Inferring Latent States with RNNs

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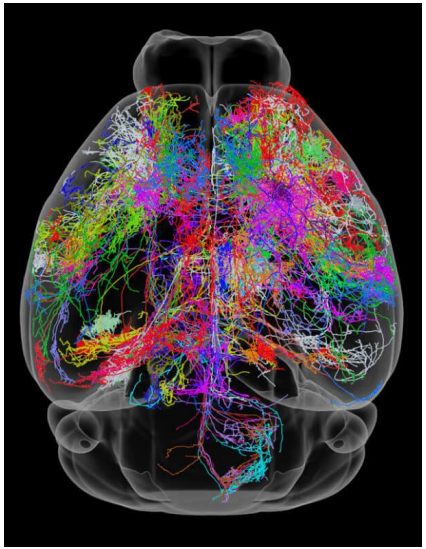
neuromatch academy

Code is available on GitHub:
https://github.com/Ninja-State/NMA-DL-Project

Introduction

- **Neuron-level recordings!**



General Research Topic

Explore the latent space of neuron-level brain recordings to cognitive functions or behavior.

How well can a seq-to-seq model predict the neural firing rates?

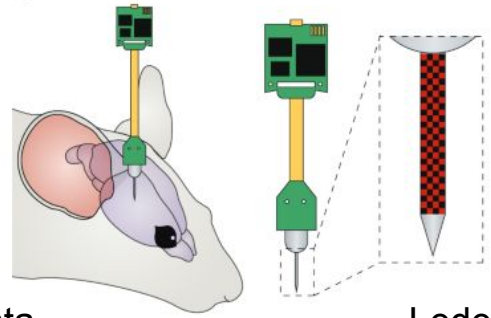
How well can RNNs predict neural activity in one brain region from activity in another brain region?

How well can RNNs classify trial accuracy?

What kind of hyperparameters can improve the predictions?

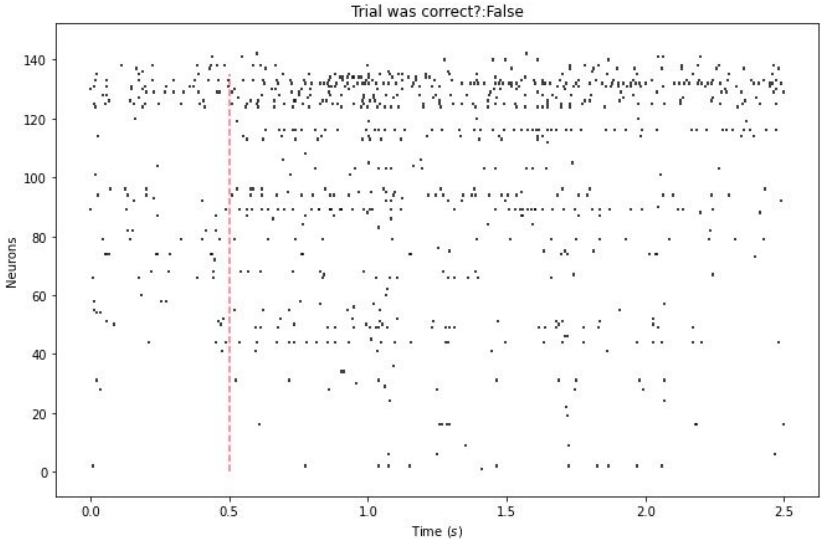
Hypothesis: Latent representations will reflect findings from Steinmetz et al. (2019)

Data



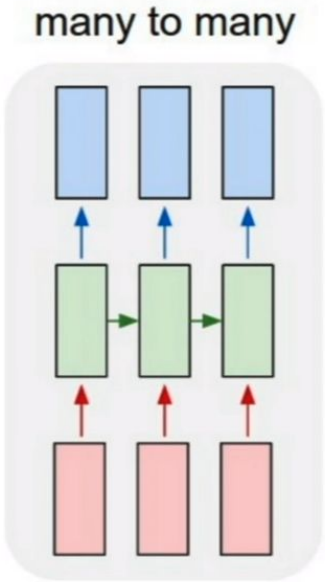
Steinmetz data

Lederberg

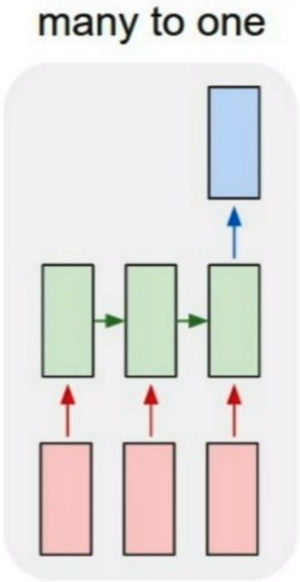


data.shape = (neurons, trials, time)

