# FIRA Autonomous Cars Race Simulation Challenge (Pro/U19) Rules 2024

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## Abstract

Autonomous cars are one of the most interesting topics in the world and developing them can be challenging in both hardware and software. The goal of FIRA Autonomous Cars Race Challenge is to encourage researchers designing and implementing an autonomous car and finally build this long-lived human imagination.
Due to the situation with covid-19 holding this challenge with participants in person is currently impossible, but a robot operating system (ROS) based 3D simulator is designed to make it possible to hold autonomous cars challenges even virtually, so participants can compete from all around the world remotely.

## Latest Version of the Rules

The most recent official version of the rules of the FIRA Autonomous Cars Race Challenge is always available here [1].

## [FAC-1] Autonomous car league scenario

In the Autonomous cars League, the car must automatically use intelligent driving in both urban and race environments. In the Autonomous cars league, in both environments, the car uses image processing, distance sensors information and LIDAR to drive autonomously.

## [FAC-2] Simulation Environment

Participants have to implement their algorithms to drive a simulated car instead of a real car.

There will be two main tracks which teams should drive in:

- Race Track
- Urban Track

The rules for these two tracks are basically similar but there are just several differences. The challenge will be held in the simulator, so the judgment will be done by the simulator itself.

## [FAC-3] Competition structure

The competition consists of two preliminary and final stages, and according to the scores obtained in the preliminary stage, some teams will advance to the final stage. The scores obtained in the preliminary stage will be eliminated by entering to the final stage, and the teams that are selected, will enter the final stage with zero scores.

The Car will start from the starting line and must pass the checkpoints to the end of the track. More checkpoint passed in a shorter period of time, the greater the score will be.

## [FAC-4] Race competition

In the race competition section, the car must automatically pass the checkpoints placed on the road. The number of remaining and earned checkpoints is indicated by the simulator.
In this section, each team will have a specific time and at this time can only start the

match once. (Before the match starts, teams have a short time to check the execution of their code in the refereeing system)

Depending on the stage, there may be obstacles on the street, and if the car hits them, the round will be considered as finished.

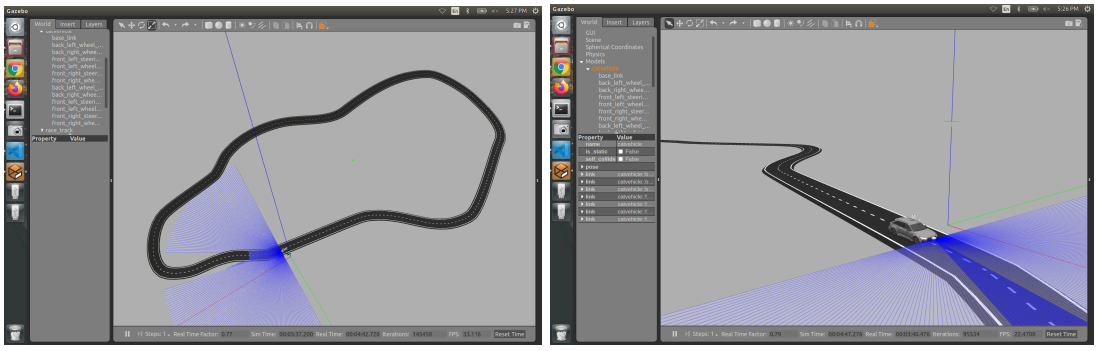


Figure 1, 2: Different views of race Track in gazebo simulator.

## [FAC-5] Urban competition

In urban driving competitions, the car must be driven automatically in the urban environment by traffic signs, street lanes, pedestrian lanes, and other environmental information (Figure 3).

The color of street lines in the urban environment is white. There are many checkpoints on the streets. Every wrong car decision will cause you to lose points, described in detail in the scoring model.

In this part of the match, each team has a specific time and can start the match only once. (Before the match starts, teams have a short time to check the execution of their code in the refereeing system)

There are traffic signs and tags (Table 1) at intersections, and failure to identify each and making the wrong decision will result in failure to continue and loss of subsequent checkpoints. The tags will be Apriltag 36h11 family.

At the intersections, there are horizontal lines that indicate reaching the crossroad and the car must stop for at least 3 seconds and then continue moving.

| id | Car Decision | Sign Marker | Sign Picture | Sign Name |
|---|---|---|---|---|
| 0 | Should not enter the street which has this sign in the beginning of it. |  |  | No Entry |
| 1 | Should not enter the street which has this sign in the beginning of it. |  |  | Dead End |
| 2 | Should choose the road on the right of the junction |  |  | Proceed Right |
| 3 | Should choose the road on the left of the junction. |  |  | Proceed Left |
| 4 | Should proceed forward. |  |  | Proceed Forward |
| 5 | Should stop (this is the destination). |  |  | Stop |

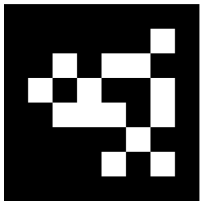
| | | | | |
|---|---|---|---|---|
| 6 | The lighting conditions change and the car's headlights have to be turned on. |  |  | Start the tunnel |
| 7 | End of tunnel and turn off car lights |  | | The end of the tunnel |

Table 1: Information about Apriltags in Urban track and what decision should the car make.

