# Individual Lab Report 3

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# I. Individual Progress:

Our team work for the last two weeks is divided as such: Parv and Shubham are responsible for the implementation of ORB-Slam on Jetson for UAV and on Zotec for Husky. I and Akshit are responsible for designing and establishing a visual algorithm for simulated fire detection. And my individual progress is as follows:

Figure 1. Flir Thermal Camera

First, Akshit and I work together to calibrate the Flir thermal camera. We use the official calibration software package provided by Flir, which greatly facilitates the calibration process. All we have to do is to put a heated item (soldering gun) with specified temperature in front of the thermal camera (the temperature goes from high to low with a decrease of 20 Celsius degree each time), and the calibration software can perform calibration automatically.

After camera calibration is done, we began to develop visual algorithms for simulated fire detection. we are not facing the actual fire in the MBZ challenge, but simulated fire source (has not been finalized yet), which should have more regular geometric shapes. Considering deep learning-based approaches might be too

computationally intense, and they require quite a number of data to train, we decided to just use traditional computer vision algorithms.

Our first trial is the watershed algorithm. Basically, it simulates the rising tide in the valley to segment the images according to the gray-scale pixel value. Actually, it works well for scenarios where the background is relatively simple, when foreground objects also have regular shapes. But when we apply the watershed algorithm to segments the pictures taken from the lab, where the background is more complex, the performance is very unsatisfying. As shown in the figure below, we observe that only edges with large-contrast can be well segmented, while most small heated areas cannot be spotted.

Figure 2. Segmentation results from Watershed Algorithm

Considering the drawback of Watershed algorithm in our scenario, we implemented another segmentation algorithm: OTSU. Basically, it's a binary segmentation algorithm, but adaptively determine the threshold by leveraging all the pixel values in the image. We show the obtained results as below:

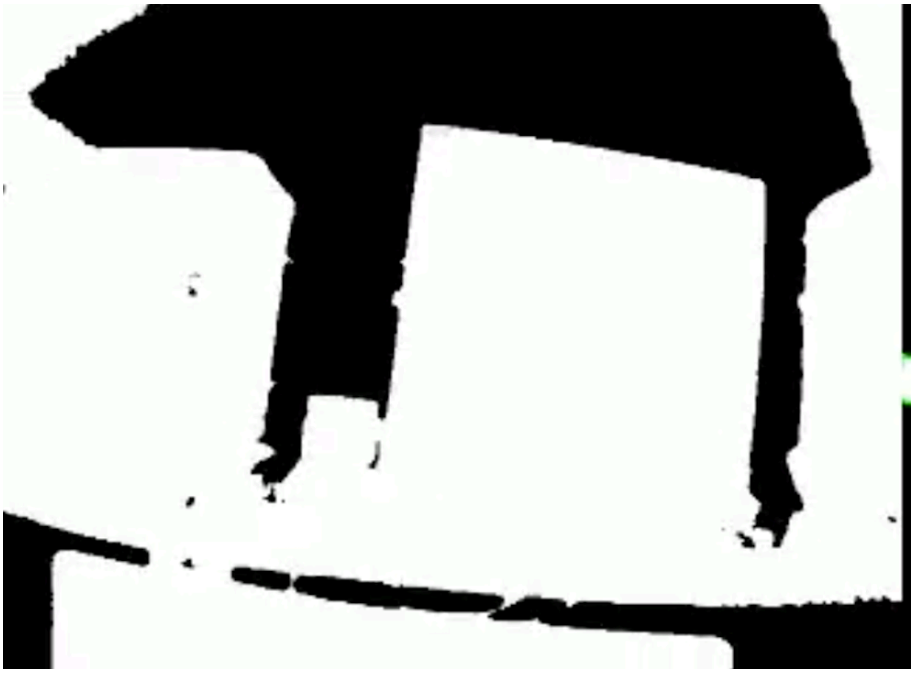

Figure 3. Segmentation results from OTSU Algorithm

As we can see, OTSU algorithm successfully segments major heated area. However, the less heated areas like objects lying next to heated objects, or even the wall are also segmented as heated area. In our scenario, we only want to segment the heat source, which has much higher temperature than other “affected” areas, which leaves OTSU algorithm ineffective as it always tries to leverage all pixel values across the image (less heated areas that take up large geometric portions of the image are given large weight).

Considering the above, we finally decided to use a constant threshold to segment images, and then erosion is applied to eliminate outliers. In addition, we draw contours along the edges for better visualization. Finally, we find small heated objects by calculating their areas, and then exclude them. The results obtained by such an approach is shown in figure 4:

We observe that the algorithm can well segment the major heated area while leaving other unheated or less heated areas invisible.

Figure 4. Segmentation results from our third algorithm

# II. Teamwork

I mainly worked with Akshit during the process of implementing the fire detection algorithm. We discussed various approaches to tackle this problem, and we progressively figured out the best way to get a good segmentation result by trying different algorithms.

# III. Challenges

The major challenge left for the fire detection module is that: actually, thermal camera not only captures the temperature of objects, but also the brightness of the objects. In other words, even if two objects that have exactly the same temperature, but if one object is brighter (in RGB sense) than another one, it also shows higher value through the thermal camera. So, to deal with this, we have to use an additional RGB camera to find the bight areas and compensate the thermal image by lowering the pixel value if it has a higher brightness.

# IV. Future Plan

The future work for our team will be divided into as follows: I and Akshit are going to improve the fire detection algorithm by considering the object brightness. Parv is responsible for designing the AGV arm which supports our water tank. Shubham will be working on PCB design. Parv and Shubham together are going to integrate the Slam output in the Husky control state machine. I will be designing the micro-controller to control the arm and water tank. Akshit will continue the outdoor stabilization test for drones. In addition, he is also going to take the UAV Pilot Test next week.