Digital Image Processing
Assignment 1

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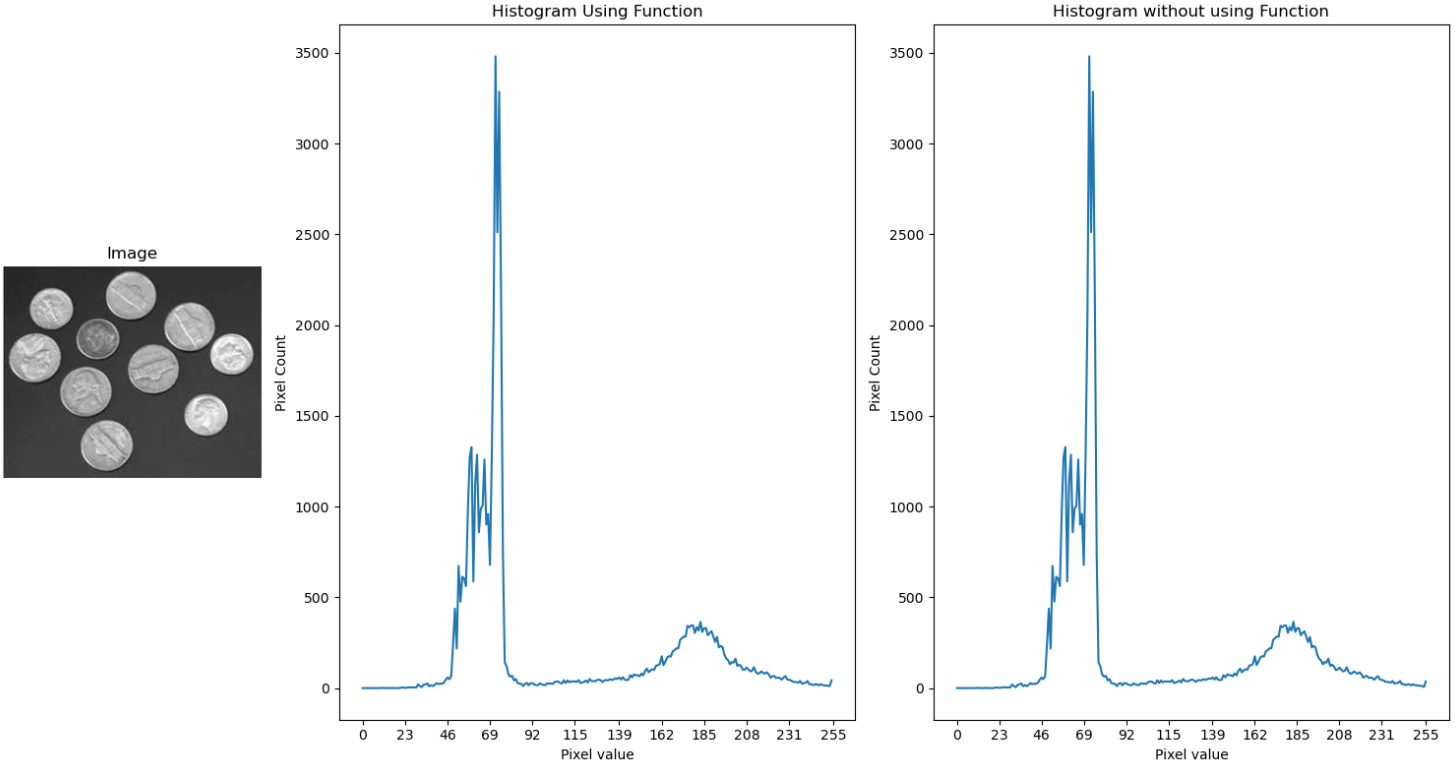
M.Tech SP

Packages used: Numpy, Scikit-image (skimage), Matplotlib

1. Histogram Computation



The task was to plot the histogram of the image which is shown on the left side of the above image (coins.png).

Inference: From the histogram, we can see that, there are 2 clusters of pixel sets in the image-

a) (46-80)
b) (160,200)

(46, 80) being in the larger number in the picture shows that the background is relatively darker than the foreground object, which can be seen in the image also.
Other thing can be seen that, the image has low intra class variance (pixel values for a class does not differ much within the class) and high inter class variance (pixel values between the 2 classes have high difference).

2. Otsu's Binarization

a. Binarize the coins.png by minimizing the intra-class variance.

Intra-Class variance is the sum of weighted variance for each class in the image. The less this intra class variance is the less pixels are spread from their class mean within each class.

