# TAS
# Group A: Project Proposal
# Topic: Parallel Parking

## 1. General Idea

Since the introduction of Light Detection and Ranging (LiDAR) as a mean to measure distances [Middleton and Spilhaus 1954], huge shifts have taken place in the (private) transport industry. Nowadays, LiDAR is said to be one of the key instruments for the success of autonomous vehicles [Roriz et al. 2022]. The core principle of LiDAR is measuring distances by computing the round-trip time of laser pulses traveling to a certain target and back (Figure 1).

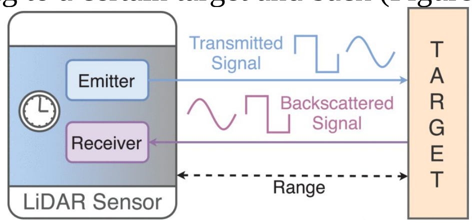


Figure 1: LiDAR operation principle [Roriz, Cabral et al. 2022].

Being one important field of future autonomous navigation, using LiDAR for parallel and reverse parking suits the scope of this project. Three different sub-tasks/phases have been deduced to work on this issue (Figure 2),consisting of spotting the parking space (phase 1), determining if it is sufficiently large to fit the TAS Car (phase 2), and lastly, the parking maneuver itself (phase 3).

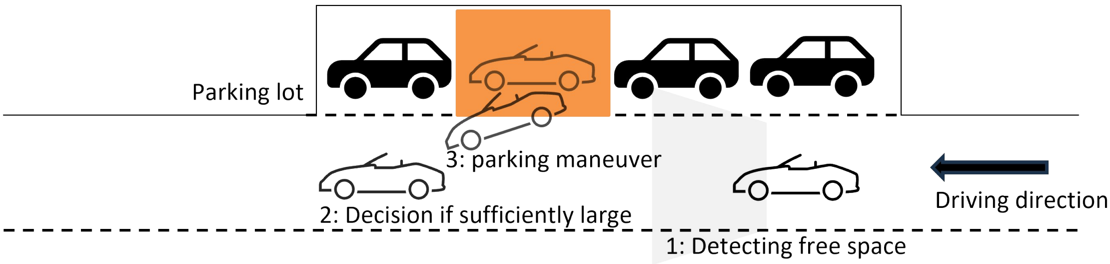


Figure 2: Parallel Parking - Sub-problems.

## 2. Approach

As already described above, the goal of this project can be divided into three phases (Figure 2), which can be tackled independently. We are planning not to use a global map. Instead, some kind of SLAM algorithm will be used throughout the process to gain information about the close proximity. We restrict our use case to the car starting in the driving direction with parked cars already next to the TAS Car. The car will choose the next best suitable parking lot. Once our car is parked, the process is finished.

### 2.1 Detecting free space

In the first phase, the task of the car is to follow the road ahead and look for possible parking spaces on its right-hand side. In this phase, we plan to control the TAS Car using the LiDAR to maintain a safe and consistent distance to the parked cars on the right. In our test setup, the already parked cars will be represented by either shoe-boxes (if they can be detected by the LiDAR) or cupboards in combination with cardboard.

### 2.2 Evaluating parking space

During the second phase of the problem, the TAS Car has to decide whether the gap found between the parked cars is sufficiently large to perform a parallel parking maneuver. Here, the LiDAR will be used to scan the available space while driving past it and compare it to the minimum space required for performing the parking maneuver. We anticipate two major challenges to address. First, there is an apparent significant blind spot for the LiDAR. Second, there seems to be a deviation between how the car is modeled and how LiDAR data is represented in ROS.

### 2.3 Parking maneuver

The third and final phase of the parallel parking goal involves the TAS Car calculating the path and trajectory needed to get into the parking space. Motion planners, such as sampling-based methods like Bi-RRT*, A* or geometric planning approaches, can be implemented to ensure high path quality and consistency across various parking scenarios. During this operation, the LiDAR and Odometry Sensors will constantly be used to update the trajectory and check for possible collisions. Here, we also expect to encounter and need to resolve the issues described in 2.2.

After checking the accuracy (0.1 to 10m: ±30mm, 10 to 30m: ±50mm), Angular Resolution: 0.25°(360°/1,440 steps) and Resolution (25msec/scan) of LiDAR from the manufacturer, it can be taken that it is more than suitable for our Use-Case. Working on all three sub-problems / phases can be done in parallel since these are independent of each other and can later be combined in a state-machine.

## 3. Potential Additional Tasks

To extend the project the parallel parking algorithm could be further developed to also be able to perform a reverse parking maneuver. In order to implement this, the already developed trajectory planning algorithm from the previous task should suffice. Therefore, only a decision making model should need implementing.
Furthermore the provided depth camera on the TAS Car could be used to enhance the performance of the algorithm. To achieve this goal a concept of sensor-fusion will have to be developed. Usage of the depth camera would also open the further possibility to incorporate street sign reading or line following into the algorithm, which would widen the scope of the test scenario and bring it closer to real world implementation.

## 4. Sources


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