RNN Architectures Used

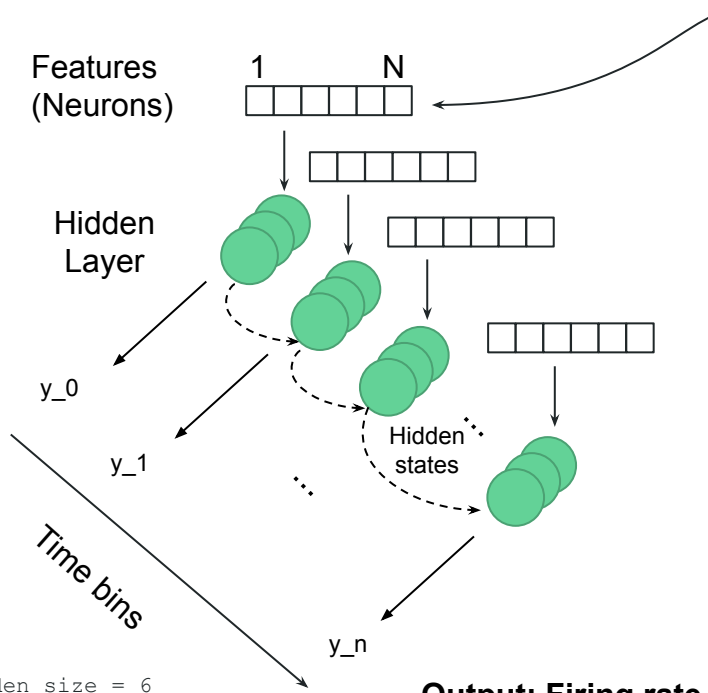


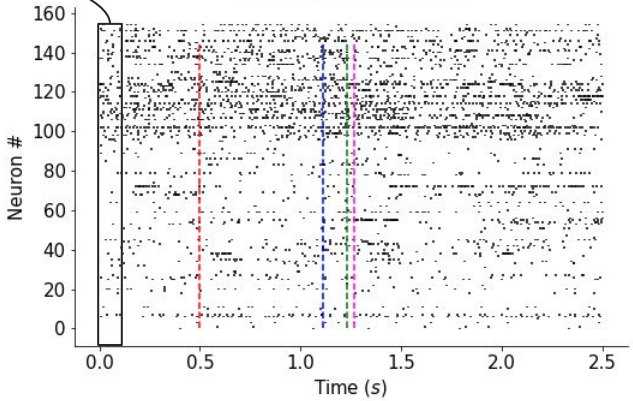
Predicting firing rates



Classification

Seq-to-seq RNN architecture






```
hidden_size = 6
num_layers = 1
learning_rate = 0.001
niter = 1000
```

