



Smoothing filters

- Linear Smoothing Filters
 1. Mean Filter (Average Filter)
 2. Gaussian Filter
 3. Box Filter

```
In [ ]: import cv2
import numpy as np
from matplotlib import pyplot as plt
```

```
In [ ]: from google.colab import drive
drive.mount('/content/drive')
```

Mounted at /content/drive

```
In [ ]: # Load image (grayscale for simplicity)
img = cv2.imread("/content/drive/MyDrive/Engineering/Sem5/PCV/PR2/saltandpepp

mean_filter = cv2.blur(img, (15, 15)) # 15x15 kernel

# 2. Box Filter - larger kernel
box_filter = cv2.boxFilter(img, -1, (15, 15), normalize=True)

# 3. Gaussian Filter - larger kernel & sigma
gaussian_filter = cv2.GaussianBlur(img, (15, 15), 5) # 15x15 kernel, sigma=

# Show results using matplotlib
titles = ['Original', 'Mean Filter', 'Box Filter', 'Gaussian Filter']
images = [img, mean_filter, box_filter, gaussian_filter]

plt.figure(figsize=(10,6))
for i in range(4):
    plt.subplot(2, 2, i+1)
    plt.imshow(images[i], cmap='gray')
    plt.title(titles[i])
    plt.axis('off')

plt.tight_layout()
plt.show()
```

Original



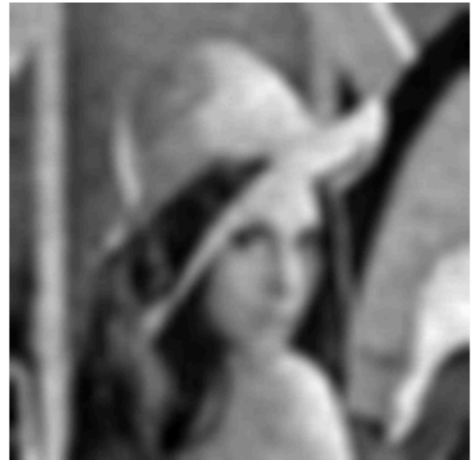
Mean Filter



Box Filter



Gaussian Filter



- Non-Linear Smoothing Filters

1. Median Filter
2. Mode Filter
3. Bilateral Filter

```
In [ ]: median_filter = cv2.medianBlur(img, 9)    # kernel size 9

# 2. Bilateral Filter - smooths while preserving edges
bilateral_filter = cv2.bilateralFilter(img, d=15, sigmaColor=80, sigmaSpace=80)

# Show results using matplotlib
titles = ['Original', 'Median Filter (k=9)', 'Bilateral Filter (d=15,  $\sigma_c$ =80,  $\sigma_s$ =80)']
images = [img, median_filter, bilateral_filter]

plt.figure(figsize=(12, 6))
for i in range(3):
    plt.subplot(1, 3, i+1)
    plt.imshow(images[i], cmap='gray')
```

```
plt.title(titles[i])
plt.axis('off')

plt.tight_layout()
plt.show()
```



- Edge-Preserving and Adaptive Filters

```
In [ ]: img = cv2.imread("/content/drive/MyDrive/Engineering/Sem5/PCV/PR2/saltandpepp")
img_color = cv2.imread("/content/drive/MyDrive/Engineering/Sem5/PCV/PR2/Image")

# 1. Edge Preserving Filter (already demonstrated, but including for completeness)
edge_preserving = cv2.edgePreservingFilter(img, flags=1, sigma_s=60, sigma_r=60)

# 2. Fast Non-local Means Denoising (for grayscale images)
fast_nl_means = cv2.fastNlMeansDenoising(img, None, 30, 7, 21)

# 3. Fast Non-local Means Denoising Colored (for color images)
fast_nl_means_color = cv2.fastNlMeansDenoisingColored(img_color, None, 10, 10, 30, 7, 21)

# Convert the color denoised image to grayscale for plotting alongside others
fast_nl_means_color_gray = cv2.cvtColor(fast_nl_means_color, cv2.COLOR_BGR2GRAY)

titles = ['Original (Gray)', 'Edge Preserving Filter', 'Fast NlMeans Denoising', 'Fast NlMeans Denoising Colored']
images = [img, edge_preserving, fast_nl_means, fast_nl_means_color_gray]

plt.figure(figsize=(15, 8))
for i in range(4):
    plt.subplot(2, 2, i+1)
    plt.imshow(images[i], cmap='gray')
    plt.title(titles[i])
    plt.axis('off')

plt.tight_layout()
plt.show()
```

