

# CAP 5415 Computer Vision

## Programming Assignment 1

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### Images used for performing Canny Edge Detection:

Image 1, Sigma=1.0, X Gaussian



Image 2, Sigma=1.0, X Gaussian



Image 3, Sigma=1.0, X Gaussian



- The model implements the Canny edge detection algorithm on images.
- It begins by defining Gaussian kernels and their derivatives based on a given sigma values – [1, 1.5, 3].
- The primary edge detection function, **canny\_edge\_detection**, first smoothens the image using a Gaussian filter to reduce noise.
- It then calculates the image gradient in both x and y directions, which is used to compute the magnitude and direction of the gradient at each pixel.
- Non-maximum suppression is applied to thin out the edges, ensuring that only the most significant edges are retained.
- Finally, hysteresis thresholding differentiates between strong and weak edges: pixels with a gradient magnitude above a high threshold are considered strong edges, those below a low threshold are discarded, and those in between are considered weak edges.
- Weak edges are only retained if they are connected to strong edges.
- The final output is a binary edge map of the image, highlighting significant edges while suppressing noise and weaker details.

The results are as shown in the following pages.

## Results for Image 1:

The results contain, X Gaussian, Y Gaussian, X Derivative, Y Derivative, Magnitude, Canny Edges, and Hysteresis outputs for the Sigma value [1, 1.5, 3].

Sigma=1.0, X Gaussian



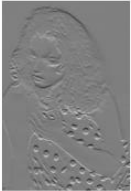
Sigma=1.0, Y Gaussian



Sigma=1.0, X Derivative



Sigma=1.0, Y Derivative



Sigma=1.0, Magnitude



Sigma=1.0, Canny Edges



Sigma=1.0, Hysteresis



Results for Image 1  
Sigma=1.5, X Gaussian



Sigma=1.5, Y Gaussian



Sigma=1.5, X Derivative



Sigma=1.5, Y Derivative



Sigma=1.5, Magnitude



Sigma=1.5, Canny Edges



Sigma=1.5, Hysteresis



Sigma=3.0, X Gaussian



Sigma=3.0, Y Gaussian



Sigma=3.0, X Derivative



Sigma=3.0, Y Derivative



Sigma=3.0, Magnitude



Sigma=3.0, Canny Edges

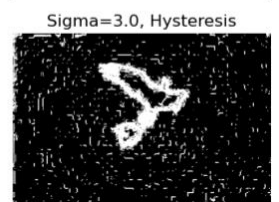
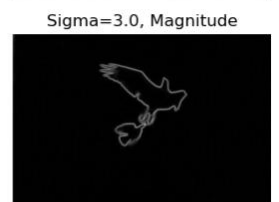
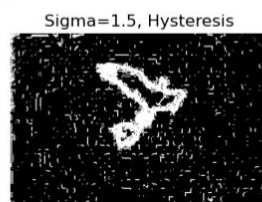
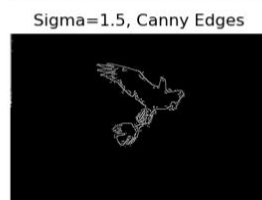
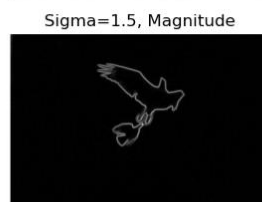
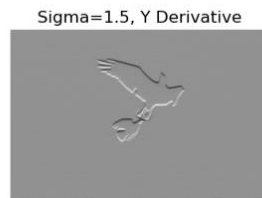
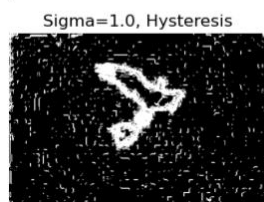
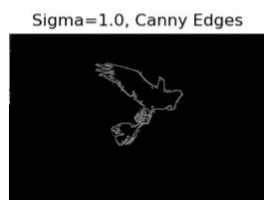
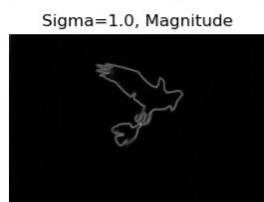


