

# Fly Sense



## Team C – ILR06

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## Work done these past 2 weeks

Over the last few weeks we have been reengaging with the work, focusing mostly on:

- a) Getting the quad flying (without our solution)
- b) Designing the algorithms we want to implement

Below a quick overview:

## Quad Flying

- Several flights have now been performed without our solution onboard (no payload), and we are trying to reduce the weight of the quadcopter so that we can fly our payload on it without substantial degradation of performance

### 2 DEPLOYING OUR SENSORS ON THE QUADCOPTER WILL CHANGE ITS DYNAMICS For discussion

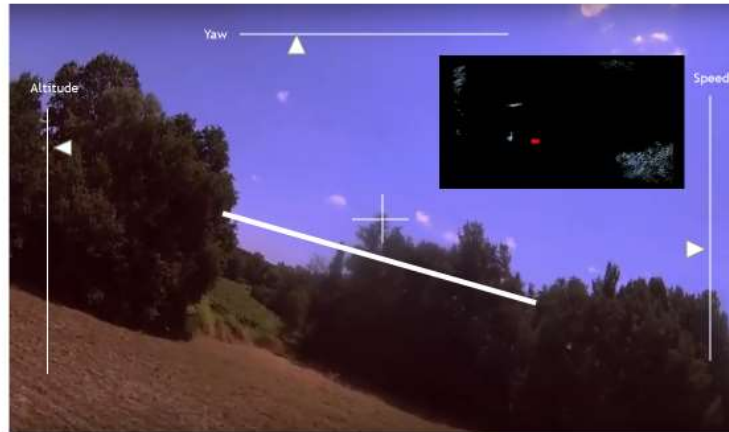
Our key challenge is to ensure thrust/weight ratios allow for take-off and maneuverability

What we plan to do		Questions for you
DJI frame (with Propeller fairings)	1924	• Do you have any other suggestions on how to lower the weight (e.g. swapping any component)?
Matrice 100 Propeller fairings	-200	
Battery	676	• In case we are not able to meet the weight threshold do you suggestions on how to increase thrust? - (e.g. bigger propellers normally imply an additional battery and more load on the quadcopter frame)
Velodyne without box and cable	800	
Cable	150	
Box	100	
Shave off velodyne box and cable	-200	
4 propellers	19.5	
Jetson TX2	82	
Heatsink with fan	67	
Orbitty	41	
Heatsink shaving	-20	
LAN cable	8	
Power cable + xt60 + fuse	16	
Power to lidar	10	
Power to jetson	10	
TTL	5	
Power module CC BEC	21	
Camera	30	
Camera cable	10	
Mouting stuff	5	
<b>TOTAL</b>	<b>3554.5</b>	<b>Already at maximum recommended take-off weight</b>

## UI/UX

- Work has focused mostly on understanding how to design an algorithm that can work in an environment that is substantially noisy.
- We are also designing the final interface for the SVE, that will be used by NEA pilot to navigate through the maze of their testing sensor using our solution. Below one of the mock-ups currently being discussed within the team:

The new screen designed specifically for the SVE



1 | FlySense

### Quadcopter dynamics

- Substantial effort has been done in analyzing the theoretical behavior of the quadcopter, so that we calibrate our models with real data as soon as possible.

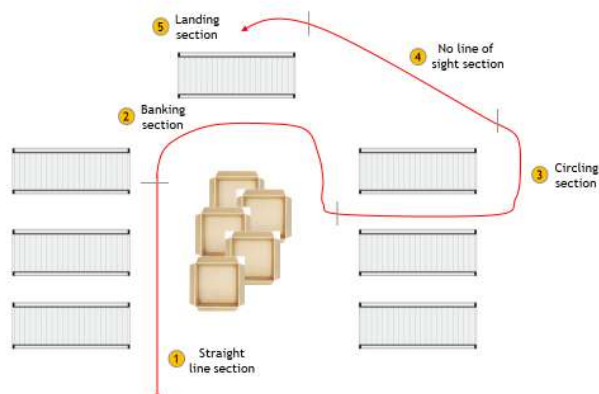
### Designing the SVE test

- Field visit to NEA test facilities has been performed in order to analyze the best way to structure SVE (that we had the opportunity to discuss with the entire class during “Design Review”

SVE TESTING FIELD: NARDO AIRFIELD (1/2)

Tentative

The maze test at NEA testing field will be done both with and without the FlySense system



8 | FlySense

## Problems Faced these past weeks

The biggest problem is, as always, a substantial load from all the courses (reminds me of when I was a business consultant ... 😊!)

