# CSCI 5561:  Programming Assignment 1 Report

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In this report, we implement about Sobel and Robert Cross edge operators to detect the edges in an image. We perform three methods here,

      1) kernel matrices convolution to get the magnitude and direction

      2) thresholding to scale down the values in the permissible range of 0-255

      3) edge thinning to perform thinning of edges in an edge to produce clear and sharp edges.

In the first two methods, we simply convolve the kernel matrix for each of the Sobel and Robert Cross operator to get the gradient magnitude and gradient direction and then scale the results in the 0-255 image. The image has to be converted to grayscale for performing all the tasks in this assignment. Post this, we put a threshold on the image intensities to get a binary image(0/255) to product clear edges. For thresholding, I have used K-means thresholding[1] method where we calculate repetitive means of the intensities of the pixels till the means converge to get the final threshold value.

Finally, we do edge thinning. Before doing edge thinning, I have applied the edge expansion technique to create better edges for doing thinning so that any connectivity between edges is not lost. Although this has some drawback in terms of visually analyzing the images in some cases where if the two edges are very close they may merge into one after expansion. After thinning, we may see edge lost. (I have included an example of lena in this report for depicting that where I compare the thinning results with and without expansion).

For edge thinning,  I have implemented two algorithms (Zhang Suen Algorithm[2] and Guo Hall Algorithm[3]) where I have compared the performance of the two both visually and computationally. These are two sub-iteration processes which work on deleting pixels simultaneously. Details of the execution results are shown below:

**Thinning processing time for lena (Sobel):**

Zhang Suen 0.15 seconds

Guo Hall - 1.37 seconds

**Thinning processing time for lena (Robert Cross):**

Zhang Suen 0.12 seconds

Guo Hall - 0.29 seconds

We see that the Zhang Suen algo is faster than the Guo Hall here and for most of the images i have tested. Although both the processes include a two -step process, Zhang Suen is better of the two.  However, I felt that Guo Hall algorithm performed better in terms of 'thinning' the edges. There were many instances where I felt Zhang Suen Algorithm didn't perform well enough. Try running the test images included in the submission.  One thing to notice here was the Guo hall runtime performance was better in the Robert Cross as compared to its performance in Sobel.

1.  Section: 4.4.3 http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/MORSE/threshold.pdf
2.  Zhang, T. Y., and C. Y. Suen. "A Fast Parallel Algorithm For Thinning Digital Patterns".*Communications of the ACM* 27.3 (1984): 236-239. Web.
3.  Guo, Zicheng, and Richard W. Hall. "Parallel Thinning With Two-Subiteration Algorithms".*Communications of the ACM* 32.3 (1989): 359-373. Web.

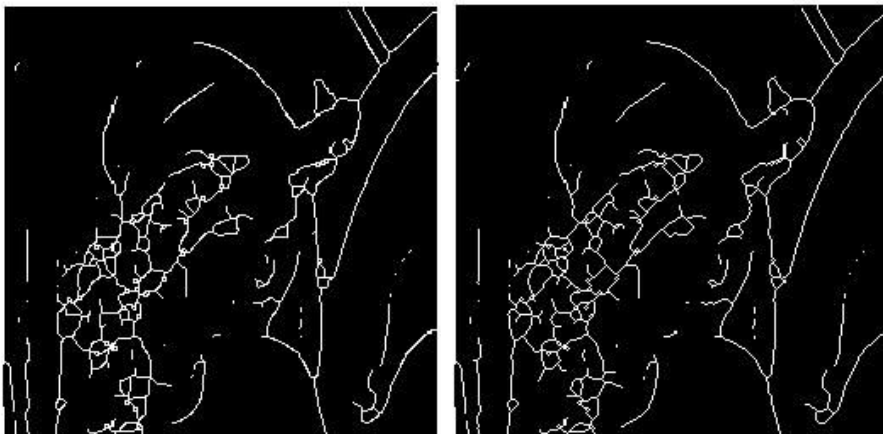Here we see the impact of doing "Expansion", where necessary details are lost (especially on the hairy part)

