Student Name: David Talson **Student number: 8419286**

Part I – Effect of noise and Image filtering

Olympics_BW.jpg and Winterlude_BW.jpg

Noise	Filter	Observation	Comparison
Gaussian noise	**Mean**	The 3x3 and 7x7 filters are able to remove some of the noise and blur the image in the process. This is expected because of the averaging nature of the mean filter and increasing the filter size removes more noise but further blurs the image and this is why the 7x7 filtered image appears blurrier than the 3x3 image	The 7x7 mean filter had the best performance in removing the noise and this is expected because of the size of the neighboring pixels used to calculate new pixel values. However, this filter produced the blurriest image. For the winterlude image, a lot of features are lost since the image is very blurry. The median filter had a better noise removal than the gaussian filter and this is expected due to the size of the filter masks used. The 3x3 mean filter had the worst performance in removing the noise but did not produce a very blurry image
	Median	The 3x3 median filter reduces some of the noise and also blurs the image in the process. This is expected because the median filter basically uses the median of nearby pixels to calculate new pixels and since the noise in the images are not outliers, they are not efficiently removed by taking the median of neighbouring pixels	
	Gaussian	The 7x7 gaussian filter reduces some of the noise with more emphasis towards the center of the image but blurs the image in the process. This is expected due to the averaging nature of the gaussian filter	
Salt and Pepper noise	**Mean**	The 3x3 mean filter reduces the noise in a smoothing fashion, due to the averaging nature of the filter and the nature of the salt of pepper noise. This filter reduces the noise but seems to produce a darker and blurry image. The 7x7 filter does the same thing but produces a blurrier image	The median filter had the best performance as it removed the noise without blurring the image. The 7x7 mean filter had a better noise removal than the 3x3 mean and gaussian filter but produced a very blurry image. The gaussian filter had the worst performance because the averaging technique favours pixels close to the middle, also because the nature of the noise is not gaussian. The 3x3 and 7x7 filter removed some of the noise but blurs the image and also darkens the image. The median is good for removing noise which are outliers as in the case of the noise the salt and pepper introduces
	Median	The 3x3 median filter is able to remove all the noise. This is expected because of the nature of the median filter which will be good for removing the added salt and pepper noise which are basically random very bright or dark pixels	
	Gaussian	The 7x7 filter removes very little of the noise and also does this in a smoothing fashion. This is expected because of the averaging weighted nature of the Gaussian filter	

Student Name: David Talson **Student number: 8419286**

Effect of Noise and Image Complexity on Edge Detection

Sobel

<table>
<tr><th>Image</th><th>Observation</th><th>Comparison</th></tr>
<tr><td>olympics_BW.jpg & winterlude_BW.jpg</td><td>Edges are well detected in both images</td><td rowspan="5">Edge detection was poor for the original with S&P noise because the salt and pepper noise adds very bright or dark pixels at random locations and the sobel edge detection works based on a sharp change in contrast, so the noise is detected as false edges</td></tr>
<tr><td>original with Gaussian noise</td><td>Edges are detected but noise is visible</td></tr>
<tr><td>original with S&P noise</td><td>Edge detection is poor</td></tr>
<tr><td>Gaussian-filtered Gaussian noise</td><td>Edges are detected but noise is visible</td></tr>
<tr><td>median-filtered S&P noise</td><td>Edges are well detected in both images</td></tr>
</table>

Prewitt

<table>
<tr><th>Image</th><th>Observation</th><th>Comparison</th></tr>
<tr><td>olympics_BW.jpg & winterlude_BW.jpg</td><td>Edges are well detected</td><td rowspan="5">Edge detection was poor for the original with S&P noise because the salt and pepper noise adds very bright or dark pixels at random locations and the prewitt edge detection works based on a sharp change in contrast, so the noise is detected as false edges</td></tr>
<tr><td>original with Gaussian noise</td><td>Edges are detected but noise is visible</td></tr>
<tr><td>original with S&P noise</td><td>Edge detection is poor</td></tr>
<tr><td>Gaussian-filtered Gaussian noise</td><td>Edges are detected but noise is also visible</td></tr>
<tr><td>Median-filtered S&P noise</td><td>Edges are well detected</td></tr>
</table>

