ISYE 8803 Homework 2 Problem 3

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1 Problem 2

In this problem, I implement Canny's algorithm for image edge detection by hand and apply it to an arbitrary image of a horse.

1.1 Gaussian filter

First, I apply the Gaussian filter shown in Equation 1 to the original image. Figure 1 shows the before and after images.

$$\frac{1}{1115}\begin{bmatrix} 1 & 4 & 7 & 10 & 7 & 4 & 1 \\ 4 & 12 & 26 & 33 & 26 & 12 & 4 \\ 7 & 26 & 55 & 71 & 55 & 26 & 7 \\ 10 & 33 & 71 & 91 & 71 & 33 & 10 \\ 7 & 26 & 55 & 71 & 55 & 26 & 7 \\ 4 & 12 & 26 & 33 & 26 & 12 & 4 \\ 1 & 4 & 7 & 10 & 7 & 4 & 1 \end{bmatrix} \tag{1}$$

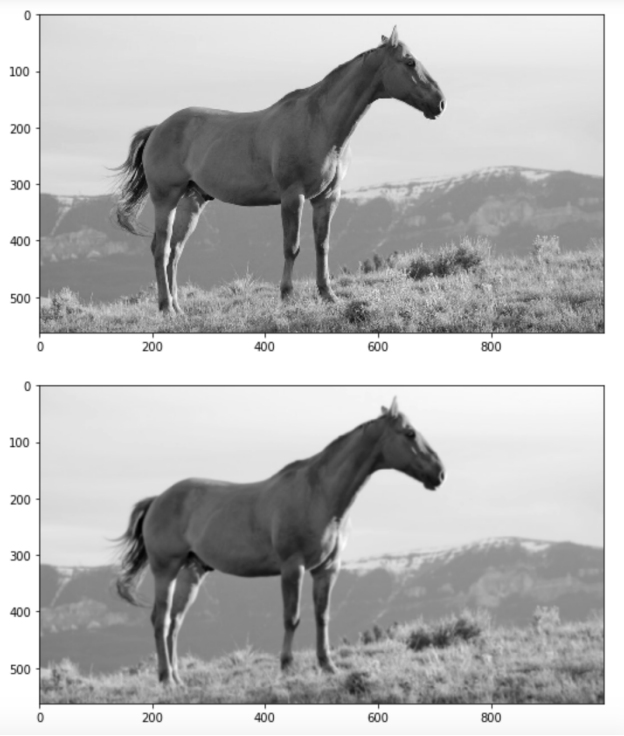

Figure 1: Original image and Gaussian-filtered image

1.2 Gradient magnitude and direction

I compute the gradient magnitude and direction of the image numerically and visualize the results. Figure 2 shows exactly this.

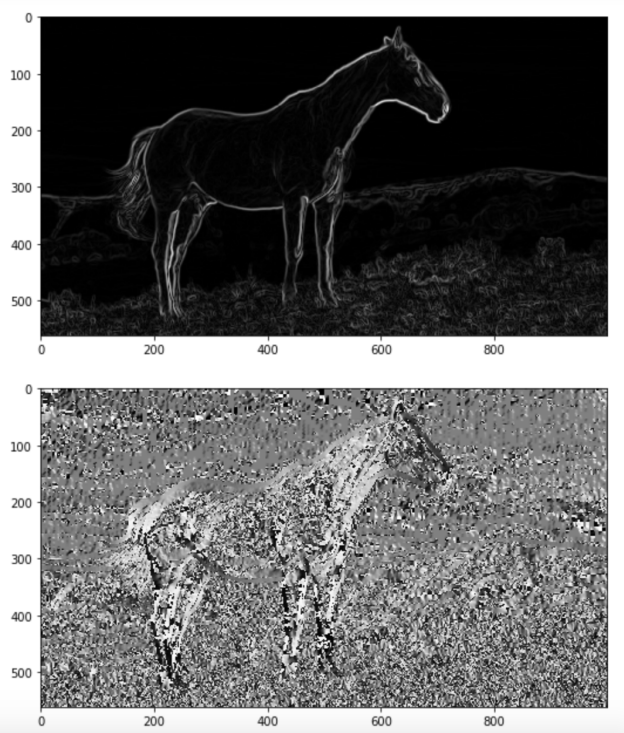

Figure 2: Gradient magnitude (top) and direction (bottom) of the image.

1.3 Edge pixel using nonmaximal suppression

Next, I discretize/quantize the gradient directions. This can be seen in Figure 3 below. I use the same criteria as seen in the prompt to determine the two neighboring pixels of each pixel in the gradient magnitude image. I then determine edge points based on the pixel intensities and the intensities of their two neighbors because, "the characteristic of an edge pixel is that its gradient magnitude is the local maximal in the gradient direction". The resulting image is $\phi(i, j)$ and this can be seen in Figure 4 with its histogram.

