Image Enhancement

Topics of Presentation

- Objective of Image Enhancement
- Gray level Transformation
- Image Histogram
- Linear and Non-linear Spatial domain filtering

Image Enhancement Techniques

- Spatial Domain Techniques
  - Modify the pixel values
- Frequency Domain Techniques
  - Modify the Fourier Transform of the image

Spatial Domain Techniques

Two types of Spatial Domain Techniques

(1) Point Operation

-Operation on individual pixel

(1) Group operation

-Operation on group of pixels

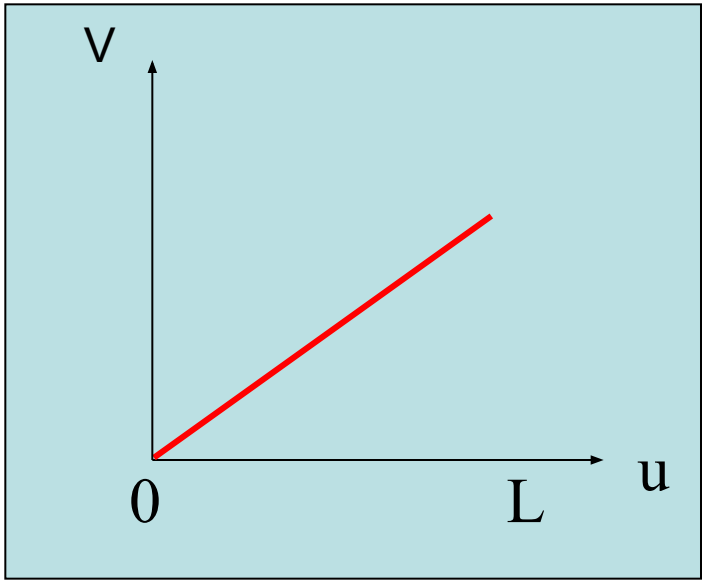
Point Operation

- Point operations are **zero-memory** operations where
- a given gray level $u \in [0,L]$ is mapped to another
- gray level $v \in [0,L]$ according to a transformation

Types of Gray level Transformation

- Lazy Man operation
- Image Negative
- Contrast Stretching
- Clipping
- Thresholding

