SIES (NERUL) COLLEGE OF ARTS, SCIENCE AND COMMERCE NERUL, NAVI MUMBAI-400706

DEPARTMENT OF COMPUTER SCIENCE

MSc(CS) PART-1 SEMESTER I

Practical Journal

in

APPLIED SIGNAL AND IMAGE PROCESSING

Submitted by

Anuj Sanjay Jambhale

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NAAC Re-Accredited 'A' Grade

Sri Chandrasekarendra Saraswathy

Vidyapuram, Plot 1-C, Sector V,

Nerul, Navi Mumbai-400 706.

CERTIFICATE

This is to certify that **Anuj Jambhale** of **Part-1(Sem-1) Masters in Science (Computer Science)** has completed the practical work in the subject **Applied Signal and Image Processing** as per the requirement of University of Mumbai in part fulfillment for the completion of PG Degree of Masters of Science (Computer Science) during the academic year 2023-2024.

Roll Number: **06** Date of Submission:

Subject: **Applied Signal and Image Processing**

Prof. Aditya Jinturkar Date: _____

(Subject Teacher)

INDEX

10	Write the program to apply segmentation for detecting lines, circles, and other shapes/objects. Also, implement edge-based and region-based segmentation.	46

Applied Signal & Image Processing Practicals

Practical-1:

Write program to demonstrate the following aspects of signal processing on suitable data.

1. Upsampling and downsampling on Image/speech signal
2. Fast Fourier Transform to compute DFT

- **Up-Sampling**

```
im = Image.open("../images/clock.jpg") # the original small clock image
pylab.imshow(im), pylab.show()
```


```
im1 = im.resize((im.width*5, im.height*5), Image.NEAREST) # nearest neighbor interpolation
pylab.figure(figsize=(10,10)), pylab.imshow(im1), pylab.show()
```

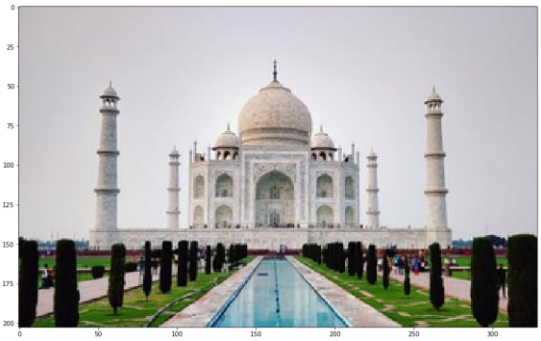

```
im1 = im.resize((im.width*5, im.height*5), Image.BILINEAR) # up-sample with bi-linear interpolation
pylab.figure(figsize=(10,10)), pylab.imshow(im1), pylab.show()
```

```
im.resize((im.width*10, im.height*10), Image.BICUBIC).show() # bi-cubic interpolation
pylab.figure(figsize=(10,10)), pylab.imshow(im1), pylab.show()
```

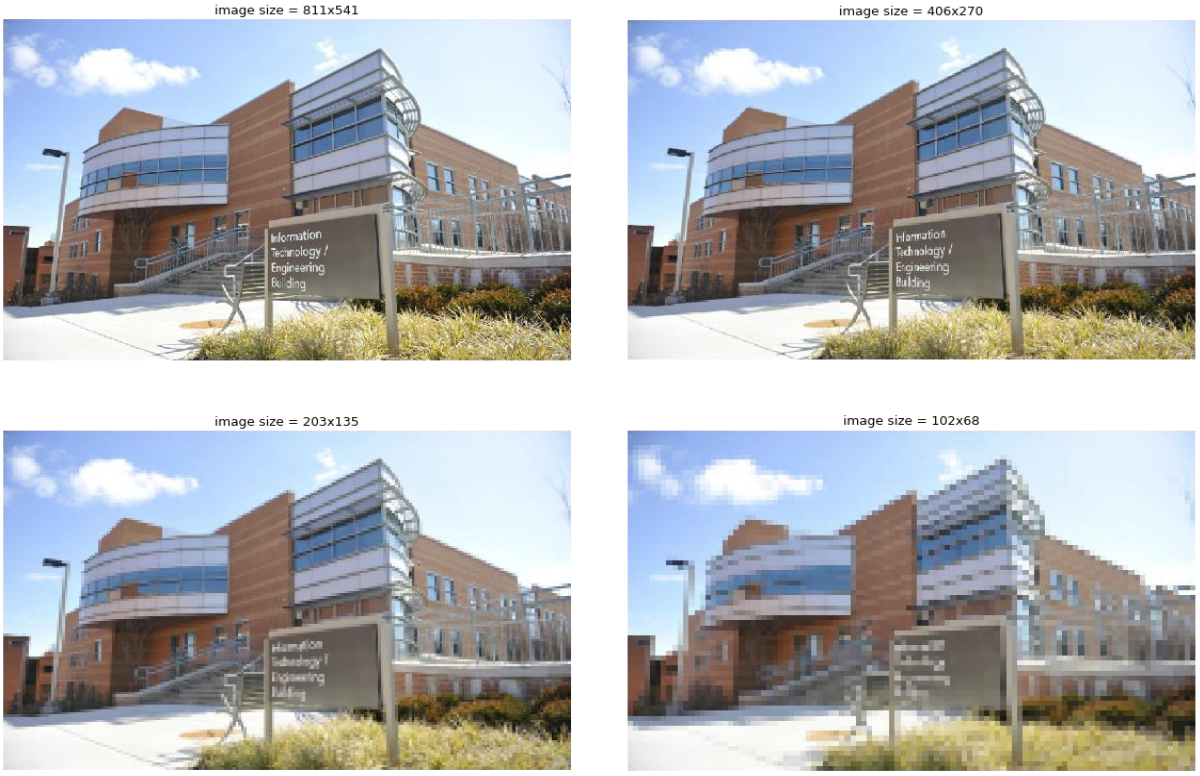
- **Down-sampling**

```
im = im.resize((im.width//5, im.height//5))
pylab.figure(figsize=(15,10)), pylab.imshow(im), pylab.show()
```

```
im = Image.open("../images/tajmahal.jpg")
im = im.resize((im.width//5, im.height//5), Image.ANTIALIAS)
pylab.figure(figsize=(15,10)), pylab.imshow(im), pylab.show()
```



```
im = imread('../images/umbc.png')
im1 = im.copy()
pylab.figure(figsize=(20,15))
for i in range(4):
    pylab.subplot(2,2,i+1), pylab.imshow(im1, cmap='gray'), pylab.axis('off')
    pylab.title('image size = ' + str(im1.shape[1]) + 'x' + str(im1.shape[0]))
    im1 = rescale(im1, scale = 0.5, multichannel=True,
    anti_aliasing=False)
pylab.subplots_adjust(wspace=0.1, hspace=0.1)
pylab.show()
```



- **FFT with the numpy.fft module**

```
import numpy.fft as fp
im1 = rgb2gray(imread('../images/house.png'))
pylab.figure(figsize=(12,10))
freq1 = fp.fft2(im1)
im1_ = fp.ifft2(freq1).real
```

```
pylab.subplot(2,2,1), pylab.imshow(im1, cmap='gray'), pylab.title('Original Image', size=20)
pylab.subplot(2,2,2), pylab.imshow(20*np.log10( 0.01 +
np.abs(fp.fftshift(freq1))), cmap='gray')
pylab.title('FFT Spectrum Maginitude', size=20)
pylab.subplot(2,2,3), pylab.imshow(np.angle(fp.fftshift(freq1)),cmap='gray')
pylab.title('FFT Phase', size=20)
pylab.subplot(2,2,4), pylab.imshow(np.clip(im1_,0,255), cmap='gray')
pylab.title('Reconstructed Image', size=20)
pylab.show()
```

Image 1:

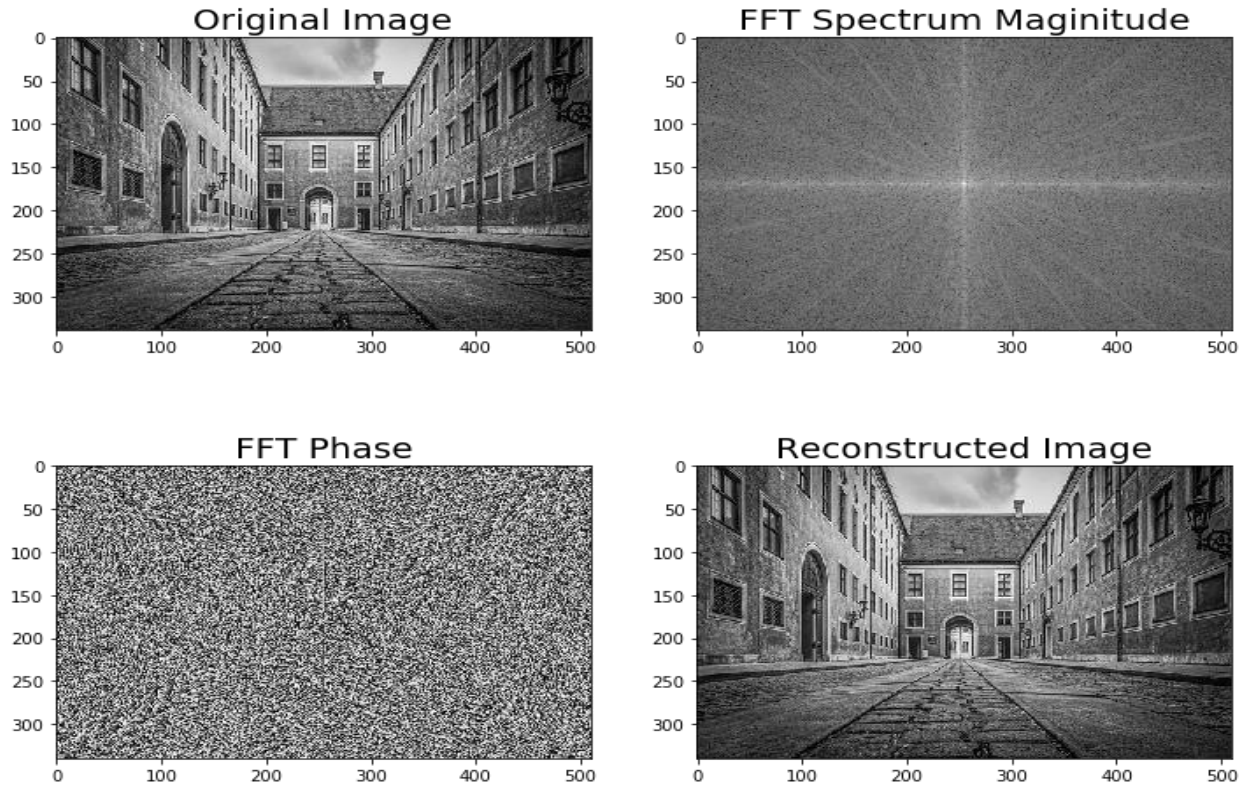
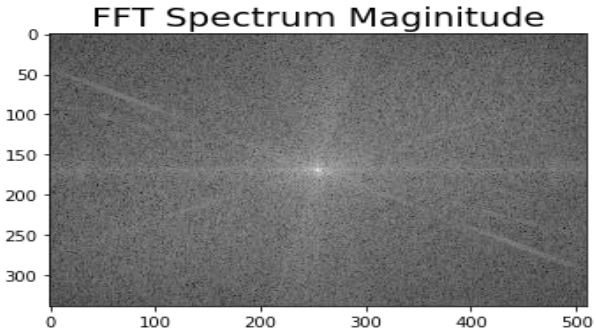
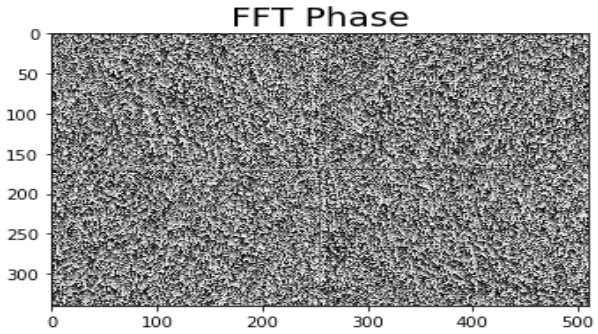
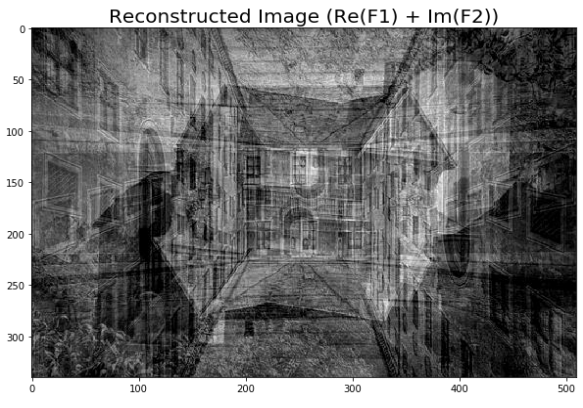


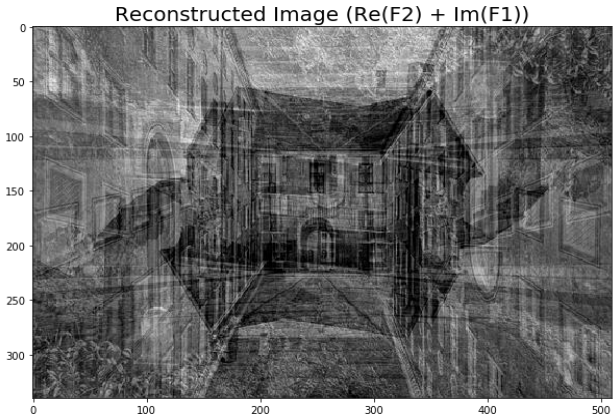
Image 2:






```
pylab.figure(figsize=(20,15))
im1_ = fp.ifft2(np.vectorize(complex)(freq1.real, freq2.imag)).real
im2_ = fp.ifft2(np.vectorize(complex)(freq2.real, freq1.imag)).real
pylab.subplot(211), pylab.imshow(np.clip(im1_,0,255), cmap='gray')
pylab.title('Reconstructed Image (Re(F1) + Im(F2))', size=20)
pylab.subplot(212), pylab.imshow(np.clip(im2_,0,255), cmap='gray')
pylab.title('Reconstructed Image (Re(F2) + Im(F1))', size=20)
pylab.show()
```





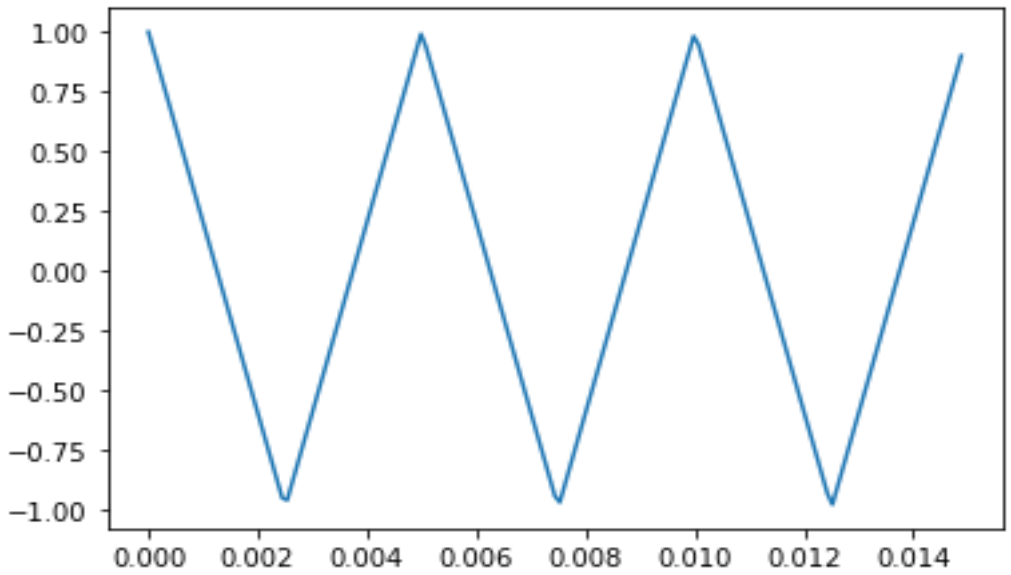
Practical-2:

Write program to perform the following on signal

1. Create a triangle signal and plot a 3-period segment.
2. For a given signal, plot the segment and compute the correlation between them.

