

ISYE 8803 Homework 2 Problem 2

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1 Problem 2

In this problem, I apply several image processing/image analysis methods and transformations to an example image of a horse. I use these techniques to make comparisons and draw conclusions.

1.1 Original image

First, I visualize the original image which can be seen in Figure 1.

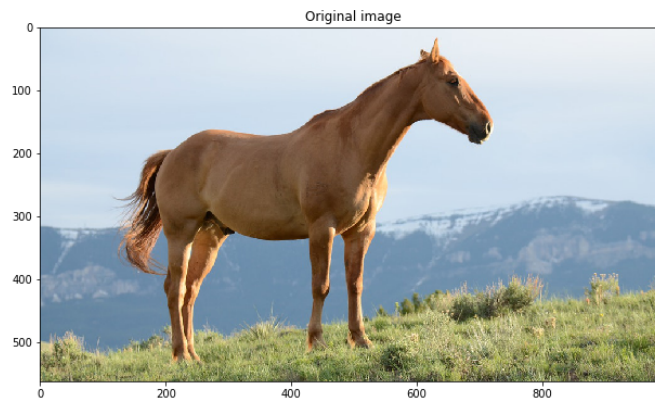


Figure 1: Original image.

1.2 Downsampled image

The shape of the original image is (563, 1000, 3) i.e. 563x1000 (height, width) and RGB image. I then simply downsampled the original image to a third of its size which becomes 188x333 as shown in Figure 2.

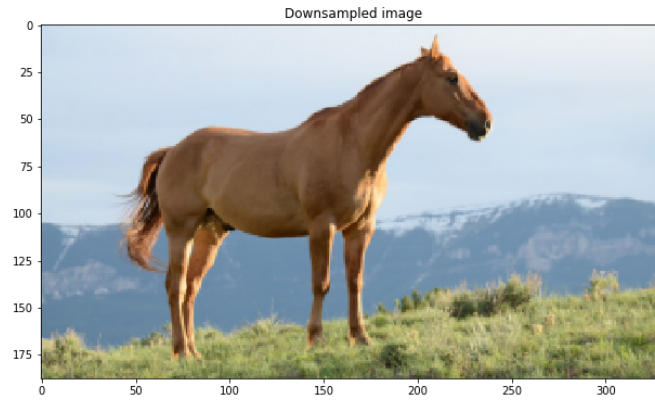


Figure 2: Original image downsampled by a factor of 3.

1.3 Grayscale and black & white images

Next, I convert the original image to grayscale and then black and white using a threshold of 0.5. Figures 3 & 4 show these respectively.

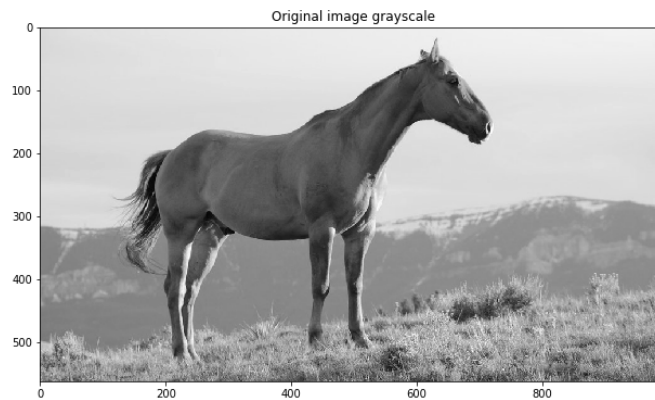


Figure 3: Grayscale of original image.

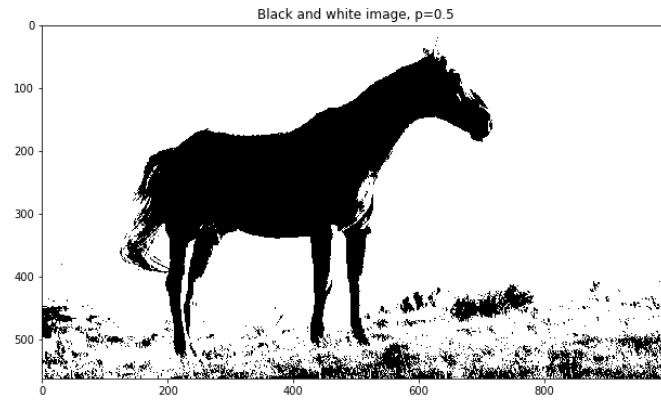


Figure 4: Black and white of original image.

