Individual Lab Report 9

Team: H

Name: Steve Zhu

Date: 10/24/2019

Team Member: Akshit Gandhi
Shubham Garg
Parv Parkhiya

1. Individual Progress:

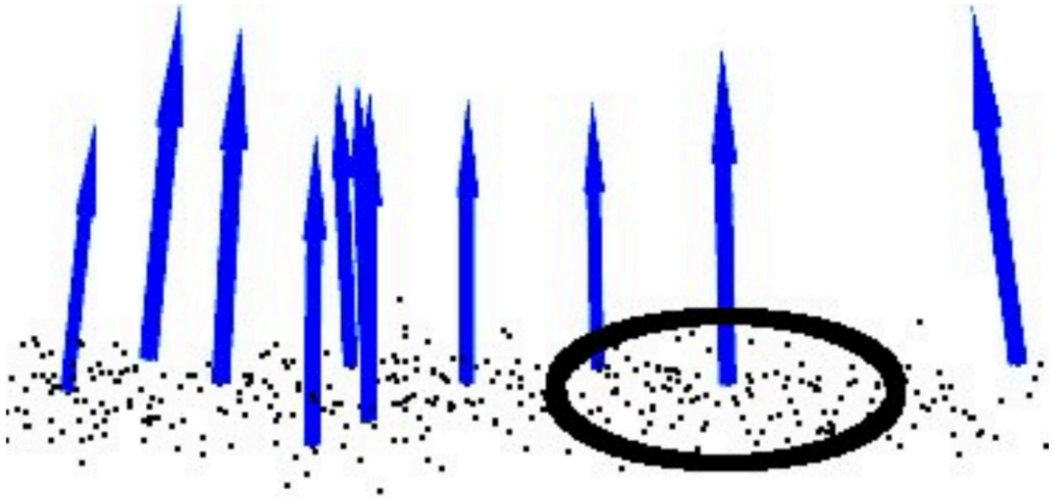
My individual progress mainly includes two parts: more robust opening window detection and new fire extinguishing mechanism experiment and testing:

1. Point cloud-based opening window detection

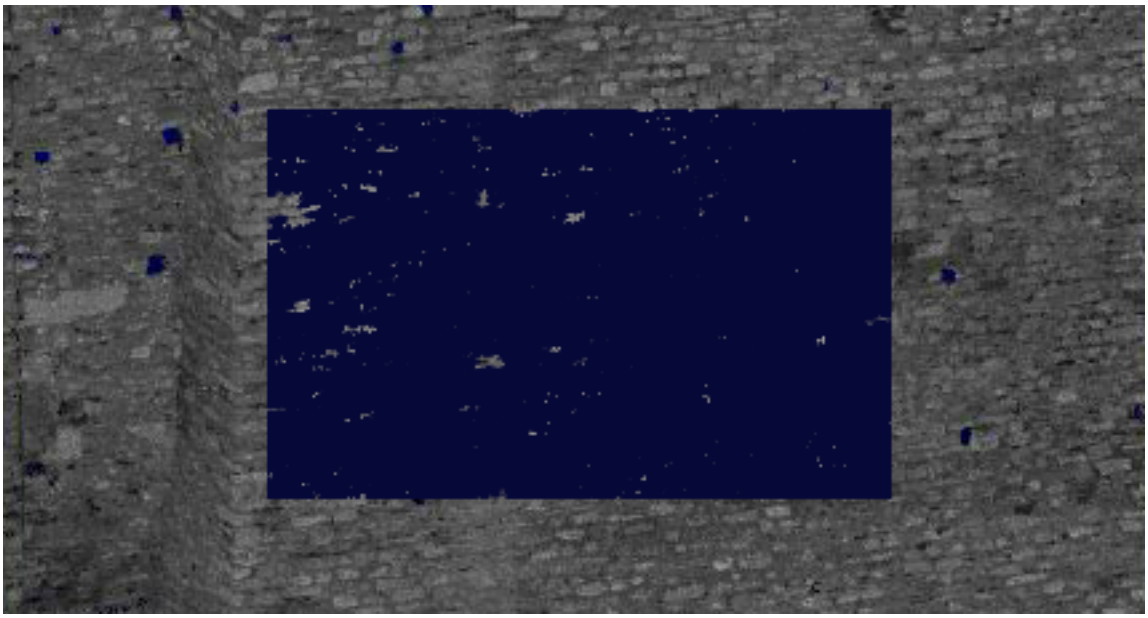
Previous, we are using depth image together with image morphology for opening window detection, but that's not robust enough as noise will easily bias the algorithm and some hyper-parameters are just hard to fine-tune. So, we decided to shift back to point cloud-based algorithm for opening window detection. Besides of the weak-robustness we faced by depth-image based algorithm, another reason for using the point cloud based method is that for our UAV to successfully fly through the window, we want it to be able to align itself with the wall's normal first (UAV fying through the window will be discussed later in more details).

