Technical University of Denmark

DTU Roadrunners - Management of Electronics in ecocar 2019

Project Report

Pelle Michael Schwartz, s147170

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1 Introduction

This report covers the work done by the student as part of a special course regarding the Ecocar for DTU Roadrunners. The Ecocar is a car built by the DTU Roadrunners to compete in a fuel efficiency challenge at the annual Shell Eco-Marathon . It also has an autonomous system, which makes the car drive completely autonomously with the aim to complete different challenges at the Autonomous Challenge (AUC) at the Shell Eco-Marathon. The course involves two main parts: Management of the team of electrical engineers at DTU Roadrunners and to learn how the Robot Operating System for the Autonomous system works. The student of the special course acted as manager for the electrical team through the course.

2 Management the Electrical Engineer Students

The management of the electrical engineers consisted of two main tasks. The first being to introduce new team members to the design of Printed Circuit Boards (PCBs) using the CAD-tool Autodesk Eagle. The second task is to manage all the students working on electronics on the Ecocar.

2.1 Teaching PCB Design

To introduce the new team members on the electrical team to work on the car, a weekly workshop for developing PCBs in Eagle was held. The students was set to design their own microcontroller using eagle. Eagle has two main steps of developing a PCB. Firstly drawing circuits with desired components on a schematic and then placing the components on the board and drawing the circuits on the board, with the aid of using "vias", which connects different layers on the board. At the start of the spring semester, the students were now ready to do their projects on the car.

2.2 Managing the Students

Managing different student projects culminating into a working car with a precise deadline requires often communication with all teams, both electrical and the mechanical. Electrical and mechanical are the two main groups of making up the team of DTU Roadrunners. Communication between these two groups is not always formidable and therefore a weekly meeting is held throughout the semesters. A single manager representing the electrical students was present at all these meetings. The task for the manager of the electrical team is to stay updated on the progression of the different project of the electrical students. The manager must know if any tasks by some of the students obstructs work planned by other students e.g. if the mechanical team has planned to dismantle the engine at the same time where the electrical team has planned to test the Engine Control Unit(ECU). Figure 1 displays the electrical team manager's role in communication. The management structure is very flat and is only added for the convenience and to increase effectiveness as well as for the course advisor to stay updated on the status of projects.

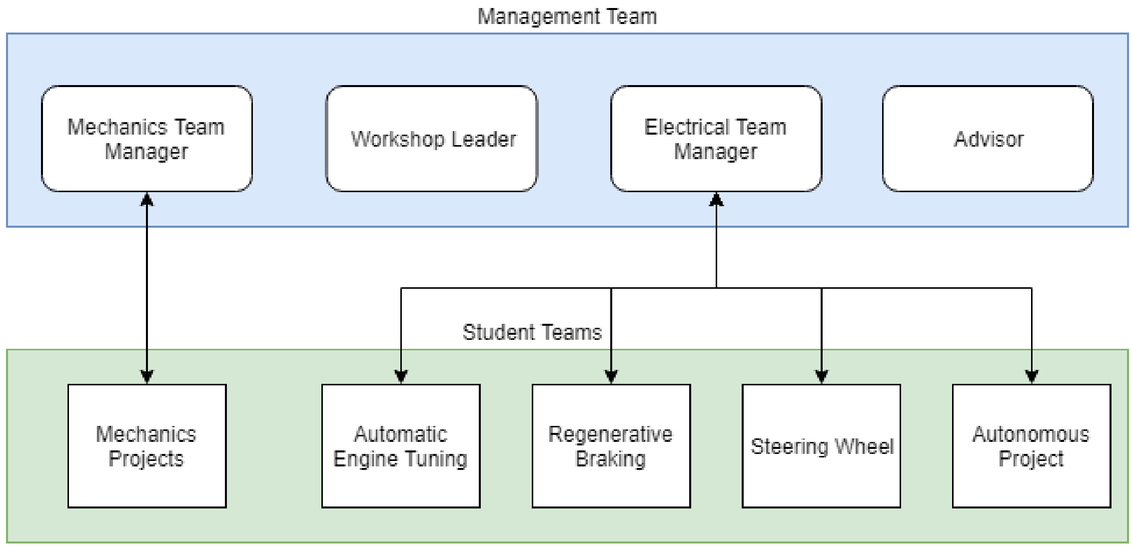

Figure 1: Depiction of the flat structure in DTU Roadrunners. The blue box represents actors in the management team and the green box are teams of students working on different projects.

