Digital Image Processing

Journal

Name : Shailesh Ashok Tagadghar

Class: M.Sc. - Sem ll. Part I

Roll Number: 31031523034

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Department of Computer Science

Somaiya Vidyavihar University

S K Somaiya College

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Practical 1

Aim :

Perform the following:

1. Showing Histogram of an Image
2. Log Transformation
3. Power Log Transformation
4. Contrast Stretching
5. Thresholding Operations

Code :

```
import os

import matplotlib.pylab as pylab
import matplotlib.pyplot as plt
import numpy as np
from PIL import Image, ImageEnhance, ImageFilter, ImageOps
from scipy import misc
from scipy import ndimage as ndi
from scipy import signal as signal
from skimage import (color, data, exposure, feature, filters,
img_as_float,
                     img_as_ubyte, io)
from skimage.color import rgb2gray
from skimage.exposure import cumulative_distribution
from skimage.filters import laplace
from skimage.io import imread
from skimage.morphology import (binary_closing, binary_dilation,
                                binary_erosion, binary_opening,
                                convex_hull_image, disk, rectangle,
                                skeletonize)
from skimage.restoration import (denoise_bilateral, denoise_nl_means,
                                 estimate_sigma)
from skimage.util import random_noise


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


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=0.8)
    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 Values", size=20),
    pylab.ylabel("Frequency", size=20)
    pylab.title(title, size=20)



im = Image.open("/Images/image.jpeg")
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, "Histpgram of RGB
Image")
pylab.show()

# log transformation
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 Transformation")
pylab.subplot(122), plot_hist(
    im_r, im_g, im_b, "Histogram of Log transform for RGB channel"
)
pylab.show()

# power log  transform
im = img_as_float(imread("/Images/image.jpeg"))
gamma = 2.5
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
channel(Input)"
)
pylab.subplot(122), plot_hist(
    im1[..., 0], im1[..., 1], im1[..., 2], "Histogram for RGB Output"
)
pylab.show()
pylab.figure(figsize=(15, 5))
pylab.subplot(121), plot_image(im, "Image original")
pylab.subplot(122), plot_image(im1, "Log Output")
```

```
pylab.show()


# constrast streching
im = Image.open("/Images/image.jpeg")
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 < 50 else (255 if c > 150 else (255 * c - 22950) /
48)


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", base=10)
pylab.show()


# thresholding operations
im = Image.open("/Images/image.jpeg").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()
```

Output :

Original Image

Histpgram of RGB Image

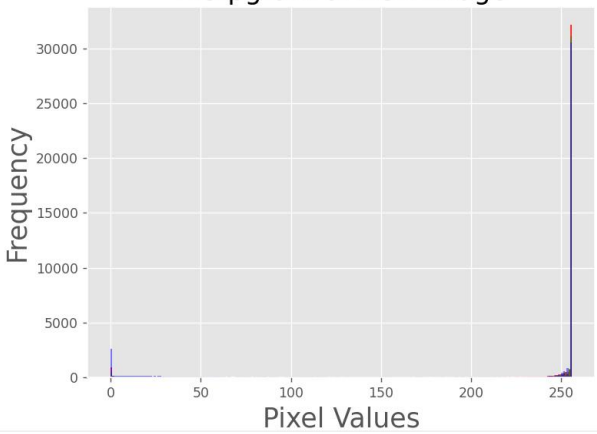
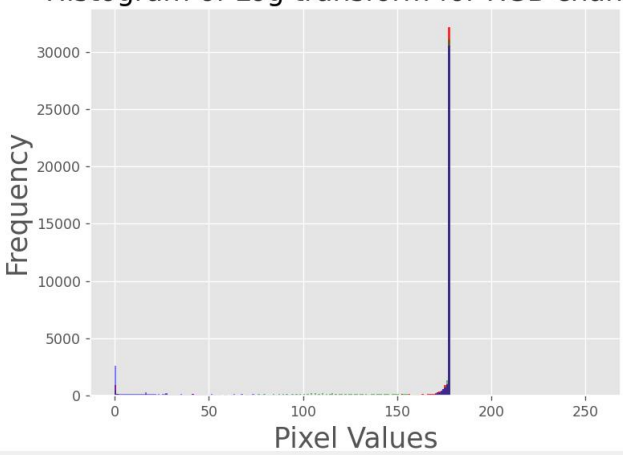
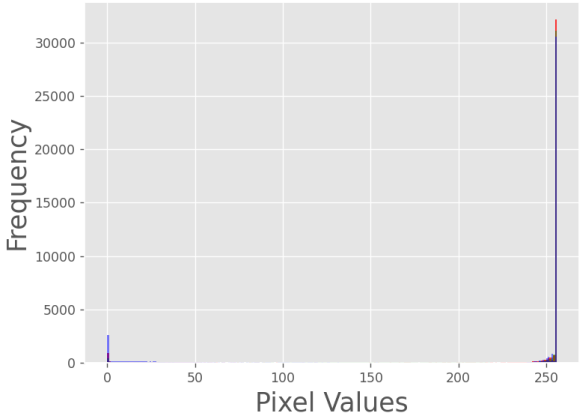


Image after Log Transformation

Histogram of Log transform for RGB channel



Histogram for RGB channel(Input)