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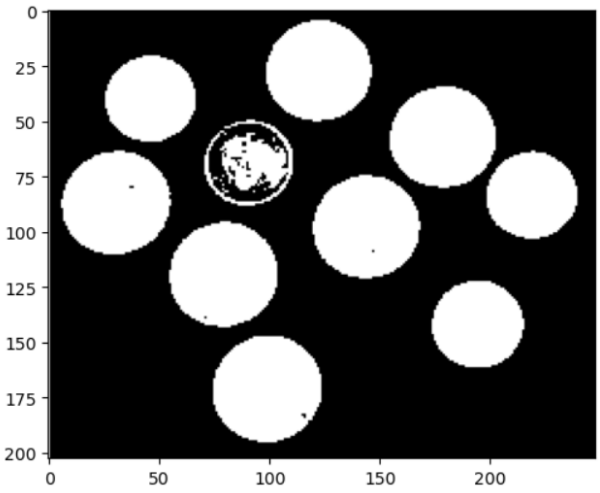
For each pixel, the intra class variance is calculated and the optimal threshold is find out, which gives the lowest intra class variance.

It turns out that this Optimal Threshold Pixel is 125.

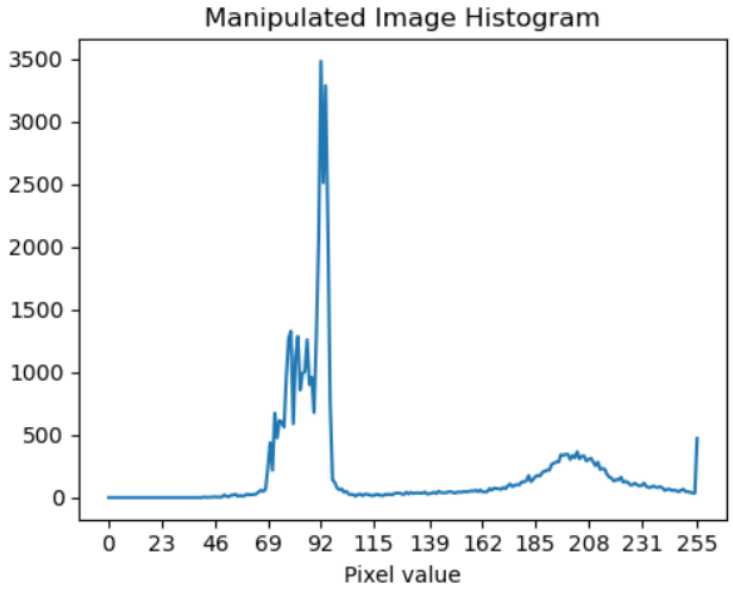
This is the Binary Image created based on the calculated threshold of 125.



From the histogram also, it can also be seen that 125 lies in the region which separates the 2 classes.

b. Create an image by adding a constant positive offset 20 and binarize this new image by maximizing the inter-class variance

New Image was created by increasing each pixel value by 20, with the caution that the maximum values must not exceed the value 255.



Inter-class variance tells how much the classes are separated from each other. More Inter-class variance means more distinctly the classes are in the image.