3 Robot Operating System on the Ecocar

In addition to working as team leader for the electrical team, the project also consisted of working in the autonomous project. The purpose was to learn the key features and properties of ROS, which is the system implemented to administrate autonomous inputs and outputs. Secondly, another task was to get an understanding of how the Ecocar's autonomous system is implemented.

3.1 ROS and its Features

ROS is a node-based framework which enables different projects to be implemented in nodes - programs that are independent to the rest of the nodes. Each node is able to *publish* a message on specified *topics*. A topic could be "autopilot_on" with a Boolean message. Nodes are then also able to *subscribe* to topics. This way they are able to collect messages published on topics and act accordingly whenever this happens. The "autopilot_on" message could start the automatic steering as soon as a message of Boolean true is sent. It will then continue until it receives a message on the "autopilot_on" of false.

This system enables parallel projects to be designed, as long as all involved teams agrees what signals they should deliver and receive. It is also easier to change a part of the system, as changing one node is easier to get an overview of compared to reviewing a program as a whole.

3.2 ROS on the Ecocar

The Ecocar has 3 different levels of processing information which are the basic levels of autonomy. Below are described which primary nodes are in each of the categories. Around 10 other nodes doing secondary tasks are not described here.

- Localization
  - velodyne_VLP16_driver
  - car_estimate_pose
- Planning
  - VLP16_obst_detection
  - voronoi_node
- Control
  - steering_node
  - braking_node
  - motor_node

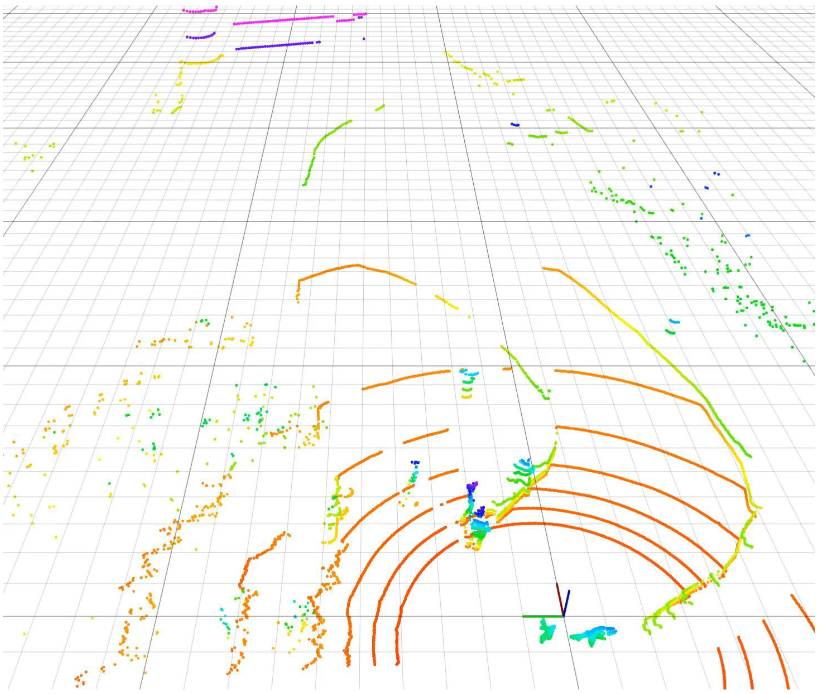

Figure 2: Point cloud generated by the VLP-16 driver. Colors of each dot represents what angle (channel) the measurement is made.

