Spiking Neural Network for Autonomous Drone Control

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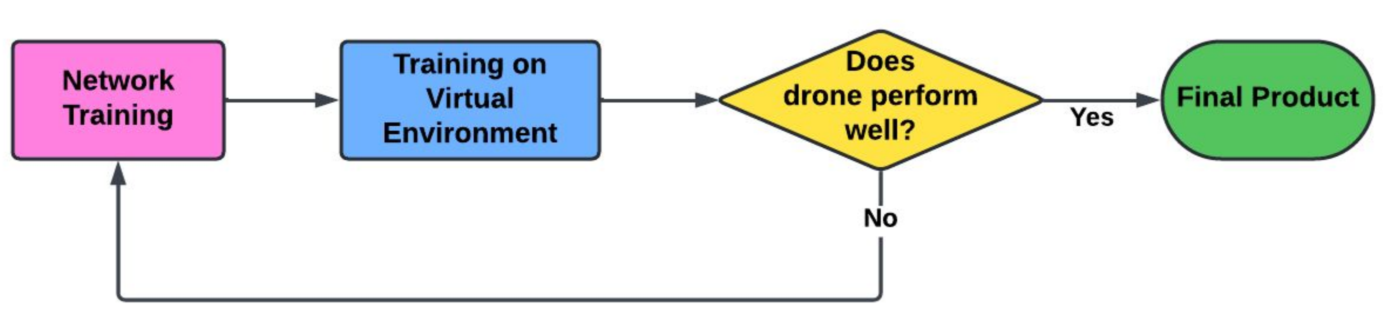
Autonomous Drone and SNN

- Research and development efforts have long been focused on **autonomous drones**, yet their energy consumption during flight remains a formidable challenge. Due to weight and size considerations, autonomous drones are limited in their battery capacity. Hence, all means of reducing energy consumption are important.
- A **spiking neural network (SNN)** is a type of neural network that more closely resembles biological neural systems through the use of neurons and simulated spikes along synapses. Compared to other neural networks, SNN has a significant advantage in **energy efficiency**, making them ideal for operating devices with limited battery capacity.

