ASSIGNMENT – 2

CSc I6716
Computer Vision

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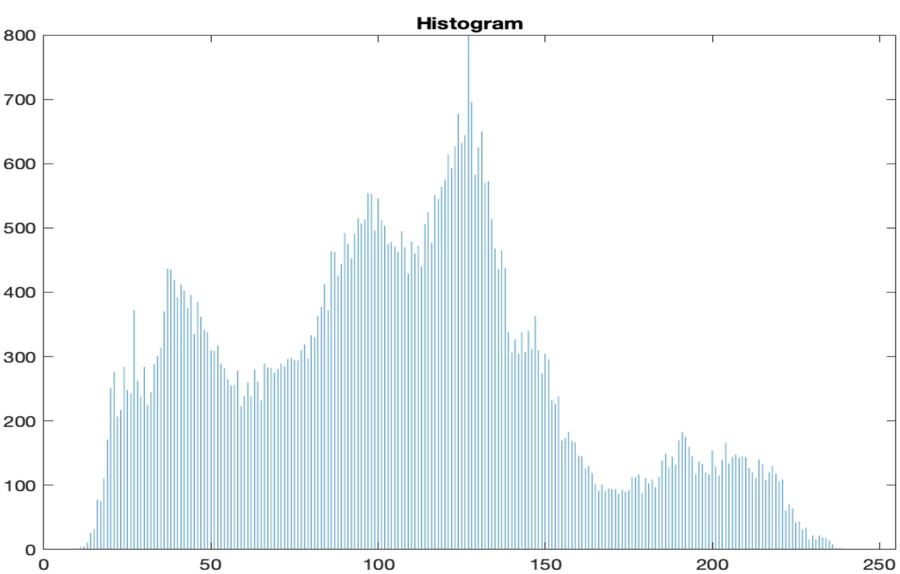
*Q.1 Generate the histogram of the image you are using, and then perform a number of histogram operations (at least including contrast enhancement, thresholding, and equalization) to make the image visually better for either viewing or processing (10 points). If it is a color image, please first turn it into an intensity image and then generate its histogram. Try to display your histograms of the original and the processed images (5 points) and make some observations of the images based on their histograms (5 points). What are the general distributions of the intensity values of each histogram? How many major peaks and valleys does your histogram have, and how do they behave? How could you use the histograms to understand, analyze or segment the image?*

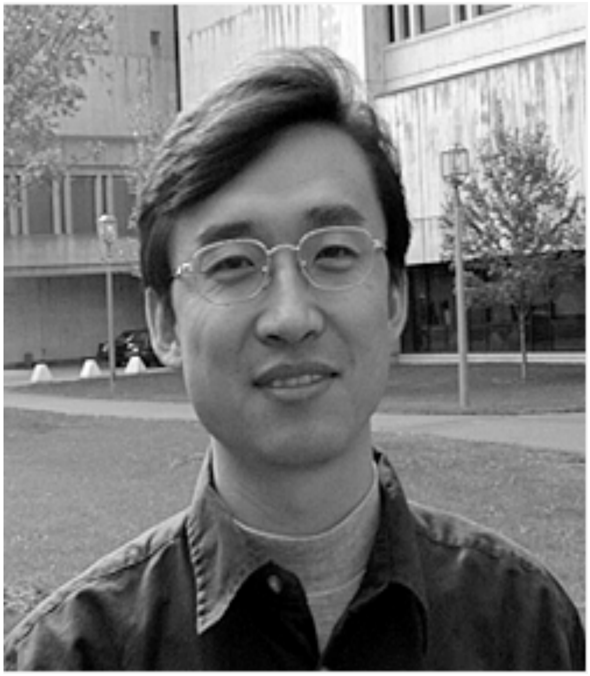
Ans.