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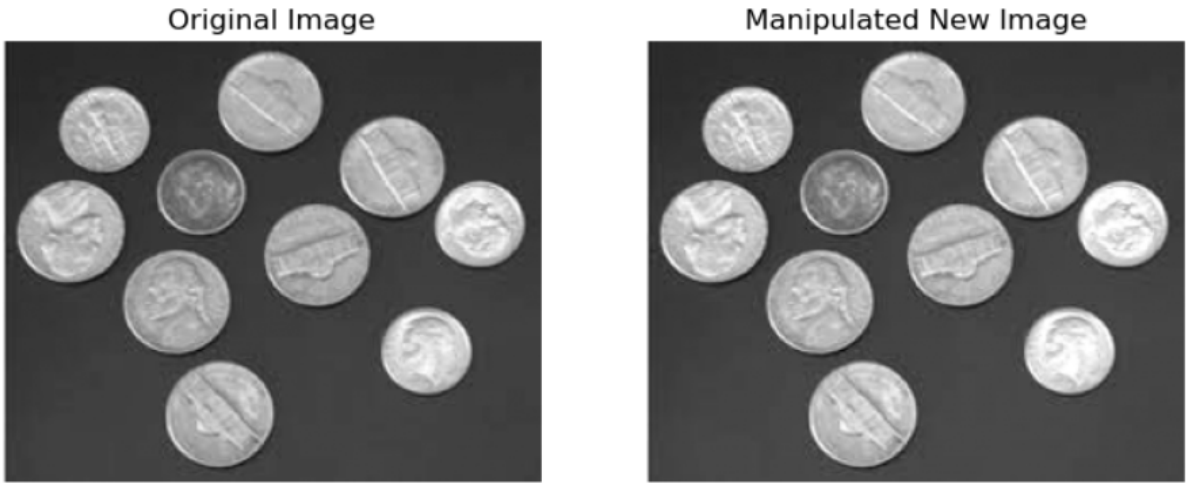
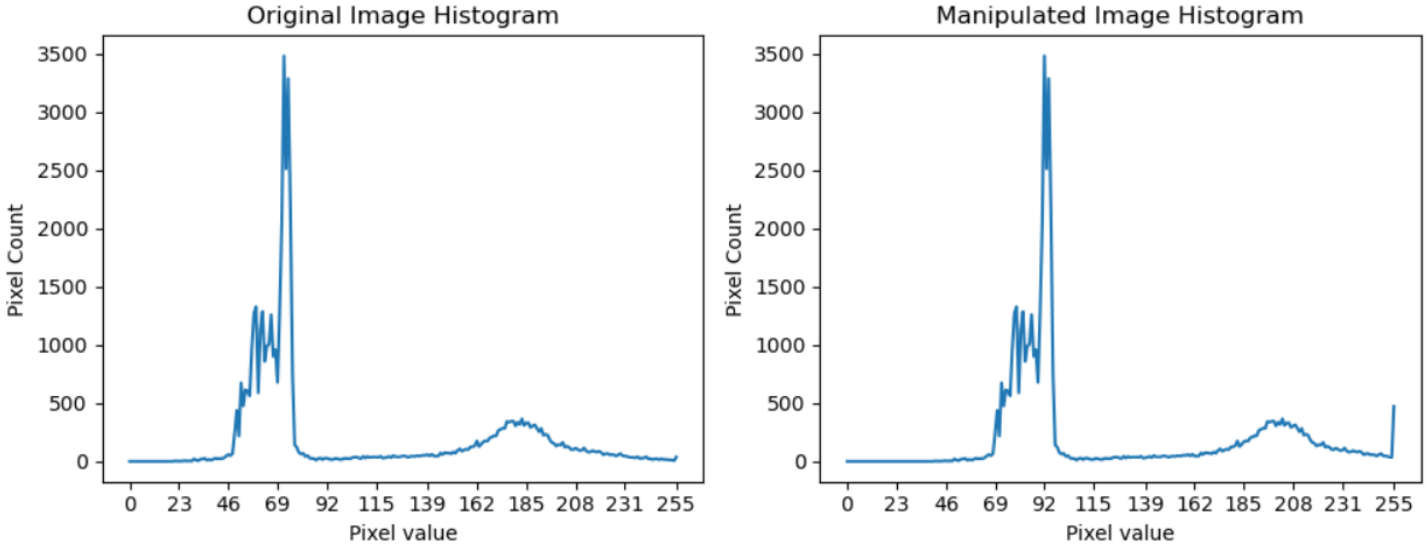
For each pixel value as threshold, Inter-class variance is calculated. The Optimal threshold was found to be 145

Analysis of the Result:



By increasing the offset by +20, it can be seen that the image became a little brighter as compared to the original image.



This can be seen from the histogram as well. The overall shape of the histogram for both the images is same, except that the histogram has been shifted towards right by 20 pixels, and since the maximum value cannot exceed 255, thus increasing the count of pixels having the value of 255.

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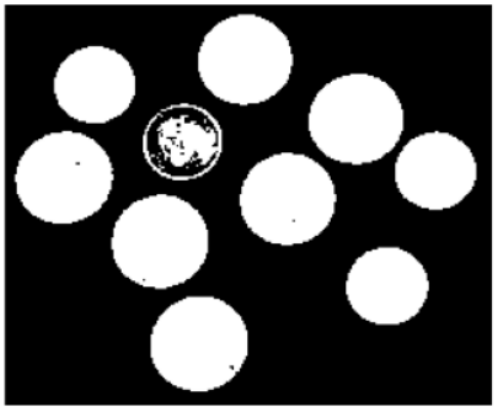
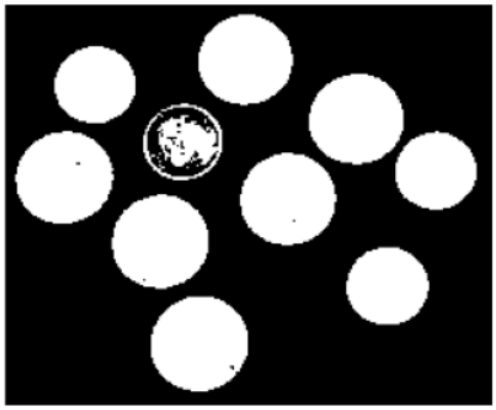
Original Image with threshold 125



Manipulated New Image with threshold 145



Looking at the Binarized image of both new and original image looks identical, even with new threshold values. This is because each pixel, that is, the entire dataset was increased by value 20, thus increasing the threshold value by 20 as well, keeping the separation between the classes same.

