



SPATIAL FILTERING

December 10, 2011

Review of Image Enhancement

- Definition of Enhancement
- $S = T(r)$ (Mathematical Definition)
- Some Enhancement Techniques
 - (a) Image Negative, Log Transformations, Gamma Transformations
 - (b) Piecewise - Linear Transformations
 - Contrast stretching, Intensity Level slicing, Bit plane slicing

Spatial Filtering

- It is an image enhancement technique
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- Spatial refers to space
- Filtering refers accepting or rejecting certain frequency components
- Types of Filter
 - Low Pass filter
 - High pass filter
 - Band pass filter
 - Band reject filter
- **SPATIAL FILTER** (spatial mask, Kernels, Templates or windows)

Neighbouring Pixels

$f(x-1,y-1)$	$f(x-1,y)$	$f(x-1,y+1)$
$f(x,y-1)$	$f(x,y)$	$f(x,y+1)$
$f(x+1,y-1)$	$f(x+1,y)$	$f(x+1,y+1)$

3 X 3 of neighbouring pixel structure of (x,y)

MASK ELEMENTS

w1	w2	w3
w4	w5	w6
w7	w8	w9

1) The weight in a mask effects overall intensity of the pixel

Weight in a mask are normalized

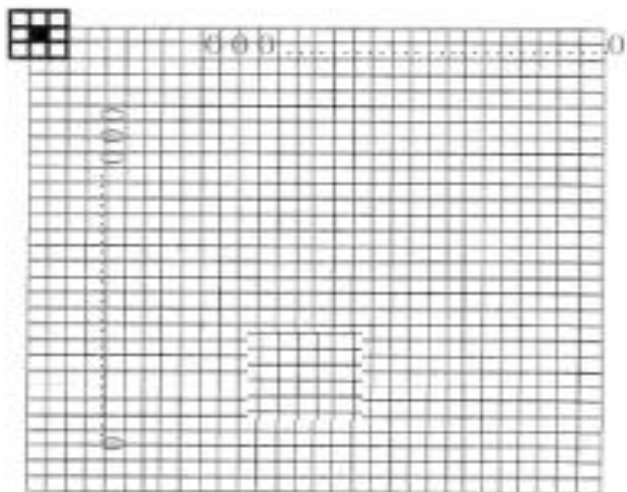
Spatial Convolution

- 1) Write General formula for intensity transformation
(i.e. weighted sum of all pixels)
- 3) Moving a filter mask over a image and computing the sum of products at each location
- 4) Does not work for corner pixels
- 5) So for corner pixels, first zero padding is done.

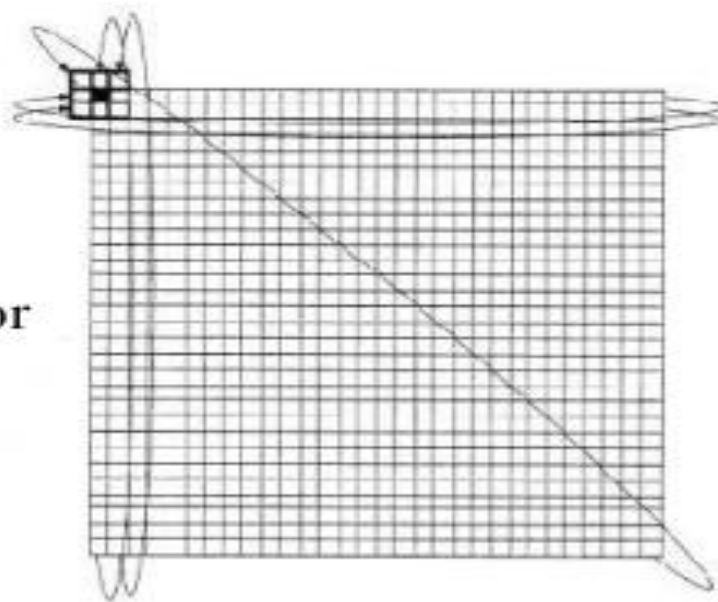
Handling Pixels Close to Boundaries

pad with zeroes

1)