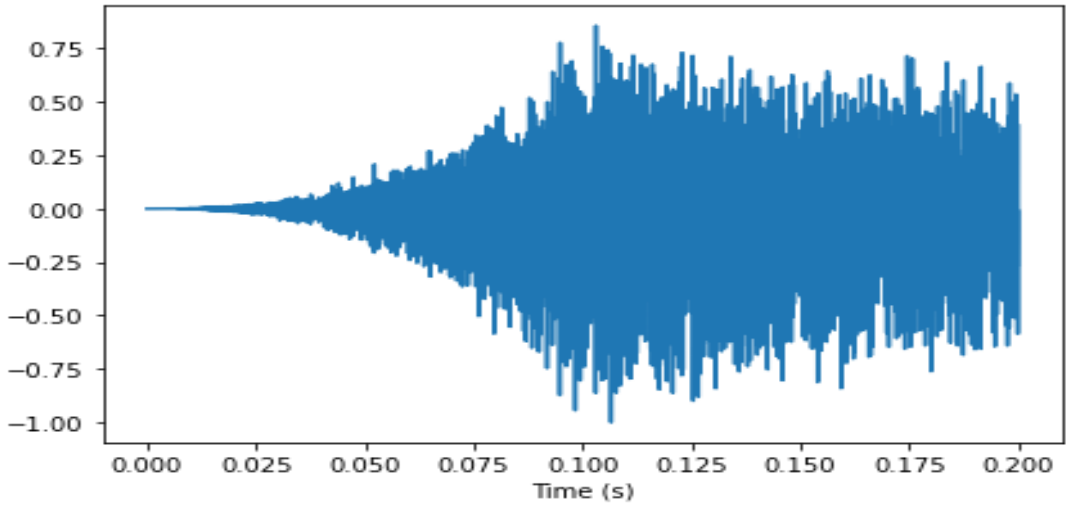
- **Create a triangle signal and plot a 3-period segment.**

```
import os
if not os.path.exists('thinkdsp.py'):
!wget https://github.com/AllenDowney/ThinkDSP/raw/master/code/thinkdsp.py

import thinkdsp
cos_sig=thinkdsp.CosSignal(freq=440,amp=1.0,offset=0)
sin_sig=thinkdsp.SinSignal(freq=880,amp=0.5,offset=0)

mix=cos_sig + sin_sig
wave = mix.make_wave(duration=0.5,start=0,framerate=11025)

period = mix.period
segment = wave.segment(start=0 , duration=period*3)
spectrum=wave.make_spectrum()
spectrum.plot()

signal=thinkdsp.TriangleSignal(200)
signal.plot()
wave= signal.make_wave(framerate=11025)
spectrum=wave.make_spectrum()
spectrum.plot()
```



- **For a given signal, plot the segment and compute the correlation between them.**

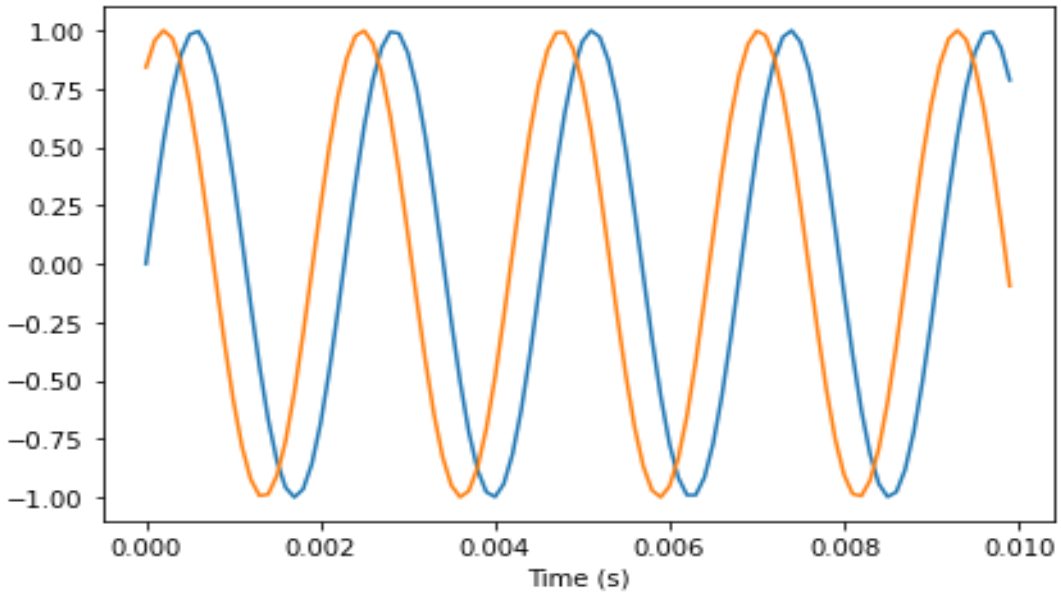
```
start = 0.0
duration = 0.2
segment = wave.segment(start, duration)
segment.plot()
decorate(xlabel='Time (s)')
```

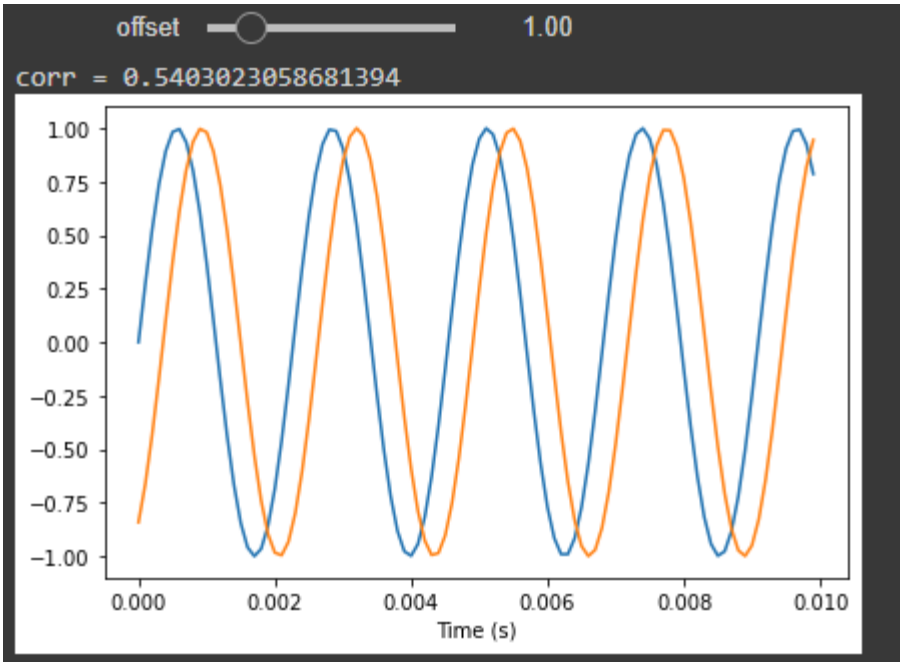



```
import numpy as np
import matplotlib.pyplot as plt

from thinkdsp import decorate

from thinkdsp import SinSignal

def make_sine(offset):
    signal = SinSignal(freq=440, offset=offset)
    wave = signal.make_wave(duration=0.5, framerate=10000)
    return wave

wave1 = make_sine(offset=0)
wave2 = make_sine(offset=1)

wave1.segment(duration=0.01).plot()
wave2.segment(duration=0.01).plot()
decorate(xlabel='Time (s)')

wave1.corr(wave2)
```

```
0.5403023058681397
```

```
def compute_corr(offset):
    wave1 = make_sine(offset=0)
    wave2 = make_sine(offset=-offset)

    wave1.segment(duration=0.01).plot()
    wave2.segment(duration=0.01).plot()

    corr = wave1.corr(wave2)
    print('corr =', corr)

    decorate(xlabel='Time (s)')

from ipywidgets import interact, interactive, fixed
import ipywidgets as widgets

PI2 = np.pi * 2
slider = widgets.FloatSlider(min=0, max=PI2, value=1)
interact(compute_corr, offset=slider);
```




offset
1.00
corr = 0.5403023058681394
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
0.000
0.002
0.004
0.006
0.008
0.010
Time (s)

Practical-2:

Write a program to demonstrate the following aspects of signal on sound/image data.

1. Convolution operation
2. Template Matching

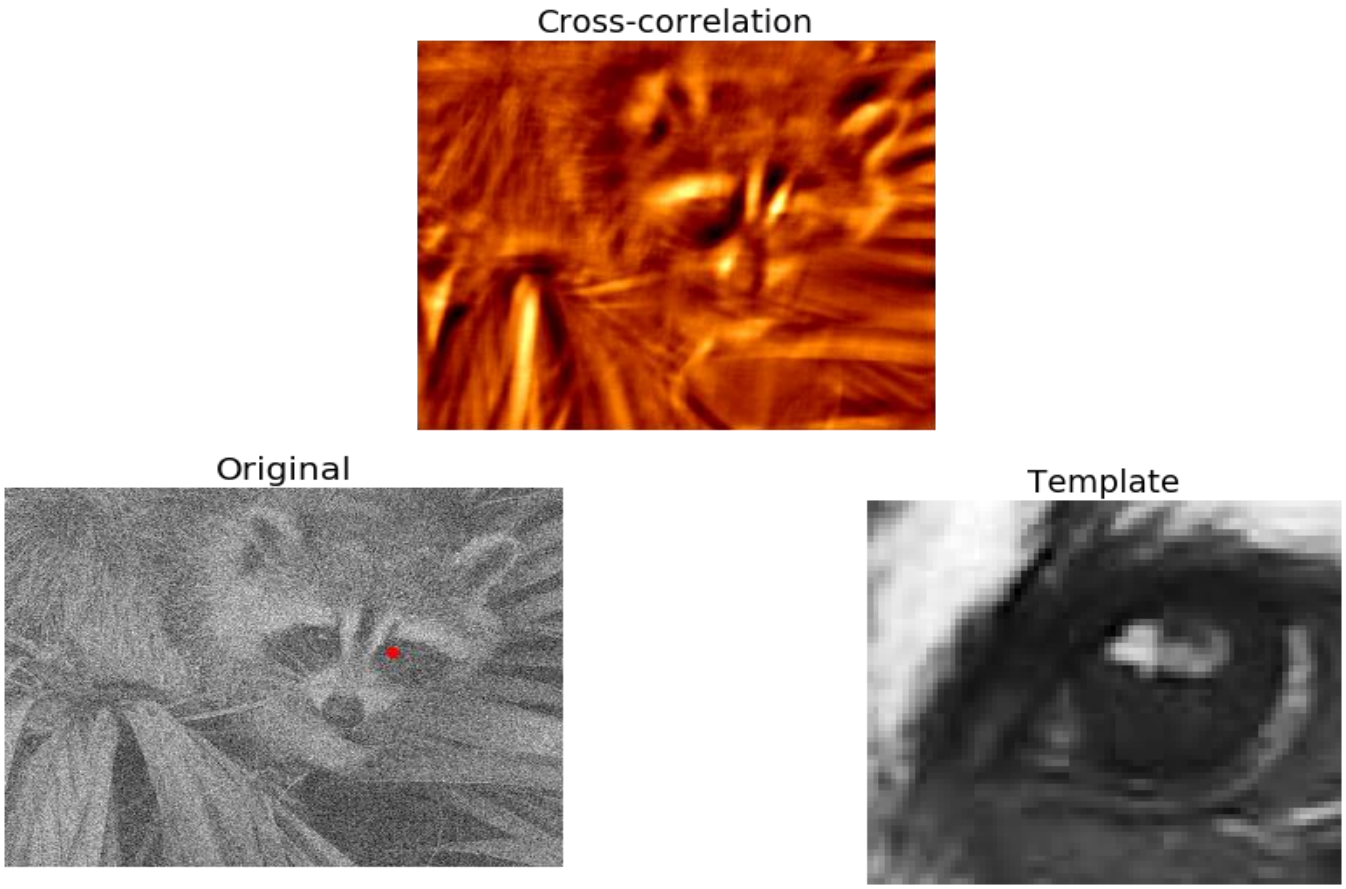
- **Applying convolution to a grayscale image**

```
im = rgb2gray(imread('../images/cameraman.jpg')).astype(float)
print(np.max(im))
print(im.shape)
blur_box_kernel = np.ones((3,3)) / 9
edge_laplace_kernel = np.array([[0,1,0],[1,-4,1],[0,1,0]])
im_blurred = signal.convolve2d(im, blur_box_kernel)
im_edges = np.clip(signal.convolve2d(im, edge_laplace_kernel), 0, 1)
fig, axes = pylab.subplots(ncols=3, sharex=True, sharey=True,
figsize=(18,6)) axes[0].imshow(im, cmap=pylab.cm.gray)
axes[0].set_title('Original Image', size=20)
axes[1].imshow(im_blurred, cmap=pylab.cm.gray)
axes[1].set_title('Box Blur', size=20)
axes[2].imshow(im_edges, cmap=pylab.cm.gray)
axes[2].set_title('Laplace Edge Detection', size=20)
for ax in axes:
    ax.axis('off')
pylab.show()
```

- **Template matching with cross-correlation between the image and template**

```
face_image = misc.face(gray=True) - misc.face(gray=True).mean()
template_image = np.copy(face_image[300:365, 670:750]) # right eye
template_image -= template_image.mean()
face_image = face_image + np.random.randn(*face_image.shape) * 50 # add random noise
```

```
correlation = signal.correlate2d(face_image, template_image, boundary='symm', mode='same')
y, x = np.unravel_index(np.argmax(correlation), correlation.shape) # find the match
fig, (ax_original, ax_template, ax_correlation) = pylab.subplots(3, 1, figsize=(6, 15))
ax_original.imshow(face_image, cmap='gray')
ax_original.set_title('Original', size=20)
ax_original.set_axis_off()
ax_template.imshow(template_image, cmap='gray')
ax_template.set_title('Template', size=20)
ax_template.set_axis_off()
ax_correlation.imshow(correlation, cmap='afmhot')
ax_correlation.set_title('Cross-correlation', size=20)
ax_correlation.set_axis_off()
ax_original.plot(x, y,
'ro') fig.show()
```



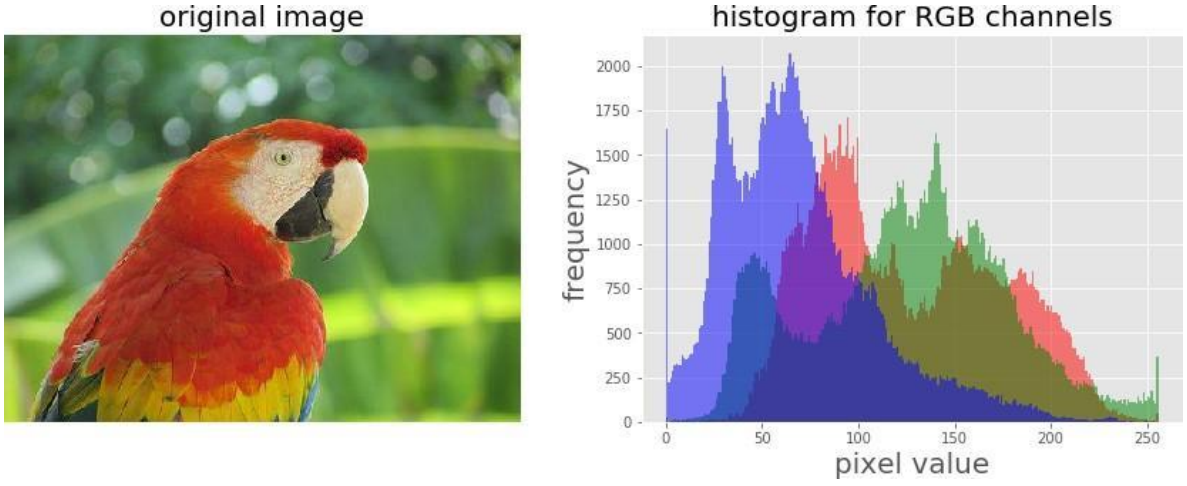
Practical-03:

Write program to implement point/pixel intensity transformations such as

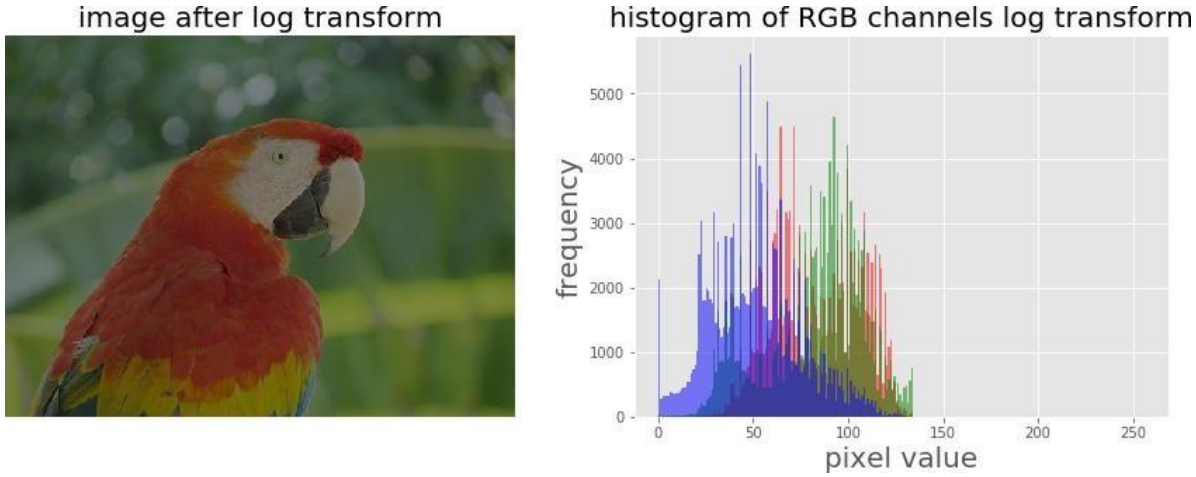
1. Log and Power-law transformations
2. Contrast adjustments
3. Histogram equalization
4. Thresholding, and halftoning operations

- **Log transform**

```
def plot_image(image, title=''):
    pylab.title(title, size=20), pylab.imshow(image)
    pylab.axis('off') # comment this line if you want axis ticks

def plot_hist(r, g, b, title=''):
    r, g, b = img_as_ubyte(r), img_as_ubyte(g), img_as_ubyte(b)
    pylab.hist(np.array(r).ravel(), bins=256, range=(0, 256), color='r', alpha=0.5)
    pylab.hist(np.array(g).ravel(), bins=256, range=(0, 256), color='g', alpha=0.5)
    pylab.hist(np.array(b).ravel(), bins=256, range=(0, 256), color='b', alpha=0.5)
    pylab.xlabel('pixel value', size=20), pylab.ylabel('frequency', size=20)
    pylab.title(title, size=20)

im = Image.open("../images/parrot.png")
im_r, im_g, im_b = im.split()
pylab.style.use('ggplot')
pylab.figure(figsize=(15,5))
pylab.subplot(121), plot_image(im, 'original image')
pylab.subplot(122), plot_hist(im_r, im_g, im_b,'histogram for RGB
channels') pylab.show()
```

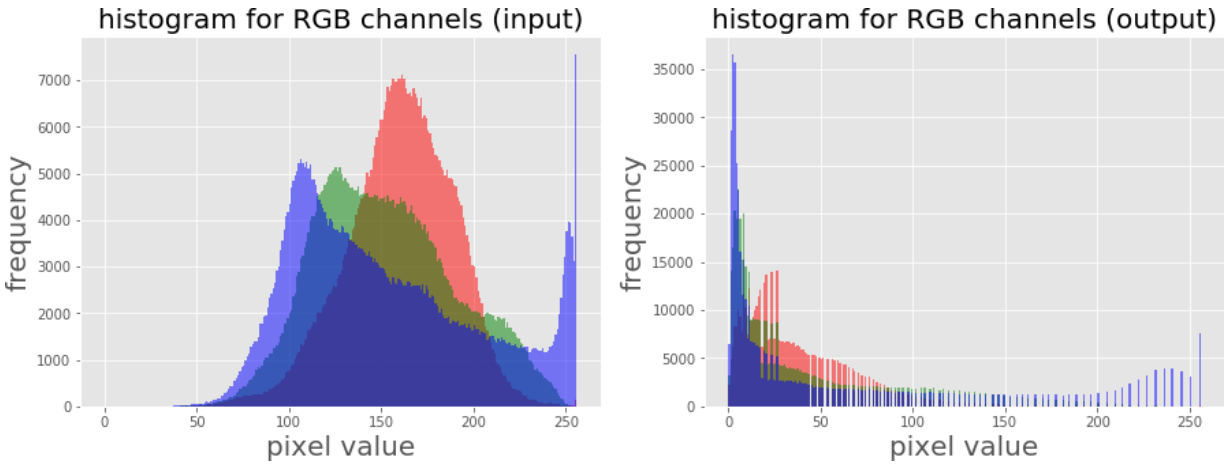


```
im = im.point(lambda i: 255*np.log(1+i/255))
im_r, im_g, im_b = im.split()
pylab.style.use('ggplot')
pylab.figure(figsize=(15,5))
pylab.subplot(121), plot_image(im, 'image after log transform')
pylab.subplot(122), plot_hist(im_r, im_g, im_b, 'histogram of RGB channels log
transform') pylab.show()
```



- **Power-law transform**

```
im =
img_as_float(imread('../images/earthfromsky.jpg'))
gamma = 5
im1 = im**gamma
pylab.style.use('ggplot')
pylab.figure(figsize=(15,5))
pylab.subplot(121), plot_hist(im[...,0], im[...,1], im[...,2], 'histogram for RGB channels (input)')
pylab.subplot(122), plot_hist(im1[...,0], im1[...,1], im1[...,2], 'histogram for RGB channels (output)')
pylab.show()
```

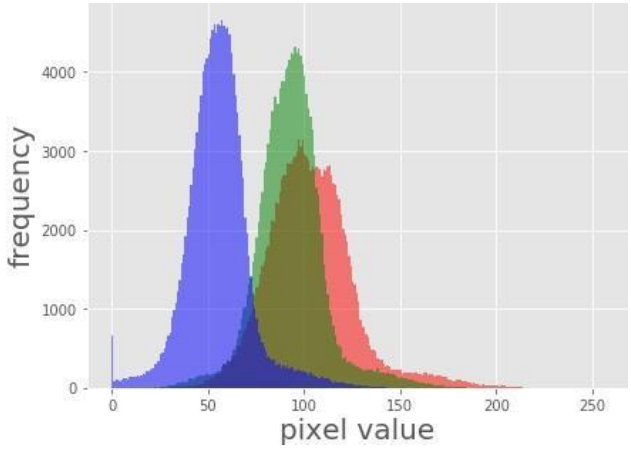


The input image (the Earth from the sky):

The output image ($\gamma = 5$):

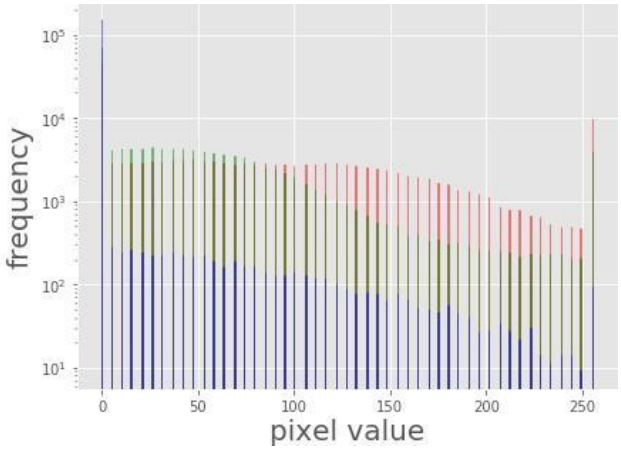
- **Contrast stretching with PIL as a point operation**

```
im = Image.open('../images/cheetah.png')
im_r, im_g, im_b, _ = im.split()
pylab.style.use('ggplot')
pylab.figure(figsize=(15,5))
pylab.subplot(121)
plot_image(im)
pylab.subplot(122)
plot_hist(im_r, im_g,
im_b) pylab.show()
```



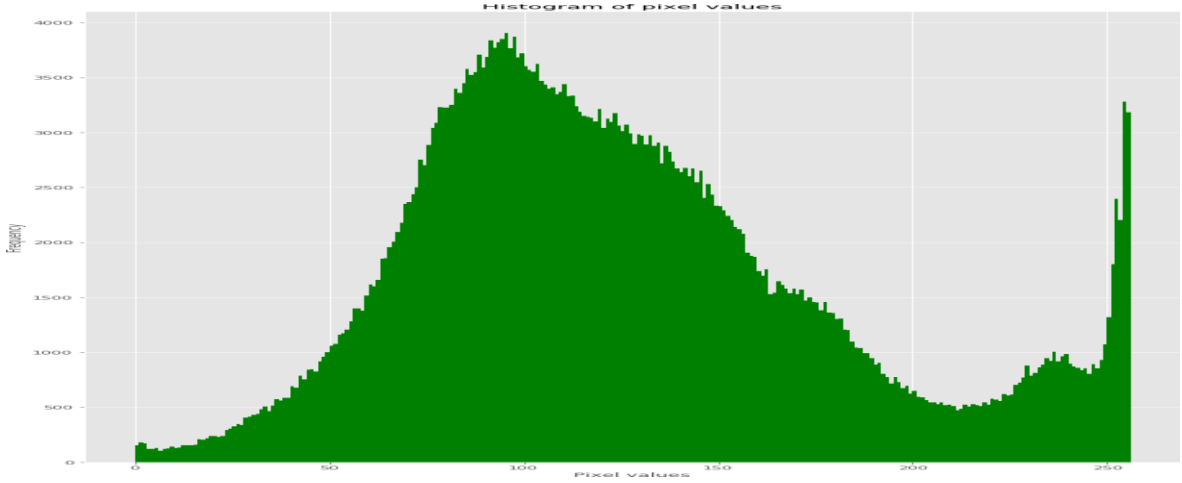

```
def contrast(c):
    return 0 if c < 70 else (255 if c > 150 else (255*c - 22950) / 48) # piece-wise linear function

im1 = im.point(contrast)
im_r, im_g, im_b, _ =
im1.split()
pylab.style.use('ggplot')
pylab.figure(figsize=(15,5))
pylab.subplot(121)
plot_image(im1)
```

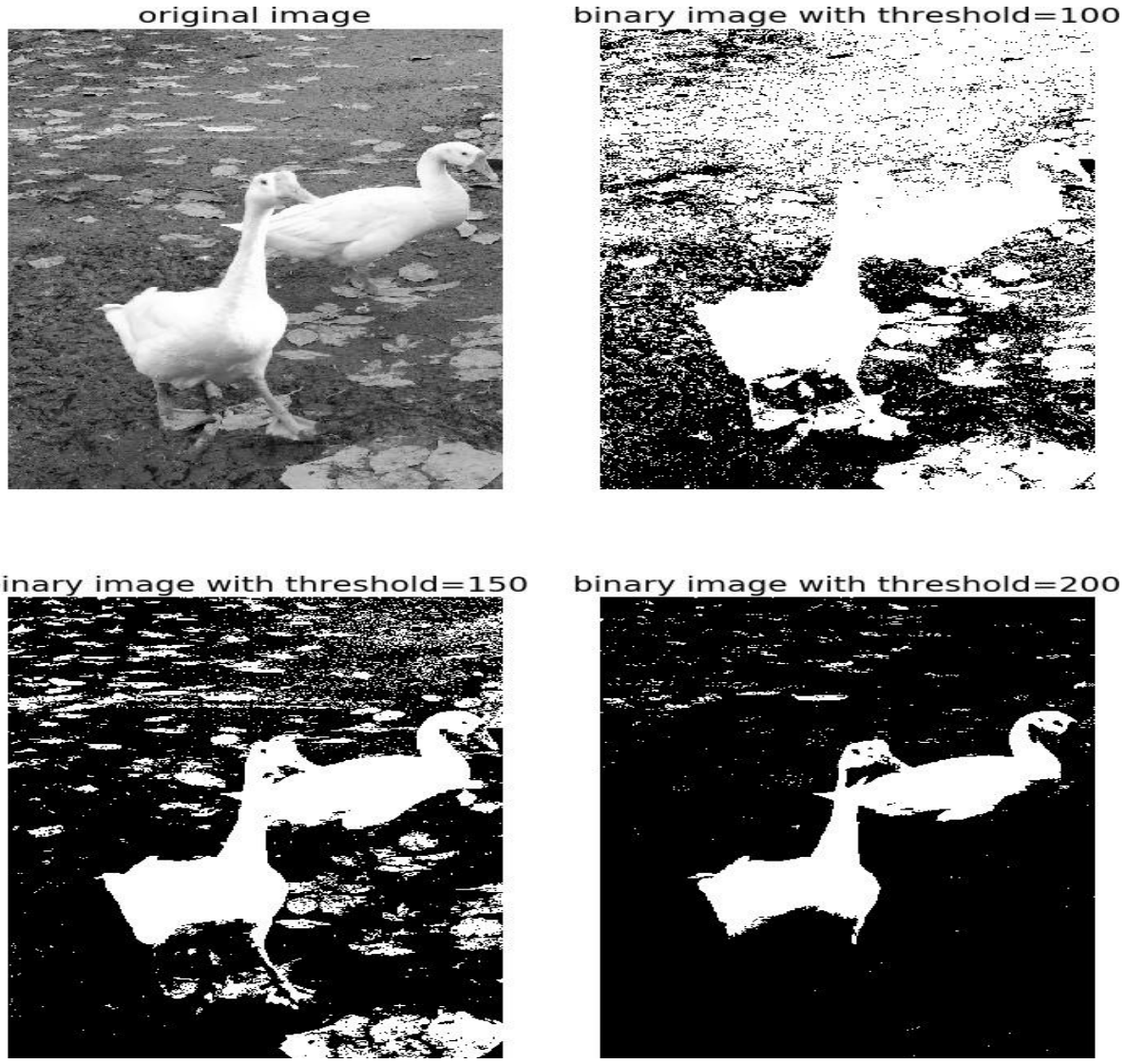
```
pylab.subplot(122)
plot_hist(im_r, im_g, im_b)
pylab.yscale('log',basey=10)
pylab.show()
```



- **Thresholding With a fixed threshold**

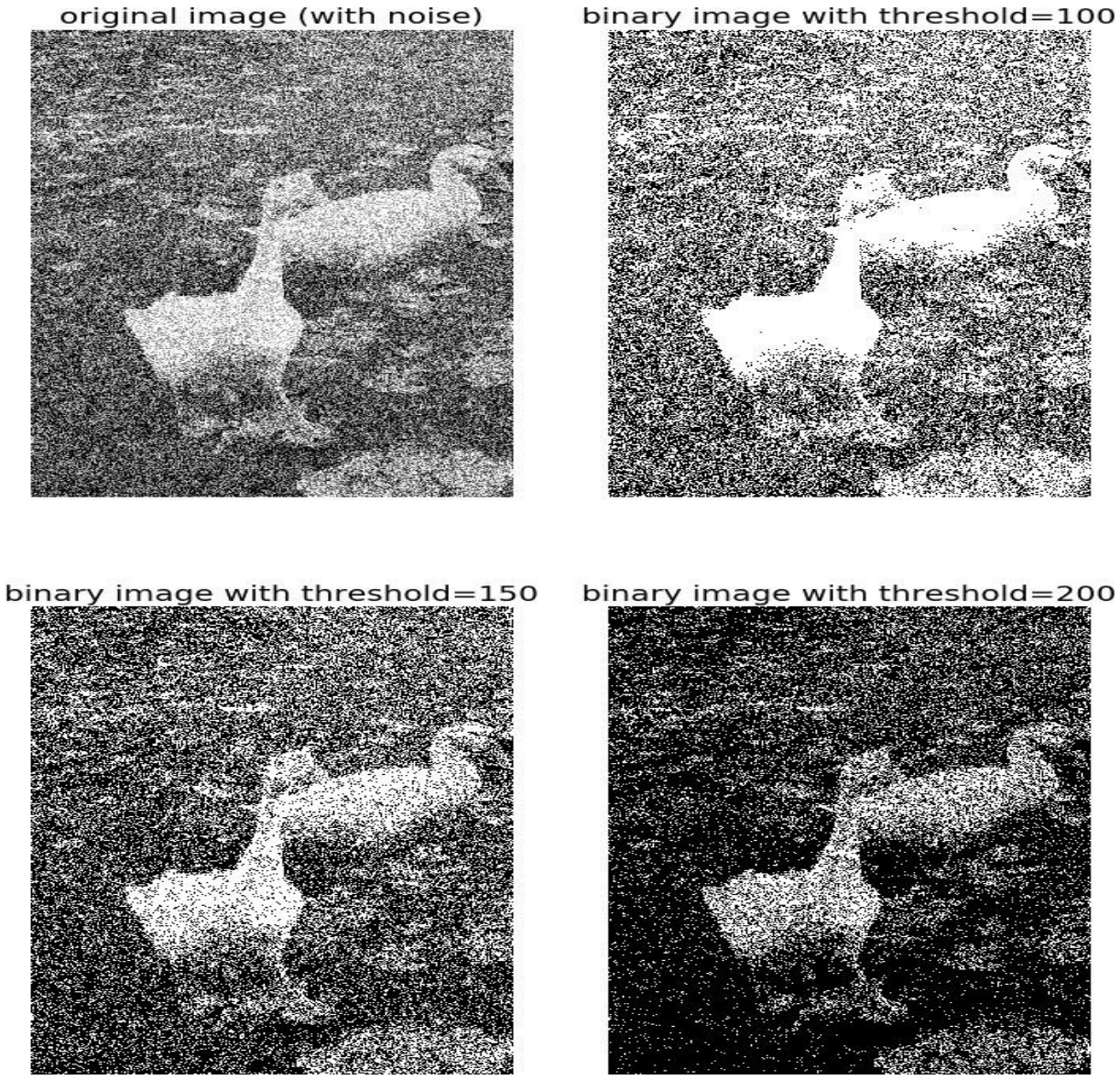
```
im = Image.open('../images/swans.jpg').convert('L')
pylab.hist(np.array(im).ravel(), bins=256, range=(0, 256), color='g')
pylab.xlabel('Pixel values'), pylab.ylabel('Frequency'),
pylab.title('Histogram of pixel values')
pylab.show()
pylab.figure(figsize=(12,18))
pylab.gray()
pylab.subplot(221), plot_image(im, 'original image'), pylab.axis('off')
th = [0, 50, 100, 150, 200]
for i in range(2, 5):
    im1 = im.point(lambda x: x > th[i])
    pylab.subplot(2,2,i), plot_image(im1, 'binary image with threshold=' + str(th[i]))
pylab.show()
```





