**Class**: LSU CSC 2262, Spring

**Instructor**: James Ghawaly

**Group ID**: “*Place Group ID here”*

**Group Team Members**:

*“Place team member names here”*

## Introduction

The project aims to simulate neuron behavior using Leaky Integrate-and-Fire (LIF) neuron and alpha synapse models. These models are fundamental in computational neuroscience, providing a simplified approach to understanding how neurons respond to stimuli and generate action potentials (spikes). The objective is to implement these models and perform various experiments to observe neuron behavior under different conditions.

By simulating these models, we aim to enhance our understanding of neuronal dynamics and how external inputs affect neuron activity. This knowledge can be applied in fields such as neural network design, brain-machine interfaces, and understanding neurological disorders.

## Methods

The code consists of two main components: the LIF neuron simulation and the alpha synapse simulation. It uses command-line arguments to accept user input and runs the specified simulation mode, either "spike" or "current," based on the provided parameters.

### LIF Neuron Simulation

* The **lifFunction** function calculates the change in membrane voltage using the Euler method. It uses parameters such as resting potential, time constant, membrane capacitance, and input current.
* The **lif\_neuron\_sim** function simulates the LIF neuron model over a specified time using the **lifFunction**. It tracks membrane voltage and checks for spikes when the voltage exceeds the spike threshold. Spikes are simulated as a sudden increase in voltage.

### Alpha Synapse Simulation

* The **alpha\_synapse\_sim** function simulates an alpha synapse model, which is a synaptic current generator based on spike inputs.
* The function calculates the synaptic current using a combination of the synaptic conductance, reversal potential, and membrane voltage.
* Spikes are generated using the **generate\_spikes** function based on the provided spike rate and simulation time.

### Execution

* The program accepts command-line arguments specifying the simulation mode (**"spike"** or **"current"**) and simulation time in milliseconds.
* For **"current"** mode, the program requires an additional argument specifying the input current in nanoamps.
* For **"spike"** mode, the program requires the input spike rate in Hz.
* The simulation results are plotted using matplotlib to visualize the membrane voltage over time for the experiments.

**Results**

*“In this section, you should use your code to perform the following experiments and answer questions about them.”*

|  |
| --- |
| For experiments 1, 2, and 3, the following parameter values should be used in your configuration. |
| For Euler’s Method: |

**Experiment 1** Run the following command:

*python neuro\_sim.py current 250 --current 0.003*

**Q1**: Show the plot of the membrane voltage, , for the duration of the experiment (250 s).

**Q2**: How many spikes were produced over the course of the experiment?

**Experiment 2** Run the following command:

*python neuro\_sim.py current 6 --current 0.003*

**Q1**: Show the plot of the membrane voltage, , for the duration of the experiment (6 s).

**Experiment 3** Run the following command:

*python neuro\_sim.py spike 100 --spike\_rate 50*

**Q1**: Show the plot of the membrane voltage, , for the duration of the experiment (100 s).

**Q2**: How many spikes were produced over the course of the experiment?

**Experiment 4** Run the following command, but change the Euler’s method time step to :

*python neuro\_sim.py current 250 --current 0.003*

**Q1**: Show the plot of the membrane voltage, , for the duration of the experiment (100 s).

**Q2**: How many spikes were produced over the course of the experiment?

**Q3**: How does this compare to the result from Experiment 1?

**Experiment 5**: Repeat experiment 3, but replace the exponential term in Equation 3, , with a 10th order Taylor Series approximation of , centered at 0.

**Q1**: Show the plot of the membrane voltage, , for the duration of the experiment (100 s).

**Q2**: How many spikes were produced over the course of the experiment?

**Q3**: How does this compare to your result with Experiment 3?

**Conclusion**

*“This section should contain a single paragraph that summarizes the project, what you did, and any discussion that you may have about your results.”*