Log

<table>
<tr><th>Image</th><th>Observation</th><th>Comparison</th></tr>
<tr><td>olympics_BW.jpg & winterlude_BW.jpg</td><td>Edges are well detected</td><td rowspan="5">Edge detection was poor for the original with gaussian noise and S&P noise because the Laplacian filter takes the double derivative and this is very sensitive to noise since when the double derivative is taken, the pixels closers to zero are detected as edges</td></tr>
<tr><td>original with Gaussian noise</td><td>Edges are poorly detected</td></tr>
<tr><td>original with S&P noise</td><td>Edges are poorly detected</td></tr>
<tr><td>Gaussian-filtered Gaussian noise</td><td>Edges are detected but noise is visible</td></tr>
<tr><td>median-filtered S&P noise</td><td>Edges are detected with little noise</td></tr>
</table>

Canny

<table>
<tr><th>Image</th><th>Observation</th><th>Comparison</th></tr>
<tr><td>olympics_BW.jpg & winterlude_BW.jpg</td><td>Edges are well detected</td><td rowspan="5">Edges were detected in all cases, but the effect of noise was very visible in original with gaussian and S&P noise. This is understandable because the canny edge detector which is based on the first derivative is sensitive to noise</td></tr>
<tr><td>original with Gaussian noise</td><td>Edges are detected noise is heavily present</td></tr>
<tr><td>original with S&P noise</td><td>Edges are detected but noise is heavily present</td></tr>
<tr><td>Gaussian-filtered Gaussian noise</td><td>Edges are detected but some noise present</td></tr>
<tr><td>median-filtered S&P noise</td><td>Edges are detected with little noise present</td></tr>
</table>

Part III: Study of Image Segmentation

Manual Thresholding

Image	Observation	Comparison
Olympics_BW.jpg and	Increasing the threshold produced better segmented images	Manual thresholding works better on images with less detail, high contrast, and uniform lighting such as the Olympics image. Also, for images with a lot of detail such as the winterlude image, a threshold value of 0.6 gave the best performance as using a higher threshold value led to loss of information
Winterlude_BW.jpg	A threshold value of 0.6 gavw the most segmented image as threshold values above this caused regions to be overlapped thereby leading to loss of information	
Olympics_RGB.jpg	Increasing the threshold produced better segmented images	
Winterlude_RGB.jpg	A threshold value of 0.6 gave the most segmented image as threshold values above this caused regions to be overlapped thereby leading to loss of information	

Otsu's Method

Image	Observation	Comparison
Olympics_BW.jpg	Image is not properly segmented as some information is missing	Adpative thresholding had the best performance on the winterlude images and this is understandable because of its nature as it uses different threshold values for different locations in the image.
Winterlude_BW.jpg	Image is properly segmented	
Olympics_RGB.jpg	Image is properly segmented	
Winterlude_RGB.jpg	Image is properly segmented	

Conclusion

Part I: Main conclusion about Filters

Images with Gaussian Noise

The mean 7x7 filter had the best performance in removing the noise but also had the most blur. The median filter had the best performance when noise removal and image sharpness was considered. figure 1 (appendix) shows the result when a mean 7x7 filter was used and figure 2 (appendix) shows the result when a median filter is used.

Theoretically, the gaussian filter should have the best performance, and this is a function of the filter mask. This means a 3x3 gaussian filter will have a better performance than a 3x3 median filter. The mean filter performance is also a function of mask size, with a smaller mask less noise will be removed but better edge preservation is gotten. With a bigger mask, a more noise is removed but a worse edge preservation is gotten. In conclusion, a gaussian filter will be best for removing gaussian noise, an appropriate filter mask just has to be selected.

Images with Salt and Pepper Noise

The median filter had the best performance, and this is theoretically expected. A median filter will have the best performance when compared with filters of the same mask size. This is expected because salt and pepper noise are basically outliers and taking the median of neighboring pixels is good for eliminating outliers. The mean and gaussian filters did not perform well in this case as they just smooth the image and due to the averaging nature of this filter, the image produced has a different shade. Figure 3 (appendix) shows the result when a median filter is used and figure 4 (appendix)

