Delta X Self-Driving Competition 2022 Rules

1. INTRODUCTION

The Delta X self-driving competition is a software challenge for developing autonomous driving solutions using toy cars. The emphasis is put on software, with no changes to the hardware allowed. The cars are equipped with a camera, driving decisions are expected to be mainly based on this camera input.

The goal of the competition is to inform IT students about self-driving technologies and offer them hands-on experience in the field. This competition is part of the Autonomous Driving Lab education strategy.

The track and toy cars are made available in September 2021, the solutions must be submitted by early January 2022. Beyond the rules stated in this document, this competition abides by the general rules of the Delta X competitions.

Credit points

In autumn semester 2020, a 6 ECTS course ”Autonomous Vehicles Project” (LTAT.06.012) will be organised. Participation in the Delta X self-driving competition is one of the possible projects in that course. The course will be taught by the lecturer of autonomous driving Naveed Muhammad. Participation in this competition can be used as a course project in various other courses, e.g. Machine Learning (MTAT.03.227) taught by Dmytro Fishman.

Thesis and internship opportunities

The task of this competition closely relates to the work done in the University of Tartu Autonomous Driving Lab. One of the goals of the competition is to inform IT students and wider audiences about the competences and work done in the Autonomous Driving Lab.

This competition provides students with a good opportunity to learn more about autonomous driving technology, including image processing, path planning, controller modules, etc. Being familiarised with and having experience in these topics will increase a student’s chances of doing an internship or thesis in the Autonomous Driving Lab. Thesis topics are available on the toy car platform as well as on the real car, Lexus RX 450h.

2. COMPETITION RULES

Below, we list the main rules of the competition. If you have doubts or questions not covered by these rules, contact the organisers (Ardi Tampuu ardi.tampuu@ut.ee). The rule ”what is not forbidden, is allowed” is not applied here. Conversely, unless coordinated with organisers, custom tricks might be forbidden after you have put considerable effort into them.

The main instructions and information page of the competition is:
https://courses.cs.ut.ee/t/DeltaX2021SelfDriving/Main/HomePage

In there you find instructions for connecting to the car and driving it manually (data collection), for controlling it via Python code and additional materials.

2.1 TASKS AND PRIZES

There are two tasks.

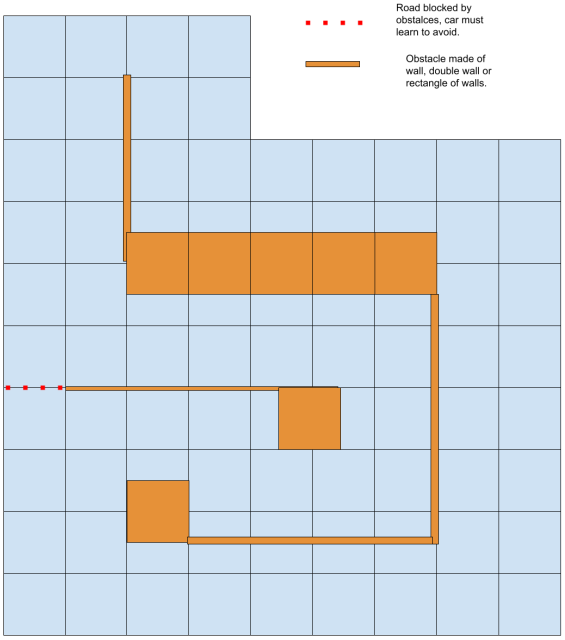
1. **Autonomous driving - obstacle avoidance**. The car must complete a lap (or complete the circuit) within the defined time limit without hitting any of the objects or the walls. Time limit is given as approximately human driving time x 2. Each team has multiple attempts.