1.4 Grayscale histogram

I plot the histogram of the grayscale image which is shown in Figure 5. The histogram appears to have 3 distinct and arguably 4 modes where pixel intensities are about the same (with different variances). It is also clear that there are a large number of light pixels which is evident in the image because the lighter sky takes up a large portion of it. The histogram makes perfect sense as we can see from the image that are mainly three shades, the super light (like the sky), the mid-level gray (like the mountains/grass), and the darker gray (like the horse).

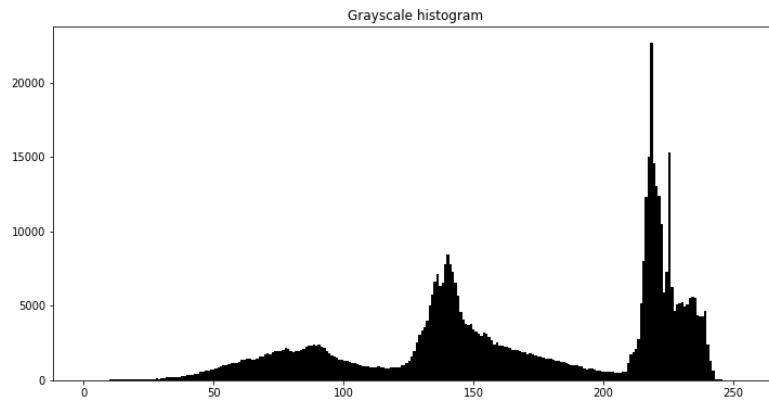


Figure 5: Histogram of grayscale image.

1.5 Image transformations

For the grayscale image, I apply several transformations which are can be used for the following reasons. The linear transformation is used to create the negative of the gray image, the log transforms are used for image enhancement or image brightening to various degrees, thresholding simply creates the black and white version of the image at varying levels of darkness which may be used for object detection, histogram shifting is used to change the brightness of an image, and lastly, histogram stretching with a unique λ allows one to set the contrast of an image where the contrast is λ itself. The contrast of the gray image is about 253.7 and here I set it to 200. Figure 6 shows the application of these transformations on the gray image and Figure 7 shows the resulting histograms.

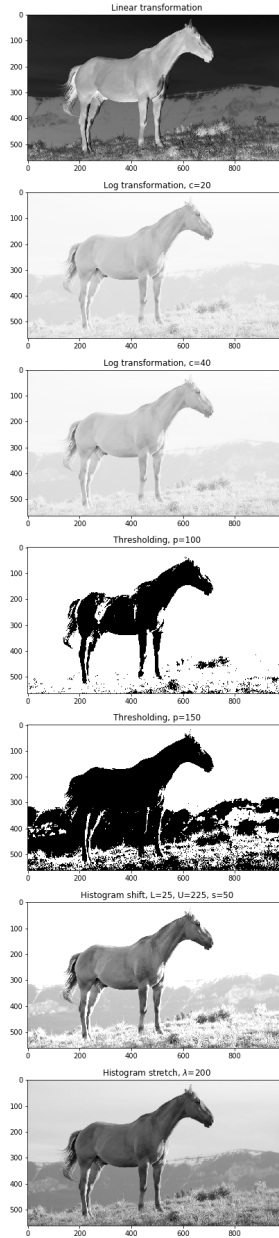


Figure 6: Various image transformations to the grayscale image.

