Fly Sense

Team C – ILR08

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Work done these past 2 weeks

Over the past two weeks we have

a) Done a detailed workshop with NEA pilots to fine tune our design (23rd of February)
b) Done multiple flights (dynamics calibration, communication testing, Velodyne testing)
c) Written the code for the new dynamic window, the new sound warnings and coloring

Nick got all the hardware up and running, Hari did the firmware updates, Nihar has been working on the new integrated screen (FPV from the quad + HUD + Bird's Eye view).

From my side, the focus has been on producing the new algorithm code that would take into account the quadcopter dynamics:

a. New dynamic window (adjusting the boarders of what the image shown to the pilot based only on current speed state - to avoid jerks no inputs are taken into account)
b. New coloring algorithm (based on time to impact with maximum possible input and the current state)
c. New sound algorithm (based on the actual pilot input and the current state since humans cope better with visual cognitive overload rather than sound cognitive overload and these should depend only on what the pilot wants to do)

NEA pilots feedback meeting notes (23rd of February)

1) Feedback on overall organization of HUD
   - Speed and altitude a must
   - roll and pitch a must, yaw optional
   - speed and altitude use rolling tape

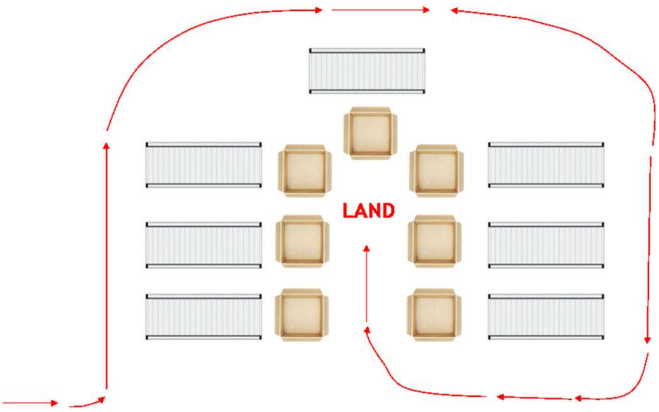
2) Bird's Eye View coloring:
   - size and position customizable (if possible)
   - Important to clearly communicate what forward is (e.g. an arrow, a triangle)
   - Dynamic window: OK to have the scale extended depend on pilot input and current state, but needs to smooth
   - Should represent ONE of the ellipsoids explicitly for reference (eventually with scale reference attached) using a ghost ring
   - Should show THREE levels of coloring on the obstacles with crisp colors
   - Most dangerous object should be blinking and have a bigger dot in the screen to clearly say to the pilot that this the reason the sound warnings are being issued
   - Consider blinking frequency of the most dangerous object to be aligned with timing between successive beeps

3) Bird's Eye view sound:
   - Regions should be consistent with the coloring regions (THREE levels of warning)
   - The sound warnings should have current pilot input into account

- Either do 360 degrees warnings to clearly differentiate spatial location of obstacles or simply do flat sound (e.g. do not distinguish left or right)
- Audio warnings should always be done at the same pitch/frequency to clearly identify that this warning is related to obstacles
- Warning setup
    i. First ring/level of danger: One single "long" beep
    ii. Second ring/level of danger: beeps of shorter duration, less spaced in time across successive beeps
    iii. Third ring/level of danger: even shorter beeps with even shorted spacing between successive beeps

4) Communicating overrides to the pilot
    - The pilot should clearly understand the dimension being constrained: speed or attitude (roll, pitch or yaw).
    - The dimension being constraint should be colored accordingly in the HUD with YELLOW or RED (e.g. constraint on speed, roll, pitch or yaw)
    - Show message at the bottom of the HUD with the dimension being overridden (e.g. "Control Override on speed") in the appropriate color of the level of constraint

5) Notes on testing at Nardos
    - Don't forget to ask NEA to bring extra batteries on the test days to ensure uninterrupted testing as much as possible (12 batteries, 6 chargers)
    - Landing should be tested explicitly to prove that the system helps with it (e.g. landing next to a pole?)
    - Real carbon fiber tail is OK, but a virtual tale can be used instead
    - Virtual obstacles are preferable to "extended obstacles" for the 2nd testing round of the emergency brake feature
    - Containers OK for the 1st testing round but testing should avoid going in between the containers (to be confirmed):