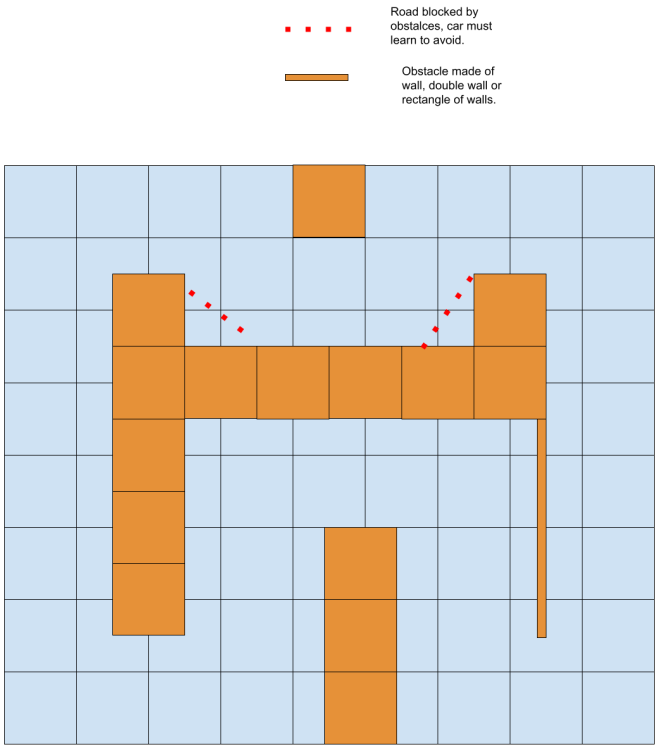
   The track width is 55-60 cm, we aim for 60cm width, but this is hard to guarantee precisely. Measurements on multiple cars confirm that the car turning diameter, as measured from the exterior wheel, is below 150cm. Hence the track is built such that multiple consecutive turns are separated sufficiently. If your car has trouble turning with this radius, your car has hardware issues. Please contact the organizers for help.

   The objects will not be placed on the inside of curves and other places where they are extremely hard to avoid due to limitations of the car's steering radius.

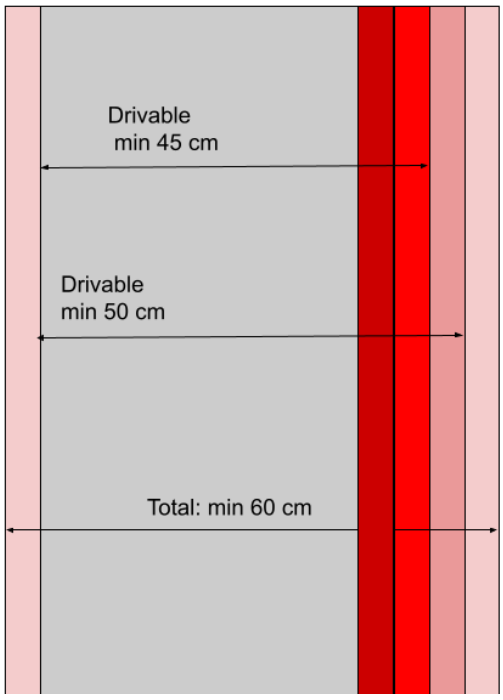
   An attempt is not interrupted at a collision if the car does not get stuck. Collisions will be counted, with long contacts with a wall being counted as multiple collisions as decided by the judges on the spot (e.g. each second counts as a separate collision). Collisions knocking down a wall will interrupt the attempt.

   Examples of possible tracks are given in the following two figures, where the unit square length is 40cm. The track is not necessarily circular and may start and end in dead-ends.



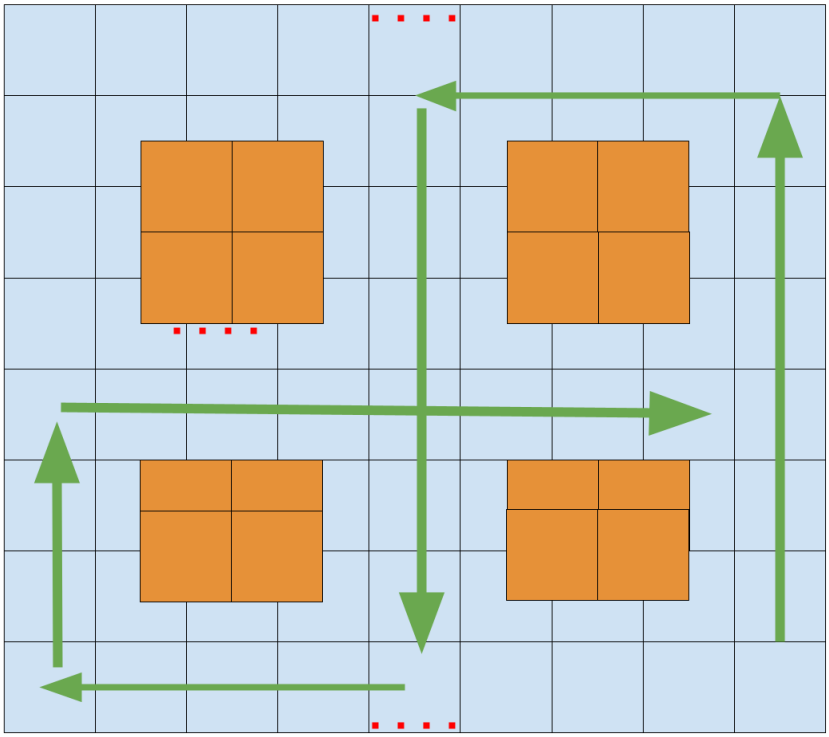


If multiple teams complete the challenge with 0 collisions, the difficulty is increased as described in Figure 3.