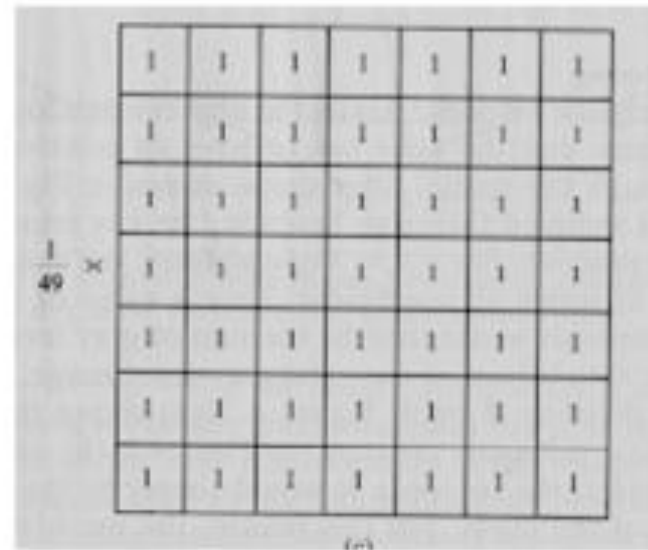
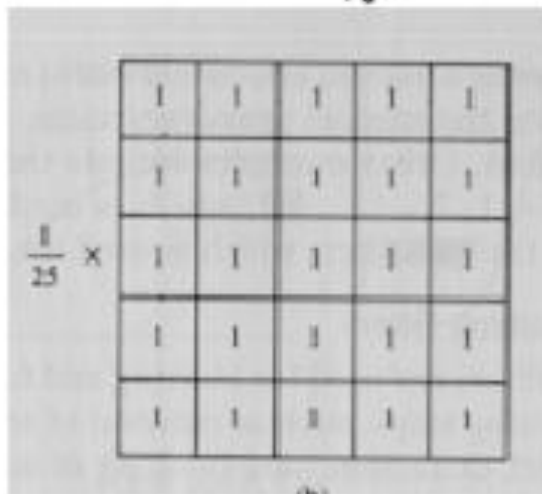
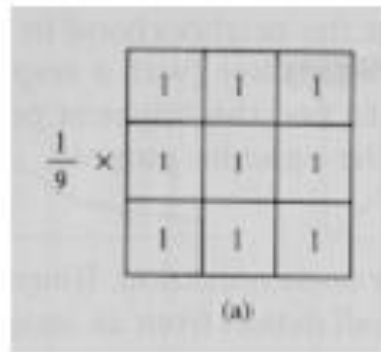
or



Spatial Correlation

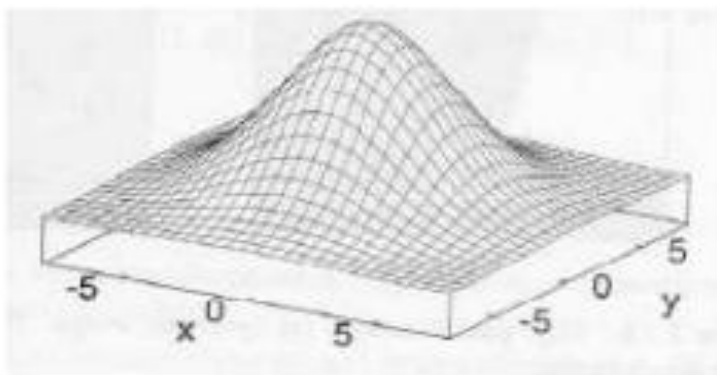
- 1) Same as spatial convolution
- 2) If mask 'w' is used for spatial correlation then rotate 'w' by 180 degree to get convolution mask

Smoothing Filters: Averaging (Low-pass filtering)