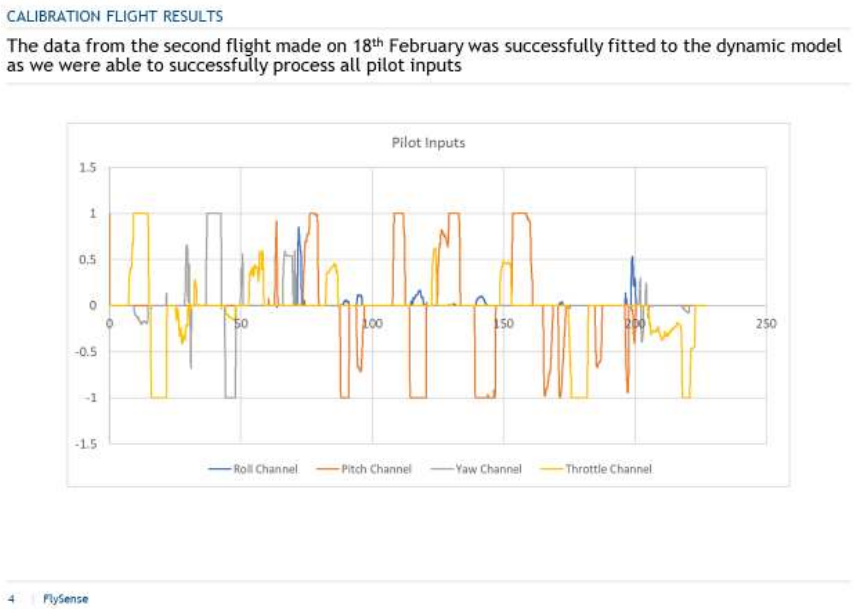


Individual achievements for the past 2 weeks

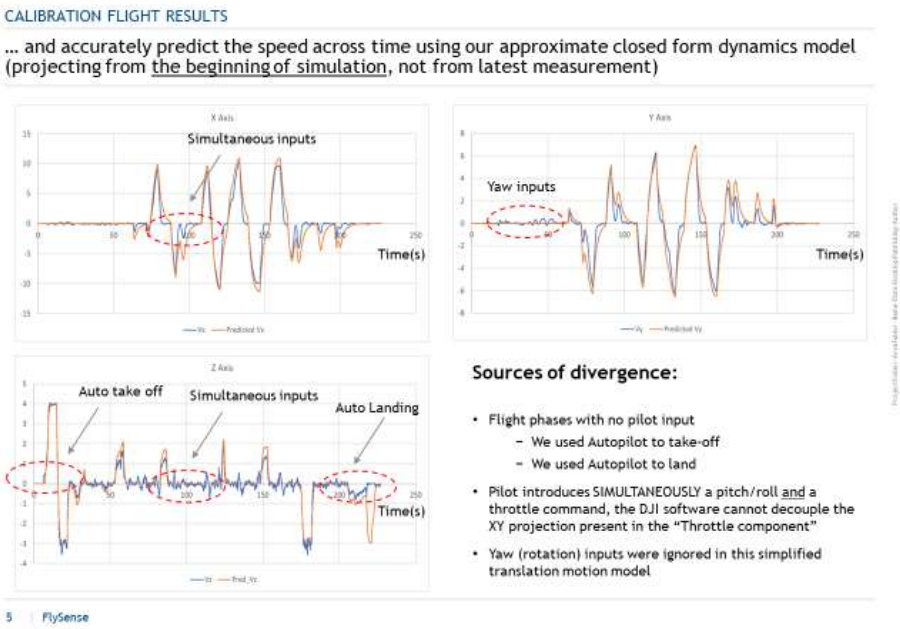
Calibration flight

The calibration flight took place on 18th of February and with the data retrieved I was able to both validate the closed form dynamics model and calibrate the unknown drag parameters (that turned out to be around 5 in the vertical direction and 1.2 in the horizontal direction).

Pilot inputs during the second flight:



Comparison between the real data and the closed form dynamics model.



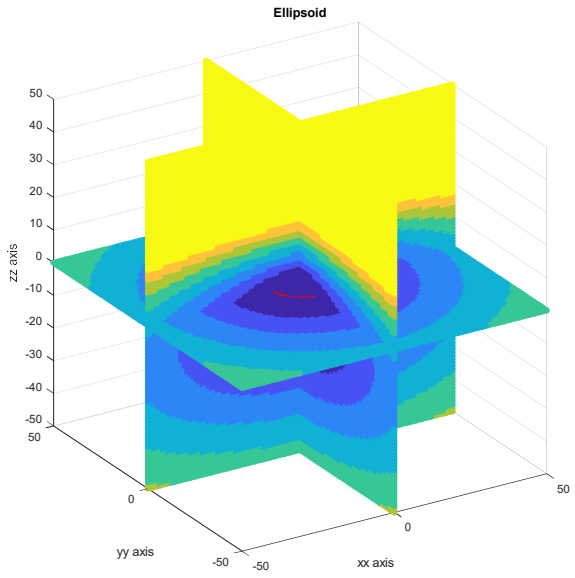
The model proved resilient enough to be used over extensive periods (250 seconds in the above calibration) and thus should be reliable enough to project 5.5 seconds into the future as intended. This was what we need for the sound warnings and coloring the obstacles presented in the bird's eye view (5.5 seconds seems to be the "magic" number for projecting into the future based on the talks with had with professor Aaron Steinfeld in the previous semester when he described his field work with bus drivers in California.)

Code implementation

The code for dynamic window, sound warnings and coloring was implemented in Matlab and Hari ported it to C++. We are now doing extensive testing on that code in order to integrate it with the ROS solution. Part of this testing will include analyzing how to increase performance to the maximum possible so that we can ensure that this is robust enough to be deployed real time on our quadcopter (let's not forget the point clouds from LIDARs have "endless" number of points).

Example of output from Matlab testing with 30k points distributed evenly over three different planes using real data from the calibration flight to produce the coloring.

Initial state: Vx0=Vy0=Vx0=0



Note: Colors were chosen automatically by Matlab, the final code will assign red to the most dangerous zones (now in blue), then yellow to the intermediate danger areas and finally green to the outer regions. The circle in red is where the quad can go in the first 2 seconds.

Milestones for next two weeks:

For the next PR I plan to have:

a) Extensive testing of the dynamics window, coloring and sound warnings after integration with the rest of the Flysense solution (working with Hari)

b) Standalone code for obstacle avoidance (emergency breaking actually, as avoidance we plan to address during the summer at NEA internship)

Problems Faced these past weeks

The biggest problem is, as always, a substantial load from all the different courses… made worst by the fact that this semester there is not only one group to interact with across three different courses, but rather a different group for each course.

Key risks:

Navigating through the heavy load coming from multiple assignments across all courses. I am beginning to regret the day I convinced professor Dolan to have 5 technical courses in a single semester (I had an MBA which made the business classes kind of redundant).