University of Lübeck
Institute for Neuro- und Bioinformatics

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Neuroinformatics (CS4405) • SS 2018

FCT 1

Place and Time: **Ü1**: Thursdays, 09:00-10:00, PC Pool 1+2 (building 64, floor)
Ü2: Thursdays, 10:00-11:00, PC Pool 1+2 (building 64, floor)
Ü3: Fridays, 14:00-15:00, PC Pool 1+2 (building 64, floor)
Website: `https://moodle.uni-luebeck.de/`

Leaky-Integrate-and-Fire Neuron

Write for each exercise a single MATLAB script (e.g. `exercise_1_1.m`). Use each script as the starting point for the subsequent exercise.

Exercise 1.1
Membrane Potential
At time t, the neuron receives a single input $x(t)$. We model the activation of the neuron $V(t)$ to reduce by $1/\tau$ in each time step, where $\tau > 1$. To this end, we use the following difference equation:

$$V(t+1) = V(t) - \frac{1}{\tau}V(t) + x(t), \qquad V(0) = x(0) = 0.$$

Implement this neuron model in MATLAB.

On the website, you find some input data (file `X.mat`) to test your implementation. Each row in matrix `X` corresponds to one input function $x(t)$, each column corresponds to a discrete point in time t. Plot $V(t)$ and $x(t)$ in the same figure/subplot with different colors. You may need to use the commands `hold on;` and `hold off;` appropriately. Start with $\tau = 3$ and then experiment with different values to see how they influence the behavior of the neuron.

Exercise 1.2
Spikes
The neuron produces a spike when its activation exceeds a constant threshold θ_0.

$$S(t) = \begin{cases} 1, & \text{if } V(t) \geq \theta_0 \\ 0, & \text{otherwise}\,. \end{cases}.$$

Extend your code to perform this thresholding operation and plot $S(t)$ and θ_0 (a constant function) together with $V(t)$ and $x(t)$. Use the function `bar(·, 0.4, 'grouped')` to plot the spikes. Try different values θ_0. *Hint:* Start with a threshold of $\theta_0 = 1$.

Exercise 1.3
Saturation
The maximum spike rate of a neuron is limited (saturation). We will model this by adding a dynamic saturation function $\Theta(t)$ to the constant threshold θ_0. This saturation function depends on the previous spike activity $S(t)$ of the neuron. The saturation function is again modelled by a difference equation ($\tau_S > 1$):

$$\Theta(t+1) = \Theta(t) - \frac{1}{\tau_S}\Theta(t) + S(t), \qquad \Theta(0) = S(0) = 0.$$

In other words, the neuron produces a spike ($S(t) = 1$) when its activation $V(t)$ exceeds the dynamic threshold $\theta(t) = \theta_0 + \Theta(t)$. Test the modified neuron on the given input data. Plot $S(t)$ (use the function `bar(·, 0.4, 'grouped')`) and the variable threshold $\theta(t)$ (instead of θ_0) together with $V(t)$ and $x(t)$ to inspect the behavior of the model.

If you have any problems or questions, please contact us via mail or moodle.