Progress Report for Autonomous Parking with DRL

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Abstract

The main problem of the project is to train an agent that controls a vehicle to park in the desired spot while avoiding collision with obstacles. This problem arises from the rapid development of autonomous vehicles. Compared to parking manually, autonomous parking not only saves time, but also achieves more compact parking spaces: it can significantly boost the operation efficiency of both private cars and commercial trucks.

We aim to train an agent that is able to park the vehicle in the target spot from any feasible starting position, under time or space constraints. We approach the problem by modeling it as an environment with continuous state space (position, angle, etc.) and discrete action space (steering, direction, etc.); then we will attempt to train the agent with two algorithms: DQN and PPO. While traditional studies often focus on the parking of cars, we will attempt to park trailer trucks, which have more complex mechanics than cars and are more common in industrial contexts. A real-world application of the problem would be autonomous parking of trailer trucks to facilitate efficient cargo loading and unloading. To start with, we aim to train the agent to back a trailer truck straight into a parking spot that is directly behind it (this is easy for cars, but tricky for trailer trucks).

Different from these existing works, we will attempt to solve the parking problem with tighter time and space constraints, in order to maximize the time and space efficiency of parking.

1 Project Overview

We aim to leverage the existing deep reinforcement learning models to solve this problem and test various algorithms to train the agent to back a trailer truck straight into a parking spot with constrained open spaces.

For the first stage of the experiments, we tested the DQN algorithm to train the agent to back a trailer truck straight into a parking spot with constrained open spaces.

2 Team Member Roles/Tasks

2.1 Yuchen Wu

1. Build the environment via gymnasium.
2. Test basic DQN algorithm
3. Writing the paper.

2.2 Zheyuan Wu

1. Provides supporting functions and code reviews for the environment
2. Test DDPG algorithm
3. Maintaining documentation and consistent environment

4. Hyperparameter tuning

5. Writing the paper and create visualization

3 Initial Results

We have implemented the environment for trailer trucks using pygame and gymnasium[2]. We have tested the DQN algorithm to train the agent to back a trailer truck straight into a parking spot with constrained open spaces.

We use stable-baselines3 [1] as our main framework for deep reinforcement learning.

4 Current Concerns and Questions

5 Tentative Plan

- Week 1: Review the existing literature and the related works.
- Week 2: implement the environment with gymnasium-like frameworks for trailer truck parking.
- Week 3: train the agent with DQN and PPO on home computer.
- Week 4: evaluate the performance of the agent and compare it with the existing literature.
- Week 5: try to use the cloud resources to train the agent with more complicated algorithms or add more constraints to the environment to make it more robust and realistic to real-world applications.
- Week 6: deliver the report and the video demonstration of the agent's performance.

References

[1] Antonin Raffin et al. "Stable-Baselines3: Reliable Reinforcement Learning Implementations". In: *Journal of Machine Learning Research* 22.268 (2021), pp. 1–8. URL: `http://jmlr.org/papers/v22/20-1364.html`.

[2] Mark Towers et al. "Gymnasium: A Standard Interface for Reinforcement Learning Environments". In: *arXiv preprint arXiv:2407.17032* (2024).