Part II: Main conclusion about edge detectors

The implementation of the various edge detection techniques show which edge detection is appropriate for various cases. For the original grayscale images, all the edge detectors were able to properly detect the edges, but the canny edge detector had the best performance, which was expected because theoretically, this edge detector has a good compromise between noise immunity and good localization of edges. Also, it applies nonmaximal suppression and thresholding to improve edge detection. The laplacian edge detector detected edges well but since it takes the second derivative, only areas with very high change in intensity are detected and this made it very sensitive to noise which had not be smoothed. The sobel and prewitt edge detectors were not as good and since the prewitt edge detector does not place emphasis on any pixels it had the worst performance. For gaussian noise images and images filtered with gaussian filter, the sobel filter had the best performance but theoretically the canny edge detector is supposed to have the best performance, the threshold value used for the canny edge detector caused this underperformance. For the median filtered image, the edge detectors were able to detect the edges well. Figure 5 (appendix) shows the winterlude BW image with the laplacian edge detector applied. Figure 6 (appendix) shows the winterlude BW image with the canny edge detector applied. Figure 7 (appendix) shows the winterlude gaussian filtered image with the sobel edge detector applied. Figure 8 (appendix) shows the winterlude gaussian filtered image with the prewitt edge detector applied

Part III

Manual vs Adaptive Thresholding

The adaptive thresholding had a better performance, and this is understandable because the adaptive thresholding does not use a constant threshold for analysis, this is good for scenarios with different lighting conditions. Manual thresholding can be suitable for images with less detail and uniform lighting where maximum performance is needed, this allows for fine tuning until a desirable threshold is reached. Figure 9 (appendix) shows the olympics BW at maximum threshold, figure 10 (appendix) shows the winterlude BW at 0.6 threshold, figure 11 (appendix) shows the olympics BW using adaptive threshold, and figure 12 (appendix) shows winterlude BW using adaptive threshold.

Appendix

Figure 1: Olympics containing gaussian noise and filtered with mean 7x7 filter

Figure 2: Olympics containing gaussian noise and filtered with median filter

Figure 3: Olympics containing salt&pepper noise and filtered with median filter

Figure 4: Olympics containing salt&pepper noise and filtered with gaussian filter