Histogram for RGB Output

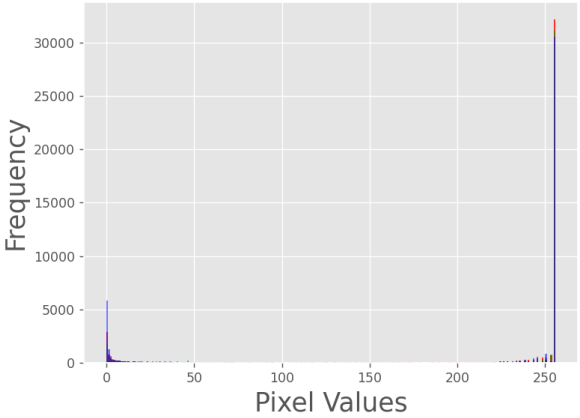
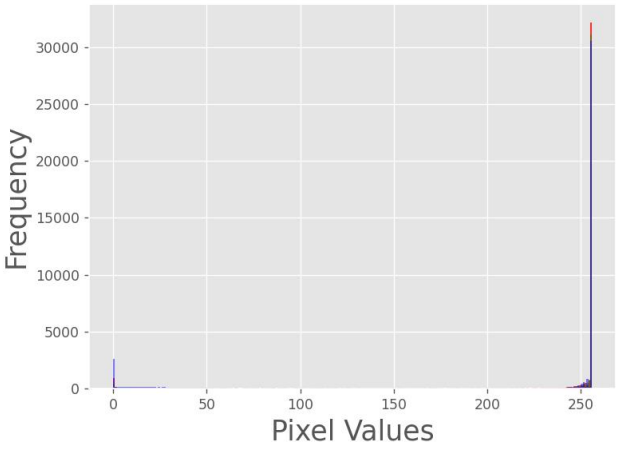
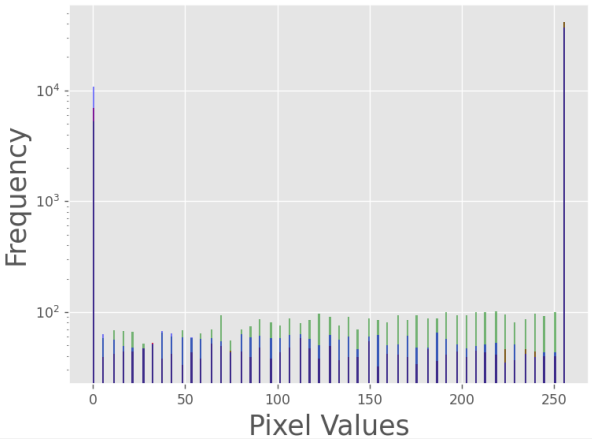
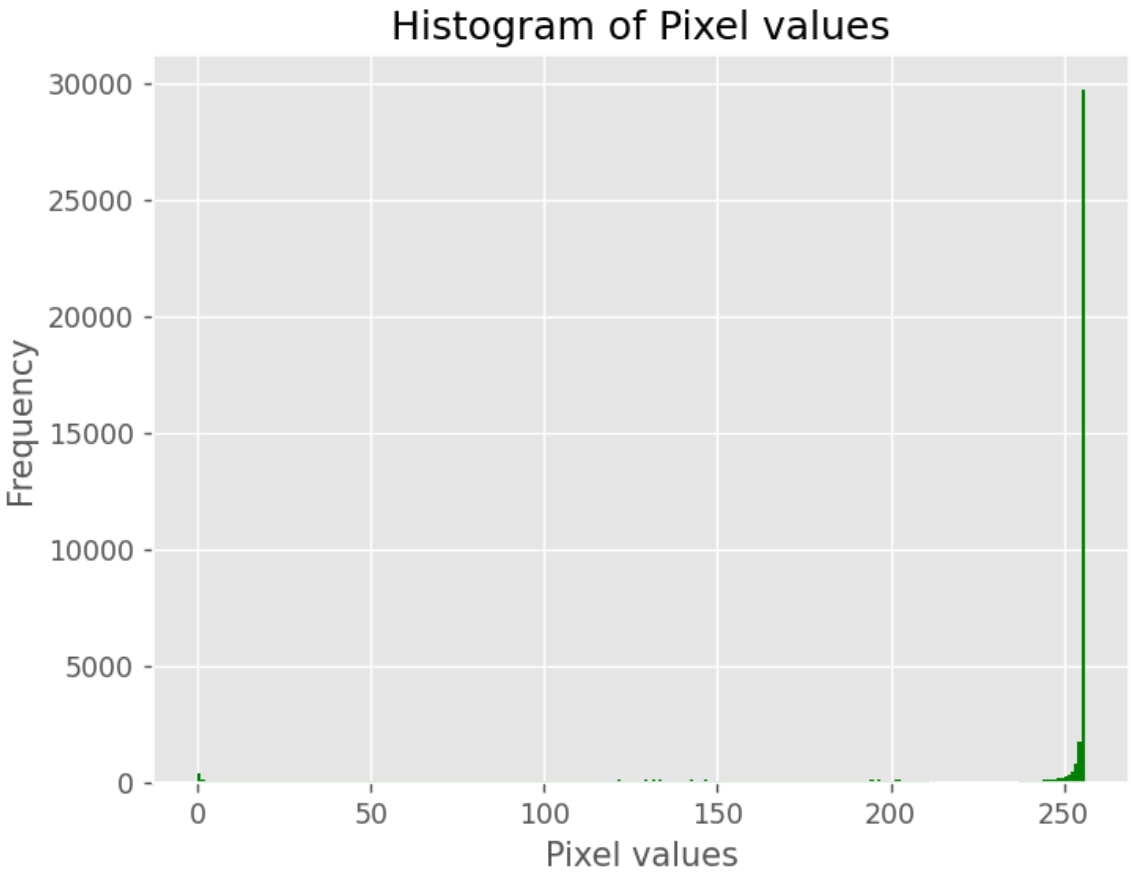


Image original

Log Output







Original Image

Binary Image with Threshold=100

Binary Image with Threshold=150

Binary Image with Threshold=200

Practical 2

Aim :

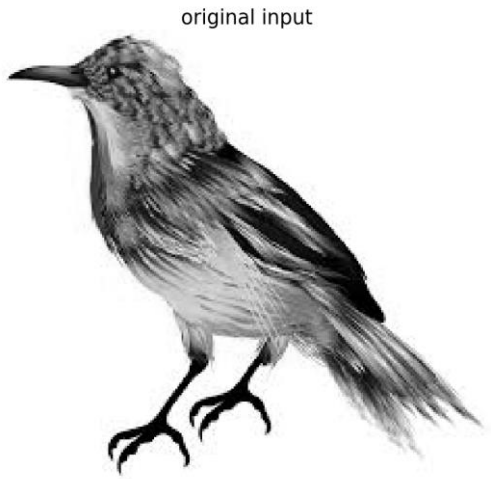
Implement Simple and Adaptive Histogram Equalization

Code :

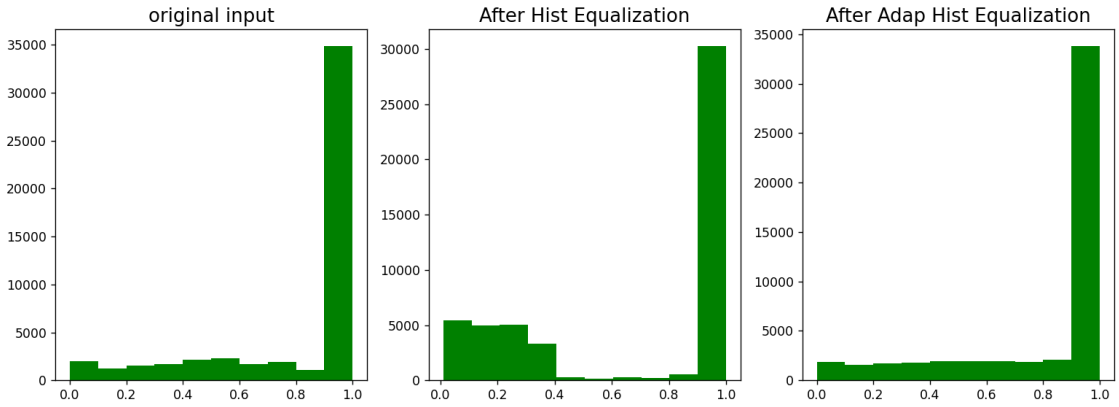
```
import os

import matplotlib.pylab as pylab
import matplotlib.pyplot as plt
import numpy as np
from PIL import Image, ImageEnhance, ImageFilter, ImageOps
from scipy import misc
from scipy import ndimage as ndi
from scipy import signal as signal
from skimage import (color, data, exposure, feature, filters,
img_as_float,
                     img_as_ubyte, io)
from skimage.color import rgb2gray
from skimage.exposure import cumulative_distribution
from skimage.filters import laplace
from skimage.io import imread
from skimage.morphology import (binary_closing, binary_dilation,
                                binary_erosion, binary_opening,
                                convex_hull_image, disk, rectangle,
                                skeletonize)
from skimage.restoration import (denoise_bilateral, denoise_nl_means,
                                 estimate_sigma)
from skimage.util import random_noise


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


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=0.8)
    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 Values", size=20),
    pylab.ylabel("Frequency", size=20)
    pylab.title(title, size=20)
```

```
# Histogram Equalization (Simple and Adaptive)
img = rgb2gray(imread("/Images/image.jpeg"))

# 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", "After Hist Equalization", "After Adap Hist
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()
```

