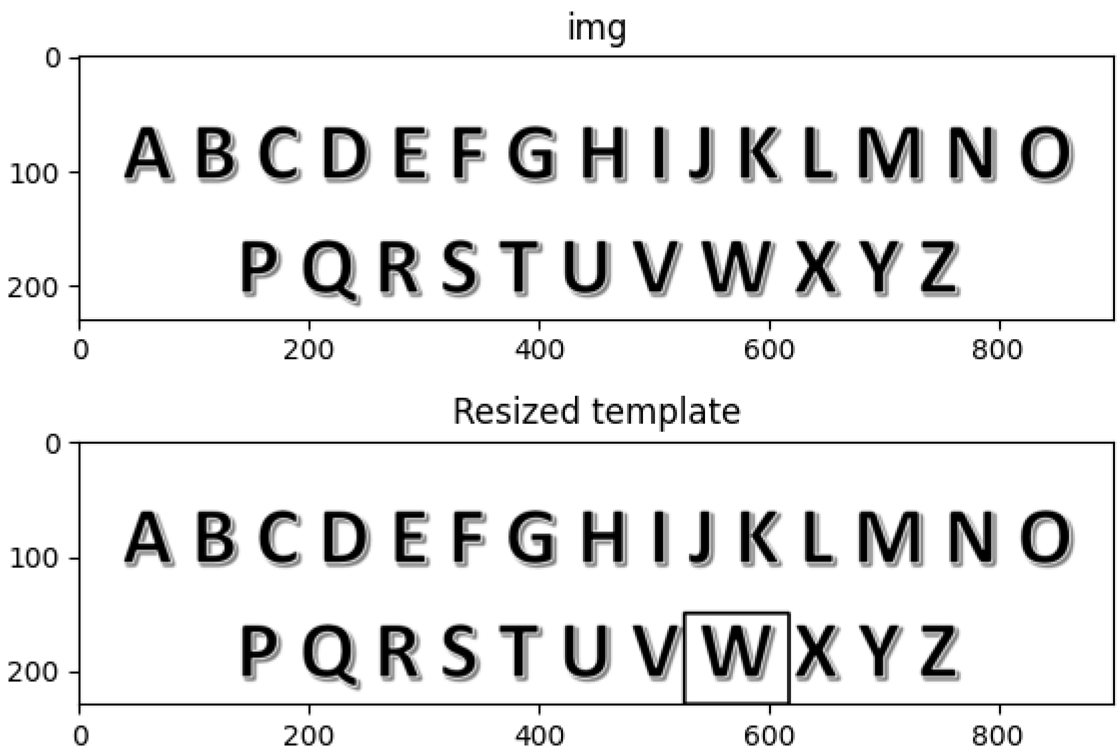
COMPUTER VISION AND IMAGE ANALYSIS

LAB TASKS

1. Perform template matching with respect to “Alphabet images” which is shared in google class room.

```
import numpy as np
import matplotlib.pyplot as plt
import cv2 as cv
!pip install sounddevice
# import sounddevice as sd
import scipy.io as spio
import scipy.signal as spsg
from skimage.filters import laplace, sobel, prewitt,
gaussian
from skimage import segmentation
from skimage.util import random_noise
from skimage.feature import canny


img = cv.imread('/content/A-Z.png',
cv.IMREAD_GRAYSCALE)
template = cv.imread('/content/W.png',
cv.IMREAD_GRAYSCALE)


plt.figure(figsize=(8, 4))
plt.subplot(211), plt.imshow(img, cmap="gray"),
plt.title("img")
plt.subplot(212), plt.imshow(template, cmap="gray"),
plt.title("template")
plt.tight_layout()
```

```
# plt.imshow(img[150:, 530:620]) ---- W sliced from the A-Z image to resize the template
# from the we can get the shape the template should be in
h, w = img[150:, 530:621].shape
template = cv.resize(template, (w, h))
plt.imshow(template, cmap="gray"), plt.title("Resized template")


img_copy = img.copy()
res = cv.matchTemplate(img, template, cv.TM_CCORR_NORMED)
min_val, max_val, min_loc, max_loc = cv.minMaxLoc(res)


top_left = max_loc
bottom_right = (top_left[0] + w, top_left[1] + h)


cv.rectangle(img, top_left, bottom_right, 0, 2)
plt.imshow(img, cmap="gray")
```



2. Perform template matching of “voice signal”. Perform the following step by step

Step 1: Record your voice with sampling rate of 8000 Hz for a duration of one second. The word to be uttered is “Hello”. This has to be done uniformly so that the length of the signal remains the same for everyone.

