Digital Image Processing

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December 24, 2014

1 Introduction

All of the programs are written in python 3. The shebangs are included and thus they should work if called using the "./program.py" notation. In case this causes a problem, please try to call them using "python3 program.py" notation.

I will provide further help on how to call each program.

1.1 libraries

I used numpy in all of the programs and scipy in some of them. I will detail when scipy is used.

2 Exercise 1

The program called ex1.py computes the histogram of a greyscale image, and enhances the image using histogram equalization. it displays the enhanced image, the histograms of the default and enhanced images, and the transformation function.
In this exercise, the matplotlib library is used to plot hitograms and functions.

2.1 Examples

2.1.1 Fig1.jpg

All of the results are obtained using the program with the call "./ex1.py Fig1.jpg"

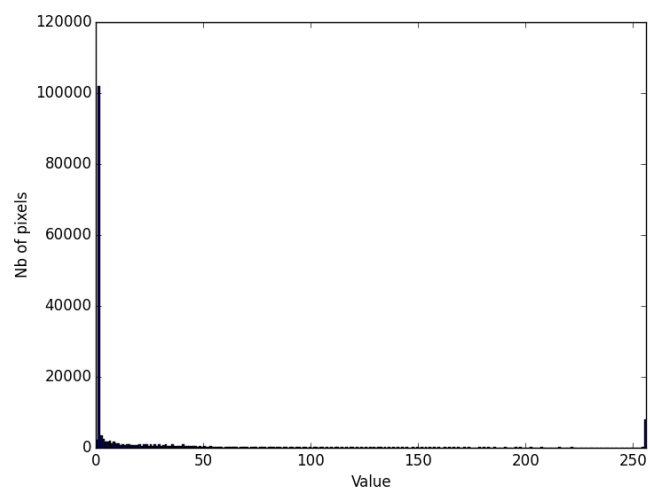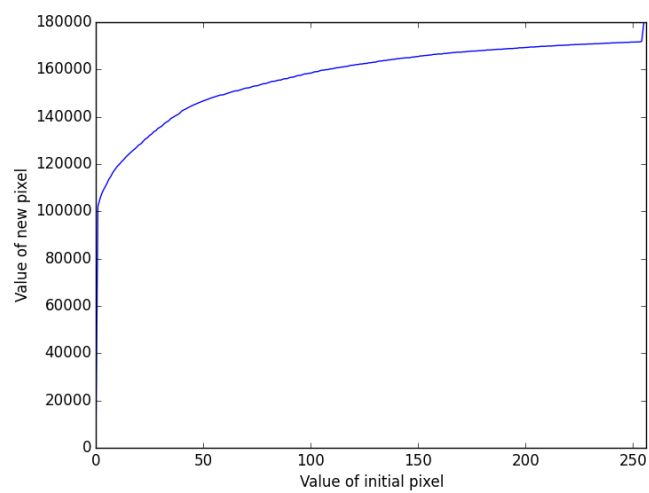Figure 1: Original image

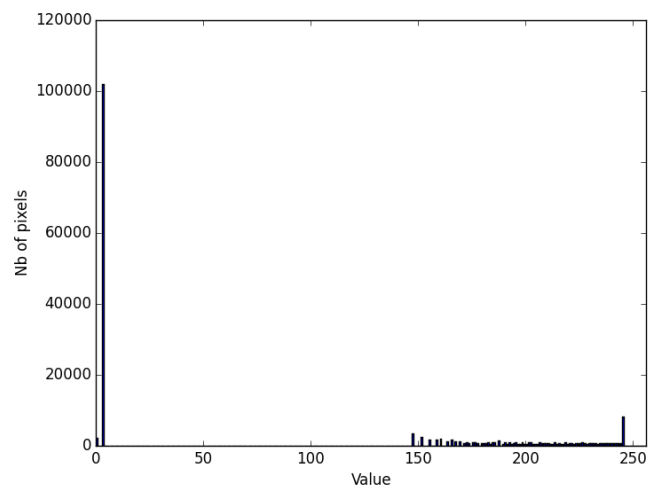Figure 2: Original image's histogram

Figure 3: Enhancement function

Figure 4: Enhanced image histogram

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Figure 5: Enhanced image

2.1.2 Fig2.jpg

All of the results are obtained using the program with the call "./ex1.py Fig2.jpg"
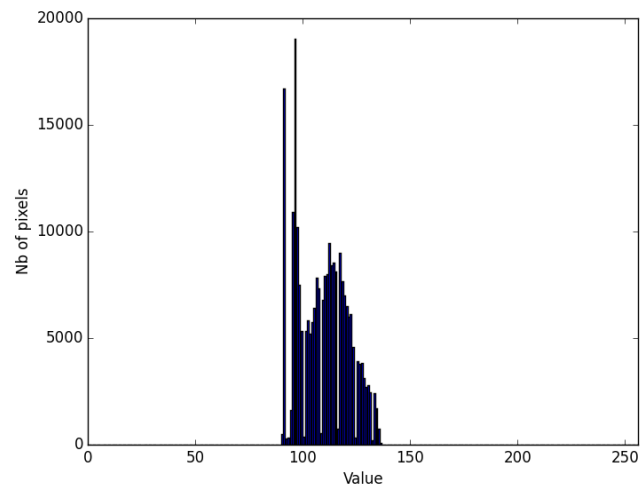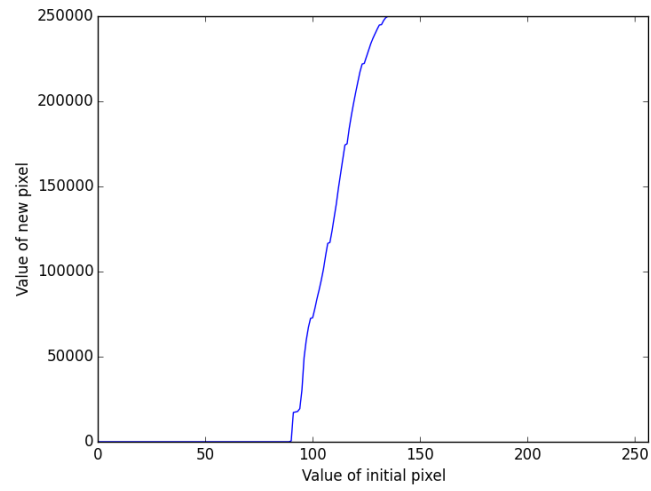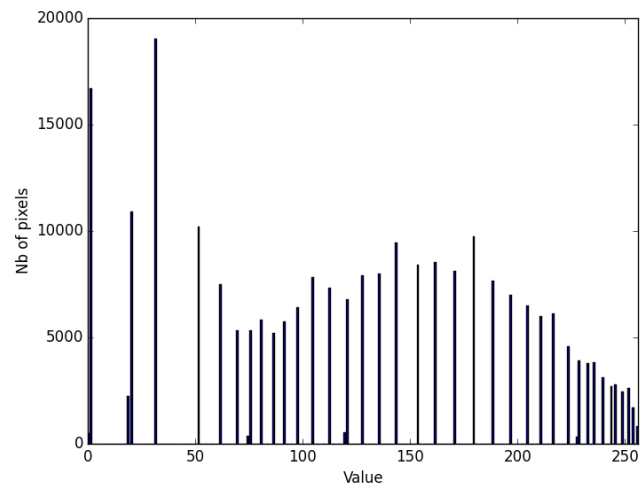

