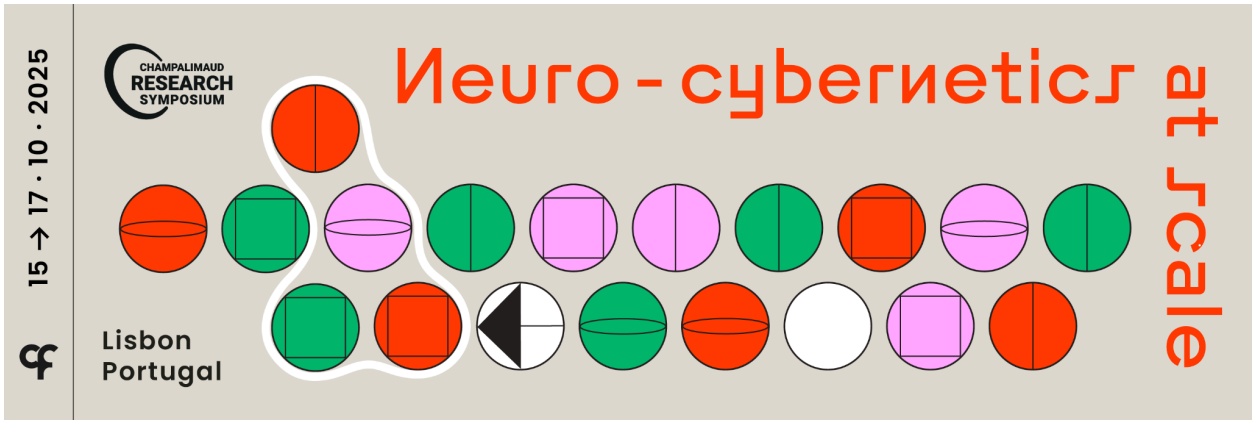

Forecasting motor cortical population activity during delayed reaching using XFADS

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We applied XFADS (eXponential FAmily Dynamical Systems (XFADS): Large-scale nonlinear Gaussian state-space modeling) [1], a nonlinear variational state-space model, to neural population recordings from motor and premotor cortex during a delayed reach task with barriers. XFADS learns a latent dynamical system that enables causal inference and long-range forecasting—beyond the capabilities of standard latent trajectory methods.

Given only the early preparatory activity, the GO cue timing, and the reaction time of the animal—prior to movement onset—XFADS was able to forecast neural activity up to ~800 ms into the future. It revealed that target and movement information was reliably encoded well before the movement initiation, even though the reaction time remained undecodable without explicit go cue input.

Accuracy of the forecasted behavior was better than baselines, particularly on trials with large deviation from the condition-average. XFADS also generalized to unseen task conditions, including novel reach directions and error trials, despite being trained only on stereotypical trials. It decoded error behaviors more accurately than condition-averaged templates.

These results demonstrate that XFADS captures causal spatiotemporal structure in motor cortical activity and highlight the potential of generative modeling for understanding motor planning at the single-trial level.

latent dynamical systems, variational inference, single-trial forecasting, motor preparation, causal inference