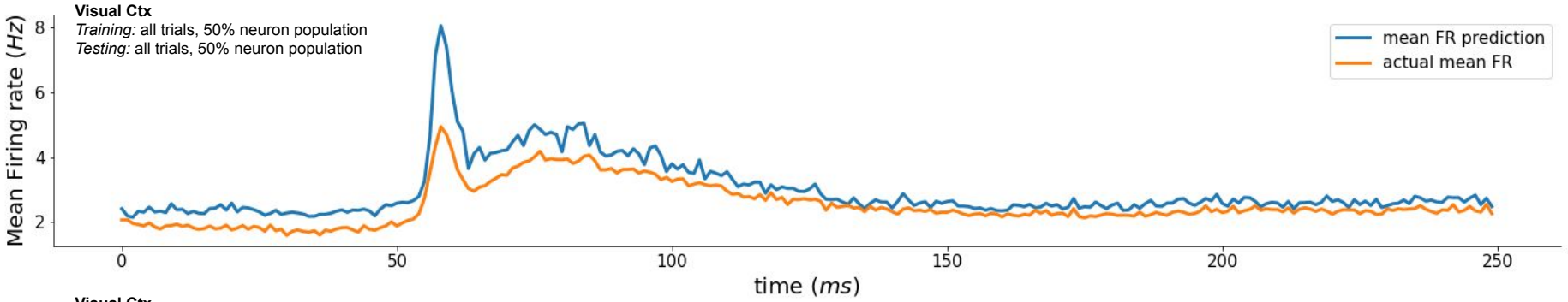
Output: Firing rate

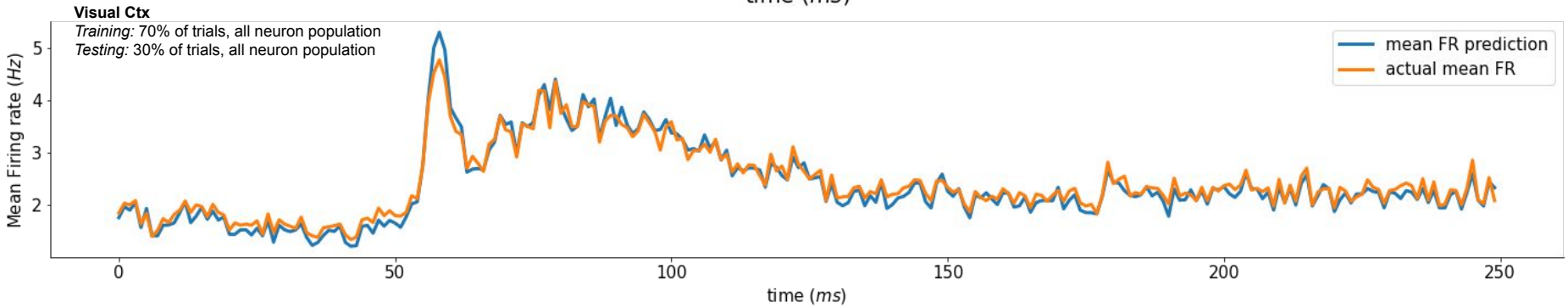
Custom Loss:

$$L(y, \hat{y}) = \frac{1}{N}\sum_{i=0}^{N}(\hat{y}_i - y_i log \hat{y}_i)$$

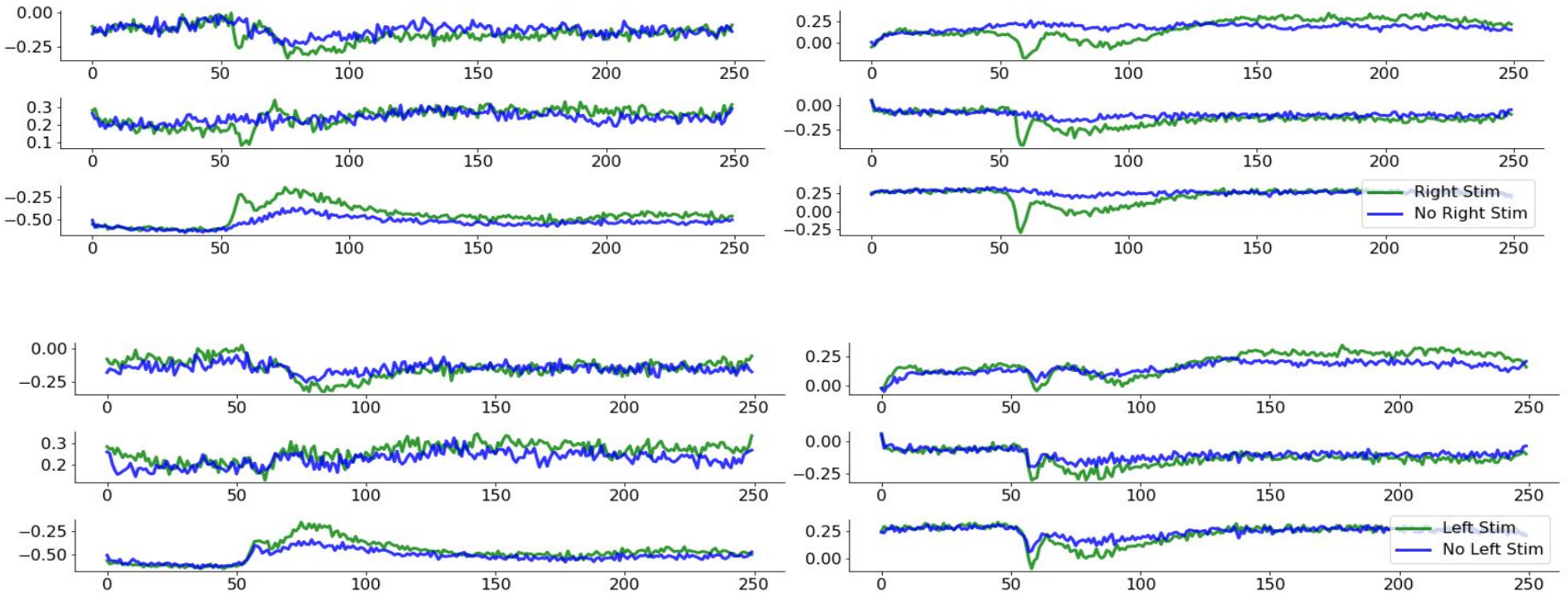
Minimizing the Poisson loss is equivalent of maximizing the likelihood of the data under the assumption that the target comes from a Poisson distribution, conditioned on the input.

