CO543 - Image Processing
Lab 03

---

1. Filtering

Filtering is the process of replacing a pixel with a value based on some operations or functions.

The functions/operations used on an original image = **FILTERS**

2. Uses of Filters

- To suppress the high frequencies in an image
    - Smoothing the image
- To suppress the low frequencies in an image
    - Enhancing / detecting edges

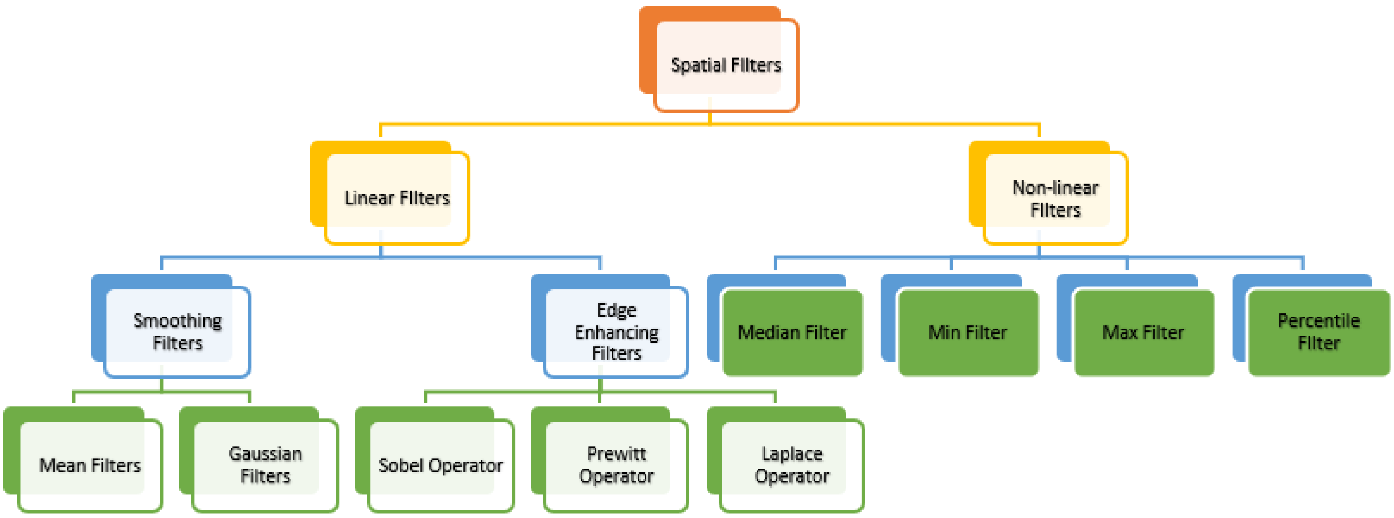
3. Filters

1. **Spatial Domain**
    - Filters are based on direct manipulation of pixels on an image plane
2. **Frequency Domain**
    - Filters are based on modifying the Fourier transform (FT) of an image.

