Ctrl-TNDM: Decoding feedback-driven movement corrections from motor cortex neurons

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**Motivation:**
- Manifold hypothesis [1]: a low number of latent dynamical factors explain a large fraction of neural variability;
- Do these factors contain information about movement corrections during the trial?

**Approach:**
- Disentangle sources of variability in behavioral data: instructed vs. uninstructed
- Find dynamic factors in neural recordings from PMd/M1 of monkeys engaged in a center-out reaching task with perturbations that explains the uninstructed behavior

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**Classic \( R^2 \):** quantifies the total behavioral variability, which is dominated by the task instruction

- Instructed
- Uninstructed

**Target direction**
- Temporal variability
- Spatial variability

**Problem:** a classic variance explained \( R^2 \) is insensitive to uninstructed variability

**Solution:** quantify the uninstructed variance explained \( R^2_{\text{uninstructed}} \)

\[
R^2_{\text{uninstructed}} = 1 - \frac{\sum_{n=1}^{N} (y_n - \bar{y})^2}{\sum_{n=1}^{N} (x_n - \bar{x})^2}
\]

**Without supervision, LFADS fails to capture the phase of the oscillations**

**Conclusion**

Movement corrections during adaptation to the force field can be decoded from PMd/M1 neuronal activity. Yet, only a small portion of neuronal variability corresponds to movement corrections. Thus, unsupervised models (LFADS) discard this uninstructed variability, modeling it as noise. A weak supervision with behavioral output (velocity) enables detection of neuronal latent dynamics that corresponds to movement corrections.

**References**


