MathWorks Minidrone Competition

Rules and Guidelines

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A. Competition Overview

The MathWorks Minidrone Competition will introduce participants to Model-Based Design using *Simulink*.

The competition consists of two rounds:

- **Round 1 Simulation Round** Teams will work virtually on designing a Minidrone line follower algorithm. Teams will need to use their modeling skills to refine a Simulink model.

- **Round 2**
  - o **Simulation and Hardware Deployment Round** The teams that qualify from Round 1 will be invited to the Round 2 live event. Teams will deploy their Simulink model at the live event on the *Parrot Mambo Minidrone* hardware using the *Simulink Support Package for Parrot Minidrones*. OR
  - o **Virtual Round** The teams that qualify from Round 1 will be invited to join virtual Round 2 event. During the virtual event, a short video submitted by the teams about the approach used to solve the problem will be showcased. This will be followed by some questions and answers with the team captain.

MathWorks will provide each participating team with complimentary software to work on the problem statement. The teams will also be provided with the Parrot Mambo Fly drone, batteries and, dongle on the day of the competition in case of an in-person event.

B. Round 1: Simulation Round

This is the virtual round of the competition which will aim at performing the line follower task in simulation using Simulink.

B.1   Pre-work

- Participating teams are expected to complete MATLAB Onramp, Simulink Onramp, and Stateflow Onramp courses before starting to work on their algorithm.
- It is recommended that participating teams view the video series MathWorks Minidrone Competition to better understand the competition details.

B.2   Rules

- Teams can use only the latest release of Simulink and related MathWorks products to complete the task. For example, if the simulation round of the competition was launched when R2020b was the latest release, the teams are expected to use R2020b for Round 2 of the competition even if R2021a may be released by that time the submissions are due.

  Please note the following:

  1. Participants using MATLAB R2023b or later versions are requested to use the following command to launch the Parrot Minidrone Competition project:

     openExample('parrot/ColorDetectionLandingOfParrotMinidroneExample');

  2. For any reason, participants choosing to use MATLAB R2023a or earlier versions, can use the below command to launch the Parrot Minidrone Competition project:

     parrotMinidroneCompetitionStart;

- The complete logic for the task completion must be contained in the *parrotMinidroneCompetition* folder that the teams submit for Round 1 evaluations.
- The models that the teams submit should be code generation capable. More details about this can be found in this video.
- A team can have minimum 2 and maximum 4 members. If there are any changes in the team structure, the application form for the competition must be resubmitted and an e-mail about the same should be dropped to minidronecompetition@mathworks.com.

B.3   Judging

- This round will be judged by MathWorks engineers.

- The model will be evaluated based on the capability of completing the line follower track followed by landing on the circular marker.

- The model must be code generation capable.

- The model will be tested on multiple tracks with multiple number of track sections oriented at different angles. The color of the track for the simulation round will be Red (#FF0000). More details about the arena can be found in Arena Details.

- The model performance will be verified using an internal judging interface prioritizing the algorithm in the following order of importance:

- Code generation capability of the model

- Number of tracks completed by the Minidrone including soft landing on the circular marker

- Accuracy of the path traced by the drone with respect to the track laid in the Simulink 3D environment

- Time taken by the drone to complete a track

- The most efficient and accurate algorithms that complete maximum number of tracks in the shortest simulation time will be shortlisted for Round 2.

- The decision made by the judges will be final.

B.4 Submission

To submit an entry, the team captain needs to send the *Project* files to MathWorks. To do so, please use the following guidelines.

1. Ensure the correct folder structure:

- Ensure that you retain the original file and folder structure from the *parrotMinidroneCompetition* project (from the Simulink Support Package for Parrot Minidrones). The original folder structure looks like the following:
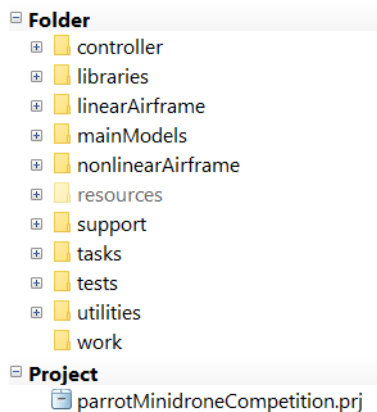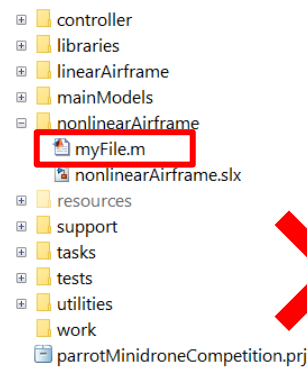

- Ensure that all the Simulink models and MATLAB files have the same names as in the original *parrotMinidroneCompetition* project.