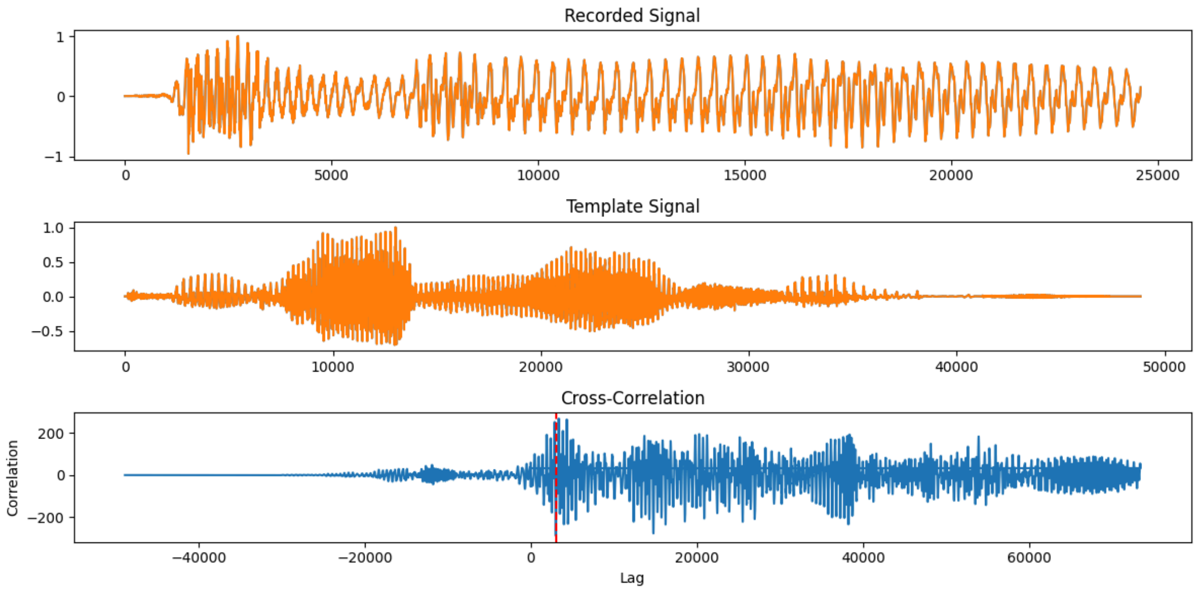
Step 2: Perform correlation of “Hello” with respect to other “Hello” signal and find the best match.

```
import numpy as np
import scipy.io.wavfile as wavfile
from scipy.signal import correlate
import matplotlib.pyplot as plt

# Load the recorded audio and template audio
recorded_rate, recorded_signal = wavfile.read('/content/hello.wav')
template_rate, template_signal = wavfile.read('/content/congo.wav')
```

```
# Ensure both signals have the same sampling rate
assert recorded_rate == template_rate, "Sampling rates do not match"

# Normalize signals
recorded_signal = recorded_signal / np.max(np.abs(recorded_signal))
template_signal = template_signal / np.max(np.abs(template_signal))

# Perform cross-correlation
correlation = correlate(recorded_signal.flatten(), template_signal.flatten(), mode='full')

# Compute lag array based on the length of correlation
lag = np.arange(-len(template_signal) + 1, len(recorded_signal))

# Adjust lag to match the length of correlation
# Correlation length is len(recorded_signal) + len(template_signal) - 1
expected_lag_length = len(correlation)
lag = np.arange(-len(template_signal) + 1, len(recorded_signal) + len(template_signal))

# Trim or pad lag to match correlation length
```

```python
if len(lag) > expected_lag_length:
    lag = lag[:expected_lag_length]
else:
        lag = np.pad(lag, (0, expected_lag_length - len(lag)), mode='constant')

# Check lengths
print(f'Length of lag: {len(lag)}')
print(f'Length of correlation: {len(correlation)}')

# Ensure lengths match
assert len(lag) == len(correlation), "Lag and correlation lengths do not match."

# Find the best match
best_match_index = np.argmax(np.abs(correlation))
best_lag = lag[best_match_index]

# Display results
plt.figure(figsize=(12, 6))

plt.subplot(3, 1, 1)
plt.plot(recorded_signal)
plt.title('Recorded Signal')

plt.subplot(3, 1, 2)
```

```
plt.plot(template_signal)
plt.title('Template Signal')


plt.subplot(3, 1, 3)
plt.plot(lag, correlation)
plt.title('Cross-Correlation')
plt.axvline(x=best_lag, color='r', linestyle='--')
plt.xlabel('Lag')
plt.ylabel('Correlation')


plt.tight_layout()
plt.show()


print(f'Best match at lag: {best_lag}')
```