Difficulty levels:
objects are placed near either or both walls, leaving at all places a drivable area of mininum:
50 cm in level1
45 cm in level 2
Etc

2. **Autonomous driving - route completion.** The car must demonstrate the ability to travel a given set of routes in the following toy town (or very similar).



In this figure, the bottom two blocks of walls are of abnormal size (not unit length) due to limitations of the total available size of the arena and the rule that road width should be around 60cm. These blocks of walls can be built by placing two |_| shaped (one side open) pieces inside each other.

An example route is given on the figure with green arrows. The routes are given to the teams at the beginning of the competition and they can either encode it into their driving system or enter high-level commands [turn left, go straight, go right] on the fly when the car is driving. The team that completes most routes wins. Hitting the walls or obstacles constitutes a crash and the route is considered incomplete. The first set of routes will have no obstacles. If multiple teams succeed in completing them with 0 infractions, obstacles will be added.

2.2 HARDWARE

The remote-controlled cars that will be used in this competition and for several thesis topics are called DonkeyCars. They come equipped with a frontal camera that is the main sensor here. They also have an IMU (inertial measurement unit), that can but doesn't need to be used. The car is

1:10 scale compared to a real car.

The computation will likely happen on Raspberry Pi, which means compute efficient solutions must be used, otherwise, the driving command will be delayed and car control becomes very hard. Students are free to do the computation outside the car in a server if they wish, but the network communication itself will add at least 100ms of delay, so be cautious with that.

The most probable route to success is via Imitation Learning - you collect data of how to drive (by driving with the car yourself). You then train a machine learning model (neural network or other) to imitate your driving. Any other solution is also allowed, you can even create handcrafted rules of what to do and when.

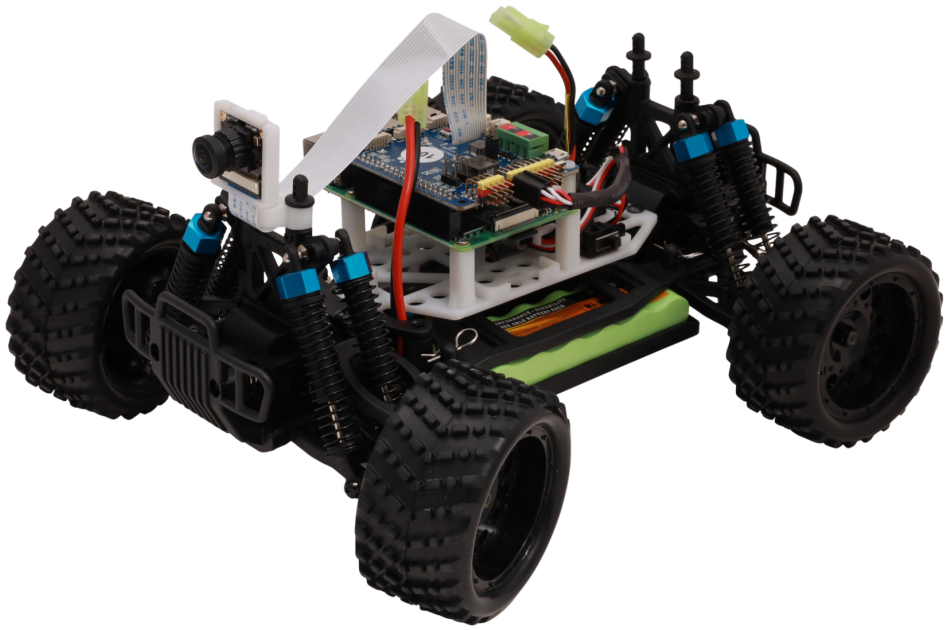


Figure 1: Remote-controlled DonkeyCar equipped with a camera, IMU, raspberry Pi and Wi-Fi connection.