... but we will manage somehow!

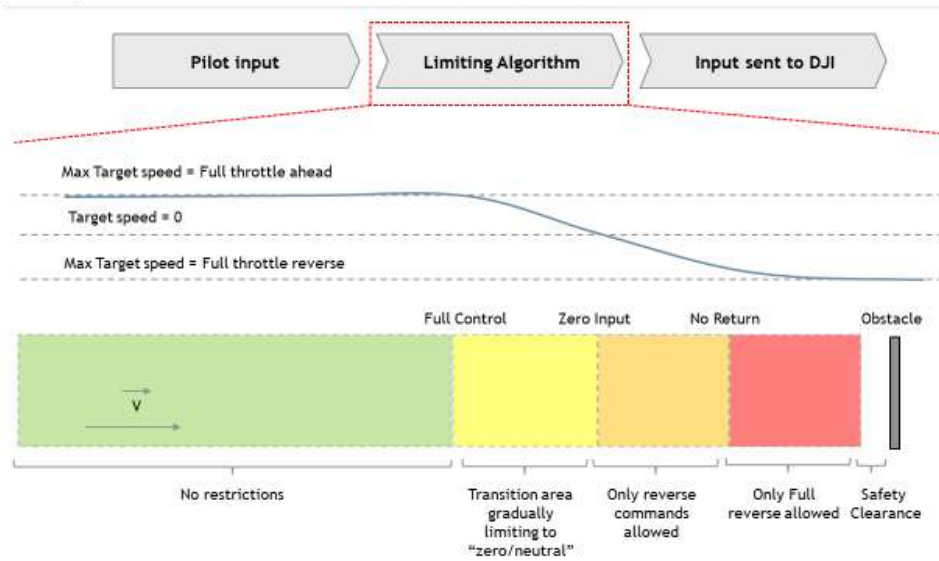
## Individual achievements for the past 2 weeks

Over the past two weeks I have:

- a) Designed the high-level concept of the obstacle avoidance feature:
  - Using a flat infinite virtual wall as an obstacle (rather than real obstacles)
  - Reusing as much as possible from DJI's interface as possible (to prevent stability, navigation or control problems)
  - Defining the control as a "limiter", only blocking pilot access to the set of commands that will "crash" into the obstacle

### 1 HOW IT WILL WORK (1/2)

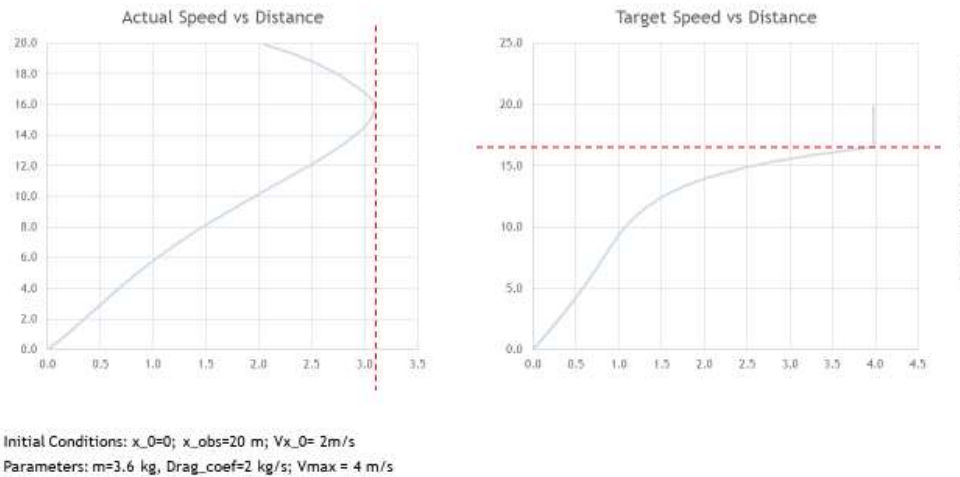
This feature will work based on a "limiter" approach that will be recursively updated and limit the pilot input to "safe commands"



- b) Understood in detail how the differential equations of a quadcopter work, having performed several dummy simulations (namely how the algorithm would behave when a pilot by default always introduced the "maximum possible" input

1 HOW IT WILL WORK (2/2)

Preliminary testing using a simplified limiting algorithm seems promising (for this simulation we assumed the pilot would always input the "maximum command available")



Note: In the slide above, on the left, the actual speed is show against the distance to the wall. On the right the target speed selected by the pilot in the control is equally shown against the distance to the wall.

