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REPORT

Digital Image Processing

« Assignments »



2014-2015

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A. Histogram Equalization

A.1 Problem statement

1. Write a computer program for computing the histogram of an image.
2. Implement the histogram equalization technique.
3. Your program must be general to allow any gray-level image as its input.

A.2 Python implementation

Usage : `python problem1.py [-h] image_path`

A.3 Figure 1

A.3.1 Histogram

Original image : [A.1](#) | Original image's histogram : [A.2](#)

A.3.2 Histogram equalization

Enhanced image : [A.3](#) | Enhanced image's histogram : [A.4](#)

A.4 Figure 2

A.4.1 Histogram

Original image : [A.5](#) | Original image's histogram : [A.6](#)

A.4.2 Histogram equalization

Enhanced image : [A.7](#) | Enhanced image's histogram : [A.8](#)



FIGURE A.1 – Original *Fig1.jpg*

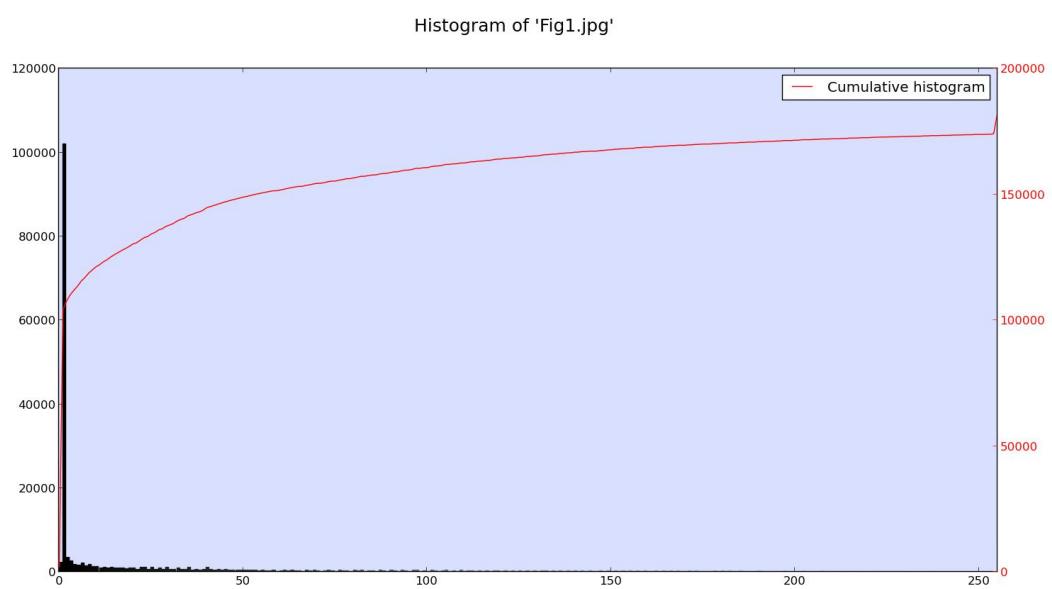


FIGURE A.2 – Histogram of *Fig1.jpg*



FIGURE A.3 – Enhanced Fig1.jpg

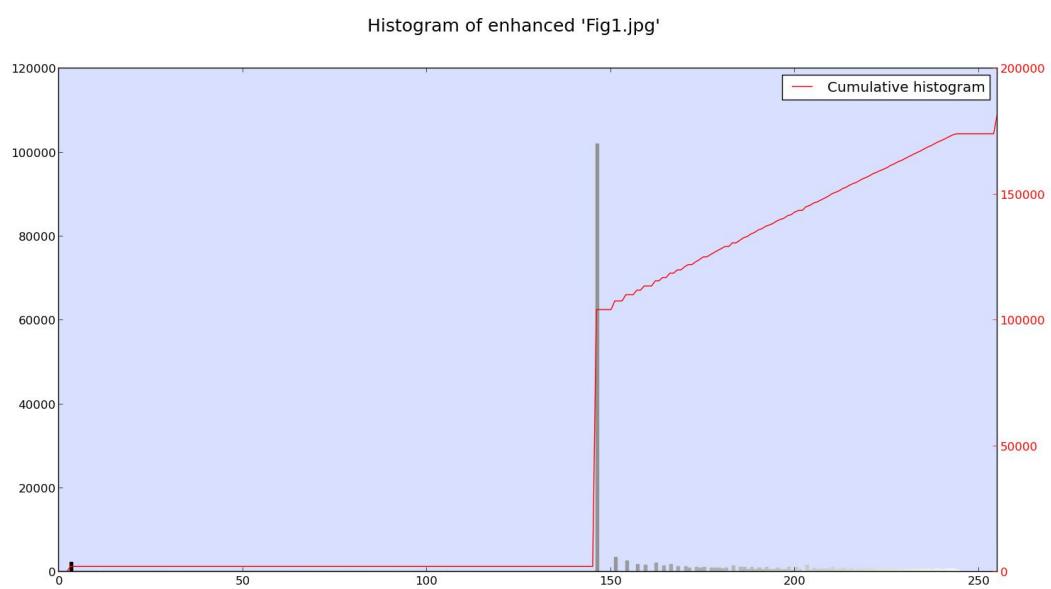


FIGURE A.4 – Equalized histogram of Fig1.jpg

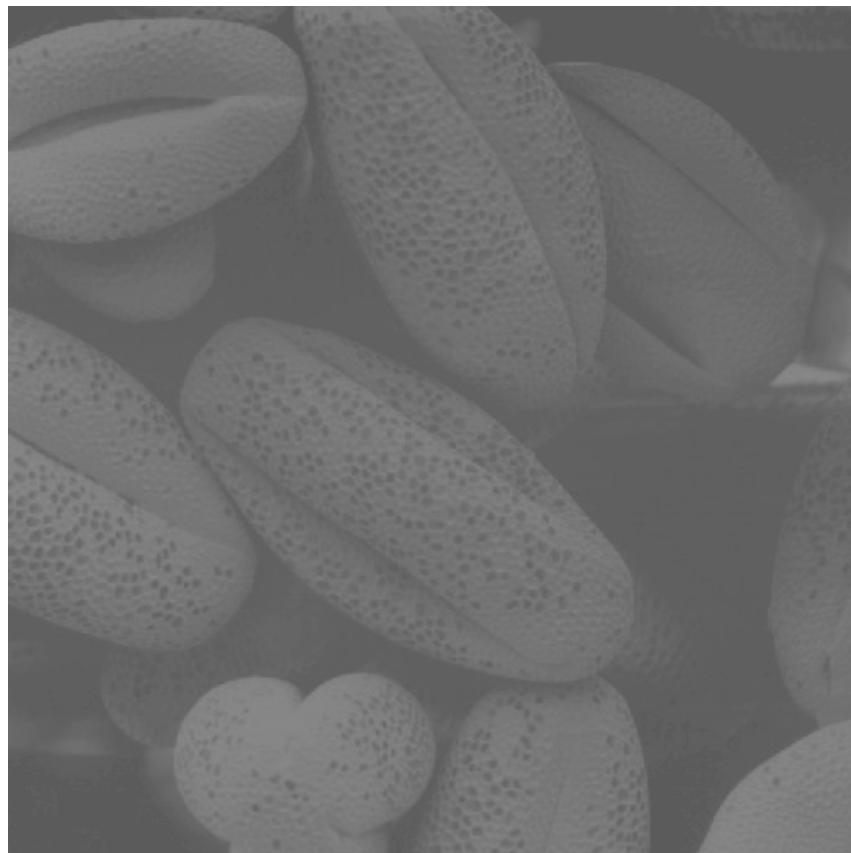


FIGURE A.5 – Original *Fig2.jpg*

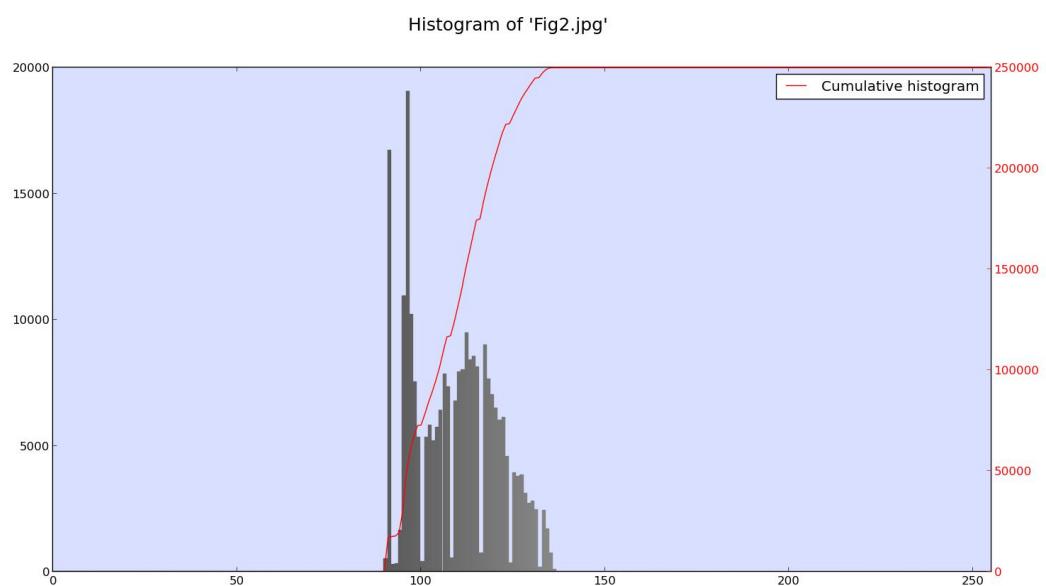


FIGURE A.6 – Histogram of *Fig2.jpg*

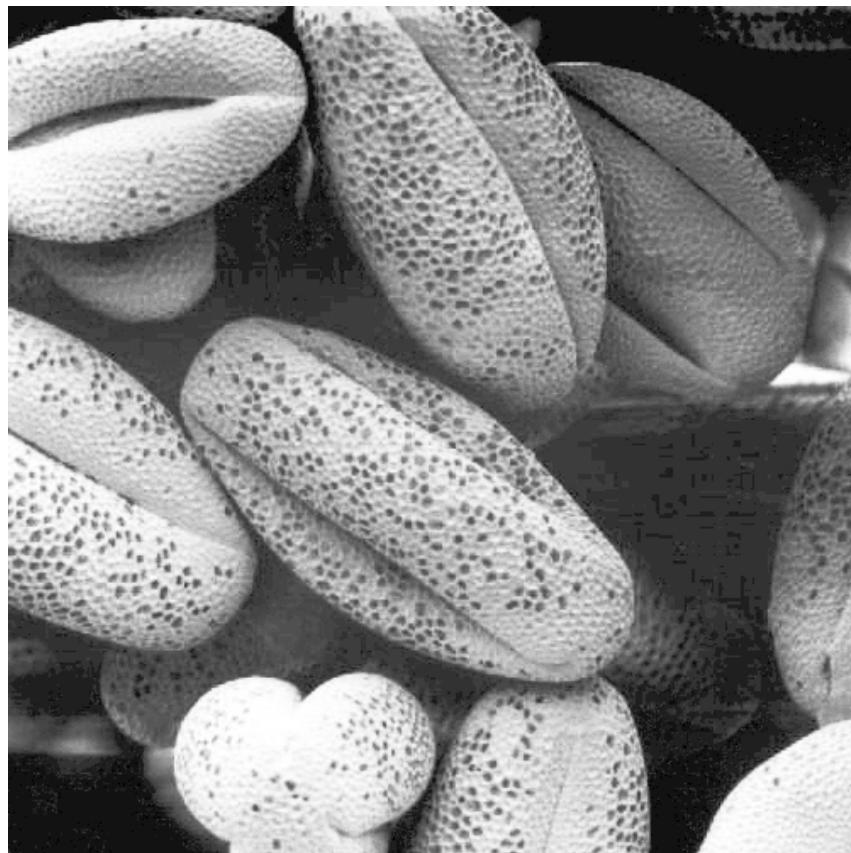


FIGURE A.7 – Enhanced *Fig2.jpg*

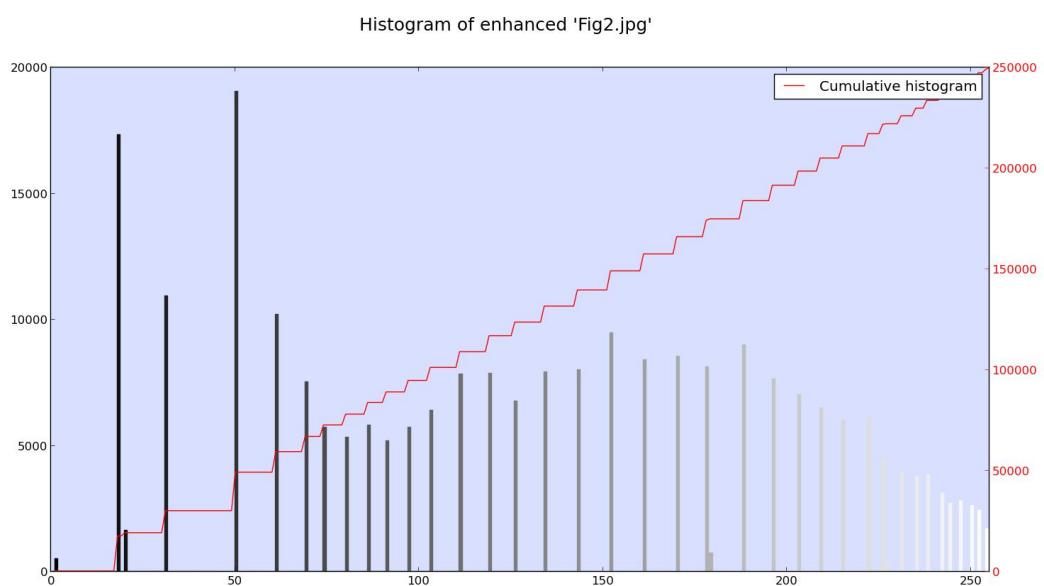


FIGURE A.8 – Equalized histogram of *Fig2.jpg*

B. Spatial enhancement methods

B.1 Problem statement

Implement the image enhancement task of Section 3.7 (Fig 3.43) (Section 3.8, Fig 3.46 in our slides).

The image to be enhanced is *skeleton_orig.tif*.

You should implement all steps in Figure 3.43.

(You cannot directly use functions of Matlab such as imfilter or fspecial, implement all functions by yourself).