- **Half-toning**

```
im = Image.open('../images/swans.jpg').convert('L')
im = Image.fromarray(np.clip(im + np.random.randint(-128, 128, (im.height, im.width)), 0,
255).astype(np.uint8))
pylab.figure(figsize=(12,18))
pylab.subplot(221), plot_image(im, 'original image (with noise)')
th = [0, 50, 100, 150, 200]
for i in range(2, 5):
    im1 = im.point(lambda x: x > th[i])
    pylab.subplot(2,2,i), plot_image(im1, 'binary image with threshold=' + str(th[i]))
 pylab.show()
```



- **Histogram equalization with scikit-image**

```
img = rgb2gray(imread('../images/earthfromsky.jpg'))
# histogram equalization
img_eq = exposure.equalize_hist(img)
# adaptive histogram equalization
img_adapteq = exposure.equalize_adapthist(img, clip_limit=0.03)
pylab.gray()
images = [img, img_eq, img_adapteq]
titles = ['original input (earth from sky)', 'after histogram equalization', 'after adaptive histogram equalization']
for i in range(3):
    pylab.figure(figsize=(20,10)), plot_image(images[i], titles[i])
```

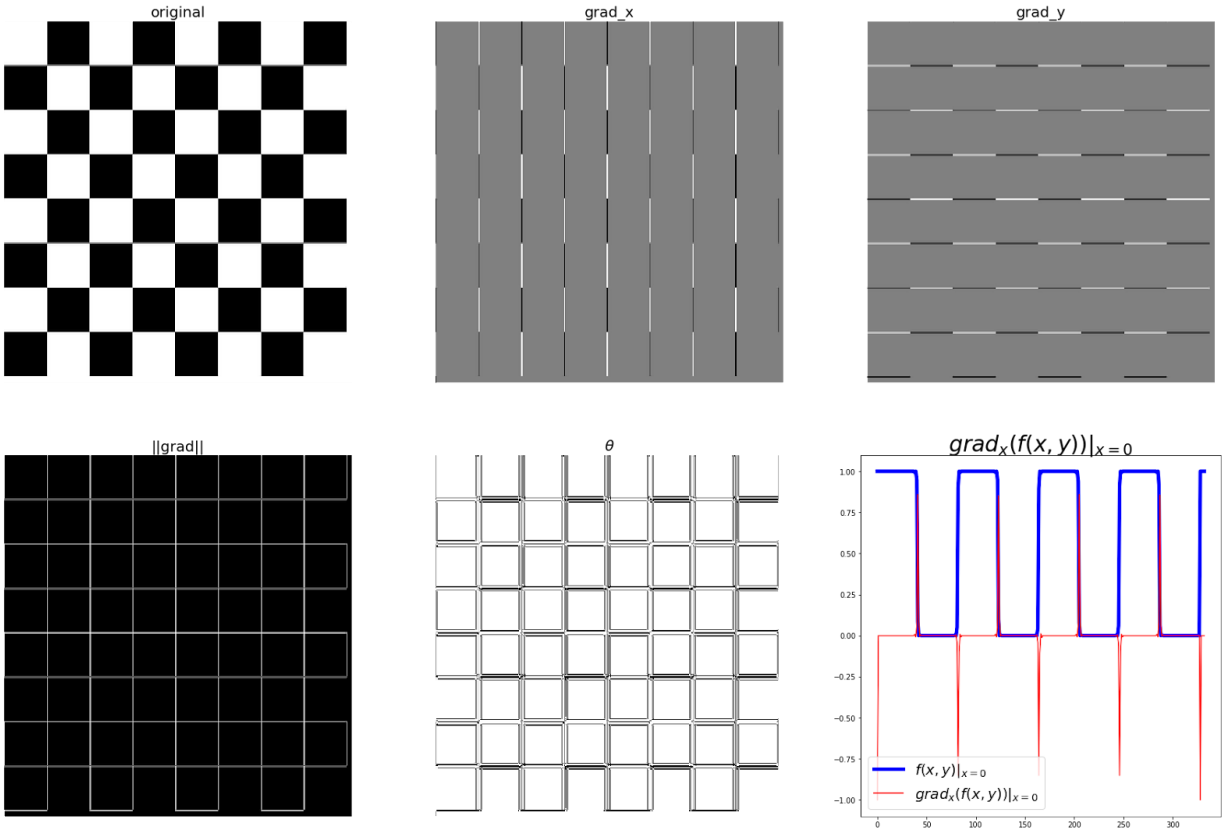
```
pylab.figure(figsize=(15,5))
for i in range(3):
    pylab.subplot(1,3,i+1), pylab.hist(images[i].ravel(), color='g'), pylab.title(titles[i], size=15)
pylab.show()
```

Practical-04:

Write a program to apply various enhancements on images using image derivatives by implementing Gradient and Laplacian Operations.

- **Derivatives and gradients**

```
def plot_image(image, title):
    pylab.imshow(image), pylab.title(title, size=20), pylab.axis('off')


ker_x = [[-1, 1]]
ker_y = [[-1], [1]]
im = rgb2gray(imread('../images/chess.png'))
im_x = signal.convolve2d(im, ker_x, mode='same')
im_y = signal.convolve2d(im, ker_y, mode='same')
im_mag = np.sqrt(im_x**2 + im_y**2)
im_dir = np.arctan(im_y/im_x)
pylab.gray()
pylab.figure(figsize=(30,20))
pylab.subplot(231), plot_image(im, 'original'), pylab.subplot(232),
plot_image(im_x, 'grad_x')
pylab.subplot(233), plot_image(im_y, 'grad_y'),
pylab.subplot(234), plot_image(im_mag, '||grad||')
pylab.subplot(235), plot_image(im_dir, r'$\theta$'), pylab.subplot(236)
pylab.plot(range(im.shape[1]), im[0,:], 'b-', label=r'$f(x,y)|_{x=0}$', linewidth=5)
pylab.plot(range(im.shape[1]), im_x[0,:], 'r-', label=r'$grad_x (f(x,y))|_{x=0}$')
pylab.title(r'$grad_x (f(x,y))|_{x=0}$', size=30)
pylab.legend(prop={'size': 20})
pylab.show()
```



- **Displaying the magnitude and the gradient on the same image**

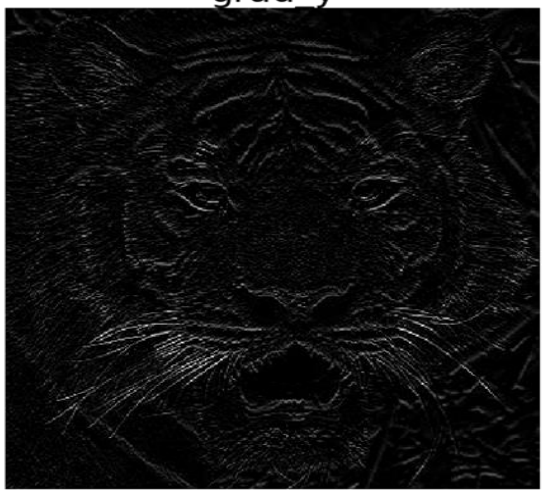
```
from skimage.io import imread
from skimage.color import rgb2gray
from skimage.util import random_noise
from skimage.filters import gaussian
import matplotlib.pylab as plt
from scipy import signal
import numpy as np
ker_x = [[-1, 1]]
ker_y = [[-1], [1]]
im = rgb2gray(imread('../images/tiger3.jpg'))
#im = random_noise(im, var=sigma**2)
#im = gaussian(im, sigma=0.25)
print(np.max(im))
im_x = np.clip(signal.convolve2d(im, ker_x, mode='same'),0,1)
im_y = np.clip(signal.convolve2d(im, ker_y, mode='same'),0,1)
im_mag = np.sqrt(im_x**2 + im_y**2)
im_ang = np.arctan(im_y/im_x)
plt.gray()
```

```
plt.figure(figsize=(20,30))
plt.subplot(321)
plt.imshow(im)
plt.title('original', size=30)
plt.axis('off')
plt.subplot(322)
plt.imshow(im_x)
plt.title('grad_x', size=30)
plt.axis('off')
plt.subplot(323)
plt.imshow(im_y)
plt.title('grad_y', size=30)
plt.axis('off')
plt.subplot(324)
plt.imshow(im_mag)
plt.title('||grad||', size=30)
plt.axis('off')
plt.subplot(325)
plt.imshow(im_ang)
plt.title(r'$\theta$', size=30)
plt.axis('off')
plt.subplot(326)
im = np.zeros((im.shape[0],im.shape[1],3))
im[...,0] = im_mag*np.sin(im_ang)
im[...,1] = im_mag*np.cos(im_ang)
plt.imshow(im)
plt.title(r'||grad||+$\theta$', size=30)
plt.axis('off')
plt.show()
```

original

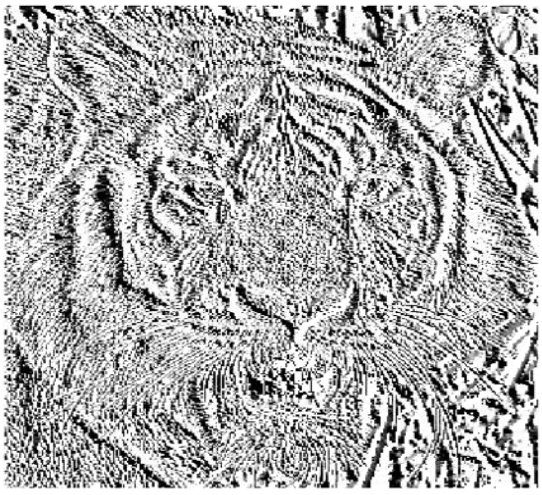
grad_x

grad_y

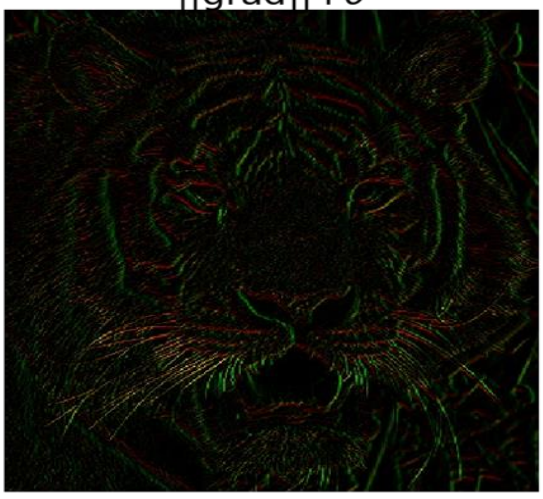


||grad||

θ



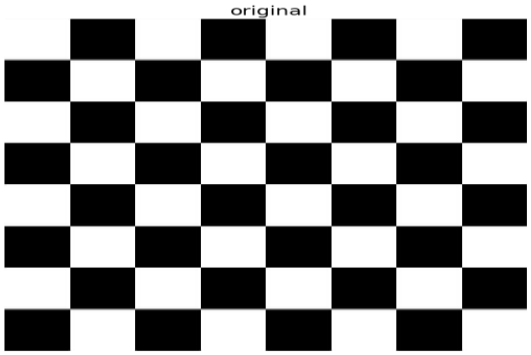
||grad||+θ

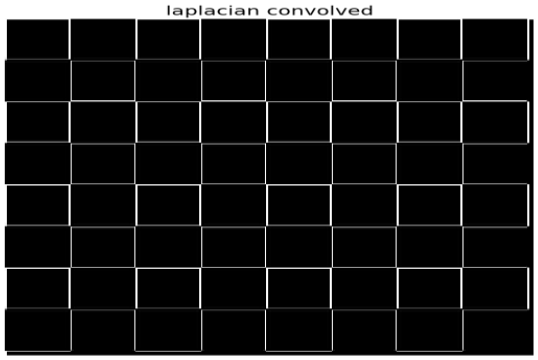


- **Laplacian**

ker_laplacian **=** [[0,**-**1,0],[**-**1, 4, **-**1],[0,**-**1,0]]

```
im = rgb2gray(imread('../images/chess.png'))
im1 = np.clip(signal.convolve2d(im, ker_laplacian, mode='same'),0,1)
pylab.gray()
pylab.figure(figsize=(20,10))
pylab.subplot(121), plot_image(im, 'original')
pylab.subplot(122), plot_image(im1, 'laplacian convolved')
pylab.show()
```





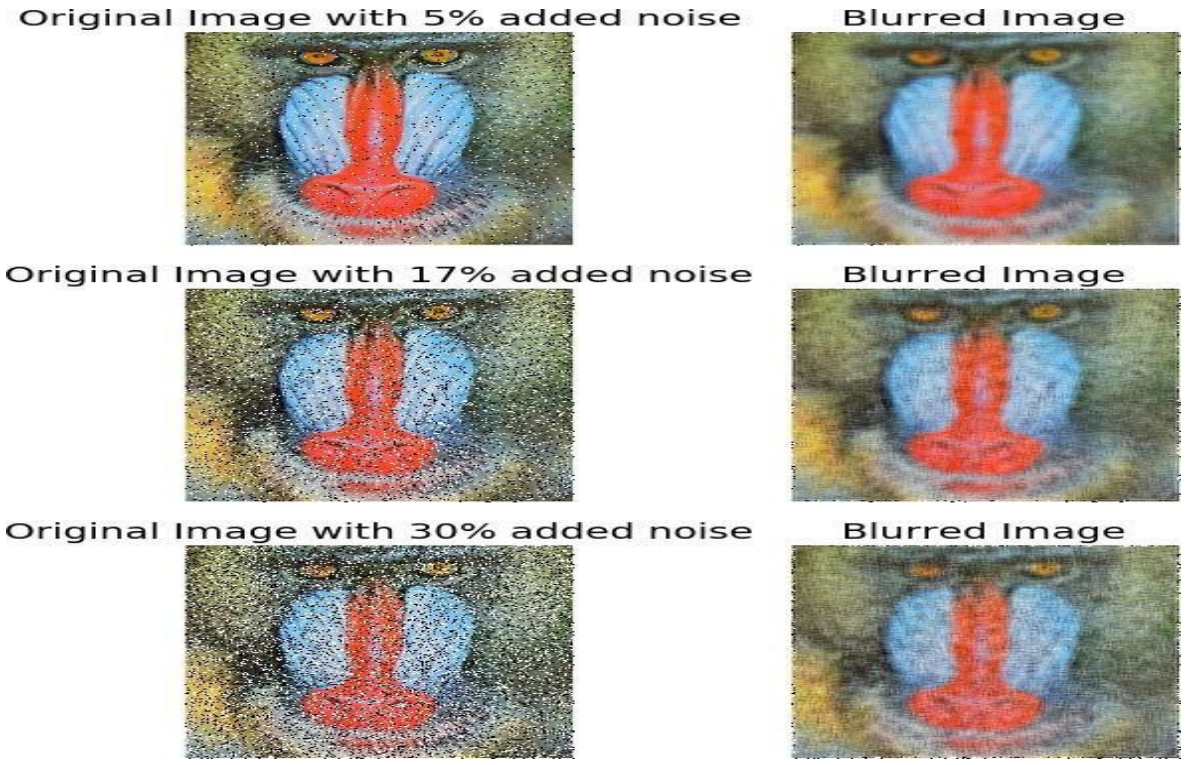
Practical-05:

Write a program to implement linear and nonlinear noise smoothing on suitable image or sound signal.