Original (Gray)



Edge Preserving Filter



Fast NlMeans Denoising (Gray)



Fast NlMeans Denoising (Color - Grayed)



- Frequency Domain Filters

```
In [ ]: # Frequency Domain Filters

# Load the image (grayscale is common for frequency domain analysis)
img_freq = cv2.imread("/content/drive/MyDrive/Engineering/Sem5/IPC/PR2/saltar

# Perform FFT to get the frequency domain representation
# The output will be a 2D complex array
dft = cv2.dft(np.float32(img_freq), flags=cv2.DFT_COMPLEX_OUTPUT)

# Shift the zero-frequency component to the center of the spectrum
dft_shift = np.fft.fftshift(dft)

# Calculate the magnitude spectrum for visualization
# This gives a visual representation of the frequencies present in the image
magnitude_spectrum = 20 * np.log(cv2.magnitude(dft_shift[:, :, 0], dft_shift[:, :, 1]))

# Now, apply a filter in the frequency domain
# For example, let's create a simple ideal Low-Pass Filter (LPF)
rows, cols = img_freq.shape
crow, ccol = int(rows / 2), int(cols / 2) # Center of the spectrum
```

```

# Create a mask for the filter
mask = np.zeros((rows, cols, 2), np.uint8)
r = 30 # Radius of the filter (determines the cutoff frequency)
center = [crow, ccol]
x, y = np.ogrid[:rows, :cols]
mask_area = (x - center[0]) ** 2 + (y - center[1]) ** 2 <= r*r
mask[mask_area] = 1

# Apply the mask to the shifted spectrum
fshift = dft_shift * mask

# Shift the zero-frequency component back for the inverse FFT
f_ishift = np.fft.ifftshift(fshift)

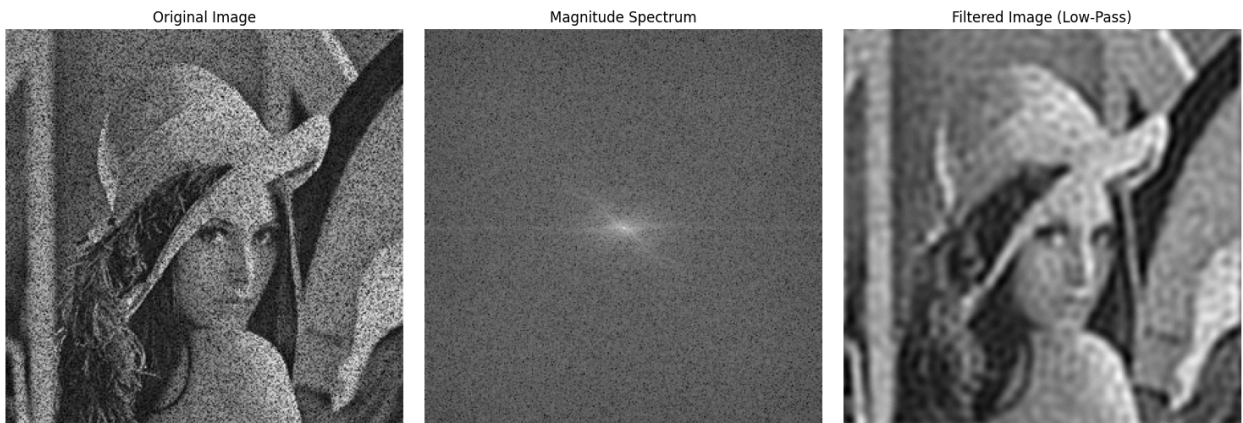
# Perform inverse FFT to get the filtered image back in the spatial domain
img_back = cv2.idft(f_ishift, flags=cv2.DFT_SCALE | cv2.DFT_REAL_OUTPUT)
img_back = np.clip(img_back, 0, 255).astype(np.uint8) # Clip values and convert

# Show results
titles = ['Original Image', 'Magnitude Spectrum', 'Filtered Image (Low-Pass)']
images = [img_freq, magnitude_spectrum, img_back]

plt.figure(figsize=(15, 5))
for i in range(3):
    plt.subplot(1, 3, i+1)
    plt.imshow(images[i], cmap='gray')
    plt.title(titles[i])
    plt.axis('off')

plt.tight_layout()
plt.show()