Sigma=3.0, Hysteresis



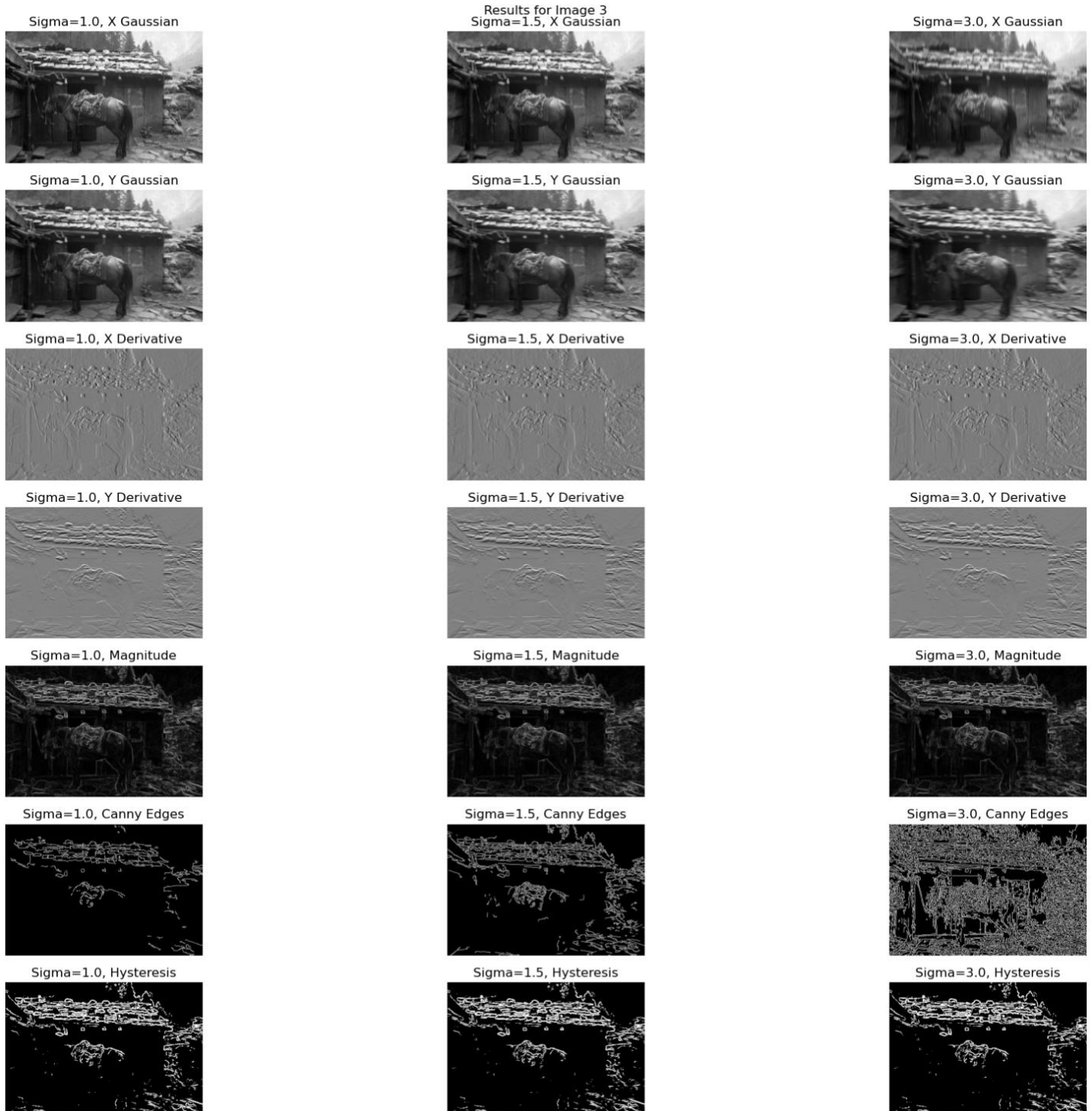
## Results for Image 2:

The results contain, X Gaussian, Y Gaussian, X Derivative, Y Derivative, Magnitude, Canny Edges, and Hysteresis outputs for the Sigma value [1, 1.5, 3].



### Results for Image 3:

The results contain, X Gaussian, Y Gaussian, X Derivative, Y Derivative, Magnitude, Canny Edges, and Hysteresis outputs for the Sigma value [1, 1.5, 3].



### Conclusion:

From the Canny edge detection process and the results we observed, we can conclude the following:

1. **Gaussian Smoothing is Crucial:** The noise in the image is significantly reduced during the Gaussian smoothing step. This makes sure that the gradient computation that follows concentrates more on the image's primary features than on noise. Higher values of the **sigma** parameter result in more pronounced blurring, which controls the degree of this smoothing.
2. **Gradient Amounts Highlight Edges:** We can locate regions of the image with abrupt intensity changes, which typically correspond to edges, by computing the gradient magnitudes using the Sobel

operator (or the convolution with the derivative of a Gaussian). The orientation of these edges is determined by the gradient's direction.

3. **Non-Maximum Suppression Refines Edges:** The third step, non-maximum suppression, refines edges by retaining only the maximum gradient values in each local area and suppressing the non-maximum values.
4. **Thresholding is Key:** For separating true edges from noise, hysteresis thresholding is essential. Only significant edges are kept using the algorithm's dual-threshold mechanism (high and low thresholds). The likelihood of noise being mistaken for an edge is decreased because weak edges are only taken into account if they are connected to strong edges.
5. **Parameters Matter:** The parameters selected have an impact on the Canny edge detection results, particularly sigma (for Gaussian smoothing) and the high/low thresholds. Different edge detection results can be obtained by varying these parameters, and they may need to be tuned based on the specific image and application.