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CSC 391: Introduction to Computer Vision

4/7/19

Project #3: Object Detection

Part 1: Project Description and Sample Images

My objective for this project is to output a message to the user “River” or “No river” for a given image as well as show a rough bounding box around the river detected in the image.
Here are the sample images I used for feature detection:

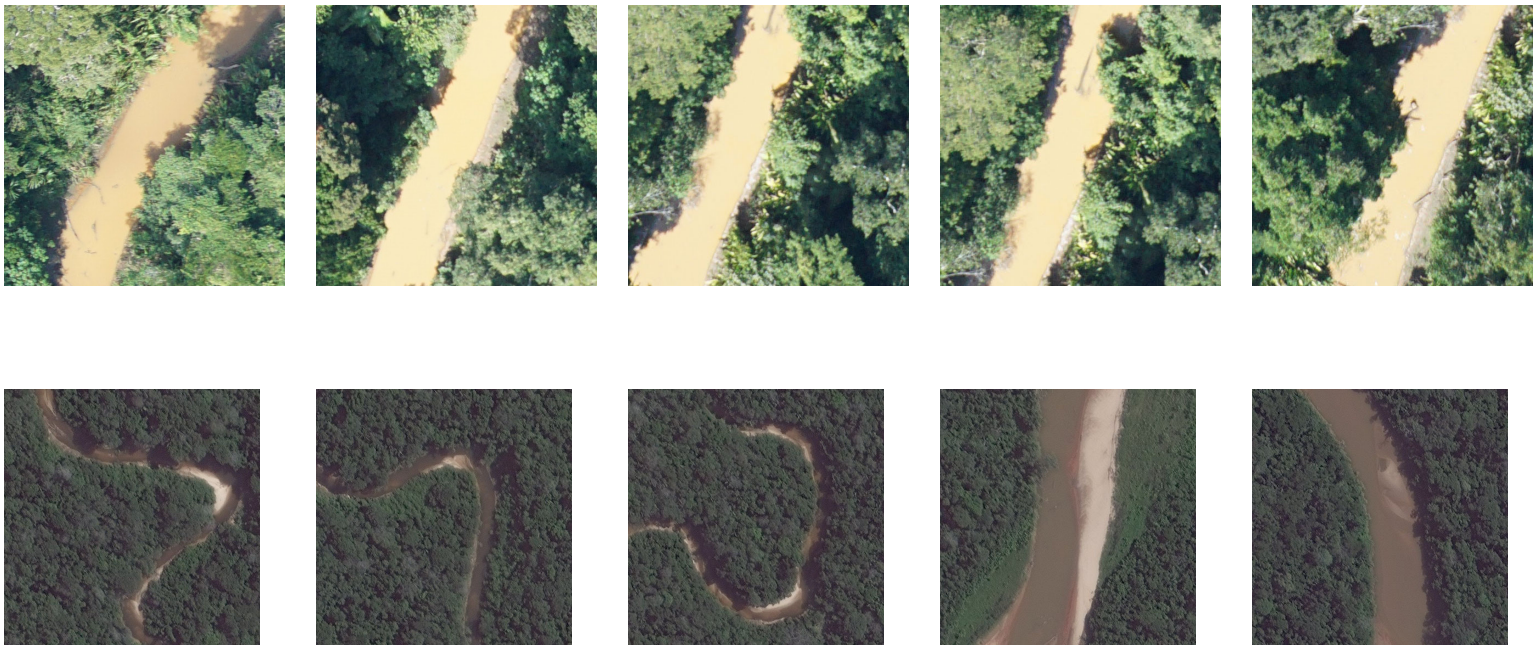


Figure 1: 10 sample images that contain rivers

Figure 2: 10 sample images that do not contain rivers

Figure 3: Large drone river image

Figure 4: Large satellite river image

I derived these smaller 512px × 512px images from two larger images, one from a drone and the other from a satellite. The original drone image was 4000px × 6000px and the satellite image was 16384px ×16384px. I applied my algorithms to these smaller images in order to achieve better, more efficient results. I chose these two images because they are different in color and gradient both in the images with rivers and those without.

