CE 6308 / CS 6396 / EEDG 6308

Real-Time Systems

Assignment 2

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Objective

The objective of this project is to move the Ego vehicle through the arena given and make the Ego vehicle park in the empty space in the parking lot.

Requirements

- Problem 1 – We were asked to search for the empty parking spot in the parking lot.
- Problem 2 – We had to park the Ego vehicle safely in the parking lot.

Designated Sensors and Actuators

- **Sensors:** DeviceRegsitry.pixels, DeviceRegistry.compass, DeviceRegistry.speedometer, DeviceRegistry.lidar, DeviceRegistry.gps
- **Actuators:** DeviceRegistry.speedControl, DeviceRegistry.brakeControl, DeviceRegistry.steeringControl.

Implementation

For the implementation of this project, we created the 5 tasks given below using the sensors, actuators and state of the Ego Vehicle.

Task List

```
protected TaskInterface[] tasks = new TaskInterface[]
    {
        new InitialPosTask(),
        new RightWallFollow(),
        new WallFinder(),
        new SearchParkingSlot(),
        new ParkingTask(),
};
```

Sensors Used

```
devices.pixels
devices.compass
devices.lidar
devices.gps
```

The **`device`** is an instance of **`DeviceRegistry`**.

Actuators Used

```
devices.speedControl
devices.steeringControl
devices. brakeControl
```

To store the current state of the vehicle, we are using Ego Vehicle's memory and we created the states as listed below.

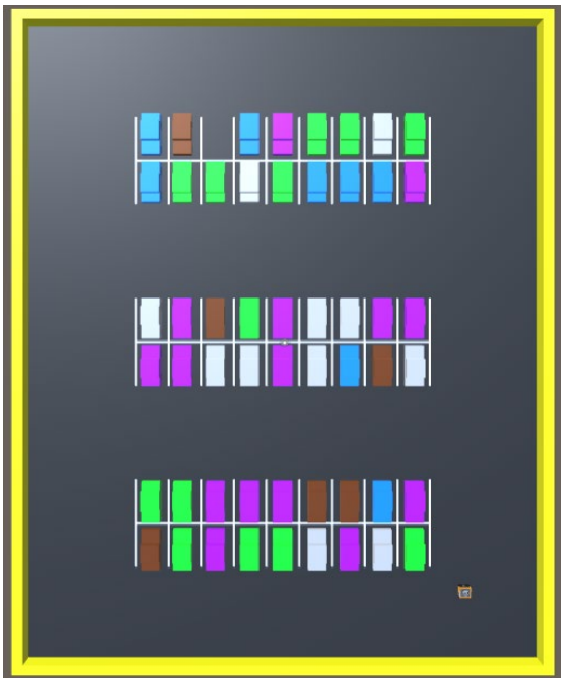
```
devices.memory
```

```
STATE_INITIAL_ORIENTATION = 0;
STATE_TAKING_INITIAL_POSITION = 1;
STATE_INITIAL_STATE_REACHED = 2;
STATE_INITIAL_DIRECTION_CALIBRATION = 3;
STATE_MOVING_FORWARD_WITH_3F_SPEED = 4;
STATE_OBJECT_DETECTION = 5;
STATE_OBJECT_DETECTED = 6;
STATE_WALL_DETECTED = 7;
STATE_FUTURE_USE = 8;
STATE_MOVING_FORWARD_WITH_1F_SPEED = 9;
STATE_LANE_DETECTION = 10;
STATE_TURNING_RIGHT = 11;
STATE_TURNING_LEFT = 12;
STATE_U_TURN_1 = 13;
STATE_ U_TURN_2 = 14;
STATE_PARKING_DETECTED = 15;
STATE_READY_FOR_PARKING = 16;
STATE_PARKING_EGO_VEHICLE = 17;
STATE_PARKING_DONE = 18;
```

Task 1: `InitialPosTask()`

Using this task, the vehicle will take its initial position by aligning itself away from the wall and near to the lane one. The vehicle will move left or right depending on its position and according to value of **`compass`**.
Using the states `STATE_INITIAL_ORIENTATION = 0` and `STATE_TAKING_INITIAL_POSITION = 1` it will orient itself towards south and move towards lane one. Using the `STATE_INITIAL_STATE_REACHED = 2` and `STATE_INITIAL_DIRECTION_CALIBRATION = 3` it will start facing the east direction.