Seq-to-seq RNN from spikes to firing rates: results





Are the Latents Encoding Anything?



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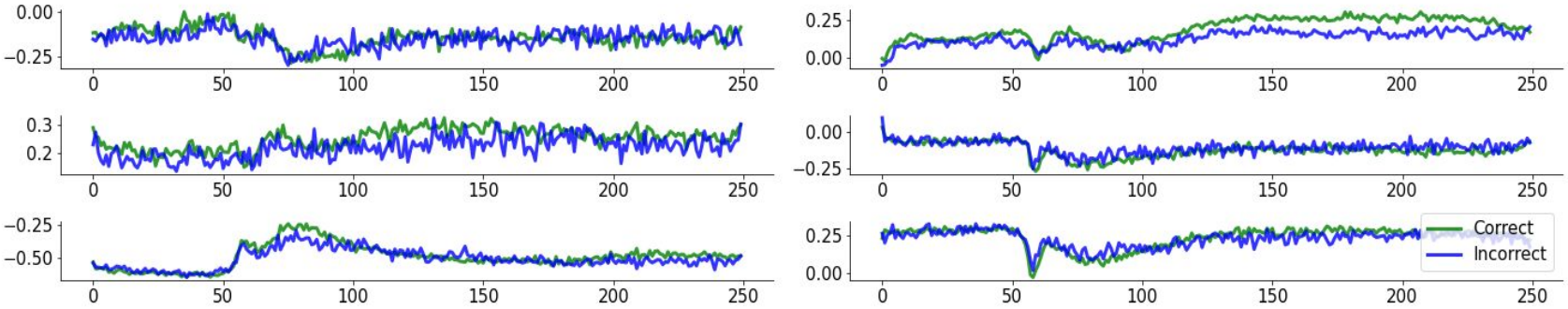
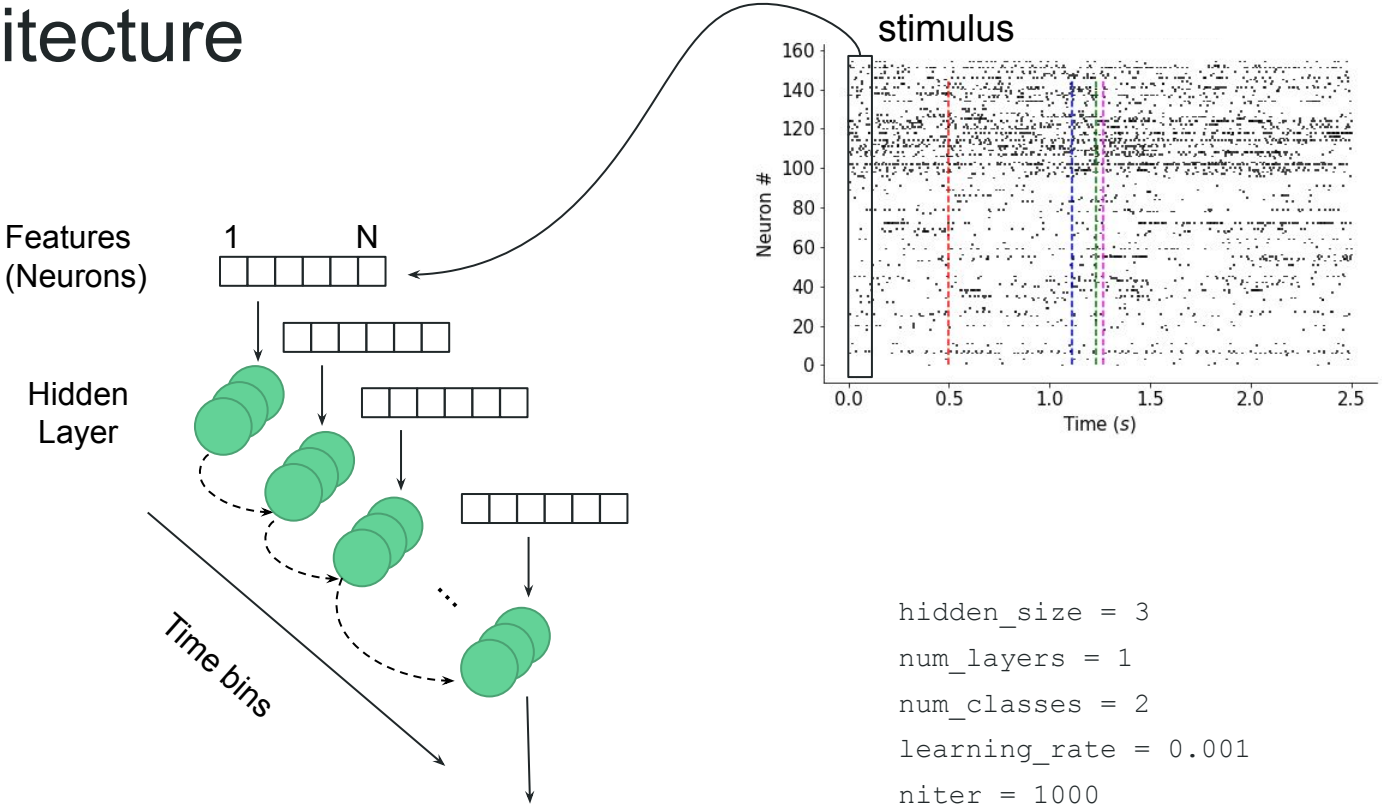