Part 2: Feature Exploration and Background

In order to best prepare myself for the classification phase of this project I used a combination of the HOG (Histogram of features) feature extraction algorithm and the ORB/SIFT keypoints detector algorithms.

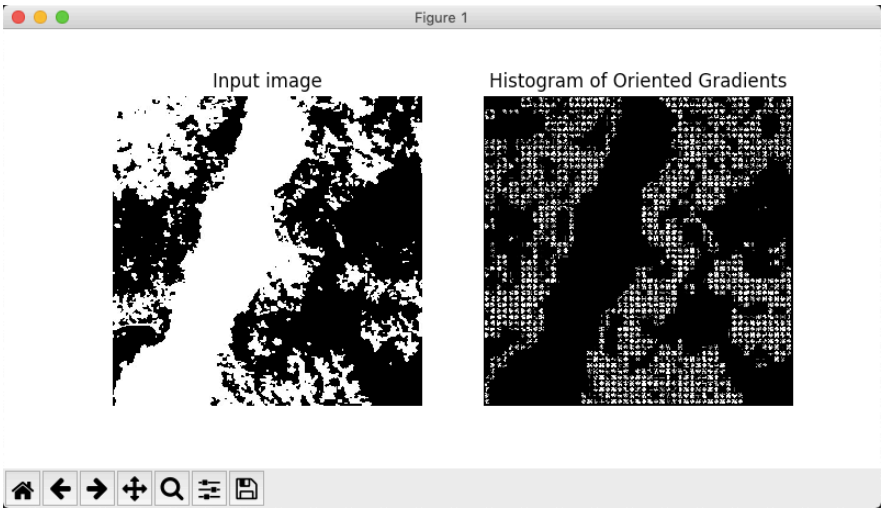
In my case, the HOG algorithm scans the input image by a 10px × 10px block in 8 different orientations creating a histogram highlighting the important gradients in an output image. It also creates a bar chart that calculates total gradient values when the pixels within each block are compared. In order to achieve the best results, I prepared the image for the HOG algorithm in three steps. First, I applied a threshold to each image including both a binary threshold and an OTSU threshold. I then applied a Gaussian blur in order to remove some of the high frequency components of the image. Lastly, I reapplied the same threshold from step 1 in order to remove the blurring effect of the Gaussian blur.

The SIFT algorithm extracts keypoints from images and computes their descriptors. When an image is translated and rotated, these keypoints and descriptors are used to recognize the locations of important features in the image. Image extrema detection, keypoint localization, orientation detection and keypoint descriptors make up the steps of the SIFT algorithm. I did not alter any of the images beforehand when I applied this algorithm.

The OpenCV orb function is an efficient alternative to the SIFT and Harris functions. ORB is short for Oriented FAST and Rotated BRIEF and was developed in 2011 as a low performance SIFT alternative. The function takes two images as inputs and computes their keypoints and descriptors. The BFMatcher function then checks for matches between the two images. When finding keypoints it uses the Harris corner algorithm and it uses the BRIEF method to create descriptors. It then displays its findings in an output image. In order to best prepare the image for the algorithm, I applied the same three steps to the each image as the HOG algorithm to achieve the best results.

Part 3: Experimentation and Analysis

When applying these algorithms to my images, I wanted to equally compare smaller images derived from the drone shot and the satellite shot. Here are my results when the HOG algorithm was applied:



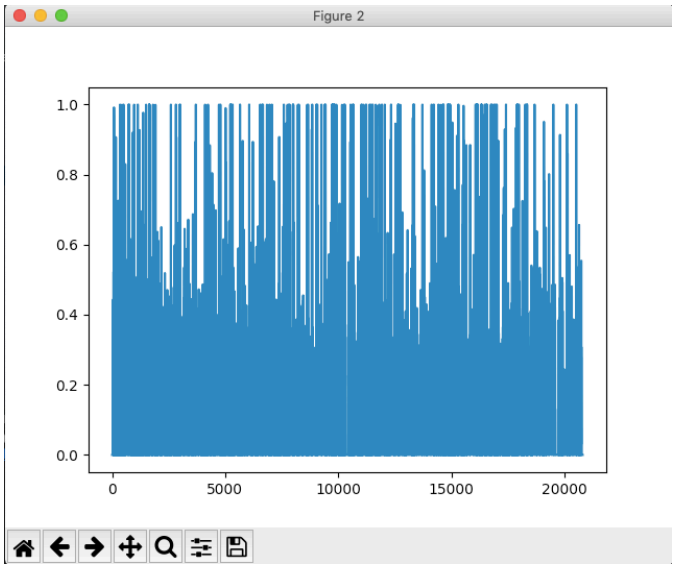
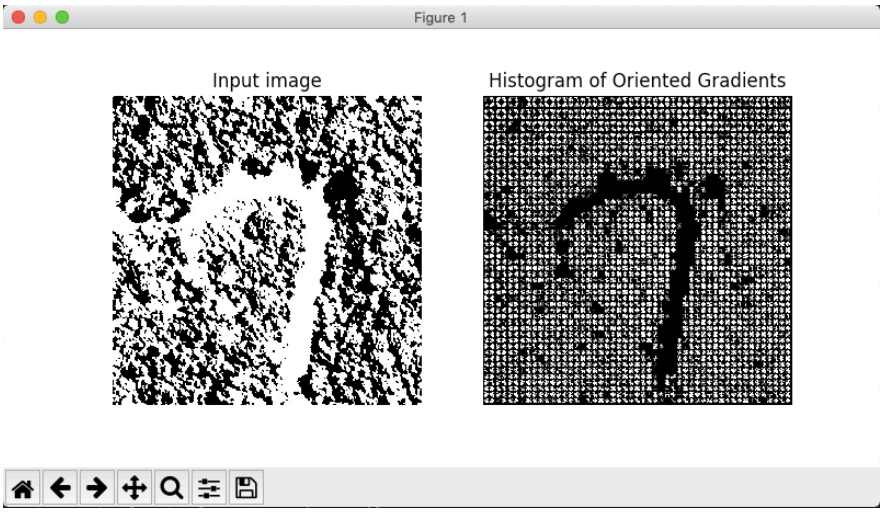


Figure 1: HOG algorithm applied to river drone shot



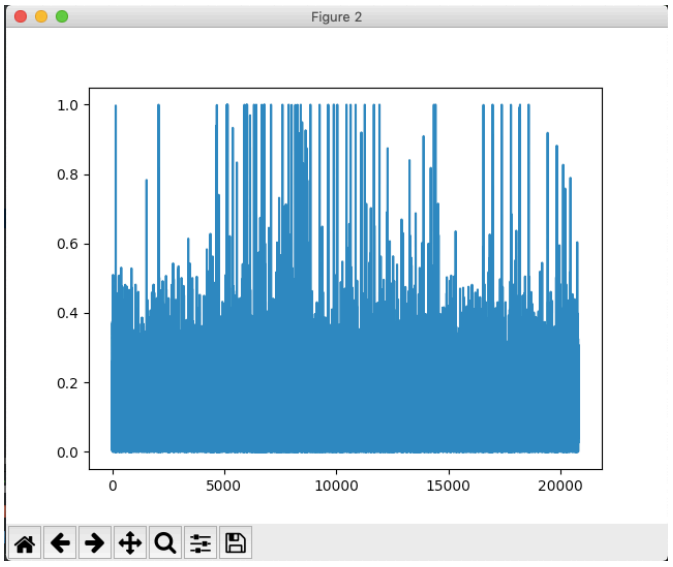
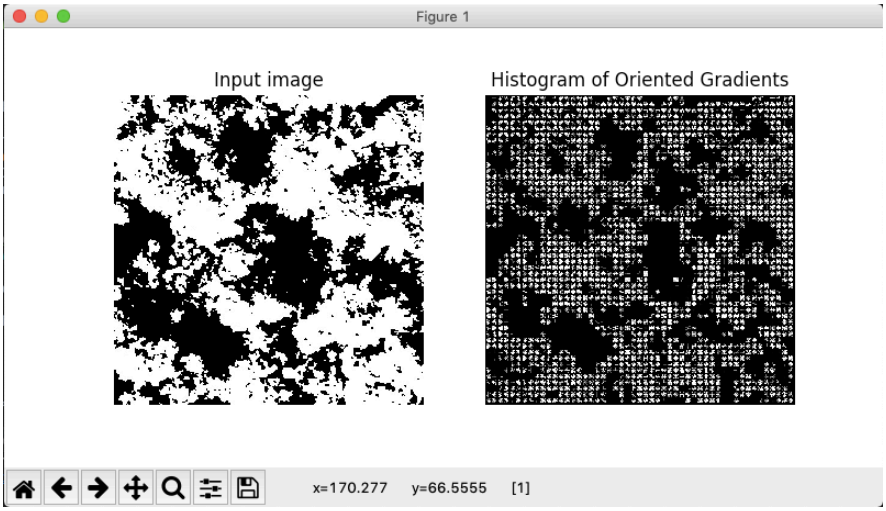


