FIRA Air - Autonomous Race

Competition Rules (U19)

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Abstract

The goal of the FIRA Air - Autonomous Race (U19) competition is to introduce high school students to develop autonomous navigation software for drones for racing in a 3d track. A suitable drone for this situation should be capable of vision-based navigation in the presence of obstacles. In the FIRA AIR 2019 competition, the track would have multiple markers to help the autonomous navigation of drones. Participant teams should use autonomous drones and FPV drones cannot participate in the main competition. To have a presentation of drones capabilities, Teams with FPV drones can participate at a side competition which would have a single separated award (Best Maneuverability).

Latest Version of the Rules

The most recent official version of the rules of the FIRA Air - Autonomous Race competition is always available here.

FIRA Air - Autonomous Race

The goal of FIRA Air - Autonomous Race competition is encouraging research teams to design an agile and autonomous navigation system for the drones which can compete against human pilots in a 3D race track.

Right now, a manually controlled drone with a skilled pilot is capable of agile maneuvers. As a result, there is a considerable gap between the performance of an autonomous navigation system and a human pilot exists. To reduce this gap and help the participant teams develop an agile navigation system, we planned the Autonomous Race competition.

In the FIRA Air - Autonomous Race 2019 (U19), We will have a main competition for the autonomous only drones, and two side competition. For the main competition, we designed a relatively simple track and teams can place their own custom marker on each gate for easier navigation.

The two side competitions are A technical challenge and an FPV only race. The technical challenge is about developing software to enable the drone to pass a moving gate autonomously. The FPV only race would have a similar track to the main competition and the team which completes the track with the best time will be the winner. The best team in a side competition will be awarded separately (regardless of main competition).

Rules of the Game

These rules are directing to develop an autonomous system for racing drones using computer vision and machine learning algorithms for indoor environments without relying on any GPS/GNSS data.

Physical specification of the drones must abide by the rules below. Otherwise, the drone is not allowed to take part in the competition.

- The size of the drone (including propellers) should be smaller than 60cm.
- The weight of the drone (when flying) should be less than 2kg.
- Only electric motors and actuators are allowed, using fuel-based motors is not allowed.

There is no limitation on the type of drone (airship, helicopter, …) except that the drone should be capable of vertical flight.

Based on the competition venue, It is possible to have a level of magnetic or electromagnetic interference in the playing field. Although the OCs will try their best to prepare the field with the best possible condition, it is recommended to have a complementary sensor system for compass reading (heading) and low dependency on wireless connections (wifi).

For general specifications relevant to all FIRA events (e.g., playing field, lighting, and responsibility of the referees) please refer to General - FIRA Laws of the Game.

[FA-1]: Game Structure

In the main competition, each team has to reach the finish position as fast a possible while passing through the gates. Each team will have 20 minutes and a maximum of 5 tries. Drones have to take off from a starting point, pass the gates in a predefined order and reach the final gate and land to complete the lap(s). This competition will have 2 stages; the preliminary and the final. Depending on the stage there can be a single or multiple laps of the track. Based on the number of participant teams and their performance, all or a selection of teams would enter the final stage. The winners of this competition are determined by their performance in the final stage.

Each race's time will be recorded and, in the end, the best attempt of the team will be selected. The time will be calculated from the take-off moment until the drone passes the last gate or lands. The order of passing gates is important and any incorrect order will result in a halt in progress of the track (last correct gate is considered) until the drone comes back and enter the missed gate.

If a team was not able to finish the race, the time of the last reached gate in the correct order will be recorded. Teams will be ranked based on their recorded time divided by their autonomy coefficient and whether they have finished the raced or not (see the “method of scoring” section).

Referees have the right to rule out any attempt if any suspicious activity or an unfair attempt is found and also to stop any dangerous run.

[FA-2]: Field of Play

Field of play is a simple field consist of take-off pad, landing pad, several gates. Gates are colored magenta (5cm wide) to make the detection easier for the teams. There will be a placeholder (A5 paper size) on the bottom edge of gate for the teams custom markers. We recommend the teams to use Apriltag (36h11) as their marker but teams are free to bring their own custom marker (passive and smaller than A5 paper) and place it on the placeholder.