Sobel Operator result (after scaling(uint8))  Sobel Operator after Thresholding



Sobel Operator after thinning without Expansion (Zhang Suen -left, Guo Hall right)
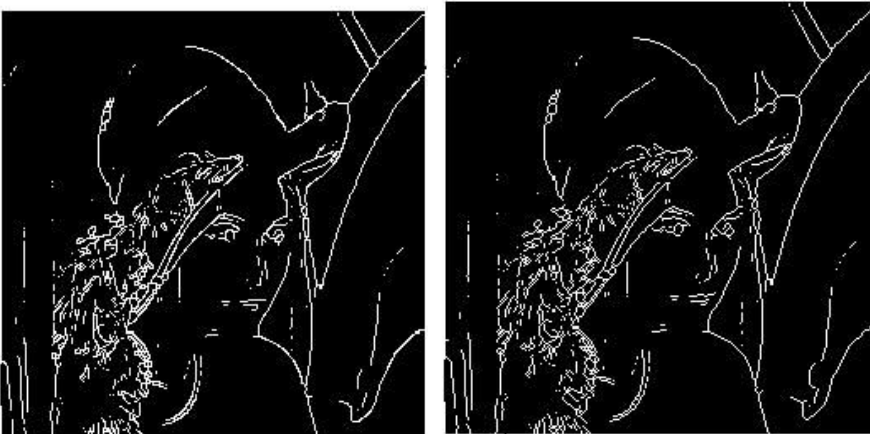


Sobel Operator results after thinning with Expansion (Zhang Suen -left, Guo Hall right)

One awkward thing to notice here was, even after scaling the values, some of the test images, didn't show up the magnitude properly. For example, Lena and Cameraman, I struggled to get the magnitude show up properly. To overcome this problem, I had to either apply uint8 to the images to check if the magnitude is fine (shown above on the second page for Lena), or after thresholding which solved the problem, to get the magnitude show the images up properly. Though, for the test images included in the submission, the 'findsuits', and the 'demo1' files I saw the magnitude properly in the form of the image(although the values were in range.

Results for magnitude after scaling for 4 images:

**Cameraman**



**Lena**



**FindSuits**
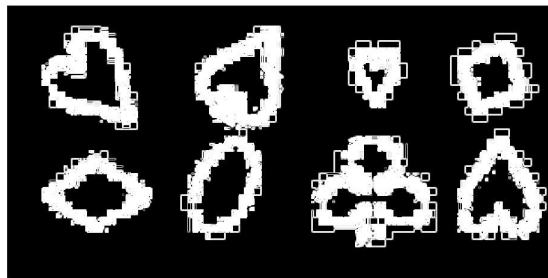


**demo1**
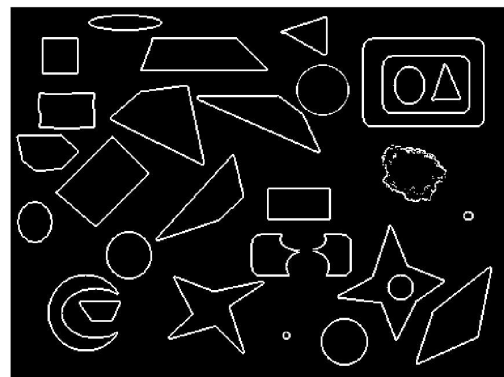
**Few other Test Results:**
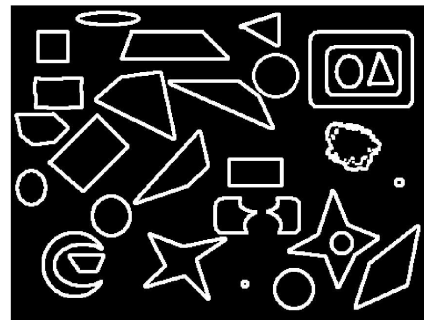
**Sobel results:**
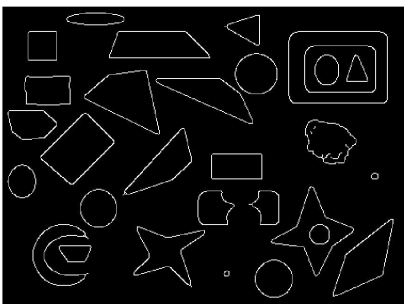
Magnitude after Scaling
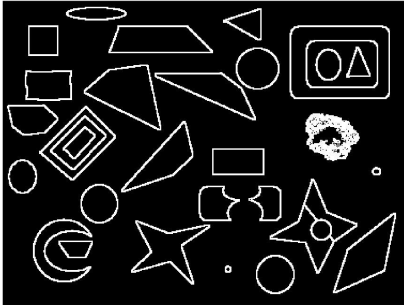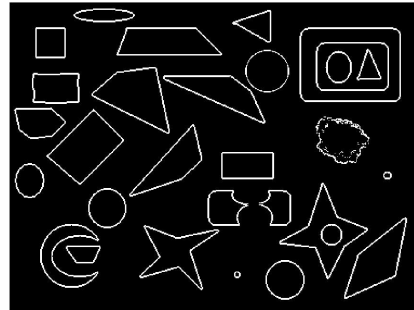
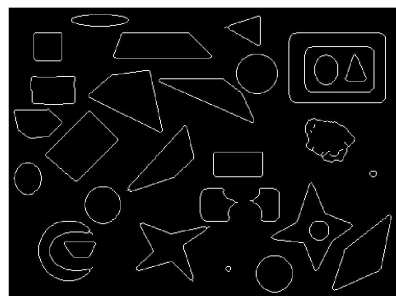Magnitude after thresholding