Output :




After Adap Hist Equalization


original input
After Hist Equalization
After Adap Hist Equalization
35000
30000
25000
20000
15000
10000
5000
0
0.0
0.2
0.4
0.6
0.8
1.0

Practical 3

Aim :

Perform the following:

1. Derivatives and Gradients
2. Laplacian Filter
3. Sharpening with Laplacian Plot
4. Unsharp Masking
5. Image Negatives

Code :

```
import os

import matplotlib.pylab as pylab
import matplotlib.pyplot as plt
import numpy as np
from PIL import Image, ImageEnhance, ImageFilter, ImageOps
from scipy import misc, ndimage, signal
from skimage.color import rgb2gray
from skimage.filters import laplace
from skimage.io import imread

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

# Derivatives and Gradients
ker_x = [[-1, 1]]
ker_y = [[-1], [1]]

im = rgb2gray(imread("/Images/image.jpeg"))
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"$\theta$")
```

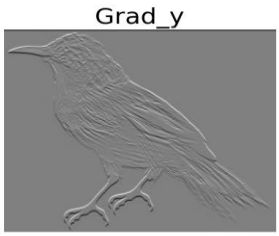
```
pylab.plot(range(im.shape[1]), im[0, :], "b-",
label=r"$f(x,y)|_{x=0}$", linewidth=5)
pylab.plot(range(im.shape[1]), im_x[0, :], "r-", label=r"$grad_x
(f(x,y))|_{x=0}$")
pylab.title(r"$grad_x (f(x, y))|_{x=0}$", size=30)
pylab.legend(prop={"size": 20})
pylab.show()


# Laplacian Filter
ker_laplacian = [[0, -1, 0], [-1, 4, -1], [0, -1, 0]]
im = rgb2gray(imread("/Images/image.jpeg"))
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 Image")
pylab.show()

# Sharpening With laplacian plot
im = rgb2gray(imread("/Images/image.jpeg"))
im1 = np.clip(laplace(im) + im, 0, 1)
pylab.figure(figsize=(10, 15))
pylab.subplot(121), plot_image(im, "Original Image")
pylab.subplot(122), plot_image(im1, "Sharpened Image with Laplace")
pylab.tight_layout()
pylab.show()


# Unsharp Masking
def rgb2gray(im):
    return np.clip(
        0.2989 * im[..., 0] + 0.5870 * im[..., 1] + 0.1140 * im[...,
2], 0, 1
    )


im = rgb2gray(img_as_float(imread("/Images/image.jpeg")))
im_blurred = ndimage.gaussian_filter(im, 3)
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", size=15), axes[1].imshow(im_blurred)
```

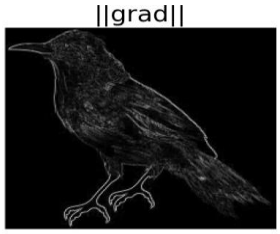
```
axes[2].set_title("Sharpened Image", size=15),
axes[2].imshow(im_detail)

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()

# Image Negative

from PIL import Image
from PIL import ImageOps
import numpy as np
import matplotlib.pyplot as plt

def compute_negative(image_path):
    original_image =  Image.open(image_path)
    original_array = np.array(original_image)
    negative_array = 255-original_array
    negative_image = Image.fromarray(negative_array)
    return original_image, negative_image

def display_images(original_image, negative_image):
    #Display the original and negative images side by side
    fig, axes = plt.subplots(1,2, figsize=(10,5))

    axes[0].imshow(original_image)
    axes[0].set_title("Original Image")

    axes[1].imshow(negative_image)
    axes[1].set_title("Negative Image")

    for ax in axes:
        ax.axis('off')
    plt.show()

if __name__=="__main__":
    image_path ="/Images/image.jpeg"
    original, negative = compute_negative(image_path)
    display_images(original, negative)
```

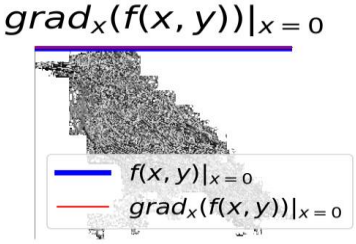
Output :

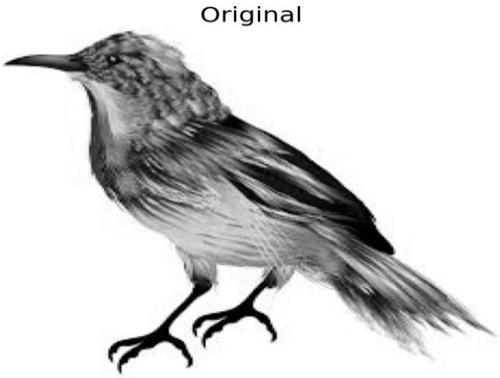

Original


Grad_x


Grad_y


||grad||


$grad_x(f(x,y))|_{x=0}$
$f(x,y)|_{x=0}$
$grad_x(f(x,y))|_{x=0}$


Original


Laplacian Convolved Image


Original Image


Sharpened Image with Laplace

Original Image

Blurred Image

Sharpened Image

Sharpened Image, alpha=1

Sharpened Image, alpha=5

Sharpened Image, alpha=10

Original Image

Negative Image

Practical 4

Aim :