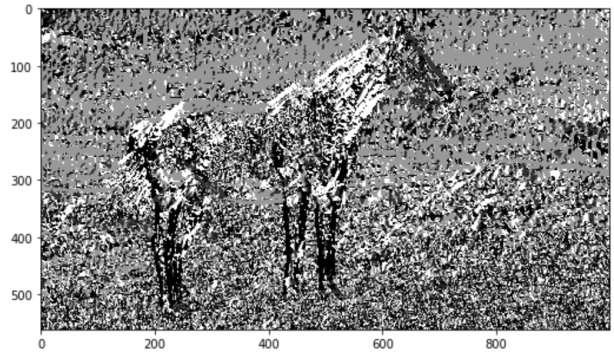

Figure 3: Quantized gradient directions.

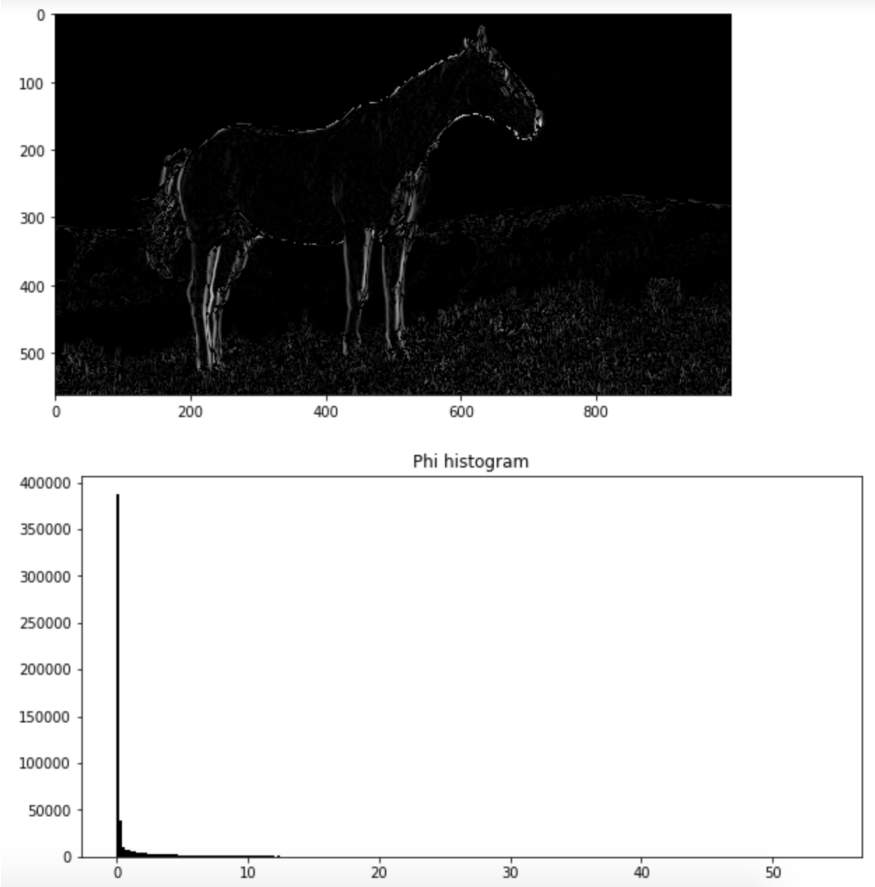

Figure 4: Edge pixels using nonmaximal suppression with histogram.

1.4 Threshold with hysteresis

Lastly, I threshold with hysteresis according to the pseudo code in the prompt. I completed this using two thresholds τ_1 and τ_2. I first tried values of 3 and 8 respectively and bumped them up to 9 and 24 to receive a better thresholded edge image. According to the algorithm, "If the value $\phi(i, j)$ of the pixel at position (i, j) in the resulting image is larger than τ_2, the pixel is definitely an edge pixel, and all such edge pixels constitute the edge output. Any pixel connected to this edge pixel that has its value larger than τ_1 is selected as an edge pixel." The resulting edge matrix/image is shown in Figure 5.

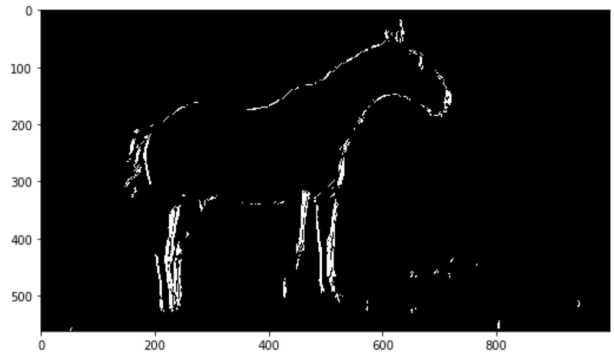

Figure 5: Edge pixels after thresholding with hysteresis.