Multi-Robot Path-Finding

Vrinda Bansal, VrindaBansal2@gmail.com
Automatic Coordination of Teams (ACT) Lab, Part of RASC
Dougherty Valley High School, Class of 2022
USC Viterbi Department of Computer Science, SHINE 2020

Introduction

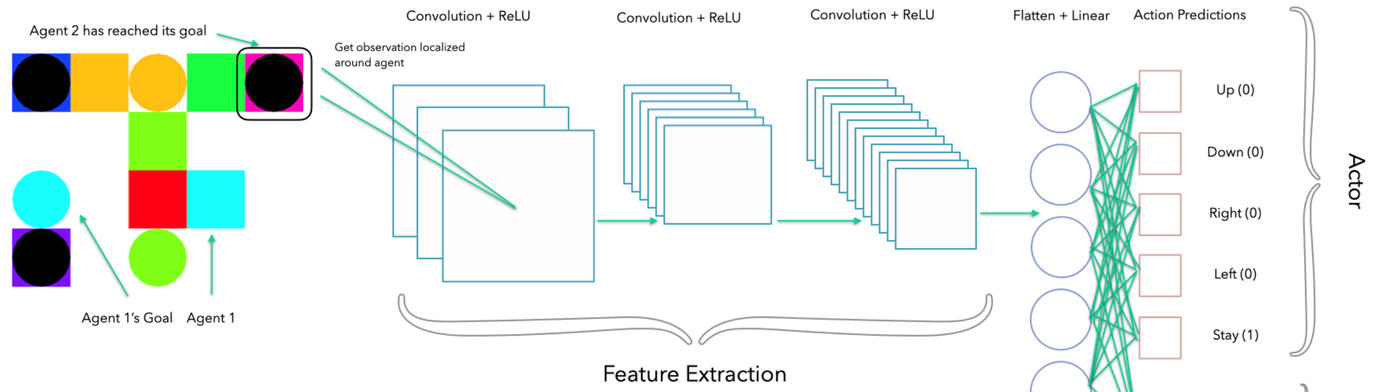
The research that the ACT LAB is doing under Professor Nora Ayanian, and Eric Ewing is Multi-Robot Path Finding, or multi-agent path finding (MAPF). This is similar to warehouse problems where there are robots transferring goods to one location and then to the other without running into other robots and completing the task in time.

Amazon is a leading example in this field as they solve and utilize this exact solution in their warehouses.

To actually test this out, ACT Lab uses drones to simulate such an environment.

Our Approach

We are solving this problem using deep neural networks with Pytorch. With neural networks we created many different layers to optimize the learning. The layers we used were, convolutional layers, linear layers, Advantage Actor Critic. These layers aided in creating a deeper network that produced more accurate results.



We tested different things along the way including adding a variety of environments, changed up the amount of robots (agents) in the environment trying to solve the problem. Eventually, we decided to make it more realistic by adding obstacles.

Training Process

We analyzed the training loss, reward, average reward and length. After a certain point (1 hr) the graph flattens out, it is done training (exploiting)

By 1 hour we see a constant negative reward. this was our exploration phase.

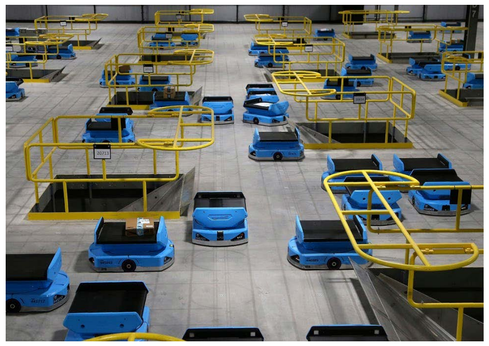
Skills learned

Throughout SHINE, I learnt many new skills. From the ACT Lab, I learned PyTorch, MatLab (used matplotlib), OpenAIGym, reinforcement learning and deep learning. From SHINE, I learned how to analyze research papers, create scholarly knowledge, and how to craft a story/present ourselves.

Problem

To solve MAPF we are essentially solving a problem where we have many robots trying to get to their own goals which could be anywhere in a confined space.

This is an optimization problem using reinforcement learning where we have to avoid conflict between the robots. Alongside this, we have to optimize the time and efficiency at which the robotics get to their destination.



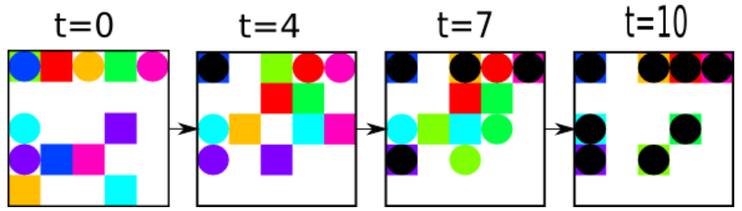
Our Results

While solving the MAPF problem, we went from basic reinforcement learning to single-agent path-finding (SAPF), to multi agent path finding & then to a more realistic environment with obstacles.

```
[[0. 1. 0. 0.]
 [0. 0. 0. 0.]
 [2. 0. 0. 0.]
 [0. 0. 0. 0.]]
[[1. 0. 0. 0.]
 [0. 0. 0. 0.]
 [2. 0. 0. 0.]
 [0. 0. 0. 0.]]
[[0. 0. 0. 0.]
 [1. 0. 0. 0.]
 [2. 0. 0. 0.]
 [0. 0. 0. 0.]]
[[0. 0. 0. 0.]
 [0. 0. 0. 0.]
 [1. 0. 0. 0.]
 [0. 0. 0. 0.]]
```

This is our first steps. The matrices indicate the environment (warehouse), 2 is the goal,1 is the agent. and 0 is empty space.

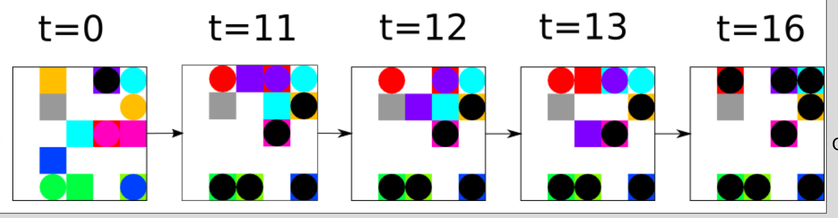
This is our SAPF example where after about 10 secs of training, our agent reaches its goal within three steps. By the end the goal is swallowed by the 1 means the agent has reached its goal.



This example is our second step of multi agent path finding with many agents in a confined space. The colored squares indicate the robots and the corresponding circle is the goal it must reach. T indicates the time step.

In this model the agents reach to their goals successfully without clashing and they work together to help each other.

Here is our fully solved environment where each agent reaches its goals successfully despite the grey obstacle. This is a unique situation where at the end the blue one is in a deadlock and despite being so close to its goal, the red and purple have to move away to yield to the blue agent.



Next Steps for Me OR Advice for Future SHINE Students

In the future, I would love to continue my work at the ACT Lab! Future SHINE students —

- Ask LOTS of questions
- Take notes
- Don't be afraid to try & test different things!

Acknowledgements

A big thank you to my PI, Dr. Nora Ayanian, my Ph.D mentor, Mr. Eric Ewing, and my lab partner, Anthony Florez-Alvarez for helping through this amazing journey. Another thank you to the whole SHINE team and Dr. Katie Mills for mentoring me on the way.

O'Brien, Matt. "As Robots Slowly Take over Amazon's Warehouses, Are They Causing More Harm than Good?" *Independent*, 30 Dec. 2019, 12:12, As robots slowly take over Amazon's warehouses, are they causing more harm than good?