- Do not add any Simulink models or MATLAB files to the subfolders. If you have written any additional MATLAB files or Simulink models, you can add them to the main *parrotMinidroneCompetition* model folder. For example, if you have created a new file supporting your model called *myFile.m*, add the file to the folder as shown by the screenshot with the check mark. Do **not** add the files inside a subfolder:
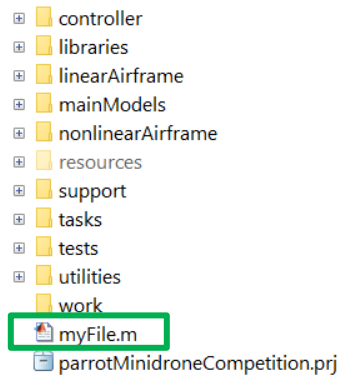
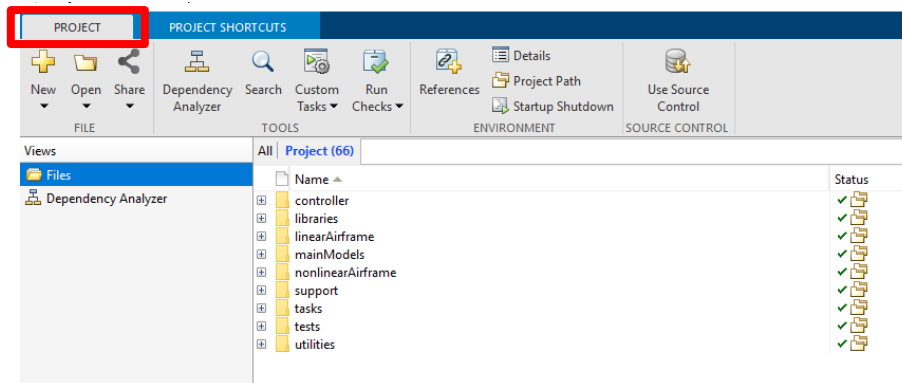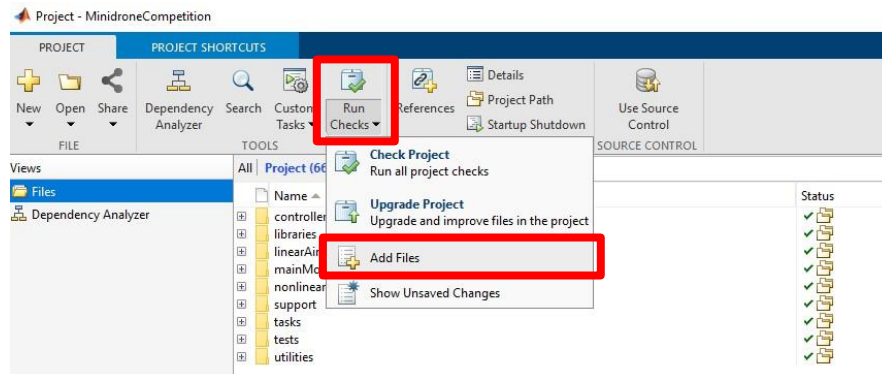*myFile.m outside the subfolders*   *myFile.m present inside a subfolder*

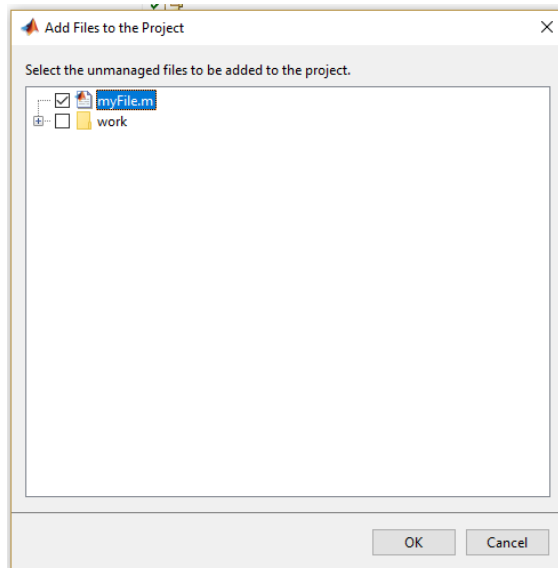## 2. Add additional files to the project