B.2 Python implementation

Usage : `python problem2.py [-h] [-laplacian] [-sobel] [-a A] [-g G] [-c C] image_path`

For example, to run the full image enhancement described in the assignment, using a 3×3 Laplacian filter with $A = 1.7$, then a Sobel, a smoothing filter and a Power-Law transformation with $c = 1$ and gamma = 0.5 type :

```
python problem2.py -laplacian -a 1.7 -sobel -g 0.5 -c 1 skeleton_orig.tif
```

B.3 Results

B.3.1 Original image

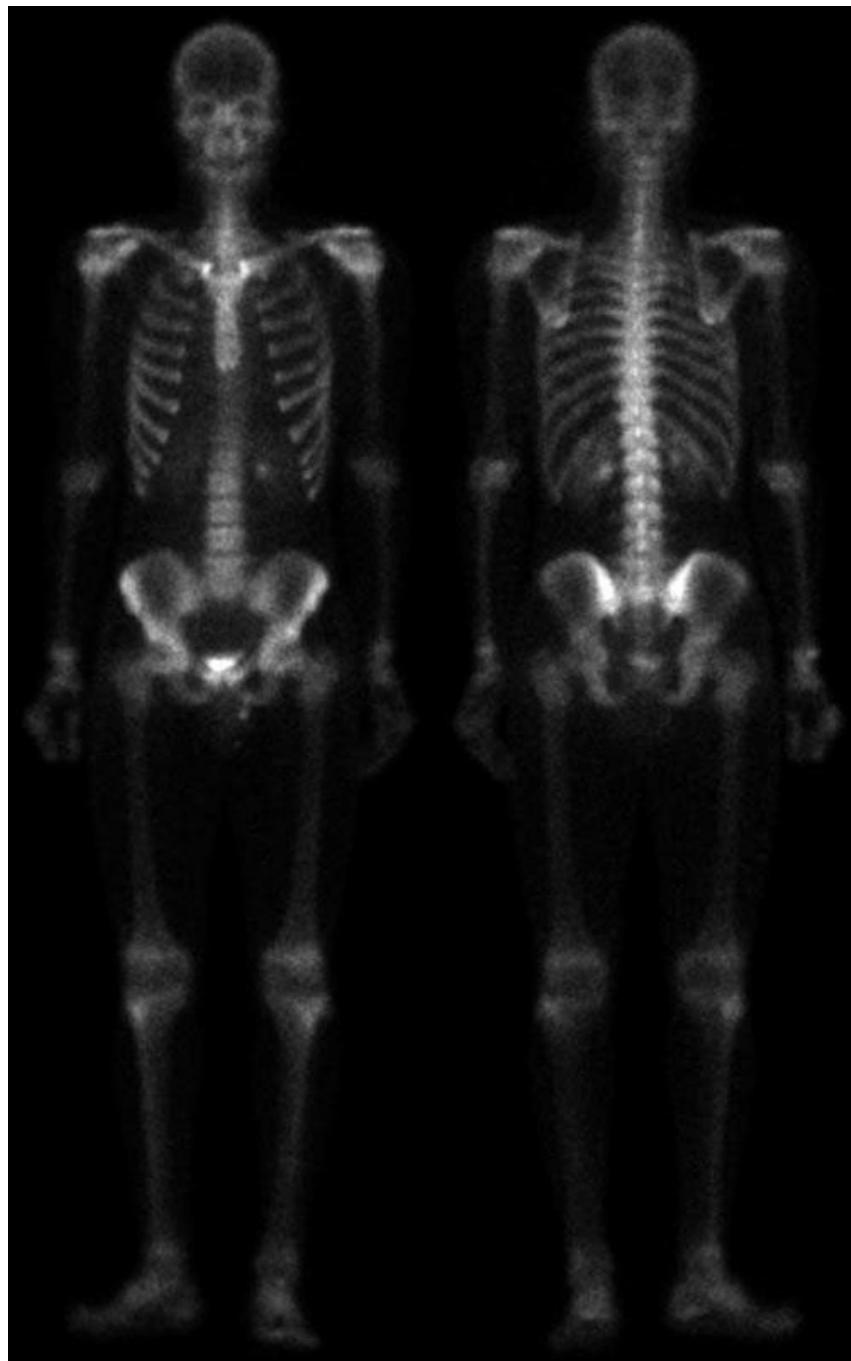


FIGURE B.1 – Original *skeleton_orig.tif*

B.3.2 3x3 Laplacian ($A = 0$)

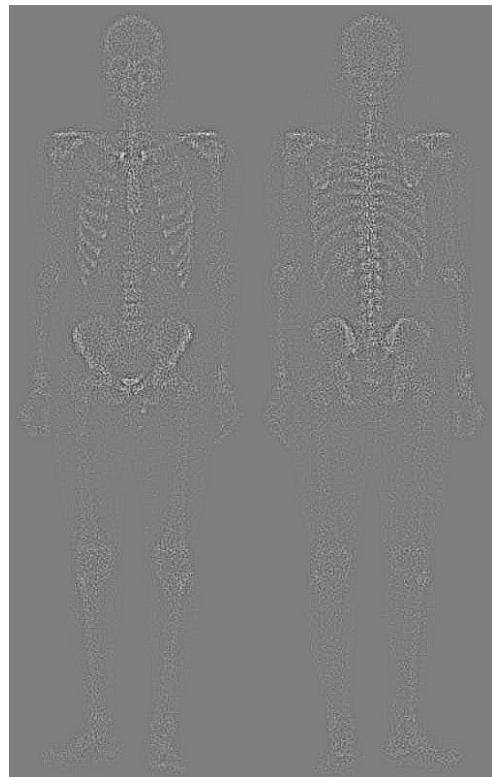


FIGURE B.2 – Laplacian ($A=0$)

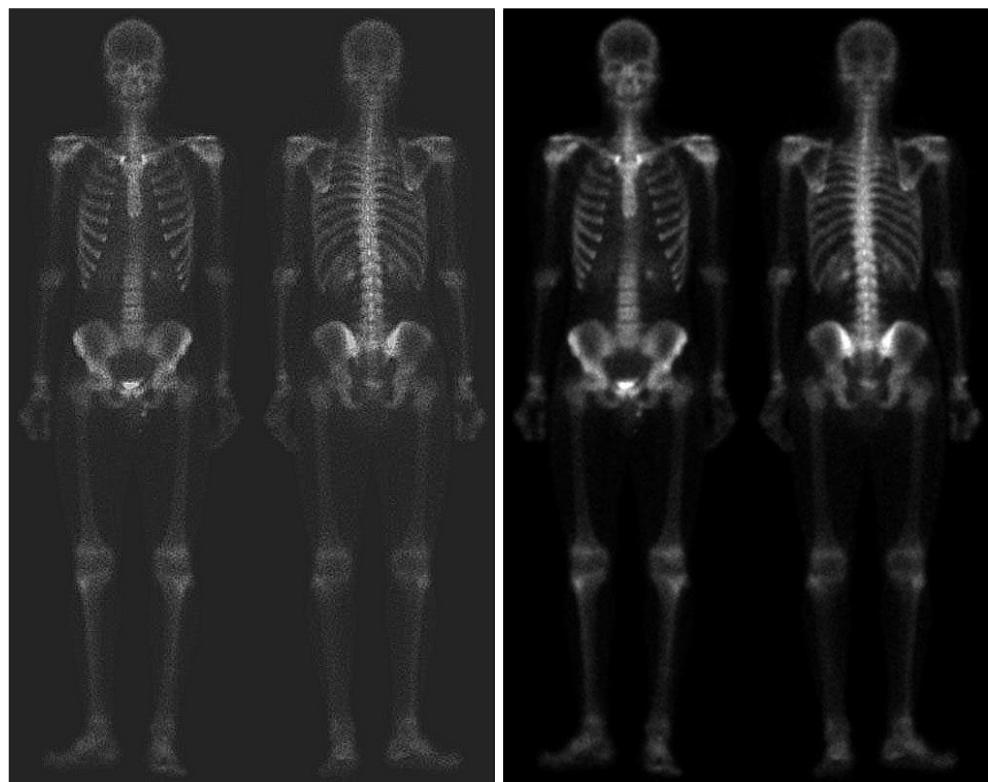


FIGURE B.3 – Sharpened image

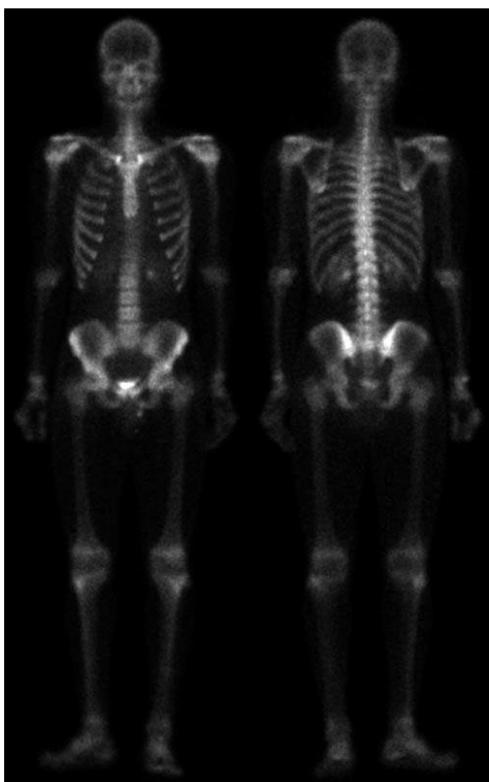


FIGURE B.4 – Original image

B.3.3 3x3 Laplacian ($A = 1$)



FIGURE B.5 – Laplacian ($A=1$)

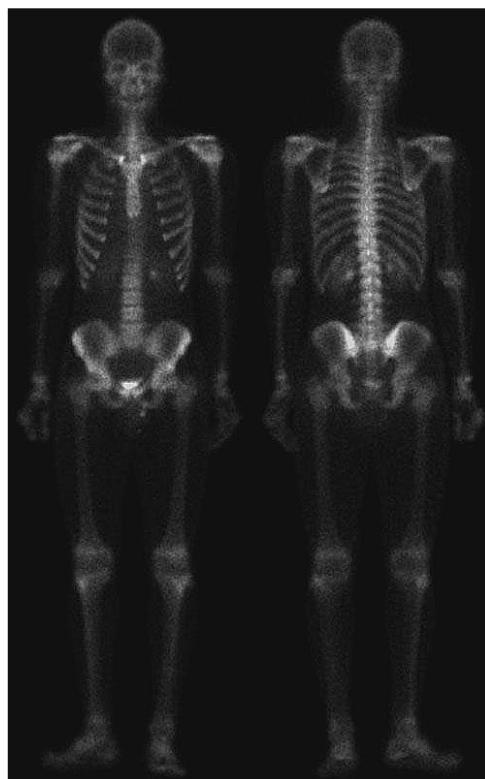


FIGURE B.6 – Sharpened image

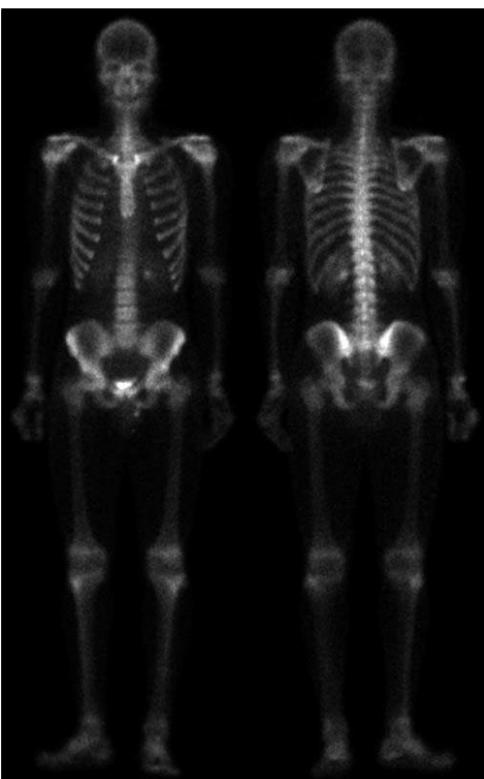


FIGURE B.7 – Original image

B.3.4 3x3 Laplacian ($A = 1.7$)

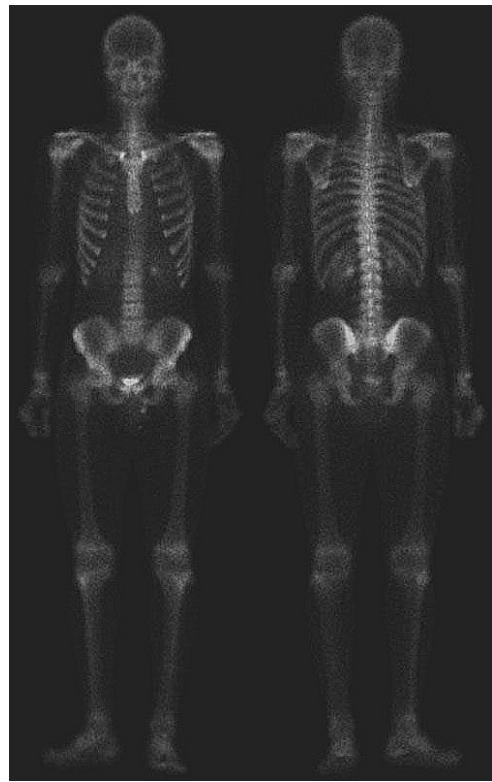


FIGURE B.8 – Laplacian ($A=1.7$)