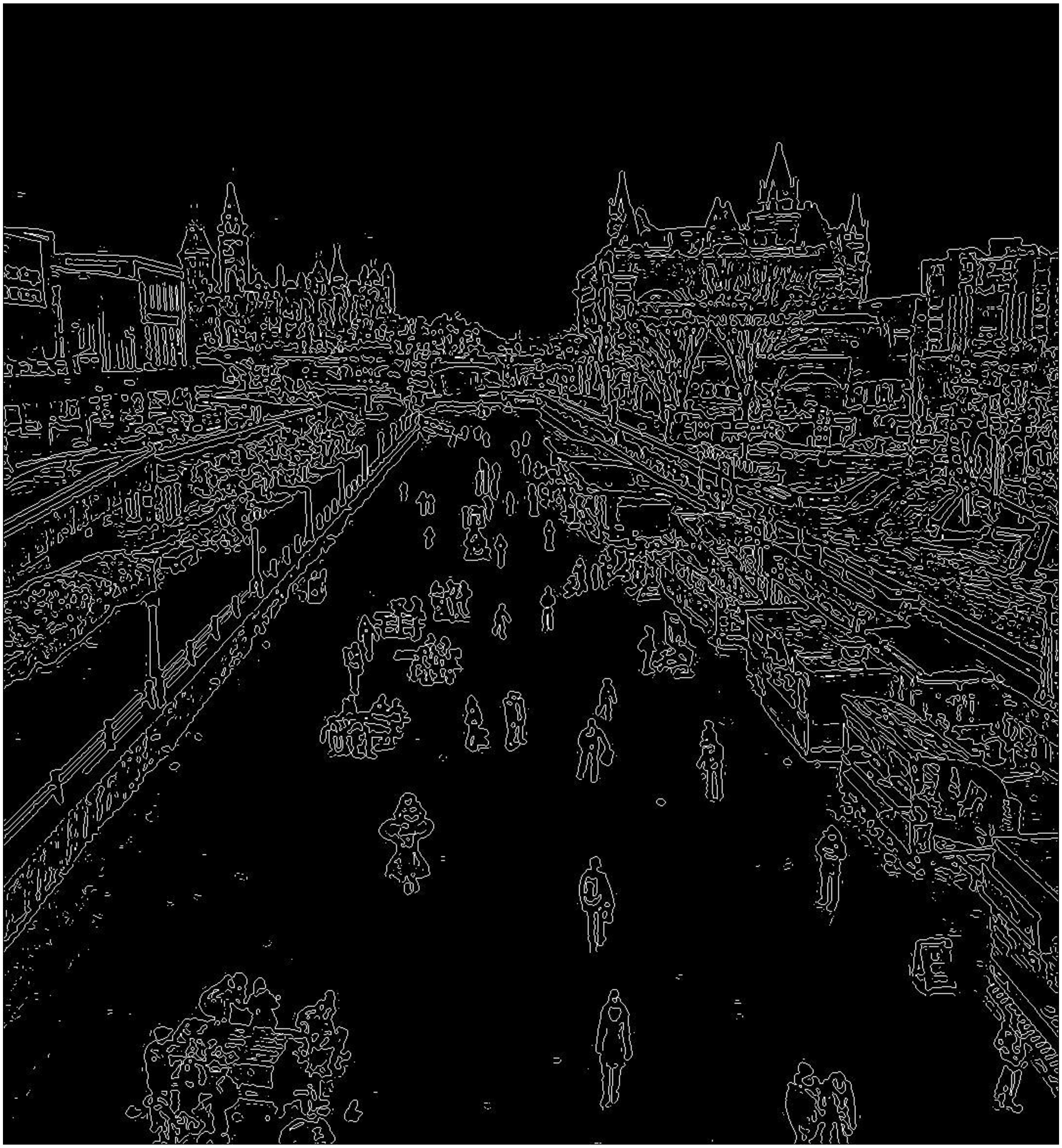

Figure 5: Winterlude BW image with laplacian edge detector applied

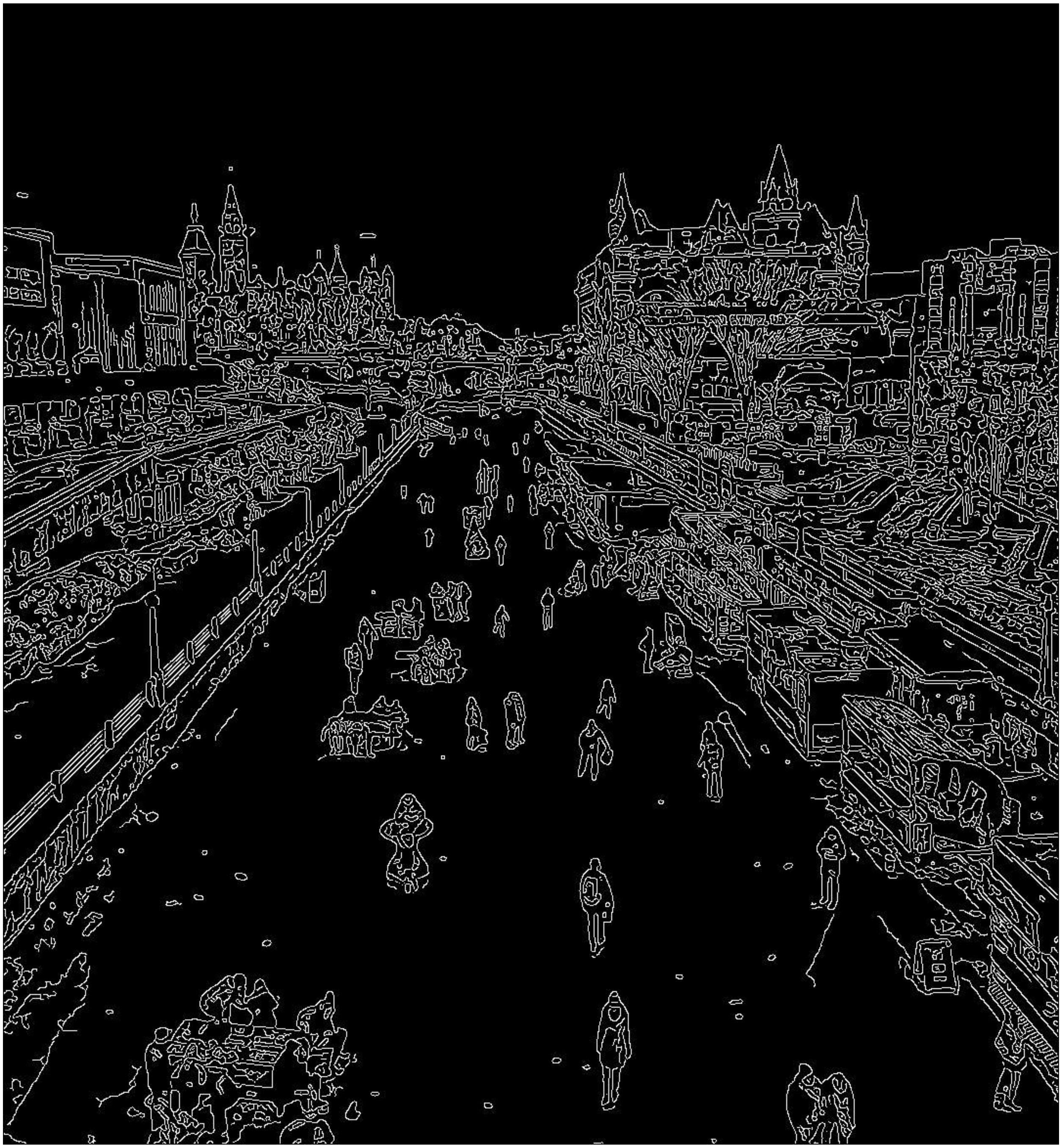

Figure 6: Winterlude BW image with laplacian edge detector applied

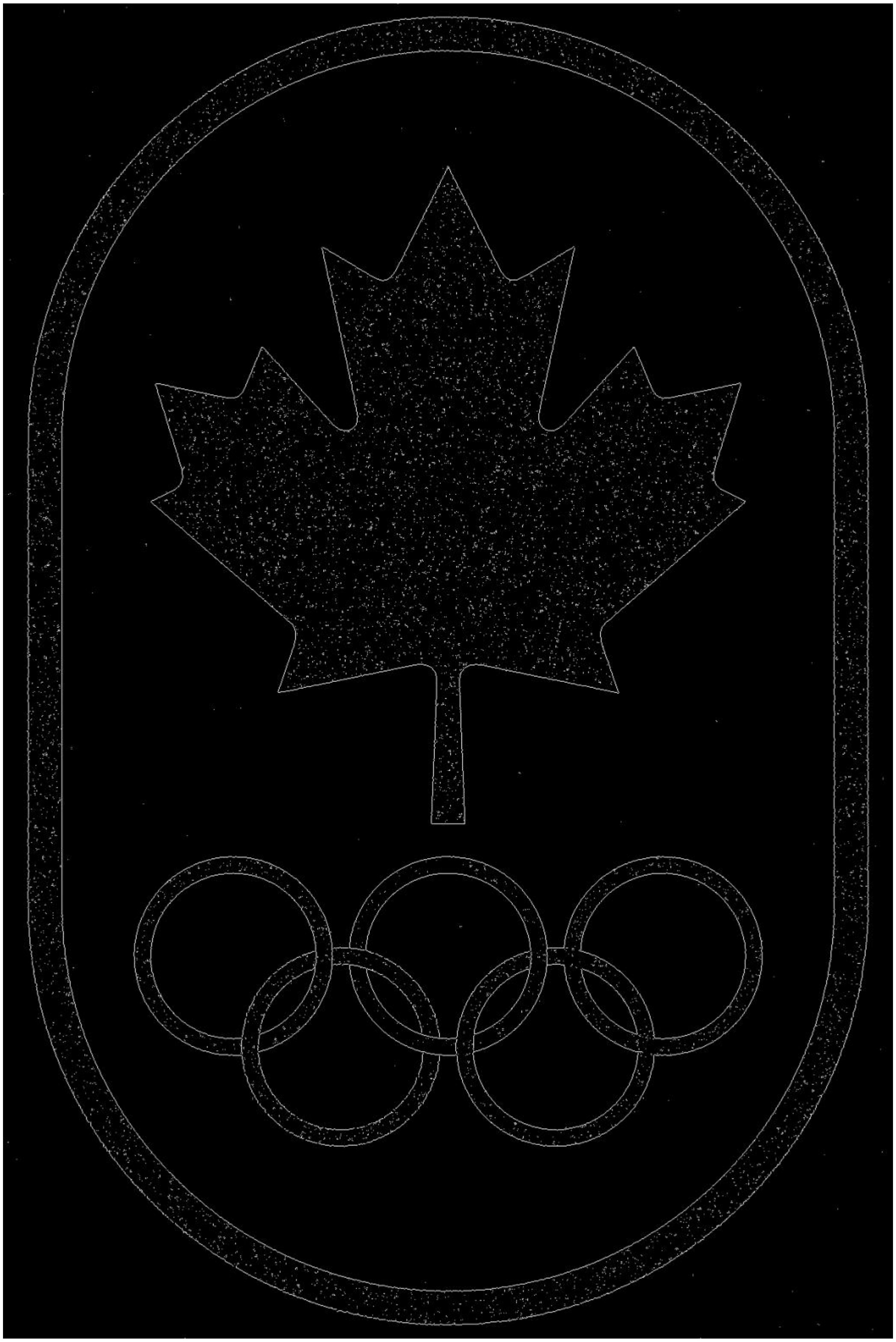

