Week 3: Representational Similarity Analysis Inspired Computations

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1 Connecting Neurons

This week we implement a model where a network of connected spiking neurons is fed with Poisson inputs with varying frequencies. In a procedure inspired by the Representational Similarity Analysis, where the responses of neural systems to varying stimuli are compared according to a similarity measure, we measure the mutual information of the neurons and construct a heat map of the similarities.

The setup of the simulation is the same as the previous two weeks, except that we now add connections to the neurons in the following line of code:

```
neuron_connection =
Connection(neurons,neurons,'s_ext',weight=1.0,sparseness=0.7)
```

We display here for illustration the spike trains with the same Poisson input (with stimulation of frequency 1.8 kHz) for the case where the neurons were not connected (Figure 1) and for the case where the neurons were connected (Figure 2).

The connected neurons show a much higher level of synchrony.

We now change the input frequencies for each neuron according to the following line of code.

```
inputs=PoissonGroup(nr_of_neurons,rates=linspace(0*kHz,5*kHz,nr_of_neurons))
```

The interconnected neurons display the following pattern of firing (Figure 3).

2 Representational Similarity Analysis analogue in spike trains with Mutual Information

Here we first display the mutual information based similarity matrix of connected neurons (Figure 4). The mutual information is on average higher than in the previous simulation, although still relatively low.

We next display the mutual information based similarity matrix for neurons with different inputs (Figure 5).

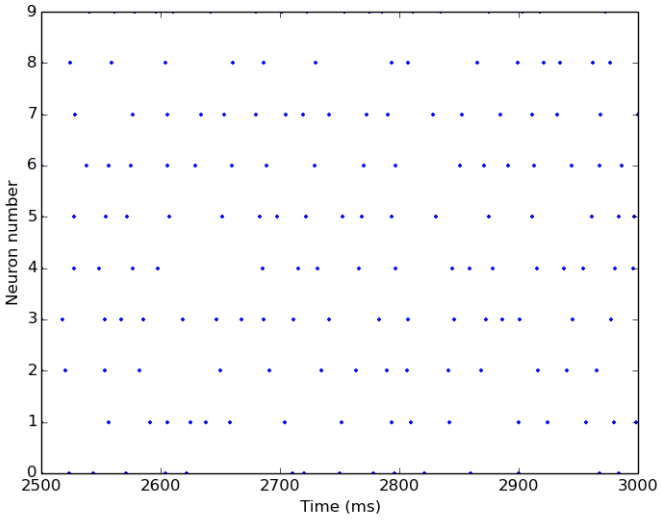

Figure 1: Spike trains before connection amongst neurons with the same input per neuron (1.8 kHz)

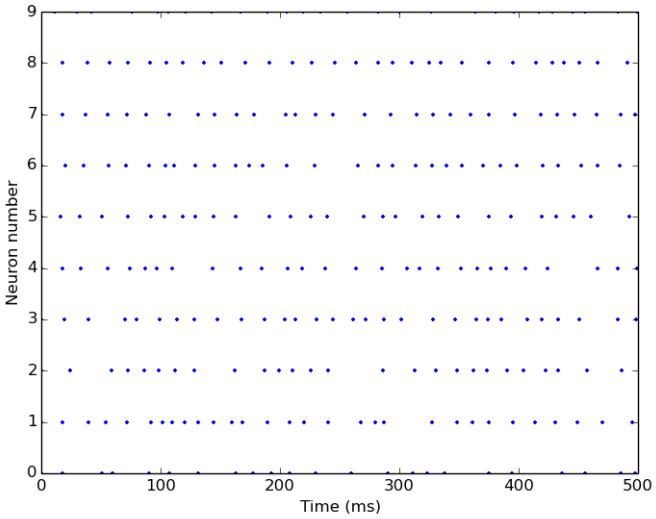

Figure 2: Spike trains after connection amongst neurons with the same input with the same input per neuron (1.8 kHz)