Figure 6: Original image

Figure 7: Original image's histogram
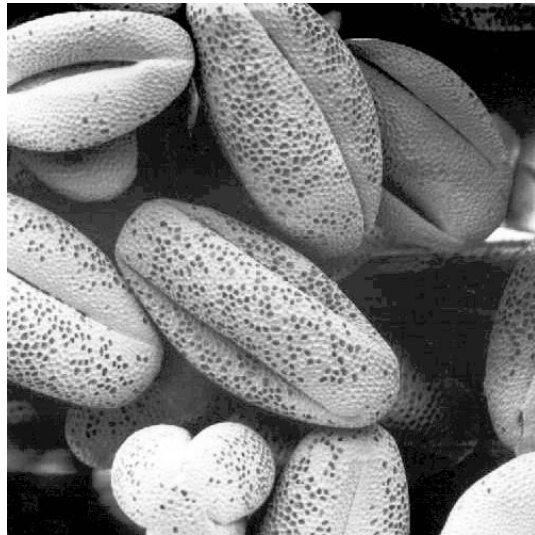
Figure 8: Enhancement function

Figure 9: Enhanced image histogram

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Figure 10: Enhanced image

3 Exercise 2

The program called ex2.py performs several spatial enhancement techniques on a given greyscale image.

3.1 Example on skeleton_orig.tif

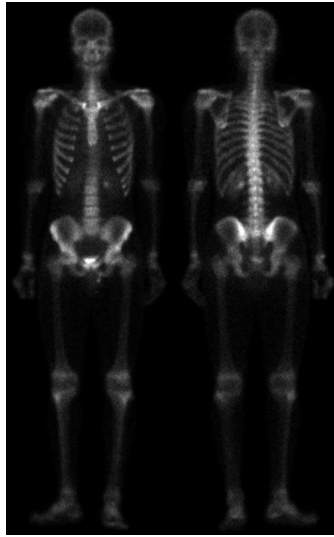All of the results are obtained using the program with the call "./ex2.py skeleton_orig.tif"
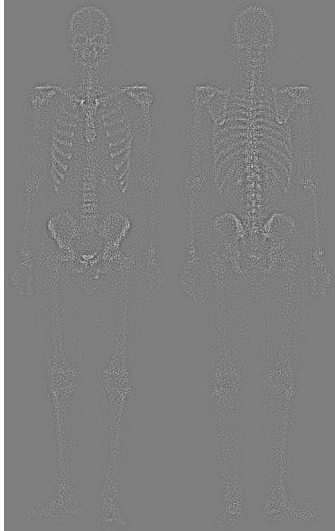

Figure 11: Original image

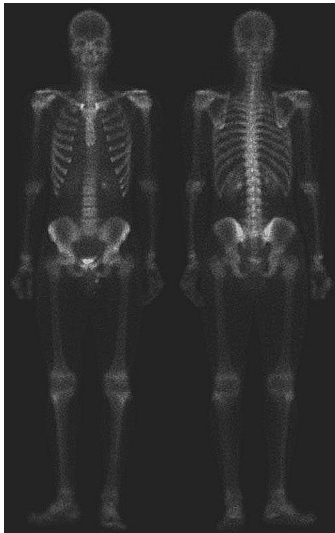Figure 12: Rescaled laplacian of image

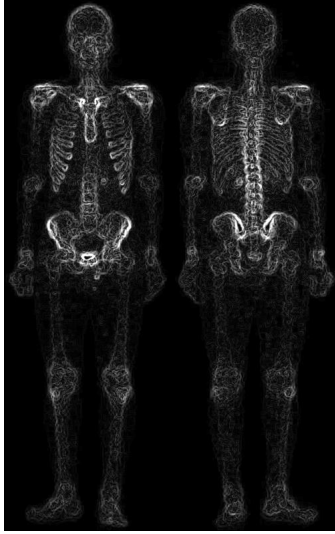Figure 13: Sum of laplacian and original image

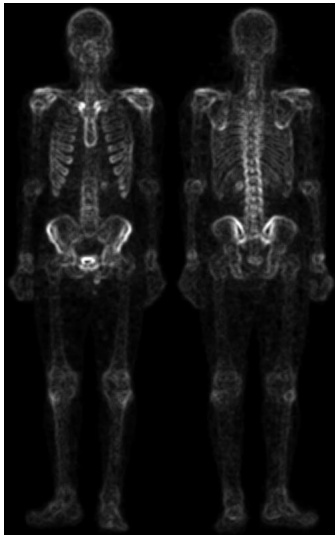Figure 14: Sobel gradient of original image