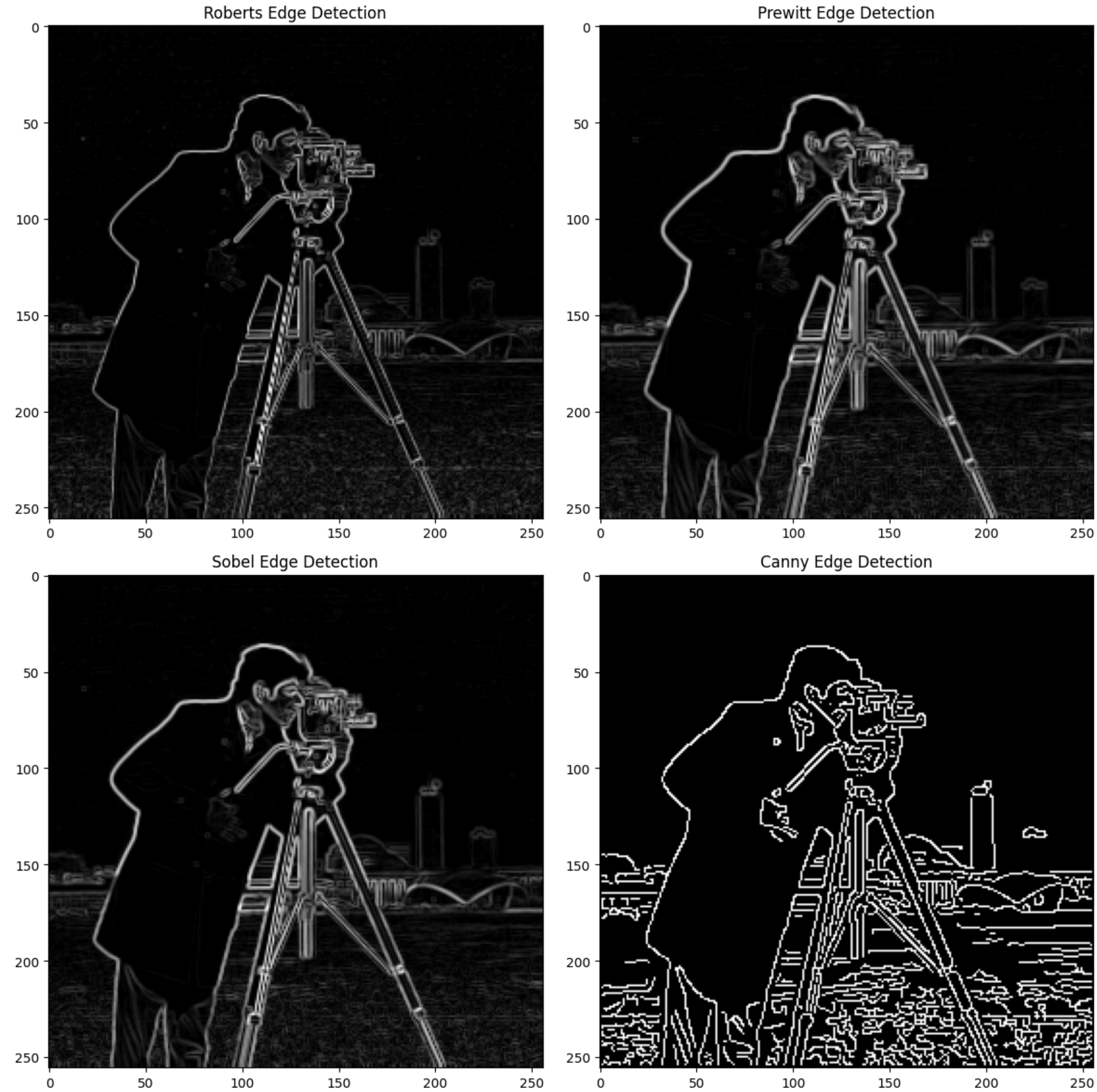
3. Edge detection task

Step 1: Take a photograph of a good document using your mobile phone. Utmost care has to be taken to capture the document image. Don't download the document image from the internet. The document wordings should be good.