Implement Sobel Image Detector & Canny Edge Detector using Scikit-Image

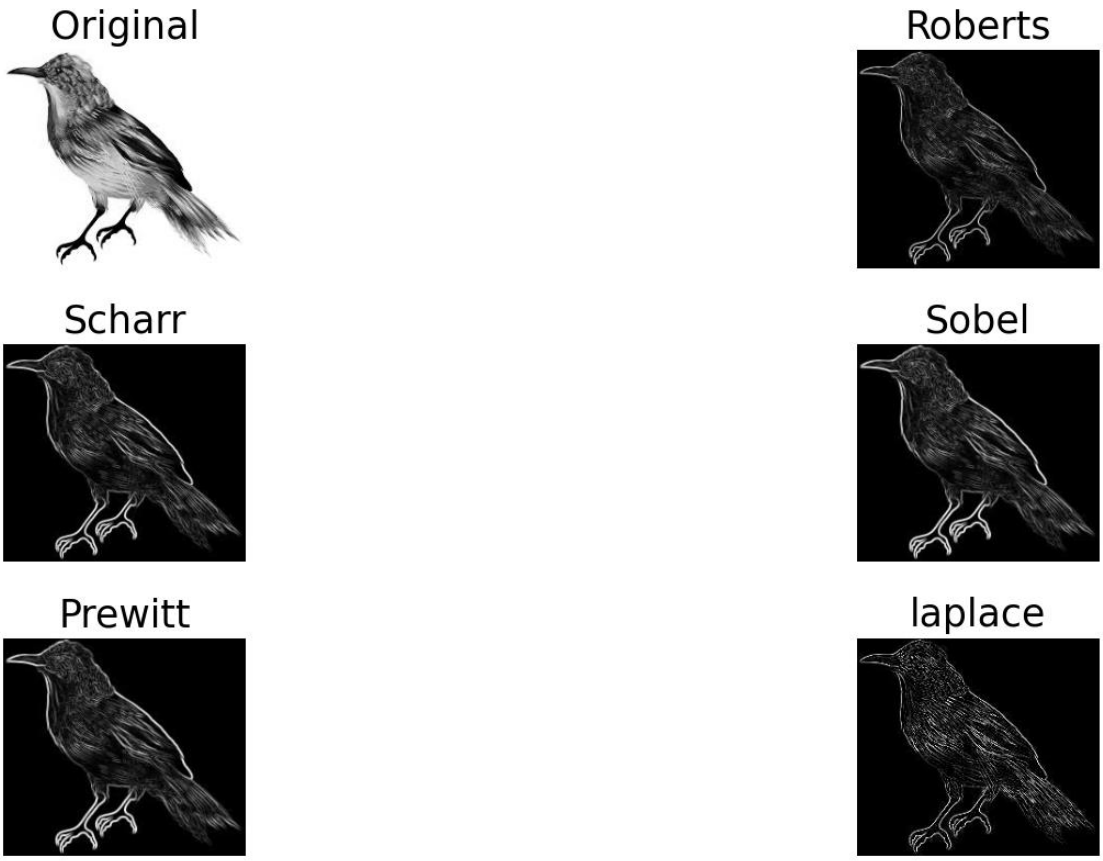
Code :

```
import matplotlib.pylab as pylab
import matplotlib.pyplot as plt
import numpy as np
from PIL import Image, ImageEnhance, ImageFilter, ImageOps
from scipy import misc, ndimage, signal
from skimage import (color, data, exposure, feature, filters,
img_as_float,
                     img_as_ubyte, io)
from skimage.color import rgb2gray
from skimage.exposure import cumulative_distribution
from skimage.filters import laplace
from skimage.io import imread
from skimage.morphology import (binary_closing, binary_dilation,
                                binary_erosion, binary_opening,
                                convex_hull_image, disk, rectangle,
                                skeletonize)
from skimage.restoration import (denoise_bilateral, denoise_nl_means,
                                 estimate_sigma)
from skimage.util import random_noise

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

pylab.gray()

im = imread("/Images/image.jpeg")
im = rgb2gray(im)
pylab.figure(figsize=(15, 15))
pylab.subplot(3, 2, 1), plot_image(im, "Original")
edges = filters.roberts(im)
pylab.subplot(3, 2, 2), plot_image(edges, "Roberts")
edges = filters.scharr(im)
pylab.subplot(3, 2, 3), plot_image(edges, "Scharr")
edges = filters.sobel(im)
pylab.subplot(3, 2, 4), plot_image(edges, "Sobel")
edges = filters.prewitt(im)
pylab.subplot(3, 2, 5), plot_image(edges, "Prewitt")
```

```
edges = np.clip(filters.laplace(im), 0, 1)
pylab.subplot(3, 2, 6), plot_image(edges, "laplace")
pylab.subplots_adjust(wspace=0.1, hspace=0.1)
pylab.show()

# Sobel Image Detector with scikit-image

im = imread("/Images/image.jpeg")
im = rgb2gray(im)
pylab.figure(figsize=(15, 15))
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()

# Canny Edge Detector with scikit-image

image = np.zeros((128, 128), dtype=float)
image[32:-32, 32:-32] = 1
image = ndimage.rotate(image, 15, mode="constant")
image = ndimage.gaussian_filter(image, 4)
image = random_noise(image, mode="speckle", mean=0.05)

edges1 = feature.canny(image)
edges2 = feature.canny(image, sigma=3)
fig, ax = plt.subplots(nrows=1, ncols=3, figsize=(8, 3))

ax[0].imshow(image, cmap="gray")
ax[0].set_title("noisy image", fontsize=10)

ax[1].imshow(edges1, cmap="gray")
ax[1].set_title(r"Canny filter, $\sigma=1$", fontsize=10)

ax[2].imshow(edges2, cmap="gray")
ax[2].set_title(r"Canny filter, $\sigma=5$", fontsize=10)

for a in ax:
    a.axis("off")
```

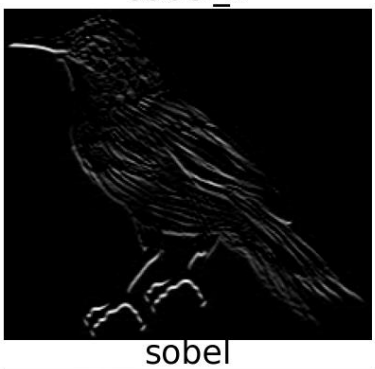
```
fig.tight_layout()
plt.show()

im = rgb2gray(imread("/Images/image.jpeg"))
im[im <= 0.5] = 0
im[im > 0.5] = 1
pylab.gray()
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()
```