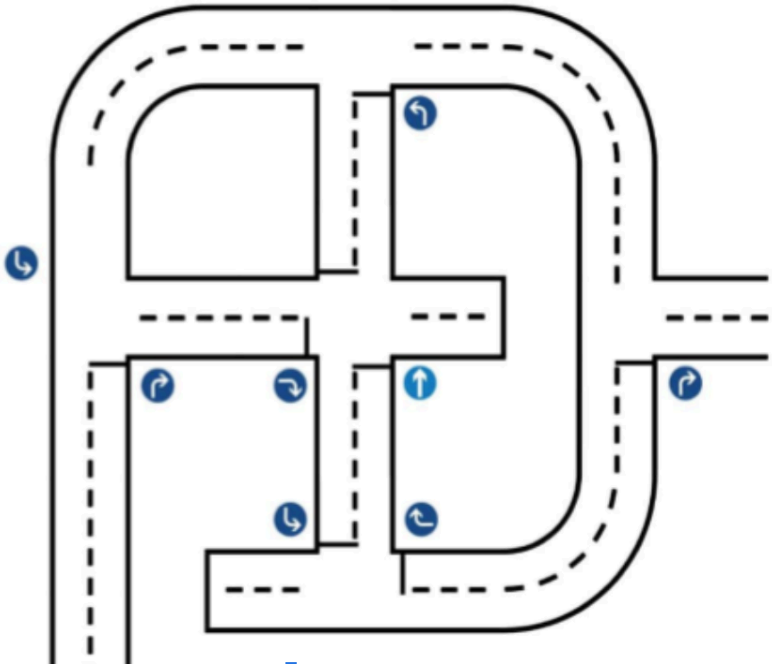


Figure 3: An example of a possible urban environment map.

The car must start by announcing the start of the race of the simulator and stop by following the traffic signs at the destination where the "stop" sign is located. There is at

least one checkpoint between the two intersections, and any wrong decision at the crossroads will deduct points, and the car will not be able to continue competing.

The car must move between street lines (in the right lane) unless it exits the right lane to avoid an obstacle. (In the new version of the simulator, to earn checkpoints, the car must be in the correct line)

Depending on the stage, there may be obstacles on the street, and if the car hits them, the competition will end.

## [FAC-6] Virtual competition

Before each match and at the time set by the referee, the teams are required to send their final project file to the technical committee. The teams' evaluation in each competition will be based on the latest files submitted until the appointed time. The received files will not be accepted after this time.

All of the competitions will be broadcast live on some social media, and teams can watch the competitions.
Details on how to hold the tournament will be announced to the teams in the coming days. Please follow the next announcements.

Each team must nominate one person as a leader to the technical committee to submit the files for each round.

## [FAC-7] Autonomous Race Scoring Model

During the race part, a score will be calculated based on the total time ($T_{total}$) and the number of checkpoints gained (cp). Total time is the sum of the time taken for the car to complete the track or pass some checkpoints and other penalties that will be added to total time depending on how well the car has followed the track autonomously. The penalties table is shown below :

| Penalty Time | Penalty Definition |
|---|---|
| $+ \ 0.5 \ * \frac{T_{stage}}{Number\ of\ all\ checkpoints}$ (s) | Skipped checkpoint (each) |

A score of this part is calculated using the following formula :

$$S_{AR} = (1 + \max\{\frac{T_{stage} - T_{total}}{T_{stage}}, 0\}) * 35 * cp$$

The stage time ($T_{stage}$) is the amount of time each team has to do the race in each stage which will vary between preliminary and final stage. For example, if a team is given 200 seconds and can finish the competition in 100 seconds and not lose any checkpoints (for example, if it scores 14 checkpoints), it will receive 735 points.

## [FAC-8] Autonomous Urban Driving Scoring Model

In this part, cars have to start from a starting point and navigate in the streets according to the signs and reach the destination point. Each checkpoint reached by car has 60 points. Sum of these points minus the sum of the penalty points each car received during its navigation will be the score of this part. The penalty points table is shown below :

| **Penalty Definition** | **Penalty Points** |
|---|---|
| No stop injunction | -10 |
| The incorrect decision injunction | -30 |
| Incorrect lane change (once between two junctions) | -20 |

$$S_{AUD} = \{60 * (\text{number of checkpoints})\} - (\text{sum of penalty points})$$

If the two teams' scores are the same in this section, the team that finishes in a shorter time will win.

Wrong decisions at the crossroads and choosing the wrong path will be considered as finishing the round.

