Individual Lab Report #5

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Team F: Rescue Rangers

Teammates:

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November 23, 2016

Contents

1. Individual Progress

1.1. Overview

During the past two weeks, I worked majorly on the following tasks:

1. Package drop mechanism design
2. Mounting 360fly camera on the drone
3. Outdoor waypoint navigation testing (team task)

1.2. Package drop mechanism design

Major requirements for the package drop mechanism: It should:

1. Carry a 10cm x 10cm, 100g package
2. Keep a good grip on the package during the flight
3. Safely release the package, when required

It made sense to first to look at the designs people have been using to drop packages. Amazon Prime air was naturally the first thing that came into my mind. Figures 1 and 2 show the designs they have been using.

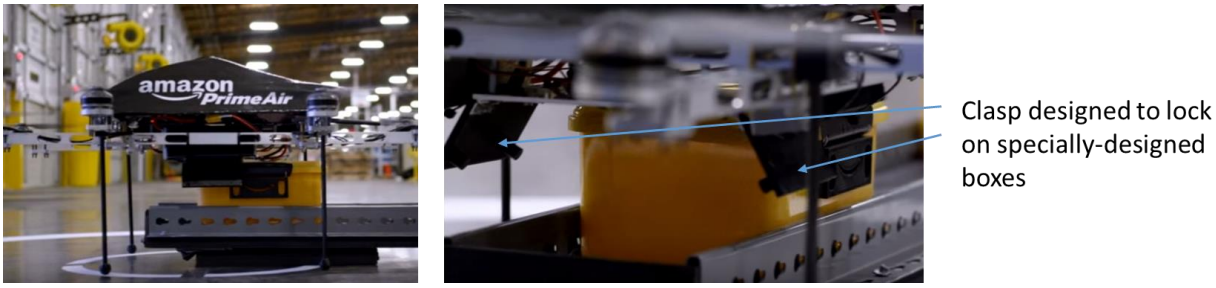

Figure 1: Amazon Prime Air: Design 1: Two clasps on the drone, designed specifically to lock on specially-designed boxes

Figure 2: Amazon Prime Air: Design 2: Double door mechanism allows flexibility in package dimensions

For our search and rescue scenario, it does not make a lot of sense to have specially-designed boxes on which the drone's clasps might lock on, as suggested by Amazon Prime Air's design 1, shown in Figure 1. Additionally, having two clasps limits the dimensions of the packages that can be carried. It makes more sense to go for something like design 2 (shown in Figure 2) since it gives flexibility in terms of the size of the package that can be dropped. Though package dimensions are fixed in our requirements, it seemed better to approach the problem more realistically.

Use of electromagnets required putting a metal plate inside the package, which also did not seem realistic to me, for our scenario.

I explored more door-opening designs, both double-door, and single-door. Some interesting examples are illustrated in Figure 3: (a) and (b).

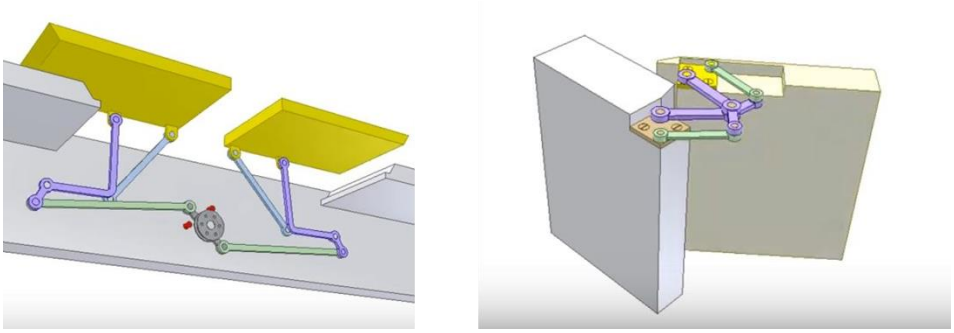

Figure 3: (a) Double-door ceiling window design[1], (b) 90 degree concealed hinge design for single door[2]

Mechanisms shown in figure 3, although robust, demand high accuracy in designing and fabrication, and thus did not seem feasible to me, given the time available. I went for a simple single-door design actuated by a servo motor. Figure 4 shows the SolidWorks designs.