- **Linear Smoothing:**

Smoothing with ImageFilter.BLUR

```
i = 1
pylab.figure(figsize=(10,25))
for prop_noise in np.linspace(0.05,0.3,3):
    im = Image.open('../images/mandrill.jpg')
    # choose 5000 random locations inside image
    n = int(im.width * im.height * prop_noise)
    x, y = np.random.randint(0, im.width, n), np.random.randint(0, im.height, n)
    for (x,y) in zip(x,y):
        im.putpixel((x, y), ((0,0,0) if np.random.rand() < 0.5 else (255,255,255))) # generate salt-and-pepper noise
    im.save('../images/mandrill_spnoise_' + str(prop_noise) + '.jpg')
    pylab.subplot(6,2,i), plot_image(im, 'Original Image with ' +
    str(int(100*prop_noise)) + '% added noise')
    i += 1
    im1 = im.filter(ImageFilter.BLUR)
    pylab.subplot(6,2,i), plot_image(im1, 'Blurred Image')
    i += 1
 pylab.show()
```

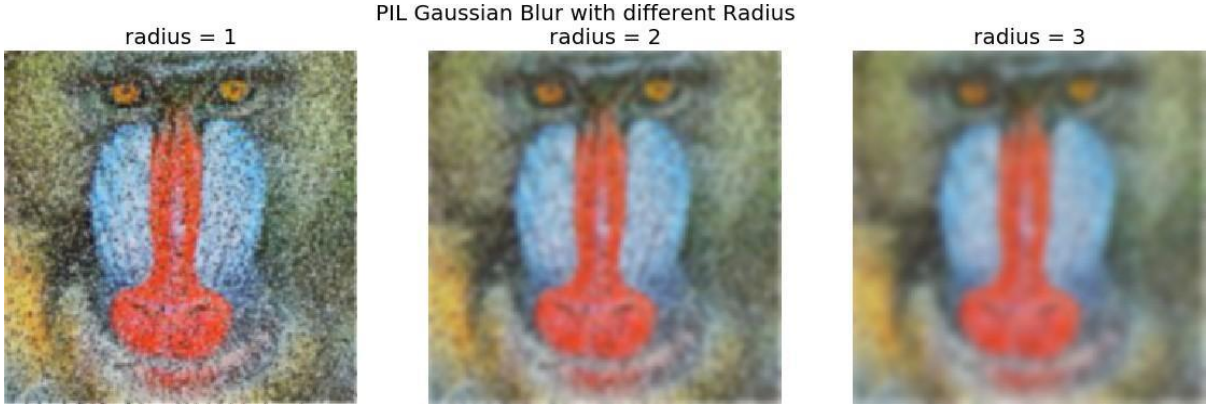


Smoothing by averaging with the box blur kernel

```
im = Image.open('../images/mandrill_spnoise_0.1.jpg')
pylab.figure(figsize=(20,7))
pylab.subplot(1,3,1), pylab.imshow(im), pylab.title('Original Image', size=30), pylab.axis('off')
for n in [3,5]:
    box_blur_kernel = np.reshape(np.ones(n*n),(n,n)) / (n*n)
    im1 = im.filter(ImageFilter.Kernel((n,n), box_blur_kernel.flatten()))
    pylab.subplot(1,3,(2 if n==3 else 3))
    plot_image(im1, 'Blurred with kernel size = ' + str(n) + 'x' + str(n))
pylab.suptitle('PIL Mean Filter (Box Blur) with different Kernel size',
size=30)
pylab.show()
```

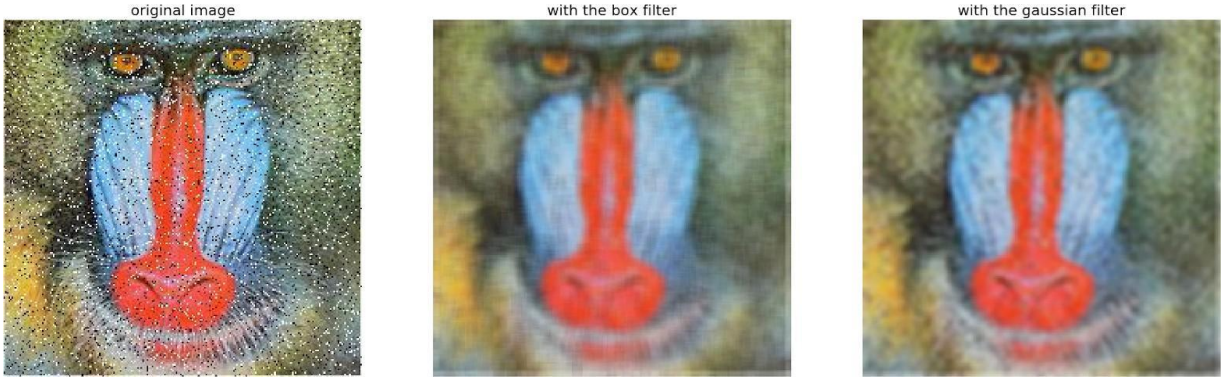
Smoothing with the Gaussian blur filter

```
im = Image.open('../images/mandrill_spnoise_0.2.jpg')
pylab.figure(figsize=(20,6))
i = 1
for radius in range(1, 4):
    im1 = im.filter(ImageFilter.GaussianBlur(radius))
    pylab.subplot(1,3,i), plot_image(im1, 'radius = ' +
    str(round(radius,2)))
    i += 1
pylab.suptitle('PIL Gaussian Blur with different Radius', size=20)
pylab.show()
```



Comparing smoothing with box and Gaussian kernels using SciPy ndimage

```
from scipy import misc, ndimage
import matplotlib.pylab as pylab
im = misc.imread('../images/mandrill_spnoise_0.1.jpg')
k = 7 # 7x7 kernel
im_box = ndimage.uniform_filter(im, size=(k,k,1))
s = 2 # sigma value
t = (((k - 1)/2)-0.5)/s # truncate parameter value for a kxk gaussian kernel with sigma s
im_gaussian = ndimage.gaussian_filter(im, sigma=(s,s,0), truncate=t)
fig = pylab.figure(figsize=(30,10))
pylab.subplot(131), plot_image(im, 'original image')
pylab.subplot(132), plot_image(im_box, 'with the box filter')
pylab.subplot(133), plot_image(im_gaussian, 'with the gaussian filter')
pylab.show()
```



- **Non-Linear Smoothing:**

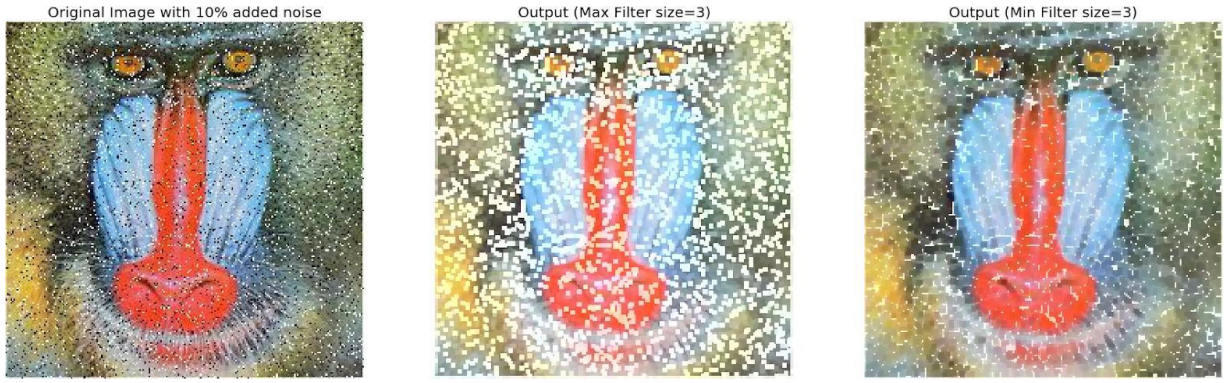
Using the median filter

```
i = 1
pylab.figure(figsize=(25,35))
for prop_noise in np.linspace(0.05,0.3,3):
    im = Image.open('../images/mandrill.jpg')
    # choose 5000 random locations inside image
    n = int(im.width * im.height * prop_noise)
    x, y = np.random.randint(0, im.width, n), np.random.randint(0, im.height, n)
    for (x,y) in zip(x,y):
        im.putpixel((x, y), ((0,0,0) if np.random.rand() < 0.5 else (255,255,255))) # geenrate
salt-and-pepper noise
    im.save('../images/mandrill_spnoise_' + str(prop_noise) + '.jpg')
    pylab.subplot(6,4,i)
    plot_image(im, 'Original Image with ' + str(int(100*prop_noise)) + '%added noise')
    i += 1
    for sz in [3,7,11]:
        im1 = im.filter(ImageFilter.MedianFilter(size=sz))
        pylab.subplot(6,4,i), plot_image(im1, 'Output (Median Filter size=' + str(sz) + ')')
        i += 1
pylab.show()
```

Using max and min filter

```
im = Image.open('../images/mandrill_spnoise_0.1.jpg')
pylab.figure(figsize=(30,10))
sz = 3
pylab.subplot(1,3,1)
plot_image(im, 'Original Image with 10% added noise')
im1 = im.filter(ImageFilter.MaxFilter(size=sz))
pylab.subplot(1,3,2), plot_image(im1, 'Output (Max Filter size=' + str(sz)+ ')')
im1 = im1.filter(ImageFilter.MinFilter(size=sz))
```

```
pylab.subplot(1,3,3), plot_image(im1, 'Output (Min Filter size=' + str(sz)+ ')')
 pylab.show()
```



Practical-06:

Write a program to apply various image enhancement using image derivatives by implementing smoothing, sharpening, and unsharp masking filters for generating suitable images for specific application requirements.

- ## Smoothing with scipy ndimage

```
lena = misc.imread('../images/lena.jpg')
# add salt-and-pepper noise to the input image
noise = np.random.random(lena.shape)
lena[noise > 0.9] = 255
lena[noise < 0.1] = 0
plot_image(lena, 'noisy image')
pylab.show()
fig = pylab.figure(figsize=(20,15))
i = 1
for p in range(25, 100, 25):
    for k in range(5, 25, 5):
        pylab.subplot(3,4,i)
        filtered = ndimage.percentile_filter(lena, percentile=p, size=(k,k,1))
        plot_image(filtered, str(p) + ' percentile, ' + str(k) + 'x' + str(k) + ' kernel')
        i += 1

 pylab.show()
```

- ## Sharpening with Laplacian

```
from skimage.filters import laplace
im = rgb2gray(imread('../images/me8.jpg'))
im1 = np.clip(laplace(im) + im, 0, 1)
```

```
pylab.figure(figsize=(10,15))
pylab.subplot(211), plot_image(im, 'original image')
pylab.subplot(212), plot_image(im1, 'sharpened image')
pylab.tight_layout()
pylab.show()
```

- **Unsharp masking**

```
def rgb2gray(im):
    '''
    the input image is an RGB image
    with pixel values for each channel in [0,1]
    '''
    return np.clip(0.2989 * im[...,0] + 0.5870 * im[...,1] + 0.1140 * im[...,2], 0, 1)

im = rgb2gray(img_as_float(misc.imread('../images/me4.jpg')))
im_blurred = ndimage.gaussian_filter(im, 5)
im_detail = np.clip(im - im_blurred, 0, 1)
pylab.gray()
fig, axes = pylab.subplots(nrows=2, ncols=3, sharex=True, sharey=True, figsize=(15, 15))
```

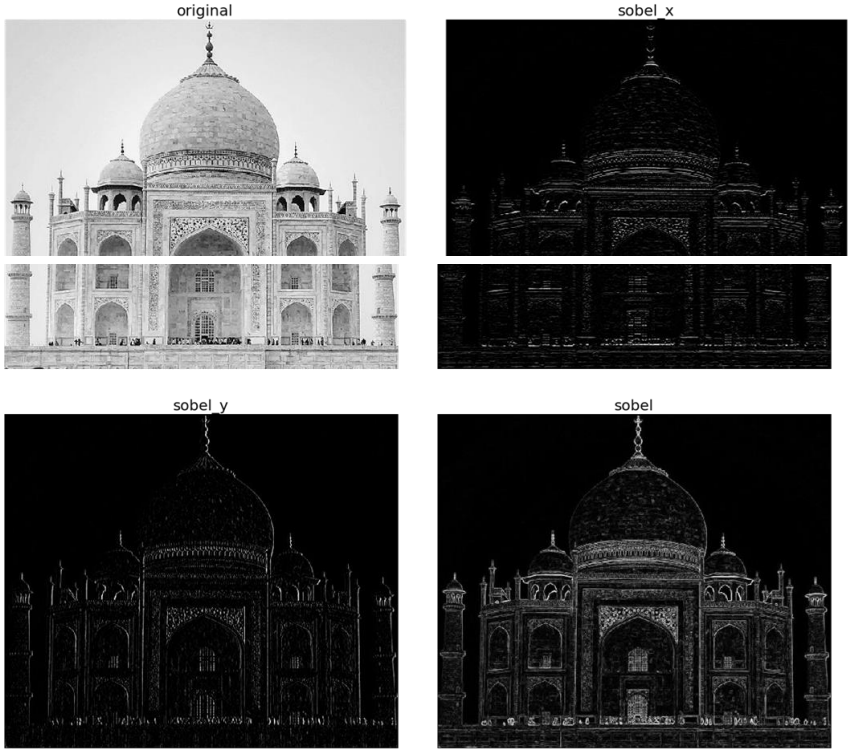
```
axes = axes.ravel()
axes[0].set_title('Original image', size=15), axes[0].imshow(im)
axes[1].set_title('Blurred image, sigma=5', size=15),
axes[1].imshow(im_blurred)
axes[2].set_title('Detail image', size=15), axes[2].imshow(im_detail)
alpha = [1, 5, 10]
for i in range(3):
    im_sharp = np.clip(im + alpha[i]*im_detail, 0, 1)
    axes[3+i].imshow(im_sharp), axes[3+i].set_title('Sharpened image, alpha=' + str(alpha[i]), size=15)
for ax in axes:
    ax.axis('off')
fig.tight_layout()
 pylab.show()
```

Practical-07:

Write a program to Apply edge detection techniques such as Sobel and Canny to extract meaningful information from the given image samples.