Lazy man operation

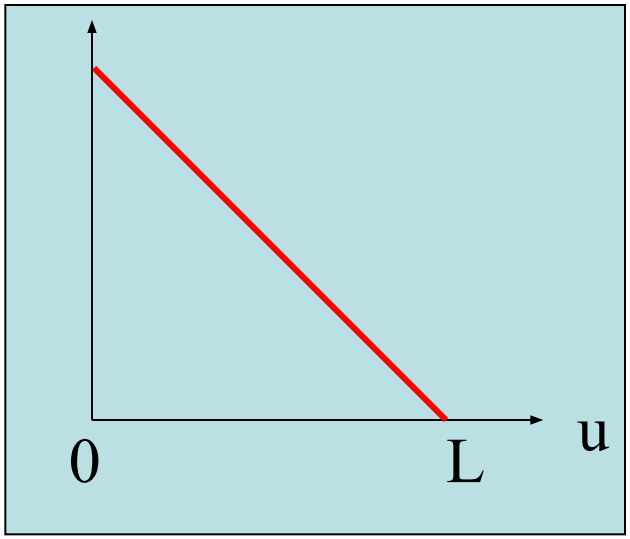


Input Image

Transformation

Output Image

Image Negative

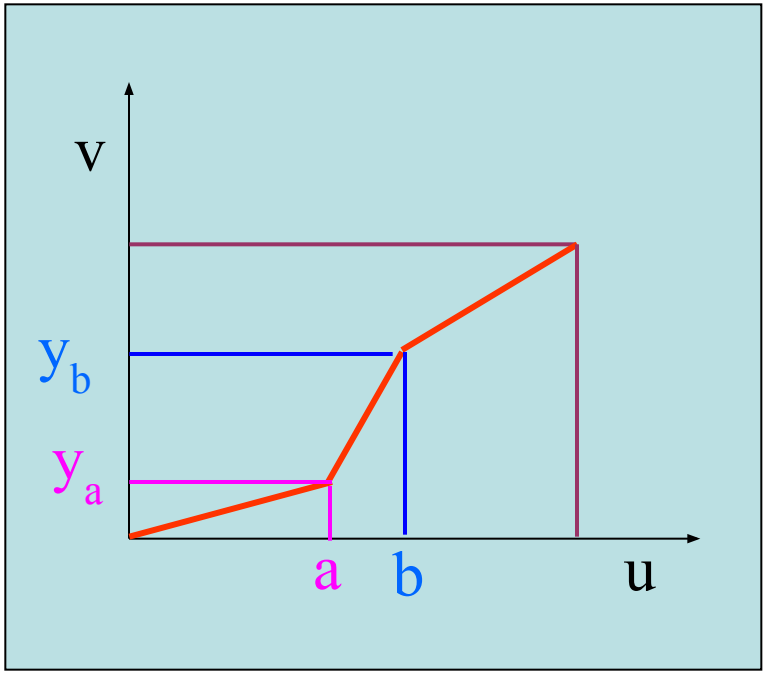


Input Image

Transformation

Output Image

Contrast Stretching

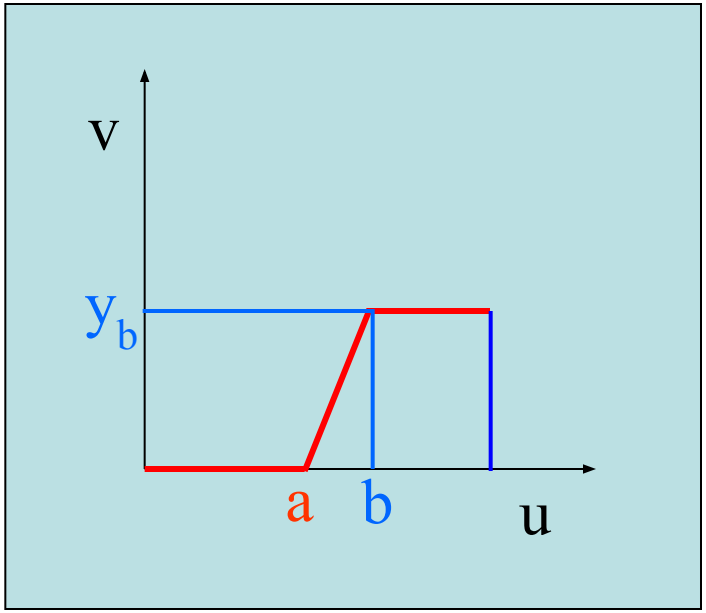


Input Image

Transformation

Output Image

Clipping



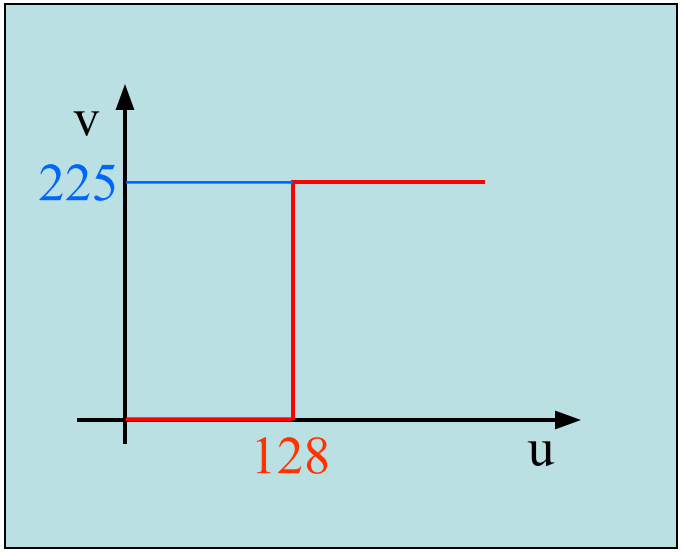
Input Image

Transformation

Output Image

Thresholding

Input Image

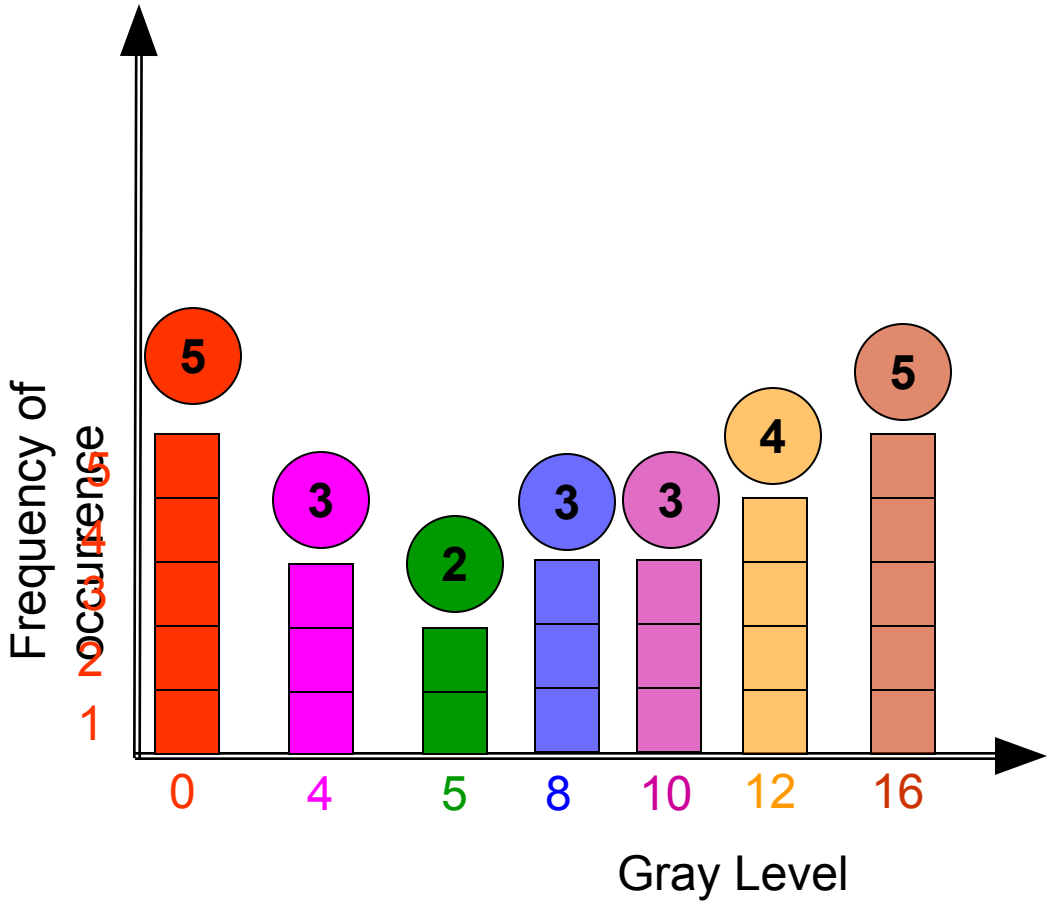


Transformation

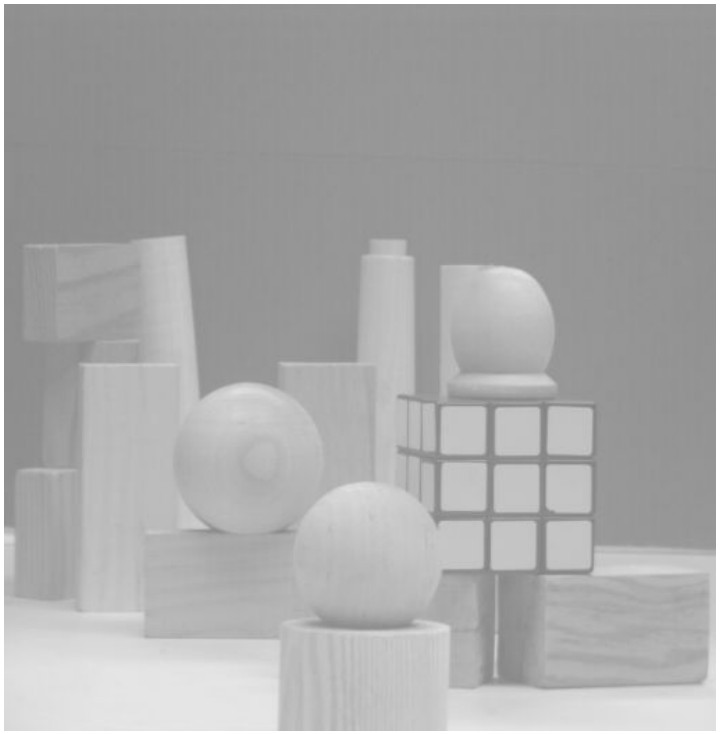
Output Image

Image Histogram

0	4	8	10	12
12	16	5	0	16
4	16	8	5	10