```



Sharpening

```

In [ ]: # 1. Laplacian Filter
laplacian = cv2.Laplacian(img, cv2.CV_64F)
laplacian = cv2.convertScaleAbs(laplacian)

```



```

laplacian_sharp = cv2.addWeighted(img, 1, laplacian, -1, 0)

# 2. Unsharp Masking
blurred = cv2.GaussianBlur(img, (5,5), 1.0)
unsharp = cv2.addWeighted(img, 1.5, blurred, -0.5, 0)

# 3. High-Boost Filtering (A=2)
A = 2
blurred_hb = cv2.GaussianBlur(img, (5,5), 1.0)
mask = cv2.subtract(img, blurred_hb)
high_boost = cv2.add(img, A * mask)

# 4. Gradient Filters
# Sobel
sobelx = cv2.Sobel(img, cv2.CV_64F, 1, 0, ksize=3)
sobely = cv2.Sobel(img, cv2.CV_64F, 0, 1, ksize=3)
sobel = cv2.magnitude(sobelx, sobely)

# Prewitt
kernelx = np.array([[ -1, 0, 1], [ -1, 0, 1], [ -1, 0, 1]])
kernely = np.array([[ -1, -1, -1], [ 0, 0, 0], [ 1, 1, 1]])
prewittx = cv2.filter2D(img, -1, kernelx)
prewitty = cv2.filter2D(img, -1, kernely)
prewitt = cv2.magnitude(prewittx.astype(float), prewitty.astype(float))

# Roberts
roberts_cross_v = np.array([[1, 0], [0, -1]])
roberts_cross_h = np.array([[0, 1], [-1, 0]])
roberts_v = cv2.filter2D(img, -1, roberts_cross_v)
roberts_h = cv2.filter2D(img, -1, roberts_cross_h)
roberts = cv2.magnitude(roberts_v.astype(float), roberts_h.astype(float))

# 5. High-Pass Filter (Spatial Domain Kernel)
hp_kernel = np.array([[ -1, -1, -1], [ -1, 8, -1], [ -1, -1, -1]])
high_pass_spatial = cv2.filter2D(img, -1, hp_kernel)

# 6. High-Pass Filter (Frequency Domain)
f = np.fft.fft2(img)
fshift = np.fft.fftshift(f)
rows, cols = img.shape
crow, ccol = rows//2, cols//2
mask = np.ones((rows, cols), np.uint8)
r = 30 # radius for low-pass cutoff
mask[crow-r:crow+r, ccol-r:ccol+r] = 0
fshift = fshift * mask
f_ishift = np.fft.ifftshift(fshift)
img_back = np.fft.ifft2(f_ishift)
high_pass_freq = np.abs(img_back)

# Show all results
titles = ["Original", "Laplacian", "Unsharp", "High-Boost",
          "Sobel", "Prewitt", "Roberts",
          "High-Pass Spatial", "High-Pass Frequency"]

```

```

images = [img, laplacian_sharp, unsharp, high_boost,
          sobel, prewitt, roberts,
          high_pass_spatial, high_pass_freq]

plt.figure(figsize=(15,10))
for i in range(len(images)):
    plt.subplot(3,3,i+1), plt.imshow(images[i], cmap='gray')
    plt.title(titles[i])
    plt.axis("off")
plt.show()

```

Original



Laplacian



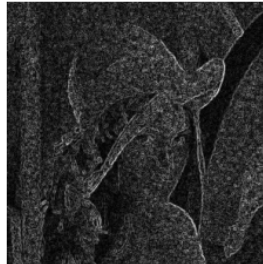
Unsharp



High-Boost



Sobel



Prewitt



Roberts



High-Pass Spatial



High-Pass Frequency

