Middle East Technical University Robotics Society

18th International METU Robotics Days - 2022

Autonomous Unmanned Aerial Vehicle Category Rules Part 2-Computer Vision

1. **AIM**

   - The goal in the computer vision category is to get the highest score. Details of the scoring are given in section 5.

2. **COMPETITION RULES**

   - Each competition group competes in turn.

   - Each team has two options for the competition. The first of these is the **Visual Navigation** task to be performed onboard on the UAV, and the second is the **Visual Navigation** and **Target Locking** tasks to be performed on the simulation using only computer vision algorithms.

   - Competitors can participate in the competition with only one of the options.

- In the next part of the specification, the mission to be performed using the UAV will be referred to as **Option-1**, and the missions to be performed on the simulation using only algorithms will be referred to as **Option-2**.

- Option-1 consists of one task and Option-2 consists of two different tasks. Details are given below.

- Competitors will upload the software they will use in the competition to the GitHub page they specified during registration.

- Competitors will give access to the GitHub pages to METU Robotics Community officials.

- Considering the date and city of the competition, one should be cautious against any weather conditions that may occur.

- As in all categories, the General Rules apply in the Autonomous Unmanned Aerial Vehicle-Computer Vision Category.

- METU Robotics Society reserves the right to make changes in the rules if deemed necessary.

- The software used by the competitors in the competition will be shared with the public as open source code after the end of the competition.

2.1.   OPTION-1 RULES

- Competitors are required to use any of the PX4 Autopilot or Ardupilot flight control software.

- Competitors can use GPS during the flight. (GPS Enabled)

- Before the start of the competition, all competitors who will compete in Option-1 will be given 10 minutes to practice at a part of the course. This period can be changed on the day of the competition depending on the number of competitors.

- It is forbidden to fly vehicles outside the track.

- All vehicles will be collected after the trial period expires and before the start of the competition. The vehicle whose turn it is to race will be taken to the track by the competitor.

- After the vehicles are collected, before the competition, the competitors will delete the software under the supervision of the referee and re-download it from the GitHub pages they specified during registration.

- The competitor has 3 rights for Option-1 and 2 rights for Option-2 with the same vehicle. For each mission, the one with the highest score among the rights of that stage will be used for the ranking criteria.

- It is forbidden to interfere in the software of the vehicles between the competition rights. Battery replacement and propeller maintenance can be done.

- The UAV, which is placed at the starting reference point for take-off by the competitor, can start the race with the approval of the referees.

- UAV is stuck, not moving on, falling, etc. In such cases or for any reason, The competitor can terminate their rights to compete at any time. After informing the referee about this, the competitor will be allowed to enter from the appropriate entrance gate of the track after the UAV is closed and a safe environment is created.

- If the UAV is inactive for a long time, the referees have the right to terminate the right of the competition, even if the competitor does not want it.

- If the UAV falls, the right to compete fails and the next right to compete, if any, is passed.

- When calculating the center of the vehicle, the intersection point of the imaginary lines connecting the opposing engines is taken as reference.

- There must be a control or a command that makes the propellers of the vehicles stop remotely. Security must be ensured while vehicles are being taken from the track.

- Damages that may occur to the vehicles during the trial and competition are within the responsibility of the competitor.

- In case of a technical problem in the course conditions, the referees may terminate the current trial and interrupt the competition.

- In order for the vehicle to be considered as landing, the propellers must stop after landing.

- It is strictly forbidden to have a hard-coded algorithm on the UAVs of the teams that will compete in Option 1, if it is detected, the competitor will be disqualified. The UAV must make all movements autonomously.

2.2. OPTION-1 VISUAL NAVIGATION TASK DESCRIPTION

- It is the only task of Option-1.

- The task is to enable the UAV to reach the target point (T) by taking off from the take-off point (H) and acting according to the symbols it sees along the way.

- During the navigation, it will be acted in two modes. These will be line tracking mode and icon tracking mode.

- The take-off will be from the (H) icon with line tracking mode and the first move will consist of following the line up to the second symbol.

- When the line tracking mode end icon (X) is noticed, the UAV will switch to icon tracking mode, and when the line tracking start icon (L) is seen, it will switch back to line tracking mode.

- The action to be taken during the icon follow mode is that the UAV takes the specified amount of distance in the direction of the arrow. The unit of specified distances is centimeters.

- An example track is given in Appendix-1.

- The aim is to ensure that the UAV reaches the target as soon as possible by following all the lines and symbols in order.

- The mission ends with the engines stopping after the UAV lands on the landing symbol (T).

- **The images processed at the time of the competition must be recorded in 720p. The output of the instantly processed symbol or figure should be processed on the left side of the video.**

- The details of the scoring are also given in the 5th section.

2.3. OPTION-2 RULES

- For Option-2, sample videos will be published to conduct trials.

- Option-2 consists of two separate tasks. Option-2 score will be determined by adding the points from the two tasks.

2.4. OPTION-2 VISUAL NAVIGATION SIMULATION TASK DESCRIPTION

- In this task, the competitors will be given a text file named **"line_frames.txt"** with the image sequence (in frame_id.jpg format) recorded while the UAV was completing the track similar to the example in ANNEX-1.

- The aim is to implement a computer vision algorithm that gives the output described below using the given image sequence and text file.

- There will be a total of 7 lines in the text file, with each line being the frame_id for a particular image. 3 of them will be on the line between the H and X symbols seen in ANNEX-1, and 4 of them will be on the line between the L and X symbols. These images will be used to simulate the line tracking mode of the UAV.