Smoothing filters: Gaussian

- The weights are samples from a Gaussian function



7 × 7 Gaussian mask

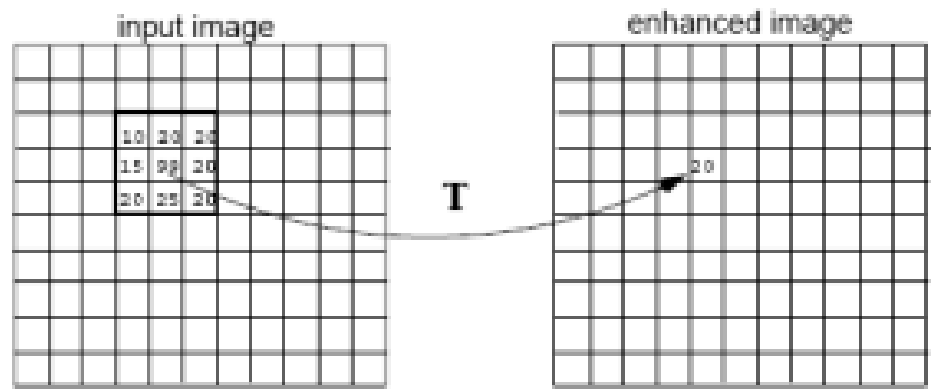
1	1	2	2	2	1	1
1	2	2	4	2	2	1
2	2	4	8	4	2	2
2	4	8	16	8	4	2
2	2	4	8	4	2	2
1	2	2	4	2	2	1
1	1	2	2	2	1	1

- The value of σ determines the degree of smoothing.

Smoothing Filter : Median Filter (Non –Linear Filter)

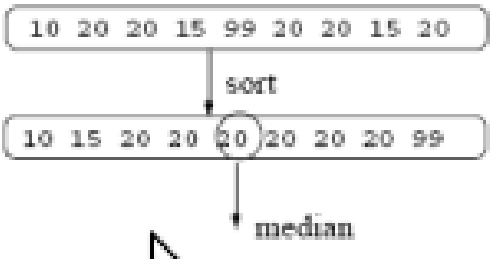
- Replace each pixel by the median in a neighborhood around the pixel.

Area or Mask Processing Methods

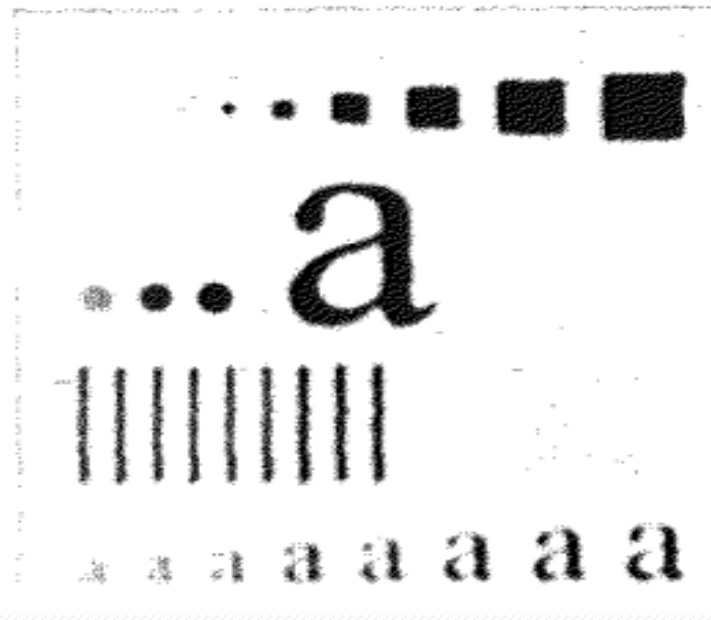
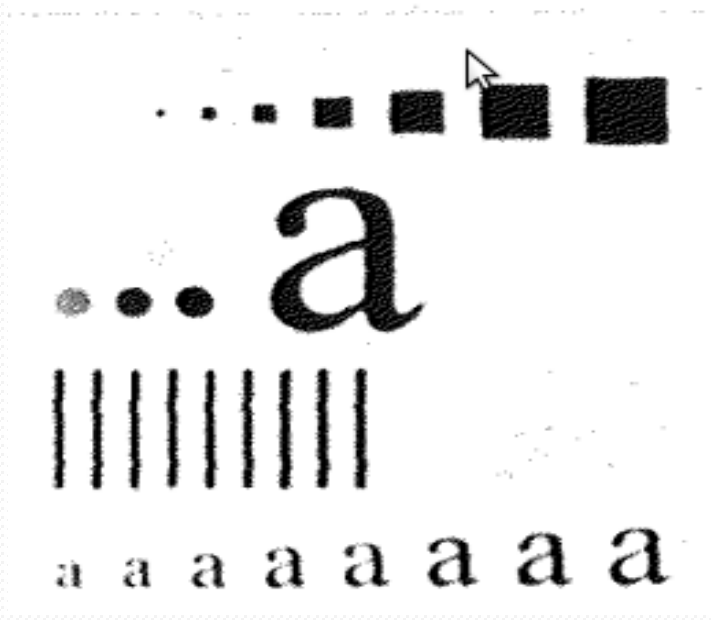
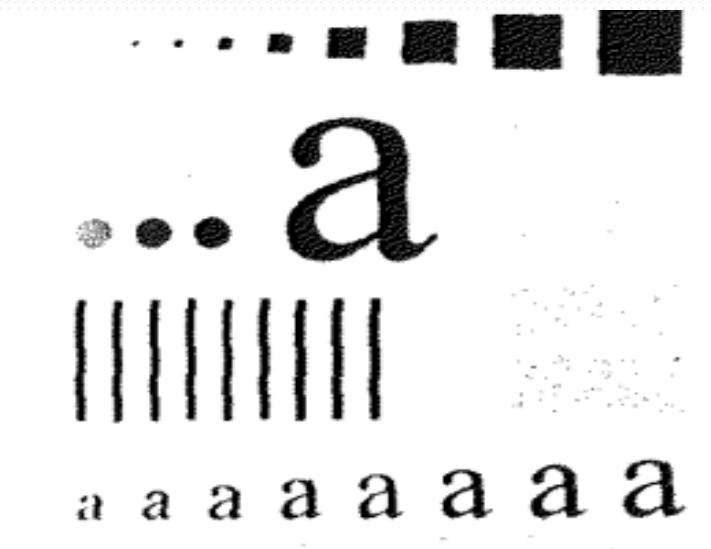


