Fly Sense

Team C – ILR 2

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Work done this week (User Interface Design)

- Summarize meeting with professor Jean Oh
- Meeting with professor Aaron Steinfeld
- Book meetings with professors Alan Black, Jack Stow and Alex Rudnick

Problems Faced (User interface Design)

This week we had MEC mid-term exam and work did not flow as much as expected/should have flow if we don't want to risk delays against our project calendar. We have been fairly conservative in our estimates and have thus far not deviated from what we expected, but we need to increase our pace over the coming weeks.

The meetings with Professors Jean Oh and Aaron Steinfeld have validated our preliminary assumptions on design rules and open a few more avenues (e.g. sound). We hope that next week we are able to meet with the "sound experts" and have a quick win on that front.

Other relevant milestones this week.

The group also acknowledge that Hololens was designed for 3D holograms while seating in a chair inside a room and that most of the design principles are not applicable to the environment of a helicopter cabin.

The "pros" that made Hololens look better than Epson in our trade study now seem irrelevant for the application we are seeking (e.g. 3D holograms that have fixed reference to the pilot, fine head tracking that may not work with the helicopter vibrations, voice commands that will not work with the helicopter noisy environment, …)

Hololens Pros	Hololens Cons
• Easy to build applications • Excellent head tracking (gaze) • 3D Audio (with no background noise) • Holographic images (3D virtual world) • Works both in wireless and wired mode • Voice Commands (with no background noise, but only works online)	• Resilience to lighting (overlaid graphs) • Windows based development (integration NEA) • Limited field of view (-30 to 30 degrees) • Feels heavy after using it for 30/40 minutes • Hand tracking not good enough for interaction • Hologram alignment lost if headset moves relative to the head of the user • Voice commands do not work with helicopter background noise (tested at Robolounge)

In that sense, next week we will receive from Amazon Epson AR unit. We were in a hurry and did not use the standard process and ordered directly. I will seek reimbursement, and know that will lose the equivalent taxes (around 50 USD) which should not be a problem.

- **Why Epson might be more adequate?**
  - No need for holograms as per the new streamlined scope (three features only)
  - Android based development (ROS-Java) easy to integrate on NEA helicopter
  - Epson AR is used on a start-up that is trying to do similar AR interfaces (track record)
  - Substantially lower cost compared to Hololens from Microsoft

- **Additional feedback gathered from pilots and CMU experts (Aaron Steinfield/Jean Oh)**
  - Pilots prefer lighter units
  - Pilots prefer voice commands to gestures
  - Voice Commands better than hand gestures
  - The simplest the interface the better
  - Vibrations in helicopter could change relative posture of headset vs pilot head

The main reason to short circuit the procurement process was that AR is a crucial part of the project, and NEA (our sponsor) is very keen on it. So, if we were to add more days to the procurement process we would stall our development in the AR front even further.

We should have ordered it much before, but group dynamics takes time and we wanted to ensure that everybody was onboard before rushing to buy equipment (after all the Hololens was borrowed 😊!)

My biggest contribution this week was preparing the PR1 report that was finalized and presented by Nick. The good thing about it was to crystalize the status update on the LIDAR and AR fronts.

The tests the team had done with the 16 channel Velodyne were presented, as well as a rudimentary version of the AR.

Milestones for next three/four weeks:

Meet with the three experts and get off-shelf code working for voice recognition and 3D sound (Jack Mostow, Alan Black, Alex Rudnicky).

a) Generating 3D sound warnings (this module is to be connected with the pilot headsets)
   a. Module should work offline – no Internet connection
   b. Module should allow pilot to at least distinguish left from right
   c. Module should generate sound more/less continuous as a parameter is changed
   d. Module should allow to customize the frequency of the sound generated
      - We will need to test several frequencies to avoid generating sounds similar to engine failure…
      - .. because pilots are trained to dive immediately when they hear this engine failure sound: https://www.youtube.com/watch?v=5__lYiDFqgM)

b) Recognizing speech (this module is to be connect with the pilot microphone)
   a. Module should work offline – no Internet connection
   b. Module should be able to recognize 5 to 10 commands
   c. Module should be resilient to extremely noisy environment (helicopter cabin)
   d. Module should be resilient to foreign accents

c) **Prepare dynamics model to select relevant space window to display the LIDAR data to the pilot (quadcopter or helicopter state model to be used).**