- **Sobel edge detector with scikit-image**

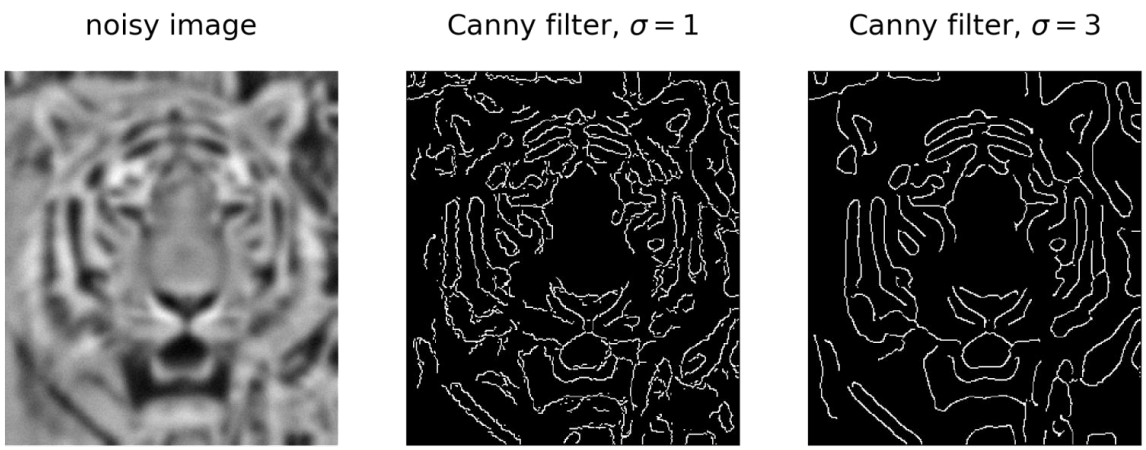
```
im = rgb2gray(imread('../images/tajmahal1.jpg')) # RGB image to grayscale
pylab.gray()
pylab.figure(figsize=(20,18))
pylab.subplot(2,2,1)
plot_image(im, 'original')
pylab.subplot(2,2,2)
edges_x = filters.sobel_h(im)
plot_image(np.clip(edges_x,0,1), 'sobel_x')
pylab.subplot(2,2,3)
edges_y = filters.sobel_v(im)
plot_image(np.clip(edges_y,0,1),
'sobel_y') pylab.subplot(2,2,4)
edges = filters.sobel(im)
plot_image(np.clip(edges,0,1), 'sobel')
pylab.subplots_adjust(wspace=0.1, hspace=0.1)
pylab.show()
```



- **The Canny edge detector with scikit-image**

```
im = rgb2gray(imread('../images/tiger3.jpg'))
```

```
im = ndimage.gaussian_filter(im, 4)
im += 0.05 * np.random.random(im.shape)
edges1 = feature.canny(im)
edges2 = feature.canny(im, sigma=2)
fig, (axes1, axes2, axes3) = pylab.subplots(nrows=1, ncols=3, figsize=(30,
12), sharex=True, sharey=True)
axes1.imshow(im, cmap=pylab.cm.gray), axes1.axis('off'),
axes1.set_title('noisy image', fontsize=50)
axes2.imshow(edges1, cmap=pylab.cm.gray), axes2.axis('off')
axes2.set_title('Canny filter, $\sigma=1$', fontsize=50)
axes3.imshow(edges2, cmap=pylab.cm.gray), axes3.axis('off')
axes3.set_title('Canny filter, $\sigma=3$', fontsize=50)
fig.tight_layout()
pylab.show()
```

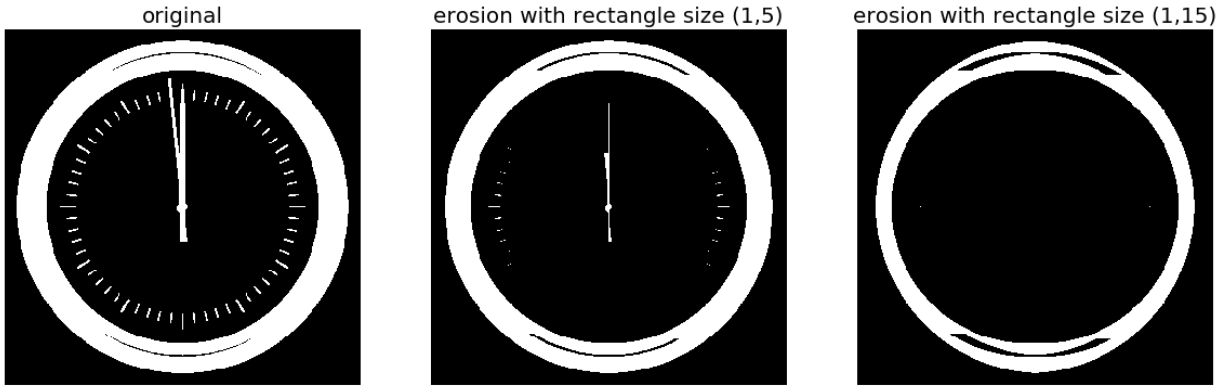


Practical-08:

Write the program to implement various morphological image processing techniques.

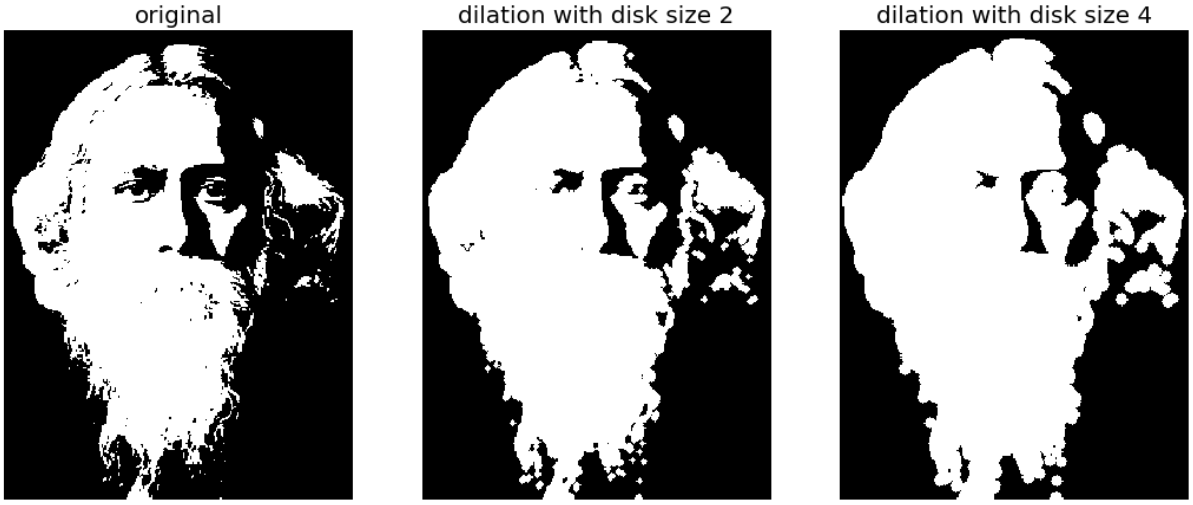
- **Erosion**

```
% matplotlib inline
from skimage.io import imread
from skimage.color import rgb2gray
import matplotlib.pylab as pylab
from skimage.morphology import binary_erosion, rectangle

def plot_image(image, title=''):
    pylab.title(title, size=20), pylab.imshow(image)
    pylab.axis('off') # comment this line if you want axis
    ticks

im = rgb2gray(imread('../images/clock2.jpg'))
im[im <= 0.5] = 0 # create binary image with fixed threshold 0.5
im[im > 0.5] = 1
pylab.gray()
pylab.figure(figsize=(20,10))
pylab.subplot(1,3,1), plot_image(im, 'original')
im1 = binary_erosion(im, rectangle(1,5))
pylab.subplot(1,3,2), plot_image(im1, 'erosion with rectangle size (1,5)')
im1 = binary_erosion(im, rectangle(1,15))
pylab.subplot(1,3,3), plot_image(im1, 'erosion with rectangle size (1,15)')
pylab.show()
```



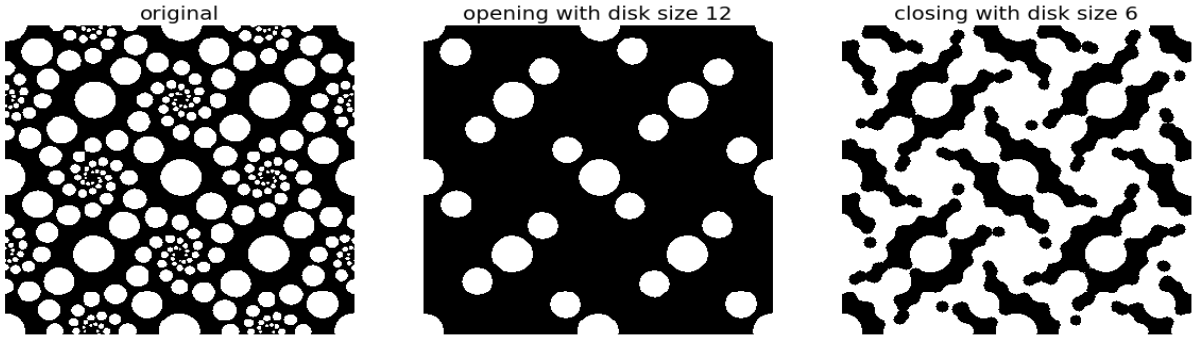
- ## Dilation

```
from skimage.morphology import binary_dilation, disk
from skimage import img_as_float
im = img_as_float(imread('../images/tagore.png'))
im = 1 - im[...,3]
im[im <= 0.5] = 0
im[im > 0.5] = 1
pylab.gray()
pylab.figure(figsize=(18,9))
pylab.subplot(131)
pylab.imshow(im)
pylab.title('original', size=20)
pylab.axis('off')
for d in range(1,3):
    pylab.subplot(1,3,d+1)
    im1 = binary_dilation(im, disk(2*d))
    pylab.imshow(im1)
    pylab.title('dilation with disk size ' + str(2*d), size=20)
    pylab.axis('off')
pylab.show()
```



- ## Opening and closing

```
from skimage.morphology import binary_opening, binary_closing, binary_erosion, binary_dilation, disk
im = rgb2gray(imread('../images/circles.jpg'))
im[im <= 0.5] = 0
im[im > 0.5] = 1
pylab.gray()
pylab.figure(figsize=(20,10))
pylab.subplot(1,3,1), plot_image(im, 'original')
im1 = binary_opening(im, disk(12))
pylab.subplot(1,3,2), plot_image(im1, 'opening with disk size ' + str(12))
im1 = binary_closing(im, disk(6))
pylab.subplot(1,3,3), plot_image(im1, 'closing with disk size ' + str(6))
pylab.show()
```



- ## Skeletonizing

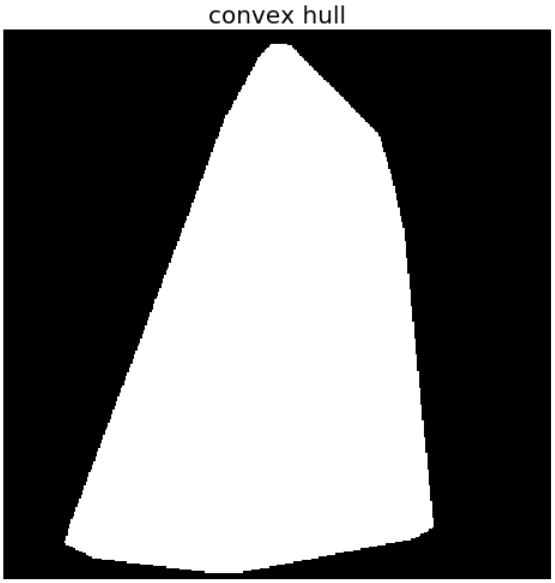
```
def plot_images_horizontally(original, filtered, filter_name, sz=(18,7)):
    pylab.gray()
```

```
    pylab.figure(figsize = sz)
    pylab.subplot(1,2,1), plot_image(original, 'original')
    pylab.subplot(1,2,2), plot_image(filtered, filter_name)
    pylab.show()
```

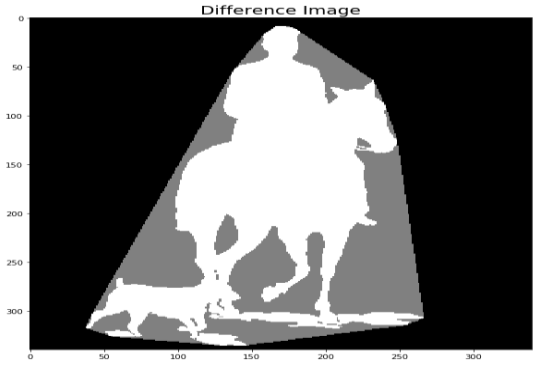
```
from skimage.morphology import skeletonize
im =
img_as_float(imread('../images/dynasaur.png')[...,3])
threshold = 0.5
im[im <= threshold] = 0
im[im > threshold] = 1
skeleton = skeletonize(im)
plot_images_horizontally(im, skeleton, 'skeleton',sz=(18,9))
```

- ## Computing the convex hull

```
from skimage.morphology import convex_hull_image
im = rgb2gray(imread('../images/horse-dog.jpg'))
threshold = 0.5
im[im < threshold] = 0 # convert to binary image
im[im >= threshold] = 1
chull = convex_hull_image(im)
plot_images_horizontally(im, chull, 'convex hull', sz=(18,9))
```

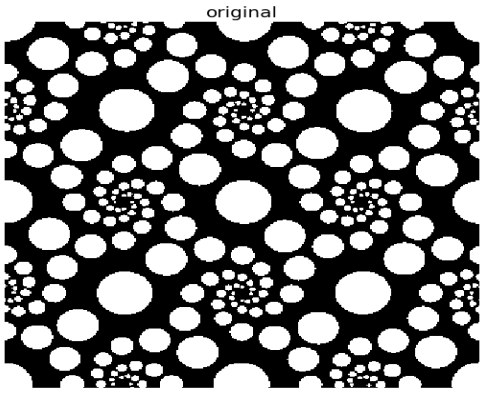


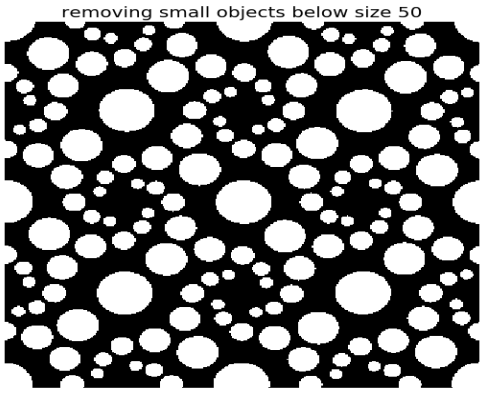

```
im = im.astype(np.bool)
chull_diff = img_as_float(chull.copy())
chull_diff[im] = 2
pylab.figure(figsize=(20,10))
pylab.imshow(chull_diff,
cmap=pylab.cm.gray, interpolation='nearest')
pylab.title('Difference Image', size=20)
pylab.show()
```

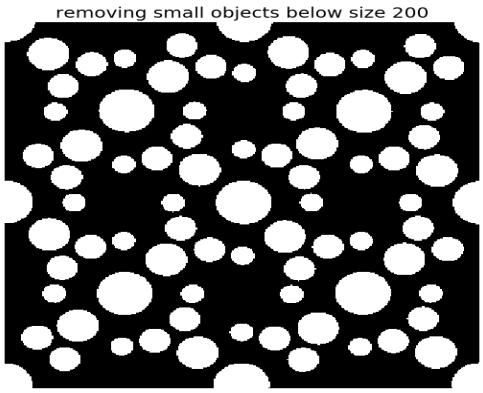


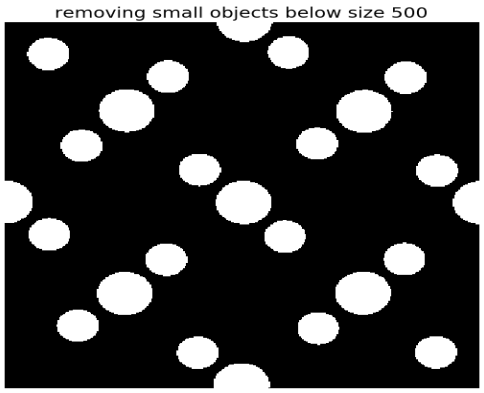
- **Removing small objects**

```
from skimage.morphology import remove_small_objects
im = rgb2gray(imread('../images/circles.jpg'))
im[im > 0.5] = 1 # create binary image by thresholding with fixed threshold
0.5
im[im <= 0.5] = 0
im = im.astype(np.bool)
pylab.figure(figsize=(20,20))
pylab.subplot(2,2,1), plot_image(im, 'original')
i = 2
for osz in [50, 200, 500]:
    im1 = remove_small_objects(im, osz, connectivity=1)
    pylab.subplot(2,2,i), plot_image(im1, 'removing small objects below size ' + str(osz))
    i += 1
pylab.show()
```



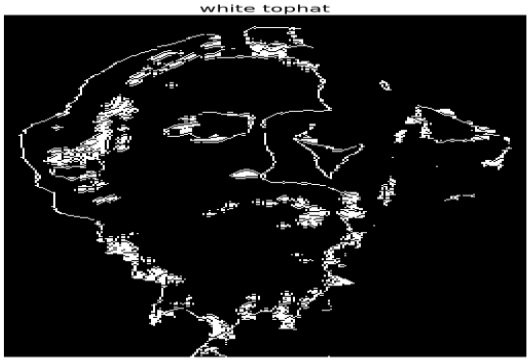


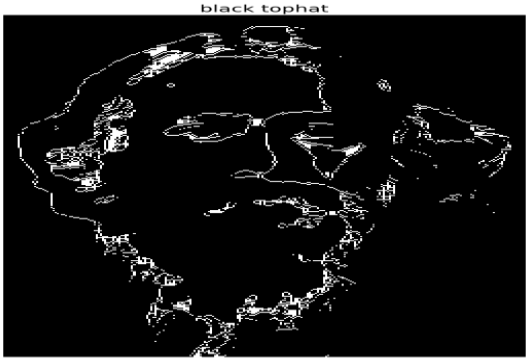




- **White and black top-hats**

```
from skimage.morphology import white_tophat, black_tophat, square
im = imread('../images/tagore.png')[...,3]
im[im <= 0.5] = 0
im[im > 0.5] = 1
im1 = white_tophat(im, square(5))
im2 = black_tophat(im, square(5))
pylab.figure(figsize=(20,15))
pylab.subplot(1,2,1), plot_image(im1, 'white tophat')
pylab.subplot(1,2,2), plot_image(im2, 'black tophat')
pylab.show()
```