Note:

This only happened because the offset was not that high. If we put the offset to a higher value, say 150, then most of the pixel will be equal to 255, and thus changing the overall shape of the histogram and changing the threshold as well.

3. Adaptive Binarization

Original Image

For 5x5 window

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For 10x10 window

For 25x25 window

For 50x50 window

For Full Image window

Observation:

It can be seen that, 5x5 window has a very fine details in the image, but also includes lots of noise, whereas the full image window, erased almost half of the image.

So, the situation where smaller window sizes will give good result is when the image has a lot of fine details. Smaller windows will be able to accurately distinguish the details from the background, even if the background is not uniform. But the disadvantage will be that it can capture significant amount of noisy information as well, due to which the result can be too grainy.

The situation where larger window sizes will give good result is when the object is a little large and clear and background is uniform. Larger window sizes take information of large number of neighbors, reducing the noises significantly, resulting in perfectly highlighting the foreground object.
But the disadvantage is that it can ignore the fine details if any, resulting in some loss of information as well.

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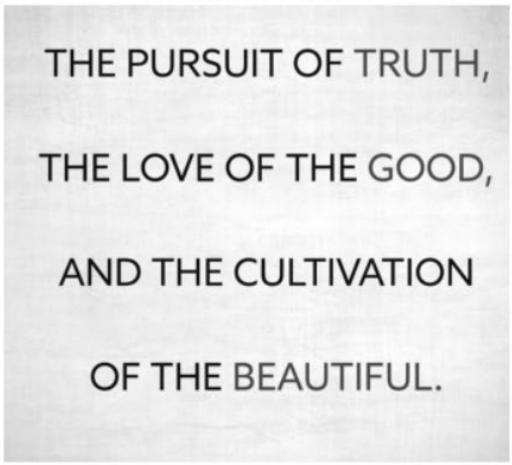
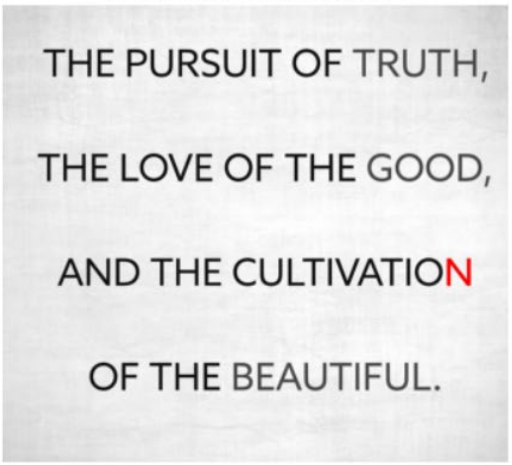
4. Connected Component

The task was to extract the connected component, get the largest component and color it red.

Original Image



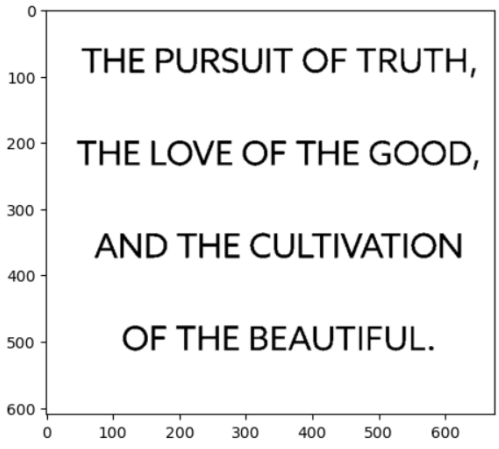
New Manipulated Image



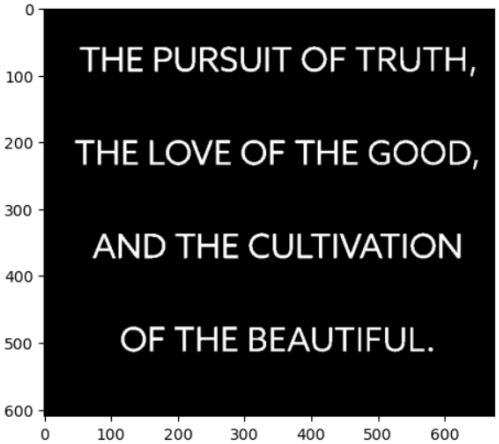
Largest component was found to be the letter N.

First the image was binarizes using Otsu's Algorithm. Threshold was found to be 142. Then the binarized image was inverted to make the background black and foreground white just for the convention.

After the binarization:



Before inverting



After inverting

For the case of equivalence, when more than one label is in the surrounding neighbor pixels, the lowest label will become the parent label. All the other labels will become the child label. All the pixels belonging to the child label will get the parent label with the help of NumPy masking.