Note2: To ensure smoothness, and correct speed of convergence, the algorithm used was based on a logarithm control based both on speeds and distances to the wall under the "maximum input allowed".

In the next few weeks, working with Shivang, I plan to log real flight data (including pilot inputs) in order to understand how DJI electronics is handling the pilot inputs and how best to implement this feature.

The dynamics of the quadcopter will be used not only on the crash avoidance, but also on the Bird Eye's view coloring of obstacles and the sound warnings generation. Both of them described in the next sections.

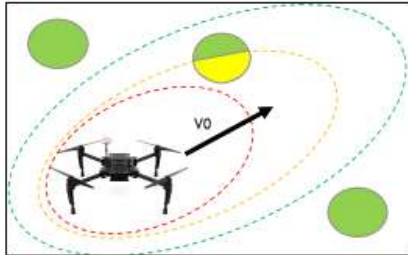
- c) Designed the concept of the coloring algorithm for the obstacles presented in the Bird's Eyes view, and did a simplified simulation in Mathematica to illustrate the concept so that it could be discussed within our group.

2 FLIGHT ENVELOPE COLORING BASED ON POTENTIAL IMPACT

For discussion

The objective of the flight envelope coloring is to alert the pilot of what he/she can do...

What we plan to do



- Area of interest selected based on dynamic window computed with vehicle dynamics
- Coloring based on maximum possible pilot input and vehicle dynamics
- Coloring based on  $\delta$  time for obstacle to be inside the flight envelope  $[(x/a)^2 + (y/b)^2 + (z/c)^2 < 1]$

Questions for you

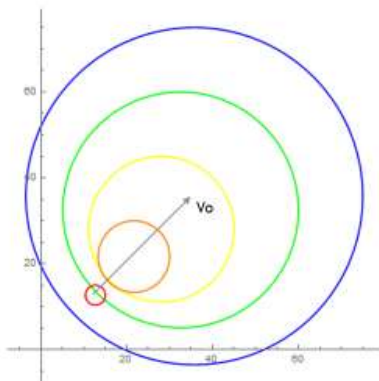
- Is the concept "maximum" input the correct one (or should we restrain it to what the pilot is actually doing right now?)
- Will it be intuitive for the pilot to have a single obstacle with multiple colors?

2 FLIGHT ENVELOPE COLORING BASED ON POTENTIAL IMPACT

For discussion

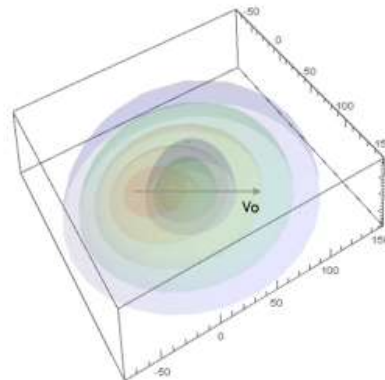
The objective of the flight envelope coloring is to alert the pilot of what he/she can do and the first simulations made in Mathematica of how the coloring tresholds will be model was already done

2D view



Initial Conditions:  $x_0=y_0=z_0=0$ ;  $Vx_0= Vy_0= 15$  m/s;  $Vz_0=0$   
 Parameters:  $m=3.6$  kg,  $Drag\_coef=.3$  kg/s;  $Vmax = 15$  m/s

3D view



d) Analyzed the implications of upgrading the sound warnings to a 3D environment where pilot inputs are taken into account to predict the quad trajectory. Preliminary simulations indicate that the Newton Method seems to be the best option available to detect the time of interception with the different obstacles. This is due to the fact that the dynamics of the quad is described by exponentials approaching a steady state speed, and thus are monotonic by nature.

**Milestones for next two weeks:**

I will be working mostly with Shivang, focused on understanding the actual dynamics of our quadcopter with our payload. This is the key achievement needed to initiate work in:

- a) Final algorithm of collision avoidance
- b) Final coloring code for the Bird's Eye view
- c) Final sound warning code for alerting near collisions

With the entire team: Discuss the Spring Validation Experiment (the clock is ticking!!!)

**Key risks:**

We have a lot of work in the coming days on the ramp up to the SVE, with risks concentrated on:

- a) Getting the quad up and running with our payload
- b) Nailing down the dynamics of the quadcopter against pilot inputs