Output :



original

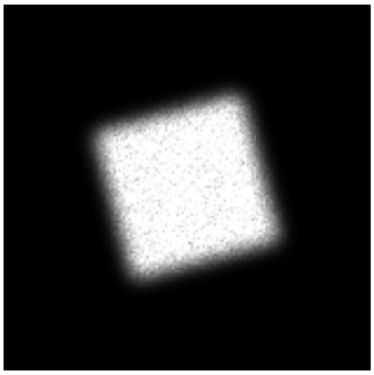
sobel_x



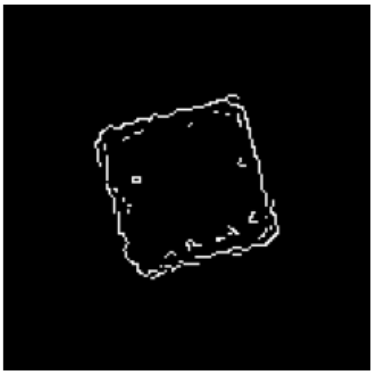
sobel_y

sobel

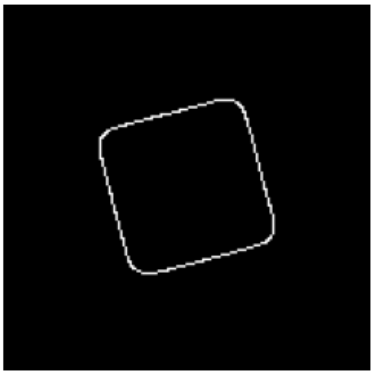
noisy image



Canny filter, $\sigma = 1$



Canny filter, $\sigma = 5$



original

erosion with rectangle size(1,5)

erosion with rectangle size(1,15)

Practical 5

Aim :

Perform the following:

1. Erosion
2. Dilation
3. Opening and Closing
4. Skeletonization
5. Covex Hull
6. White and Black Top-Hats
7. Boundary Extraction

Code :

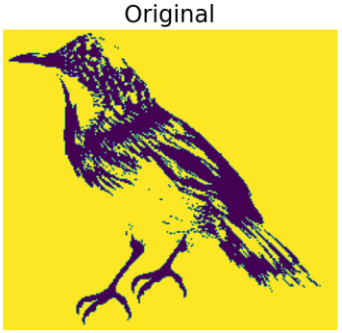
```
import matplotlib.pylab as pylab
import matplotlib.pyplot as plt
import numpy as np
from PIL import Image, ImageEnhance, ImageFilter, ImageOps
from scipy import misc, ndimage, signal
from skimage import (color, data, exposure, feature, filters,
img_as_float,
                     img_as_ubyte, io)
from skimage.color import rgb2gray
from skimage.exposure import cumulative_distribution
from skimage.filters import laplace
from skimage.io import imread
from skimage.morphology import (binary_closing, binary_dilation,
                                binary_erosion, binary_opening,
                                convex_hull_image, disk, rectangle,
                                skeletonize)
from skimage.restoration import (denoise_bilateral, denoise_nl_means,
                                 estimate_sigma)
from skimage.util import random_noise

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


# Erosion
im = rgb2gray(imread("/Images/image.jpeg"))
im[im <= 0.5] = 0 # Create binary image with fixed threshold 0.5
im[im > 0.5] = 1
```

```
pylab.figure(figsize=(20, 20))
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

im = img_as_float(imread("/Images/image.jpeg"))
im = 1 - im[..., 2]
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("Dilated image" + str(2 * d), size=20)
    pylab.axis("off")
pylab.show()

# Opening and Closing

im=rgb2gray(imread("/Images/image.jpeg"))
im[im<=0.5]=0
im[im>0.5]=1
pylab.gray()
pylab.figure(figsize=(20,14))
pylab.subplot(1,3,1), plot_image(im, 'Opening')
im1 = binary_opening(im, disk(5))
pylab.subplot(1,3,2), plot_image(im1, 'Opening with disk ='+str(5))
im1 = binary_closing(im, disk(3))
pylab.subplot(1,3,3), plot_image(im1, 'Closing with disk ='+str(3))

# Skeletonization

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

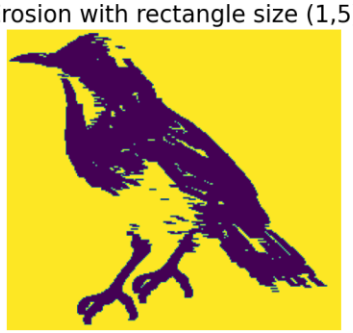
```
    pylab.figure(figsize =sz)
    pylab.subplot(1,2,1), plot_image(original, 'Original')
    pylab.subplot(1,2,2), plot_image(filtered, filter_name)
    pylab.show()

im = img_as_float(imread('/Images/image.jpeg')[...,2])
threshold =0.5
im[im<=threshold]=0
im[im>threshold]=1
skeleton=skeletonize(im)
plot_images_horizontally(im, skeleton, 'skeleton', sz=(18,9))

# Convex Hull

from skimage.morphology import convex_hull_image

im=rgb2gray(imread('/Images/image.jpeg'))
threshold=0.5
im[im<=threshold]=0
im[im>threshold]=1
con_hull=convex_hull_image(im)
plot_images_horizontally(im ,con_hull,'convex hull', sz=(18,9))

# White-Hat, Black-Hat

from skimage.morphology import white_tophat, black_tophat,square

im = imread('/Images/image.jpeg')[...,2]
threshold=0.5
im[im<=threshold]=0
im[im>threshold]=1
im1=white_tophat(im,square(10))
im2=black_tophat(im,square(10))
pylab.figure(figsize=(20,15))
pylab.subplot(1,2,1), plot_image(im1, 'White Top-hat')
pylab.subplot(1,2,2), plot_image(im2, 'Black Top-hat')
pylab.show()

