**Principles of Brain Computation KU**

708.086 18S

# Homework Sheet 1

Problems marked with * are optional.

# The LIF model [5P]

In this task, we investigate a simple spiking model for neuron, the leaky integrate-and-fire (LIF) model. The membrane potential evolves according to

$$\tau_{\mathrm{m}} \frac{du}{dt} = -\left(u - u_{\mathrm{rest}}\right) + R_{\mathrm{m}} I(t) \ , \tag{1}$$

where

- $u$ is the membrane potential,
- $\tau_{\mathrm{m}} = R_{\mathrm{m}} C_{\mathrm{m}}$ is the membrane time constant,
- $R_{\mathrm{m}}$ is the membrane resistance,
- $C_{\mathrm{m}}$ is the membrane capacitance, and
- $u_{\mathrm{rest}}$ is the resting potential.

If the membrane potential reaches the firing threshold, a spike is generated and the membrane potential is reset to the reset potential $u_{\mathrm{reset}}$:

$$\text{if } u \geq \vartheta : \ u \leftarrow u_{\mathrm{reset}} \ . \tag{2}$$

If there is an absolute refractory period $\Delta_{\mathrm{abs}} > 0$, the membrane potential is clamped to $u_{\mathrm{reset}}$ for the duration of $\Delta_{\mathrm{abs}}$, after which it may evolve freely.

## Task 1a [2.5P]

Compute the spike frequency of a LIF neuron assuming a constant current $I(t) \equiv I$ and the absence of an absolute refractory period ($\Delta_{\mathrm{abs}} = 0$). (Hint: Assume that the neuron has produced a spike at $t = 0$. Then, the interspike interval is equal to the time that the neuron reaches the threshold, assuming there is no noise present.)

## Task 1b [0.5P]

Now assume an absolute refractory period $\Delta_{\text{abs}} > 0$. Compute the spike frequency.

## Task 1c [2P]

Verify your results use the PyNEST. Use the provided code template. Instead of simulating the idealized case without noise, we will look at the mean interspike interval of a neuron which is subject to noise.

- Create an LIF neuron of type `iaf_psc_delta`. Use the following parameters:

| parameter | $R_m$ | $C_m$ | $u_{\text{rest}}$ | $u_{\text{reset}}$ | $\vartheta$ | $\Delta_{\text{abs}}$ |
|---|---|---|---|---|---|---|
| unit | GΩ | pF | mV | mV | mV | ms |
| value | 0.03 | 1000 | -65 | -80 | -45 | 5 |

- Inject a constant current ($I = 3000$ pA) into the neuron using a `dc_generator`.
- Inject noise ($\mu = 0$, $\sigma = 1000$ pA) into the neuron using a `noise_generator`.
- Simulate the neuron for a long time (e.g. 20 s). Plot a histogram of interspike intervals. Calculate the expected interspike interval and compare it to the mean interspike interval you observe in your simulation.

**Submit the code until 8:00 AM of the day of submission** to `mueller@igi.tugraz.at` and `lydia.lindner@student.tugraz.at`. Use `PoBC HW1,` ⟨`name team member 1`⟩ ⟨`name team member 2`⟩ as email subject. Only one email per team is necessary. You need to hand in a printed version of your report at the submission session. Each team member needs to write their own report. Use the cover sheet provided on the course website.

## Appedix

See `http://www.nest-simulator.org/` for information on how to obtain and install NEST. There is live medium available with NEST preinstalled on Ubuntu for running in VirtualBox.