Aligning Neural Activity Recorded from Rats during Locomotion Across Time And Subjects

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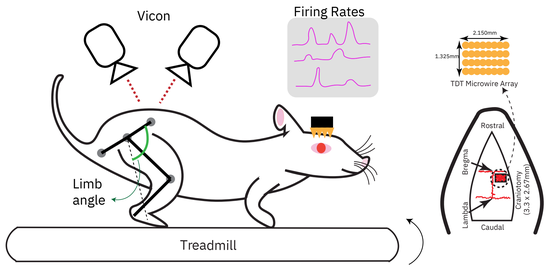
Motivation

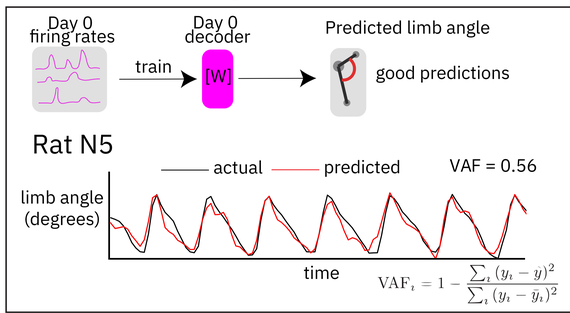
- Trained neural decoders predict behavior from recorded firing rates to drive a brain-computer interface (BCI).
- Decoder performance worsens over time due to turnover in recorded neurons.
- Decoders fail to generalize to different subjects or after physiological changes such as spinal cord injury (SCI).
- Work in monkeys suggests that "alignment" of neural activity back to the initial state which the decoder was trained on can restore performance.
- **Here, we examine whether neural alignment can restore decoder performance in rats undergoing a locomotion task. We then extend this method to suggest practical ways to apply a previously trained decoder to avoid having to train a new one from scratch.**

Methods

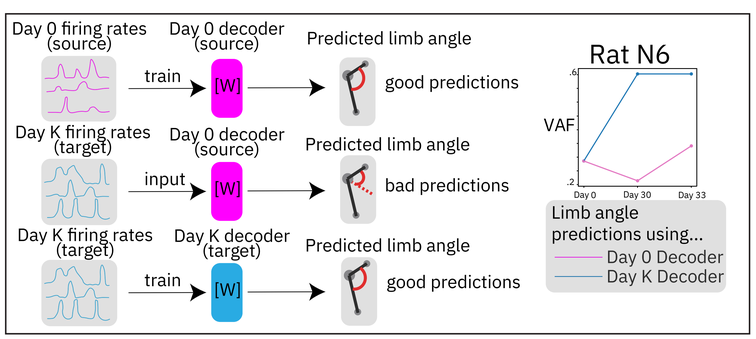
- We implant 32-channel intracortical electrodes in the hindlimb representation of sensorimotor cortex of rats.
- We simultaneously record multi-unit neural activity and kinematics during treadmill locomotion over several weeks.



Training Linear Decoder

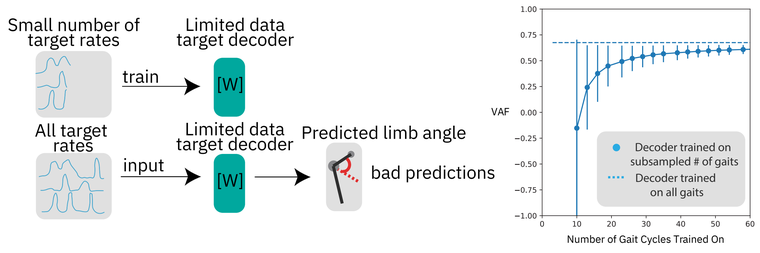


Decoder Performance Worsens Over Time



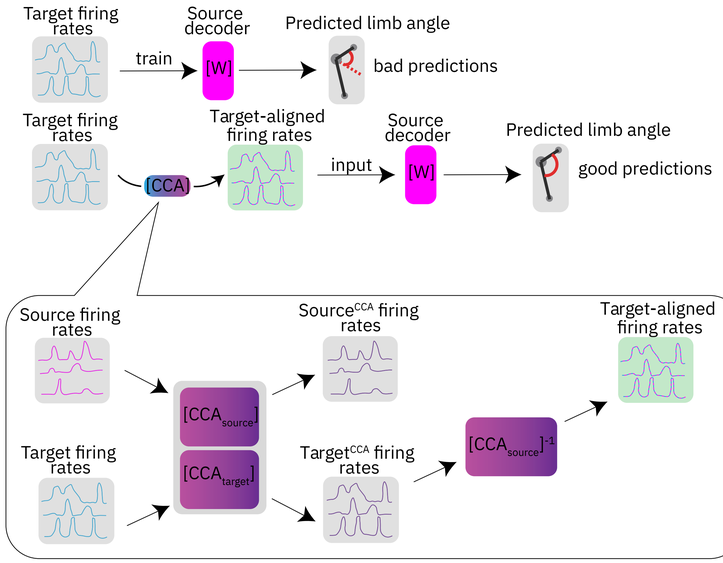
Why Not Just Retrain Decoder?