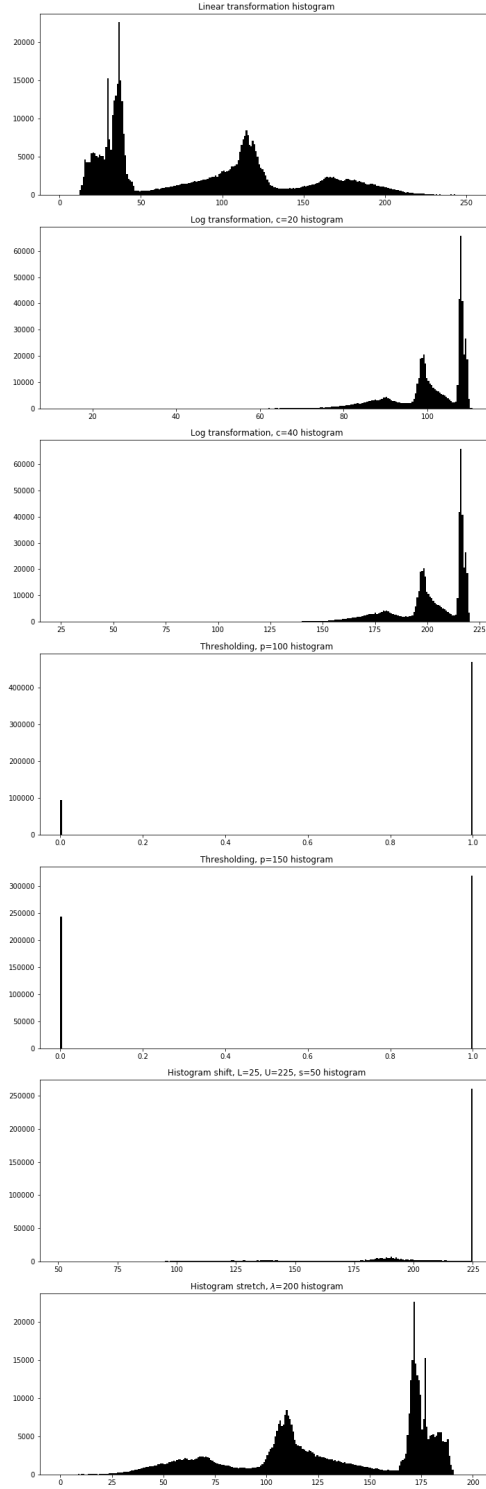


Figure 7: Histograms of the image transformations from Figure 6.

1.6 Denoising

Next, I create a noisy image by adding random noise with $\mu=0$ and $\sigma^2=100$ to the gray image. I convolve the noisy gray image with the denoising mask in Equation 1 below to denoise the image. Figure 8 shows the noisy and denoised image.

$$\frac{1}{9} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \quad (1)$$

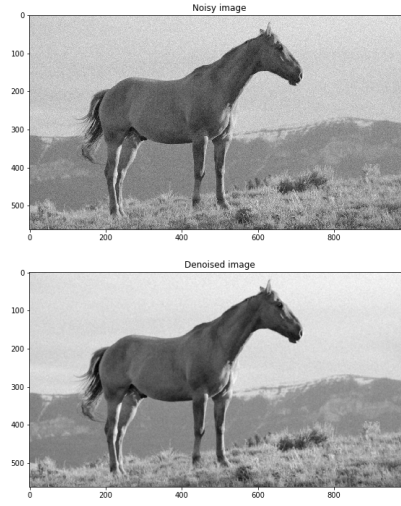


Figure 8: Noisy and denoised image after applying the mask in Equation 1.

1.7 Sharpening

I now sharpen the original image by applying a sharpening convolution mask shown in Equation 2. Figure 9 shows the before and after of the sharpening.

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix} \quad (2)$$

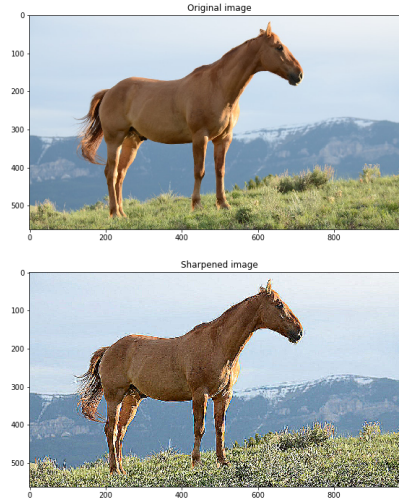


Figure 9: Original and sharpened image after applying mask in Equation 2.

1.8 Otsu's method

I implement Otsu's method and segment the gray image into 2, 3, 4, and 5 levels. Figure 10 shows the results from this segmentation. The threshold values found for each of these levels are summarized in Table 1.

