Individual Lab Report #9

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Contents

1. Individual Progress

1.1. Overview

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

1. Outdoor testing and data collection (as a team)
2. Test and improve human signature location estimation
3. HSV thresholding for RGB images
4. Intensity thresholding for thermal images

1.2.1. Outdoor testing and data collection

During the past two weeks, we were able to do a lot of outdoor testing with both the microphone and the newly acquired camera. In total, we had ~15 flights, wherein we tested:

- Different configurations of the microphone: mounted directly on the drone, suspended from the drone with different lengths of rope
- Different camera angles
- Different flight parameters: different flight altitudes and velocities
- Including multiple human signatures (sound, hot water, bright-colored air mattresses in addition to humans)
- Including different human poses

Apart from collecting a good amount of data to test our algorithms on, we also got some idea of what our flight parameters be for good results.

1.2.2. Test and improve human signature location estimation

To test the algorithm I had developed during the earlier weeks, I made two major additions/ modifications to the implementation:

a. Functionality to read the logged flight data to get the drone attitude and altitude (with respect to starting location) information
b. Match a given image's timestamp with the data read from (a) to get drone's attitude and altitude at the time the image was taken

Following is the analysis of some of the test results:

Figure 1: Images (a), (b), and (c) for which human signature location estimation algorithm's results and analyses have been presented here

Analysis of results for the image (a) in Figure 1:

Reported drone location (D):	40.472267, -79.966124
Actual Mattress location (SA):	40.47232217624828, -79.96601281695064
Calculated Mattress location (SC):	40.472320339270574, -79.96603301939723
D-SA (displacement from SA to D)	11 meters NE (56°)
D-SC (displacement from SC to D)	9 meters NE (52°)
SC-SA (displacement from SA to SC)	1 meters E (83°)

Analysis of results for the image (b) in Figure 1:

Reported drone location (D):	40.472196, -79.966329
Actual Human location (SA):	40.47232230197682, -79.96626913554962
Calculated Human location (SC):	40.47210993039628, -79.9663917235796
D-SA (displacement from SA to D)	14 meters N (19°)
D-SC (displacement from SC to D)	10 meters SW (209°)
SC-SA (displacement from SA to SC)	25 meters NE (23°)

Analysis of results for the image (c) in Figure 1:

Reported drone location (D):	40.472284, -79.966083
Actual Mattress location (SA):	40.47237301249101, -79.96585213586684
Calculated Mattress location (SC):	40.47231216286925, -79.96596290714584
D-SA (displacement from SA to D)	21 meters NE (63°)
D-SC (displacement from SC to D)	10 meters E (72°)
SC-SA (displacement from SA to SC)	11 meters NE (54°)

As it can be seen, while the algorithm gives a good result for the first case, it seems to have some considerable issues. Following are the areas I will look into to solve the issues:

1. Final conversion of distances from drone to GPS locations
2. Better deal with the transformations required, in a systematic manner

Figure 2: *(a) Hot object detection using intensity thresholding in thermal images, (b) Bright-colored object detection using HSV-thresholding*

1.2.3. HSV thresholding for RGB images

As a step towards detecting bright colored objects like camping gear tents and air mattresses, I implemented a simple thresholding based on 'Value' and 'Saturation'. 'Value' threshold of 0.9 and 'Saturation' threshold of 0.3 seems to work well for us for now and gives us good results in even varying lighting conditions. Figure 2 (b) illustrates the algorithm in action.

We might look into further improving this and making it more robust.

1.2.4. Intensity thresholding for thermal images

Since we think thermal abnormalities in the scene could be a potential human signature, for example, a fire or a heated stove indicating cooking, I implemented a simple intensity thresholding on thermal images which easily isolates such heat signatures from the background. Figure 2 (a) illustrates the algorithm in action.

As can be seen from the figure, we also get the bare skin (face, hands, legs, etc.) of humans as regions of interest using this. Also, we get very less false positives using this as compared to the HOG+SVM algorithm we use for human detection. Integrating this thresholding into the human detection algorithm led to a significant reduction in false positives.

We will further work on it to make it more robust and integrate it with human detection algorithm in such a way that it improves the latter's performance and reports non-human thermal signatures as well.

2. Challenges

1. Estimating drone's heading:

I had a hard time figuring out how to get drone's heading from the flight data since the flight data has only altitude, roll, pitch, and yaw information and documentation by DJI is not good. After a lot of research, I came to the conclusion that the 'yaw' reported can directly be taken as the heading but I still need to do some testing to be completely sure about this.

2. Estimating signature GPS location:

Right now, there seem to be multiple issues with the algorithm as there are a lot of uncertainties in the calculations:

a. Since the flight data only provides barometric altitude with respect to the starting GPS location, we query Google Maps Elevation to get terrain altitude at both the starting location and the drone location. All three altitudes mentioned have some uncertainties
b. Output GPS locations seem to be along incorrect directions with respect to the drone
c. We assume that the ground is flat
d. We assume that the drone has no 'roll'

As a result, it seems a bit difficult to identify the exact reasons for failure. I plan to deal with each module separately and in much more detail to improve the algorithm, as this is a crucial part of our system.

3. Teamwork

As a team, we did a lot of outdoor testing and data collection, and also discussed how our final fusion of different algorithms be like.

Work done by individual team members:

- Juncheng Zhang:
  - Work on porting the code for HOG+SVM to python
- Sumit Saxena:
  - Test and improve human signature location estimation
  - HSV thresholding for RGB images
  - Intensity thresholding for thermal images
- Karthik Ramachandran:
  - Test voice activity detection on new data
- Xiaoyang Liu:
  - Adapt the integrated thermal and RGB human detection algorithm to our camera data and test its performance

4. Future plans

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

1. Improve and rigorously test the signature GPS location estimation algorithm
2. Camera calibration
3. System integration
4. Port code for various algorithms to Python
5. Explore feasibility of Faster R-CNN and Yolo and implement, if feasible
6. Improve hot object detection to make it more robust
7. Final SVE design