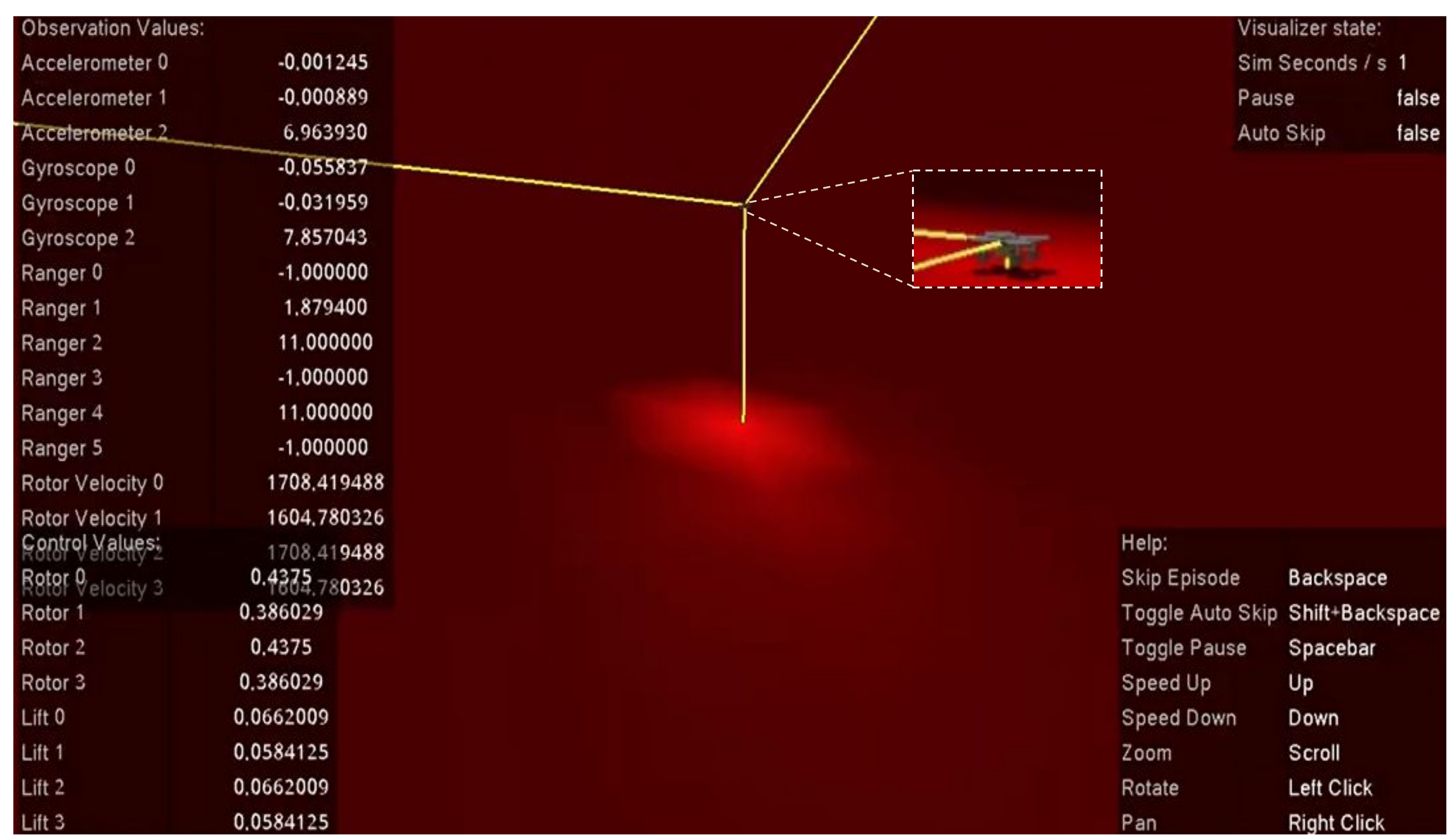
Technical Approach

- To design SNN architecture, we used the evolutionary algorithm **EONS (Evolutionary Optimization for Neuromorphic Systems)** from TENNLab to evolve a SNN through a process similar to natural selection [2].
- We utilized the **simulator** created by the previous senior design team to assess the network's proficiency to fly the drone.
  - MuJoCo connected into TENNLab's C++ framework
- Using EONS, we **trained SNNs** and tested trained SNNs on the simulator. Training is repeated until the drone performs well on the virtual environment.
  - Performance goal: a drone flies for a fixed height, hovers and stays for awhile, then lands without crashing in the simulation



Implementation

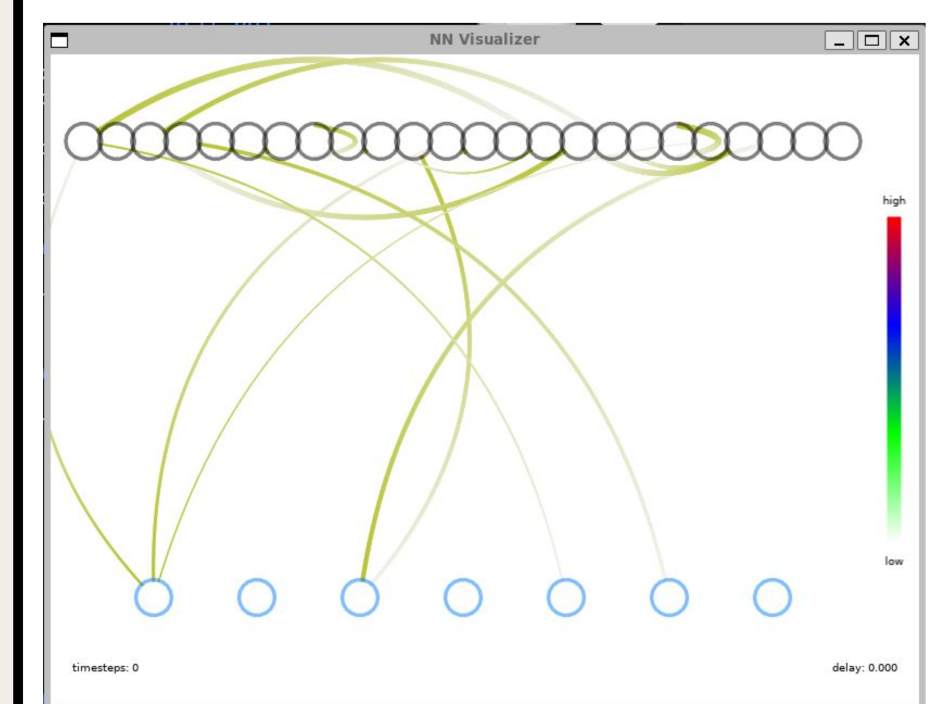
- Our primary focus throughout our workflow and implementation revolved around refining the **reward structure of the network** which is broken into two parts that affect the reward given to the network:
  - **Reward**
    - Checked every timestep; run efficiently
    - Had largest impact on overall performance of the drone
  - **Final_Reward**
    - Checked 100 times over the training period; a bit slower
    - Played less significant role
      - Discourage horizontal displacement using function that is not Big-O efficient