So, below is the explicit explanation of how our opening algorithm works:

1.1 First, we get the point cloud data, and we utilized the PCL library for finding the normal of the dominant plane (in our case, the dominant plane corresponds to the wall). For instance, the normal will look like this:

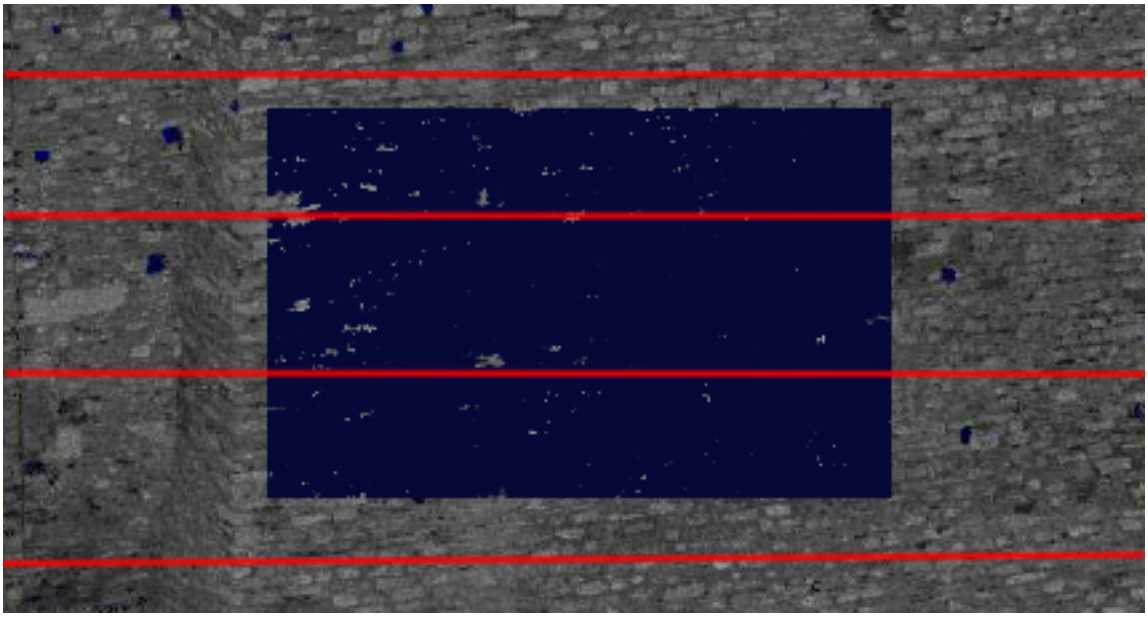


1.2 Then, we will align the camera along with the wall's plane's normal, which makes the point cloud look like the following image:



the grey part of the image corresponds to the wall, while the blue parts are the window.

1.3 Next step is to find both the vertical and horizontal edges of the window. And we will be searching for the vertical window edges first by doing multiple scan along the y axis (every 0.2 meter in our case, as we don't know the horizontal edge for this moment), which is like this:



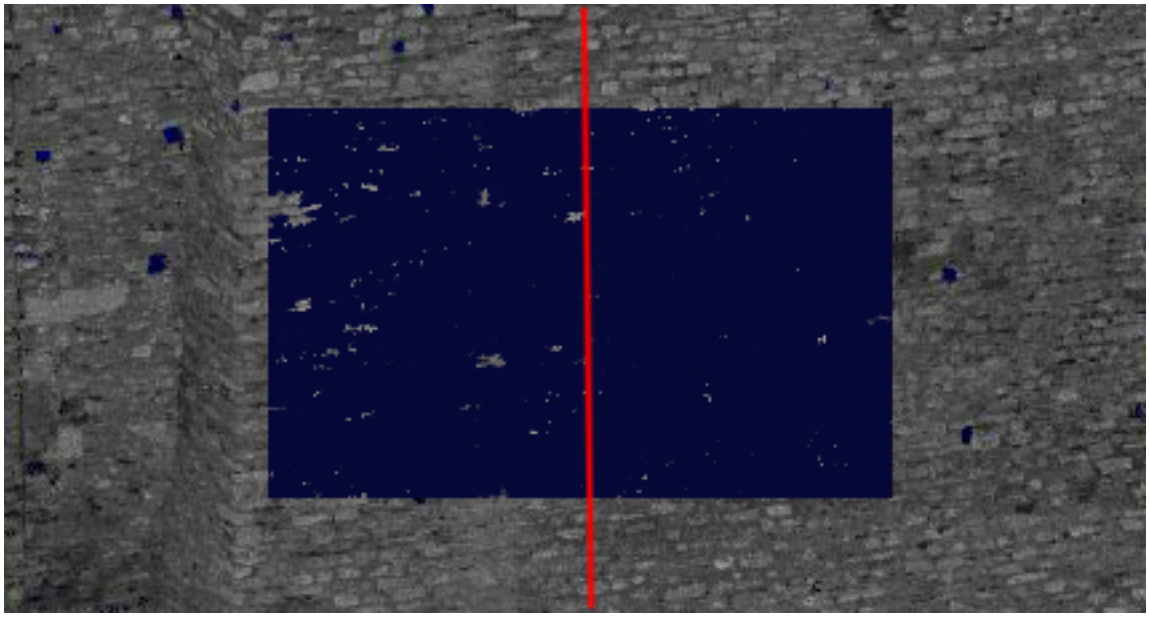
And for each horizontal scan, we apply sliding window to find the edges: for instance if the window size is 100, and we denote the pixel index is from i to i+100, we do a calculation as following:

$$gradient = sum(line[i + 50 : i + 100]) - sum(line[i : i + 50])$$

So, then regions corresponding to the wall will have a very small gradient score, while the edge areas will have a larger gradient score (if the center of sliding window is at the edge, we will have the largest gradient).

After applying the sliding window, we can find the two vertical edges, and thus find the horizontal center of the window. Next step is to find the horizontal edges of the window.

In order to find the horizontal edges of the window, we just need to do one single vertical scan of the point cloud where the horizontal coordinates is the horizontal center we just found previously. The new point cloud will look like this:



Similarly, after the sliding window, we can have the positions of the two horizontal edges of the window.

Until now, we have found the spatial center of the window.

And for the drone to fly through the window, after we align the drone with wall's normal, we fly it horizontally to align with the center of the window that we found (in front of it in two 2 meters). Once it reaches the desired position, we just need to command it tot fly forward for two meters to go through the window.

2. New fire extinguishing mechanism experiment and testing

We tried test two kinds of extinguishing materials: foam and water (which we used before). The foam's advantages are it's light-weight and has strong projectile force (reaches 3~4 meters), but the disadvantages are also obvious: we can not re-fill it up, and also the mounting for foam spray will be very tricky.

Then, for the water, compared to the foam, the disadvantages are that it's heavy weight and may have the dripping issue. But the advantages are that it's much easier to re-fill up and mount with the robot.

After comparing all the above elements, we finally decide to use the water as our fire extinguishing material. The new mounting with the DJI UAV is as following:

3. Team Work

Me and Shubham worked together to implement the opening window detection, as it needs to coordinates with other subsystems, we do find some small bugs consistently wrote by each one of us, and by collaborating with each other, we are able to finally implement a robust system. I also worked with Parv and Akshit for testing various fire extinguishing mechanisms (like material comparison, and mounting mechanism).

4. Challenge

The challenges we faced include testing and debugging the window opening detection pipeline, as there are quite some parameter tuning as well as algorithm architecture changes. Then, because we haven't figured out how to move around DJI's API to disable the DJI's stereo camera (like to keep flying even in front of the obstacle), we just covered the DJI's stereo camera. Another challenge is to test and finalize the fire extinguishing mechanism, which takes a lot of experiments as well as testing (including building and attaching the mounts).

5. Future Work

1. To actuate water pump to deploy water, integrate Thermal camera (to detect the fire location), Microcontroller (to control the motor/pump), Relay switch (to prevent the water dripping issue).

2. Integrate various software packages and create pipeline

3. Perform UAV mission with deployment capabilities

4. Perform AGV mission with deployment capabilities

5. Global path planning in abstract simulation