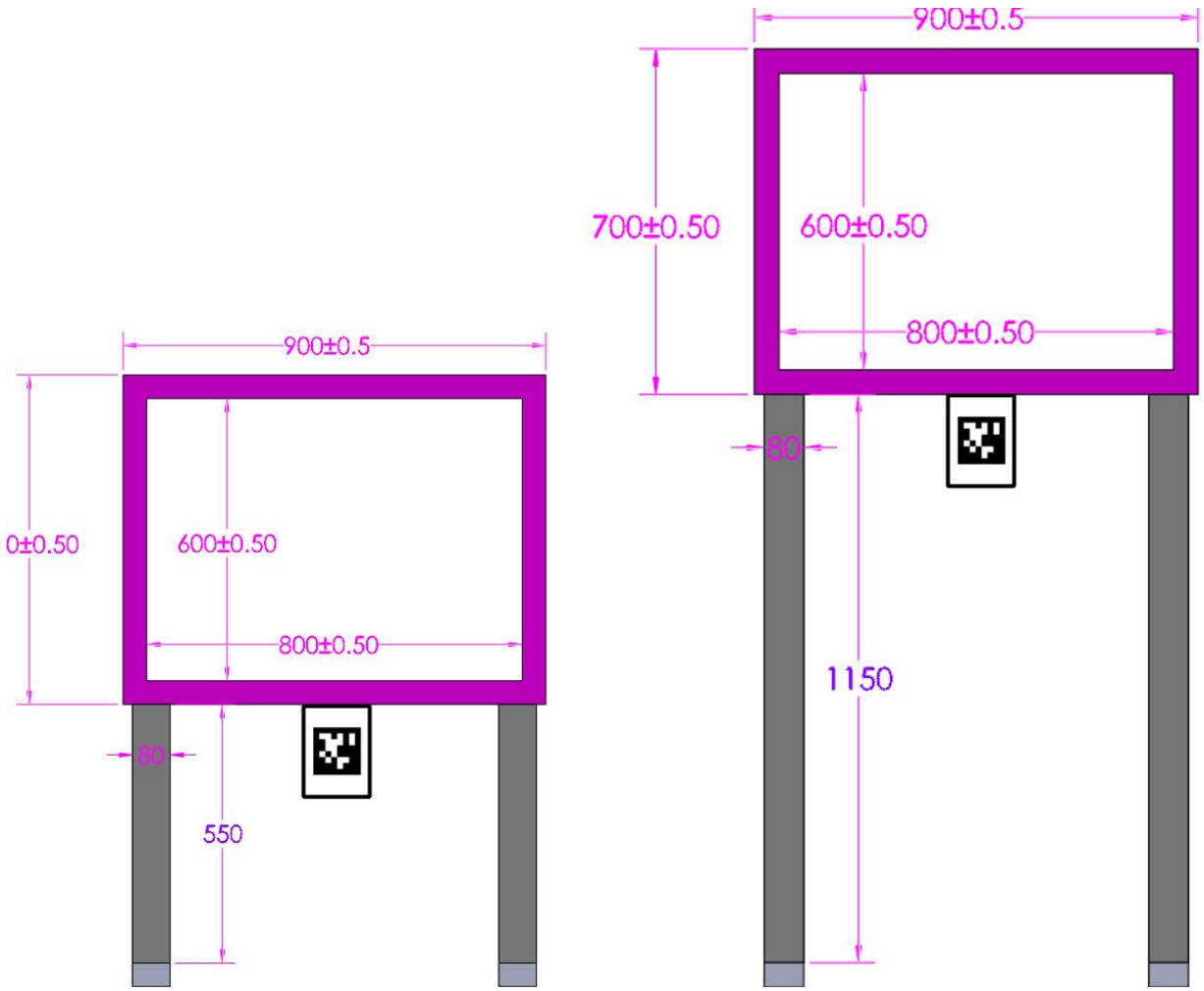

Figure 2, The gates and their dimensions

Starting pad and finish pad (takeoff and landing) is a 0.5m x 0.5m square pad with a blue H mark on it. The location and number of gates, position of take-off and landing pads will be decided by referees on the competition days. The drone should takeoff from the pad, follow the race track and land on the pad to finish the race. It is possible to skip the landing on the pad (land anywhere on the floor) but in this case, the team will miss the landing bonus points (see the "method of scoring" section).

