Contents

1 Meetings

1.1 DONE Meeting with Dr Amber

Participants:

- Dr Ityonna Amber
- Vi Kumar

1.2 DONE Meeting

Participants:

- Dr Ityonna Amber
- Dr Mehdi Nazarinia
- Sherrif Abdullah
- Vi Kumar

Little more than second year knowledge required but should be fun. Control Scheme is hardest part BUT that's the crux of the competition.

1.2.1 Action items summary

- Finish Onramp training and get software installed and ready
- Lookup previous years drones and results
  - Research about drone line-followers would be nice
- Background Research on Control Theory
  - Definitely a bit on the practical side since trusting EEs to make theory simple is a bad move.

1.3 TODO Meeting

Participants:

- Dr Ityonna Amber
- Dr Mehdi Nazarinia
- Sherrif Abdullah
- Vi Kumar

Decide then whether to have weekly or biweekly meetings

2 Competition **SLIDE**

Email: roboticsarena@mathworks.com

Round 1 - Simulation in Simulink Round 2 - Deployment Round on Parrot Mambo Minidrone

2.1 Timeline **SLIDE**

Competition launch	03 Feb 2020
Round 1 application closure	06 July 2020, 6 PM BST
Round 1 submission	27 July 2020
Round 1 result declaration	01 Sept 2020
Round 2 live event and winners	01 Oct 2020

2.1.1 Submit application

Should be as simple as sending in a list of names.

2.1.2 Round 1 - Simulation in Simulink

Simulink model is submitted.

Submitted models are graded on:

- Accuracy of the traced path
- Time taken to complete track
- Successful landing on end marker
- NOTE Code generation is required.
- NOTE Multiple evaluation passes are done by Mathworks Engineers

2.1.3 Round 2 - Deployment Round

<2020-04-26 Sun> Somewhat uncertain due to the whole coronavirus lockdown. Probably going to be a virtual thing. ~Dr Mehdi

Practice Round

- not evaluated
- two slots of 15 minutes
- Calibrate and test algorithms

Live Round

- one 15-minute slot
- Seven chances to run the hardware
- Nomination of one chance.
- Graded based on number of track sections completed.
- Judges decide which stages are considered complete.

2.2 Software Requirements SLIDE

- Latest version of Matlab
- Optional Simulink OnRamp
- Simulink Package for ParrotDrone
  - Allows you to deploy simulink models to Parrot Drone

2.2.1 TODO OnRamp Online Courses

Finish it for the minimum training required for the competition.

- Matlab Onramp
- Simulink Onramp
- Stateflow Onramp

Work w/ Abdullah on this. Should be doable by next meeting. Definitely need to keep track of it.

2.2.2 WAITING Simulink Package Configuration

Bluetooth issues for Windows (Send the online help page to Dr Mehdi) Hardware Deployment Issues

NOTE: Need to try simulation before actually figuring hardware issues

2.3 TODO Control Schemes

with drone context

Work w/ Abdullah on this. Need to make a plan for next steps.

2.4 DONE Create a Microsoft Teams group

2.4.1 DONE Upload some basic information about the competition

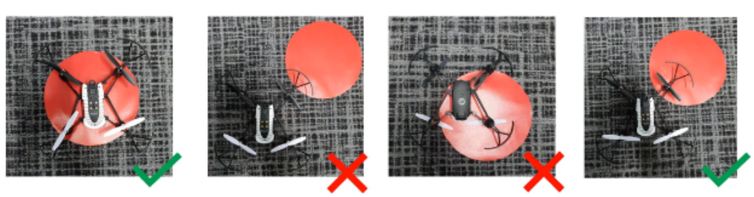
Competition rules and this doc.

2.5 Mission objective SLIDE

- Take off from a circular pad
- Follow a track laid on floor
  - Track sections have straight lines with no curves
  - Downward facing camera to track lines
- Land on circular end marker

  Time considered only when the minidrone lands on the end marker. In order for the minidrone to be considered as having landed:

  - Minidrone must be upright.
  - Minidrone's bottom surface has to touch the floor.



3 Parrot Mambo Drone General info SLIDE

3.1 Miscellaneous

3.1.1 Energy

660mAh LiPo Battery 8 min autonomy with accessory connected or bumpers 10 min autonomy with neither accessory nor bumpers 30 min charging time with a 2,1A charger

3.1.2 SDK

SDK: OS Linux. SDK available on Parrot.com We might find documentation useful, especially if the Simulink model neglects to mention something.

