IKV2 final project

The goal of the final project is to learn to construct a more complex network inspired by state-of-the-art research, analyze the results and present them in a written form. Our motivation will be the publication

Kumar A., Cardanobile S., Rotter S. and Aertsen A., The role of inhibition in generating and controlling Parkinson's disease oscillations in the basal ganglia, 2011, Front. Syst. Neurosci. https://doi.org/10.3389/fnsys.2011.00086

In this paper, Kumar et al. explore the origin of beta oscillations involved in Parkinson's disease and how to suppress them with deep brain stimulation (DBS). We will build a smaller network with adjusted parameters that exhibits similar behaviour.

1. Network construction

Create 2 populations of neurons:

- 300 neurons (analogue to STN, excitatory)
- 500 neurons (analogue to GPe, inhibitory)

Neurons in both populations have the same parameters:

Membrane capacity: 30pF
Leak reversal potential: -70 mV
Reset potential: -70 mV
Spike threshold: -60 mV
Refractory period: 2 ms
Membrane time constant: 20ms
Time constant of an excitatory synapse: 1ms
Time constant of an inhibitory synapse: 10ms

Connect neurons in both populations (both within and across populations) with the connection rule "fixed indegree". Set the parameters of the connections as follows:

	indegree	synaptic weight (pA)	synaptic delay (ms)
GPe -> STN	30	-15	5
STN -> GPe	50	30	5
GPe -> GPe	30	-5	2
STN -> STN	50	50	2

Next, create one Poisson generator with rate 800Hz and create connect it to the GPe with weight 40pA and to the STN with weight 65pA.

Create a spike recorder a connect each population to it. If you wish, you can also create and connect a voltmeter to observe the membrane potential.

Now you are ready to simulate the network and observe the activity.

2. Increased inhibitory input to the GPe

Create a Poisson generator with mean firing rate 800 Hz and connect it to all neurons in the GPe with weight -5 pA. Pick a start and stop time to still see some activity without this input.

3. Deep brain stimulation

Create a direct current generator with current amplitude -180 pA and connect it to all neurons in the STN. Pick start and stop time so that you see activity in all three conditions (no additional input, additional inhibitory Poisson input to GPe, additional Poisson input to GPe and DBS to STN).

4. Analysis of results

1. Plot a raster plot of spikes to see how activity changes when you switch on and off the additional external inputs.
2. Plot the mean firing rate for each population in all three conditions.
3. Plot the power spectrum of the population firing rate in all three conditions. You can choose to present the power spectrum in the form of a spectrogram.
4. Plot the cross-correlation of the population firing rate for each population and each conditions.
5. Test different amplitudes of the DBS. How sensitive is the effect to changes in the DBS amplitude? Create figures to demonstrate your results.

5. Report

Write a report summarizing your results and demonstrating them in annotated figures.
Send a pdf to karolina.korvasova@mff.cuni.cz.