$$g(x,y) = T[f(x,y)]$$

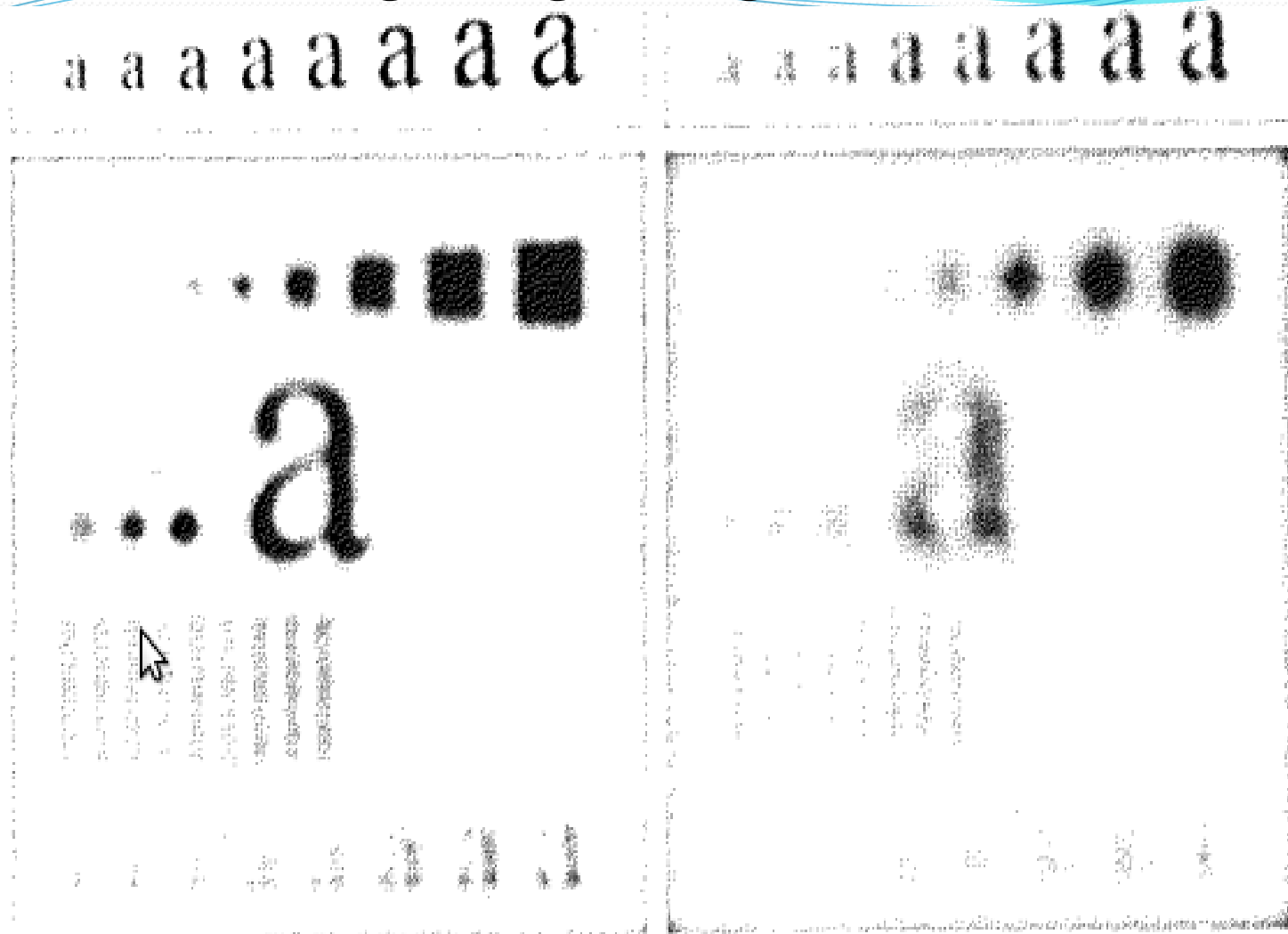
T operates on a neighborhood of pixels



Smoothing Using Average Filter

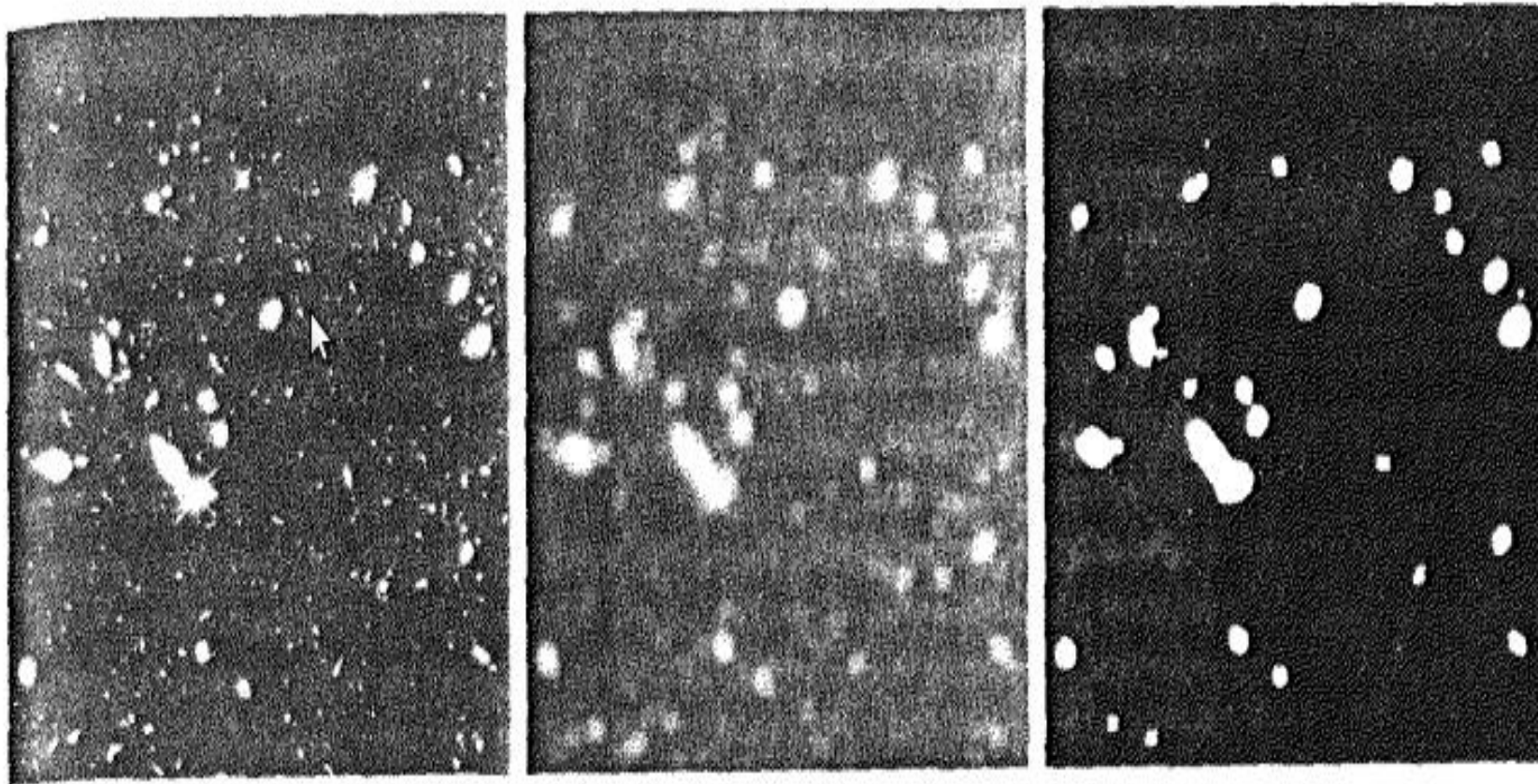


Smoothing Using Average Filter



Original image, of size 500×500 pixels. (b)–(f) Results of smoothing with square averaging filter masks