3.2 Sensors

3.2.1 Stabilization sensors :

Inertial Measurement Unit to evaluate speed, tilt and obstacle contact (3-axis accelerometer and 3-axis gyroscope) Ultrasound sensor Pressure sensor Camera sensor

3.2.2 Speed measurement :

60 FPS vertical camera 120x160 pixel resolution Ultrasound sensor

3.2.3 Streaming Camera

Streaming and Recording HD 720p 30 FPS FOV 120°

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3.3 Physical Characteristics

Need to get a MoI matrix from this

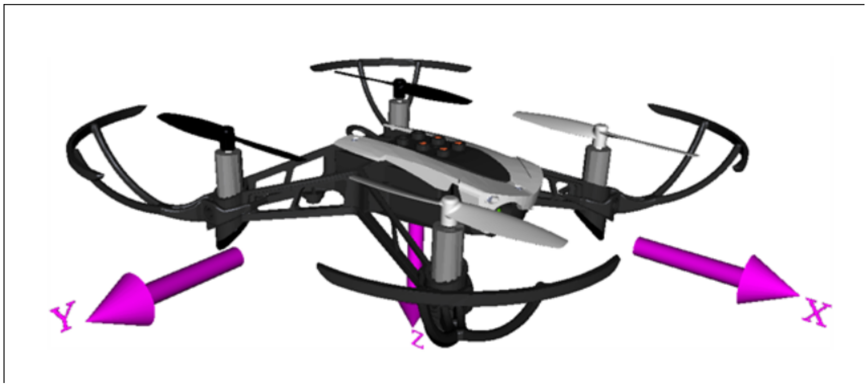
3.3.1 Weight :

Weight: 2.22 oz / 63g (without bumpers or accessories) Weight with Camera: 73g

3.3.2 Dimensions

7.1 x 7.1 in. / 18 x 18 cm with Bumpers

3.3.3 Rotor Characteristics



Right-hand Coordinate Frame centered at Center of gravity.

Rotor #1 rotates positively with respect to the z-axis. It is located parallel to the xy-plane, -45 degrees from the x-axis.

Rotor #2 rotates negatively with respect to the body's z-axis. It is located parallel to the xy-plane, -135 degrees from the x-axis.

Rotor #3 has the same rotation direction as rotor #1. It is located parallel to the xy-plane, 135 degrees from the x-axis.

Rotor #4 has the same rotation direction as rotor #2. It is located parallel to the xy-plane, 45 degrees from the x-axis.

4 Control **SLIDE**

4.1 Simulink Model Description

- flight Control system
- Image processing
  - Loads of OpenCV-like filters
  - Rate Transition since control system runs faster than image processing
    - Any way to create multiple buffers for image processing? This would allow much better "time resolution"
- Drone Controller
  - Real-time measurement
- Control path planning algorithm

4.1.1 TODO Sensor Filter

Extended Kalman Feedback is what I'm familiar with BUT

- it's a linear filter, how does it deal with a drone's non-linearities? Kalman filters assume Gaussian noise on "true" values that are linear-ish How accurate is this model?
- Is it even worthwhile to bother with it is a simpler scheme works?

1. **TODO** How to use vision-based feedback in the correction step? Vision-based odometry is apparently a thing for drones.

   Contact Dr Mehdi & Dr Tadhg for vision processing and path planning. ~Dr Amber

   Definitely need to figure out how to use the data after we've manipulated the raw data from the drone camera.

4.1.2 TODO Control Schemes

To be researched. But really need value judgements from a human.

- PID
- Fuzzy PID
- LQR
- LQG/LTR
- H-infinity
- Loop Shaping
- MPC

Perhaps a silly question, can we improve upon a previous run for a given track? How can we use existing data to contruct a "true-er" model from a previous run (especially at section junction)

4.2 Sensor Hardware & Related thoughts

4.2.1 Inertial Measurement Unit (IMU)

Inertial Measurement Unit to evaluate speed, tilt and obstacle contact

- 3-axis accelerometer
- 3-axis gyroscope

Definitely need to get accurate specs for this. The Parrot AR Drone had pretty good IMU chips so pretty sure that even a "low-cost" model should have something with:

- accelerometer +-2g
- Bandwidth ~1000Hz
- Low cross-axis misalignment

Not sure how Mathworks's Simulink package deals with the hardware flags but should be interesting to see.

1. Accelerometer Characterization
   - Bias factor
   - Scale factor
   - Thermal drift (check if it's relevant? Should be a simple correction)

4.2.2 Downward facing Camera

60 FPS vertical camera 120x160 pixel resolution

Located near COG and next to the ultrasound sensor.

- Do we need to worry about the actual picture being distorted? OpenCV has a little camera calibration thingy that takes care of camera distortion. A chessboard pattern? Something similar here would be sweet.
- How do we detect the red path and convert it to a line path? More of a question for the control scheme but should keep in mind.

1. How to do the binary switch for on-off image processing

   canny edge to hough processing

   canny edge to hough processing

   do it for submission

   move towards code that focuses on deviation from the center.

   Ask Dr Mehdi for help with Mathworks documentations

5 Image processing summary

canny edge > hough transform
inaccuracy in the image or just plain ol' reliability
Also need to figure out if there are better methods out there.
test suite of red track on carpet.
Spepd of camera and te type of communication for the same
FPV camera to predict future paths as well

6 Application

- Code generation
- Forth year and Third year examinations.
- Sample images from Dr Mehsi after that.
- 17th Sunday