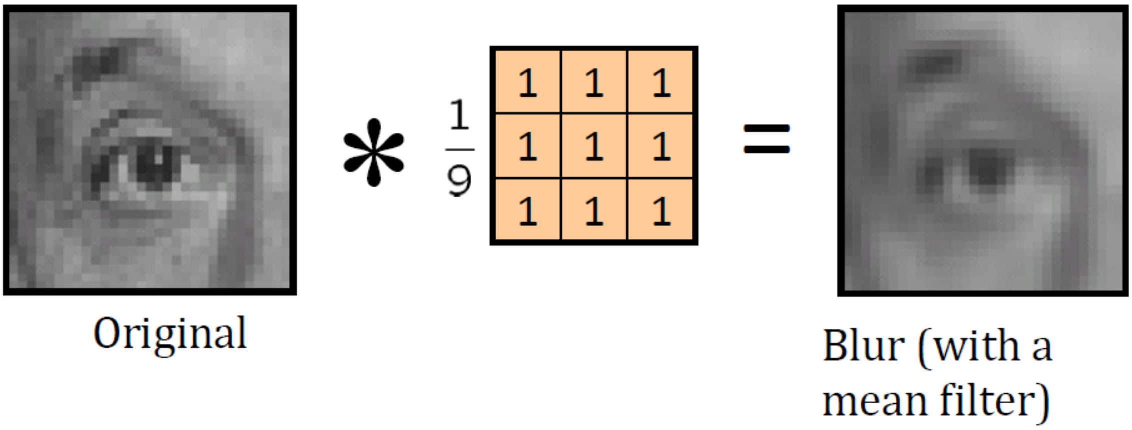
4. Spatial Filters

A spatial filter consists of

- **A neighborhood** - a small rectangular region
- **A predefined operation** - performed on the image pixels covered by the neighborhood



5. Mean Filters



$H * F = G$

H

F

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

G

	0	10	20	30	30	30	20	10	
	0	20	40	60	60	60	40	20	
	0	30	60	90	90	90	60	30	
	0	30	50	80	80	90	60	30	
	0	30	50	80	80	90	60	30	
	0	20	30	50	50	60	40	20	
	10	20	30	30	30	30	20	10	
	10	10	10	0	0	0	0	0	

6. MedianFilters

- Replace a pixel value with the median of its neighboring pixel values

Neighborhood values:
15, 19, 20, 23,
24, 25, 26, 27, 50

Median value: 24

	23	25	26	30	40	
	22	**24**	**26**	**27**	35	
	18	**20**	**50**	**25**	34	
	19	**15**	**19**	**23**	33	
	11	16	10	20	30	

7. Gaussian Filters

This filter is a 2-D convolution operator. It is used to blur images. Also, it removes details and noises. The Gaussian filter is similar to the mean filter. But the main difference is, Gaussian filters use a kernel.

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

1/16

1	2	1
2	4	2
1	2	1

3x3 kernel

1/173

1	4	7	4	1
4	16	26	16	4
7	26	41	26	7
4	16	26	16	4
1	4	7	4	1

5x5 kernel

3X3 Kernel

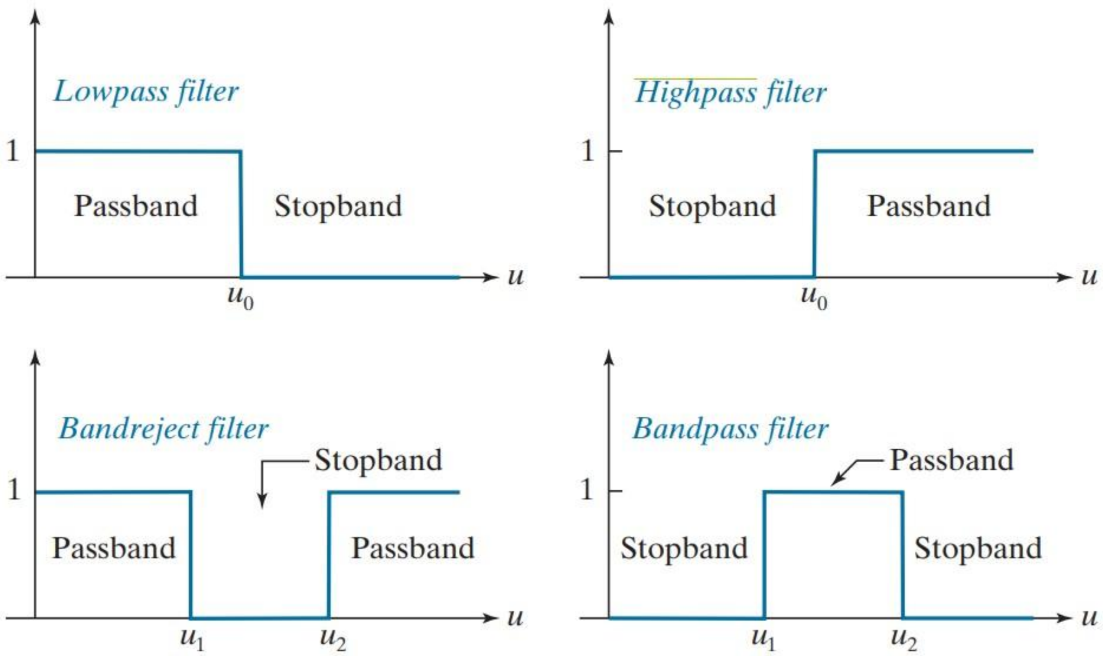
5x5 Kernel

8. Lowpass Filters

Low pass filtering is employed to remove high spatial frequency noise from a digital image. The low-pass filters usually employ a moving window operator which affects one pixel of the image at a time, changing its value by some function of a local region (window) of pixels.