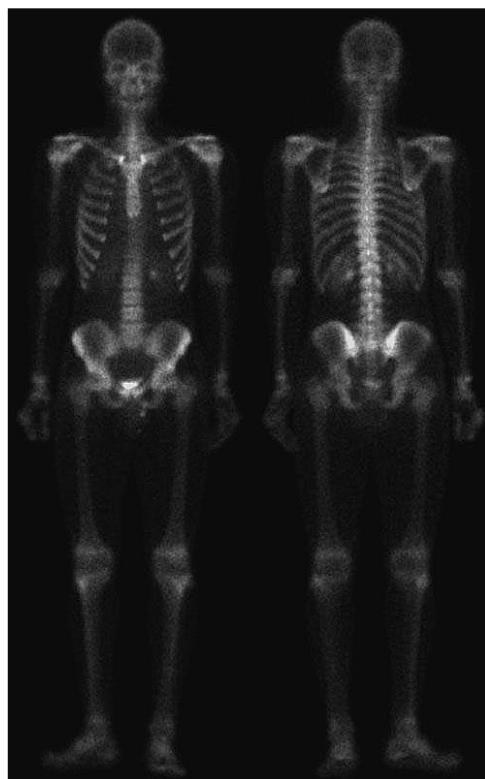


FIGURE B.9 – Sharpened image

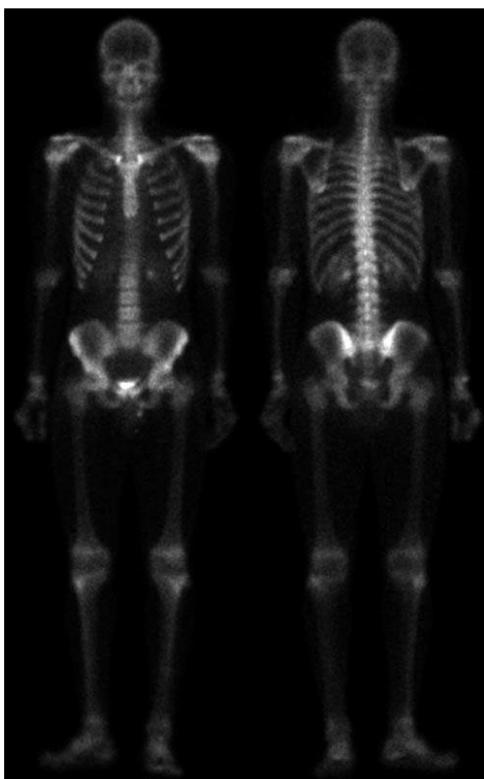


FIGURE B.10 – Original image

B.3.5 Sobel

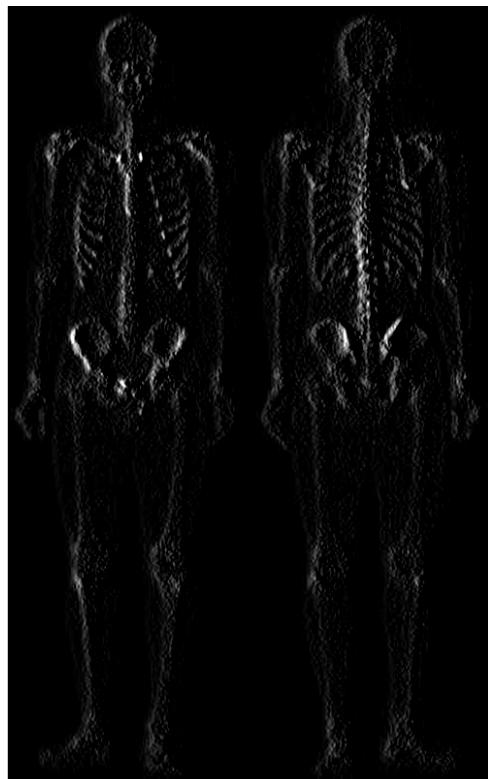


FIGURE B.11 – Sobel x-gradient

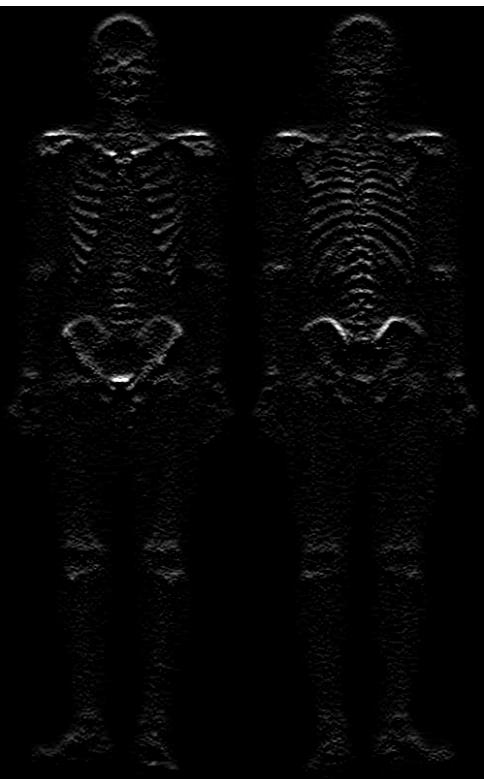


FIGURE B.12 – Sobel y-gradient



FIGURE B.13 – Sobel image



FIGURE B.14 – Original image

B.3.6 Smoothing, Sharpening and Power-Law transformation

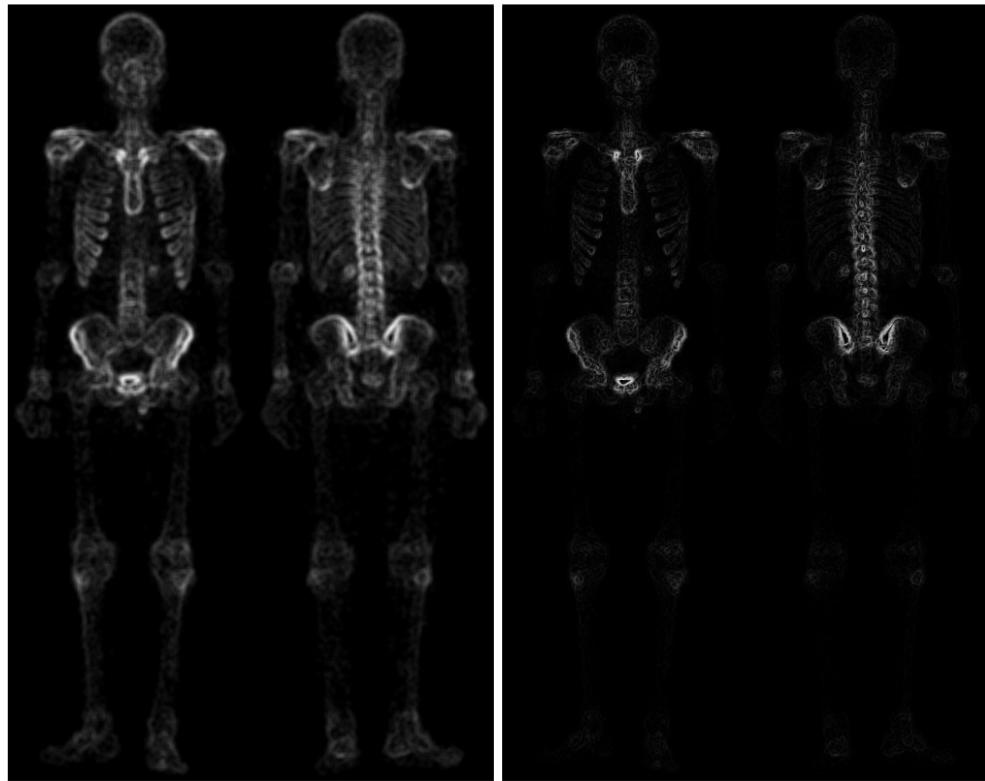


FIGURE B.15 – Smooth Sobel

FIGURE B.16 – Laplacian x Sobel



FIGURE B.17 – Original + Laplacian x Smooth Sobel

FIGURE B.18 – Final image (after Power-Law ($c=1, g=0.5$)))

B.3.7 Comparison

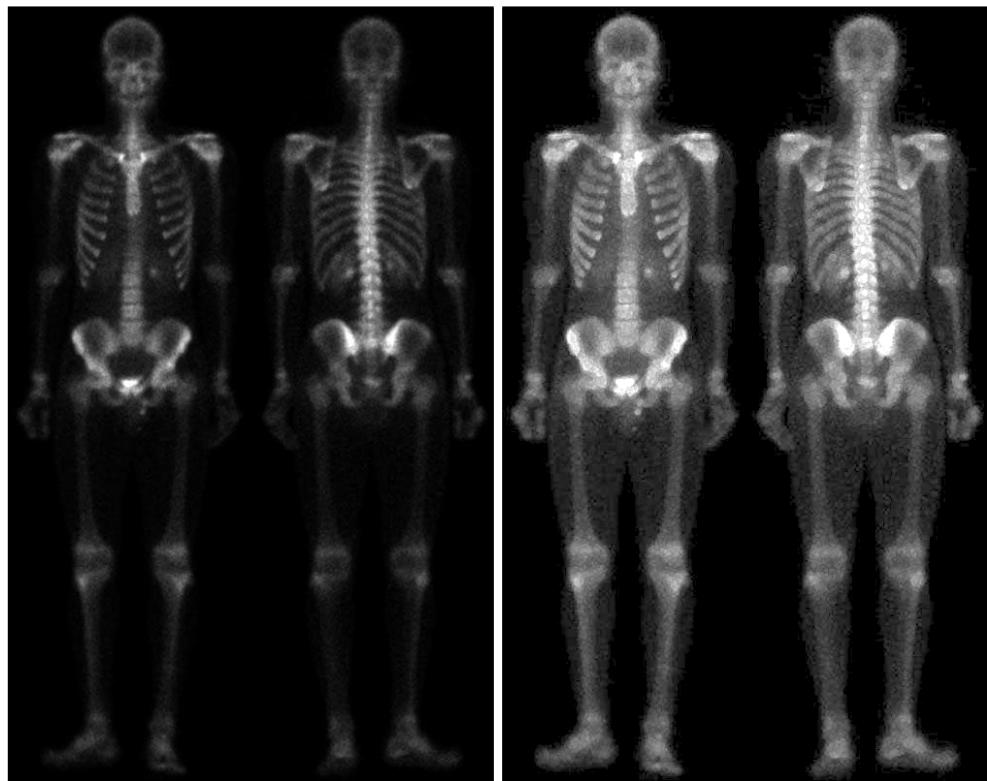


FIGURE B.19 – Original

FIGURE B.20 – Final image

C. Filtering in frequency domain

C.1 Problem statement

Implement the ideal, Butterworth and Gaussian lowpass and highpass filters and test them under different parameters using *characters_test_pattern.tif*.

C.2 Python implementation

```
Usage : python problem3.py [-h] [-ideal] [-butterworth] [-gaussian]
(-low | -high) [-npp] [-d D] [-n N] image_path
```

Use `python problem3.py -h` to see the help.

C.3 Results

C.3.1 Original image

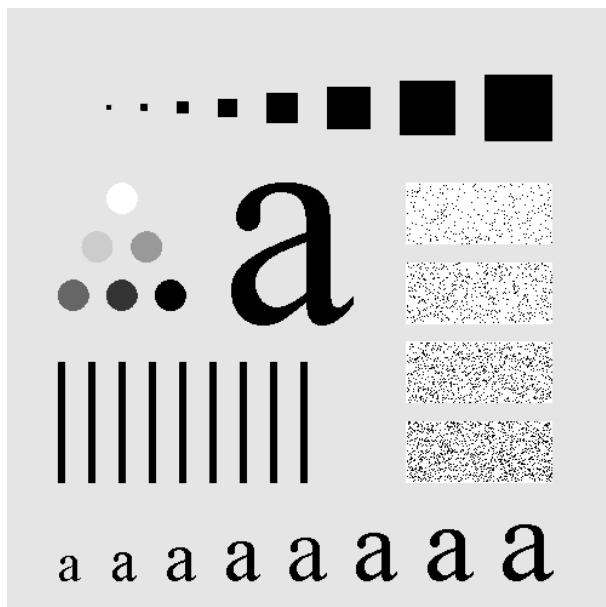


FIGURE C.1 – Original *characters_test_pattern.tif*

C.3.2 Ideal filter

Low pass

```
python problem3.py -ideal -d 5 -low characters_test_pattern.tif
```



FIGURE C.2 – Original image

FIGURE C.3 – Ideal low 5

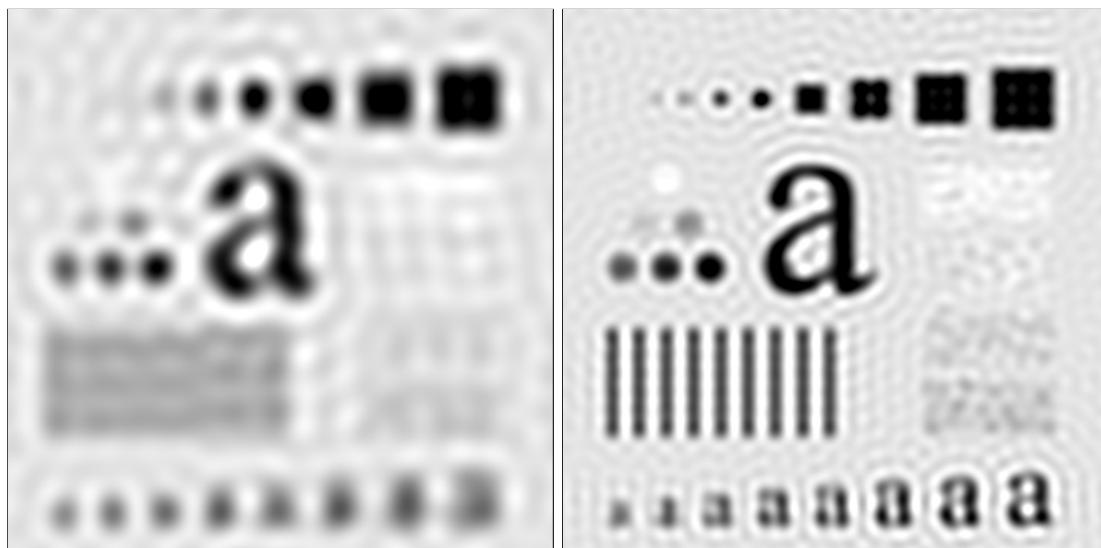


FIGURE C.4 – Ideal low 15

FIGURE C.5 – Ideal low 30

High pass

```
python problem3.py -ideal -d 5 -high characters_test_pattern.tif
```

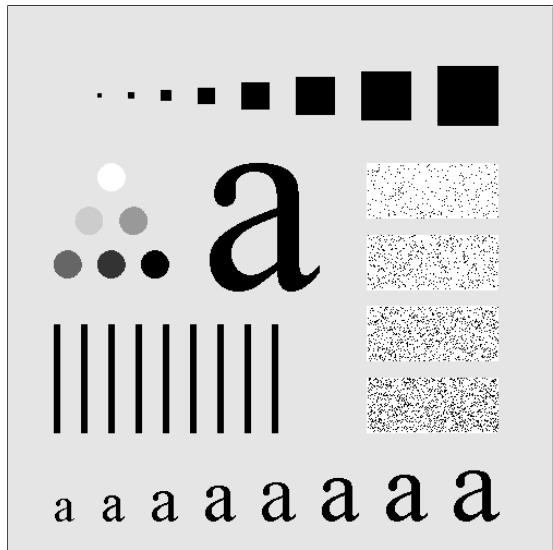


FIGURE C.6 – Original image



FIGURE C.7 – Ideal high 5

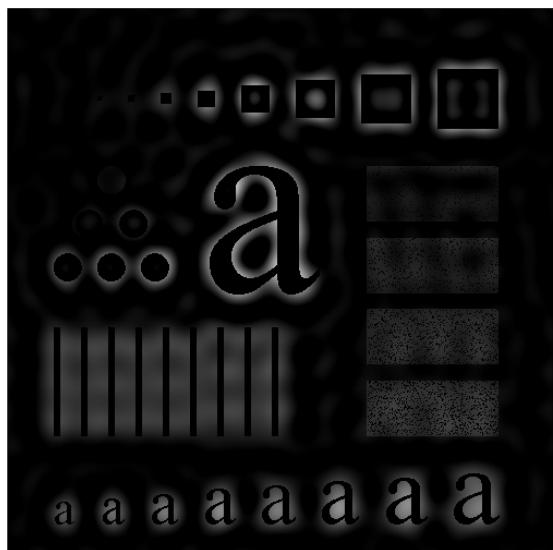


FIGURE C.8 – Ideal high 15

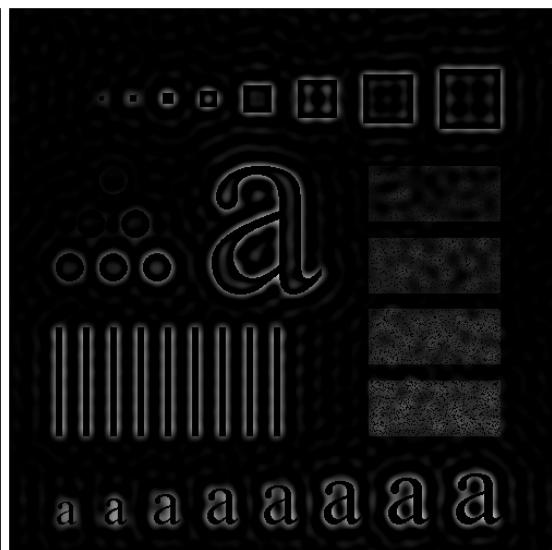


FIGURE C.9 – Ideal high 30

C.3.3 Butterworth order 2 filter

Low pass

```
python problem3.py -butterworth -d 5 -n 2 -low characters_test_pattern.tif
```



FIGURE C.10 – Original image

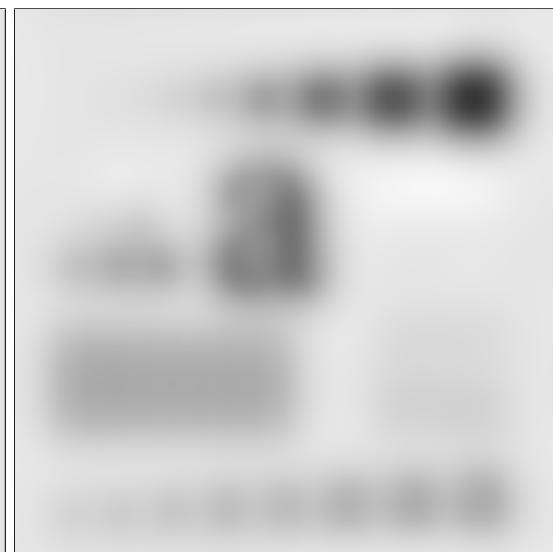


FIGURE C.11 – Butterworth low 5



FIGURE C.12 – Butterworth low 15



FIGURE C.13 – Butterworth low 30

High pass

```
python problem3.py -butterworth -d 5 -n 2 -high characters_test_pattern.tif
```