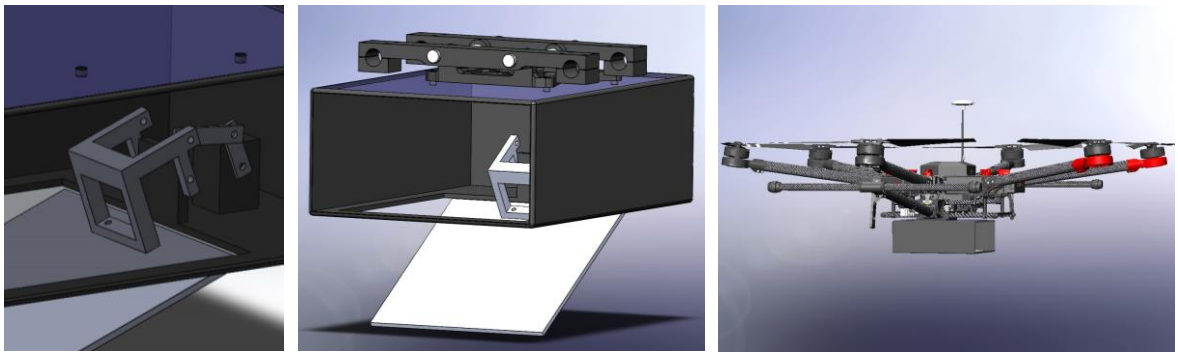

Figure 4: (a) Single-door opening mechanism actuated by a servo motor, (b) Resultant SolidWorks assembly with mount for Matrice 600 (sponsor's drone), (c) Assembly mounted on Matrice 600

[1] Source: https://www.youtube.com/watch?v=N395Mxotd2M&list=LLGf5Pj2o8dBralE6LTRcnPq&index=2,
[2] Source: https://www.youtube.com/watch?v=lE-HTMKPDjQ&list=LLGf5Pj2o8dBralE6LTRcnPq&index=3

The design developed, shown in figure 4, has the following advantages:

1. Flexible, to an extent, in terms of allowed package dimensions
2. Ease of loading: You just need to place the package inside from the front door (not shown in the model) and tighten the straps (not shown in the model). The straps will go over the package and would be tightened from outside.
3. Firm grip over the package: With the straps, the package would be tied to its position and thus, not move inside the box, preventing any effect on the drone's dynamics

But this design has some disadvantages too:

1. The door has to be held closed by the servo motor's torque, which is a little bit of risk. It would have been better if the lock was some physical structure rather than the torque applied by the motor
2. The mechanism is a bit bulky (mainly because of the box) and still not very easy to fabricate

I went over one more design which is **much simpler, compact and does not depend on motor's torque for locking the package.**

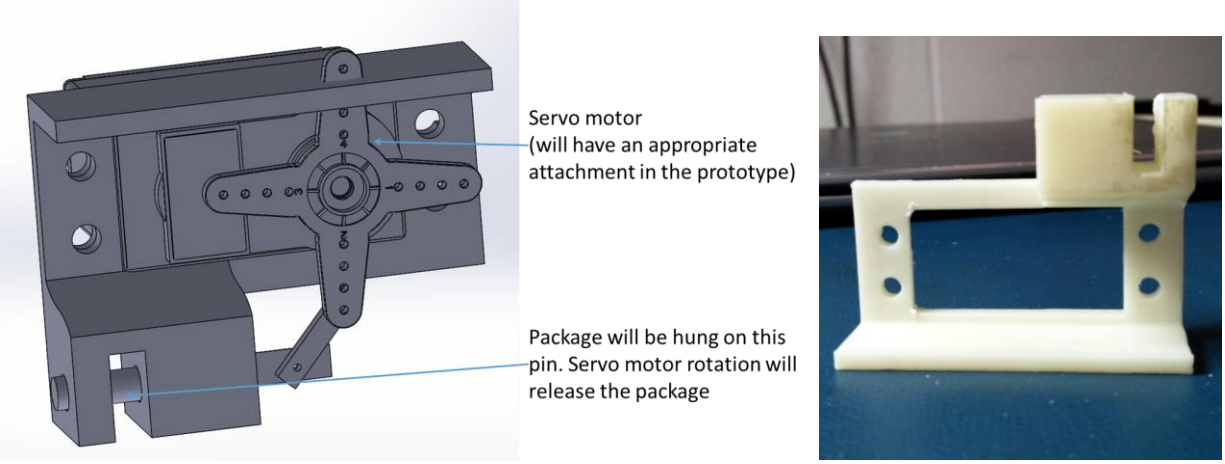

Figure 5: (a) SolidWorks model for simple servo-driven pin lock for hanging a package, (b) 3-D printed base frame

With this design, there is a concern of the hanging package affecting our drone' dynamics. But since our package has to weigh just 100g, we don't think it will be much of an issue. For now, we are going with this design and have started fabricating it. Flight-testing with the mechanism might change our decision later. Figure 5 shows the SolidWorks model and progress on fabrication.

1.3. 360fly camera mounting on the drone

In order to enable validation of the altitude our drone flies at, and accuracy with which it reaches the given waypoints, we decided to mount a camera on the drone. We got a '360Fly'

camera, from our sponsors, which is capable of giving Full 360° horizontal x 240° vertical field of view. But, we will use it for simple POV images.

I designed the camera mount, 3-D printed it, and then, mounted the camera on the drone.