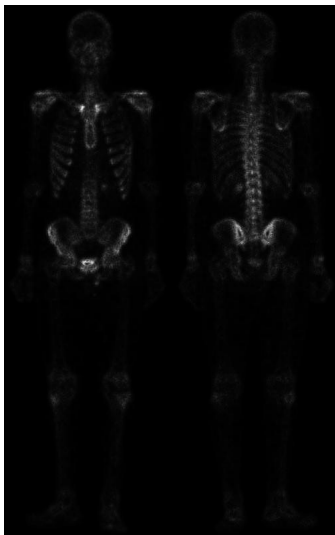Figure 15: Smoothed Sobel gradient of original image

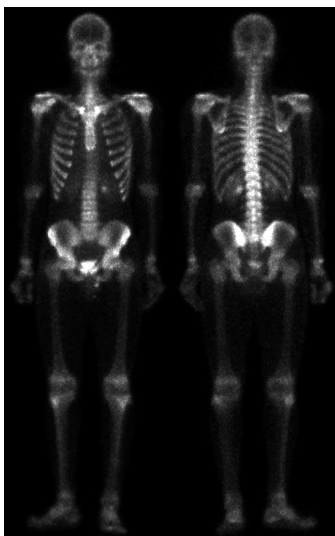Figure 16: Product of smoothed Sobel gradient and of the previous sum of laplacian and original

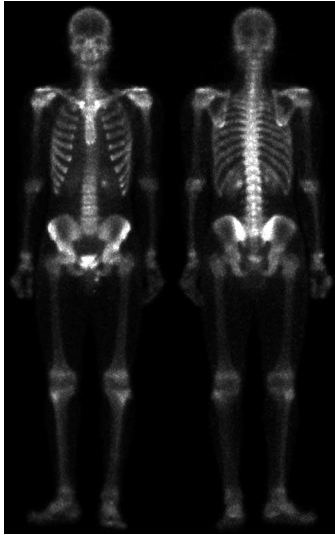Figure 17: Sum of original image and previous image

Figure 18: Power law of original image, gamma = 0.5, c = 1

4 Exercise 3

The program called ex3.py performs several frequency domain enhancement techniques on a given greyscale image.

4.1 Examples

4.1.1 Ideal filter

Those images are obtained using the call "./ex3 –ideal –highpass cutoff image" for highpass images, and "./ex3 –ideal –lowpass cutoff image" for lowpass images.

Figure 19: Cutoff 10 Ideal lowpass filter

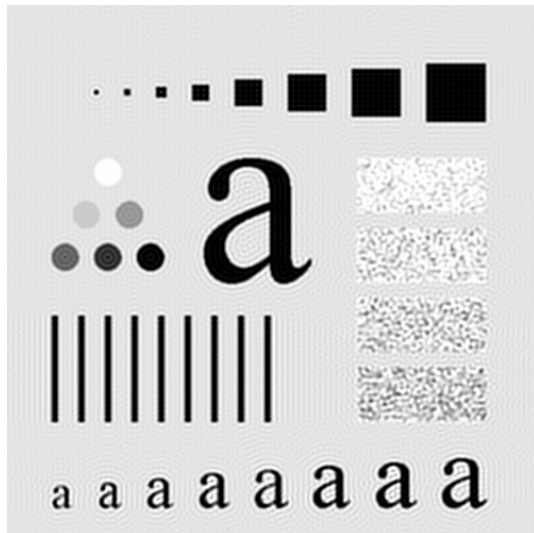Figure 20: Cutoff 30 Ideal lowpass filter
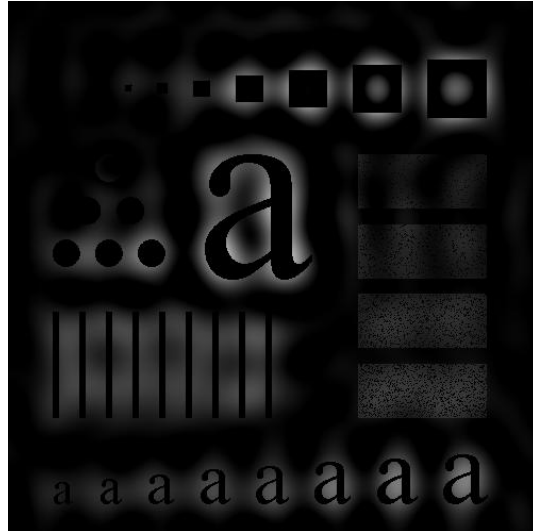

Figure 21: Cutoff 100 Ideal lowpass filter

Figure 22: Cutoff 10 Ideal highpass filter
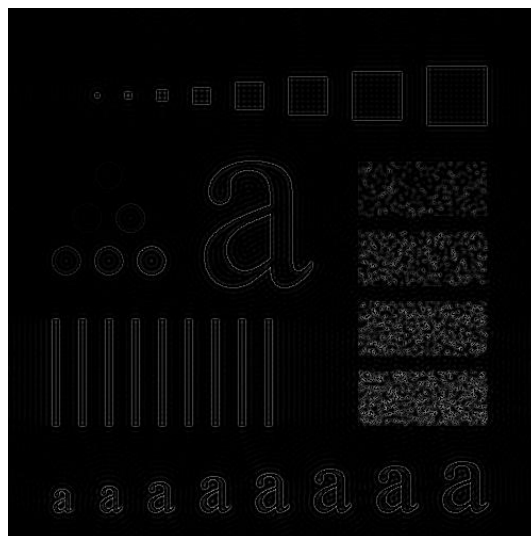

Figure 23: Cutoff 30 Ideal highpass filter

Figure 24: Cutoff 100 Ideal highpass filter

4.1.2 Gaussian filter

Those images are obtained using the call "./ex3 –gaussian –highpass cutoff image" for highpass images, and "./ex3 –gaussian –lowpass cutoff image" for lowpass images.