Figure 7: Olympics gaussian filtered image with sobel edge detector applied

Student Name: David Talson **Student number: 8419286**

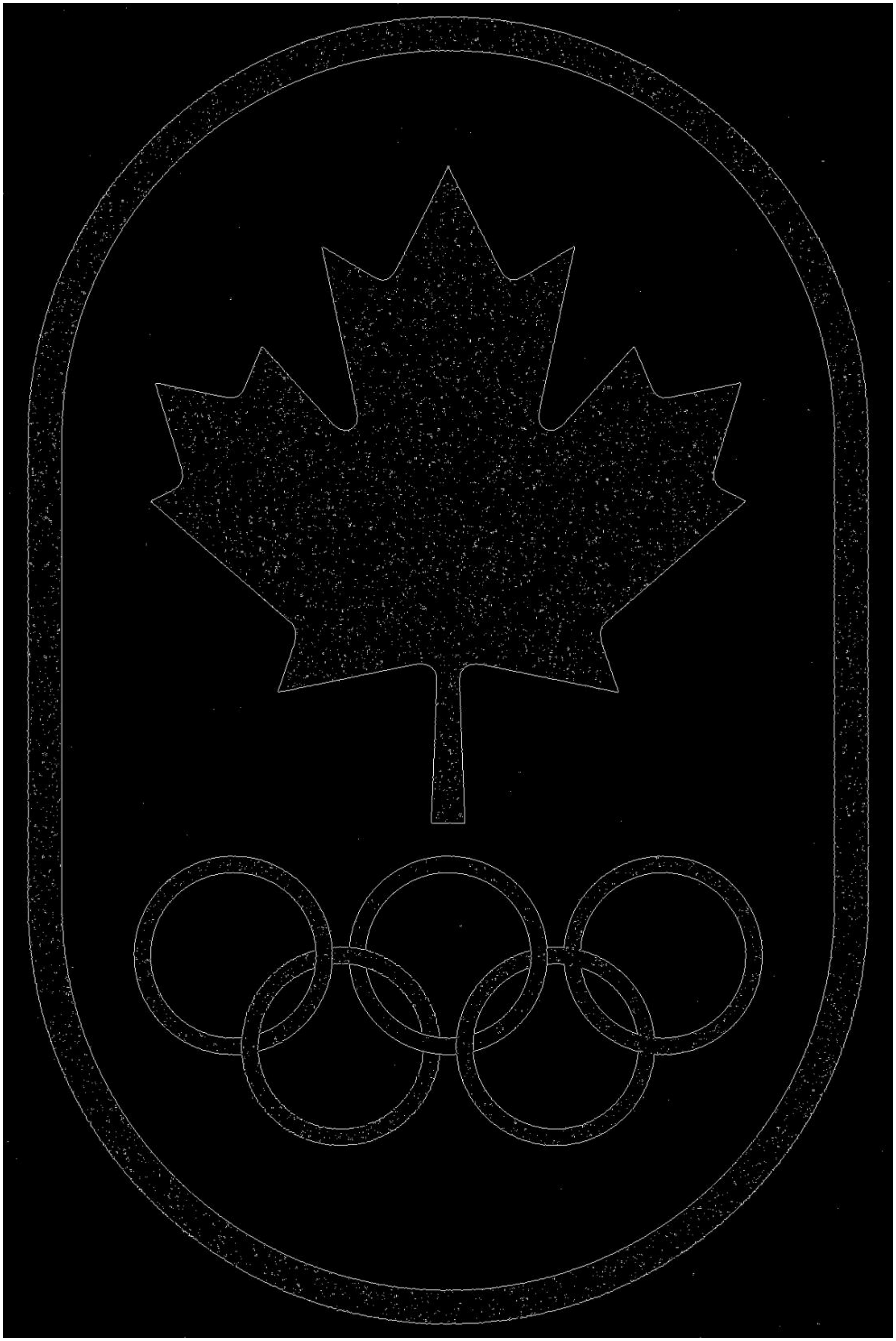

Figure 8: Olympics gaussian filtered image with prewitt edge detector applied

Figure 9: Olympics BW at maximum manual threshold

Figure 10: Winterlude BW at 0.6 threshold

Student Name: David Talson **Student number: 8419286**

Figure 11: Olympics BW using adaptive thresholding

Figure 12: Winterlude BW using adaptive thresholding