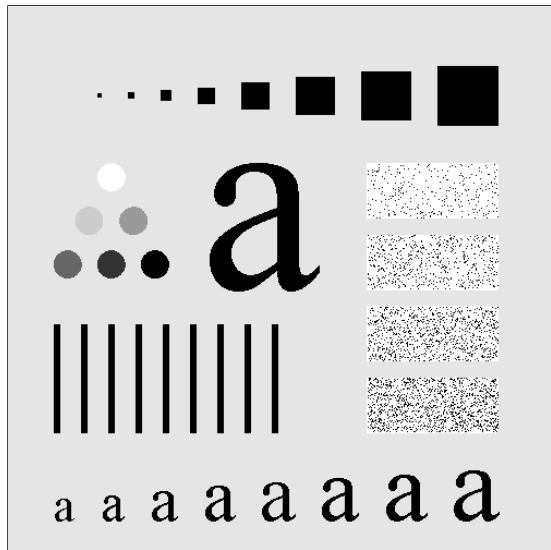


FIGURE C.14 – Original image



FIGURE C.15 – Butterworth high 5

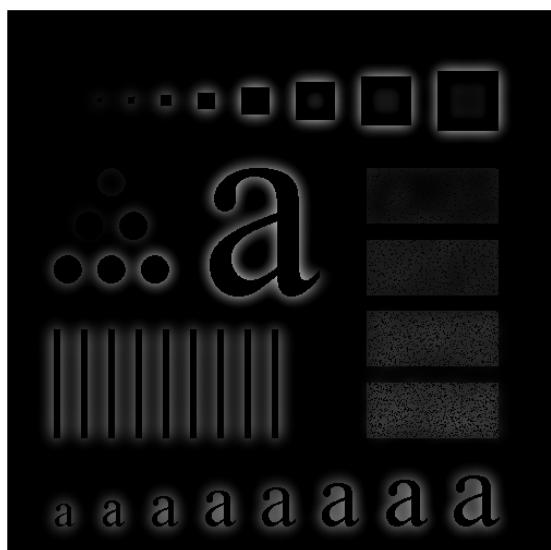


FIGURE C.16 – Butterworth high 15

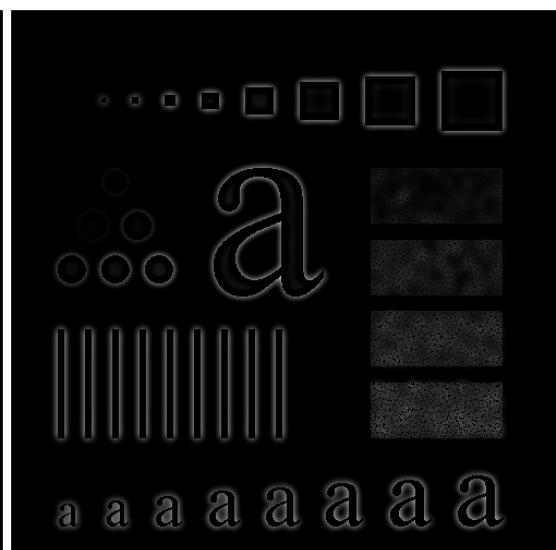


FIGURE C.17 – Butterworth high 30

C.3.4 Butterworth order 5 filter

Low pass

```
python problem3.py -butterworth -d 5 -n 5 -low characters_test_pattern.tif
```

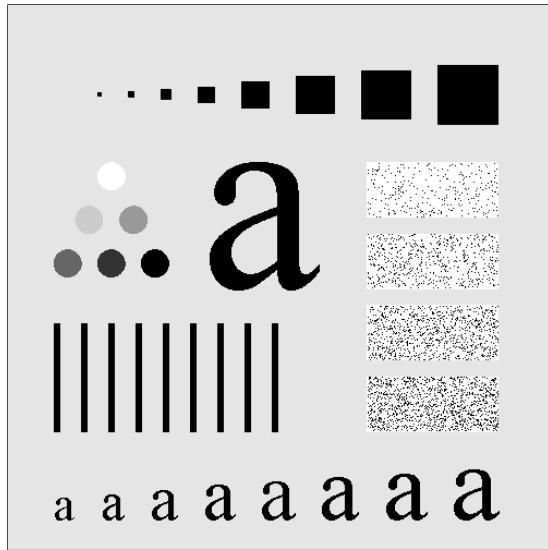


FIGURE C.18 – Original image

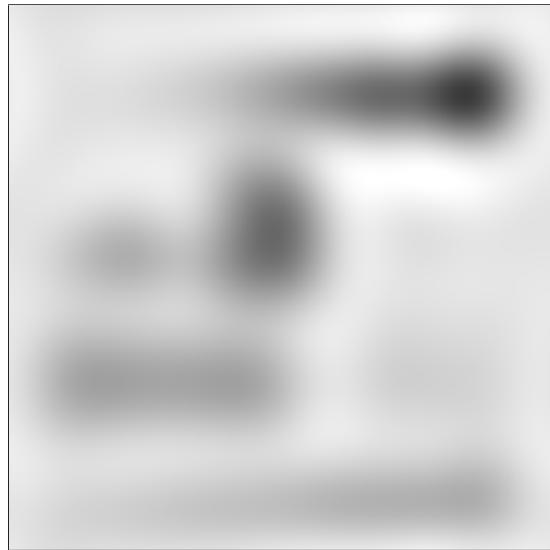


FIGURE C.19 – Butterworth low 5

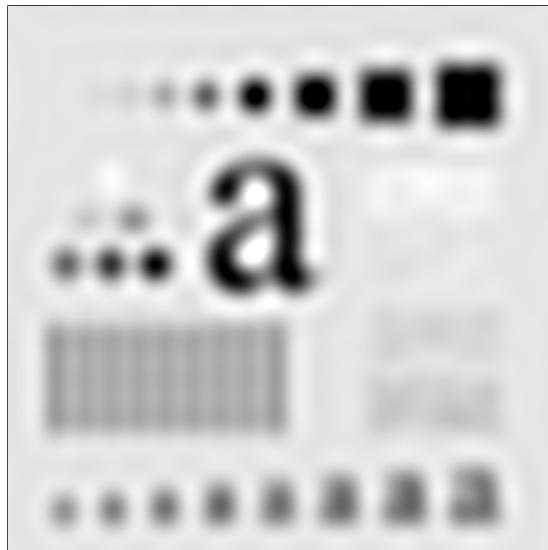


FIGURE C.20 – Butterworth low 15



FIGURE C.21 – Butterworth low 30

High pass

```
python problem3.py -butterworth -d 5 -n 5 -high characters_test_pattern.tif
```

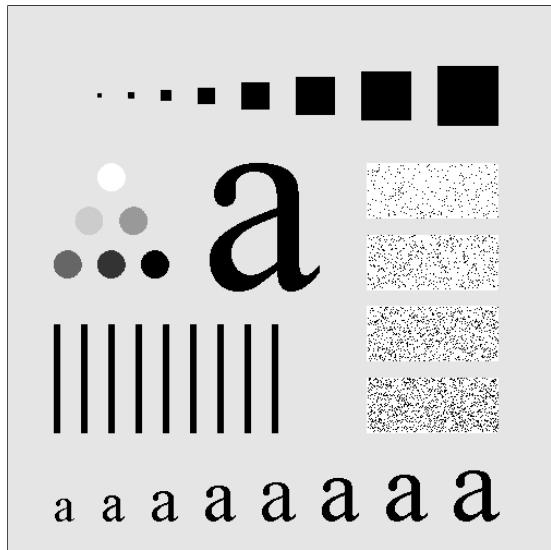


FIGURE C.22 – Original image



FIGURE C.23 – Butterworth high 5

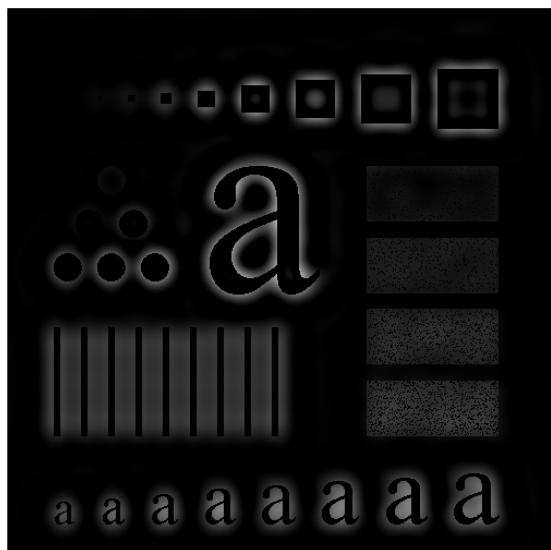


FIGURE C.24 – Butterworth high 15

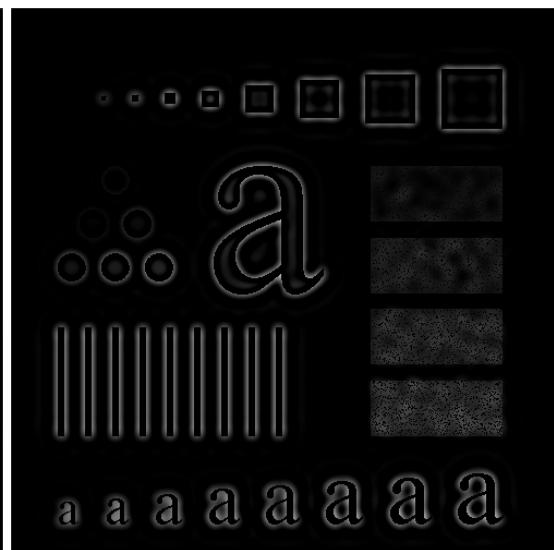


FIGURE C.25 – Butterworth high 30

C.3.5 Gaussian filter

Low pass

```
python problem3.py -gaussian -d 5 -low characters_test_pattern.tif
```

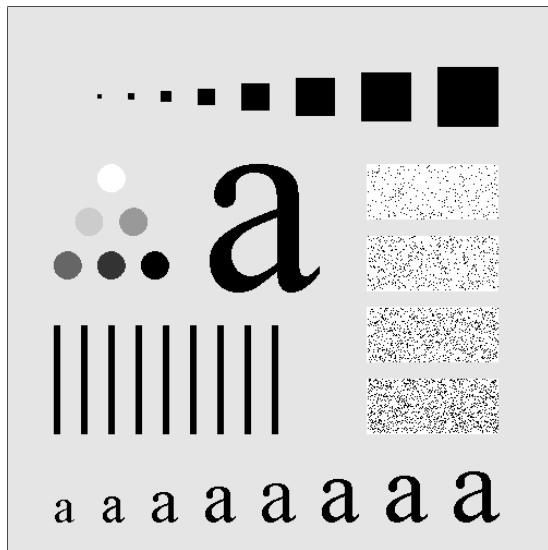


FIGURE C.26 – Original image

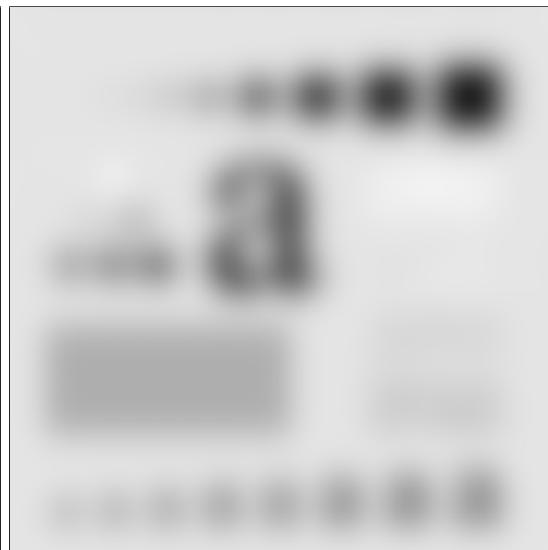


FIGURE C.27 – Gaussian low 5



FIGURE C.28 – Gaussian low 15



FIGURE C.29 – Gaussian low 30

High pass

```
python problem3.py -gaussian -d 5 -high characters_test_pattern.tif
```

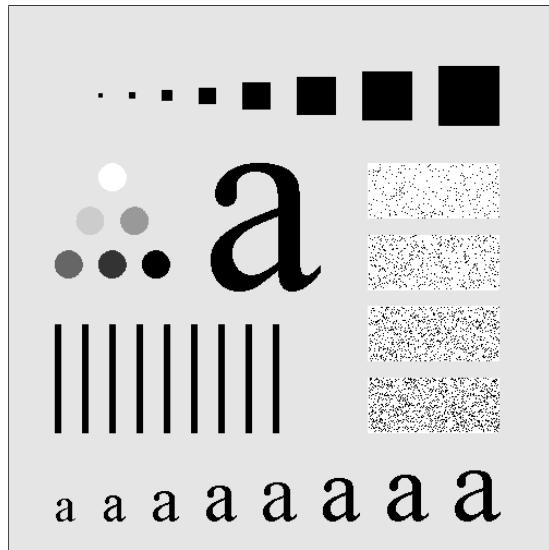


FIGURE C.30 – Original image

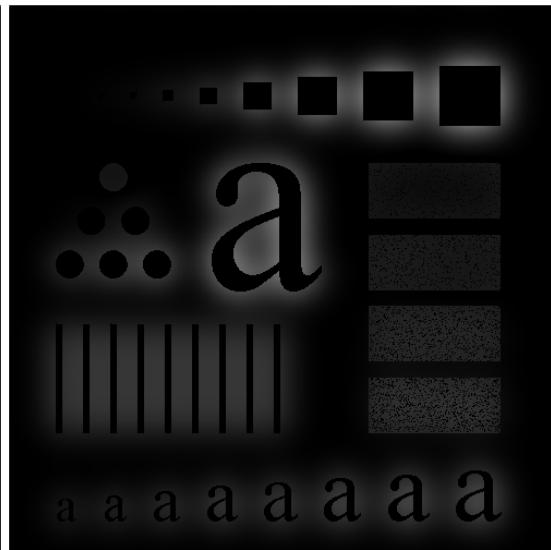


FIGURE C.31 – Gaussian high 5

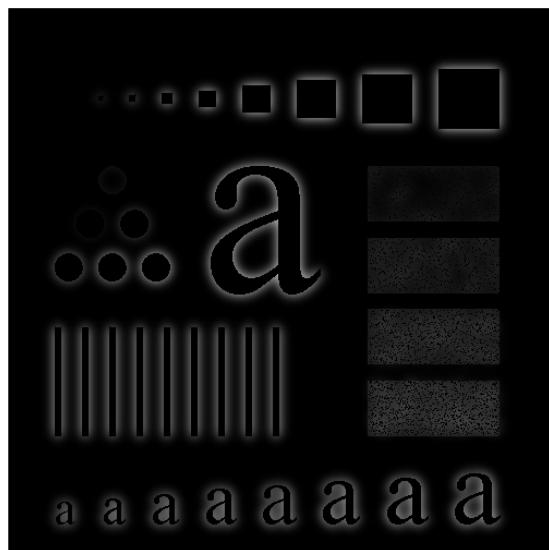


FIGURE C.32 – Gaussian high 15

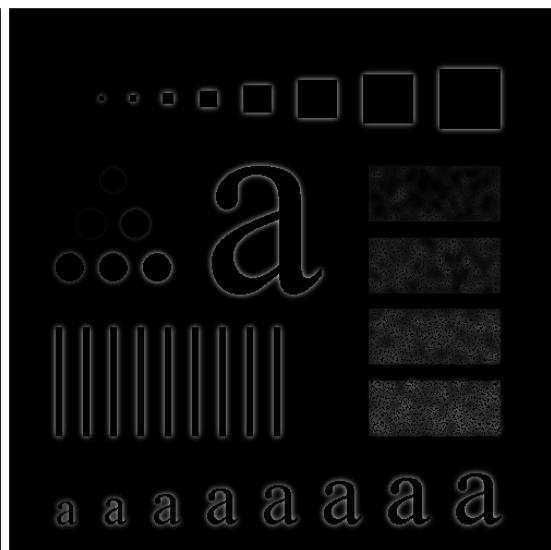


FIGURE C.33 – Gaussian high 30

D. Noise generation and noise reduction

D.1 Problem statement

In this problem, you are required to write a program to generate different types of random noises started from the Uniform noise and Gaussian noise.

And then add some of these noises to the circuit image and investigate the different mean filters and order statistics as the textbook did at pages 344-352.

D.2 Python implementation

```
Usage : problem4.py [-h] (-uniform | -gaussian) [-histogram]
[-arithmetic] [-geometric] [-harmonic] [-contraharmonic] [-q Q]
[-median] [-max] [-min] [-midpoint] [-alpha] [-d D]
image_path
```

Use **python problem4.py -h** to see the help.