of sizes $n = 3, 5, 9, 15,$ and 35 , respectively. The black squares at the top are of sizes $3, 5, 9, 15, 25, 35, 45,$ and 55 pixels, respectively; their hor-

Application of smoothing Filter using Thresholding



a b c

(a) Image from the Hubble Space Telescope. (b) Image processed by a 15×15 averaging mask. (c) Result of thresholding (b). (Original image courtesy of NASA.)

Application of Smoothing filter

1) Used to make sharpening Filter

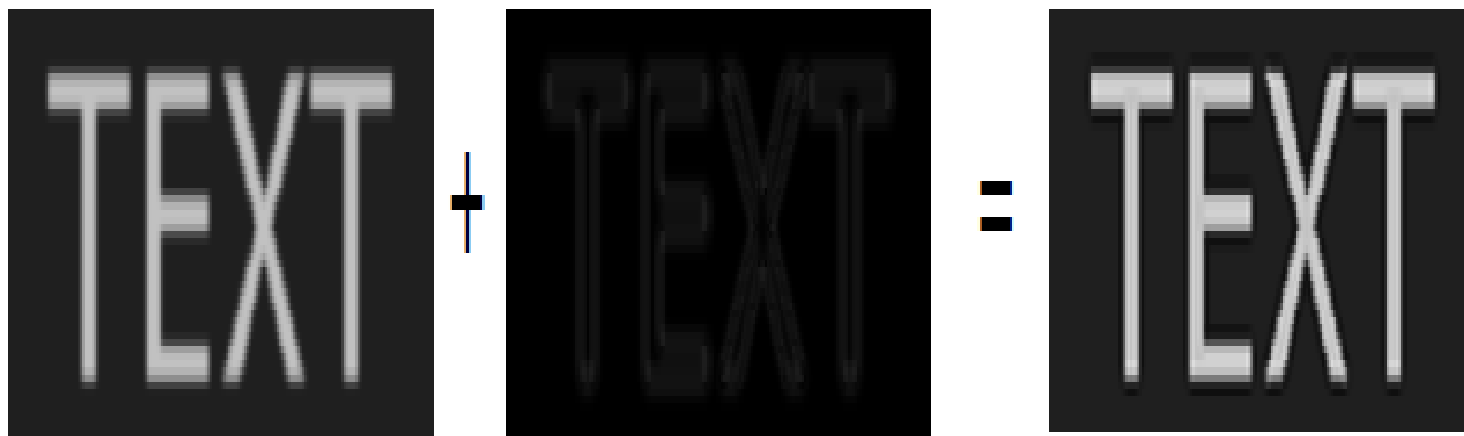
Sharpening Filters: Unsharp Masking

- In general, a sharp image can be obtained by subtracting a lowpass filtered image from the original image:

$$\textit{Highpass} = \textit{Original} - \textit{Lowpass}$$



ADDING HIGH PASS FILTER TO INPUT IMAGE



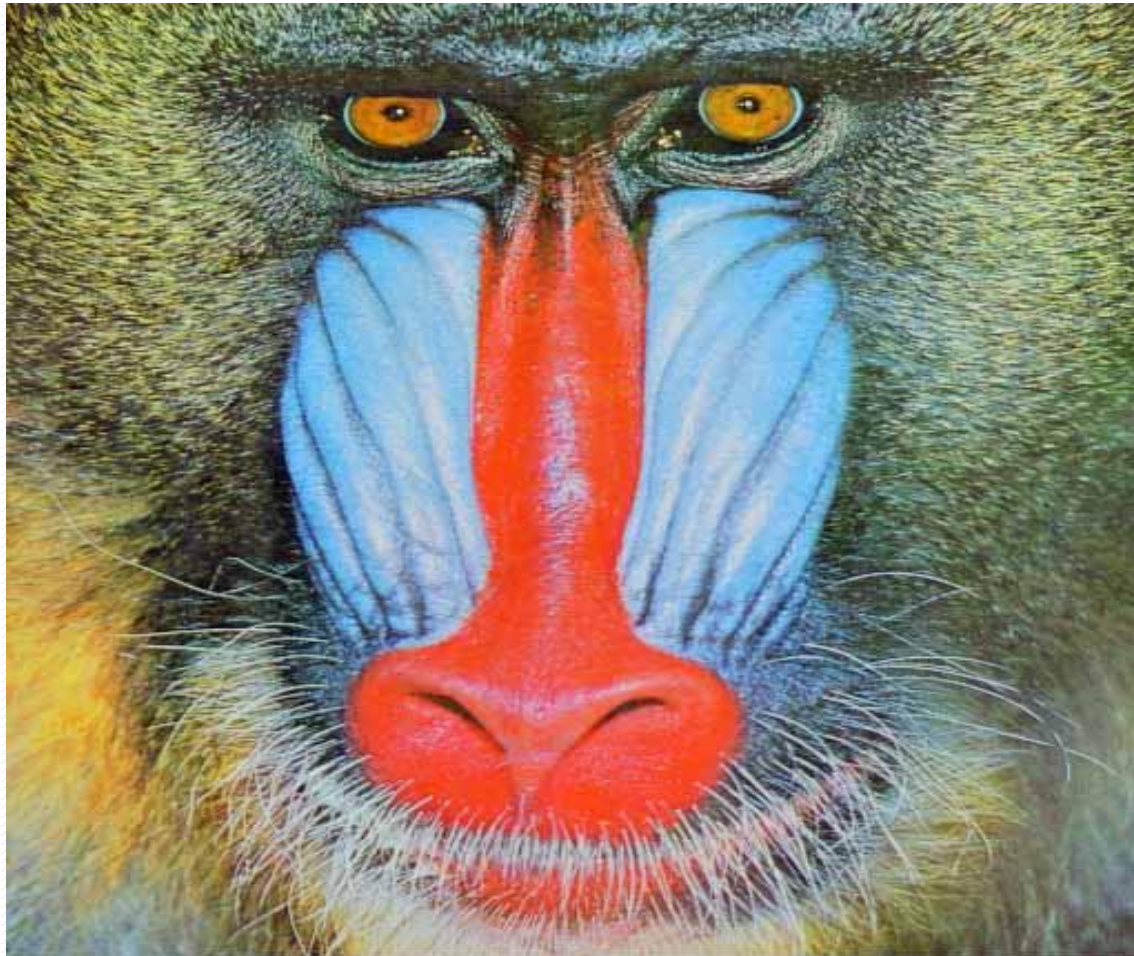
TYPES OF IMAGES

1) Smooth Images



TYPES OF IMAGES

1) EDGY Images



LOW Pass Filter and High Pass Filter

- 1) Smoothing Filter is known as Low Pass Filter
- 2) Sharpening Filter is known as High Pass Filter