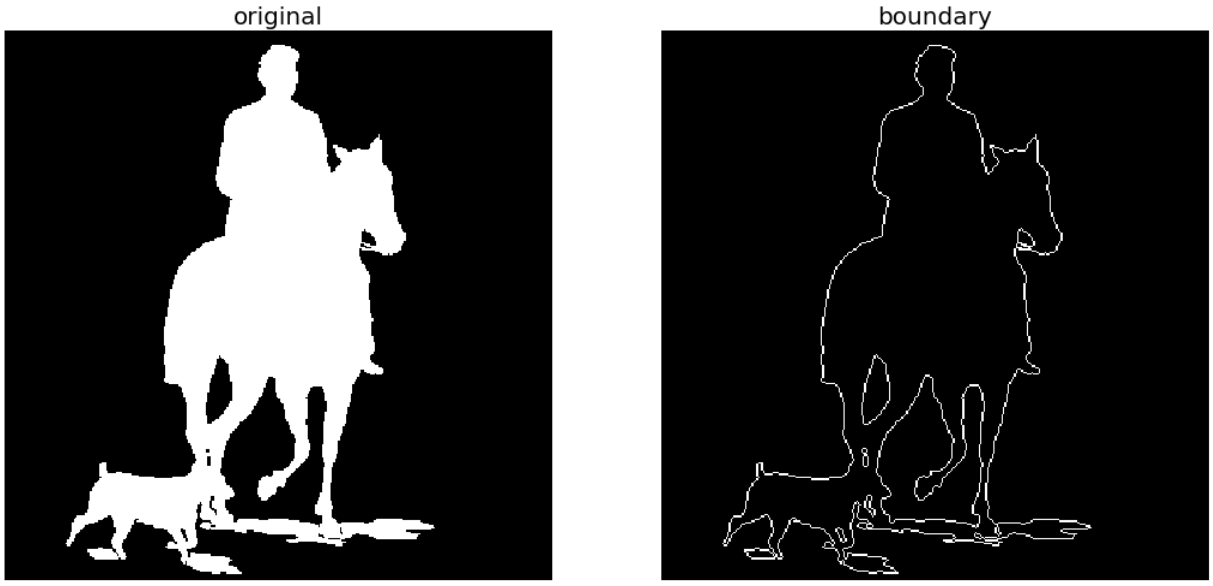




- **Extracting the boundary**

```
from skimage.morphology import binary_erosion
```

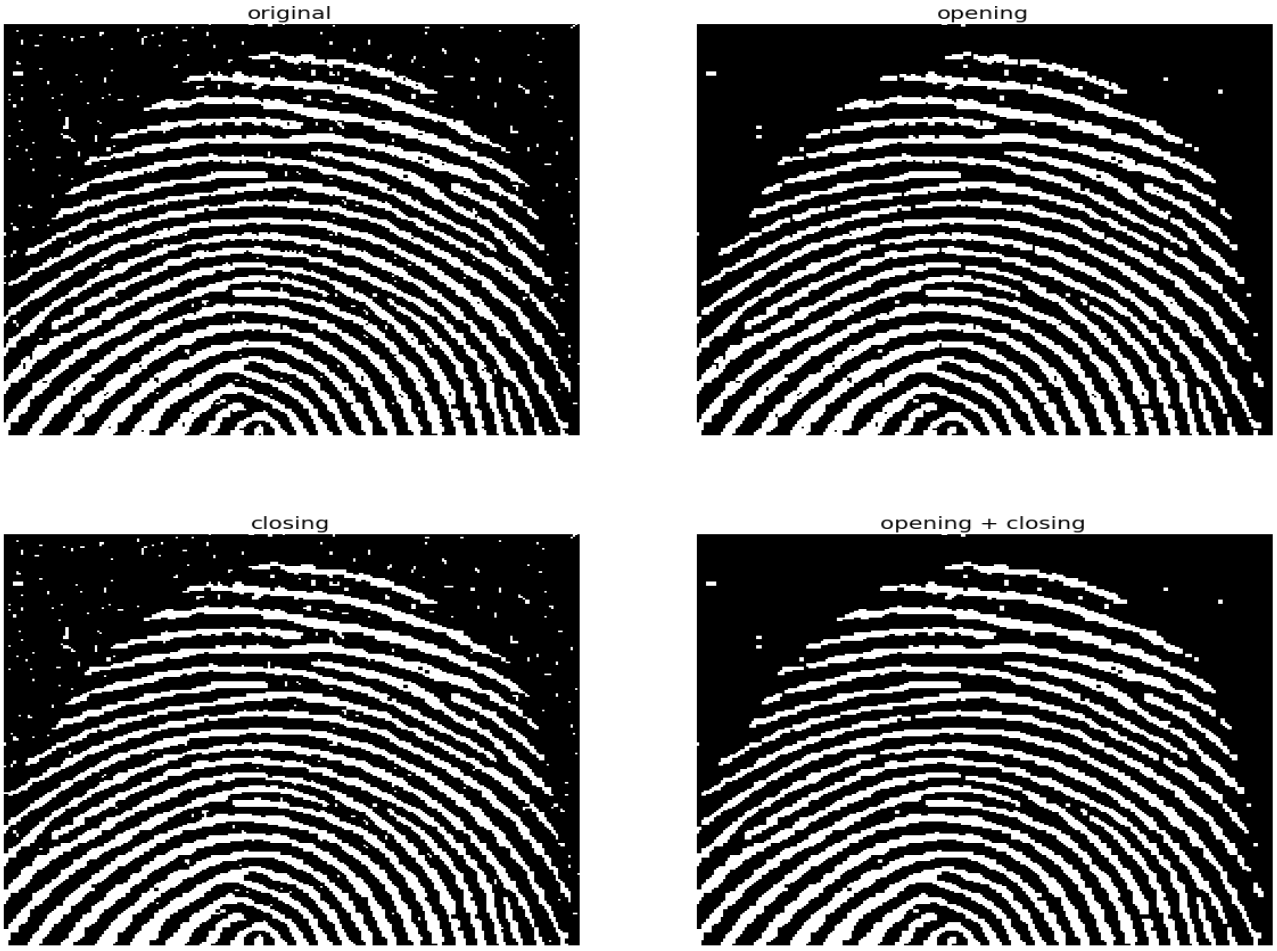
```
im = rgb2gray(imread('../images/horse-dog.jpg'))
threshold = 0.5
im[im < threshold] = 0
im[im >= threshold] = 1
boundary = im - binary_erosion(im)
plot_images_horizontally(im, boundary,
```




```
'boundary',sz=(18,9))
```

- **Fingerprint cleaning with opening and closing**

```
im = rgb2gray(imread('../images/fingerprint.jpg'))
im[im <= 0.5] = 0 # binarize
im[im > 0.5] = 1
im_o = binary_opening(im, square(2))
im_c = binary_closing(im, square(2))
im_oc = binary_closing(binary_opening(im, square(2)), square(2))
pylab.figure(figsize=(20,20))
pylab.subplot(221), plot_image(im, 'original')
pylab.subplot(222), plot_image(im_o, 'opening')
pylab.subplot(223), plot_image(im_c, 'closing')
pylab.subplot(224), plot_image(im_oc, 'opening + closing')
pylab.show()
```



- **Morphological contrast enhancement**

```
from skimage.filters.rank import enhance_contrast
from skimage import exposure
def plot_gray_image(ax, image, title):
    ax.imshow(image, cmap=pylab.cm.gray),
    ax.set_title(title), ax.axis('off')
    ax.set_adjustable('box-forced')

image = rgb2gray(imread('../images/squirrel.jpg'))
sigma = 0.05
noisy_image = np.clip(image + sigma * np.random.standard_normal(image.shape), 0, 1)
enhanced_image = enhance_contrast(noisy_image, disk(5))
equalized_image = exposure.equalize_adapthist(noisy_image)

fig, axes = pylab.subplots(1, 3, figsize=[18, 7], sharex='row',sharey='row')
axes1, axes2, axes3 = axes.ravel()
```

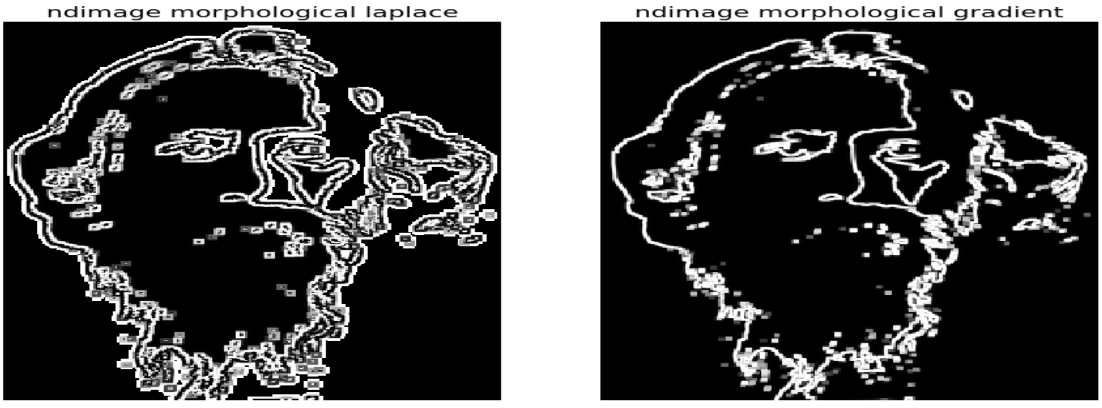
plot_gray_image(axes1, noisy_image, 'Original')

plot_gray_image(axes2, enhanced_image, 'Local morphological contrast enhancement')

plot_gray_image(axes3, equalized_image, 'Adaptive Histogram equalization')

- ## Computing the morphological Laplace

```
im = imread('../images/tagore.png')[...,3]
im_g = ndimage.morphological_gradient(im, size=(3,3))
im_l = ndimage.morphological_laplace(im, size=(5,5))
pylab.figure(figsize=(15,10))
pylab.subplot(121), pylab.title('ndimage morphological laplace', size=20), pylab.imshow(im_l)
pylab.axis('off')
pylab.subplot(122), pylab.title('ndimage morphological gradient', size=20),
pylab.imshow(im_g)
pylab.axis('off')
pylab.show()
```

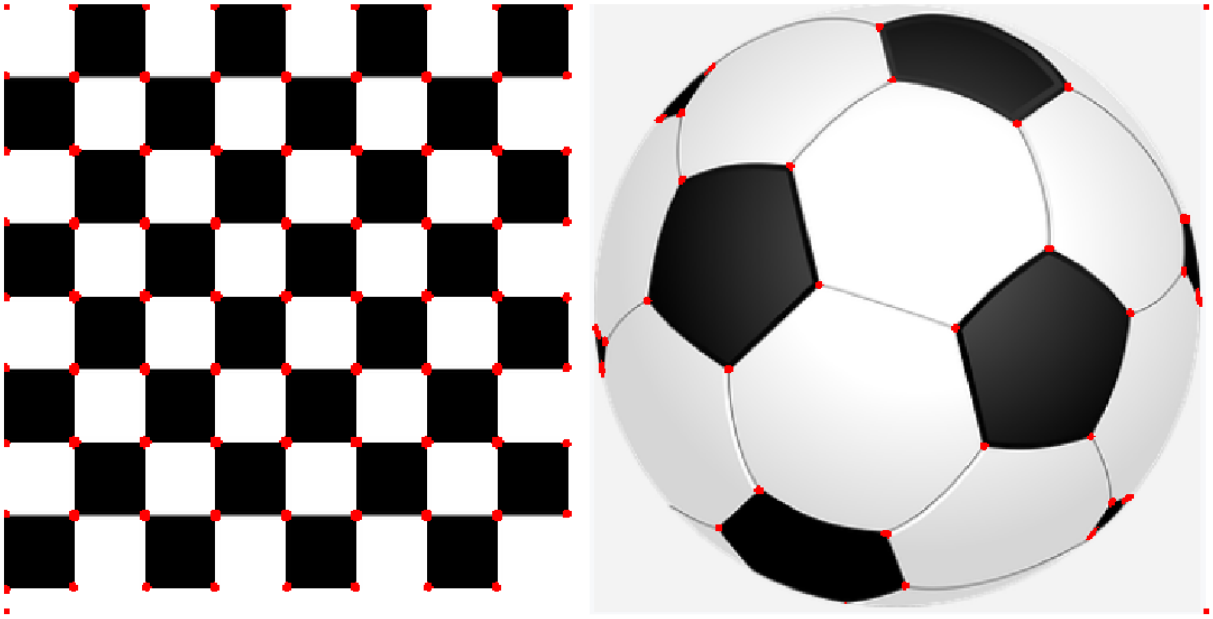


Practical-09:

Write the program to extract image features by implementing methods like corner and blob detectors, HoG and Haar features.

- **Harris Corner Detector With scikit-image**

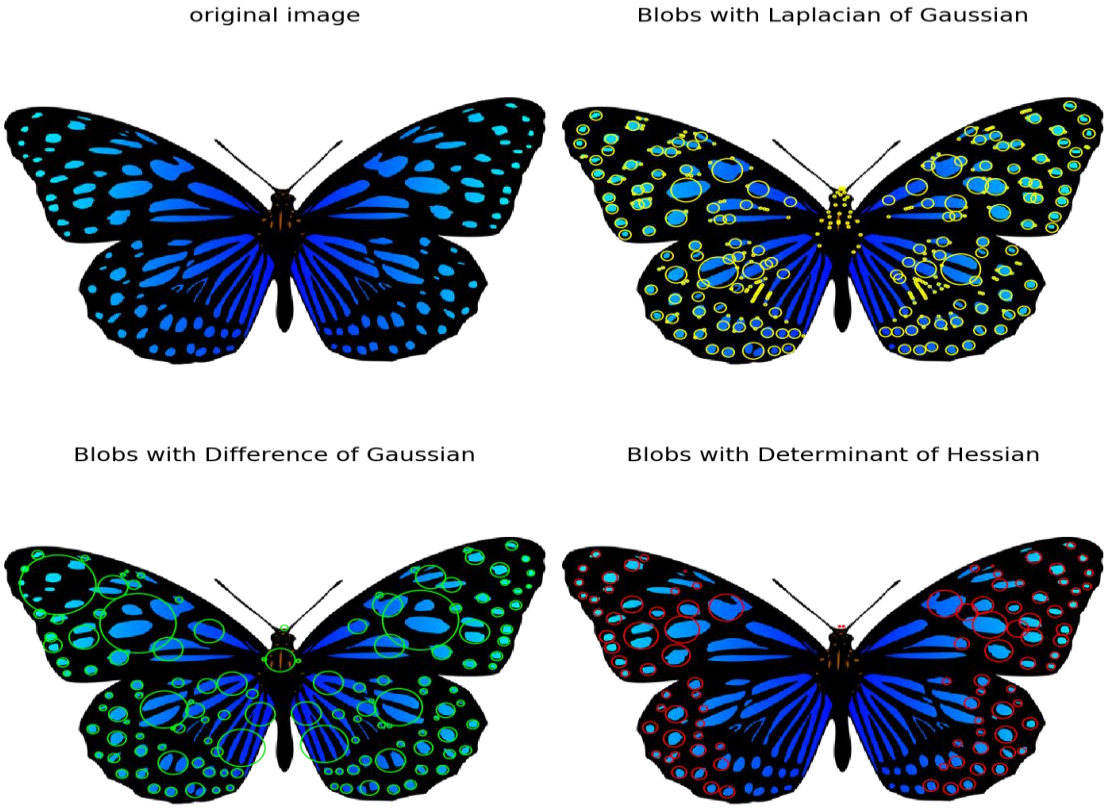
```
image = imread('../images/chess_football.png') # RGB image
image_gray = rgb2gray(image)
coordinates = corner_harris(image_gray, k =0.001)
image[coordinates>0.01*coordinates.max()]=[255,0,0,255]
pylab.figure(figsize=(20,10))
pylab.imshow(image), pylab.axis('off'), pylab.show()
```