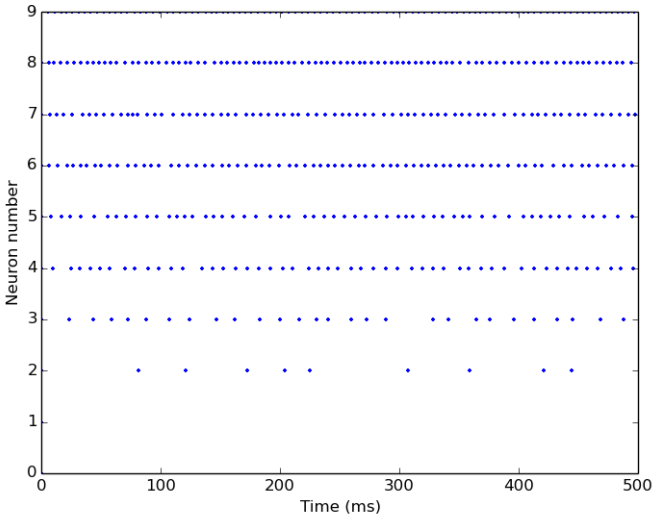

Figure 3: Spike trains after connection amongst neurons with the same input with the same input per neuron (1.8 kHz)

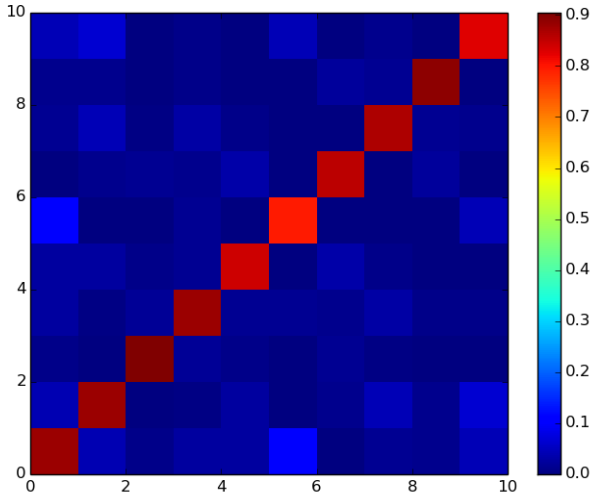

Figure 4: Mutual information based similarity matrix of neurons with identical inputs

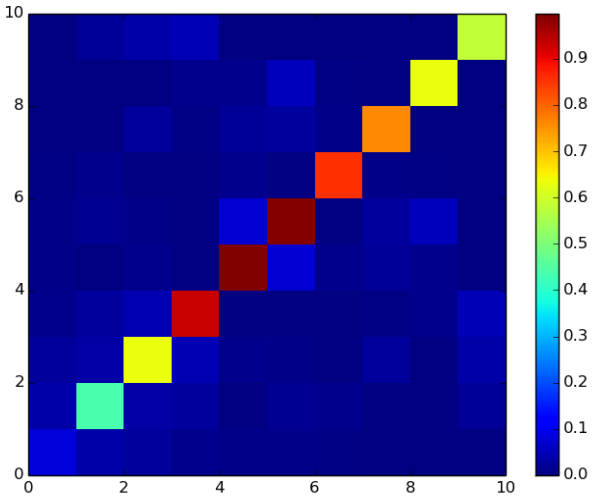

Figure 5: Mutual information based similarity matrix of neurons with different inputs

3 Concluding Remarks

This week's work expanded the previous work in two dimensions: firstly, we made random connections among the neurons in the simulation and secondly, we passed different stimuli to the neurons in the simulation. We used a technique inspired by Representational Similarity Analysis (1) using mutual information as a metric to quantify the similarities between the neurons stimulated with different stimuli.

4 References

(1) Haxby, J., Connolly, A., Guntupalli, S."Decoding Neural Representation Spaces Using Multivariate Pattern Analysis", Annual Reviews Neuroscience, 2014