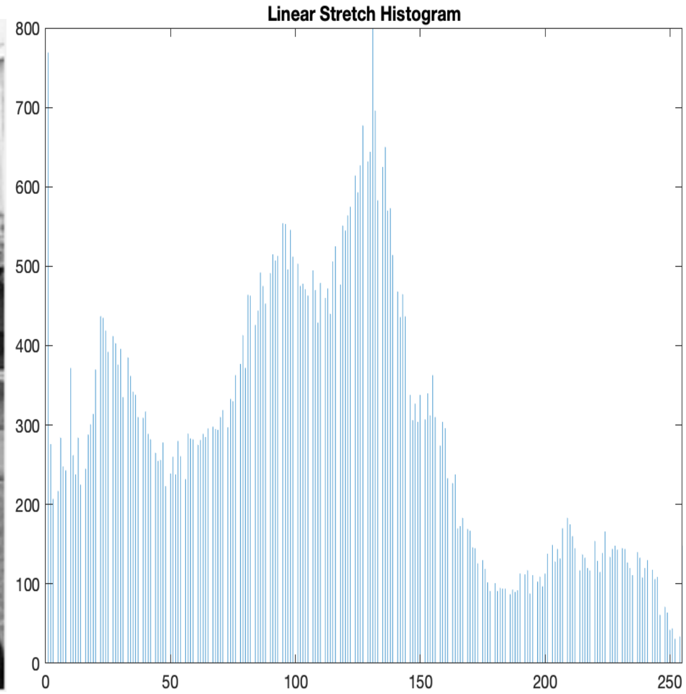
Original Image

Intensity Image

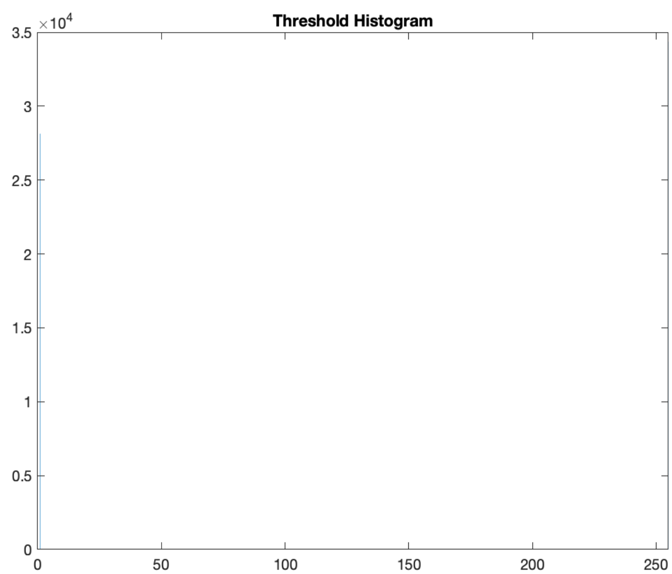


Contrast Enhancement

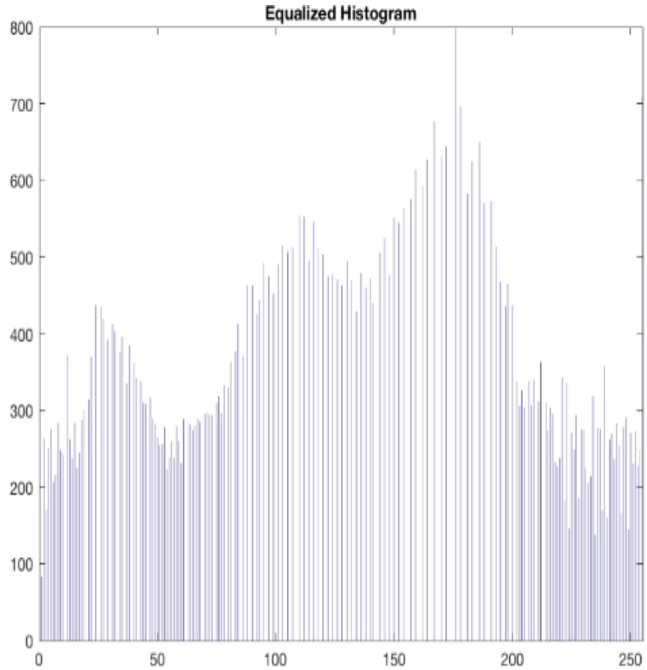





Threshold Image



Equalization Image




A histogram has peaks, which represent many pixels concentrated in a few gray levels and plains, which represent a small number of pixels distributed over a wider range of gray levels. In the histogram of the original intensity image we see that the most pixels are concentrated in the gray levels between approximately 80 and 130.