Step 2: Apply the following operators (i) Robert (ii) Prewitt (iii) Sobel and (iv) Canny edge detector to the input document image and analyse the result.

```
import numpy as np
import matplotlib.pyplot as plt
from skimage import io, color
from skimage.filters import roberts, prewitt, sobel
from skimage.feature import canny

# Load the image
image_path = '/content/cameraman.png'   # Replace with your image path
image = io.imread(image_path)

# Check if the image is already grayscale
if len(image.shape) == 2:  # Grayscale image
    gray_image = image
else:  # RGB image
    gray_image = color.rgb2gray(image)

# Apply edge detection operators
edges_roberts = roberts(gray_image)
edges_prewitt = prewitt(gray_image)
edges_sobel = sobel(gray_image)
```

```python
edges_canny = canny(gray_image)


# Plot the results
plt.figure(figsize=(12, 12))


plt.subplot(2, 2, 1)
plt.imshow(edges_roberts, cmap='gray')
plt.title('Roberts Edge Detection')


plt.subplot(2, 2, 2)
plt.imshow(edges_prewitt, cmap='gray')
plt.title('Prewitt Edge Detection')


plt.subplot(2, 2, 3)
plt.imshow(edges_sobel, cmap='gray')
plt.title('Sobel Edge Detection')


plt.subplot(2, 2, 4)
plt.imshow(edges_canny, cmap='gray')
plt.title('Canny Edge Detection')


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



4. Watershed algorithm

The sample code given below performs image segmentation using watershed algorithm. Analyse the role of elevation map and marker. For elevation map, Laplacian operator which is basically a second order derivative is applied. What will happen it is replaced by first order derivative filters like Sobel, Prewit and Canny? Will it be possible to show that water shed algorithm results in over segmentation in the presence of noise?

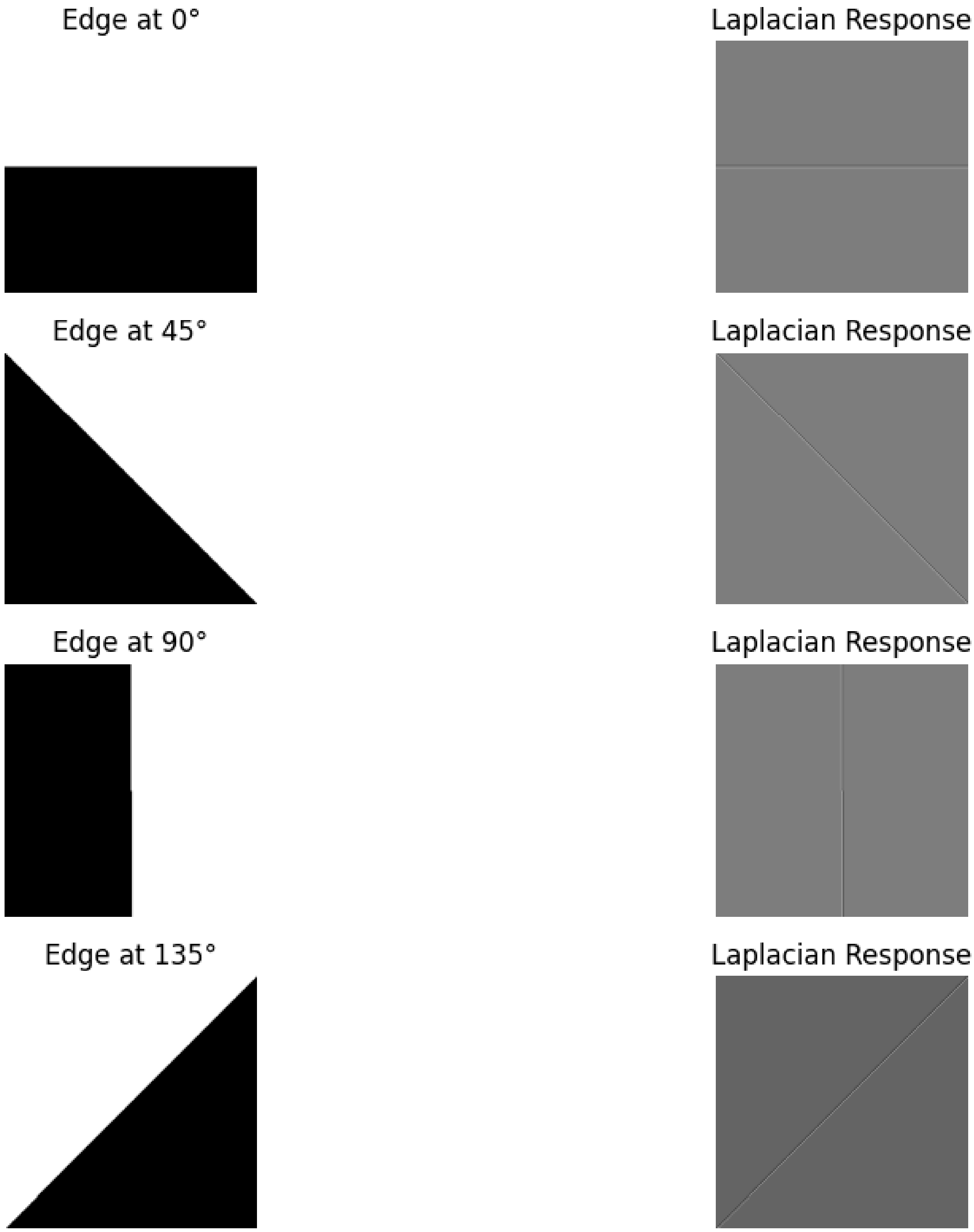
```
import cv2
import matplotlib.pyplot as plt
import numpy as np
from skimage.filters import laplace
from skimage import segmentation
#Step 1: Read the input image
img=cv2.imread("cameraman.tif",0)
#Step 2: Extract the edge information
elevation_map=laplace(img)
#Step3: Define the markers
markers=np.zeros_like(img)
markers[img<[illegible]]=1
markers[img>125]=2
#Step 4: Perform watershed based segmentation
segmented_img=segmentation.watershed(elevation_map,markers)
#Step 5: Displaying the results
plt.subplot(1,2,1);plt.imshow(img,cmap="gray")
plt.title("Input image")
plt.subplot(1,2,2);plt.imshow(segmented_img,cmap="gray")
plt.title("Output image")
plt.tight_layout()
```

5. Write a python code to prove that "Laplacian" operator is an "isotropic" operator.