Figure 2: HOG algorithm applied to river satellite shot



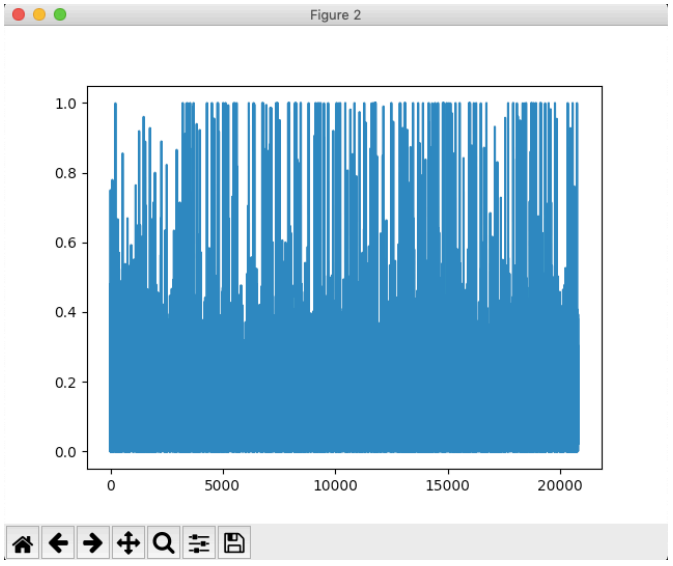
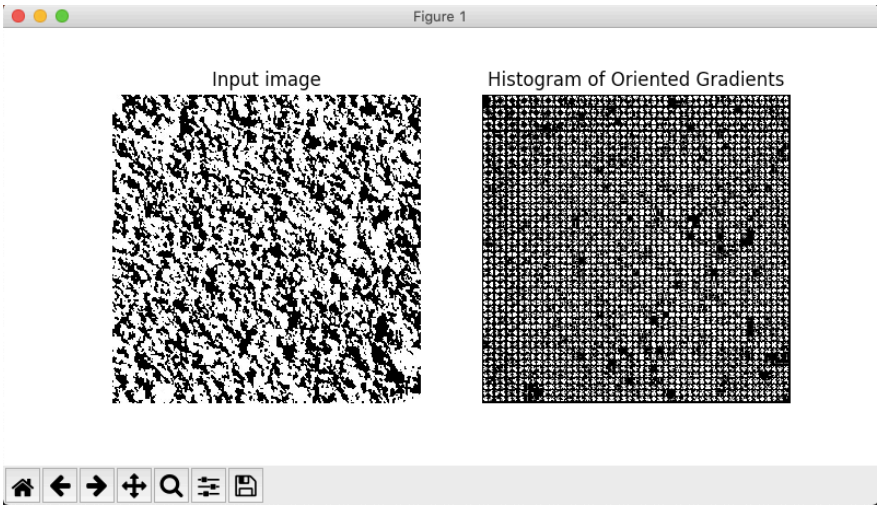