The three major Histogram operations performed are:

1. Contrast Enhancement: Images with low contrast have pixel values concentrated near a narrow range of gray values. Using contrast enhancement, we can change image value to cover a wide range. From the original image histogram, the gray values range is [20, 230] and the desired range is [0, 250]. The contrast enhancement transformed image has a higher contrast than the original.

2. Threshold: Image thresholding is a segmentation technique, which converts grayscale images into binary images. As can be observed from the image and the histogram, the only pixel values available for this image are 0 and 255, black and white.

3. Histogram Equalization: Using histogram equalization we can modify the gray levels of an image so that histogram of the modified image is flat. During histogram equalization, the values occurring in the empty regions of the histogram are redistributed equally among the peaks and valleys

*Q. 2 Apply BOTH the 1×2 operator and Sobel operator to your image and analyze and compare the results of the gradient magnitude images (including vertical gradients, horizontal gradients, and the combined) (10 points). Please don't forget to normalize your gradient images, noting that the original vertical and horizontal gradients have both positive and negative values. I would recommend you to display the absolute values of the horizontal and vertical gradient images. Does the Sobel operator have any clear visual and processing advantages over the 1×2 operator? Any disadvantages (5 points)? If you subtract the normalized 1×2 gradient image from the normalized Sobel gradient image, are there any residuals? You might use two different types of images: one ideal man-made image, and one image of a real scene with more details (5 points).*

Ans Sobel Operator: X - Dir $\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$

Y – Dir $\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$

1x2 Operator: X – Dir $\begin{bmatrix} 1 & -1 \end{bmatrix}$

Y – Dir $\begin{bmatrix} 1 \\ -1 \end{bmatrix}$

**Sobel gradient**

**1x2**

Vertical Sobel gradient

1x2 Vertical gradient

Horizontal Sobel gradient

1x2 Horizontal gradient

**<u>Compare and Analysis</u>**

When applying a horizontal or vertical kernel only the respective gradient is calculated, which leads to detecting only the horizontal or vertical edges. By comparing the combined Sobel with the combined 1x2, the horizontal Sobel with the horizontal 1x2 and the vertical Sobel with the vertical 1x2 it can be observed in all cases that the Sobel operator is more accurate than the 1x2 operator. This is because the 1x2 operator is very sensitive to noise. By combining the 1x2 operator with an average mask better edge detection can be achieved (as in the case of the Sobel operator).

Advantages of Sobel:

The primary advantages of the Sobel operator is its simplicity. The Sobel method provides a approximation to the gradient magnitude. Another advantage of the Sobel operator is, it can detect edges and their orientations. In this cross operator, the detection of edges and their orientations is said to be simple due to the approximation of the gradient magnitude.

Disadvantages of Sobel:

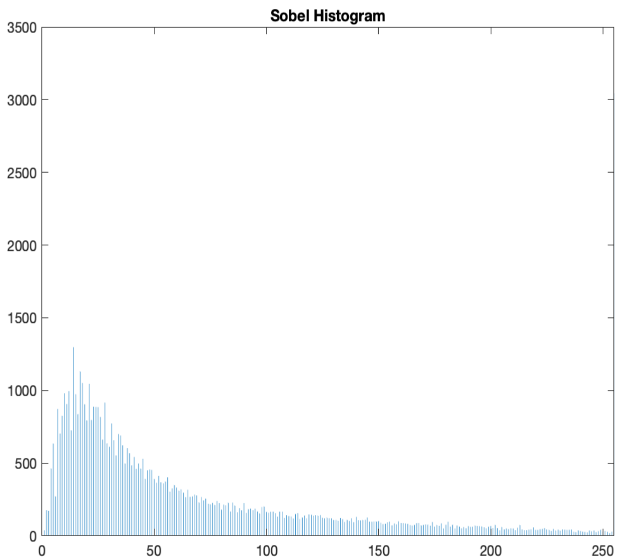
It is sensitive to the noise. The magnitude of the edges will degrade as the level of noise present in image increases. As a result, Sobel operator accuracy suffers as the magnitude of the edges decreases. Overall, the Sobel method cannot produce accurate edge detection with thin and smooth edge.

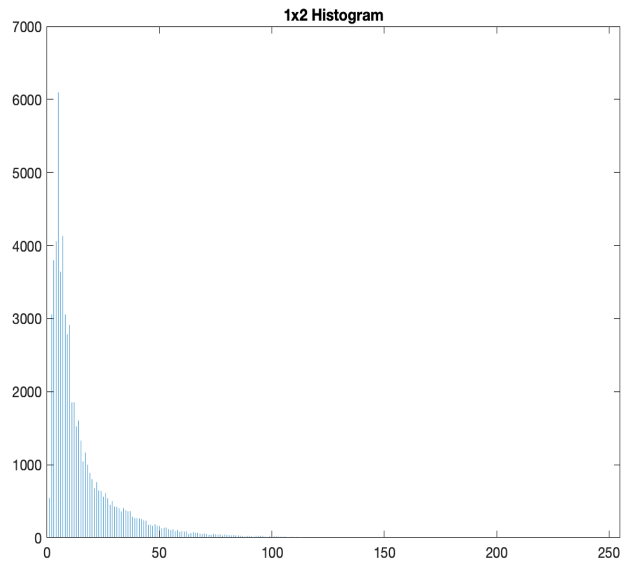
Sobel - 1x2

Generally, any residual image is better than the original image. Any residuals produced during the subtraction are better than the original image.

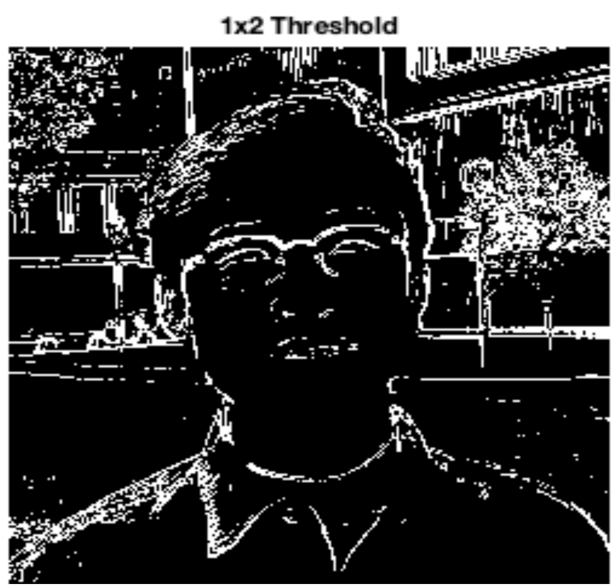
*Q. 3 Generate edge maps of the above two combined gradient maps (10 points). An edge image should be a binary image with 1s as edge points and 0s as non-edge points. You may first generate a histogram of each combined gradient map, and only keep certain percentage of pixels (e.g. 5% of the pixels with the highest gradient values) as edge pixels (edges). Please study what is the best percentage for a specific image, and why. Use the varying percentage to automatically find a corresponding threshold for the gradient magnitudes, and then pick up the one having the best visual performance. In your report, please write up the description and probably equations for finding the threshold and discuss what percentage is a good value (5 points). You may also consider using local, adaptive thresholds to different portions of the image so that all major edges will be shown up nicely (5 points). In the end, please try to generate a sketch of an image, such as the ID image of Prof. Zhu.*

Ans. Edge maps are generated by turning a gradient image into a binary image, through thresholding. By using the histograms of the Sobel and 1x2 gradient images we can choose a threshold level.
In the histogram of the 1x2 gradient image all the peak values are approximately in the 0-50 range, so I chose a threshold value of 35 so that the pixels with the highest gradient values are edges. In the histogram of the Sobel gradient image the peak values are approximately in the 5-150 range, so I chose a threshold value of 120. Because many edges can be buried into noise, thresholding helps to determine which edges pixels should be discarded as noise and which should be retained.




