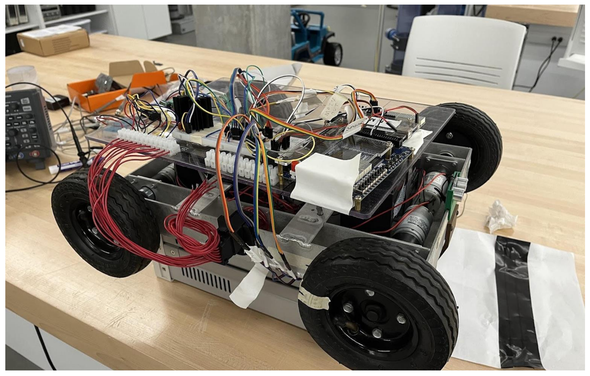
Purdue Research Foundation – Team 34

Simulation and Training of Neuromorphic Hardware

Academic Mentor: Milton Aguirre Team Members: Dev Joshi, Koki Inaba, Rohit Ramaswamy, Siddhant Lamichhane

OBJECTIVE

Fully simulate and train a hardware based Spiking Neural Network (SNN) using Python and optimize the synaptic weights on the neural network to be able to fine tune the performance of the SNN on a line-following EV car.



CUSTOMER PROBLEM AND BACKGROUND

As part of a larger collaborative effort to design and control a line-following electric vehicle (EV), our team—Team 34—was responsible for simulating and training a Spiking Neural Network (SNN) to optimize synaptic voltage weights for decision-making.

Central to our approach was a deep understanding of Spiking Neural Networks (SNNs), which differ from traditional artificial neural networks by using discrete voltage spikes to encode and transmit information.

The spikes are characterized by their timing and frequency. They more closely mimic biological neural activity and offer advantages in energy efficiency and event-driven computation.

Our simulation enabled us to train and test various synaptic configurations and observe how changes in spike behavior influenced the EV's ability to interpret sensor data and follow the track accurately.

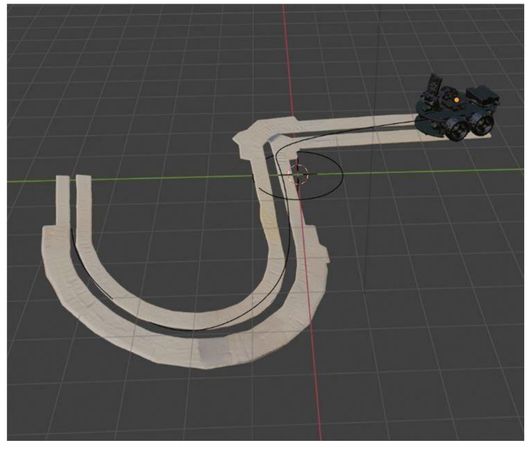
CONCEPTS AND EXPERIMENTATION

The SNN utilizes a framework of synapses and somas. Each synapse has a voltage weight supplied to it which determines the current output of each synapse and the spiking rate.

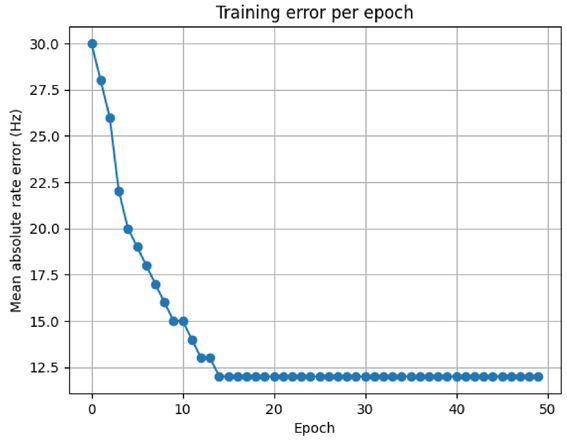
We built the simulation using Brian2, a Python library specialized for SNNs. Brian2 allows for easy implementation and deployment of the SNN. Brian2 provides us with functions that allow us to use the equations used to find the current out of each synapse or the voltage out of each soma.

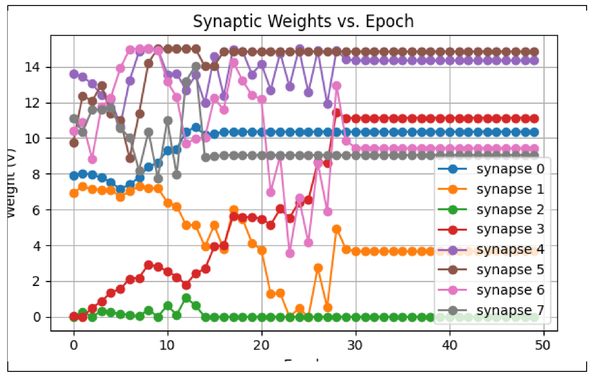
After the network sufficiently learns the input pattern and adjusts the weights accordingly, the weights will stabilize at the optimal voltage. These are the new weights that will be implemented onto the system.

REQUIREMENTS AND FINAL DESIGN



3D Environment of the car and track





PURDUE UNIVERSITY

Polytechnic Institute

Our simulation team included Dev Joshi, Koki Inaba, Rohit Ramaswamy, and Siddhant Lamichhane. Professor Milton Aguirre mentored us on presenting our findings. Our client, Masoome and Dr. Nawrocki, guided our technical objectives and provided feedback, while Yi, a former graduate student familiar with the simulation, regularly reviewed our progress and offered detailed suggestions.

TESTING RESULTS

CONCLUSION AND RECOMMENDATIONS

We successfully developed a framework for an SNN model which simulates the behaviors of neuromorphic hardware and a 3D testing environment for the line-following car and the track it follows.

In the future we want to adapt our SNN model to operate directly on biological hardware on the EV car and expand the model as necessary to increase complexity and computation.

To obtain more extensive and detailed datasets, we recommend constant communication between both teams to request and receive data as quickly as possible.

As for the model, incorporating real-world experimental data would enhance the practical relevance of the model. Additionally, we may modify our training algorithm to introduce novel improvements and compare it against existing methods to highlight its advancements.