- Retraining a new decoder from scratch requires generating a significant amount of training data.
- Constantly having to generate training data defeats the purpose of a closed-loop, "autonomously-driven" BCI.
- Studies on post-SCI animals cannot generate significant training data at all.

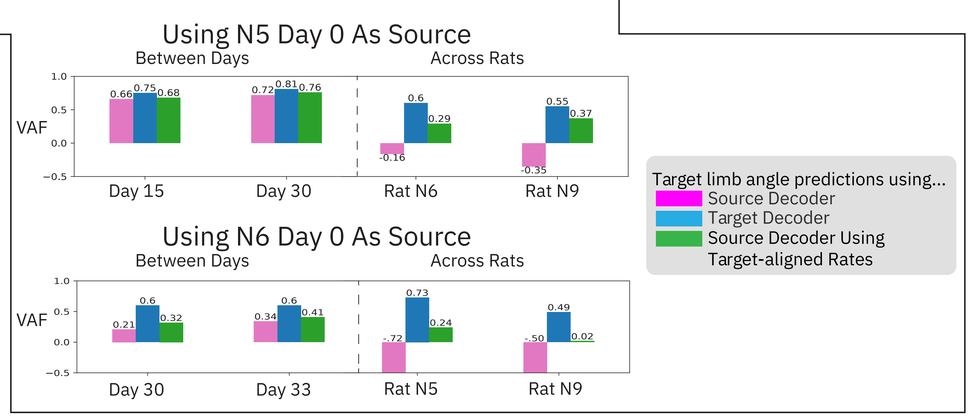


Neural Alignment Improves Decoder Performance

- Canonical Correlation Analysis (CCA) can align target neural firing rates (such as Day K) to source neural firing rates (such as Day 0).

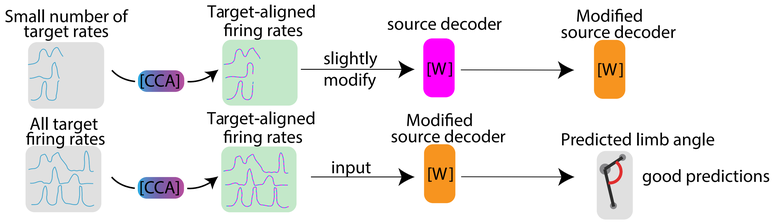


- Neural alignment improves source decoder performance across time, and restores source decoder performance across rats.

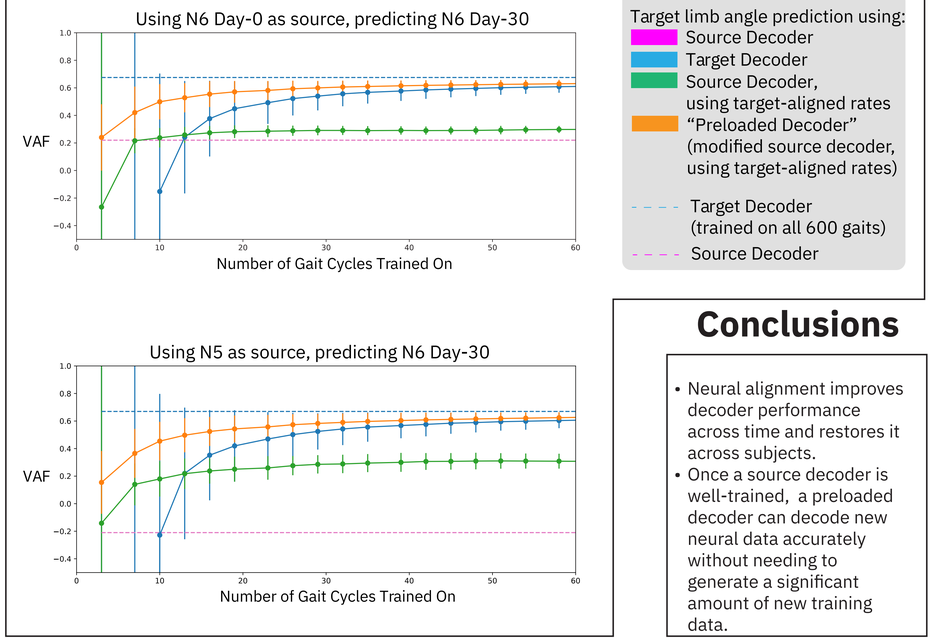


Combining Alignment With Training

- Since just using CCA doesn't completely optimize prediction accuracy on the target dataset, can we apply transfer learning from the source decoder to learn a target decoder with less training data?
- When we train a "preloaded decoder", we hone the weights of a source decoder by correlating a small number of target kinematics with target-aligned neural data.
- We modify source decoder with regression: $\underset{W_{modify}}{\operatorname{argmin}} \|Y - X(W_{source} - W_{modify})\|^2 + \alpha(W_{modify})$



Evaluating Decoding Methods On Subsampled Target Data



Conclusions

- Neural alignment improves decoder performance across time and restores it across subjects.
- Once a source decoder is well-trained, a preloaded decoder can decode new neural data accurately without needing to generate a significant amount of new training data.

Future Work

- Next steps are applying these methods, among other transfer learning techniques, to help build decoders post-SCI, where generating new training data is difficult.