Starting point:
- VA balance network
- Izhikevich model

Goals:
- using the Izhikevich model in the VA network
- implement STDP
- implement distance-dependent connectivity
- implement distance-dependent synaptic delay
- vary the stimulus
- vary the neurons ratio
- vary the synaptic weights

To achieve these goals, we first relied on SpiNNaker to benefit from neuromorphic computing; however, we encountered many problems within the post-processing (not being able to execute also the provided notebook from the CNT-2024 repo).

The 4 .ipynb have the same pipeline but with slight differences to explore neuron populations' behaviour in different conditions. Our project thus involves both the implementation of the previously cited properties and an investigation under different conditions (varying stimulus, neuron ratio and synaptic weights).

The **basic** version is similar to the VA balance network provided in the CNT-2024, having a similar neuron ratio and a similar thalamic stimulus; while implementing STDP, distance-dependent connectivity, distance-dependent synaptic delay and using the Izhikevich model.

The **stimulus** version is identical to the basic version, but with 100 thalamic cells instead of 20, and a stimulus rate of 200Hz instead of 100Hz. All these changes brought 22.344 spikes in the excitatory population instead of the 16.346 spikes seen in the excitatory population of the basic pipeline.

The **neuron_ratio** differs from the basic version in the fact that the inhibitory population is made of 1089 neurons instead of 256 neurons (the excitatory population, as in the basic version, is made of 1089 neurons resulting in a 1:1 ratio). We also increased the weight of synapses going from inhibitory to excitatory neurons. As expected, these changes brought a reduction in spikes, which were 12.432.

The last version, the **synapses_weight,** differs in the synaptic configuration; where we set the max weight to 5.0. In this case, we saw an increased neuron activity, having 21.064 spikes in the excitatory population (the basic version had 16.346 spikes). Another difference noticeable in the spikes plot is that firings of action potentials are more concentrated in time points and less spread out (there is a lot of variability in the density of spikes, with some points of accumulation); this is because a high weight value for synapses will “emphasize” the activity.

Plots: for analysing the simulations we relied on several plots (each applied both to excitatory and inhibitory populations)

- plot showing synaptic weights evolution for a subset of 10 synapses to check the STDP effects
- plot showing the population spike trains
    - y-axis: single neurons
    - x-axis: time
- plot showing the state variable evolution in time (in our case, membrane potential and recovery variable)
    - y-axis: single neurons
    - x-axis: time
- single cell analysis, which was useful for finetuning cell parameters; it allowed us for example to look at single spike trains in terms of membrane potential evolution in time.