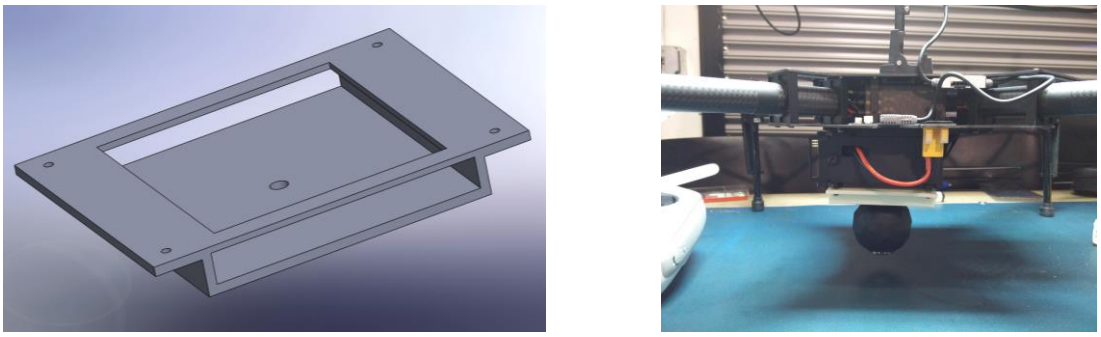

Figure 6: 360Fly camera mounting (a) SolidWorks model (b) Camera mounted on the drone

1.4. Outdoor waypoint navigation testing (team task)

To ensure accuracy in reaching waypoints, we need to have as many test flights as possible, to ensure that we reach the waypoints accurately and consistently. But unfortunately, during this week, we have been able to fly successfully only once while we had to abort our testing due to bad weather conditions, three times. After mounting the camera, we also utilized these flights to take some photos of a big red dot, and an AprilTag to see how we can estimate the drone's altitude using these images. Figure 7 shows two of these images.

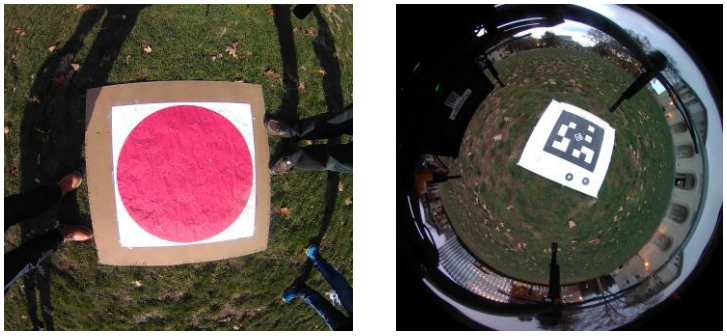

Figure 7: Images taken from 360Fly camera on the drone to estimate drone's altitude: (a) drone hand-held because of inability to fly due to bad weather conditions, (b) taken during flight

2. Challenges:

I faced following challenges during my work:

1. Deciding on the package drop mechanism to go with:

   I have a lot of ideas for designing the mechanism and each of them has certain pros and cons. Since our package drop mechanism's requirements are not very complex, almost all designs seem to work for us. With limited time at hand, it was difficult to decide on which mechanism to go with, because going with the wrong design could cause great delay. For now, I am going with the simplest design and trying to prototype it as soon as possible, so that we have time to reiterate, in case we need to.

2. Issues with 3-D printers:

   When I went on to 3-D print the camera mount, it took me almost a day to print such a simple component. None of the printers seemed to work. I tried all the printers, different settings for my parts, and both the extruders on two of the printers, but got no success. I did not know how to fix them. Ultimately, Nima helped me clean the jam in one of the extruders and I was able to print the part.

As a team, we are facing a huge challenge of not being able to fly the drone due to bad weather conditions. We are trying hard to overcome this challenge.

3. Teamwork:

Work done by individual team members:

- Team:
  - Outdoor waypoint navigation testing and imaging
- Juncheng Zhang:
  - Human detection in RGB images: He implemented edge-detection and blob-detection algorithms to identify humans in the images.
- Sumit Saxena:
  - Package drop mechanism design
  - 360Fly camera mount
- Karthik Ramachandran:
  - Waypoint navigation app improvement: He worked on displaying on the app, GPS coordinates for the specified waypoints (till now, we only had markers which could be placed anywhere on the map. There was no way of knowing what the selected location's GPS coordinates were). This will enable us to place

appropriate physical identifiers (red dots/AprilTags) at the waypoints which will, in turn, help us verify the accuracy with which our drone reaches the waypoints.

- Xiaoyang Liu:
    - Human detection in RGB images: She implemented Background Subtraction using ViBe algorithm, to identify outlines of moving objects (potential human beings) in the images

4. Future plans:

Following are the tasks I plan to work on until the FVE:

1. Package drop assembly prototype:
    - Complete fabrication of the first prototype as soon as possible, and test it
    - In case of any issues, move to the next best design and fabricate it
    - Make final improvements, and design the demo for the FVE
2. Drone's altitude estimation using images of an AprilTag taken from the drone
3. Figure out ways to help us fly the drone for some time, even in cold conditions
4. Outdoor waypoint navigation testing