Omer Hazon : 005828994
Vasily Kruzhilin : 006193288

Project category: Life Sciences

This project is an application of machine learning techniques to neural decoding. We are interested in analysing a dataset of calcium imaging of neurons from the mouse hippocampus and prefrontal cortex in a freely moving animal performing a decision of making a left or a right turn. We plan to investigate whether the ensemble, or population coding of the neurons contribute more information than each neuron considered independently by applying shuffles across similar trials as a control. Additionally we will examine the timeline of the decision-making process analyzing the neural activity recording before the decision can be observed externally.

We plan to apply linear and nonlinear support vector machines (and possibly other methods) to decode decision or space information from neural activity, as well as naive Bayes methods as comparisons.
The significance being that naive Bayes makes the independence assumption with regard to the features, meaning that its performance will not change on the shuffled dataset, while the SVM does not make such an assumption and could detect patterns based on dependencies between neurons.

To address the question of the importance of correlation between different neurons we will compare the performance of different decoding approaches on the original experimental data and the experimental data with signals from particular neurons shuffled between trials. The statistically significant difference in performance will point to the importance of the inter-neuron correlations, while the opposite result will support the hypothesis of independent activity of neurons.
Conclusions about mice decision-making process can be made by evaluating the performance of the decoding procedure for different sequential points in time (or positions in space). We will analyse our ability to predict the outcome of the trial in such a manner to identify the timeline of formation of a decision representation forms in the brain.
Additionally we will evaluate the accuracy of different algorithms and their dependence on the training dataset for the task of neural decoding.

The datasets for analysis were collected by the Schnitzer lab and consist of calcium imaging recordings of ~300 hippocampus neurons in one mouse across three days, performing a simple reinforcement learning task, as well as a similar dataset from a different mouse recorded from the prefrontal cortex.
https://www.nature.com/neuro/journal/v20/n9/full/nn.4627.html
This paper discusses methods of generating null distributions from population neural recording data which preserve the primary features of the data along each axis (time, neuron, and condition) and claims to be better for analyzing ensemble coding properties than simple shuffling in the case of different experimental conditions.

https://arxiv.org/abs/1708.00909

This paper reviews different modern machine learning algorithms applied to the problem of neural decoding to various modalities, including position, and comparing them with more traditional nonparametric methods, claiming a significant improvement in error.