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Deep Reinforcement Learning
for Autonomous Driving: A Survey

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Paper Review

The Paper overview

This paper discusses the role of Reinforcement learning (RL) for the construction of Autonomous driving (AD) systems. Classical supervised learning methods are no longer applicable for some of the tasks such as optimal driving speed, optimal trajectory ... etc. The agent, which is in this case the autonomous car, is required to take the optimal action, a.k.a policy, at each instance.

This Review convers the notions of RL, its uses and deployments in the domain of driving policy and finally demonstrate the challenges and risks when applying different RL algorithms.

The problem that the paper solves

When designing an AD system, to achieve high precision we need to address the following issues: the prediction of agent future optimal actions to accomplish optimal driving speed for example, dealing with the uncertainty in the environment and control the dynamics of the agent through supervisory signals such as time to collision and later error with respect to optimal trajectory of the agent.

To address such problems, we need to maximize the stochastic cost function and the agent is required to learn new configurations (exploration) of the environment and predict optimal decision at each instance while navigating through it. This can be achieved through the integration of RL. This paper tries to show how to use RL in AD systems to solve these problems as well as the risks and computation challenges that we face when applying current day RL algorithms such imitation learning, deep Q learning, among others.

The basic directions of the related work so far in literature

The trends of publications show that the use of RL or keep RL applied to self-driving is an emergent field. This is due to the increased use of RL/DRL algorithms in recent years, which has created plenty of real-world implementation and deployment issues.

The basic direction of related work in literature is toward solving some of the real-world challenges and future perspectives such as: validating RL systems, bridging the simulation-reality gap, sample efficiency, exploration issues with imitation, Intrinsic Reward functions, Incorporating safety in DRL and finally multi-agent reinforcement learning.

The relevant Topic of the machine intelligence and how this paper addressed the problem that it tries to solve

This paper solves the problem discussed earlier using RL. AD tasks where RL could be applied include path planning and trajectory optimization, motion planning, development of driving policies, scenario-based policy learning, reward learning with RL from data for intent prediction for traffic actors and finally learning of policies that ensures safety and perform risk estimation.

First step to apply RL to AD systems is to design adequate state and action spaces and reward functions. Some of the features that are used for state space are the position, heading and velocity. The actuators can be represented by the steering angle, brake gear … Some of the criteria for the reward functions may be the distance travelled, the speed, collisions with other objects or agents.

Motion planning and the trajectory optimization ensures that there exists a path between the target and the destination. Some of the suggested application of RL for path planning in dynamic environments is through the use of deep neural networks to generate predictions in simulated environments over hundreds of time stops. RL methods are also used to perform optimal control in stochastic settings.

One important task is the simulator and scenario generation tools. This task requires an environment where state-action pairs can be tried to model the dynamics of the vehicle and the uncertainty of the environment and of the vehicle movement itself.

Learning from demonstration (LFD) and inverse reinforcement learning (IRL) may be used for AD application. Example of LFD is Behavior Cloning (BC) which mimic the behavior of an expert, but it is implemented using supervised learning which means that it is hard to adapt to new environments. Also, IRL may be used by inferring the reward function of the agent, given its policy or observed behavior.

The paper Scientific contribution

This work's primary contributions can be summarized as follows:

- As it is no well-known, this paper offers an overview of RL background for the community of automotives.
- It also provides a focused literature review for the use of RL for difference tasks of autonomous driving
- It discusses the key obstacles/challenges and potential for the application of RL in real-world autonomous driving.

Evaluation of the paper

From my point of view, this paper provides a great knowledge in a very simple and understandable way. It groups years of science and development into few pages and summarizes some of the most important, basic and popular topics used in this machine intelligence in a very clear way.

The paper is very well organized, before starting with the use of RL in AD systems, it provided a very good explanation of RL and its equations. Not to mention the literature that it is referring to is very helpful and detailed. The literature covers all the related topics and references the points that it did not cover so deeply.

Overall, I learned so much from reading this paper. And it clarified a lot of concepts and showed me how RL is used in real-world applications.