9. Highpass Filters

A high-pass filter can be used to make an image appear sharper. These filters emphasize fine details in the image - the opposite of the low-pass filter. High-pass filtering works in the same way as low-pass filtering; it just uses a different convolution kernel.

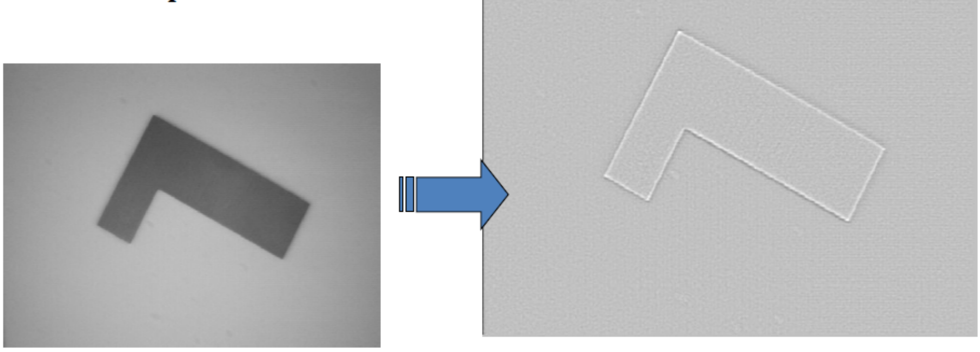


10. Laplacian Filters

Second derivative of a two dimensional function f(x,y)

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$
$$= [f(x+1,y)+f(x-1,y)+f(x,y+1)+f(x,y-1)]$$
$$-4f(x,y)$$

– example:



Since the input image is represented as a set of discrete pixels, we have to find a discrete convolution kernel that can approximate the second derivatives in the definition of Laplacian.
Three commonly used small kernels are as below

0	1	0
1	−4	1
0	1	0

1	1	1
1	−8	1
1	1	1

−1	2	−1
2	−4	2
−1	2	−1

Because these kernels are approximating a second derivative measurement on the image, they are very sensitive to noise. To counter this, the image is often Gaussian Smoothed before applying the Laplacian filter. This preprocessing step reduces the high frequency noise components prior to the differentiation step.

Lab Task

Apply Denoising Filters

In this lab, you will study the performance of the filters in denoising images.

Write your own functions. You can use an image which is photographs corrupted with different types of noise (a sample image is given in the course page).

Try to reduce the effect of noise from each of them by applying:

1. Apply Mean filtering with mask size 3x3 and 5x5
2. Apply Highpass filtering with mask size 3x3 and 5x5
3. Apply lowpass filtering with mask size 3x3 and 5x5
4. A bilateral filter with mask size 5×5 with appropriate values of σ and , set 2 d σr 2 through experimentation.
5. A Gaussian filter with mask size 5×5 appropriate values of σ .
6. A laplacian filter with mask size 5×5 appropriate values of σ .
7. A median filter of appropriate window size. Verify your implementation with OpenCV filtering functions.

** Once the filtering is done, observe the changes in the histogram of the images and write your observations. Compare the point down below.

- Original image with the Filtered image
- Original histogram with the Filtered image histogram

Submission

You need to submit all python files containing the relevant functions named according to the relevant question names or as indicated in the lab sheet, along with the main function to run them and display your outputs. Make sure to include the images you used to run the codes as well.

You need to submit a report (e17XXXresults.pdf) including

- Screenshots for the codes
- all results from your code (your input and output images under each section after performing the required functions).
- Necessary explanations

under every part of the lab task.

You can submit a single ZIP file as e17XXXlab03.zip including all:

- Python source codes
- All Input images
- Report

Note: XXX indicates your registration number in all cases.