Figure 25: Cutoff 10 Gaussian lowpass filter
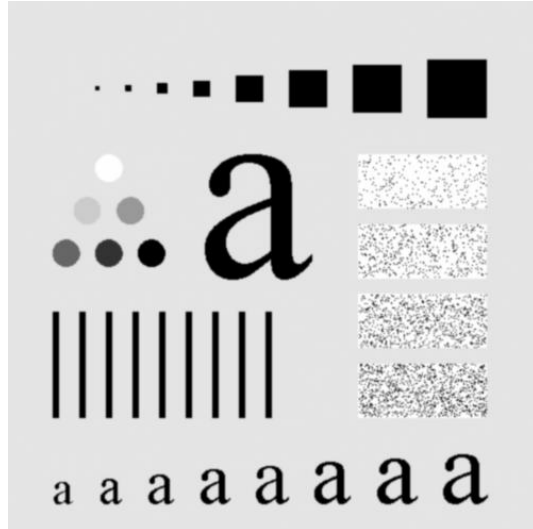

Figure 26: Cutoff 30 Gaussian lowpass filter
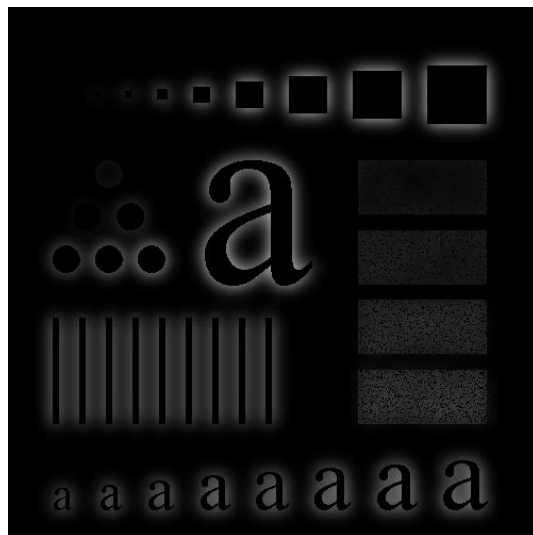
Figure 27: Cutoff 100 Gaussian lowpass filter
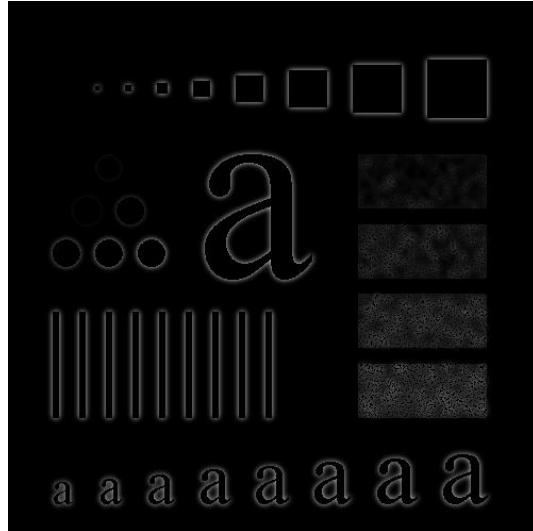

Figure 28: Cutoff 10 Gaussian highpass filter
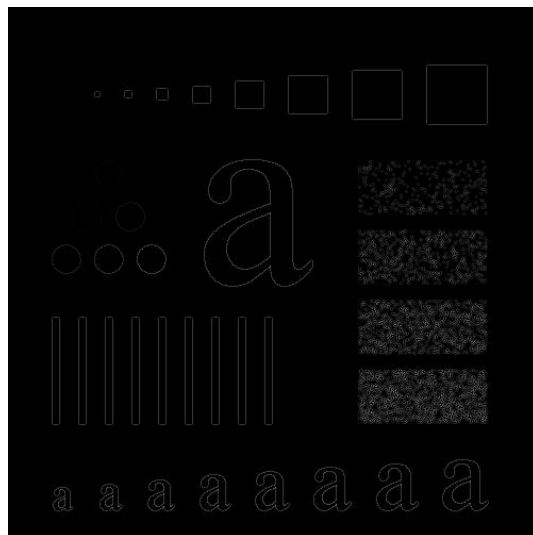
Figure 29: Cutoff 30 gaussian highpass filter

Figure 30: Cutoff 100 Gaussian highpass filter

4.1.3 Butterworth filter

Those images are obtained using the call "./ex3 –butterworth –highpass –order order cutoff image" for highpass images, and "./ex3 –butterworth –lowpass – order order cutoff image" for lowpass images.
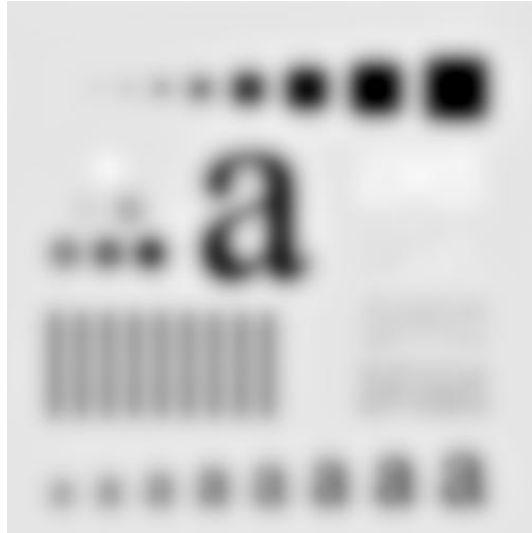

Figure 31: Cutoff 10 order 2 Butterworth lowpass filter
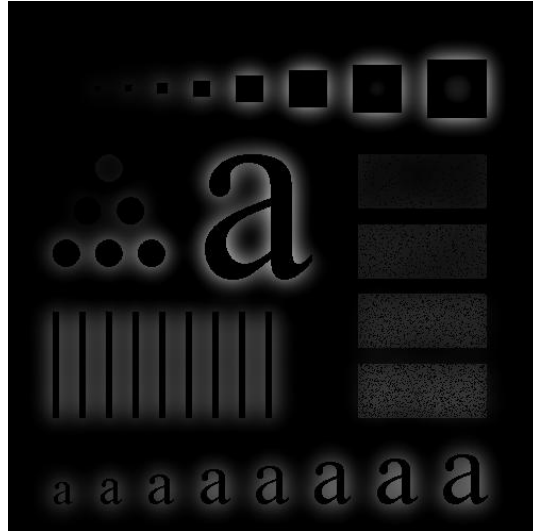

