Progress Review 2

Project Pegasus

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Team A - Avengers
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1. Individual Progress

Setting up BeagleBone Black

For this week we I was responsible for setting up the Beagleboard with OpenCV and testing marker detection algorithms for accuracy and efficiency on the laptop. Due to various challenges, my plan for the week had to change multiple times.

I set up OpenCV on Beagleboard xM. I had to build OpenCV from source for this (as we had finalized on using ROS indigo which does not include OpenCV). But, while analyzing risks for the Systems presentation, we realized we only had one Beagleboard xM and they were not being sold anymore. We decided to switch to Beaglebone Black (BBB) as it had the same processing power but no DSP. Immediately I set out to set up the Beaglebone Black with an Ubuntu 14.04 image. This took me a day to do after having done a similar thing on the BB xM.

Switching to Odroid

In parallel, I was researching on markers and detection algorithms which were capable of running on single-board computers. We also talked to last year teams that worked on vision based landing for UAVs. Soon, we realized that the processing power of the BBB would be limiting in terms of speed that can be achieved while detecting markers. Hence, we decided to switch to the Odroid XU4 as it had almost 4 times the processing power of the BBB and was proven to work with UAV vision systems. I ordered the Odroid and decided to concentrate on vision algorithms.

Vision Algorithms – Color Thresholding and Centroid

I decided to test the processing speeds attained by simple color thresholding and centroid detection as a benchmark for the other tests.

FPS: 25 fps
Detection: Neutral
Robustness: Very bad results in varying lighting

Vision Algorithms – Checkerboard Pattern detection

After the first test, I realized that color thresholding is not robust enough to be used in an outdoor environment with varying lighting conditions. Next, I tested the checkerboard pattern detection algorithm, as it is a specific pattern which would not be available generically in nature.

FPS: 13 fps (3 fps when partially visible)
Detection: Good
Robustness: Robust to lighting and scale changes

Vision Algorithms – April Tags

Due to the limitations of the checkerboard detection algorithms, I tried a highly recommended, and commonly-used April Tag detection algorithm. April Tags are small markers which can store some data and have robust detection techniques.

I studied the April tag library to understand how the algorithm worked and if we can reduce any parts to make our detection system faster.

FPS: 14 fps (all cases)
Detection: Very good.
Robustness: Very good results in varying lighting distance and homographies.

Vision Algorithms – Lucas Kanade Tracking

Another interesting test was for the Lucas Kanade tracking system, the idea was that once a marker is detected correctly, we might prefer tracking it as the UAV moves instead of trying to detect it in every frame. This might make the overall algorithm a lot faster. I tried the basic Lucas Kanade tracker for "good' features on an April Tag.

FPS: 30 fps (all cases)
Detection: Needs featured to be tracked.
Robustness: Very good results if no occlusions and marker stays in frame. Requires re-calibration otherwise.

2. Challenges

I faced many challenges:

Setting up the BBB

The BBB system had several variations from the BB xM. These took me some time to understand. The BBB console works as a local adhoc network with a default IP (192.168.7.2) which was different from a serial connection on the BB xM. Furthermore, after generating an image, it needs to be flashed onto the eMMC from the SD card on the BBB while it ran off the SD card on the BB xM.

When trying to set up internet on the BBB, I got stuck in the Domain Name Resolution step. The BBB got a network IP and could ping by IP over the internet but the name resolution for a server did not work. Before I could solve this issue, we decided to switch to the Odroid for vision processing.

Vision Algorithms

There is limited research available on the types of markers for visual detection and performance analysis across those. Because of that, I had to try most algorithms I could imagine working for us without much prior knowledge of their performance.

3. Teamwork

This week, Sean and Pratik worked on characterizing the obstacle detection sensors. We realized a large number of iterations would be required before we can have a confident obstacle detection system covering the vehicle. The basic versions of combo tests were made and results obtained, but many more need to be done to obtain a satisfactory system for obstacle detection.

We finally progressed on the UAV front. Birds Eye View Aerobotics, after signing the NDA with CMU, got on a call with us to share details of their proprietary systems that would prove very useful for our project. After that call with them, Adam and I discussed the electronics architecture in the UAV and finalized our orders for parts (including spares). The body of the airplanes are currently in the mail and arriving soon.

We had a good discussion with last year team members – Sahil Shah and Abhishek Goudar about the systems they used and problems they faced when developing a similar drone docking system. This led us to switch our SBC in favour of Odroid, even though it will have a steep learning curve.

4. Future Plans

In this week, Pratik will primarily concentrate on obtaining the sensor metrics for finalizing obstacle detection sensors. He shall try other sensors like the Lidar Lite, using PWM outputs instead of the analog outputs for Ultrasonic sensors and switching the sensors on/off to prevent interference.

As we have now received the CAD of the underbelly of the UAV, Sean will go ahead and design the underbelly to get an initial estimate of where to place various components there.

Adam will be working with the Pixhawk to run a motor. He will also understand proprietary system we received from BEVA. He would get a basic system ready in time we receive the UAV and its components. If time permits, he shall also integrate the optical flow sensors with the Pixhawk system.

I will be primarily working on optimizing the marker detection algorithms, understanding what optimizations can be made for our use-case and finally, testing them to scale for our application (in terms of size and distance). I might also try using other cameras to compare their performance in comparison to that of the Logitech C260.