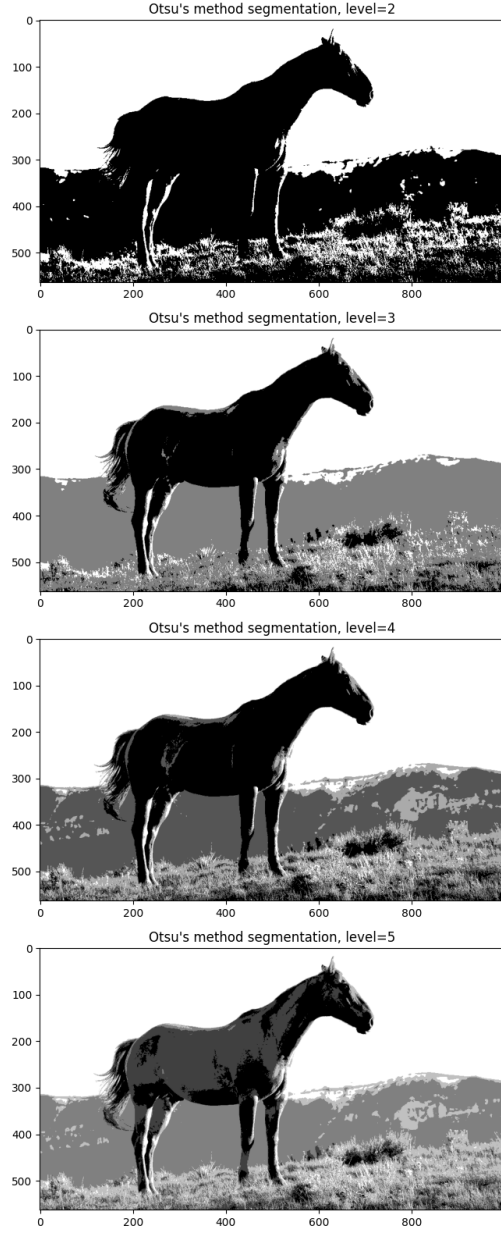


Figure 10: Segmentation using Otsu's method and different levels

level	threshold(s)
2	166.80791699
3	111.23087012, 183.67952051
4	106.26863379, 153.90610254, 196.58133496
5	75.50276855, 115.20065918, 155.89099707, 197.57378223

Table 1: Otsu's method thresholds at different levels

1.9 K means clustering

I now complete a similar segmentation task but I use k-means clustering with 2, 3, 4, and 5 clusters. Figure 11 shows the resulting colored image clustered into these different sized clusterings.

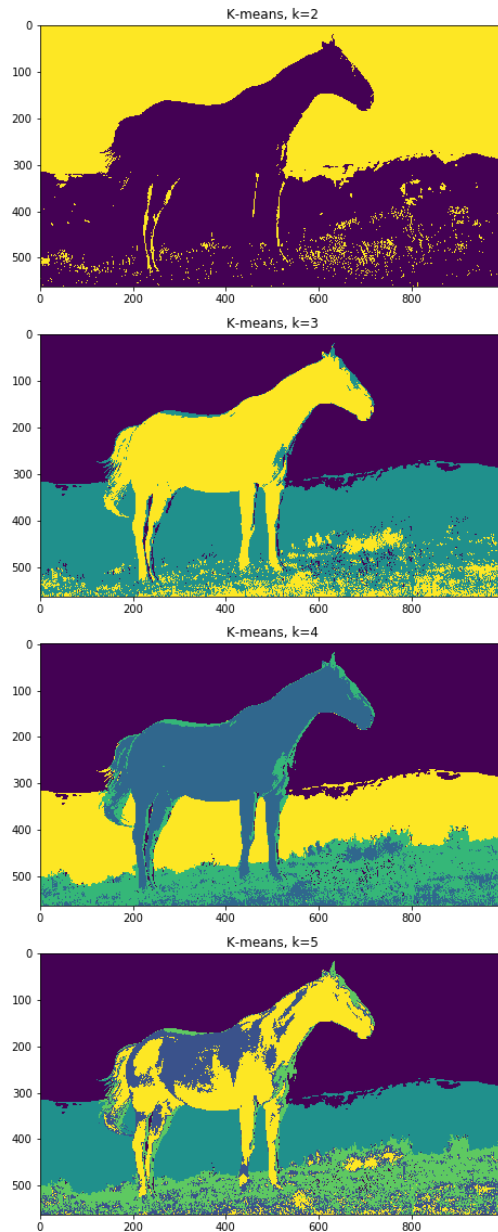


Figure 11: Segmentation of original image using k-means clustering.

1.10 Sobel and Prewitt methods

Lastly, I use Sobel and Prewitt methods to make edge detections on the gray image. Figure 12 shows the black and white images of edge detections at various thresholds using Sobel method and Figure 13 shows the same for the Prewitt method. For both methods, as I increase the threshold less and less edges are shown so what is really being seen are the strong edges as detected by the filters i.e. we see high gradient areas and more of just the horses outline and less of the grass that is waving in various directions.