Figure 32: Cutoff 30 order 2 Butterworth lowpass filter

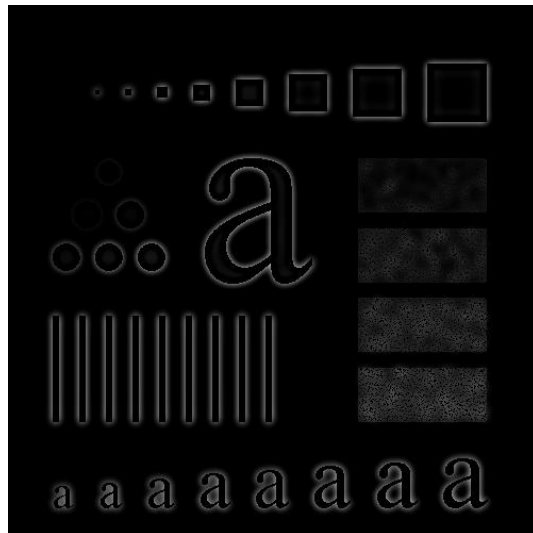Figure 33: Cutoff 10 order 2 Butterworth highpass filter

Figure 34: Cutoff 30 order 2 Butterworth highpass filter

5 Exercise 4

For exercise 4, the program gaussNoise.py adds gaussian noise of desired mean and variance o an image. The program uniNoise.py adds uniform noise of desired lower and upper bound to an image. The program filtering.py uses different means of filtering an image.
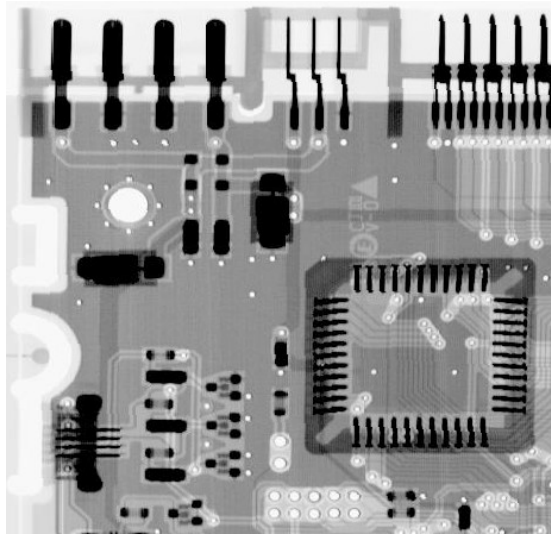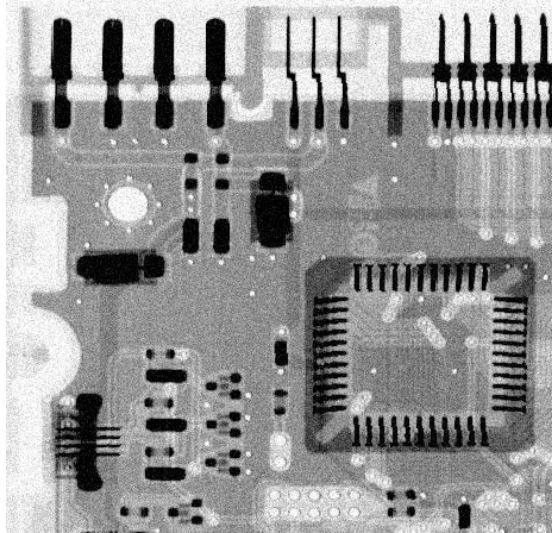
5.1 Examples

Figure 35: Original image

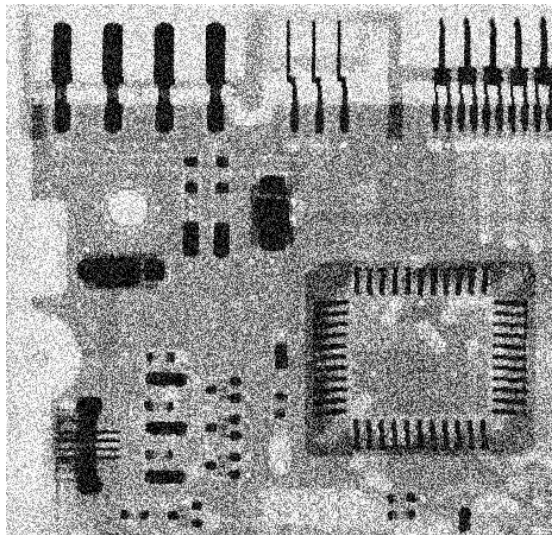Figure 36: Original image with gaussian noise of mean 0 and variance 260

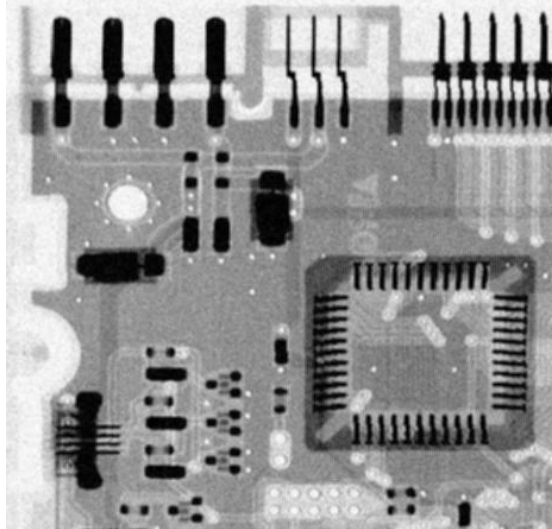Figure 37: Original image with uniform noise in the [-100, 100] range