- The outputs will be printed in a file named **"output.txt"** in the following output formats, with each output on a new line, a total of 16 lines.

- If there is one of the symbols (H), (X), (L) or (T) in the image, the type and position of the symbol should be output together with the frame_id. **This output should be printed only once for the same symbol and on the image where it was first detected.**
  Example output: 5-digit-frame-id_Column_Row_Type
    - Column = column number in the image of the center of the circle surrounding the letter
    - Line = line number in the image of the center of the circle surrounding the letter
    - Type = type of icon read in image. For example X, L, H, T

- For images with a line and whose frame_id information is specified in the text file, it is requested as the output, on which side of the line the middle point of the image lies, together with the frame_id. While determining the location of the center, the main direction on which the UAV is moving on the line will be considered as front, and it will be decided whether the center is on the right or left.

  Example output: 5-digit-frame-id_Direction

    - A value of 0 for the right and 1 for the left will be used as the direction.

- If there is an arrow in the image, together with the frame_id, the narrow angle made by the arrow with the long edge of the image and the distance written

next to the arrow are requested as output. This output should be printed only once for the same arrow symbol and on the image where it was first detected.

Example output: 5-digit-frame-id_alpha_distance

- o alpha = narrow angle between the long edge of the image and the arrow
- o distance = value in cm of the distance specified next to the arrow

- The details of the scoring are also given in the 5th section.

2.5. OPTION-2 LOCK TO TARGET SIMULATION TASK DESCRIPTION

- Participation in the Option-2 Visual Navigation Simulation task is mandatory to perform the task and get points.

- Competitors are expected to report the position and boundaries of a particular object (target) in each image in a given sequence of images using computer vision algorithms.

- The input to the algorithm must be an image sequence. The output of the algorithm should be the coordinates of the object in each frame where the object is located.

- The algorithm should only report on frames where the target is in the image.

- A maximum of one output should be reported for one video frame.

- Output format; <Frame number> <Top-left corner column number> <Top-left corner row number> <Width> <Height> must be in the format.

- An example output might look like this:

  1 48 290 50 80

  2 50 291 51 79

  5 55 287 55 75

  6 56 285 55 77

  …

- The goal is to report the output that will produce the highest Intersection Over Union (IoU) value when the target is found in the image and not report when the target is not found in the image.

- The details of the scoring are also given in the 5th section.

3. RUNWAY GENERAL FEATURES

- The track measures 10 meters x 10 meters x 10 meters.

- There will be gray profiles at the corner points of the track.

- The roof of the track and its surroundings will be covered with a net to prevent the UAVs from going out of the track.

- Cameras can be found at the corners of the walls of the track for shooting.

- There will be no color or pattern on the floor other than the shapes mentioned above.

4. ROBOT FEATURES

- Competitors must use a controller to start, stop, take off manually and switch to autonomous mode. **It is strictly forbidden to control the vehicle with a computer or send commands to the vehicle.** All remaining functions must be performed on the vehicle. It is forbidden to touch the control, to process the data outside the vehicle and to give a remote command to the vehicle before finishing the track and after the vehicle has passed the starting line.

- Competitors will pass a verbal test before starting their trial, in which the judges are asked to answer questions about how their autonomous vehicles are controlled and communicated. Within the test, the codes of autonomous vehicles should be open to review by the referees. In addition, the referees can ask some questions over the codes. Contestants are required to answer the questions satisfactorily. After the required conditions are fulfilled and the questions are answered clearly, the contestants can start their competition rights.

- The trial-competition intervals of teams that use a component that emits an amount of electronic noise that may interfere with the flight of other teams may be restricted.

5. SCORING

- The team with the highest score will be the winner.

- If two teams competing in different options get the same score, the ranking will be made with the team competing in Option-1 having priority.

- If the two teams competing in Option-1 have the same success in completing the task; If both teams have completed the task or were able to read an equal number of symbols, the ranking will be made taking into account the duration of the task.

5.1. OPTION-1 SCORING

- Detecting each symbol (X, L, T) will earn 15 points, detecting arrows will earn 5 points, reading distances will earn 5 points. There is a possibility to collect the highest 100 points.

- When the competitor decides to stop the competition for any reason, the scoring for that right is made on the symbols read so far.

- The right with the highest score among the competition rights will be valid in the ranking.

5.2. OPTION-2 VISUAL NAVIGATION SIMULATION TASK SCORING

- A maximum of 50 points can be obtained in this task.

- In the output of the arrow symbols, 2.5 points are obtained for the correct estimation of the angle with ±10 degrees of error, and 2.5 points for the correct reading of the distance.

- A score of 2.5 is obtained if the entire output line for the detection of symbols is correct, and 0 otherwise.

- In cases where the location of the center of the image, in line with the line is desired, 2.5 points are obtained for the correct output and 0 points for the incorrect output.

5.3. OPTION-2 LOCK TO TARGET SIMULATION TASK SCORING

- Intersection over Union (IoU) values will be used for scoring.

- IoU values will be summed for frames where the target is in the image.

- If reporting is made for frames where the target is not in the image, the maximum IoU value (1) will be subtracted from the total.

- The final score will be obtained by dividing the total by the number of squares on which the target is visible and multiplying by 50.

- Since the maximum IoU value is (1), the highest possible score for this task will be 50.

- Contestants are advised to be wary of negative scores, as there is no minimum score limit.

ANNEX-1