Direction after Thresholding
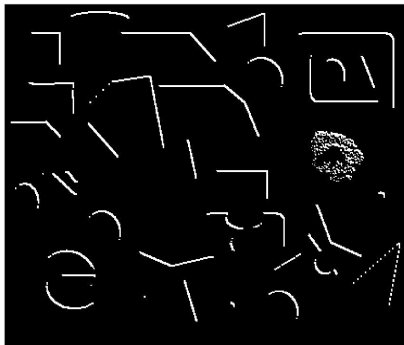
Magnitude after expansion

Magnitude after Zhang Suen Thinning

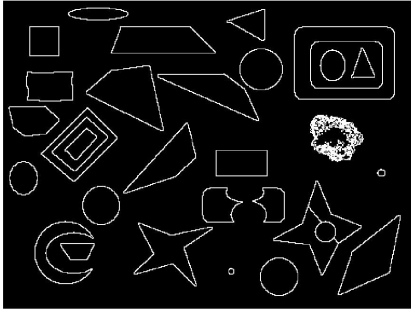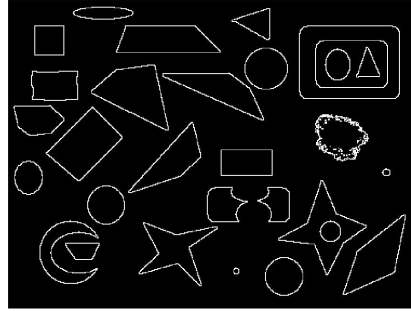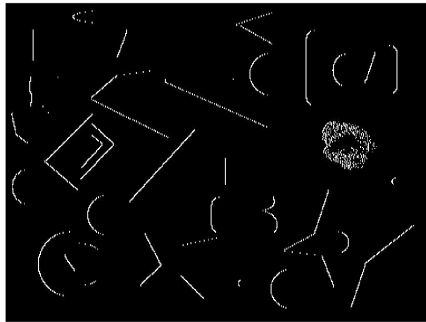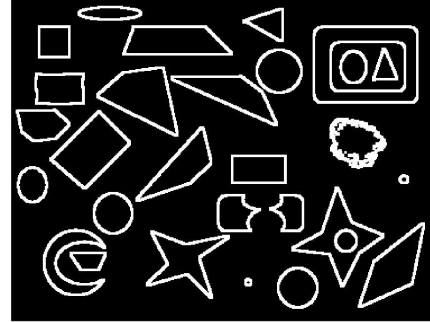Magnitude after Guo Hall Thinning

**Robert Cross Results**

Magnitude after Scaling

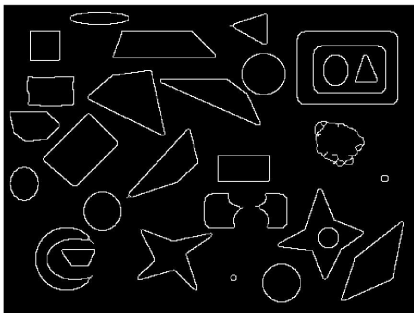Magnitude after thresholding

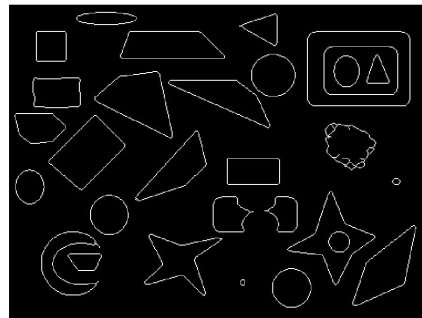



Direction after Thresholding

Magnitude after expansion





Magnitude after Zhang Suen Thinning

Magnitude after Guo Hall Thinning





NOTE: All the other test results are included in the test_results folder for the submission.