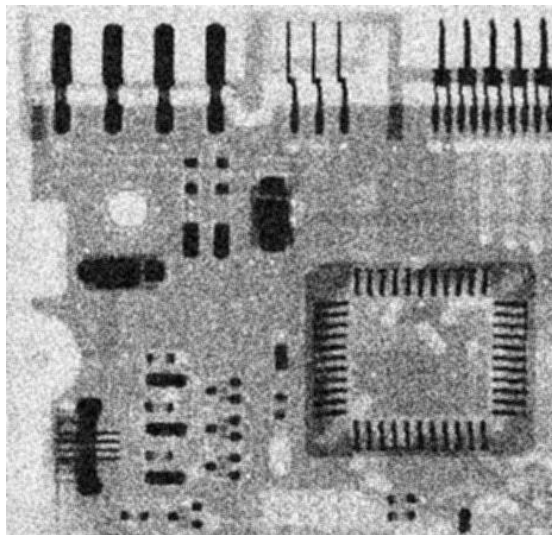Figure 38: Image with gaussian noise enhanced with arithmetic mean

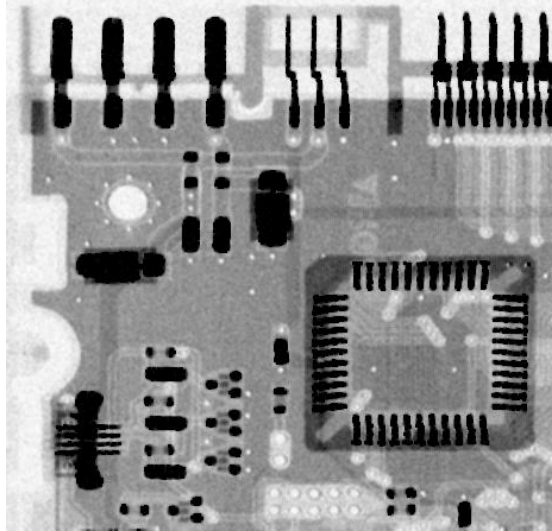Figure 39: Image with uniform noise enhanced with arithmetic mean

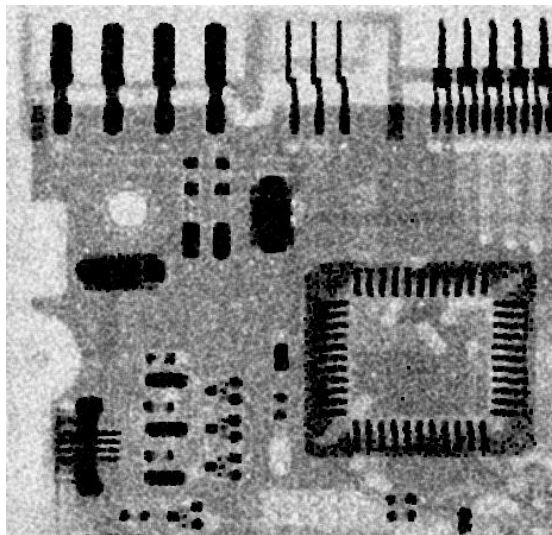Figure 40: Image with gaussian noise enhanced with geometric mean

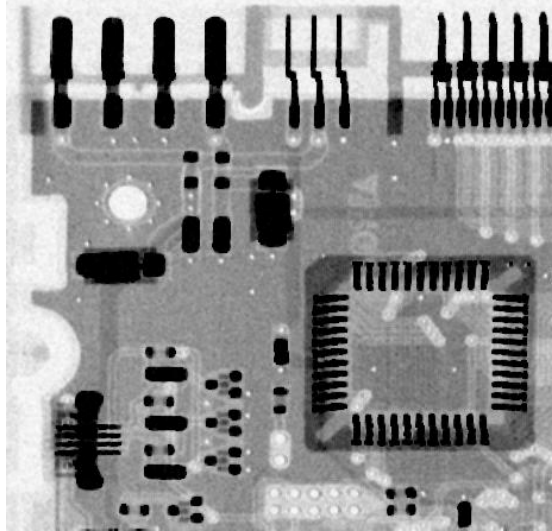Figure 41: Image with uniform noise enhanced with geometric mean

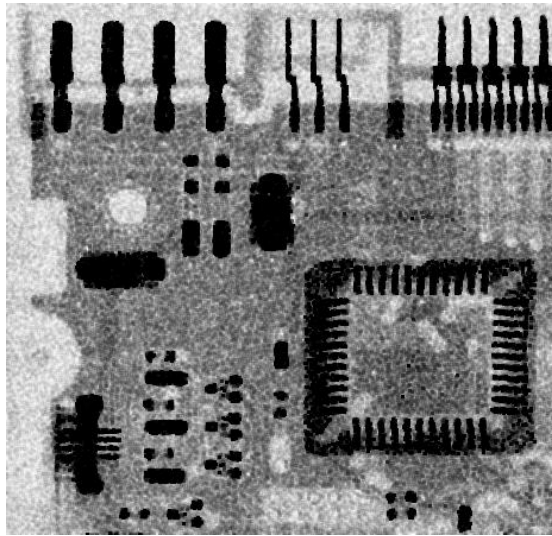Figure 42: Image with gaussian noise enhanced with harmonic filter