# Boundary Extraction

from skimage.morphology import binary_erosion

im=rgb2gray(imread('/Images/image.jpeg'))
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))
```

Output :

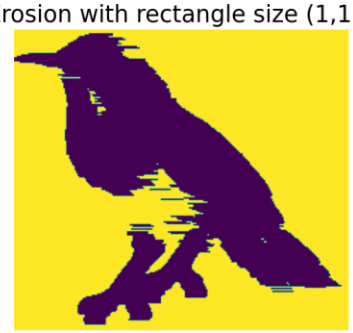
Original



Erosion with rectangle size (1,5)



Erosion with rectangle size (1,15)



original

Dilated image2

Dilated image4

Opening

Opening with disk =5

Closing with disk =3

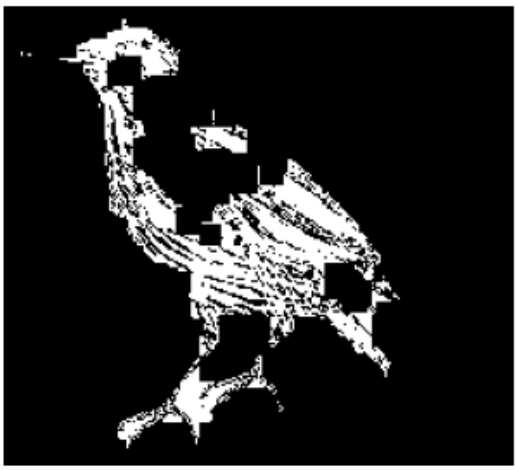
Original

skeleton

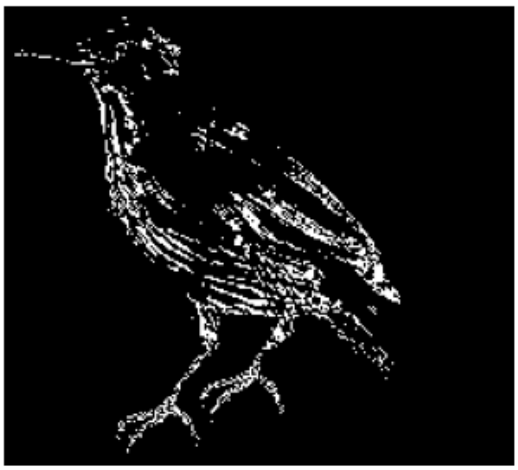
Original

convex hull

White Top-hat

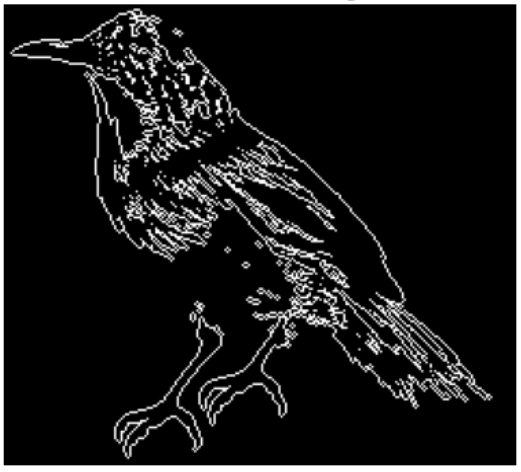


Black Top-hat



Original

boundary



Practical 6

Aim :

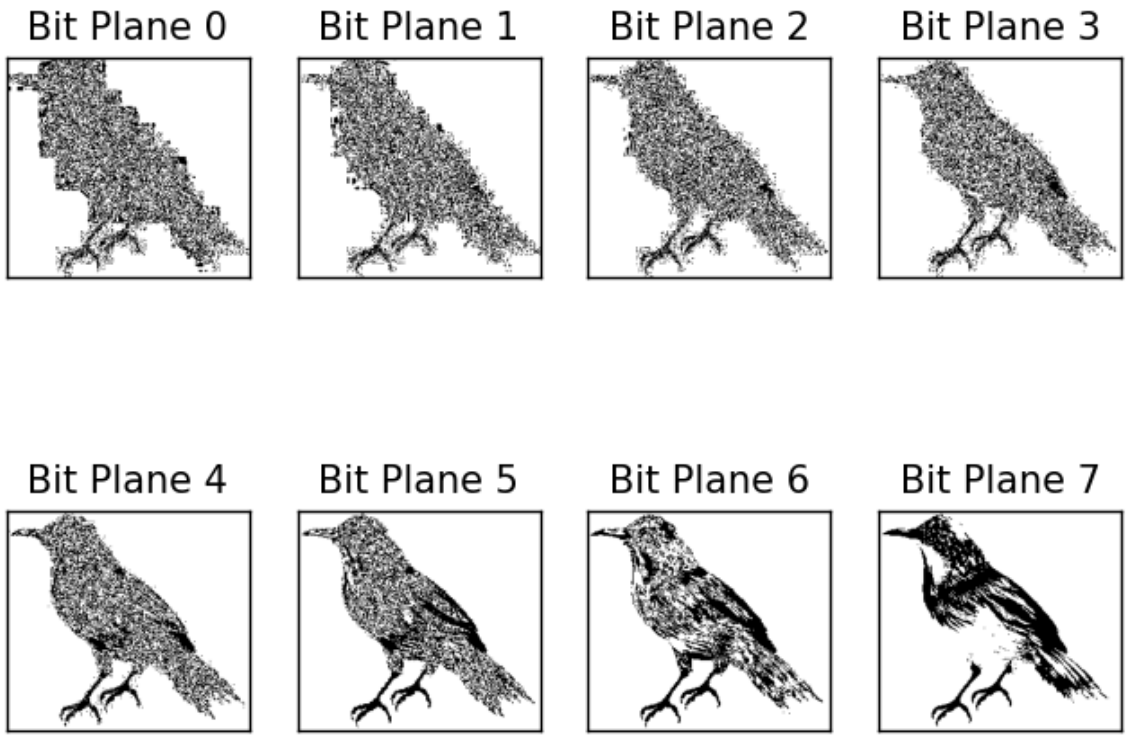
Implement Bit-Plane Slicing

Code :

```
import matplotlib.pylab as pylab
import matplotlib.pyplot as plt
import numpy as np
from PIL import Image, ImageEnhance, ImageFilter, ImageOps
from scipy import misc, ndimage, signal
from skimage import (color, data, exposure, feature, filters,
img_as_float,
                     img_as_ubyte, io)
from skimage.color import rgb2gray
from skimage.exposure import cumulative_distribution
from skimage.filters import laplace
from skimage.io import imread
from skimage.morphology import (binary_closing, binary_dilation,
                                binary_erosion, binary_opening,
                                convex_hull_image, disk, rectangle,
                                skeletonize)
from skimage.restoration import (denoise_bilateral, denoise_nl_means,
                                 estimate_sigma)
from skimage.util import random_noise


input_file ="/Images/image.jpeg"
input_img = Image.open(input_file)

# converts image into numpy array
input_img = input_img.convert('L')
input_arr = np.array(input_img)

# perform bit-plane slicng
bit_planes = []
for i in range(8):
    bit_plane = np.bitwise_and(input_arr, 2**i)
    bit_plane = bit_plane.astype(np.uint8)
    bit_planes.append(bit_plane)

# display the resulting images
for i in range(8):
    plt.subplot(2,4, i+1)
    plt.imshow(bit_planes[i], cmap='gray')
    plt.title("Bit Plane {}".format(i))
```

```
    plt.xticks([])
    plt.yticks([])

plt.show()
```

Code :



Practical 7

Aim :

Implement Basic Compression

Code :

```
# Compression (use BMP and output will be JPEG)

from PIL import Image
import os

bmp_file = "/Images/nature.bmp"
bmp_img = Image.open(bmp_file)

# compress the bmp image into jpeg format
jpeg_img =bmp_img.convert("RGB")
jpeg_file = "output.jpeg"
jpeg_img.save(jpeg_file,"JPEG",quality=50)

# print the size of both files
bmp_size = os.path.getsize(bmp_file)
jpeg_size = os.path.getsize(jpeg_file)
print("Original BMP file size: ",bmp_size,"bytes")
print("Compressed JPEG file size: ",jpeg_size,"bytes")

jpeg_img.save(jpeg_file)
```

Output :