- *Note:* Move to *(3) Submit Project Archive* if there aren't any additional files to be added.
- Add the necessary files to the Project by navigating to Project tab

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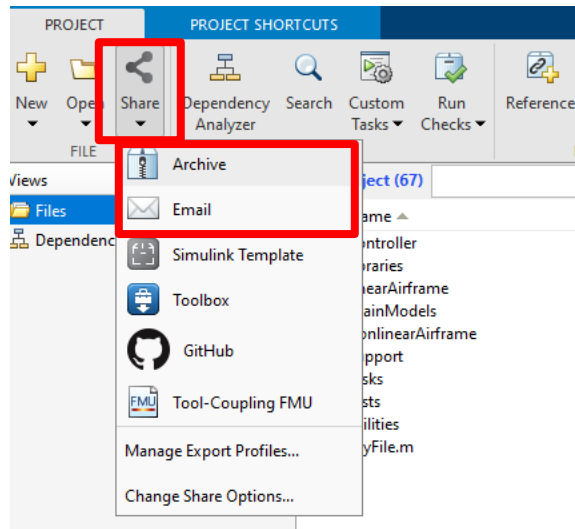
- Select Run Checks -> Add Files.

- Check the boxes for the necessary files and click OK.

3. Submit the Project Archive

• In the Projects folder, click on Share and then select *Archive* or *E-mail*.

• Select *Export Profile* as 'Whole Project' and name the Project Archive as `<TeamName>` where `<TeamName>` is the name of your team.

• Send the Project Archive (.mlproj) to *minidronecompetition@mathworks.com* with the subject as '`<TeamName>` at `<EventName>` `<EventYear>`' where `<EventName>` is the name of the event as found on the web page for the competition (often a location, conference, or university) and `<EventYear>` is the year when the deployment round of the competition is to be held. For example, if your team name is 'Drone Squad' and you are participating in the event at IROS 2019, your email would be titled 'Drone Squad at IROS 2019'.

• The Team Captain should submit the model using their registered email address.

C. Round 2: Simulation and Deployment Round OR Virtual Round

Round 2 could be a an in-person round or a virtual round. Please refer to Section C.1. if the competition you are participating has an in-person round. Refer to section C.2 if the competition will be held virtually.

C.1 Simulation and Deployment Round

C.1.1 General Guidelines

- Round 2 of the competition will be judged by a designated set of engineers organizing the event.

- Round 2 of the competition will be judged by a designated set of engineers organizing the event.

- The Minidrone should follow the line follower track laid on the arena and land on the *End Circular Marker* in the shortest time to win.

- Teams will be ranked in the ascending order of time taken to complete the track and land on the circular marker.

- The track will be divided into multiple sections. The track will have only straight lines and no smooth curves.

- The track will be disclosed to the teams only on the day of the deployment round.

- The track layout can differ between Practice Round and the Live Round. However, the color of the track will remain the same.

C.1.2 Competition Set-Up

The deployment round will be one- or two-day event. The competition will be divided into two parts:

a. Practice Round:

- In this round, each team gets **two slots of 15 minutes each** in the Arena to calibrate their model gains and thresholds.

- Performance of the Minidrone during this round will not be considered to declare the winners.

b. Live Round:

- Each team will get one **15-minute** assigned slot in the arena. This includes the setup time and the Minidrone flight.

- Each team gets **maximum 7 chances** during the 15 minutes to fly the Minidrone.

Note: The time allocated for each round may vary depending on the judge and will be communicated to the teams by the judge before the round begins.

C.1.3 Scoring and Judging

- The judge will be responsible for assessing the Minidrone's *Stage* in each Minidrone run.

- The decision of the judges will be final.

- The scoring will be based on the conditions if the team has landed their drone correctly on the circular marker or not:

  o If the drone is in Stage Complete*:

    ▪ **The time factor will come into account only when the drone is in *Stage Complete*.**

    ▪ The team that reaches Stage Complete in the shortest time, wins the competition.

    ▪ A team is in *Stage Complete* when the Minidrone bottom touches the landing marker and stays there.

