Event Driven Reinforcement Learning for Visual Navigation Using Neuromorphic Camera

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Introduction

Event Camera

- A novel type of sensor that records changes in pixel brightness, rather than entire frames
- Pixels operate independently of each other and only respond when brightness changes
- Data recorded is asynchronous and sparse
  - More efficient than normal camera

Reinforcement Learning

- A type of machine learning that trains algorithms to make decisions that lead to the desired result
- When the agent makes a decision that brings it closer to the desired result, it receives a reward
  - Algorithm seeks to maximize the reward
- Essentially, it is learning by trial and error

Goal of Project

The overall goal of this project is to enable a robot to autonomously navigate and avoid obstacles using an event camera.

Development

Event Histograms

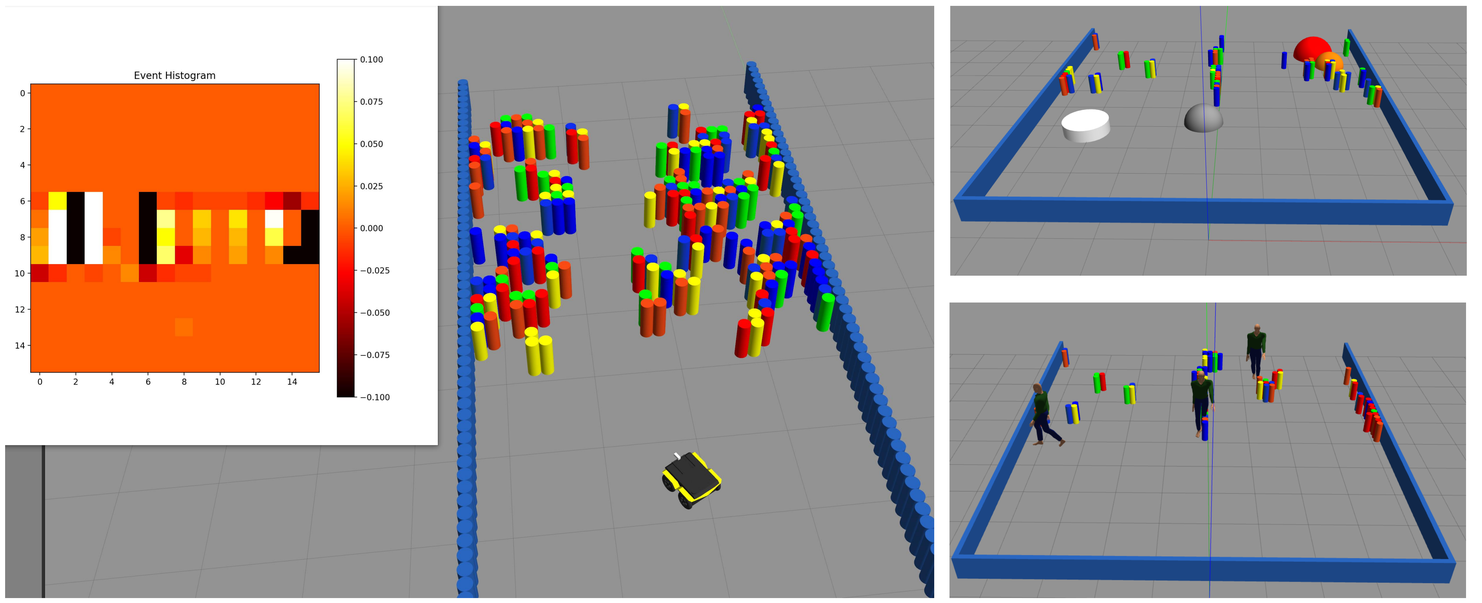
- Representations of event data in an image-like form
- White represents positive events, where the camera has seen an increase in brightness
- Black represents negative events, where the camera has seen a decrease in brightness
- Orange represents an absence of events
- The agent will guide the robot towards areas with no events, which indicate an absence of obstacles

Simulated Environments

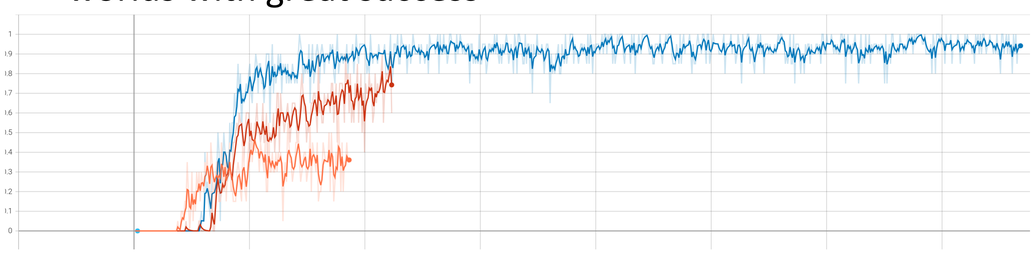
- The more variety in the simulated environments the algorithm learns to navigate, the more robust and capable the final model will be
- We will use **static worlds** with shapes that don't move, **dynamic worlds** with shapes that move at random angles, and **hybrid worlds** with a combination of static and dynamic shapes

Results

- Shown below are some simulated worlds for training. The event histogram is from the camera mounted on the ground robot.



- We are still in early phases of training, but the algorithm is learning to navigate static worlds with great success



Graph shows successful navigation vs training steps, converging to >90%

Conclusions & Future Work

- Event cameras have much lower latency than normal cameras, making them ideal for autonomous navigation where response time is important (i.e. self-driving cars)
- We plan to publish this work, and it will serve as a benchmark for navigation techniques with event cameras
  - Currently, our success is comparable to obstacle avoidance algorithms that use other types of sensors [1]
- Future Steps
  - Fully train model in all world types
  - Conduct real world experiments with Jackal UGV

References

[1] Zifan Xu, Bo Liu, Xuesu Xiao, Anirudh Nair, and Peter Stone. "Benchmarking Reinforcement Learning Techniques for Autonomous Navigation." 2023 IEEE International Conference on Robotics and Automation, May 29-June 2, 2023.

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