D.3 Gaussian noise

D.3.1 Noise generation and histogram

```
python problem4.py -gaussian circuit.tif
```

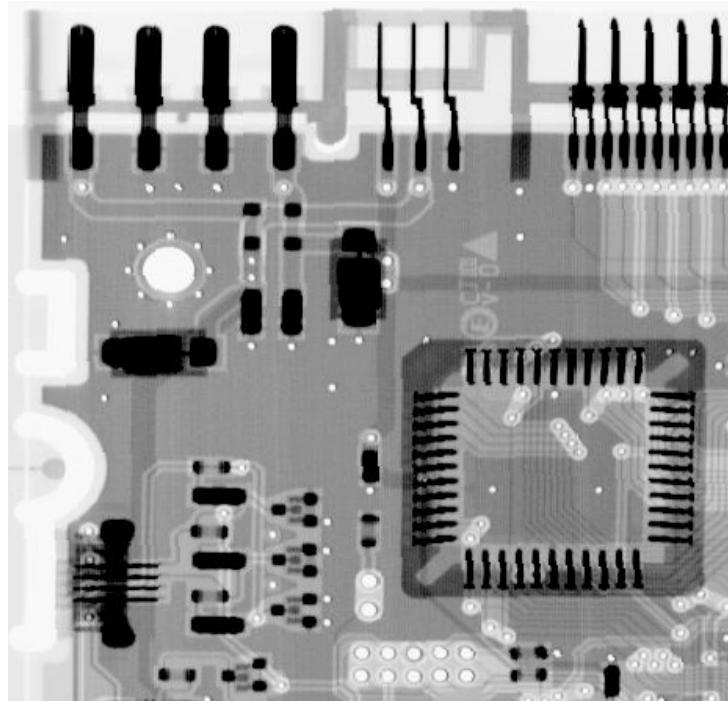


FIGURE D.1 – Original image

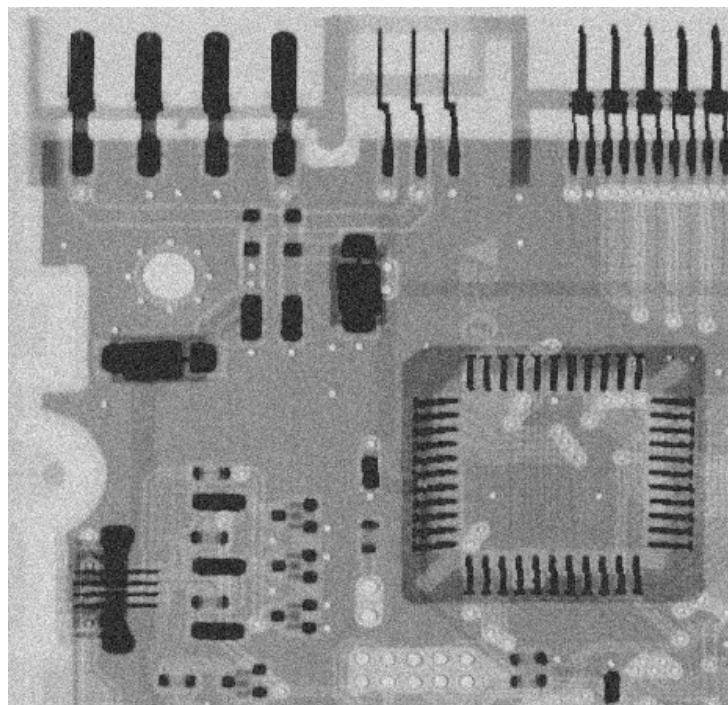


FIGURE D.2 – Image + Gaussian noise ($\mu = 0, \sigma = 20$)

```
python problem4.py -gaussian -histogram circuit.tif
```

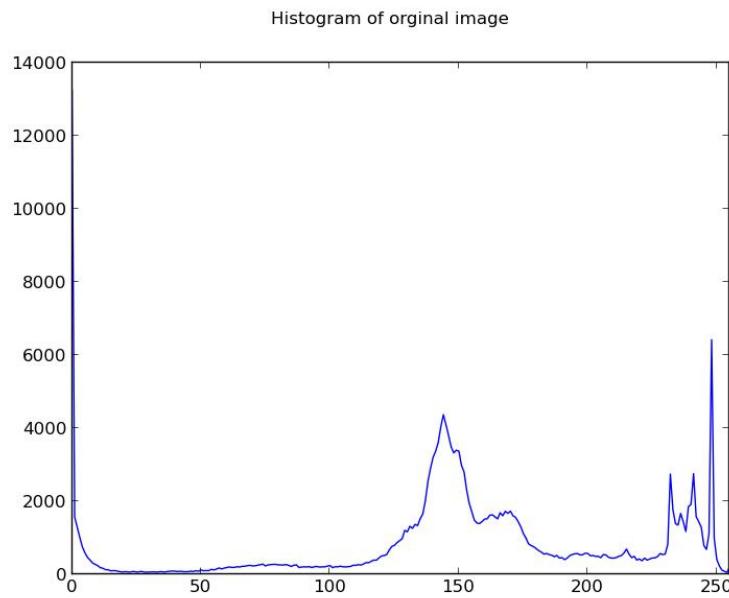


FIGURE D.3 – Histogram of original image

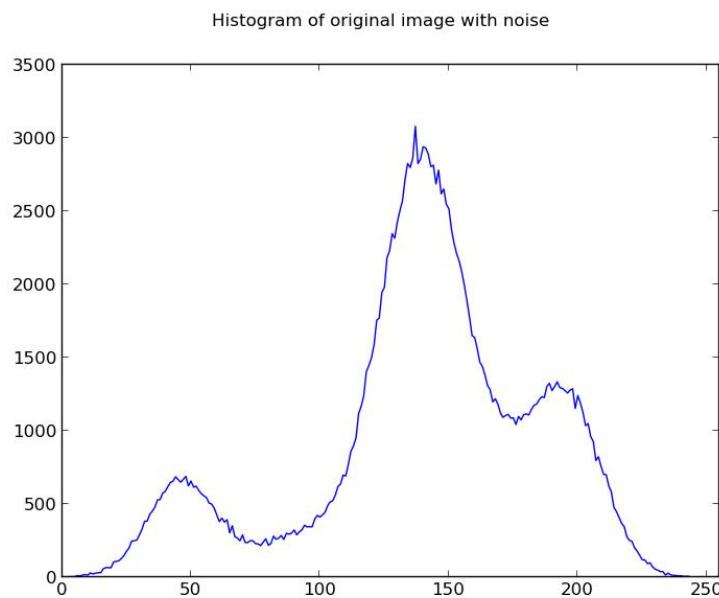


FIGURE D.4 – Histogram of image with Gaussian noise

D.3.2 Noise reduction

Mean filters

```
python problem4.py -gaussian -arithmetic circuit.tif  
python problem4.py -gaussian -geometric circuit.tif
```

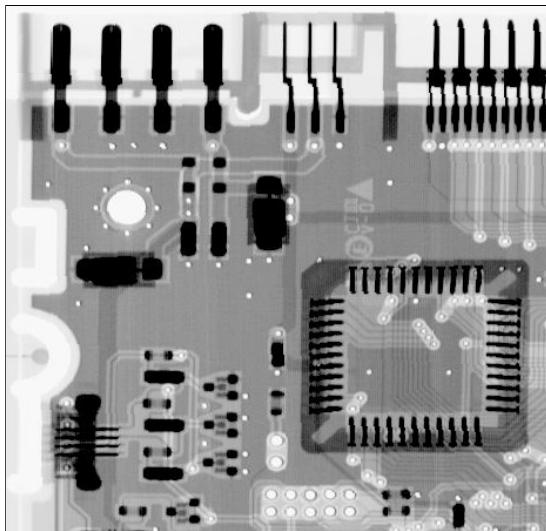


FIGURE D.5 – Original image

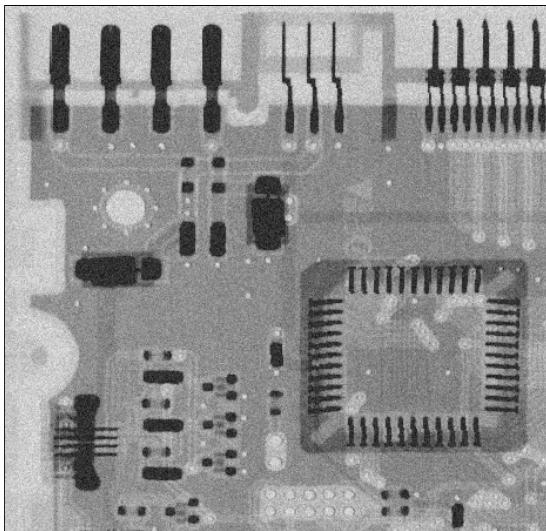


FIGURE D.6 – Image + Gaussian

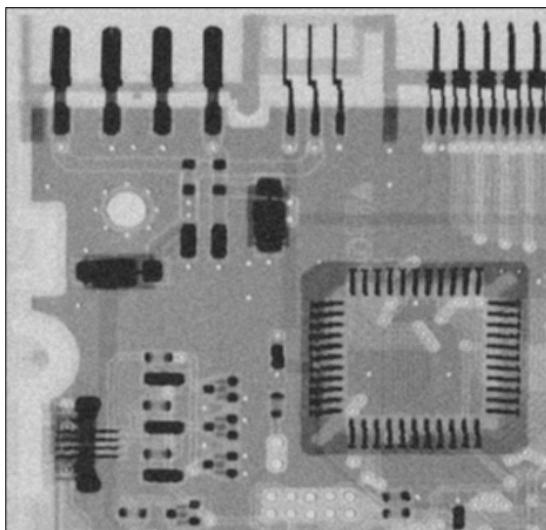


FIGURE D.7 – Arithmetic filter

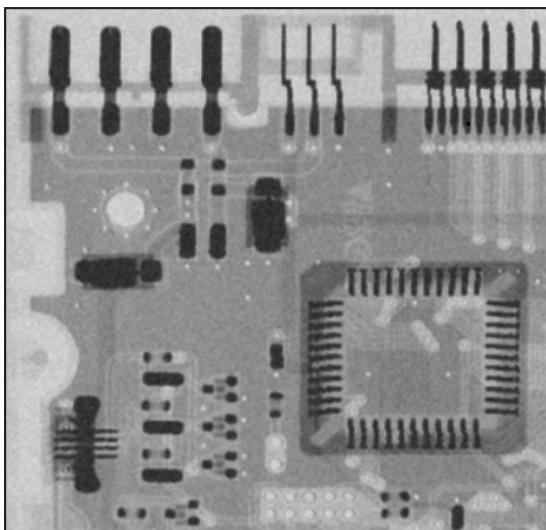


FIGURE D.8 – Geometric filter

```
python problem4.py -gaussian -harmonic circuit.tif
```

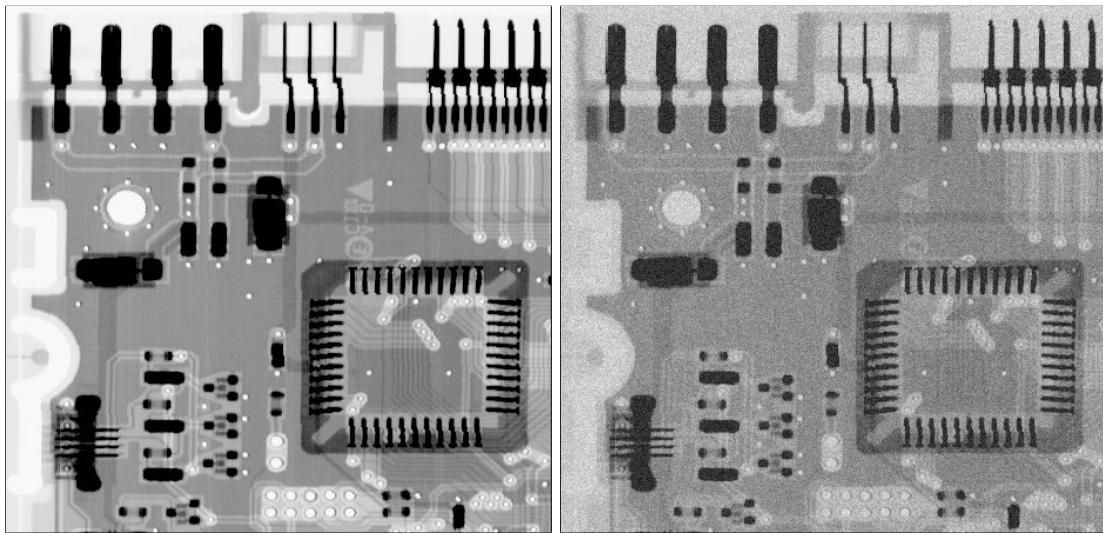


FIGURE D.9 – Original image

FIGURE D.10 – Image + Gaussian

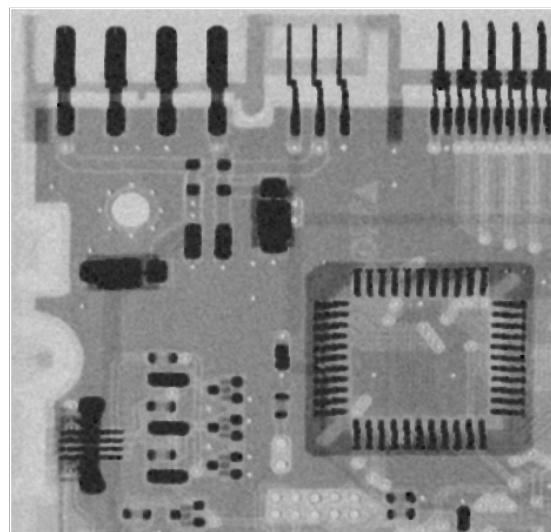


FIGURE D.11 – Harmonic filter

```
python problem4.py -gaussian -contraharmonic -q 1.5 circuit.tif  
python problem4.py -gaussian -contraharmonic -q -1.5 circuit.tif
```

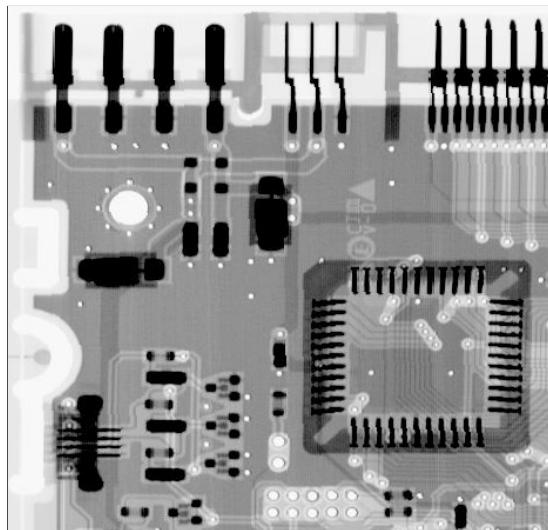


FIGURE D.12 – Original image

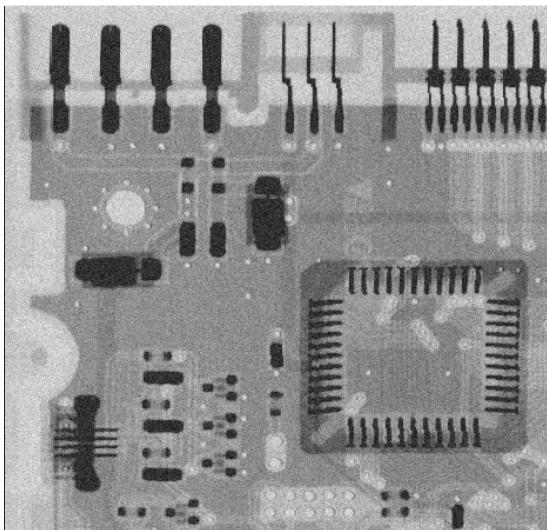


FIGURE D.13 – Image + Gaussian

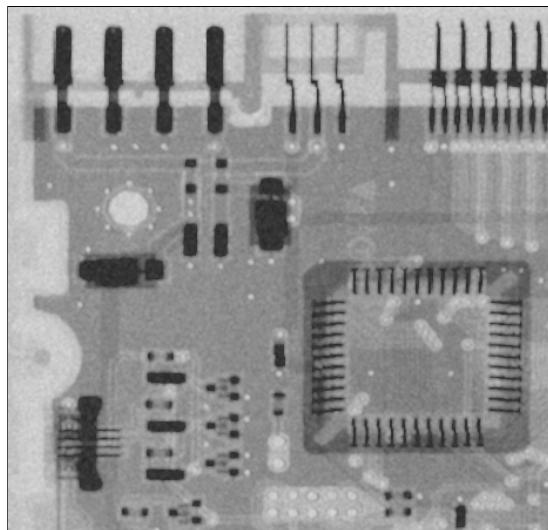


FIGURE D.14 – Contra-harmonic filter (Q=1.5)