Figure 3: HOG algorithm applied to drone shot without river



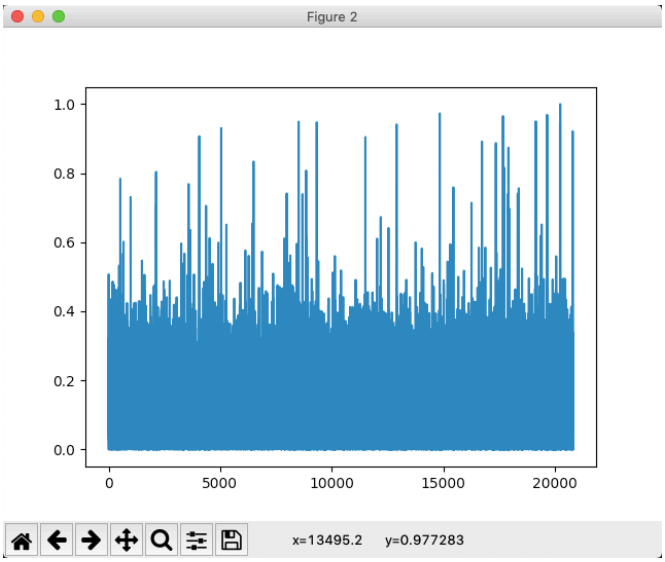


Figure 4: HOG algorithm applied to satellite shot without river

When applying the HOG algorithm to the images that contain rivers it is easy to see the outline of the body of water for both the drone and satellite shots. What is interesting to note is that the gradient values are on average lower across all blocks between the images without rivers compared to the ones with rivers as seen by the blue bar graph. Figure 1 and Figure 3 must be compared however, to see a noticeable difference in the values. Vice versa, Figures 2 and 4 should be compared to see the biggest degree of value differences. The graph that corresponds to Figure 1 for example, contains many lines that reach a value of 1, representing the black outline of the river as compared to Figure 3 that on average does not contain as many values of 1.0 especially between blocks 0 and 5000.

The analysis is simpler after applying the SIFT algorithm. I used a parameter of 500 features for the algorithm to detect in order to achieve the best results:

Figure 5a: SIFT algorithm applied to drone image with river

Figure 5b: SIFT algorithm applied to satellite image with river

Figure 6a: SIFT algorithm applied to drone image without river

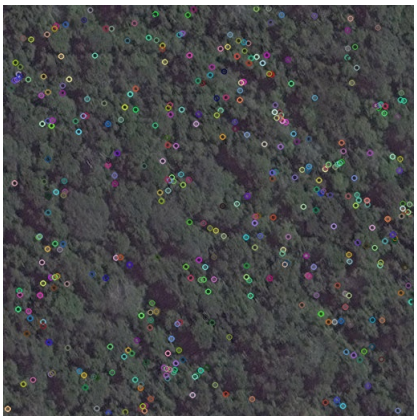


Figure 6b: SIFT algorithm applied to satellite image without river

When viewing the images after the SIFT algorithm has been applied, it is easy to see that in both the drone and satellite images, the rivers contain few to no keypoints. In the images without rivers, the keypoints are scattered throughout the images suggesting the lack of a river present. I suspect that the consistency of the color of the river allows it to avoid being detected as a keypoint. This lack of identification will be important for the classification phase as part of our next project.

The last algorithm that was applied to the images was the ORB algorithm. The keypoints of two samples of river images were compared within the drone sample and the satellite sample for comparison:

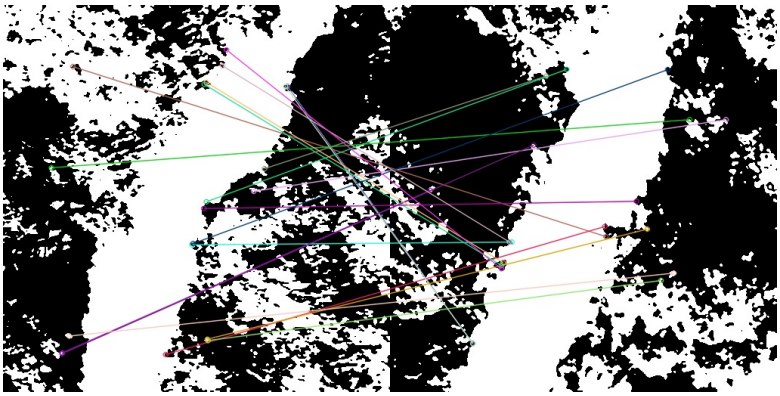


Figure 7a: ORB matching algorithm applied to drone images with river

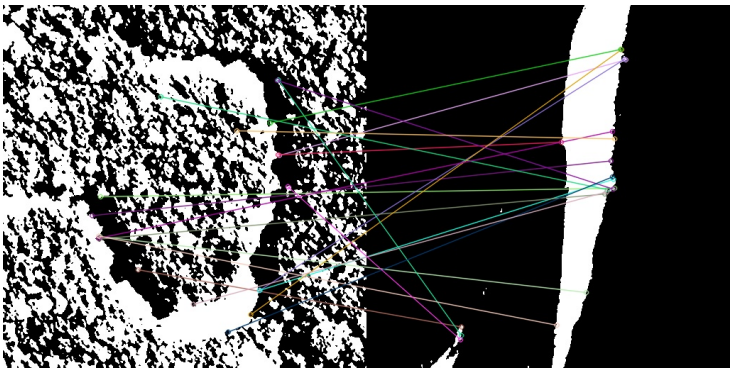


Figure 7b: ORB matching algorithm applied to satellite images with river

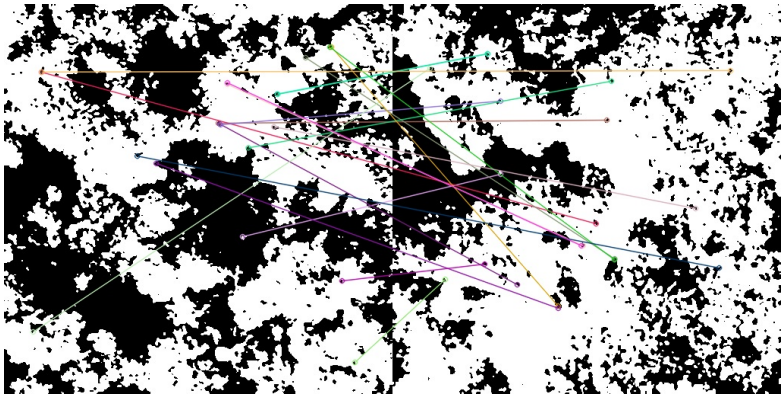


Figure 8a: ORB matching algorithm applied to drone images without river

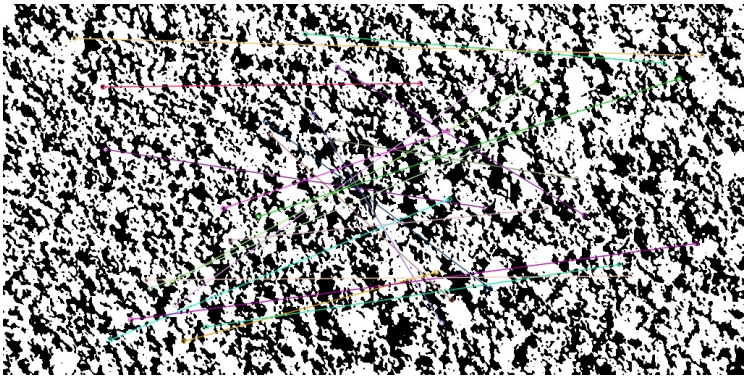


Figure 8b: ORB matching algorithm applied to satellite images without river

As seen in Figure 7a and Figure 7b, the ORB algorithm is successful in matching the outline of the rivers in the drone and satellite images. When applying the algorithm, 10 keypoint matches were compared. When observing Figure 8a and Figure 8b, the matches are inconsistent with no clear correlation present. The keypoint matching with pictures that contain rivers will be crucial to the success of determining if and where the rivers are located in future target images.

I plan to incorporate all three of these methods in the next project to accurately classify images with rivers and those without as well as offer a rough estimate to the location of the rivers in the images.