The number of gates (4,5, or 6), their location and the number of laps (1,2, or 3) will be decided on the venue, but There will be a minimum 2m clearance between the gates and the length of the track will not be more than 50m. Also, Some (random) visual features will be added on the ground which can be used for optical flow sensors. As an example, a schema of a possible track is illustrated in Fig. 3.

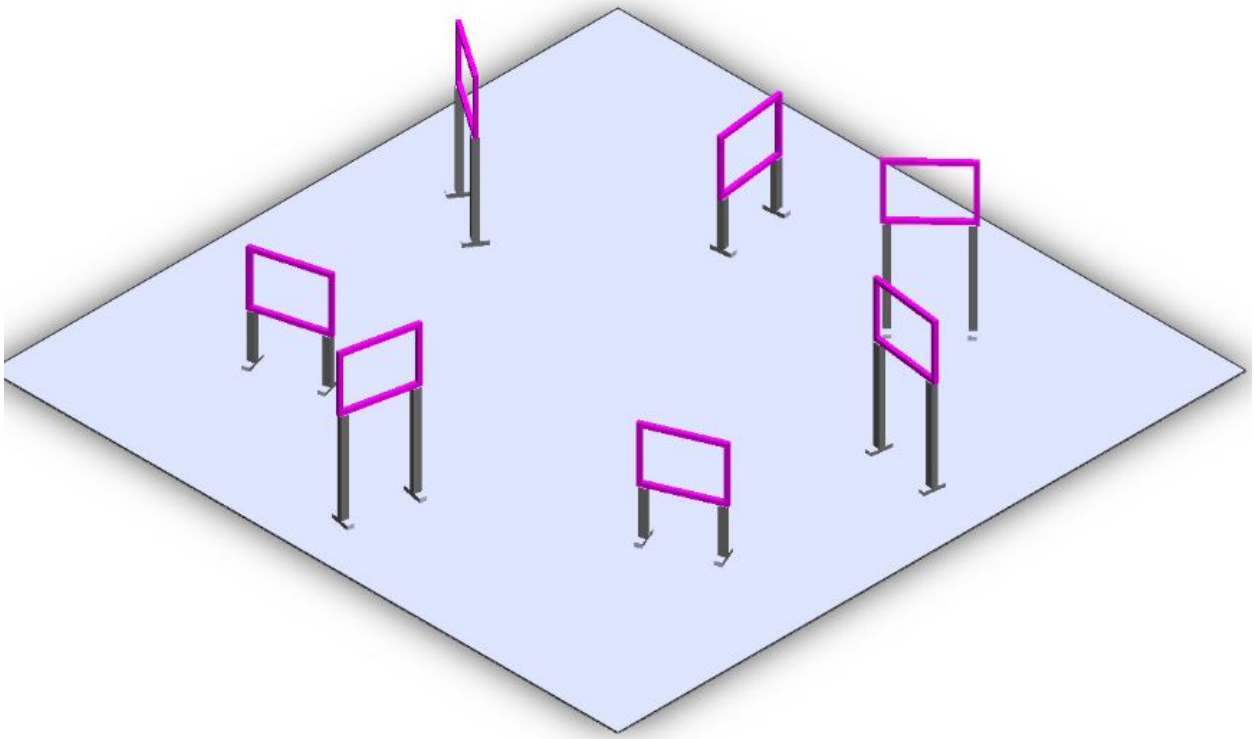

Figure 3, An example of a possible track

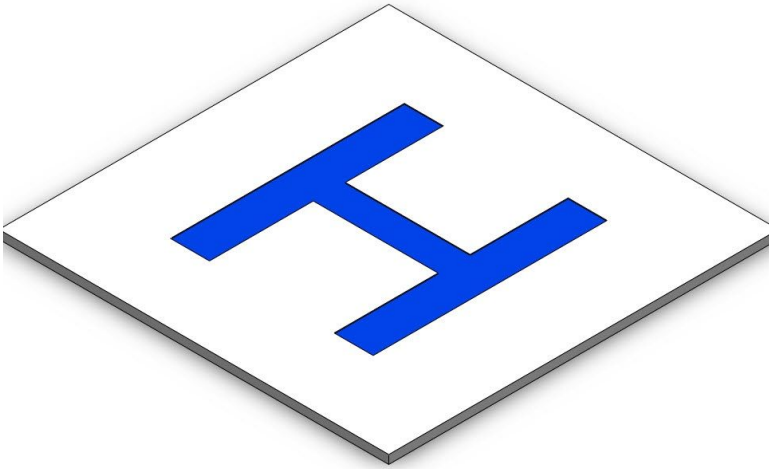

Figure 4, The landing pad

[FA-3]: Number of Drones

A single drone competes in each attempt. Teams are allowed to use different drones for different attempts.

[FA-4]: Level of Autonomy

In the main competition the autonomy consists of 2 levels: autonomous control with off-board processing and autonomous control with onboard processing. Based on the level of autonomy of the drone during race, the race time will be divided by the ka coefficient. The level of autonomy should not be change during the race track but it can be different in different trials.

The coefficients are defined in the following table:

Level of autonomy	**Ka (Coefficient)**	**Comments**
Autonomous (off-board Process)	1	Control and navigation of the drone is performed autonomously, and some processes are done using a computer outside of the drone itself. (e.g. Tello and Bebop drones)
Autonomous (on-board Process)	1.5	Control and navigation of the drone is performed autonomously, and all of the processes are done using a computer inside the drone itself.

[FA-5]: Method of Scoring

The score of a race (time trial) depends on the performance of drone and the level of autonomy. It will be calculated using the formula below:

$$Trial\ Record = (Race\ Time + n * 40) * bonus / Ka$$

In this formula, **n** is the number of remained gates (if the track is not completed), "**Race Time**" is the time recorded between a start and finish in an attempt (in seconds), and **Ka** is the autonomy factor.

The **bonus** coefficient will be considered 0.8 if the drone lands on the landing pad after finishing the track. if the drone lands outside of the landing pad or doesn't complete the track, it will be

equal to 1.

Examples of scoring for a track with 5 gates and 2 laps:

A- An autonomous (offboard) drone, completes the track in the 100s and land on the landing pad. The trial record will be:

$$Trial\ Record = (100 + 0 * 40) * 0.8/1 = 80s$$

B- An autonomous (offboard) drone, passes through 9 gates in the 80s and land outside of the landing pad. The trial record will be:

$$Trial\ Record = (80 + 1 * 40) * 1/1 = 120s$$

C- An autonomous (onboard) drone, passes through 8 gates in the 80s and land outside of the landing pad. The trial record will be:

$$Trial\ Record = (80 + 2 * 40) * 1/1.5 = 106.66s$$

Important notes:

- The drones should at least enter the second gate to be eligible for scoring (passing less than 2 gates has no score). In the case of failure, the maximum trial record (500s) will be considered for the team.
- The drone is passed the gate if it goes though it without major collision with the gate (crashing). Minor collision is acceptable if the drone is still airborne.
- The teams are not allowed to add external marker to the field.
- The teams will be ranked based on best final record (lower is better).

[FA-6]: Technical Challenge

Apart from the main competition, there will be an additional side competition (a technical challenge) for the participant teams. The details of this challenge will be announced on the setup day and during the competition days, the teams should develop a system to overcome this challenge. The main theme of 2019 technical challenge is “passing through a moving gate”. The team with the best performance in the technical challenge will be awarded. Scores and award of the technical challenge are completely independent of the main competition.

[FA-7]: FPV Race

A short FPV only race, will be organized during the event as a side competition for the participant teams. This side competition can show the difference between the performance of human pilot and current autonomous systems. The best performing team in FPV competition will be awarded as the best maneuverability (independent of their performance in the main

autonomous race).

[FA-8]: Age Classification

The Junior Autonomous Drone Racing league competition is limited to high school students. Junior teams may include a team official who may be an adult. With the exception of the team official, who shall not help the students in the development of their robot, all team members must be high school, junior high school, or elementary school students or the equivalent school level in the country of origin of the team. (U19 is for students younger than 19 years old. The age of the student is determined by calendar year.)