Dependencies: `DeviceRegistry.compass`, `DeviceRegistry.gps`, `Device.memory`, `DeviceRegistry.steeringControl`

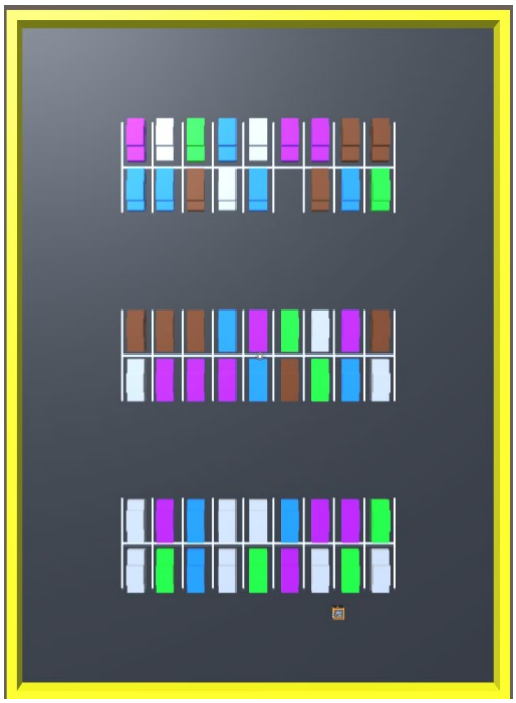


The vehicle has taken the initial position to move forward in the lane 1.

Task 2: `RightWallFollow()`

We have used the right-hand rule or the wall follower strategy therefore this task moves the ego vehicle in a straight path in the lanes. The states of the Ego vehicle are as follows -
`STATE_MOVING_FORWARD_WITH_3F_SPEED = 4;` For moving in the lanes with speed 3f
`STATE_OBJECT_DETECTION = 5;` For detects if there is an object in the path
`STATE_MOVING_FORWARD_WITH_1F_SPEED = 9;` For moving towards another lane with 1f speed
`STATE_LANE_DETECTION = 10;` Detects the other lanes
`STATE_U_TURN_1 = 13;` Used while moving from lane 2 to 3 and 4 to 5

Dependencies:
`DeviceRegistry.lidar`, `DeviceRegistry.gps`, `Device.memory`, `DeviceRegistry.pixels`



Ego Vehicle is moving in the forward direction using the right-hand rule.

Task 3: `WallFinder()`

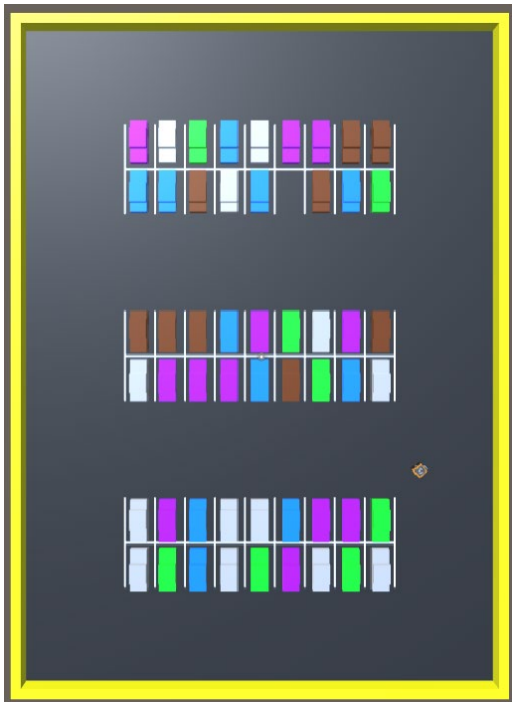
As the name suggests, the Ego vehicle is trying to find the outer walls. According to the GPS values, it will align itself away from the wall. Following states are used for this task:

`STATE_OBJECT_DETECTED = 6;` Indicates that something is in the path of the ego vehicle.
`STATE_WALL_DETECTED = 7;` Tells the Ego vehicle that the object is a wall

`STATE_TURNING_RIGHT = 11;` Taking a right turn away from the wall
`STATE_TURNING_LEFT = 12;` Taking a left turn away from the wall

`STATE_ U_TURN_2 = 14;` Using this it will take a left turn after detecting the lane

Dependencies:
`DeviceRegistry.compass`, `DeviceRegistry.gps`, `Device.memory`, `DeviceRegistry.steeringControl`.



The Ego vehicle is taking a U turn to travel from lane 2 to lane 3

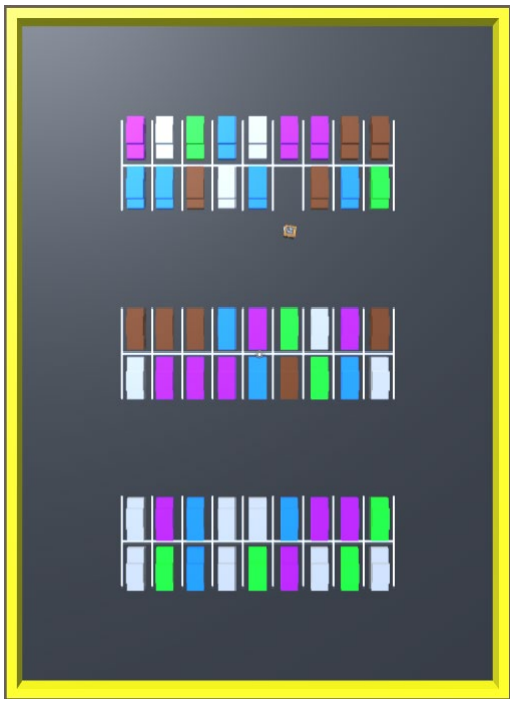
Task 4: `SearchParkingSlot()`

Using this task, the Ego vehicle is searching for the empty parking slot using lidar sensors 3 and 4. If it detects the empty space, it stops there. The states used here are:

`STATE_OBJECT_DETECTION = 5;` Used for detecting the object

`STATE_PARKING_DETECTED = 15;` Indicates that an empty spot is detected

Dependencies:
`DeviceRegistry.steeringControl, DeviceRegistry.lidar, DeviceRegistry.memory, DeviceRegistry.gps`



The Ego vehicle has detected empty parking slot and is now starting to orient itself towards the parking slot.