```
Original BMP file size:  818058 bytes
Compressed JPEG file size:  40103 bytes
```

Compressed Image :

Practical 8

Aim :

Implement LZW Compression

Code :

```
# LZW
from PIL import Image
import numpy as np

def lzw_compress(data):
    dict = {chr(i): i for i in range(256)}
    result = []
    w = ""
    for c in data:
        wc = w + c
        if wc in dict:
            w = wc
        else:
            result.append(dict[w])
            dict[wc] = len(dict)
            w = c

    if w:
        result.append(dict[w])
    return result

input = "ABABABABABABABABA"

# Compress using LZW Compression
compressed_data = lzw_compress(input)

# Compute
original_size = len(input)
compressed_size = len(compressed_data)
compression_ratio = compressed_size / original_size

redundant_data = original_size - compressed_size

print("Input Data: ", input)
print("Compressed Data: ", compressed_data)
print("Original Size: ", original_size, "bytes")
print("Compressed Size: ", compressed_size, "bytes")
print("Compression Ratio: ", compression_ratio)
print("Redundancy Ratio: ", 1 - compression_ratio)
print("Redundant Data: ", redundant_data, "bytes")
```

```
##########################################################################
####

def lzw_compress(input_sequence):
    dict_size = 256
    dict = {chr(i): i for i in range(dict_size)}
    compressed_data = []
    w = ""

    for symbol in input_sequence:
        ws = w + symbol
        if ws in dict:
            w = ws
        else:
            compressed_data.append(dict[w])
            dict[ws] = dict_size
            dict_size += 1
            w = symbol

    if w:
        compressed_data.append(dict[w])

    return compressed_data

def imagetolzw(image):
    img = Image.open(image).convert('L')

    pixels = list(img.getdata())
    pixel_sequence = ''.join([chr(pixel) for pixel in pixels])

    compressed_data = lzw_compress(pixel_sequence)

    return compressed_data

# Example
image = '/Images/nature.bmp'
compressed_data = imagetolzw(image)
print(f"Compressed Data Size: {len(compressed_data)} elements")
```

Output :

```
Input Data:  ABABABABABABABABA
Compressed Data:  [65, 66, 256, 258, 257, 260, 259, 65]
Original Size:  17 bytes
Compressed Size:  8 bytes
Compression Ratio:  0.47058823529411764
Redundancy Ratio:  0.5294117647058824
Redundant Data:  9 bytes
```

```
Compressed Data Size: 130230 elements
```

Practical 9

Aim :

Program for Upsampling and Downsampling of an image.

Code :

```
import numpy as np
import matplotlib.pyplot as plt
from scipy import ndimage
from scipy import misc

def display_image(image, title):
  plt.imshow(image, cmap = 'gray')
  plt.title(title)
  plt.axis('off')
  plt.show()

def upsampling_downsampling_demo(image, scale_factor):
  upsampled_image=ndimage.zoom(image,zoom=scale_factor,order=3)
  downsampled_image=ndimage.zoom(image,zoom=1/scale_factor,order=3)

  display_image(image,'Original Image')
  display_image(upsampled_image,f'Upsampled Image(Scale
Factor:{scale_factor})')
  display_image(downsampled_image,f'Downsampled Image(Scale
Factor:{scale_factor})')

  print(f"Original Image Shape: {image.shape}")
  print(f"Upsampled Image Shape: {upsampled_image.shape}")
  print(f"Downsampled Image Shape: {downsampled_image.shape}")

def main():
  image=misc.ascent()
  scale_factor=2
  upsampling_downsampling_demo(image,scale_factor)

if __name__ == "__main__":
  main()
```

Output :

Original Image

Upsampled Image(Scale Factor:2)

Downsampled Image(Scale Factor:2)

```
Original Image Shape: (512, 512)
Upsampled Image Shape: (1024, 1024)
Downsampled Image Shape: (256, 256)
```

Practical 10

Aim :

Perform the following:

1. Image Steganography
2. Visible Watermarking

Code :

```
# Image Steganography

from PIL import Image
import numpy as np
import cv2

def encode_text_in_image(image_path, text, output_path):
    img = Image.open("/Images/image.jpeg")
    img = img.convert('RGBA')
    data = np.array(img)

    binary_text = ''.join(format(ord(i), '08b') for i in text)
    binary_text += '1111111111111110'
    if len(binary_text) > data.size:
        raise ValueError("Text is too long to be encoded in the image")

    # Encode text into image
    data_flat = data.flatten()
    for i in range(len(binary_text)):
        if binary_text[i] == '0':
            if data_flat[i] % 2 != 0:
                data_flat[i] -= 1  # Make it even
        else:
            if data_flat[i] % 2 == 0:
                data_flat[i] += 1  # Make it odd

    # Reshape and save the new image
    data = data_flat.reshape(data.shape)
    encoded_img = Image.fromarray(data)
    encoded_img.save(output_path)

    return output_path


def decode_text_from_image(image_path):
    # Load the image
    img = Image.open(image_path)
    data = np.array(img)
```

```
    # Flatten the image array and extract the LSB of each element
    data_flat = data.flatten()
    binary_text = ''.join(['1' if i % 2 else '0' for i in data_flat])

    # Split the binary text into 8-bit chunks and convert to characters
    chars = [binary_text[i:i+8] for i in range(0, len(binary_text), 8)]
    text = ''.join([chr(int(c, 2)) for c in chars])

    # Detect the delimiter to signify end of text
    delimiter = text.find('\xff\xff')
    if delimiter != -1:
        text = text[:delimiter]

    return text


# Set the paths and text
original_image_path = "/Images/image.jpeg"
encoded_image_path = "encoded_image.png"
text_to_hide = "Hello, world. We are in Class!"

# Encode the text into the image
encode_text_in_image(original_image_path, text_to_hide,
encoded_image_path)

# Decode the text from the image
hidden_text = decode_text_from_image(encoded_image_path)
print("Decoded text:", hidden_text)
```

Output :

```
Decoded text: Hello, world. We are in Class!ÿþß□□ÿuWwû·»ÿ¿ÿ÷Uõ□
```

Code :

```
# Visible Watermarking

def watermark_image(image_path, watermark_path, output_path):
    """Embeds a visible watermark onto an image."""