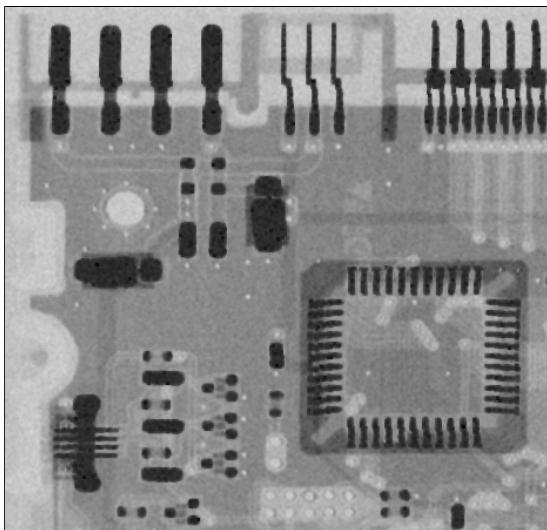


FIGURE D.15 – Contra-harmonic filter (Q=-1.5)

Order-Statistic filters

```
python problem4.py -gaussian -median circuit.tif
```

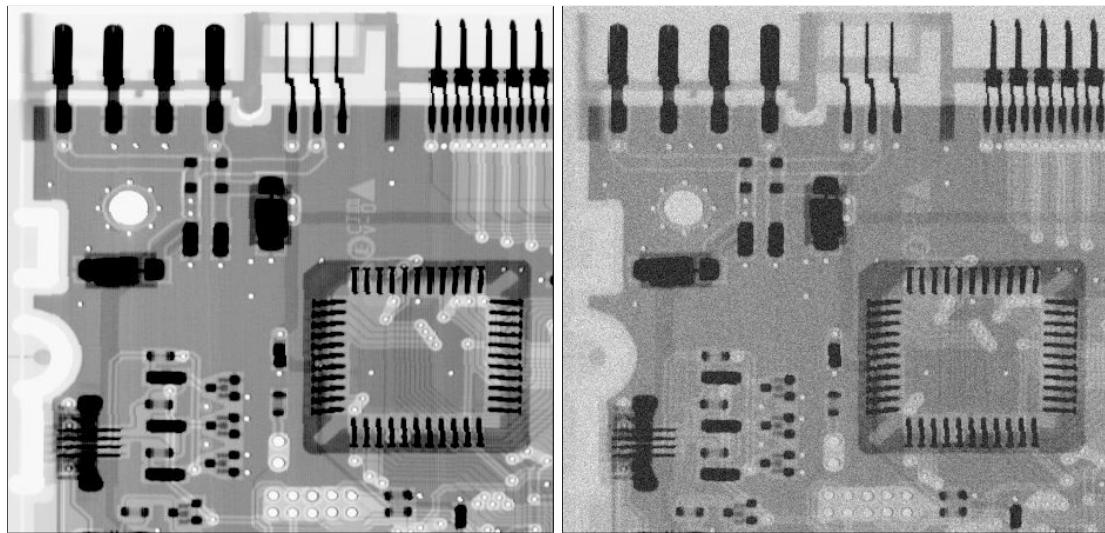


FIGURE D.16 – Original image

FIGURE D.17 – Image + Gaussian

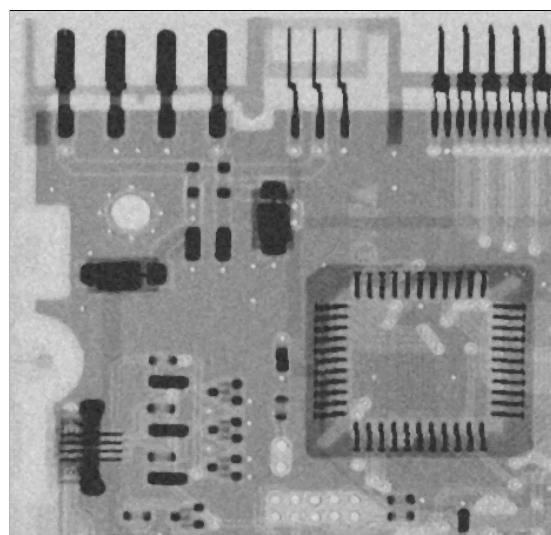


FIGURE D.18 – Median filter

```
python problem4.py -gaussian -max circuit.tif  
python problem4.py -gaussian -min circuit.tif
```

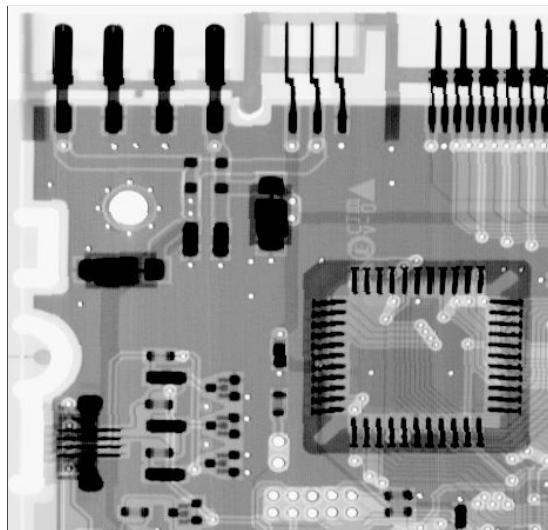


FIGURE D.19 – Original image

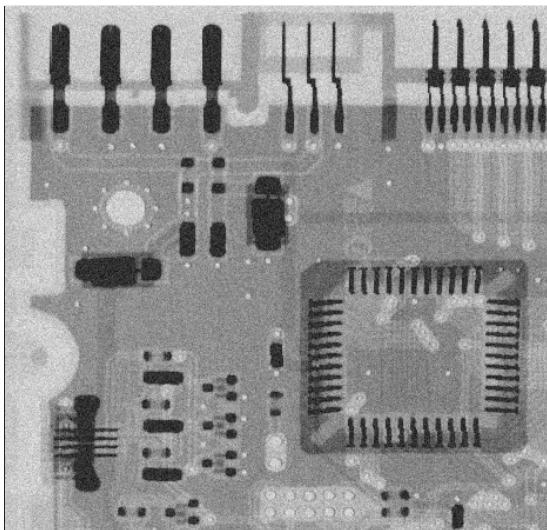


FIGURE D.20 – Image + Gaussian

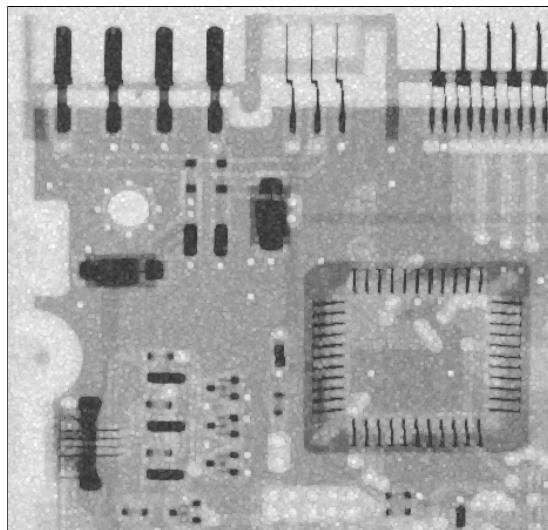


FIGURE D.21 – Max filter

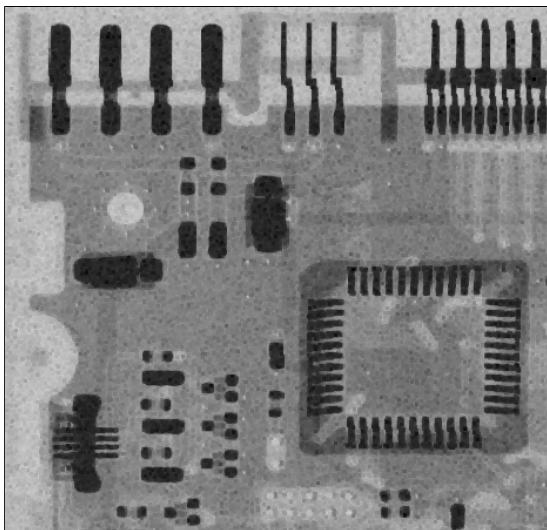


FIGURE D.22 – Min filter

```
python problem4.py -gaussian -midpoint circuit.tif
```

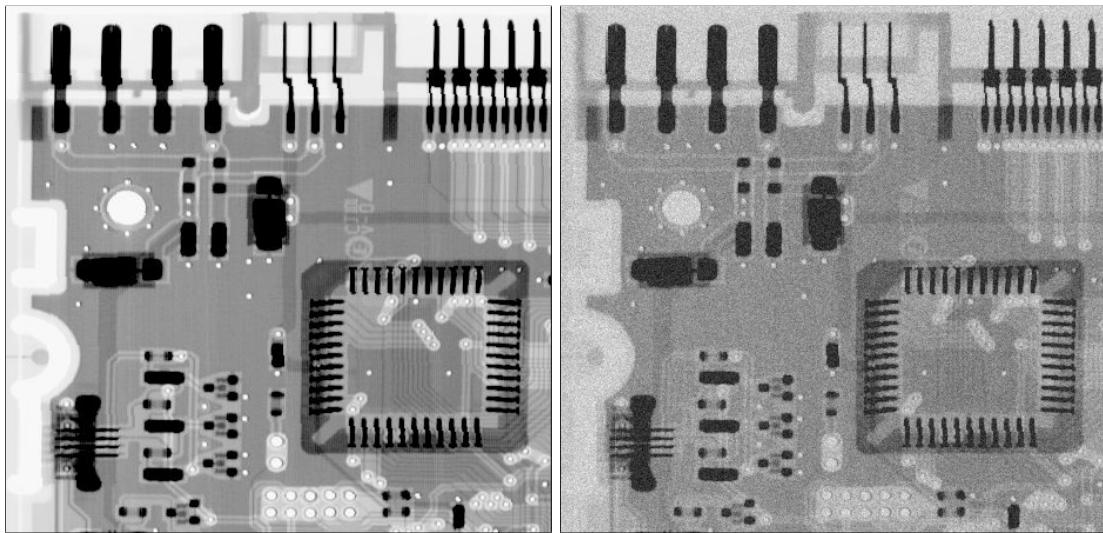


FIGURE D.23 – Original image

FIGURE D.24 – Image + Gaussian

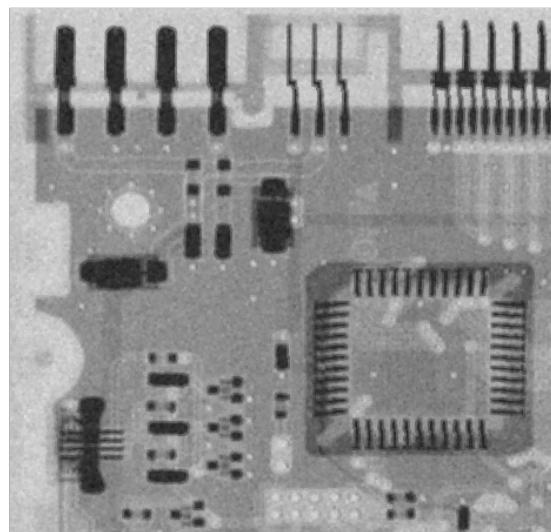


FIGURE D.25 – Midpoint filter

```
python problem4.py -gaussian -alpha -d 2 circuit.tif  
python problem4.py -gaussian -alpha -d 4 circuit.tif
```

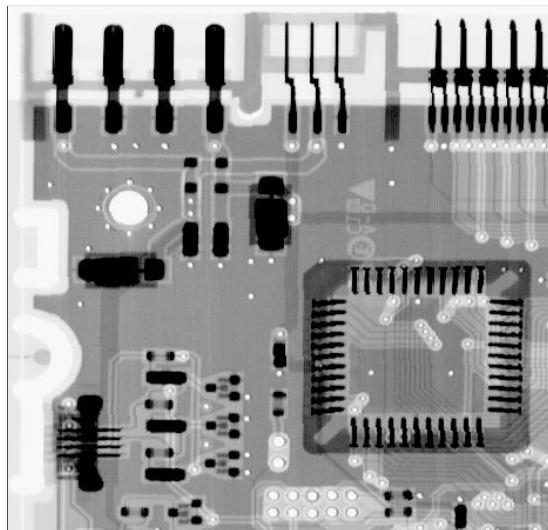


FIGURE D.26 – Original image

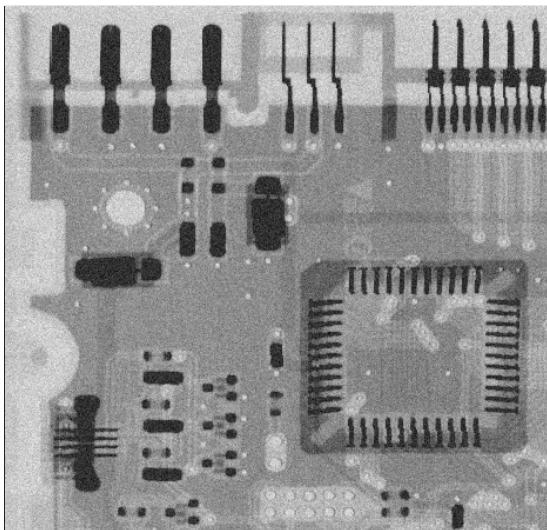


FIGURE D.27 – Image + Gaussian

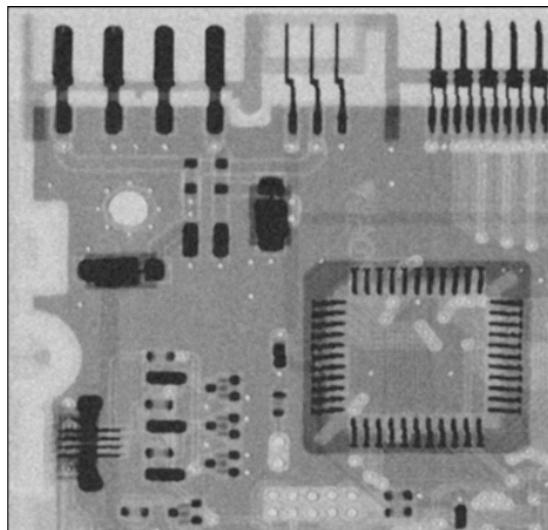


FIGURE D.28 – Alpha-trimmed filter
($d = 2$)

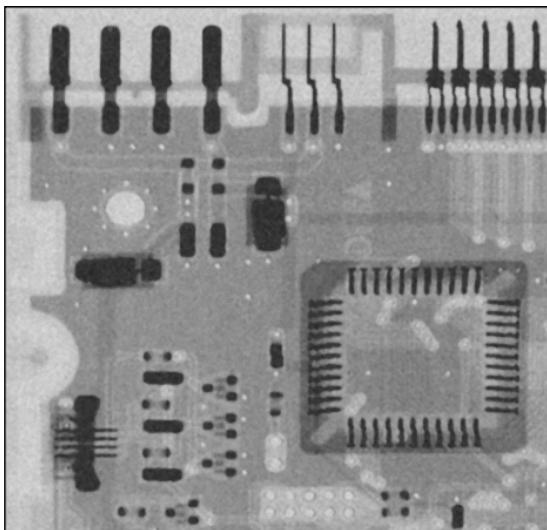


FIGURE D.29 – Alpha-trimmed filter
($d = 4$)

D.4 Uniform noise

D.4.1 Noise generation and histogram

```
python problem4.py -uniform circuit.tif
```