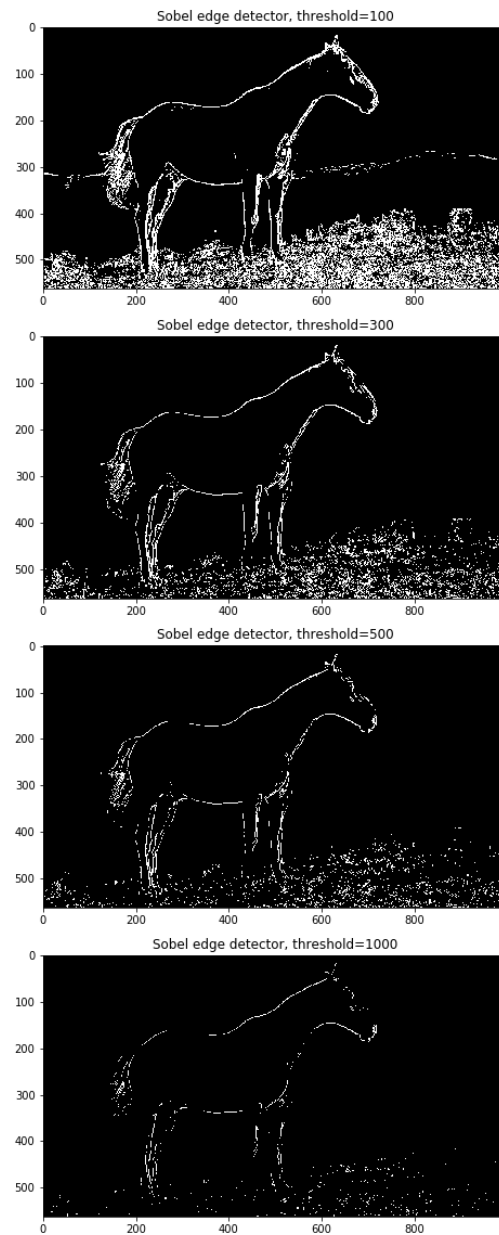


Figure 12: Edge detection on gray image using Sobel method and different thresholds.

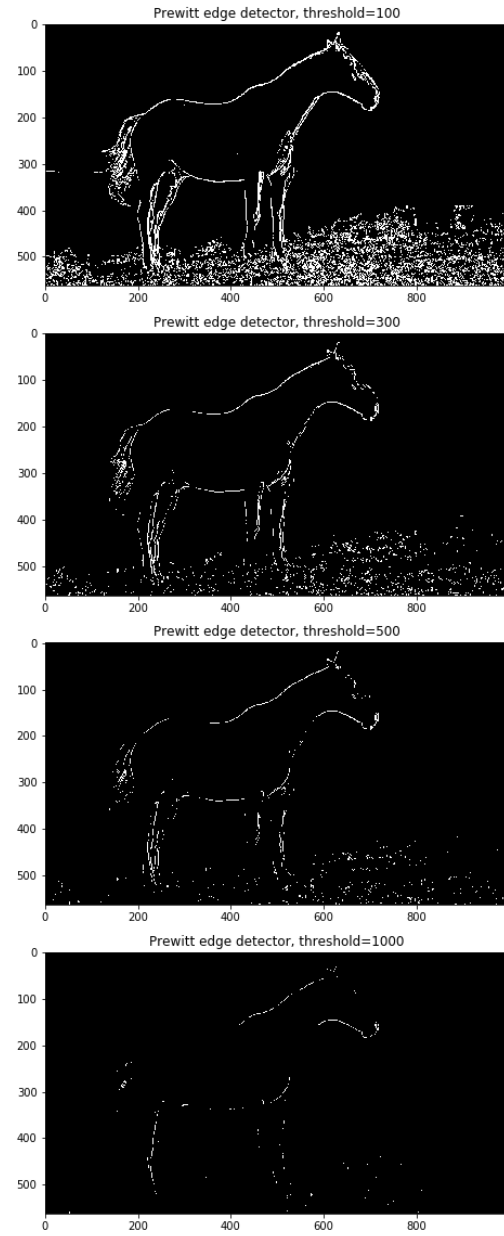


Figure 13: Edge detection on gray image using Prewitt method and different thresholds.

References

[1]