The *velodyne_VLP16_driver* interprets information given by the VLP-16 LiDAR which yields a *point-cloud* describing the sorrounding with a point-cloud each 100 ms. Figrure 2 shows a grapichal rendition of the point cloud. The car_estimate_pose node uses LiDAR information as well as gyroscope and wheel sensors to determine the location of the car. These two nodes makes up the localization or, more commonly named, the odometry of the vehicle.
The path planning is done in two steps. First the point cloud from the VLP-16 driver is interpreted using ground/obstacle detection to yield a two-dimensional top-down view of all detected obstacle points, which are grouped into obstacle hulls. These are then interpreted by the Voronoi node through the use of the Voronoi-algorithm to generate drive points in the middle of the road. Figure 3 shows how the obstacles has been sorted and drive points have been generated.

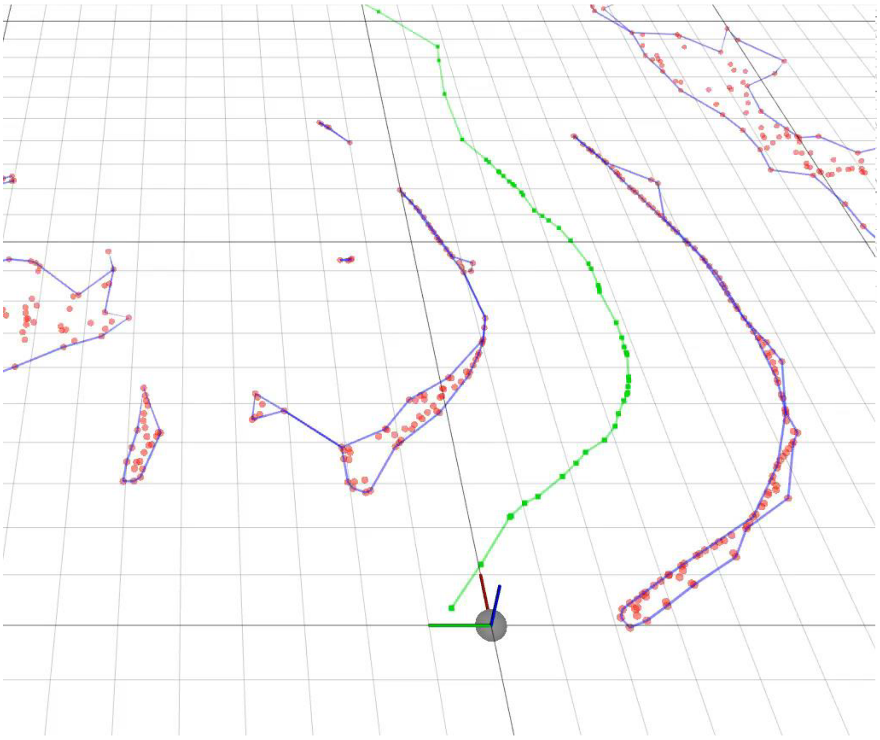

Figure 3: The middle of the road extracted for navigation marked by a green line with dots. The obstacles are red dots grouped in hulls by by the blue lines.

The steering node subscribes to the topic with drive points published by the Voronoi node. It also subscribes to the odometry to know the location as well as the speed of the car. Using this information it is able to use an algorithm called *line drive* to steer the car satisfyingly towards the generated drive point. The braking node is a controller for the linear actuator used to brake the car. Whenever a desired braking power is needed by the navigation the braking node will control it. Lastly the motor node uses the vehicle speed from the odometry to throttle whenever the car reaches below a certain threshold and stops throtteling when an upper threshold is reached. This is because the engine is only designed to give full throttle or none.

4 Conclusion

The team was working well together through the semesters, and this was partly aided by this project, which was then able to improve communication between the teams of students working on each part of the Ecocar. The student has learned how ROS functions as well as how the autonomous system is implemented on the Ecocar.

References

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