Figure 43: Image with uniform noise enhanced with harmonic filter
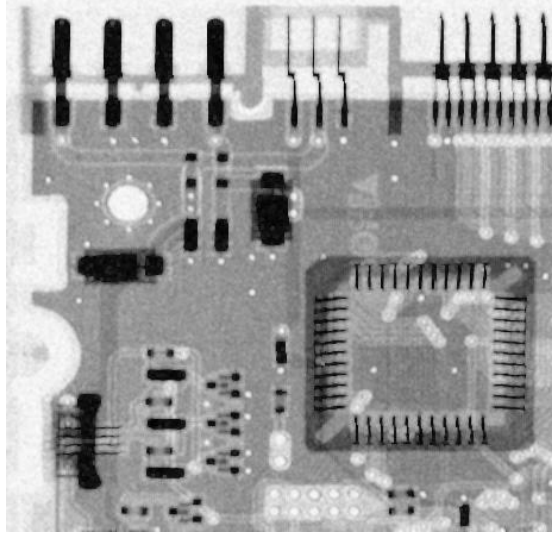
Figure 44: Image with gaussian noise enhanced with contra harmonic filter of order 1.5
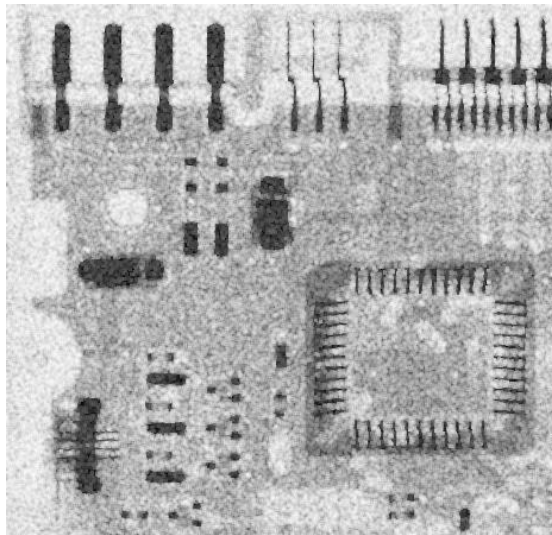

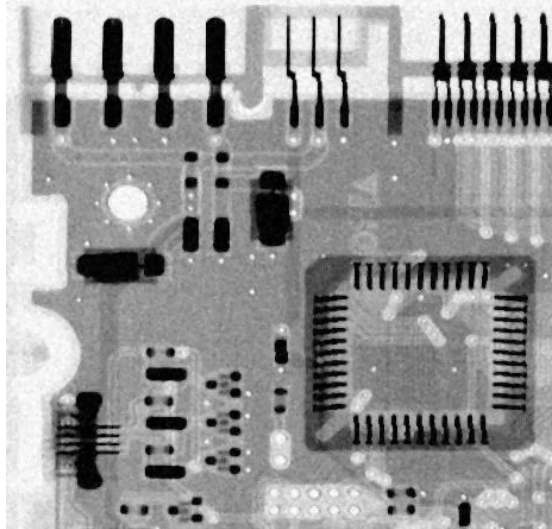Figure 45: Image with uniform noise enhanced with contra harmonic filter of order 1.5

Figure 46: Image with gaussian noise enhanced with median filter
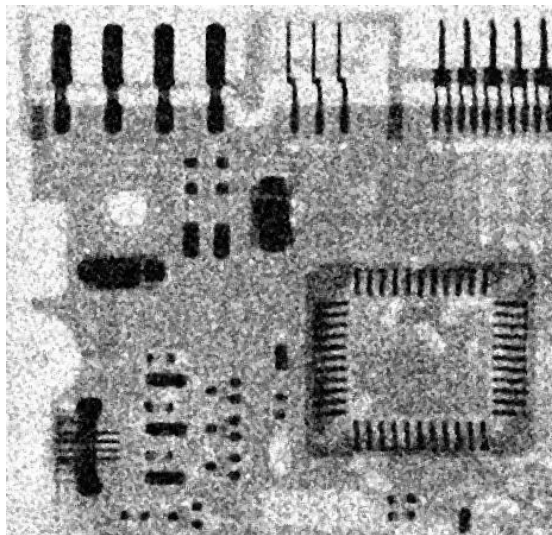

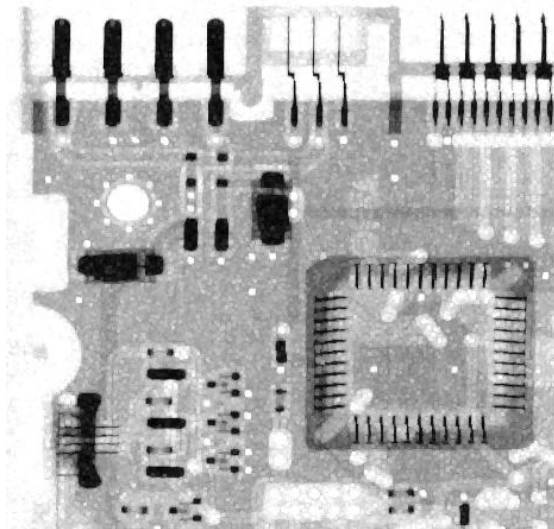Figure 47: Image with uniform noise enhanced with median filter

Figure 48: Image with gaussian noise enhanced with max filter
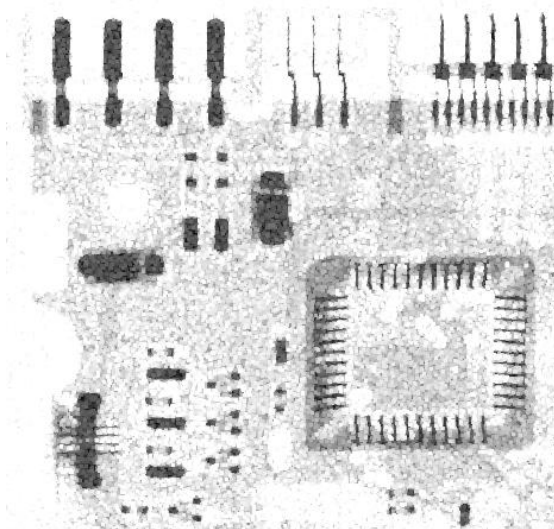