RNN architecture

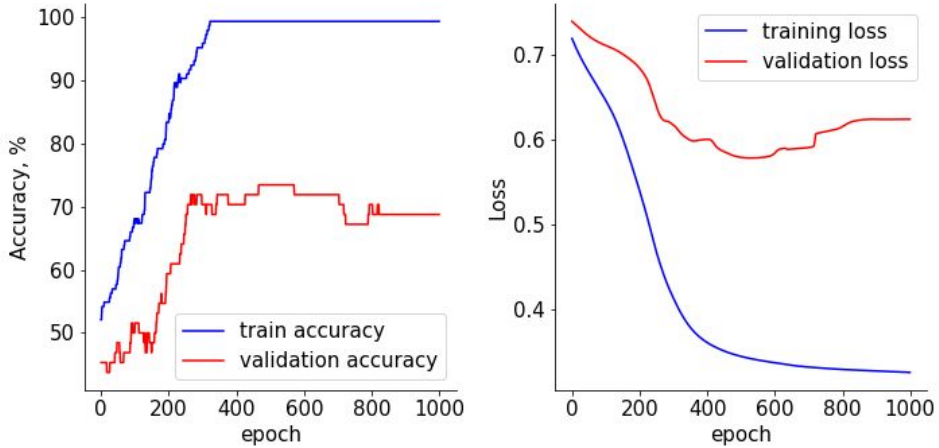



```
hidden_size = 3
num_layers = 1
num_classes = 2
learning_rate = 0.001
niter = 1000
```

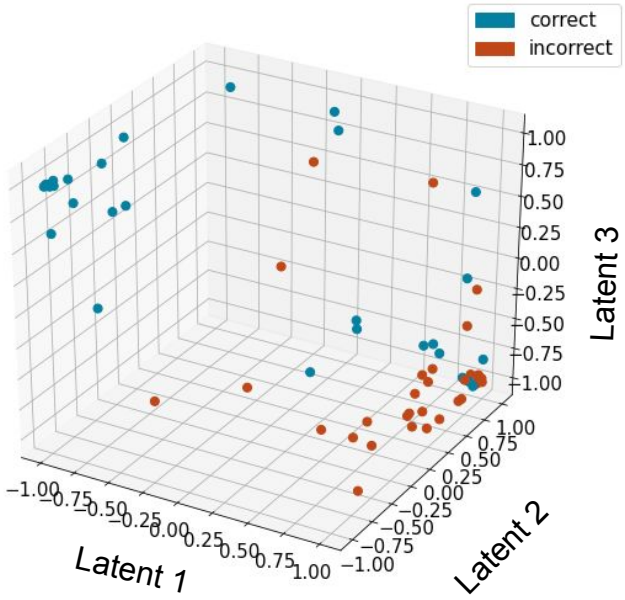
Output: correct/incorrect

Results

Predicting correct and incorrect responses to the stimuli from spiking activity in **thalamus**



Latent space



Potential problems:

- Unbalanced dataset: 65% trials are correct, 35% incorrect
- Small training dataset after balancing (140 trials)
- Neural data is noisy; the decision is encoded across brain regions; stimuli intensity is variable

Reference

Steinmetz, N. A., Zatka-Haas, P., Carandini, M., & Harris, K. D. (2019). Distributed coding of choice, action and engagement across the mouse brain. *Nature*, *576*(7786), 266-273. https://doi.org/10.1038/s41586-019-1787-x

https://deeplearning.neuromatch.io/projects/Neuroscience/neuro_seq_to_seq.html

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