Rogues Gallery – Neuromorphic Team - Fall 2021

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Introduction & Goals

Introduction

The Neuromorphic Team specializes in neuromorphic, also known as brain-inspired, computing applications.

Semester Goals

- Develop an architecture for an autonomous navigation system, with communication between components.
- Assemble NeuroCar/camera components and configure ROS to prepare for software running on the vehicle.
- Introduce new members to neuromorphic tools and concepts.

Key Concepts & Results

Deep Deterministic Policy Gradient (DDPG)

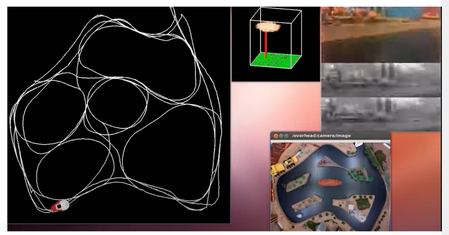
- A reinforcement learning technique that combines both Q-learning and Policy gradients. We chose to work with this algorithm as it operates over continuous action spaces, which is well-suited for our autonomous driving environment.
- We initially created a simple physics environment (DDPG-playground) to evaluate DDPG for vehicle control. The network receives 2D map of an environment and vehicle odometry, then outputs throttle and steering value.

Nengo Maze

- Uses Nengo LearningRules to "learn" to approximate Dijkstra's algorithm on a maze with limited sight radius.
- POC of algorithm that would be used by NeuroCar

RatSLAM

- A form of Simultaneous Localization and Mapping (SLAM) inspired by rat brains.This is a neuromorphic method of mapping and tracking location within an environment. We are using an Open Source version called OpenRatSLAM.



The Neuro-Car

A small-scale, low-power autonomous vehicle that utilizes spiking neural networks to power onboard decision-making.

Chassis

- The chassis is a SunFounder PiCar-S, an affordable and simple Raspberry Pi 4-based robot with rear-wheel drive and front-wheel steering. It exposes a set of Python bindings to control its servos and motors for movement.

Manual Control

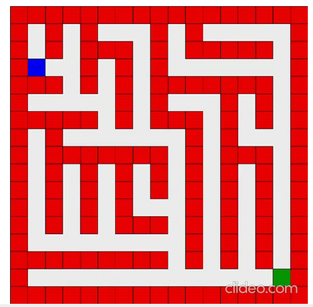
- For performance testing as well as data collection, a custom client-server architecture for manual control of the chassis has been created to handle both keyboard and Xbox controller inputs.

Camera & Video Streaming

- The chassis has a front-mounted camera module. The video stream can be viewed via a web browser which is provided by the MJPG Streamer library.

BCI- Classifying Motor Control Signals

We continued the development of a Brain Computer Interface using continuous EEG data with a SNN. EEG data for finger pose movement was used to train a classifier in Nengo, which is currently being tweaked and cleaned up to increase classification accuracy.



Next Steps & Challenges

Challenges

- Working with ROS (Robotic Operating System).
- Assembling and controlling the PiCar chassis.
- Implementing a version of DDPG applicable to our use cases.

Next Steps

- Get OpenRatSLAM running on the NeuroCar.
- Train a DDPG model to work on the NeuroCar.