Task 5: `ParkingTask()`

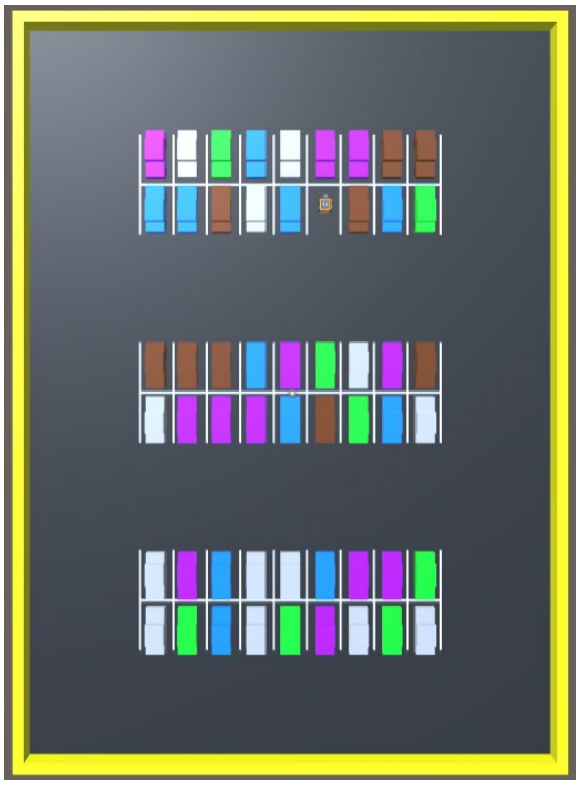
We are using this task to park the Ego Vehicle into the empty parking slot. The states we used here are:

`STATE_READY_FOR_PARKING = 16;` Using this state the ego vehicle will orient itself towards the parking slot.

`STATE_PARKING_EGO_VEHICLE = 17;` The state helps the Ego vehicle to move forward while detecting the car in front of it using the lidar.

`STATE_PARKING_DONE = 18;` This is the state of the Ego vehicle when it is successfully parked.

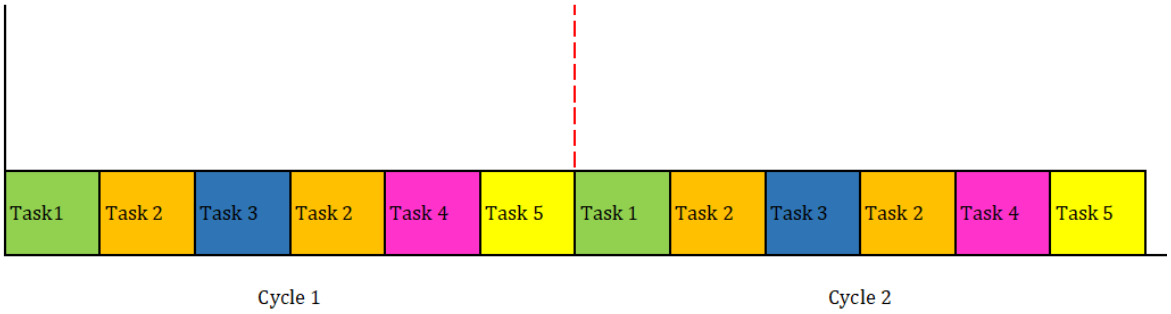
Dependencies:
`DeviceRegistry.compass, DeviceRegistry.steeringControl, DeviceRegistry.memory, DeviceRegistry.lidar, DeviceRegistry.gps`



The Ego vehicle is parked.

Task Graph for 2 cycles of simulation

The graph is made keeping in mind that the parking slot is available in lane 2.



Task 1	InitialPosTask ()
Task 2	RightWallFollow ()
Task 3	WallFinder ()
Task 4	SearchParking ()
Task 5	ParkingTask()

Task 1: InitialPosTask ( )

The ego vehicle rotates itself and align away from the wall near lane 1.

Task 2: RightWallFollow( )

Moves forward in the lanes.

Task 3: WallFinder( )

Checks the wall distance when it has to change to adjacent lanes.

Task 4: SearchParking( )

Stops near the empty parking spot.

Task 5: ParkingTask( )

Parks the ego vehicle in the empty parking spot.

Cycle 2 is same as Cycle 1