Figure 49: Image with uniform noise enhanced with max filter
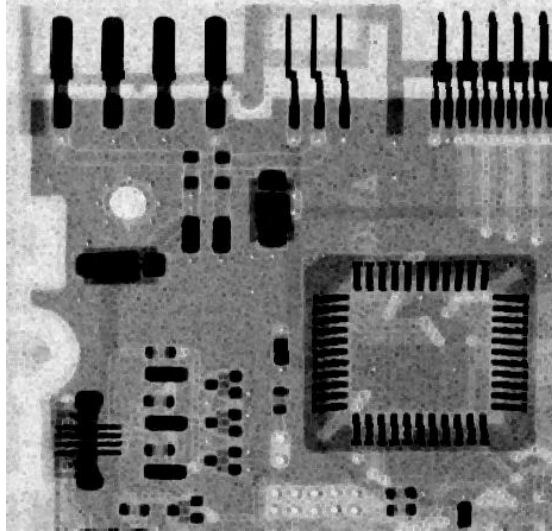
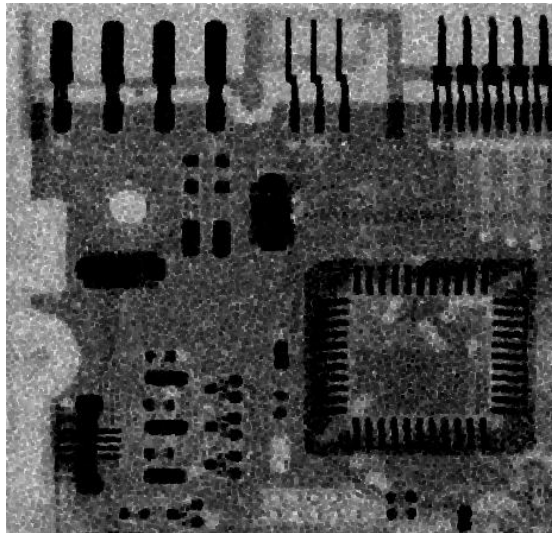Figure 50: Image with gaussian noise enhanced with min filter

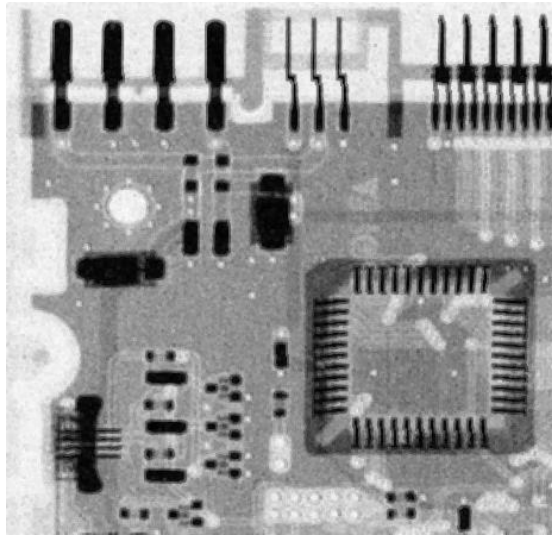Figure 51: Image with uniform noise enhanced with min filter

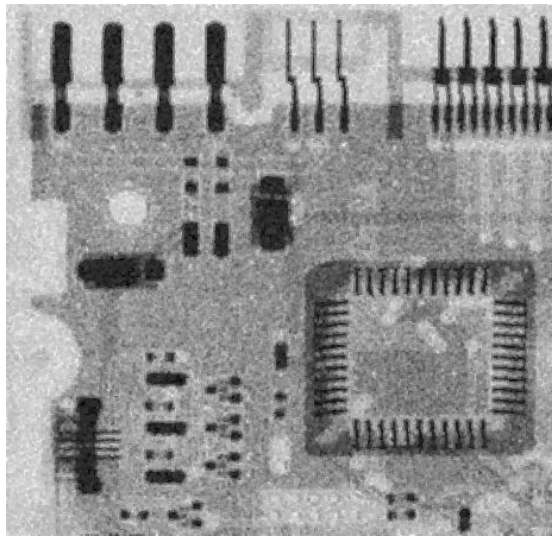Figure 52: Image with gaussian noise enhanced with midpoint filter

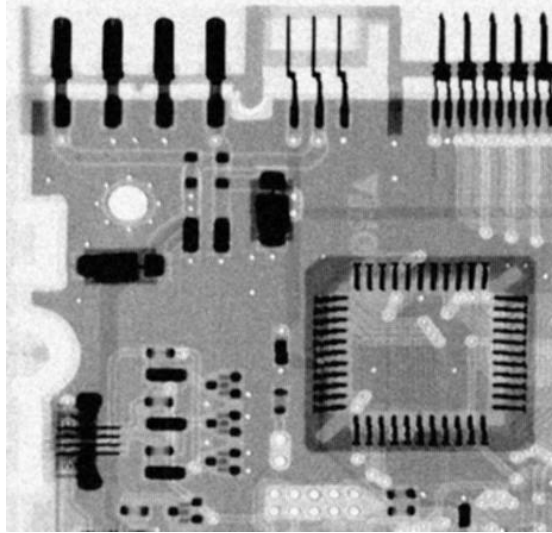Figure 53: Image with uniform noise enhanced with midpoint filter

Figure 54: Image with gaussian noise enhanced with alpha trimmed filter of order 2
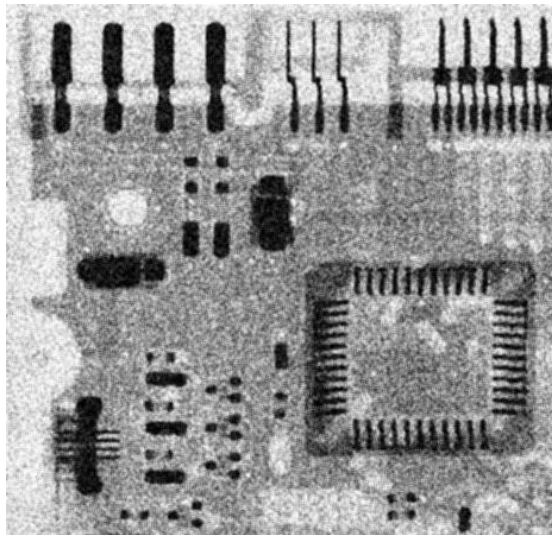

Figure 55: Image with uniform noise enhanced with alpha trimmed filter of order 2