

# Autonomous Car Parking

## CS7IS2 Project (2021/2022)

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**Abstract.** Motivation behind the work, high level description of the problem, how it was solved by the proposed algorithms.

**Keywords:** soft-actor-critic, behaviour cloning, evolutionary algorithm, parking

## 1 Introduction

The Autonomous Vehicle (AV) industry is one of the most active and promising area in the recent years with many ongoing research to make it fully autonomous [14]. The International Society of Automotive Engineers (SAE) proposed a six-degree autonomy scale with level 0 as no automation and level 5 as full automation without any human interventions [12]. The current level of autonomy scale achieved today is between level 2 and 3 requiring some assistance from the driver and limited to ideal conditions.

Car parking is challenging and disliked by most drivers due to time required searching for spaces, risk of scratching vehicle, safety of pedestrian, etc [1][7]. It requires the driver to estimate the space required for the car and manoeuvre it into available space by controlling the steering angle and accelerator. While in fact the traffic report statistics survey results found in 12 million traffic accidents, there are about 10,000 traffic accidents occurring in the parking lots with many more number of accidents not reported [16].

Most vehicles are parked 95% throughout the lifetime [3]. Parking is required by every driver and apply AV will greatly improve the quality of life and ease of drivers. It increases driving safety by utilising various sensors to understand the environment surround vehicle and park at the designated space avoid collisions due to lack of human experiences [16]. Other potential application for autonomous car parking is saving spaces in car parking lots by parking in an optimal grid resulting in a much efficient parking lot capable of more car [3].

The highway-env github repository<sup>1</sup> contains a collection of autonomous driving and tactical decision-making tasks environment [8]. The parking environment<sup>2</sup> is selected for the project which is a goal-conditioned continuous control task in a given space with a vehicle aiming to reach the destination point. The

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<sup>1</sup> <https://github.com/eleurent/highway-env>

<sup>2</sup> id of "parking-v0"

parking environment uses a grid like layout similar to actual car parks. the vehicle requires input of the steering angle and accelerator. Policy based algorithm is commonly used for autonomous vehicles instead of value based algorithm due its large action decision requiring huge memory [13]. The selected algorithms to be investigated in the project are Soft-Actor-Critic (SAC) from the reinforcement learning family, behaviour cloning from the imitation family and evolutionary algorithm from the genetic population-based family.

## 2 Related Work

The autonomous vehicle control system consists of mission trajectory planning system generating path for vehicle to reach target, navigation system detecting environment and either moving or fixed target and trajectory tracking controller to navigate the vehicle accordingly [9]. Path planning problem is the main subject of most autonomous vehicle studies. Prior to path planning, the algorithm needs to know the state of the vehicle such as its position and direction. GPS is commonly used to deduce the state by using signals Line Of Sight (LOS) from positioning satellite but not possible in the context of indoor parking lots [5] and high-rise buildings [11]. Instead other data be used to monitor the state of vehicle such as vision-based sensors and LiDAR sensors [2]. The works related to autonomous car parking uses different inputs and types algorithm families, this section will mainly focus on selected algorithms in Section 1.

Behaviour Cloning (BC) is from the Imitation learning family which uses observations from the expert to learn [15]. In paper [11] trains a Recurrent Convolutional Network for autonomous driving in lane changing context by using BC to learn from human experts driving vehicles. The paper noted the ease of changing architecture when using BC technique and found that spatio-temporal properties worked well in dynamic environments. The huge advantage of BC algorithm is its end-to-end trainable architecture which uses supervised learning to learn policies from an expert by inferring expert's actions [4][6][10][11]. However the BC approach suffers from several limitations such as over-fitting and generalisation issue [4]. BC algorithm is a simple yet effective approach in the project and it can be used to learn the other algorithms selected in the project.

## 3 Problem Definition and Algorithm

Problem definition and algorithm

## 4 Experimental Results

Experimental result

## 5 Conclusions

Conclusion

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