WASP Project Course 2021

Vision-Based Deep Reinforcement Learning for Robot Navigation

Background

The goal of this project is to apply reinforcement learning (RL) to control a robot in the task of autonomous navigation. As a first step, experiments would be conducted in the virtual world where the task and environment can be configured on demand. Navigation tasks of interest include, but are not limited to, driving along a road, navigating around obstacles, and following other agents. To this end, the Algoryx simulator could be a possible option for our experiments.

Further plans for this project are to perform real-world experiments and to investigate to what extent a simulated environment can be applied as a pretraining resource for similar tasks in a real environment. However, accomplishing the shift from simulation to the real world during the project period depends largely on the situation, and particularly the pandemic.

The real-world experiments would be performed on a Husqvarna Research Platform (HRP), which is a Husqvarna Automower that can be controlled through a wired interface. Additionally, "Visionen" at Linköping University is considered as our configurable real-world environment, which is equipped with cameras projecting images of roads, grass, obstacles etc. onto the floor.

The RL agents in this project are vision-based, and therefore, a perception module is required to train them. However, since the main focus of this project is reinforcement learning rather than perception, the idea is to use an already existing perception module for this purpose. One possible solution is to apply an ImageNet-pretrained network to generate deep features as the input for our RL agent, or alternatively, histograms based on segmentation predictions [1].

Constraints: Algoryx simulation environment, Visionen at Linköping University as the potential real-world environment, Husqvarna Research Platform (HRP) as the physical RL agent platform.

Figure 1: Husqvarna Automower, simulated (left) and real (right).

Participants

Industrial partner: Husqvarna

Industrial supervisor: Georg Hägele, georg.hagele@husqvarnagroup.com

Academic supervisor: Zahra Gharaee, zahra.gharaee@liu.se, Computer Vision Laboratory, Linköping University

Coordinating WARA representative: Jonas Larsson, WARA Robotics

Suggested WASP PhD students: Arvi Jonnarth

Challenges to investigate

- Which RL method is most suitable to address our research problem? (literature study)
- How should the reward function be designed and implemented to be applicable both in the virtual and real world? (design and implementation)
- What types of input features are suitable for training the RL agent both in the virtual and the real world? (design and implementation)
- Which is more practical and desirable for generating the input space: The ground-truth semantic segmentation map or the pre-trained deep features? (comparison)
- How should the action space be designed and implemented to be applicable both in the virtual and the real world? (design and implementation)

Resources

- Algoryx simulator
- Computing hardware for training the RL agents
- Husqvarna Research Platform (HRP) (if real-world experiments are possible)
- Visionen at LiU (if real-world experiments are possible)

Deliverables

- RL agent that can navigate in a simulated environment.
- A technical report describing the choices made for the questions posed in *Challenges to investigate*.

If time and the pandemic situation permit:

- RL agent capable of navigating in the real world.
- An investigation on whether a simulated environment can be used to pre-train an RL agent for the real world.

References

[1] Z. Gharaee, K. Holmquist, L. He, and M. Felsberg. A Bayesian Approach to Reinforcement Learning of Vision-Based Vehicular Control. *25th International Conference on Pattern Recognition (ICPR)*, pages 3947-3954, 2021.

Keywords

Robot navigation, reinforcement learning, autonomous systems, computer vision, simulation, digital twin.