## [FAC-9] Total Score

The total score is sum of the autonomous racing and autonomous urban driving scores:

$$S_T = S_{AR} + S_{AUD}$$

But for 2021 the total score is equal to the score of autonomous urban driving section:

$$S_T = S_{AUD}$$

**Notes:**

- The finish line is considered a checkpoint.
- The car must be entirely on the road and in the right lane while passing a checkpoint; otherwise, the checkpoint will be considered a miss.
- The scores of each part can not become negative.
- If the car hits an obstacle, the run is considered finished. If the car gets out of the road in an urban environment, it will be considered as a collision with the road barrier and the round will be finished.
- The total time of autonomous race competition is determined so that the maximum points obtained in the autonomous race competition and Autonomous Urban Driving competition are approximately the same.
- After the judgment of the final stage and determining the top teams, they are required to send the codes and algorithms to the technical committee. After reviewing the codes and algorithms by the technical committee, the final teams will be determined.

- The round ends when the participant notifies the referee that the match is over or the car hits an obstacle.

## [FAC-10] Simulator

There is a simulator entirely developed and based on open-source platforms. All the processes for car control is being handled by Robot operating system (ROS) and simulating the 3D environment of this challenge is designed and being handled by Gazebo simulator (Figure 4, 5)

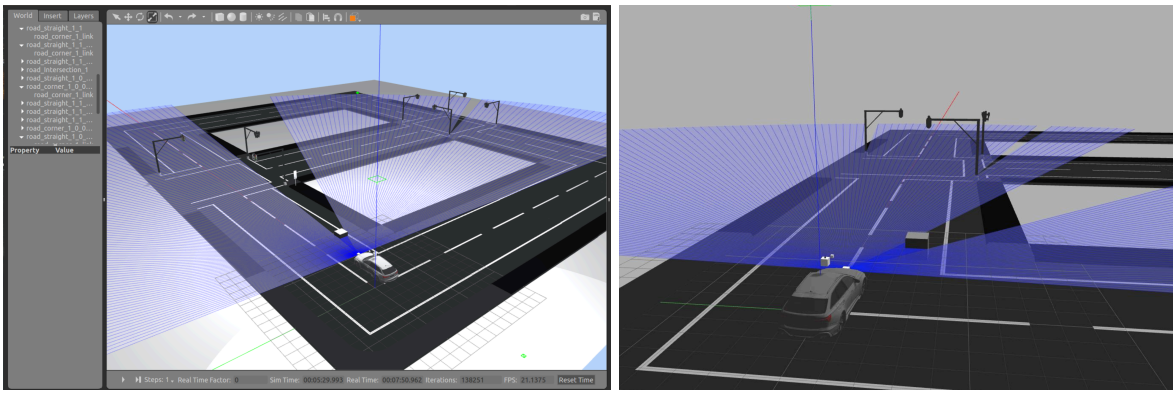


Figure 4, 5: Different views of the Urban track in Gazebo simulator.

The simulator is accessible from [FIRA Autonomous Car Github][2] and installation instructions will also be available there.

The performance of the gazebo simulator along with all of the nodes needed to drive the car is shown in (Table 2). $T_{RT}$ being Real time and $T_{ST}$ being Sim time.

| Performance | FPS | Real Time Factor | $T_{RT}$ - $T_{ST}$ (s) |
|---|---|---|---|
| Best | ≈ 30 | ≈ 1 | ≈ 0 |
| Average | ≈ 20 | ≈ 0.6 | ≈ 0.3 |

Table 2: The performance of the simulator in details

The results shown in (Table 2) were conducted on a PC with the specification below so it will be considered as the minimum requirement[2]:

- CPU: Intel® Core™ i5-5257U CPU @ 2.70GHz

- GPU: 2GB VRAM
- RAM: 8 GB
- Ubuntu 20.04
- ROS Noetic

## [FAC-10] Running the Simulator

After successfully finishing the installation process, everything is ready.
Launching the following command will start the gazebo simulator in the race track.

```
roslaunch avisengine_environment track_race_simple.launch
```

Participants get the front camera *image* from */catvehicle/camera_front/image_raw_front/compressed* topic and must send *steering* and *velocity* through */catvehicle/cmd_vel_safe*.

The car can also be driven manually by launching the following command:

```
roslaunch catvehicle_tests cmdvel_unsafetest.launch
```

There are also many different other parameters and topics which the use of them will be available on FIRA Autonomous Car Github[2] Wiki.

## [FAC-11] Team Description Paper and Video Documents

Each team has to submit:

1. Team description paper (TDP)
2. Video from the performance of the car in the simulator

You can find the **TDP** template inside the FIRA website (the preferred format is Springer LNCS format). The **TDP** should contain information about the logic behind the **software** running on top of the simulator (e.g. your computer vision algorithms, control method.)

## References


[1] "Latest Version of this document" [Online].https://docs.google.com/document/d/1JlDED3eSy1eIq4Jrc4L8M0LGSziAxxGFpkfxNDrqXAQ/edit?usp=sharing

[2] "FIRA Autonomous Cars Github organization profile" [Online].https://github.com/Fira-Autonomous-Cars