    ▪ The judge will note the time from the Minidrone's takeoff to landing.

  o If a team does not reach Stage Complete:

    ▪ The consistency of the algorithm will be considered.

    ▪ They will be ranked based on the farthest stage they have reached and the number of times they reached it (so the team that reached the farthest stage the highest number of times would be given a higher ranking).

  o To understand the evaluations, let us take an example. Let's assume that the competition had 4 sections and seven teams in the final. We would name Stage Land as Stage 5 and Stage Complete as Stage 6, for convenience (See *Note).

    ▪ Team *IJK* has been ranked higher than team *ABC* because team *IJK* completed the task in the shortest time even though team ABC has completed Stage 6 (Stage Complete) a greater number of times in the seven attempts.

    ▪ The farthest stage team *DEF* and team *PQR* have reached is Stage 5. However, team *DEF* has reached Stage 5 two times whereas team *PQR* has reached the stage just once. Hence, team *DEF* has been ranked higher.

Note: The scoring criteria used for evaluation will be based on the maximum number of section stages the Minidrone has completed. The following are the guidelines for the division of the task into stages (*N* is the number of track sections):
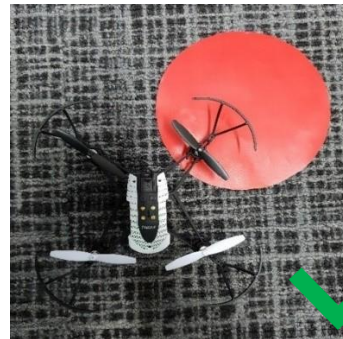
- o **Stage 0:** Take off complete
- o **Stage 1:** Track Section 1 complete
- o **Stage 2:** Track Section 2 complete
- o **Stage 3:** Track Section 3 complete
- o **Stage 4:** Track Section 4 complete
  - • .
  - • .
  - • .
- o **Stage N:** Track Section *N* complete
- o **Stage Land:** Landing Complete
- o **Stage Complete:** Validating landing on the circular marker

A few examples of correct and incorrect landings are illustrated below:

Successful landings:

Complete minidrone landing on the circle   *A part of minidrone landing on the circle*

Unsuccessful Landings:

Minidrone's bumper hovering over the circle   *Minidrone landing upside down on the circle*

C.2   Virtual Round

C.2.1 Scoring and Judging

- The top 5-7 teams from Round 1 will be shortlisted for the Round 2 which would be a virtual round.

- The results for Round 2 will be based on the simulation performance of the teams in Round 1. Check Section B.3 for more details.

- The team captain must attend the virtual event to be eligible for a prize. If any of the teams is not in attendance, their prize will be awarded to the next-placed team.

- The decision of the judges will be final.

C.2.2 Video Submission

- The top teams shortlisted for final round will submit a minimum 5 minute and maximum 7-minute video about the approach used to solve the problem statement by the submission deadline.

- The teams can consider the following structure for the presentation video, but not restricted to the same:
  - Team introduction
  - Approach used to solve the problem
    - Image processing subsystem
    - Path Planning subsystem
  - Challenges you faced and how did you tackle them
  - Key learnings and takeaways

- The team captain has to e-mail the video to minidronecompetition@mathworks.com by the specified deadline with the title as '`<TeamName>` at `<EventName>` `<EventYear>` video ' where `<EventName>` is the name of the event as found on the web page for the competition (often a location, conference, or university) and `<EventYear>` is the year when the deployment round of the competition is to be held. For example, if your team name is 'Drone Squad' and you are participating in the event at IROS 2019, your email would be titled 'Drone Squad at IROS 2019 video'.

C.2.3 Competition Set-Up

- The team captains must attend the virtual finals. It is recommended for the entire team to attend the finals.

- The virtual round will be 90 to 150-minute virtual event.

- The details about the virtual session will be shared with the team captain. The team captain must join the session 30 minutes in advance.

- The videos submitted by the team will be streamed on the virtual platform for the virtual round.

- The organizers will also have a question and answer session with the team captain about the video submissions and the approach used in the model. The audience would also be allowed to ask questions to the team captain.

- The top 3 winners will be declared towards the end of the virtual event.

D. Arena Details

This detail of the arena is valid for Round 1 as well as Round 2. The following are the details about the arena track:

- The arena would be a 4-meter * 4-meter space enclosed by nets on all sides.