```
import numpy as np

import cv2

import matplotlib.pyplot as plt


def create_edge_image(size, angle):

    """Create an image with an edge oriented at a specific angle."""

    image = np.zeros((size, size), dtype=np.float32)

    center = size // 2

    for y in range(size):

        for x in range(size):

            if y < center + np.tan(np.deg2rad(angle)) * (x - center):

                image[y, x] = 255

    return image


def apply_laplacian(image):

    """Apply Laplacian operator to an image."""

    image = np.uint8(image)  # Convert image to 8-bit format
```

```python
    laplacian = cv2.Laplacian(image, cv2.CV_64F)  # Apply Laplacian operator
    return laplacian

# Parameters
size = 256
angles = [0, 45, 90, 135]  # Different edge orientations

# Create figures
plt.figure(figsize=(12, 8))

for i, angle in enumerate(angles):
    # Create edge image
    edge_image = create_edge_image(size, angle)

    # Apply Laplacian operator
    laplacian_image = apply_laplacian(edge_image)

    # Plot original edge image
    plt.subplot(len(angles), 2, 2*i + 1)
    plt.imshow(edge_image, cmap='gray')
    plt.title(f'Edge at {angle}°')
    plt.axis('off')

    # Plot Laplacian of the image
```

```
    plt.subplot(len(angles), 2, 2*i + 2)
    plt.imshow(laplacian_image, cmap='gray')
    plt.title(f'Laplacian Response')
    plt.axis('off')

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



Hint: An isotropic operator in an image processing context is one which applies equally well in all directions in an image, with no particular sensitivity or bias towards one particular set of directions