10	0	4	12	16
12	0	16	0	8



Histogram of Overexposed Image



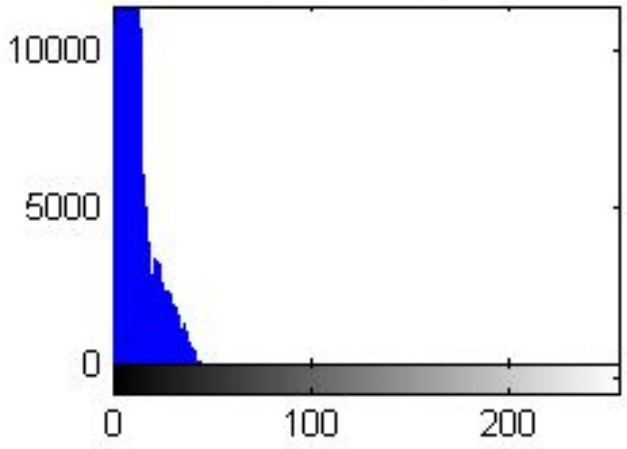
Histogram of Underexposed Image

Histogram Equalization

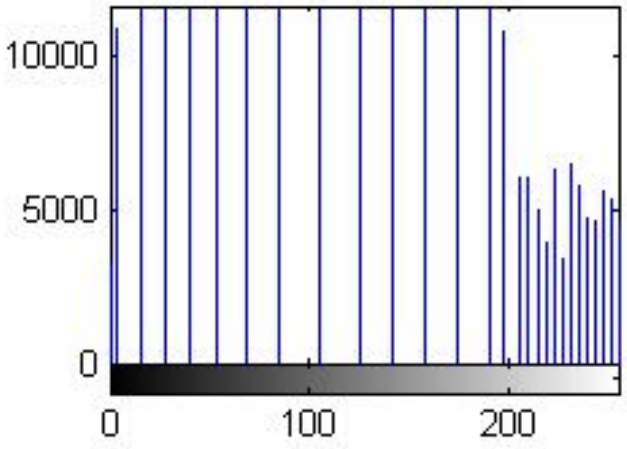
original image

After histogram equalization

original histogram



After histogram equalization



Properties of Histogram

- Many to one mapping
- Invariant to rotation, translation

Illustration of Spatial filtering

7	9	11
10	50	8
9	5	6

Original Image

1/9

1	1	1
1	1	1
1	1	1

3 x 3 Averaging Mask

0	0	0	0	0
0	7	9	11	0
0	10	50	8	0
0	9	5	6	0
0	0	0	0	0

Input Image after zero padding

Movement of Spatial Mask