- The arena track will be 10 cm in width.

- The landing circular marker will have a diameter of 20 cm.

- The line follower track will consist of connected line segments only and will not have any smooth curves at the connections.

- The angle between any two track sections could have a value between 10 degrees to 350 degrees.

- The track can have anywhere between 1 to 10 connected line segments. The initial position of the drone will always be on the start of the line. However, the mouth of the drone may not always face the direction of the first line on the track.

- The distance from the end of the track to the center of the circle will be 25 cm.

- The background on which the track will be laid may not be a single color and will have texture.

- The color and the track for the in-person round will be disclosed on the day of the competition**.**

- The track for the Practice Round and the Live Round may be different in case on an in-person round.

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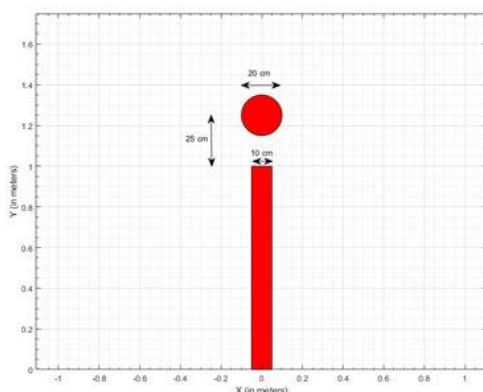
E. Safety Rules

These rules are applicable in case on an in-person final round.

- Teams will not be allowed to fly the Minidrone outside the arena.
- No team member can enter the Arena while the Minidrone is flying.
- No team member is allowed in the Arena during the Live Round. The Judge will oversee placing the Minidrone at the necessary location on the track.
- Team members entering the arena during the Practice Round must wear safety goggles which will be available on the day of the competition.
- If the Minidrone crashes into the net during a live round run, the entry for that run will be disqualified.

F. Participation Requirements

It is mandatory for teams to be present on the day of the **in-person** round with the following:

- **MATLAB installation:**

  A system with the latest release of MATLAB used during the simulation round installed.

  For example, if the simulation round of the competition was launched when R2020b was the latest release, the teams are expected to use R2020b for Round 2 of the competition (virtual/in-person) even if R2021a may be released by that time.

- **Hardware Support Package installation:**

  Teams should install 'Simulink Support Package for Parrot Minidrones'. The procedure for installation of the support package can be found below:

  https://www.mathworks.com/help/supportpkg/parrot/ug/install-support-for-parrot-minidrone.html

- **Competition Model:**

  The submitted simulation model with changes, if necessary.

G. Reference Material

- Recommended Tutorials:
  - MATLAB Onramp:
    https://matlabacademy.mathworks.com/
  - Simulink Onramp:
    https://www.mathworks.com/learn/tutorials/simulink-onramp.html
  - Stateflow Onramp:
    https://www.mathworks.com/learn/tutorials/stateflow-onramp.html
  - Image Processing Onramp:
    https://www.mathworks.com/learn/tutorials/image-processing-onramp.html
  - MathWorks Minidrone Competition Video Series
    https://www.mathworks.com/videos/series/mathworks-minidrone-competition.html

- Additional Video Tutorials:
  - Tech Talk on Drone Simulation and Control:
    https://www.mathworks.com/videos/series/drone-simulation-and-control.html
  - Programming Drones using Simulink:
    https://www.mathworks.com/videos/programming-drones-with-simulink-1513024653640.html
  - Tutorials on Computer Vision and Code Generation:
    https://www.mathworks.com/academia/student-competitions/tutorials-videos.html
  - Tech Talk on State Machines:
    https://www.mathworks.com/videos/tech-talks/state-machines.html
  - Tutorials on Stateflow:
    https://www.mathworks.com/videos/series/stateflow-tutorials-94460.html

- Documentation Links:
  - Simulink Support Package for Parrot Minidrones:
    https://www.mathworks.com/hardware-support/parrot-minidrones.html
    https://www.mathworks.com/help/supportpkg/parrot/index.html
  - Aerospace Blockset:
    https://www.mathworks.com/products/aeroblks.html
  - Simulink 3D Animation:
    https://www.mathworks.com/products/3d-animation.html
  - Stateflow:
    https://www.mathworks.com/products/stateflow.html
  - Color Thresholder App:
    https://www.mathworks.com/help/images/ref/colorthresholder-app.html