    # Load images
    image = cv2.imread(image_path)
    watermark = cv2.imread(watermark_path, cv2.IMREAD_UNCHANGED)
```

```
    # Resize watermark (adjust as needed)
    watermark_resized = cv2.resize(watermark, (int(image.shape[1] *
0.2), int(image.shape[0] * 0.2)))

    # Define placement (adjust coordinates)
    x_offset, y_offset = 10, 10

    # Overlay with transparency
    alpha = watermark_resized[:, :, 2] / 255.0  # Extract alpha channel
    for c in range(0, 3):
        image[y_offset:y_offset + watermark_resized.shape[0],
x_offset:x_offset + watermark_resized.shape[1], c] = (
            alpha * watermark_resized[:, :, c] +
            (1 - alpha) * image[y_offset:y_offset +
watermark_resized.shape[0], x_offset:x_offset +
watermark_resized.shape[1], c]
        )

    # Save
    cv2.imwrite(output_path, image)
# Example usage
image_path = "/Images/image.jpeg"
watermark_path = "/Images/watermark.jpeg"
output_path = "watermarked_image.jpg"

watermark_image(image_path, watermark_path, output_path)

print("Watermarked image saved to:", output_path)
```

Output :

```
Watermarked image saved to: watermarked_image.jpg
```

Watermarked image Output :

Practical 11

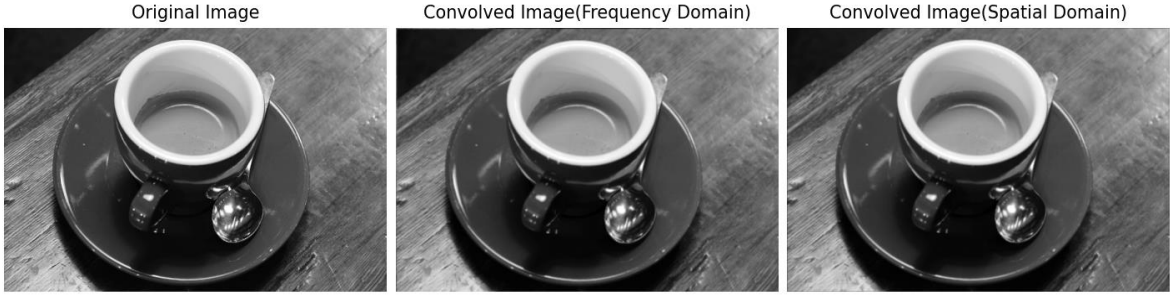
Aim :

Program for 2D Convolution in frequency domain in an input image.

Code :

```
import matplotlib.pyplot as plt
import numpy as np
from scipy.fft import fft2, fftshift, ifft2
from scipy.signal import convolve2d
from skimage import color, data, util

image = color.rgb2gray(data.coffee())
image = util.img_as_float(image)

kernel = np.array([[1, 2, 1], [2, 4, 2], [1, 2, 1]])
kernel = kernel / np.sum(kernel)

fft_image = fft2(image)
fft_kernel = fft2(kernel, s=image.shape)

fft_result = fft_image * fft_kernel
convolved_image = ifft2(fft_result).real
direct_convolution = convolve2d(image, kernel, mode="same")
fig, ax = plt.subplots(1, 3, figsize=(15, 5))

ax[0].imshow(image, cmap="gray")
ax[0].set_title("Original Image")
ax[0].axis("off")
ax[1].imshow(convolved_image, cmap="gray")
ax[1].set_title("Convolved Image(Frequency Domain)")
ax[1].axis("off")
ax[2].imshow(direct_convolution, cmap="gray")
ax[2].set_title("Convolved Image(Spatial Domain)")
ax[2].axis("off")
plt.show()
```

Output :



Practical 12

Aim :

Implement Lowpass Filters in Frequency Domain.

Code :

```
import matplotlib.pyplot as plt
import numpy as np
from scipy.fft import fft2, fftshift, ifft2, ifftshift
from skimage import color, data, util

# Helper functions to create filters
def ideal_lowpass_filter(shape, cutoff):
    rows, cols = shape
    center_row, center_col = rows // 2, cols // 2
    filter = np.zeros((rows, cols))
    for x in range(cols):
        for y in range(rows):
            if (x - center_col) ** 2 + (y - center_row) ** 2 <
cutoff**2:
                filter[y, x] = 1
    return filter


def butterworth_lowpass_filter(shape, cutoff, order):
    rows, cols = shape
    center_row, center_col = rows // 2, cols // 2
    filter = np.zeros((rows, cols))
    for x in range(cols):
        for y in range(rows):
            distance = np.sqrt((x - center_col) ** 2 + (y - center_row)
** 2)
            filter[y, x] = 1 / (1 + (distance / cutoff) ** (2 * order))
    return filter


def gaussian_lowpass_filter(shape, cutoff):
    rows, cols = shape
    center_row, center_col = rows // 2, cols // 2
    filter = np.zeros((rows, cols))
    for x in range(cols):
        for y in range(rows):
            distance = np.sqrt((x - center_col) ** 2 + (y - center_row)
** 2)
            filter[y, x] = np.exp(-(distance**2) / (2 * (cutoff**2)))
    return filter
```

```
# Load an example image and convert it to grayscale
image = color.rgb2gray(data.coffee())
image = util.img_as_float(image)

# FFT of the image
fft_image = fftshift(fft2(image))

# Filter parameters
cutoff = 50  # Cutoff frequency
order = 2  # Order for Butterworth filter

# Create filters
ideal_filter = ideal_lowpass_filter(image.shape, cutoff)
butterworth_filter = butterworth_lowpass_filter(image.shape, cutoff,
order)
gaussian_filter = gaussian_lowpass_filter(image.shape, cutoff)

# Apply filters
ideal_result = ifft2(ifftshift(fft_image * ideal_filter)).real
butterworth_result = ifft2(ifftshift(fft_image *
butterworth_filter)).real
gaussian_result = ifft2(ifftshift(fft_image * gaussian_filter)).real

# Plotting
fig, ax = plt.subplots(2, 4, figsize=(20, 10))
ax[0, 0].imshow(image, cmap="gray")
ax[0, 0].set_title("Original Image")
ax[0, 0].axis("off")

ax[0, 1].imshow(ideal_filter, cmap="gray")
ax[0, 1].set_title("Ideal Filter")
ax[0, 1].axis("off")

ax[0, 2].imshow(butterworth_filter, cmap="gray")
ax[0, 2].set_title("Butterworth Filter")
ax[0, 2].axis("off")
ax[0, 3].imshow(gaussian_filter, cmap="gray")
ax[0, 3].set_title("Gaussian Filter")
ax[0, 3].axis("off")

ax[1, 1].imshow(ideal_result, cmap="gray")
ax[1, 1].set_title("Ideal Filter Result")
ax[1, 1].axis("off")

ax[1, 2].imshow(butterworth_result, cmap="gray")
ax[1, 2].set_title("Butterworth Result")
ax[1, 2].axis("off")
ax[1, 3].imshow(gaussian_result, cmap="gray")
```

```
ax[1, 3].set_title("Gaussian Result")
ax[1, 3].axis("off")

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

Output :