- Our final version of code checks if the drone is in a designated 'box' off of the ground and **rewards** based on how **stable** the drone is. Once drone **lands**, it was **penalized** for being in the box to prevent 'hopping' behavior.
- Testing was an iteration of trial-and-error approach. We adjusted the **reward function**, ran it on the different **seeds**, and check which model had the best **drone performance** on the simulator.

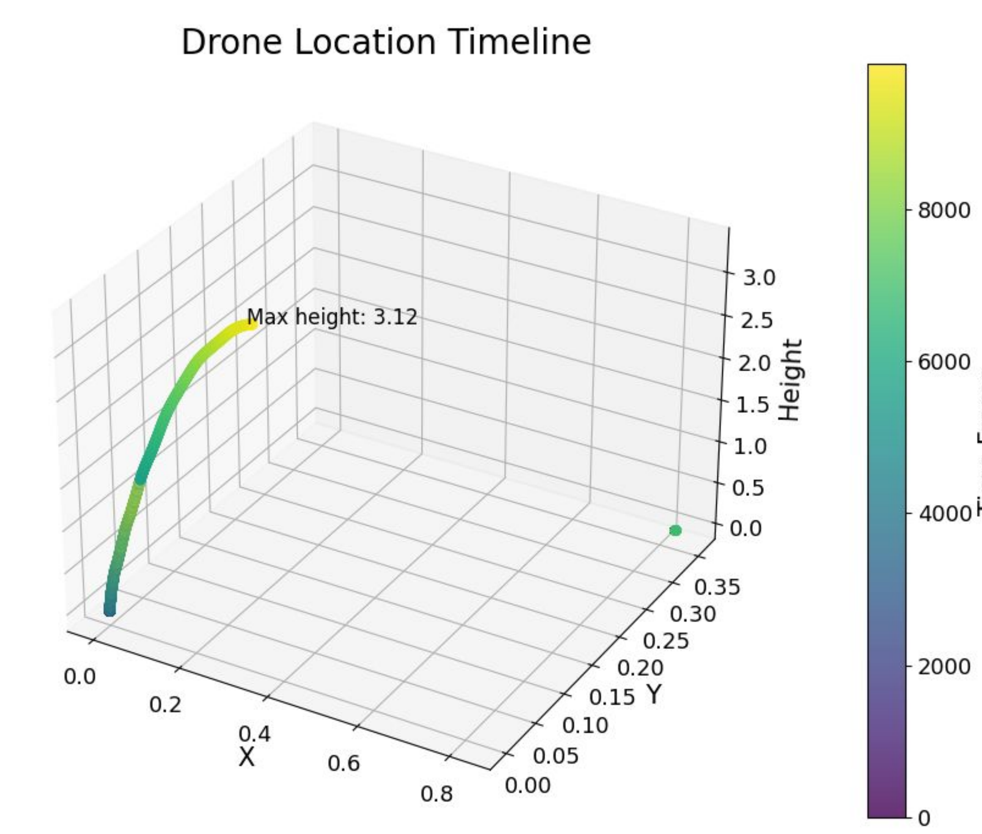
Result

- Our drone successfully **flies**, **hovers**, and **lands** in the simulator with seed=2.



- Created **network** with the **best performance** using TENNLab network visualizer
- Input layers are directly connected to the output layers
  - No intermediate layers

- Visualized **flight path** of the drone
  - For this network, drone reached 3.12 meters then landed



Conclusion

- Our drone performed well and did an excellent job of **hovering** and **landing** safely.
- For the future work, we want to implement and test it to the **physical** crazyflie drone hardware.
- Also, we will **improve performance** of the drone and try performing **different tasks** not only hovering but also going to the designed destination and coming back.

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