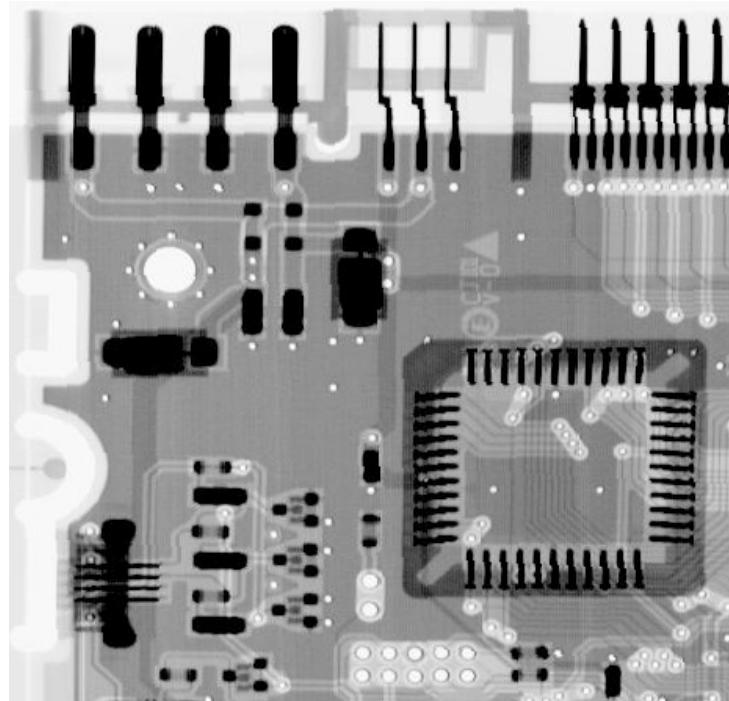


FIGURE D.30 – Original image

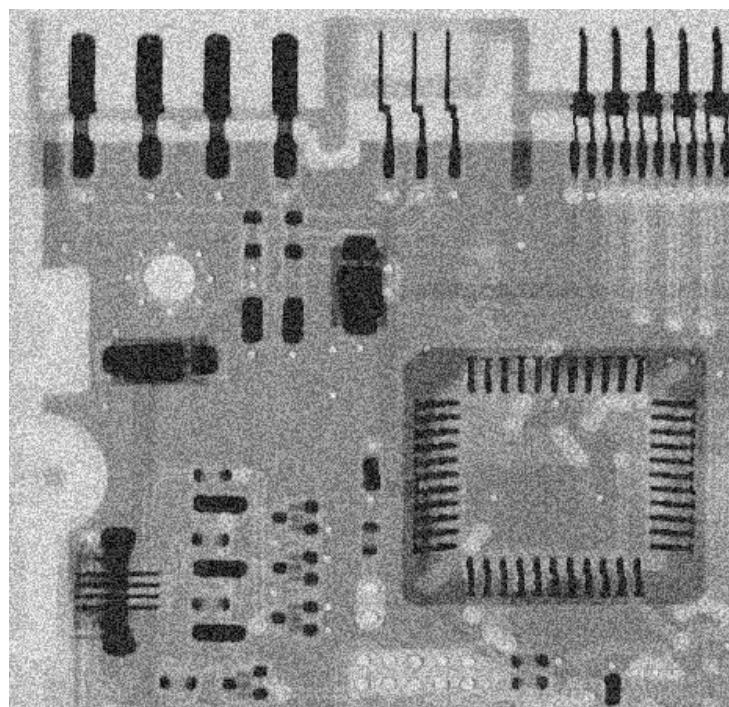


FIGURE D.31 – Image + Uniform noise (min = 0, max = 128)

```
python problem4.py -uniform -histogram circuit.tif
```

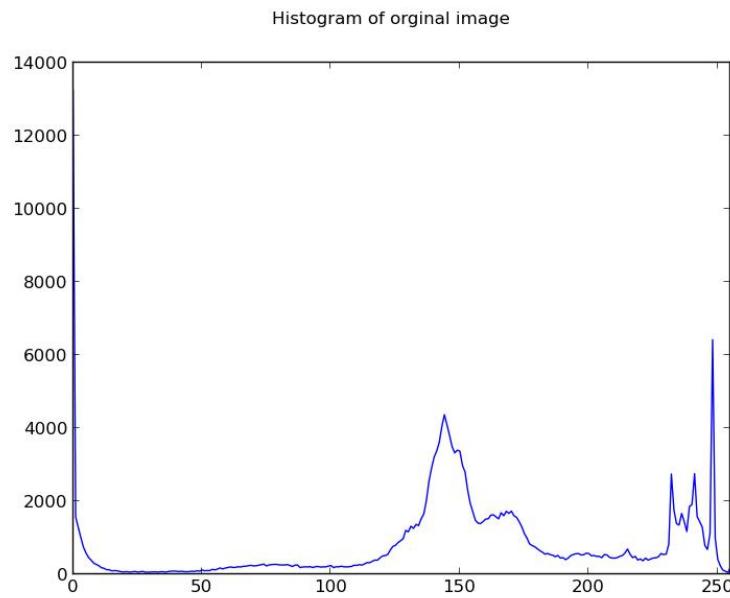


FIGURE D.32 – Histogram of original image

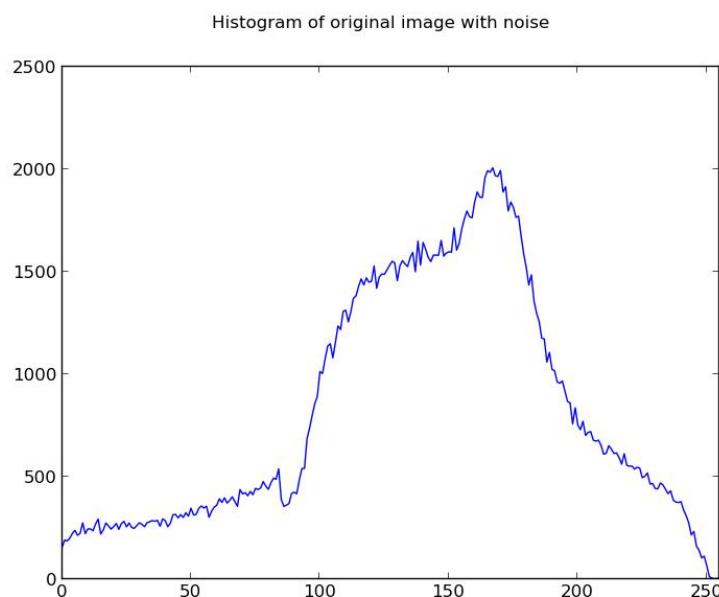


FIGURE D.33 – Histogram of image with Uniform noise

D.4.2 Noise reduction

Mean filters

```
python problem4.py -uniform -arithmetic circuit.tif  
python problem4.py -uniform -geometric circuit.tif
```

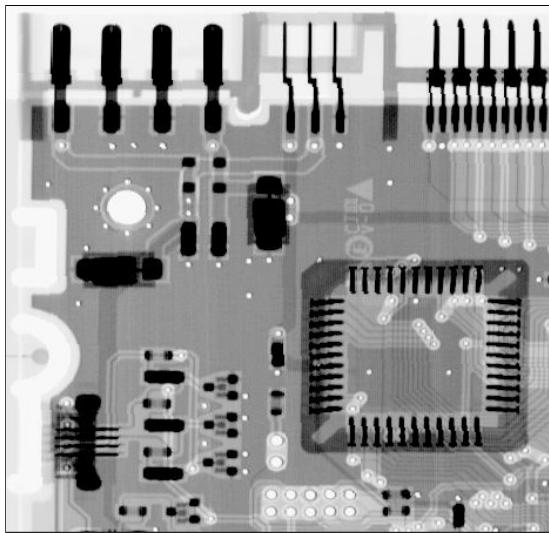


FIGURE D.34 – Original image

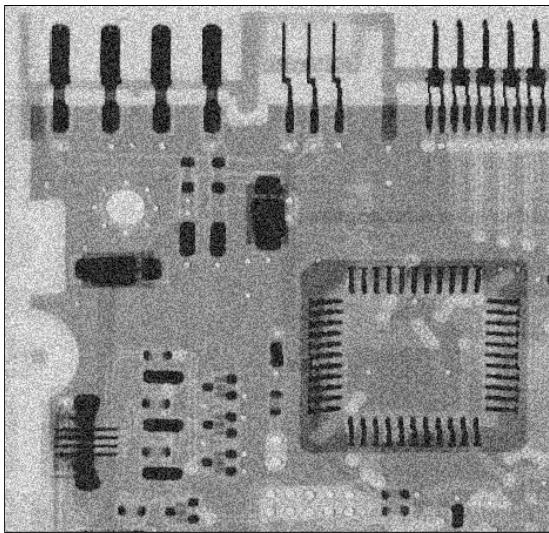


FIGURE D.35 – Image + Uniform

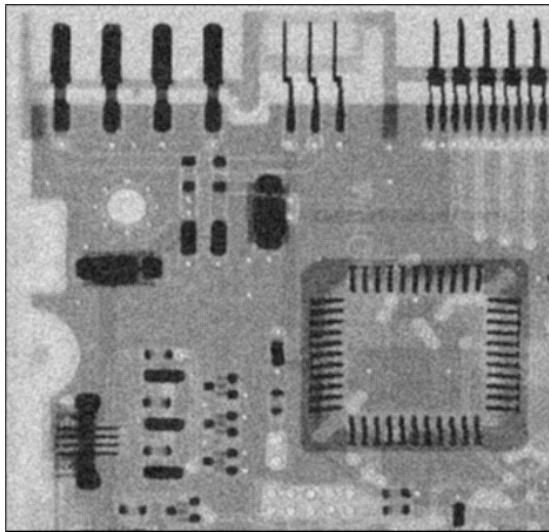


FIGURE D.36 – Arithmetic filter

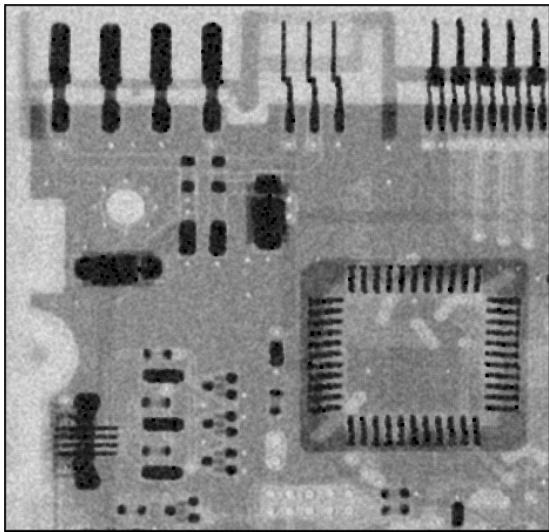


FIGURE D.37 – Geometric filter

```
python problem4.py -uniform -harmonic circuit.tif
```

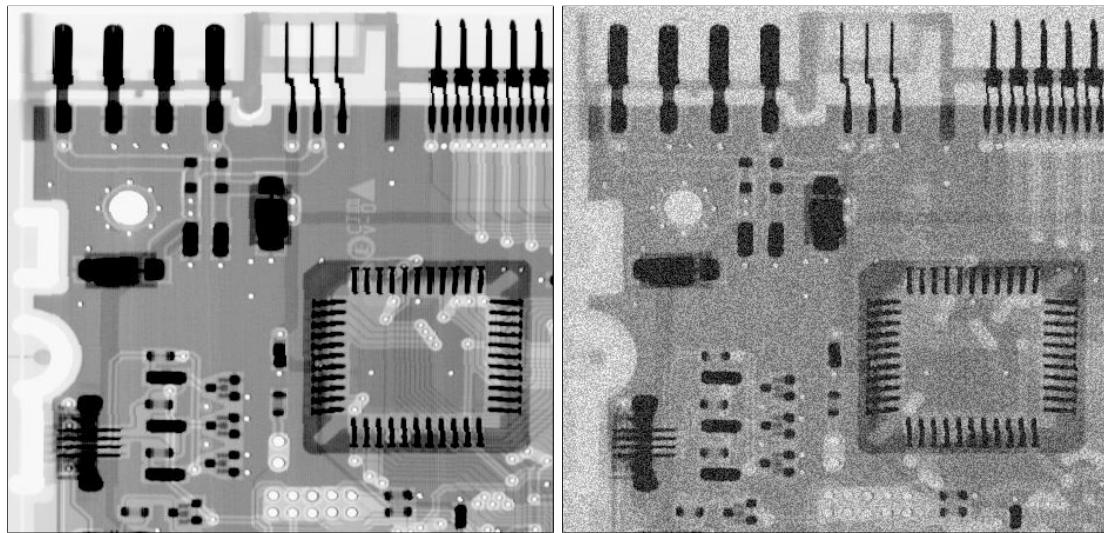


FIGURE D.38 – Original image

FIGURE D.39 – Image + Uniform

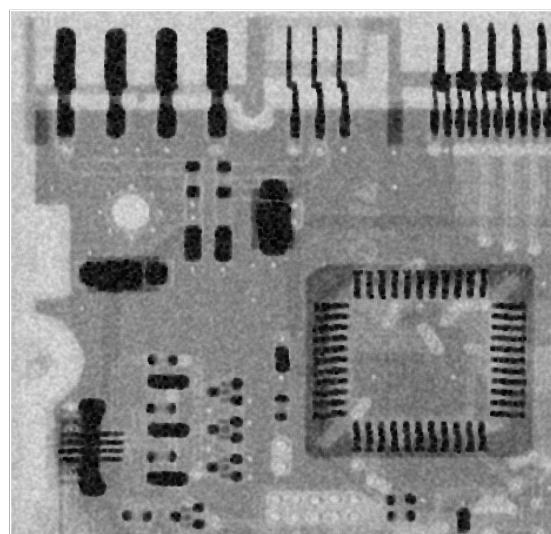


FIGURE D.40 – Harmonic filter

```
python problem4.py -uniform -contraharmonic -q 1.5 circuit.tif  
python problem4.py -uniform -contraharmonic -q -1.5 circuit.tif
```

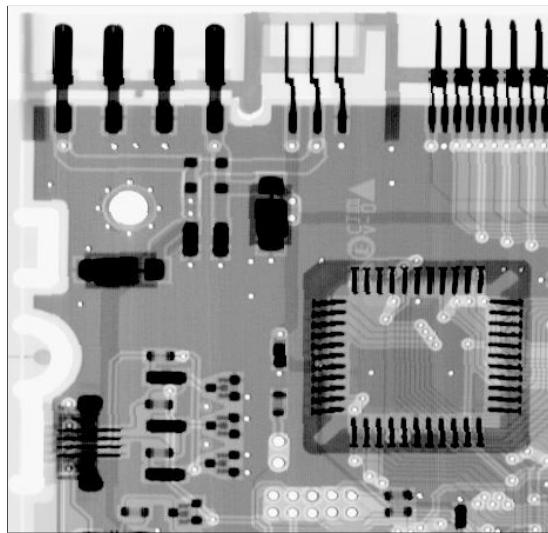


FIGURE D.41 – Original image

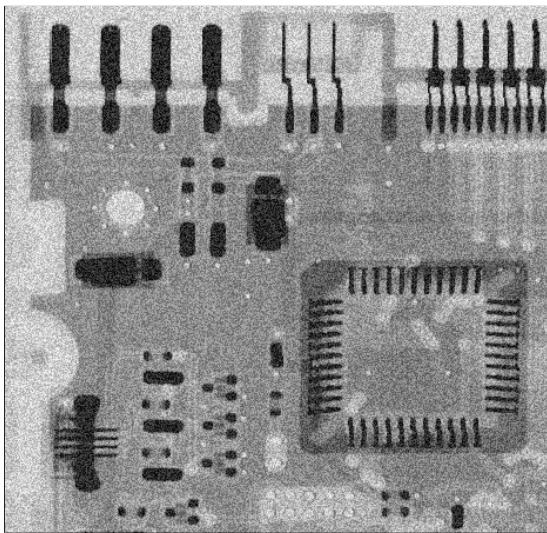


FIGURE D.42 – Image + Uniform

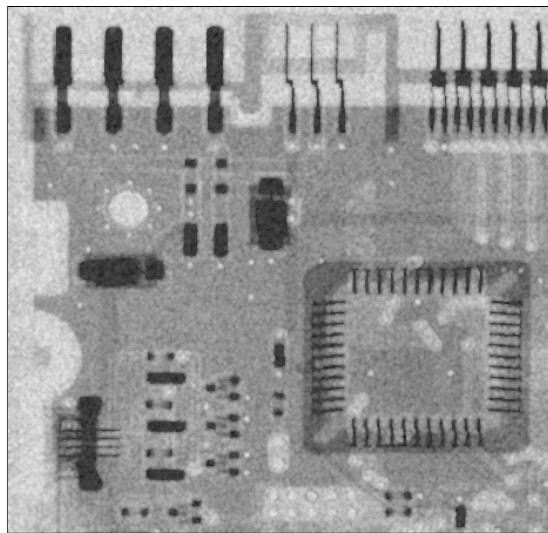


FIGURE D.43 – Contra-harmonic filter (Q=1.5)