Summary of meeting with Professor Aaron Steinfeld

a) FPV displays are shooting are normally called “Contact Analog” or “Registered Display”

b) Icon based displays are less prone to vibrations (e.g. bird’s eye view and standard displays) and thus easier to implement.

c) Major issues to avoid designing interfaces are:
    i. Cognitive capture: when reality and the display don’t match, people tend to believe the display
    ii. Masking reality: display may be hiding something relevant behind it
    iii. Misperception of depth distance: focal distance of the display should be as big as possible (our eyes assume 30 meters as infinity)

d) Graded warnings are a good way to avoid cognitive saturation
    a. Aaron used this approach on bus drivers (paper from Christophe Mertz on the details of how it was done was later published)
        i. Key metric to track is time to contact (forward collision)
        ii. For lateral collision they integrated in time and saw probability of trajectory interception
            1. Yellow: Possible (be alert)
            2. Red: Imminent (act now)
        iii. Time windows for lateral collision were up to 5 seconds into the future (further than that too many false positives)
    b. To communicate with the bus drivers, Aaron used peripherical warnings in the bus pillars (as it was an extra set of rear mirrors)
    c. Part of the warnings were arrows point to directions where danger could come from

e) Using automatic pop-ups is a good practice
    a. Aaron used it with military truck drivers
    b. The problem was that the cabins have commands that are too complicate (they cater to anything that may happen)
    c. When drivers are given a display that automatically shows something when is relevant (e.g. pushing the engine too far) the number of broken down equipment went down

f) Hepatic vibrations as warnings do not work well
    i. In controls pilots cannot distinguish from mechanical problems
    ii. In the seat pilots may not feel it after a few hours of sitting down
    iii. In a helicopter, vehicle vibrations may not be easy to distinguish from the hepatic warnings

g) Sound commands may be a good idea
    i. Recognizing five/ten commands should be feasible

ii. We will contact three people at LTI (Alan W Black – speech recognition in noise environments, Alexander I. Rudnicky – speech recognition with accents, Jack Mostow – works with kids)
iii. Aaron agreed to copy him on those emails

h) 3D warnings may be a good idea if embedded in the pilot's headsets (otherwise noise cancellation features will filter it away)

i) It is critical to manage the color scheme proactively depending on the external lightning conditions (e.g. use a camera).

Summary of meeting with Jean Oh

In our meeting with Jean Oh, we discussed the limitations of user interface with the pilots. Jean advised us to bridge with LTI through professor Aaron. Jean's experience in her ATLAS project:

- **Project objective**
  - Reduce the number of pilots onboard to one (not necessarily remove pilot)

- **Primary user interface was considered "primitive"**
  - In Jean's previous project, they used a tablet to interface with the pilot
  - Every control had to be automated so that the pilot could focus on the tablet

- **Voice Commands as alternative user interface**
  - Pilots referred several times that they would rather issue commands to their "automated co-pilot"
  - Technical teams dismissed the feedback several times deeming it impossible due to noisy environment
  - But when the technical teams (finally) looked into it, it turns out that tremendous progress had been done in the last 2/3 years and they are now working on it
  - The commands they are trying to automate require confirmation from the pilot on the order given (e.g. engines off, arm missile,…) but that will not be needed for our interface (overlay on or off)

- **Testing results for Cortana Hololens**
  - We tested Hololens and Cortana (speech recognition app) works very well in a silent room
  - Does not work well with the sound system of the Robolounge playing helicopter noise in the background and it needs an online connection (which is not practical on a helicopter)
  - But Cortana was designed for speech recognition, not recognition of isolated commands and Jean believes we can train a simple speech recognition tool to work with 10 words in a noisy environment