- **Blob detectors with LoG, DoG and DoH**

```
from numpy import sqrt
from skimage.feature import blob_dog, blob_log, blob_doh
im = imread('../images/butterfly.png')
im_gray = rgb2gray(im)
log_blobs = blob_log(im_gray, max_sigma=30, num_sigma=10,
threshold=.1) log_blobs[:, 2] = sqrt(2) * log_blobs[:, 2] # Compute radius in
the 3rd column dog_blobs = blob_dog(im_gray, max_sigma=30,
threshold=0.1)
dog_blobs[:, 2] = sqrt(2) * dog_blobs[:, 2]
doh_blobs = blob_doh(im_gray, max_sigma=30,
threshold=0.005) list_blobs = [log_blobs, dog_blobs, doh_blobs]
```

```
colors, titles = ['yellow', 'lime', 'red'], ['Laplacian of Gaussian', 'Difference of Gaussian', 'Determinant of Hessian']
sequence = zip(list_blobs, colors, titles)
fig, axes = pylab.subplots(2, 2, figsize=(20, 20), sharex=True,
sharey=True) axes = axes.ravel()
axes[0].imshow(im, interpolation='nearest')
axes[0].set_title('original image', size=30), axes[0].set_axis_off()
for idx, (blobs, color, title) in enumerate(sequence):
    axes[idx+1].imshow(im, interpolation='nearest')
    axes[idx+1].set_title('Blobs with ' + title, size=30)
    for blob in blobs:
        y, x, row = blob
        col = pylab.Circle((x, y), row, color=color, linewidth=2,
        fill=False) axes[idx+1].add_patch(col),
        axes[idx+1].set_axis_off()
pylab.tight_layout(), pylab.show()
```



- ## Compute HOG descriptors with scikit-image

```
from skimage.feature import hog
from skimage import exposure
image = rgb2gray(imread('../images/cameraman.jpg'))
fd, hog_image = hog(image, orientations=8, pixels_per_cell=(16, 16),
```

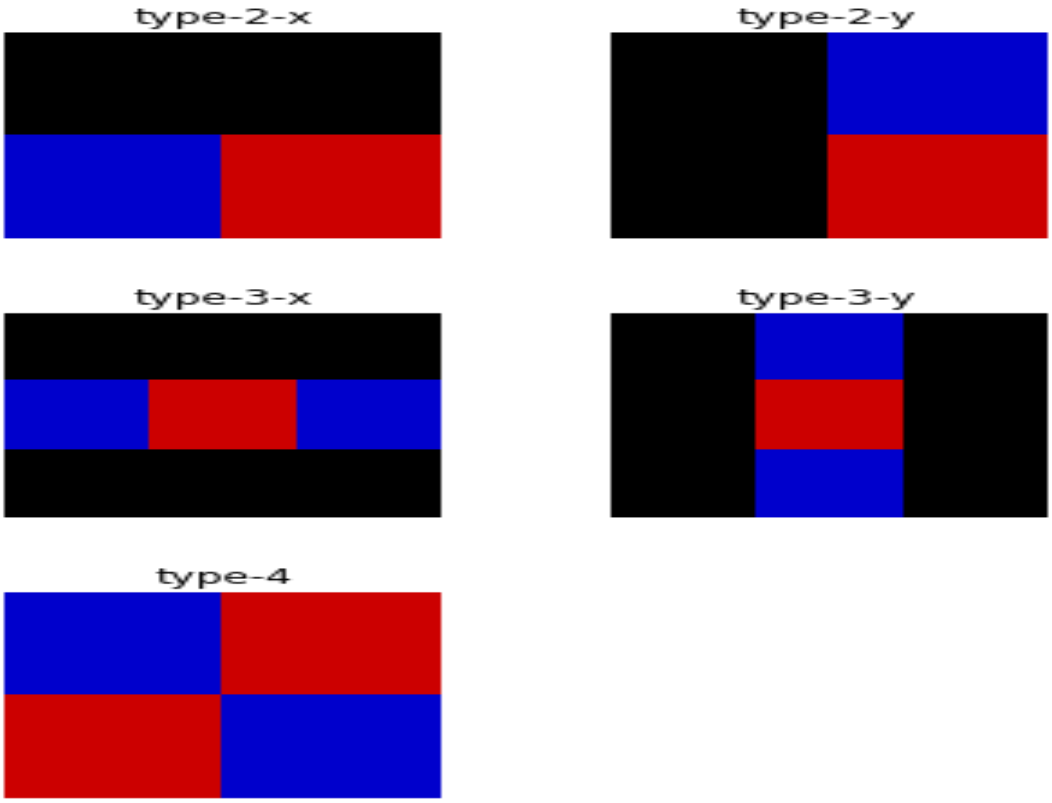
```
cells_per_block=(1, 1),
visualize=True) print(image.shape,
len(fd))
# ((256L, 256L), 2048)
fig, (axes1, axes2) = pylab.subplots(1, 2, figsize=(15, 10), sharex=True, sharey=True)
axes1.axis('off'), axes1.imshow(image, cmap=pylab.cm.gray), axes1.set_title('Input image')
hog_image_rescaled = exposure.rescale_intensity(hog_image, in_range=(0, 10))
axes2.axis('off'), axes2.imshow(hog_image_rescaled, cmap=pylab.cm.gray),
axes2.set_title('Histogram of Oriented Gradients')
pylab.show()
```

- ## Haar-like feature descriptor with scikit-image

```
from skimage.feature import haar_like_feature_coord
from skimage.feature import draw_haar_like_feature
images = [np.zeros((2, 2)), np.zeros((2, 2)), np.zeros((3, 3)),
np.zeros((3, 3)), np.zeros((2, 2))]
feature_types = ['type-2-x', 'type-2-y', 'type-3-x', 'type-3-y', 'type-4']
fig, axes = pylab.subplots(3, 2, figsize=(5,7))
for axes, img, feat_t in zip(np.ravel(axes), images, feature_types):
    coordinates, _ = haar_like_feature_coord(img.shape[0], img.shape[1], feat_t)
    haar_feature = draw_haar_like_feature(img, 0, 0, img.shape[0],img.shape[1], coordinates, max_n_features=1,
random_state=0, color_positive_block=(1.0, 0.0, 0.0), color_negative_block=(0.0, 0.0, 1.0), alpha=0.8)
    axes.imshow(haar_feature), axes.set_title(feat_t), axes.set_axis_off()
```

#fig.suptitle('Different Haar-like feature descriptors')

pylab.axis('off'), pylab.tight_layout(), pylab.show()



Practical-10:

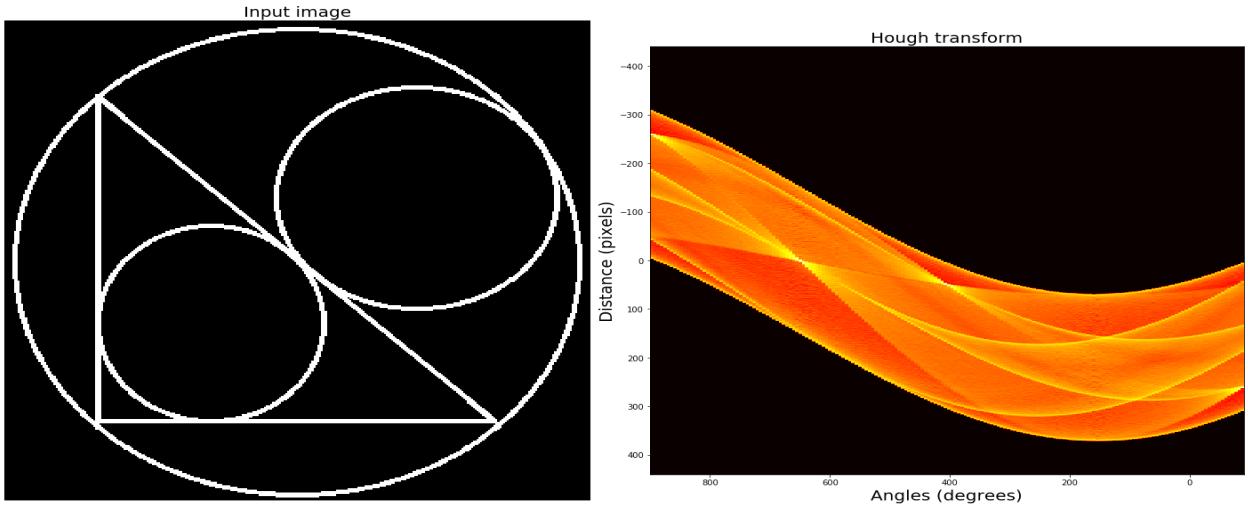
Write the program to apply segmentation for detecting lines, circles, and other shapes/objects. Also, implement edge-based and region-based segmentation.

- **Hough transform – detecting lines and circles**

```
image = rgb2gray(imread('../images/triangle_circle.png'))

# Classic straight-line Hough transform
h, theta, d = hough_line(image)

# Generating figure 1
fig, axes = plt.subplots(2, 2, figsize=(20, 20))
ax = axes.ravel()

ax[0].imshow(image, cmap=cm.gray)
ax[0].set_title('Input image', size=20)
ax[0].set_axis_off()

ax[1].imshow(np.log(1 + h),
             extent=[10*np.rad2deg(theta[-1]), np.rad2deg(theta[0]), d[-1], d[0]],
             cmap=cm.hot, aspect=1/1.5)
ax[1].set_title('Hough transform', size=20)
ax[1].set_xlabel('Angles (degrees)', size=20)
ax[1].set_ylabel('Distance (pixels)', size=20)
ax[1].axis('image')

ax[2].imshow(image, cmap=cm.gray)
for _, angle, dist in zip(*hough_line_peaks(h, theta, d)):
    y0 = (dist - 0 * np.cos(angle)) / np.sin(angle)
    y1 = (dist - image.shape[1] * np.cos(angle)) / np.sin(angle)
    ax[2].plot((0, image.shape[1]), (y0, y1), '-r')
ax[2].set_xlim((0, image.shape[1]))
ax[2].set_ylim((image.shape[0], 0))
ax[2].set_axis_off()
ax[2].set_title('Detected lines', size=20)
```

```
hough_radii = np.arange(50, 100, 2)
hough_res = hough_circle(image, hough_radii)

# Select the most prominent 5 circles
accums, cx, cy, radii = hough_circle_peaks(hough_res, hough_radii, total_num_peaks=6)

image = gray2rgb(image)
for center_y, center_x, radius in zip(cy, cx, radii):
    circy, circx = circle_perimeter(center_y, center_x,
    radius) image[circy, circx] = (0.9, 0.2, 0.2)

ax[3].imshow(image, cmap=plt.cm.gray)
ax[3].set_axis_off()
ax[3].set_title('Detected Circles', size=20)

plt.tight_layout()
plt.show()

image = rgb2gray(imread('../images/coins.png'))

fig, axes = plt.subplots(1, 2, figsize=(20, 10), sharex=True,
sharey=True) ax = axes.ravel()

ax[0].imshow(image, cmap=plt.cm.gray)
ax[0].set_axis_off()
ax[0].set_title('Original Image', size=20)

hough_radii = np.arange(65, 75, 1)
hough_res = hough_circle(image, hough_radii)

# Select the most prominent 5 circles
accums, cx, cy, radii = hough_circle_peaks(hough_res, hough_radii, total_num_peaks=4)

image = gray2rgb(image)
for center_y, center_x, radius in zip(cy, cx, radii):
    circy, circx = circle_perimeter(center_y, center_x,
    radius) image[circy, circx] = (1, 0, 0)

ax[1].imshow(image, cmap=plt.cm.gray)
```

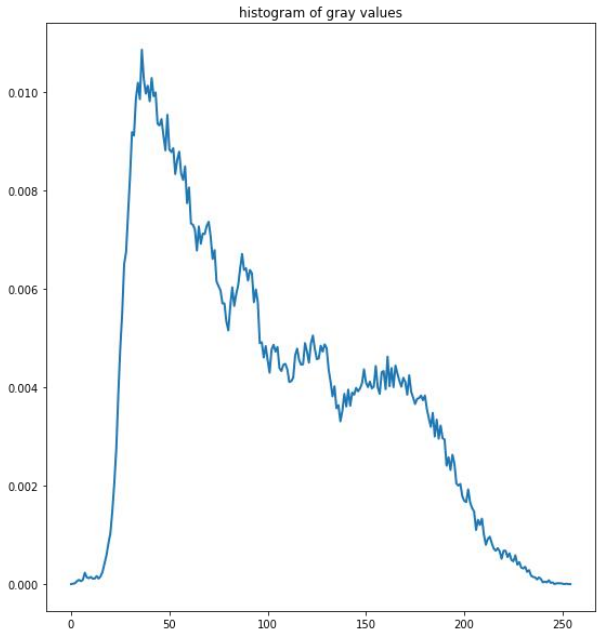
```
ax[1].set_axis_off()
ax[1].set_title('Detected Circles', size=20)

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



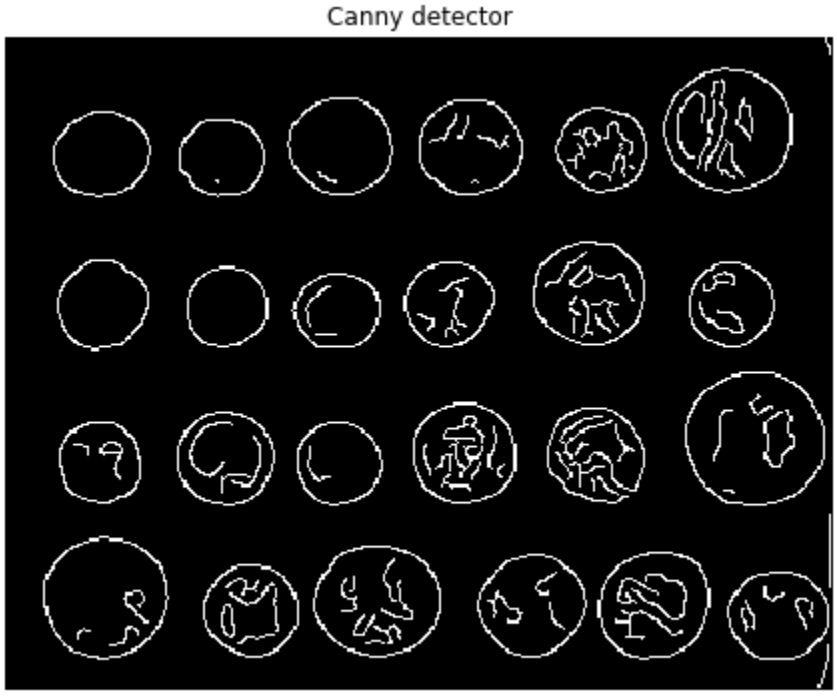
- **Edges-based/region-based segmentation**

```
coins = data.coins()
```

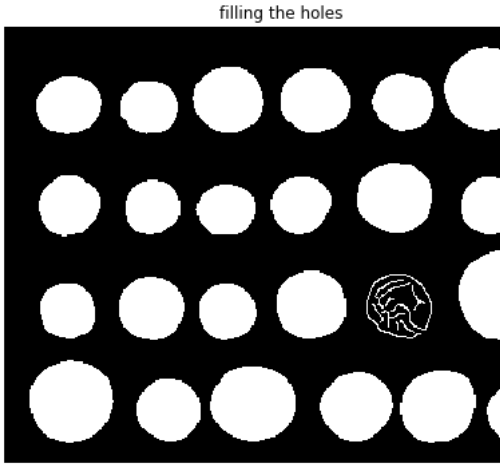
```
#print(np.max(coins), np.min(coins), np.mean(coins))
hist = np.histogram(coins, bins=np.arange(0, 256), normed=True)
#print(hist)

fig, axes = plt.subplots(1, 2, figsize=(20, 10))
axes[0].imshow(coins, cmap=plt.cm.gray,
interpolation='nearest') axes[0].axis('off')
axes[1].plot(hist[1][:-1], hist[0], lw=2)
axes[1].set_title('histogram of gray values')
plt.show()
```




```
edges = canny(coins, sigma=2)

fig, ax = plt.subplots(figsize=(10, 6))
ax.imshow(edges, cmap=plt.cm.gray, interpolation='nearest')
ax.set_title('Canny detector')
ax.axis('off')
plt.show()
```




```
from scipy import ndimage as ndi

fill_coins = ndi.binary_fill_holes(edges)

fig, ax = plt.subplots(figsize=(10, 6))
ax.imshow(fill_coins, cmap=plt.cm.gray,
interpolation='nearest') ax.set_title('filling the holes')
ax.axis('off')
plt.show()
```




```
segmentation = morphology.watershed(elevation_map, markers)
fig, ax = plt.subplots(figsize=(10, 6))
ax.imshow(segmentation, cmap=plt.cm.gray, interpolation='nearest')
```

```
ax.set_title('segmentation')
ax.axis('off')
plt.show()
```