Deep Reinforcement Learning for Autonomous Systems

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This document represents the summary of my master thesis project. The source code of this work is publicly available at `https://github.com/pieromacaluso/Deep-RL-Autonomous-Systems`

1. Introduction

Because of its potential to thoroughly change mobility and transport, autonomous systems and self-driving vehicles are attracting much attention from both the research community and industry. Recent work has demonstrated that it is possible to rely on a comprehensive understanding of the immediate environment while following simple high-level directions, to obtain a more scalable approach that can revolutionise autonomous driving by making it a ubiquitous technology. However, to date, the majority of the methods concentrate on deterministic control optimisation algorithms to select the right action, while the usage of deep learning and machine learning is entirely dedicated to object detection and recognition.

Recently, we have witnessed a remarkable increase in interest in Reinforcement Learning (RL). It is a machine learning field focused on solving Markov Decision Processes (MDP), where an agent learns to act in an environment by mapping situations and actions, trying to maximise some reward function. It learns to make decisions according to the information it gathers from the surrounding environment and from the reward it receives. As researchers discovered, it can be surprisingly useful to solve tasks in simulated environments like games and computer games, and it showed encouraging performance in tasks with robotic manipulators. Furthermore, the great fervour produced by the widespread exploitation of deep learning opened the doors to function approximation with convolutional neural networks, developing what is nowadays known as deep reinforcement learning.

1.1. Objective

In this Thesis, we argue that the generality of reinforcement learning makes it a useful framework where to apply autonomous driving to inject artificial intelligence not only in the detection component but also in the decision-making one. The focus of the majority of reinforcement learning projects is on a simulated environment. However, a more challenging approach of reinforcement learning consists of the application of this type of algorithms in the real world. For this reason, we designed and implemented a control system for Cozmo, a small toy robot developed by Anki company, by exploiting the Cozmo SDK and OpenAI Gym to build up a standardised environment in which to apply any reinforcement learning algorithm. This implementation represents the first contribution of our thesis. The second contribution of our work consists of the implementation of Soft Actor-Critic (SAC), a model-free reinforcement learning algorithm suitable for real-world experiments, to solve the self-driving task. The maximum value reached in the testing phase by the agent is beyond 3 metres with a mean of almost 1 metre. However, because of the instability of the results obtained, we focused on strength and weaknesses of this approach outlining what could be next steps to make this cutting-edge technology concrete and efficient.

2. Design of the control system

3. Experiments

3.1. Experiments with Pendulum-v0

3.2. Experiments with CozmoDriver-v0

4. Conclusions

4.1. Future Work

References