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

1/9 0	1/9 0	1/9 0	0	0
1/9 0	1/9 7	1/9 9	11	0
1/9 0	1/9 10	1/9 50	8	0
0	9	5	6	0
0	0	0	0	0

$$0 \times 1/9 + 0 \times 1/9 + 0 \times 1/9 + 0 \times 1/9 + 7 \times 1/9 + 9 \times 1/9 + 0 \times 1/9 + 10 \times 1/9 + 50 \times 1/9 = 8.4$$

Movement of Spatial Mask (Cont..)

1/9 0	1/9 0	1/9 0	1/9 0	0
1/9 0	1/9 8.4	1/9 9	1/9 11	0
1/9 0	1/9 10	1/9 50	1/9 8	0
0	9	5	6	0
0	0	0	0	0

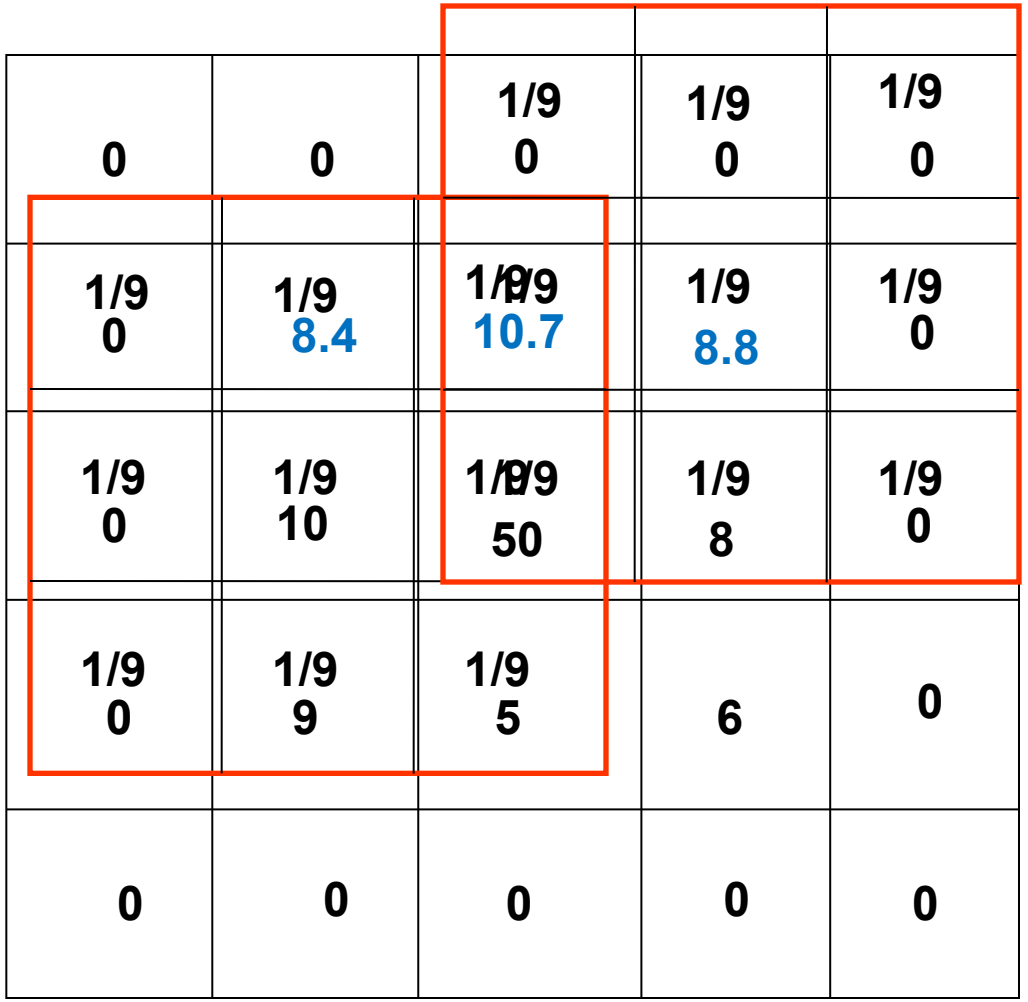
0 x 1/9+ 0 x 1/9 +0 x 1/9+ 8.4 x 1/9+9 x 1/9 +11 x 1/9+10 x 1/9+50 x 1/9+ 8 x 1/9
= 10.7

Movement of Spatial Mask (Cont..)