By comparing the 1x2 edge map with the Sobel edge map it can be seen that the Sobel operator is more accurate than the 1x2 operator. The reason for that is because since the 1x2 kernel takes the difference of consecutive pixels it is more sensitive to noise. A 3x3 kernel such as the Sobel operator will always be more accurate than smaller kernels.

Equations used for threshold $G_x = \text{sqrt}(X^2 + Y^2)$ and 70% is a good value.

*Q.4 What happens when you increase the size of the edge detection kernel from 1×2 to 3×3 and then to 5×5, or 7×7? Discuss (1) computational cost (in terms of members of operations, and the real machine running times – 5 points); (2) edge detection results (5 points) and (3) sensitivity to noise, etc. (5 points). Note that your larger kernel should still be an edge detector. Please list your kernels as matrices in your report and tell us what they are good for (5 points).*

Ans.

1. As observed above, a 3x3 kernel will always be more accurate than smaller kernels but will be more computationally expensive.
2. Increasing the kernel to 5x5 or 7x7 will result in thicker edges but will be less sensitive to noise. This is because the 1x2 kernel relies on the difference between two consecutive pixels in the horizontal and vertical directions.
3. A larger kernel such as the Sobel operator is the result of combining the 1x2 kernel with an averaging mask. The larger convolution kernel will smooth the input image and so make the kernel less sensitive to noise.

Sobel Kernel: X - Dir $\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$

Y – Dir $\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$

Advantages:

The primary advantages of the Sobel is its simplicity. The Sobel method provides a approximation to the gradient magnitude. Another advantage of the Sobel operator is, it can detect edges and their orientations. In this cross operator, the detection of edges and their orientations is said to be simple due to the approximation of the gradient magnitude.

1x2 Kernel: X – Dir $\begin{bmatrix} 1 & -1 \end{bmatrix}$

Y – Dir $\begin{bmatrix} 1 \\ -1 \end{bmatrix}$

Advantages:

The 1x2 operator is simple, it is sensitive to image noise since the kernel relies on the differences between two consecutive pixels, in the vertical and horizontal directions, respectively.

*Q.5 Suppose you apply the Sobel operator to each of the RGB color bands of a color image.  How might you combine these results into a color edge detector (5 points)?  Do the resulting edge differ from the gray scale results?  How and why (5 points)? You may compare the edge maps of the intensity image (of the color image), the gray-scale edge map that are the combination of the three edge maps from three color bands, or a real color edge map that edge points have colors (5 points). Please discuss their similarities and differences, and how each of them can be used for image enhancement or feature extraction (5 points). Note that you want to first generate gradient maps and then using thresholding to generate edge maps.  In the end, please try to generate a color sketch of an image, such as the ID image of Prof. Zhu. You may also consider local, adaptive thresholding in generating a color edge map.*

Ans. In order to develop an edge detector to an RGB image, Sobel kernel was applied to each color band of the image and concatenated the three colors gradient bands which produced the color Sobel gradient image below. In order to generate the grayscale edge map and to find the intensity image of the RGB Sobel gradient image and using its histogram to choose a threshold value of 120 I transformed it into a binary edge map.

Color Sobel

RGB Sobel Threshold

RGB Sobel Intensity

RGB Sobel Intensity Threshold

By comparing the Sobel edge maps created using the RGB image and the intensity image we see that there is no visible difference between the two edge maps.