2.3 RESTRICTIONS ON THE CREATED SOFTWARE AND COMPUTATIONAL RESOURCES

To claim the prizes, competing solutions must make their driving decisions based on image inputs (also IMU inputs can be used, but don't need to be). Image-dependent driving decisions must be taken with a higher frequency than 1Hz. The way of using image input is not restricted - it can be hand-designed heuristic rules or advanced machine learning models, mapping-and-localization

based solutions or others. Solutions **may not** consist in replaying a recorded set of actions, hence the rule of decisions needing to be image-based and regular.

There are no restrictions on the computational resources the teams can use. The organizers do not provide access to a computing cluster, but the participants are allowed to use hardware or web services of their choice. However, DonkeyCar discord claims that in competition usually, systems that do all the compute on board (with the raspberry) prevail.

For claiming the prizes, the created software must be labeled with a **free-to-use licence**, so that the next generation of students could learn from it. The code must be made available to the organizers via a GitHub repository. The repository should be private at first but made public to claim the prizes.

An example of a forbidden solution *is a model that replays one or multiple predefined sequences of commands (lasting the entire route or significant parts of a route, respectively) because in that case the driving is not based on image input (or images are used very rarely). Rule-based solutions inherently make use of predefined commands that follow the fulfillment of certain criteria in the input. This is allowed if the input is compared and decisions made regularly, say every one second. Defined behaviour between two decisions should not last longer than one turn on the track.*

2.4 FINAL COMPETITION, END OF JANUARY

The town/route for Task 1 will be reconfigured for the final competition, the examples above are just examples.
The town for Task 2 is fixed, the set of routes to complete in this town will be given to the participants as soon as the competition for Task1 has finished.

By January 21st the teams must report if they wish to participate in the final competition and demonstrate the ability to perform at least one of the Tasks in minimal difficulty settings (e.g. by filming it).

2.5 TEAM FORMATION

- A team may have up to five persons and a supervisor. However, teams are encouraged to collaborate in the early stages of the competition, e.g. for data collection. The team can find a supervisor who does not count as a team member.

- As per Delta X general rules, at least half of the members of each team must be students.

- The last deadline for registering teams to the self-driving competition is 30 November. To

register your team, write to Ardi Tampuu (ardi.tampuu@ut.ee). **Exceptions can be made.**

Figure 2: A toy town for Task 1. The surrounding walls and walls within the track are 10 cm high.

2.6 TRACK DETAILS

The track is located on the second floor of Delta building, at the end of the hallway toward Narva mnt street.

The track is formed by placing plywood walls with a height of 10 cm into an area of 3.6meters x (3.2 -4 meters). The width of the streets varies between 50-60 cm.

The surface of the track is covered by the ceramic tiles covering the floors of the Delta building.

2.7 AVAIL OBJ ABILITY OF DATA

The organisers will provide a small curated dataset for participants because some teams might be located far from the track in the Delta Centre where data can be generated. The dataset contains recordings of human driving, with video frames and recorded driving commands.

https://owncloud.ut.ee/owncloud/index.php/apps/files/?dir=/data&fileid=87360958

The data consists of recording folders. Each folder contains a piece of recording - the camera feed, IMU recordings and the command the human driver executed.

The participants might nevertheless find it useful to generate their data by driving the car by themselves (look at concepts like curriculum learning, dagger, learning from interventions). The car can be controlled via mobile app, web app or with a game controller connected to the car. The first two options also show you the live video feed of what the car sees. Web app also allows to use the game controller.

There is no support from the organisers' side for remote data collection and testing of the car for teams not located in Tartu. Such teams will have access to driving recordings to train their models and to compare their models' outputs with. However, they must find a person to place the car in the town in Delta Centre to test the autonomous driving ability of their solution in the real world (in the town). A person is needed to be present to take the car from storage (and return it), be responsible for the car, place the car into the town, monitor whether the driving is safe for the car, change batteries if needed, etc.

However, if a sufficient number of teams are interested, intermediate test-competitions could be held at an agreed time. In such events, the teams not physically present can also participate.

2.8 DATA COLLECTION SCHEDULE

Teams can book times at the track by contacting the organizers via writing to ardi.tampuu@ut.ee. If agreed between themselves, multiple teams can work at the track simultaneously. There will be certain restrictions for track usage:

- Each team will have a limited amount of time they can book per week. If the track is empty, any team can also use the track beyond their booked time.
- The organisers have the right to pre-book some time slots for their usage or for a team (e.g. from outside of Tartu) that specifically needs some timeslot.

3. CHANGES AND CANCELLATIONS IN RULES

The organisers maintain the liberty of making any changes to the rules if such need arises. However, the changes will be justified and explained to the participants.