0	1/9 0	1/9 0	1/9 0	1/9 0
0	1/9 8.4	1/9 10.7	1/9 11	1/9 0
0	1/9 10	1/9 50	1/9 8	1/9 0
0	9	5	6	0
0	0	0	0	0

0 x 1/9+ 0 x 1/9 +0 x 1/9+10.7 x 1/9+11 x 1/9+0 x 1/9 +50 x 1/9 + 8 x 1/9 + 0 x 1/9
= 8.8

Movement of Spatial Mask (Cont..)



0 x 1/9+ 8.4 x 1/9+10.7 x 1/9+ 0 x 1/9 +10 x 1/9+50 x 1/9+0 x 1/9+9 x 1/9+ 5 x 1/9
= 10.3

Movement of Spatial Mask (Cont..)

0	0	0	0	0
1/9 0	1/9 8.4	1/9 10.7	1/9 8.8	0
1/9 0	1/9 10.3	1/9 50	1/9 8	0
1/9 0	1/9 9	1/9 5	1/9 6	0
0	0	0	0	0

8.4 x 1/9+ 10.7 x 1/9+8.8 x 1/9+10.3 x 1/9+50 x 1/9+8 x 1/9 + 9 x 1/9 +5 x 1/9+ 6 x 1/9

= 12.9

Movement of Spatial Mask (Cont..)

0	0	0	0	0
0	1/9 8.4	1/9 10.7	1/9 8.8	1/9 0
0	1/9 10.3	1/9 12.9	1/9 8	1/9 0
0	1/9 9	1/9 5	1/9 6	1/9 0
0	0	0	0	0

$$10.7 \times 1/9 + 8.8 \times 1/9 + 0 \times 1/9 + 12.9 \times 1/9 + 8 \times 1/9 + 0 \times 1/9 + 5 \times 1/9 + 6 \times 1/9 + 0 \times 1/9 = 5.7$$

Movement of Spatial Mask (Cont..)

0	0	0	0	0
0	8.4	1/9 10.7	1/9 8.8	1/9 0
1/9 0	1/9 10.3	1/9 12.9	1/9 5.7	1/9 0
1/9 0	1/9 9	1/9 5	1/9 6	1/9 0
1/9 0	1/9 0	1/9 0	0	0

0 x 1/9 +10.3 x 1/9+12.9 x 1/9 +0 x 1/9 +9 x 1/9+ 5 x 1/9+0 x 1/9 + 0x 1/9 +0 x 1/9

= 4.1

Movement of Spatial Mask (Cont..)

0	0	0	0	0
0	8.4	10.7	8.8	0
1/9 0	1/9 10.3	1/9 12.9	1/9 5.7	0
1/9 0	1/9 4.1	1/9 5	1/9 6	0
1/9 0	1/9 0	1/9 0	1/9 0	0

10.3 x 1/9 +12.9 x 1/9+ 5.7x 1/9 + 4.1 x 1/9+5 x 1/9+ 6 x 1/9+0 x 1/9+0 x 1/9+0 x 1/9

= 4.6

Movement of Spatial Mask (Cont..)

0	0	0	0	0
0	8.4	10.7	8.8	0
0	1/9 10.3	1/9 12.9	1/9 5.7	1/9 0
0	1/9 4.1	1/9 4.6	1/9 6	1/9 0
0	1/9 0	1/9 0	1/9 0	1/9 0

12.9 x 1/9 + 5.7 x 1/9 + 0 x 1/9 + 4.6 x 1/9 + 6 x 1/9 + 0 x 1/9 + 0 x 1/9 + 0 x 1/9 + 0 x 1/9

= 3.2

Movement of Spatial Mask (Cont..)

