Individual Lab Report #8

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Team F: Rescue Rangers

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1. Individual Progress

1.1. Overview

During the past two weeks, I worked on developing an algorithm to estimate GPS locations of signatures identified in the images.

1.2. Estimate GPS locations of signatures identified in the images

After we detect a human or human signature in an image, it is important for us to estimate the GPS location of the identified signature to be able to convey a location as close as possible to the signature for rescue. Although while flying at low altitudes, you can do away with using the drone's GPS location, the distance between the drone and the identified signature can be significantly large when flying at higher altitudes.

We have the following information available which we could make use of:

- Pixel location of the identified signature in the image
- Camera angle and field of view
- Drone's GPS location, heading, and altitude above mean sea level (AMSL) from the flight controller

Calculating Altitude above ground level:

The first important step was to calculate the drone's altitude above ground level (AGL) as it would affect any further calculations we do and could play an important role in determining the accuracy of our algorithm.

I found the Elevation Point Query Service provided by U.S. Geological Survey (USGS), which returns the elevation in international feet or meters for a specific latitude/longitude (NAD 1983) point from the USGS 3DEP 1/3 arc-second layer hosted at the National Geospatial Technical Operations Center (NGTOC).

I also found Google Maps Elevation API which we could access through an HTTP interface, with requests constructed as a URL string, using latitude/longitude coordinates to identify the locations. You can simply make an HTTP request with GPS location as arguments and you get the ground elevation as the response. I used this option because of its relative simplicity.

Using this ground altitude and AMSL from drone's flight controller, I calculate the drone's AGL:

AGL = AMSL - Ground altitude

Calculating signature's displacement from the drone:

To calculate the signature's GPS location, it is enough for us to know the displacement between the drone and the signature in the ground plane. It should be noted, however, that since we are trying to estimate the distance of signature using a single image, we cannot get an exact solution since we cannot precisely account for depth.

I use simple trigonometry to calculate the image's ground footprint in both x and y directions and then estimate the distance to the signature by interpolation (using signature's pixel location). Figure 1 below gives you an idea of how this problem can be perceived from a trigonometric point of view to facilitate easy calculation of image footprint in one direction.

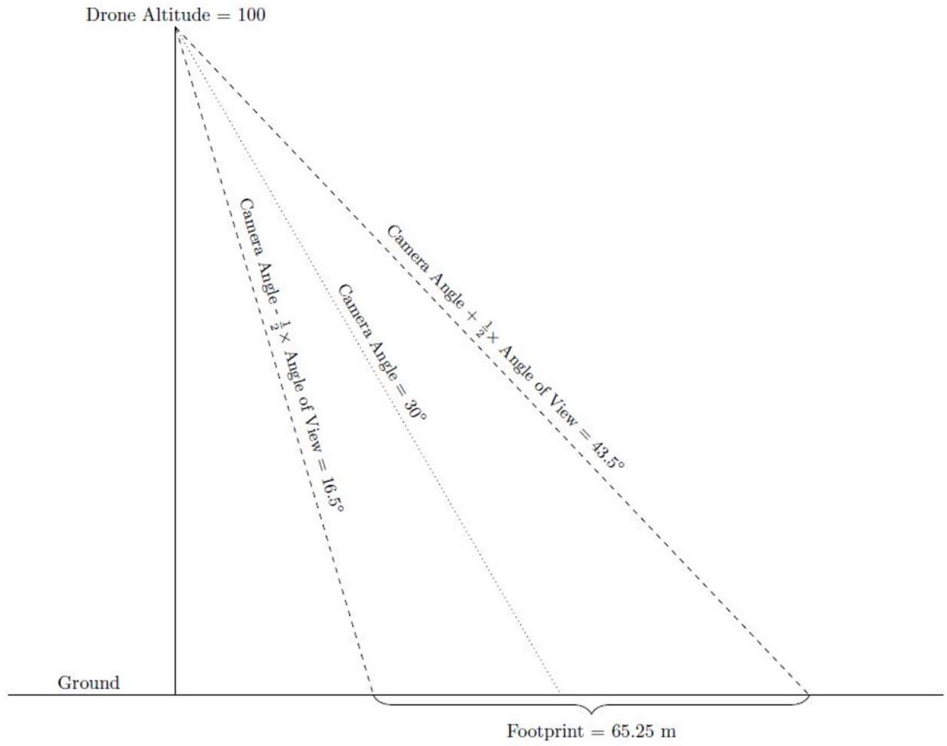

Figure 1: *Reference figure enabling easy trigonometric calculation of image's footprint on ground in one direction using drone's AGL, camera's angle and FOV (the values shown in the figure are fictitious)*

Calculating GPS location of the signature:

The key to solving this problem was calculating the direction vector from the drone to the signature and using it as bearing change needed to get to the signature from the drone's location. Using the calculated bearing change and the drone's heading, we can calculate the bearing needed to reach the signature. After these calculations, getting the signature GPS location using start location and bearing is just Mathematics. I found some good sources explaining the calculation and found a useful library 'geographiclib' which made the implementation pretty simple.

I have implemented the entire algorithm in python and have performed some sanity checks to ensure high-level correctness. We will soon test the algorithm when we start collecting the data using our newly acquired camera.

Caveats:

1. Clearly, the idea of using interpolation between two extremes of the image footprint to calculate the distance to the identified signature is flawed since it assumes distance ratio correspondence between ground distance and image pixel distance. This might cause problems if we take pictures at high altitudes. I will look into ways to better approximate the distance.
2. AGL calculation is also approximate. While Google Maps Elevation API does promise good resolution, we can be sure about the accuracy only after field testing.

2. Challenges

Estimating drone's AGL:

This is a critical part of our algorithm to calculate the GPS locations of signatures. But initially, I was not able to find any good solutions to do this. It took thorough Google search to finally get my hands on some good solutions.

3. Teamwork

Work done by individual team members:

- Juncheng Zhang:
  - Experiment with tracking methods
- Sumit Saxena:
  - Develop an algorithm to estimate GPS locations of signatures identified in the images
- Karthik Ramachandran:
  - Work on developing end-to-end data processing pipeline
- Xiaoyang Liu:
  - Integration of thermal and RGB detection algorithm using simple weighting mechanism

4. Future plans

Following are the tasks I plan to work on until the next PR:

1. System integration: Help in mounting camera and microphone on the drone
2. Field testing and data collection
3. Work on improving the algorithm to detect bright-colored objects
4. Port code for various algorithms to Python
5. Look into Region Proposal algorithms to locate human signatures in images after classification using neural network-based approaches.