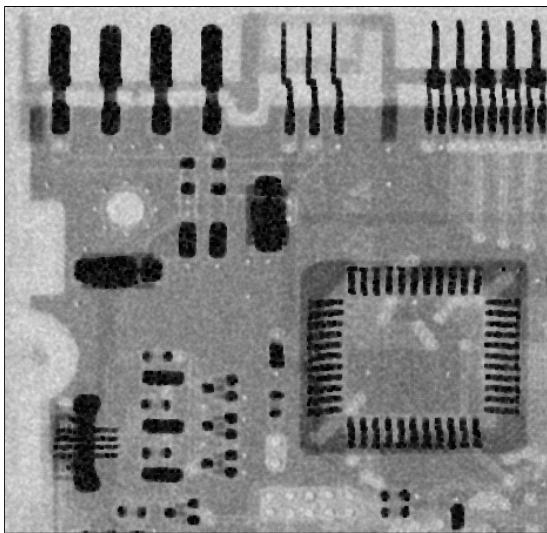


FIGURE D.44 – Contra-harmonic filter (Q=-1.5)

Order-Statistic filters

```
python problem4.py -uniform -median circuit.tif
```

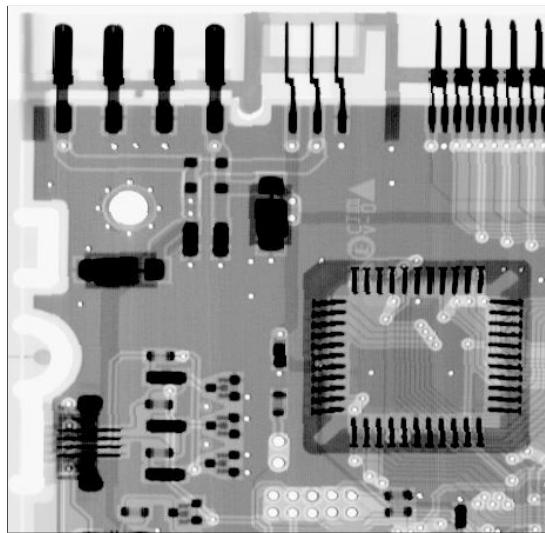


FIGURE D.45 – Original image

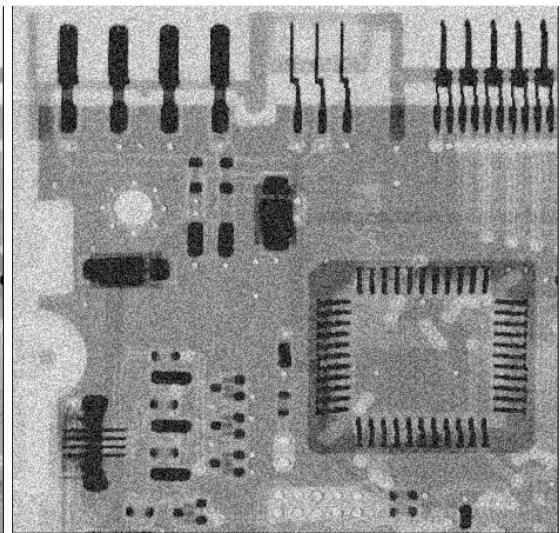


FIGURE D.46 – Image + Uniform

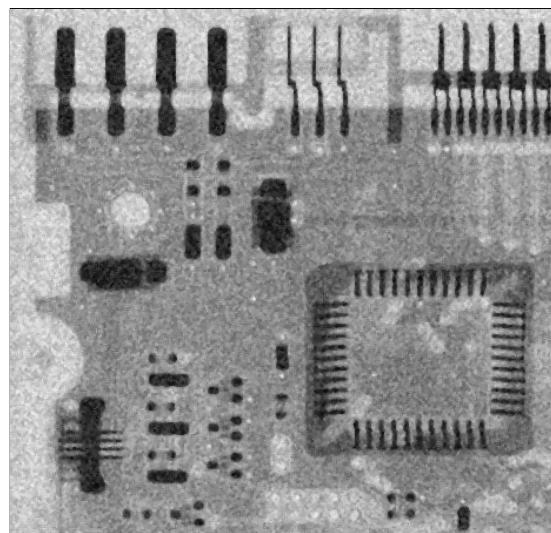


FIGURE D.47 – Median filter

```
python problem4.py -uniform -max circuit.tif  
python problem4.py -uniform -min circuit.tif
```

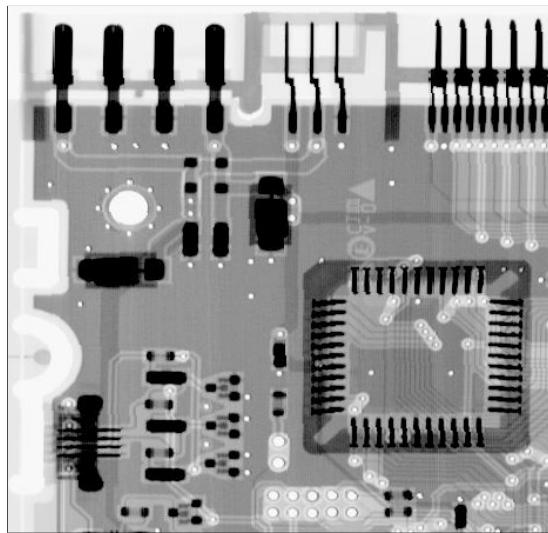


FIGURE D.48 – Original image

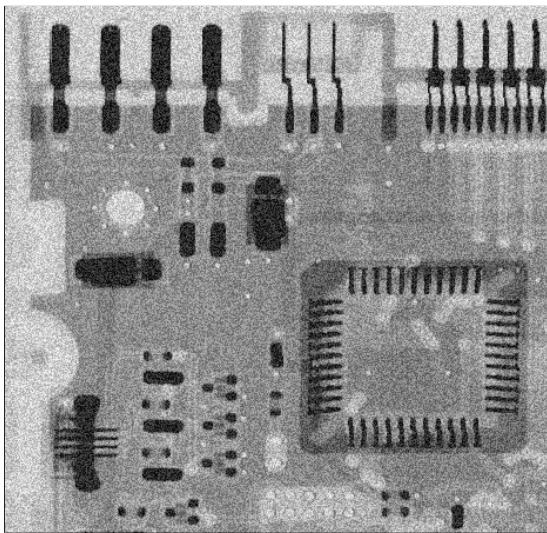


FIGURE D.49 – Image + Uniform

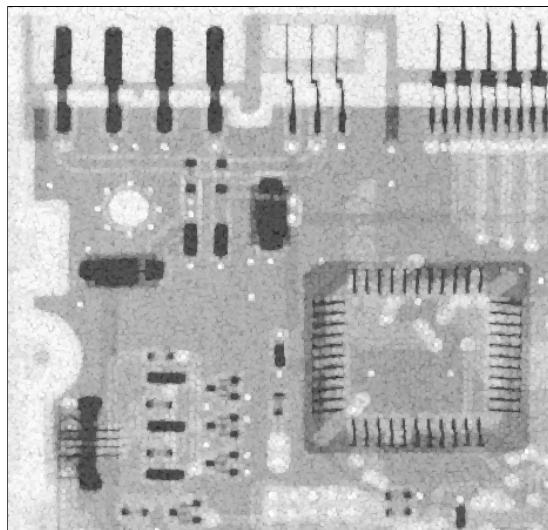


FIGURE D.50 – Max filter

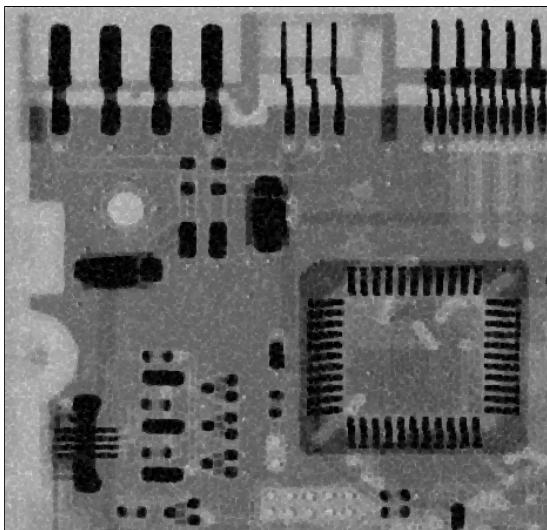


FIGURE D.51 – Min filter

```
python problem4.py -uniform -midpoint circuit.tif
```

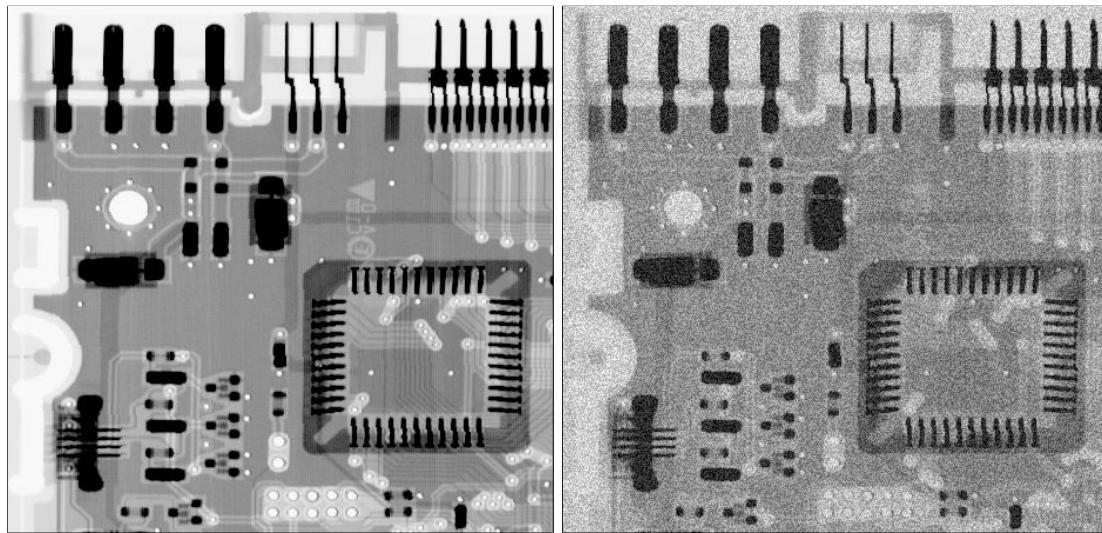


FIGURE D.52 – Original image

FIGURE D.53 – Image + Uniform

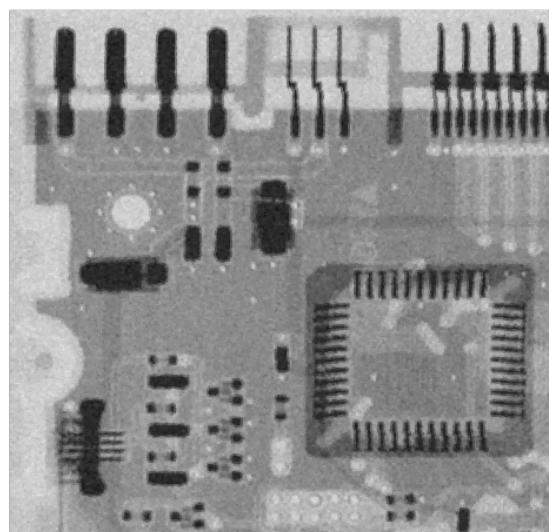


FIGURE D.54 – Midpoint filter

```
python problem4.py -uniform -alpha -d 2 circuit.tif  
python problem4.py -uniform -alpha -d 4 circuit.tif
```

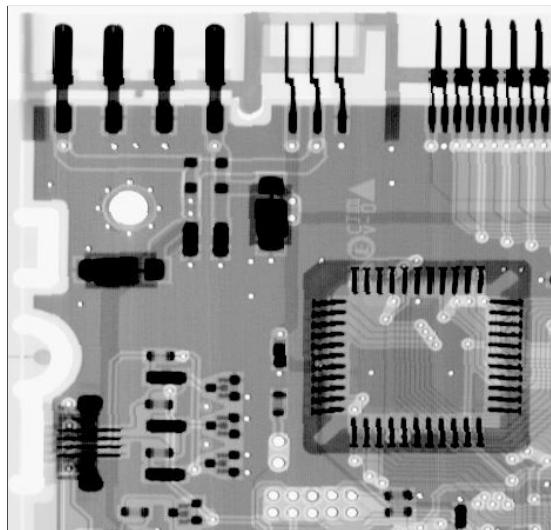


FIGURE D.55 – Original image

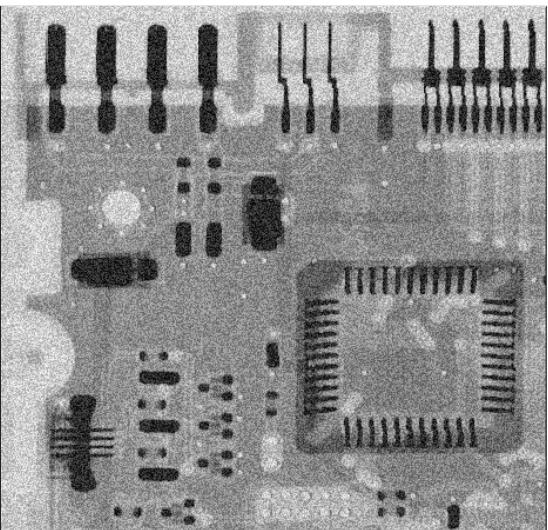


FIGURE D.56 – Image + Uniform

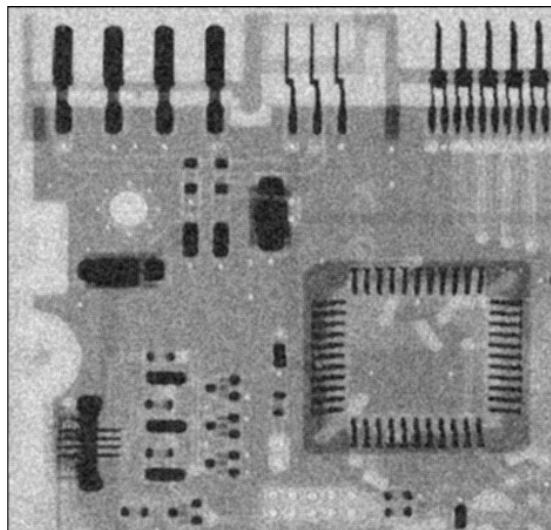


FIGURE D.57 – Alpha-trimmed filter
($d = 2$)

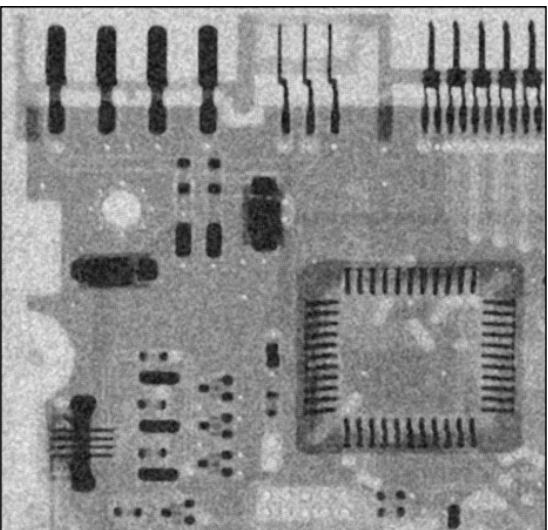


FIGURE D.58 – Alpha-trimmed filter
($d = 4$)