0	0	0	0	0
0	8.4	10.7	8.8	0
0	10.3	12.9	5.7	0
0	4.1	4.6	3.2	0
0	0	0	0	0

Result of Averaging filter

7	9	11
10	50	8
9	5	6

Original Image

8.4	10.7	8.8
10.3	12.9	5.7
4.1	4.6	3.2

Image after Spatial Averaging

Spatial Averaging

Original Image

3 x 3
Smoothing
filter

Smoothened Image

Spatial Averaging

Original Image

5 x 5
Smoothing
filter

Smoothened Image

Average Vs Weighted Average

Original Image

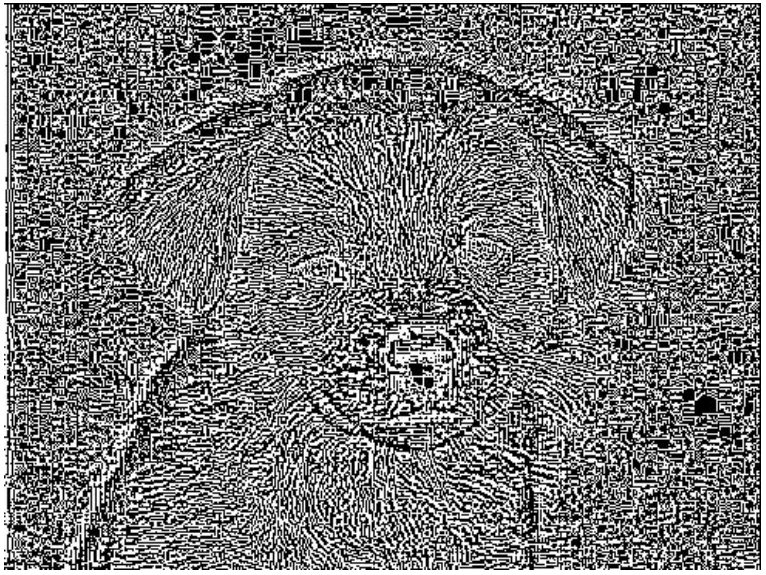
$$\frac{1}{9}\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix}$$

$$\frac{1}{16}\begin{bmatrix}1 & 2 & 1\\ 2 & 4 & 2\\ 1 & 2 & 1\end{bmatrix}$$

Image Sharpening

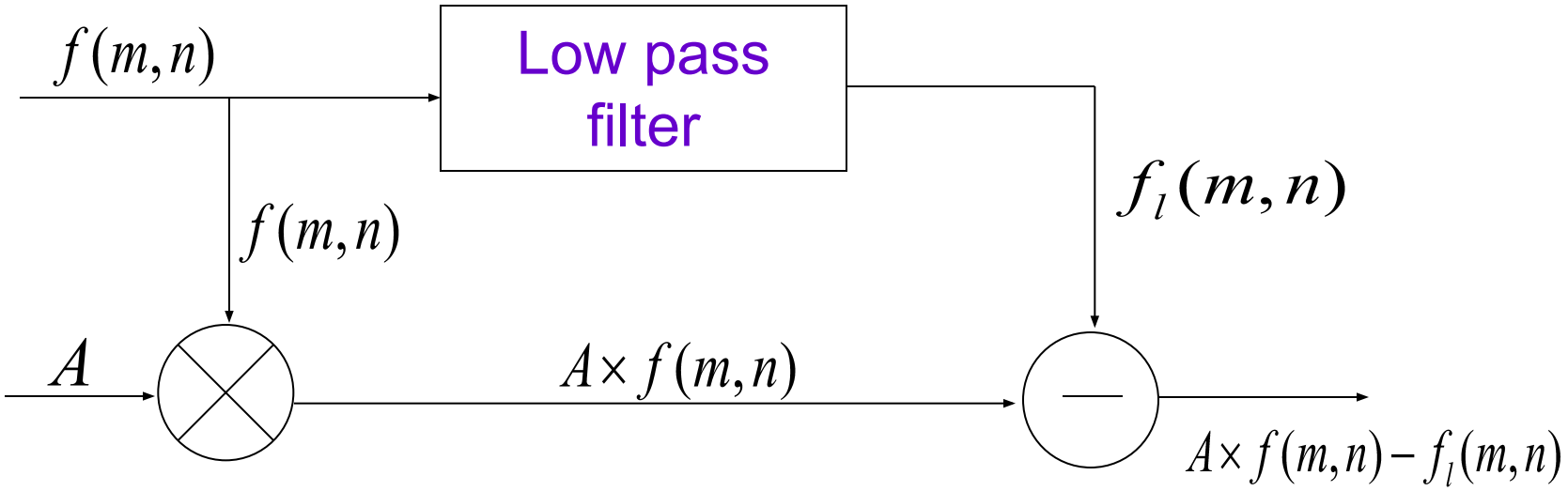
Original Image

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

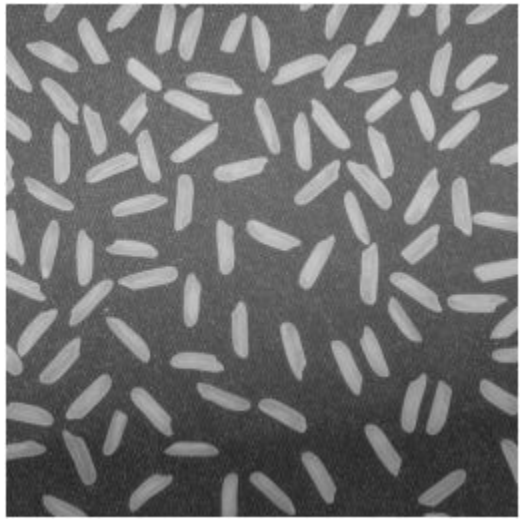


Edge Enhanced Image

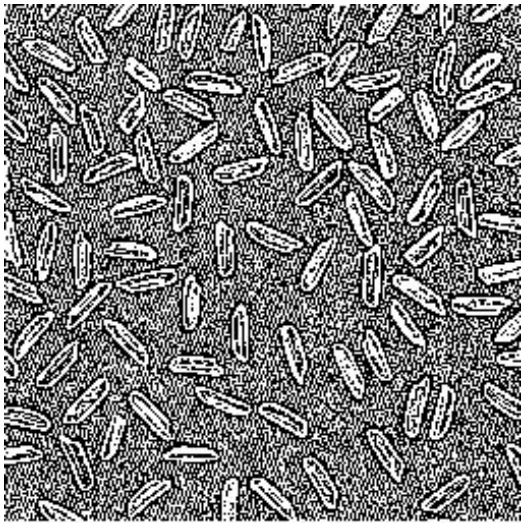
High boost filtering



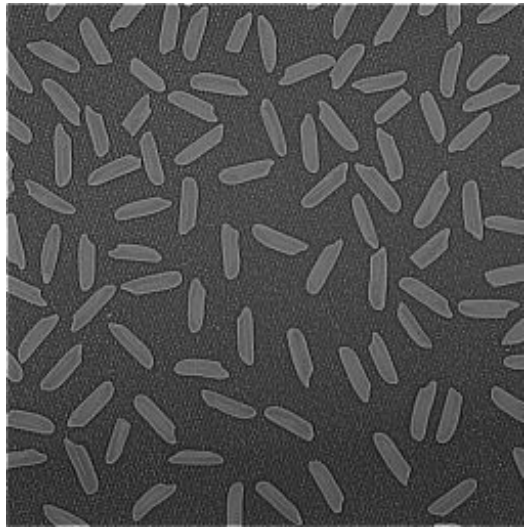
High pass Vs High boost filtering



Original Image

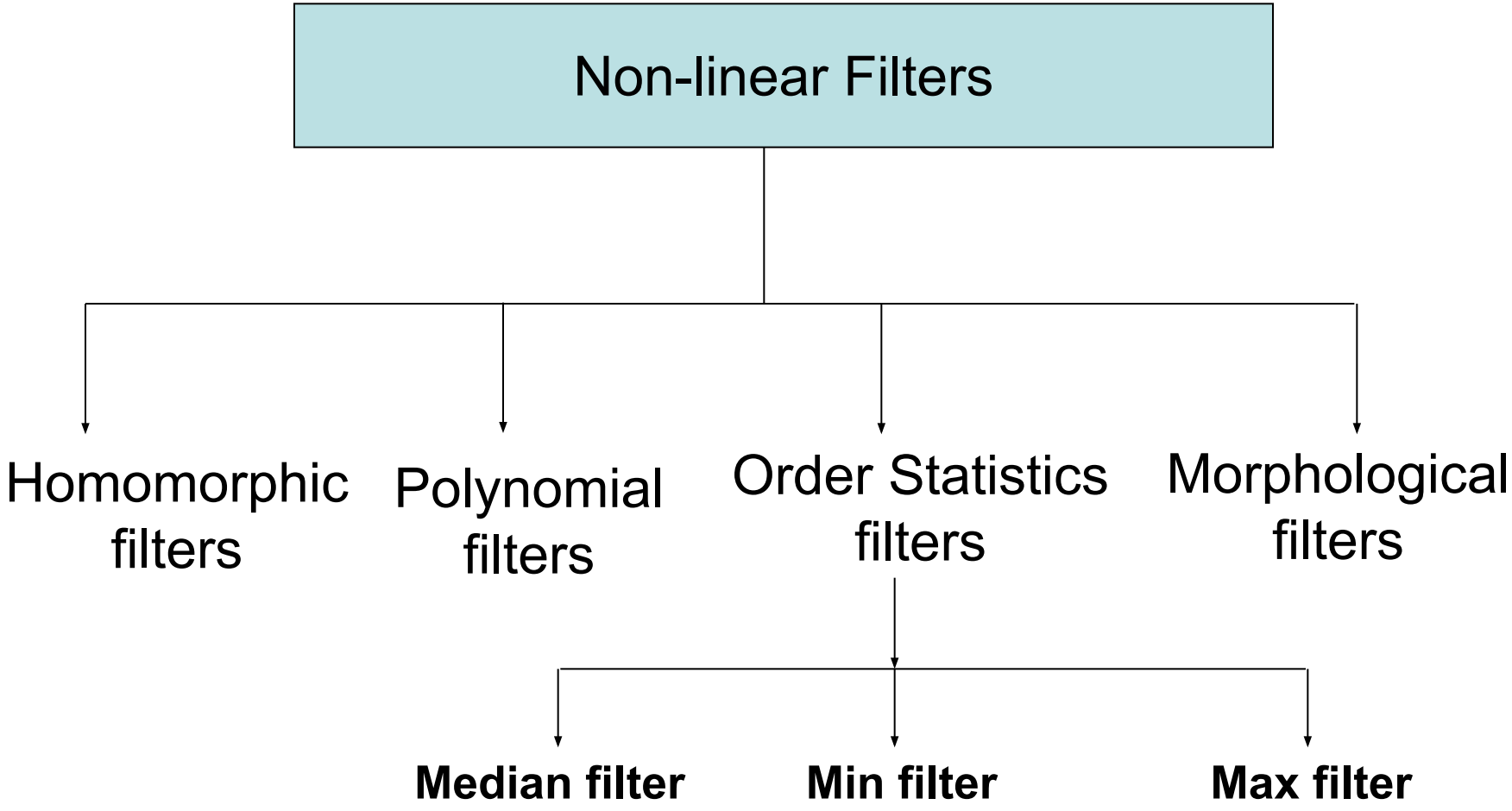


High pass filtered image

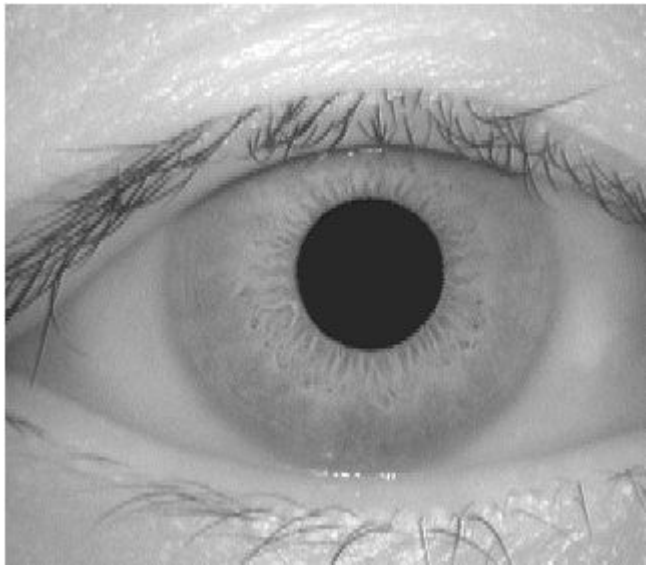


High boost filtered image

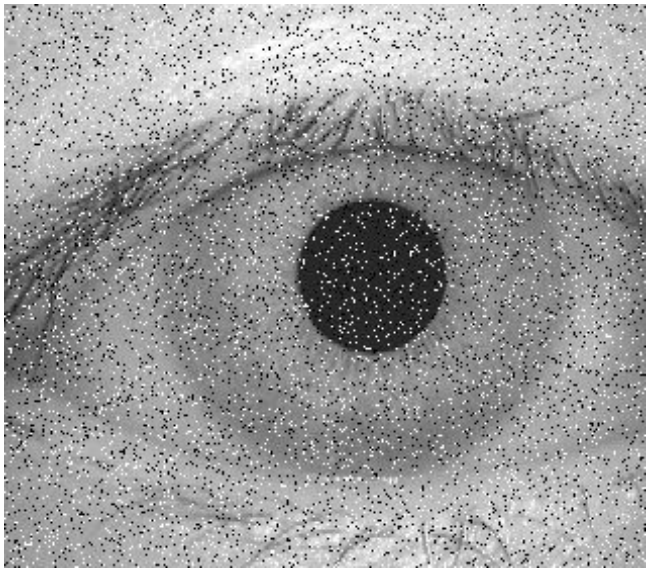
Non-linear Filter



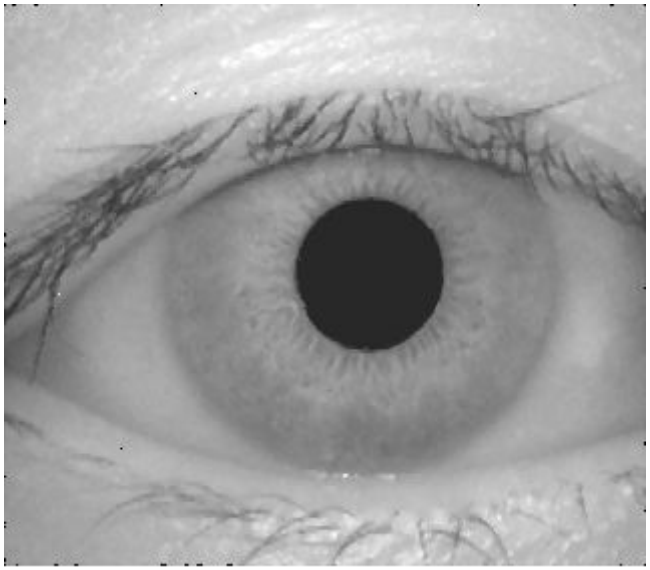
Median filter



Original Image



Corrupted Image



Median filtered Image

Drawbacks of Median filter

- Removes image details
- Signal Dependent Noise

Variations of Median filter

- Weighted Median filter
- Center Weighted Median filter
- Adaptive Center Weighted Median filter