This is a python project that implement the function imfilter in the first part and a new function called my_compose

Part 1: Implementing the imfilter function.

write r=my_imfilter(s,filter,pad) a function that "filters" the source image (a square matrix of some size) according to a filter of some size. with the help of the function you wrote, you will perform smoothing and sharpening of the given image.

• Implement 3 types of padding

• Work on photos you took, transfer them to gray levels, size (256X256)

• Compare the result with running the cipher functions. What is the biggest difference? from where Where does the difference come from? Is it visually noticeable?

• Compare the performance against the library functions.

• Do not use library functions in the implementation.

In [1]:

```
# installing opencv
#!pip install opencv
```

In [2]:

```
# Imports
import numpy as np
import cv2 as cv
import time
import matplotlib.pyplot as plt
```

Defining 3 padding

In [3]:

```
# Defining the 3 padding options to be used in the my_imfilter function
def zero_padding(image, pad_size):
    height, width = image.shape
    padded_image = np.zeros((height + 2 * pad_size, width + 2 * pad_size)) # Initialize t
    padded_image[pad_size:pad_size + height, pad_size:pad_size + width] = image # Apply t
    return padded_image

def replicate_padding(image, pad_size):
    height, width = image.shape
    padded_image = np.zeros((height + 2 * pad_size, width + 2 * pad_size))

    # padding the top, bottom, left, and right borders
    padded_image[:pad_size, pad_size:-pad_size] = image[0, :] # Top
    padded_image[-pad_size:, pad_size:-pad_size] = image[-1, :] # Bottom
    padded_image[pad_size:-pad_size, :pad_size] = image[:, 0].reshape(-1, 1) # Left
    padded_image[pad_size:-pad_size, -pad_size:] = image[:, -1].reshape(-1, 1) # Right

    # padding the corner areas
    padded_image[:pad_size, :pad_size] = image[0, 0] # Top-left corner
    padded_image[:pad_size, -pad_size:] = image[0, -1] # Top-right corner
    padded_image[-pad_size:, :pad_size] = image[-1, 0] # Bottom-left corner
    padded_image[-pad_size:, -pad_size:] = image[-1, -1] # Bottom-right corner

    # adding to the central area of the proccessed image the original image
    padded_image[pad_size:pad_size + height, pad_size:pad_size + width] = image

    return padded_image

def reflect_padding(image, pad_size):
    height, width = image.shape
    padded_image = np.zeros((height + 2 * pad_size, width + 2 * pad_size))

    # padding the top, bottom, left, and right borders of the image
    padded_image[:pad_size, pad_size:-pad_size] = np.flipud(image[:pad_size, :]) # Top
    padded_image[-pad_size:, pad_size:-pad_size] = np.flipud(image[-pad_size:, :]) # Bott
    padded_image[pad_size:-pad_size, :pad_size] = np.fliplr(image[:, :pad_size]) # Left
    padded_image[pad_size:-pad_size, -pad_size:] = np.fliplr(image[:, -pad_size:]) # Righ

    # padding the corner areas with the reflected values
    padded_image[:pad_size, :pad_size] = np.flipud(np.fliplr(image[:pad_size, :pad_size])
    padded_image[:pad_size, -pad_size:] = np.flipud(np.fliplr(image[:pad_size, -pad_size:
    padded_image[-pad_size:, :pad_size] = np.flipud(np.fliplr(image[-pad_size:, :pad_size
    padded_image[-pad_size:, -pad_size:] = np.flipud(np.fliplr(image[-pad_size:, -pad_siz

    # adding to the central area of the proccesssed image the original image
    padded_image[pad_size:pad_size + height, pad_size:pad_size + width] = image

    return padded_image
```

The main function my_imfilter

In [4]:

```
# Defining the imfilter function with 3 diffrent types of paddings
def my_imfilter(s, filter, pad):
    # Defining a dictionary to map all padding options to padding operations
    padding_operations = {
        'zero': lambda img, pad_size: zero_padding(img, pad_size),
        'replicate': lambda img, pad_size: replicate_padding(img, pad_size),
        'reflect': lambda img, pad_size: reflect_padding(img, pad_size)
    }

    # Checking if the padding option choosen is valid
    if pad not in padding_operations:
        raise ValueError("invalid padding option")

    # Grabing the padding operation for the wanted padding option
    padding_function = padding_operations[pad]

    # Determining the padding size by the filter size (should be odd number)
    filter_size = filter.shape[0]
    pad_size = (filter_size - 1) // 2

    # Appling padding using the choosen padding
    padded_image = padding_function(s, pad_size)

    output = np.zeros_like(s) # The processed image will be saved here, so we initialize

    for i in range(s.shape[0]):
        for j in range(s.shape[1]):
            window = padded_image[i:i+filter_size, j:j+filter_size] # this is the area we
            output[i, j] = np.sum(window * filter)

    return output
```

In [5]:

```
# Loading my image and converting it to grayscale and then resizing it to (256, 256)
image = cv.imread('my_dog.jpg')
gray_image = cv.cvtColor(image, cv.COLOR_BGR2GRAY)
gray_image = cv.resize(gray_image, (256, 256))

# Defining my smoothing and sharpening filters
smoothing_filter = np.ones((3, 3)) / 9
sharpening_filter = np.array([[0, -1, 0],
                              [-1, 5, -1],
                              [0, -1, 0]])


# Smoothing
smoothed_image_zero = my_imfilter(gray_image, smoothing_filter, pad='zero')
smoothed_image_replicate = my_imfilter(gray_image, smoothing_filter, pad='replicate')
smoothed_image_reflect = my_imfilter(gray_image, smoothing_filter, pad='reflect')

# Sharpening
sharpened_image_zero = my_imfilter(gray_image, sharpening_filter, pad='zero')
sharpened_image_replicate = my_imfilter(gray_image, sharpening_filter, pad='replicate')
sharpened_image_reflect = my_imfilter(gray_image, sharpening_filter, pad='reflect')
```

Comparing the performance against the library functions (OpenCV) by comparing the time it took to work.

Comparing smoothing:

In [6]:

```
# Timing for my_imfilter
start_time = time.time()
result_smoothing = my_imfilter(gray_image, smoothing_filter, pad='zero')
end_time = time.time()
print("My filter execution time with smoothing:", end_time - start_time)

# Timing for OpenCV GaussianBlur
start_time = time.time()
result_gaussian = cv.GaussianBlur(gray_image, (3, 3), 0)
end_time = time.time()
print("OpenCV GaussianBlur execution time:", end_time - start_time)
```

```
My filter execution time with smoothing: 0.3849914073944092
OpenCV GaussianBlur execution time: 0.0
```

Comparing sharpening:

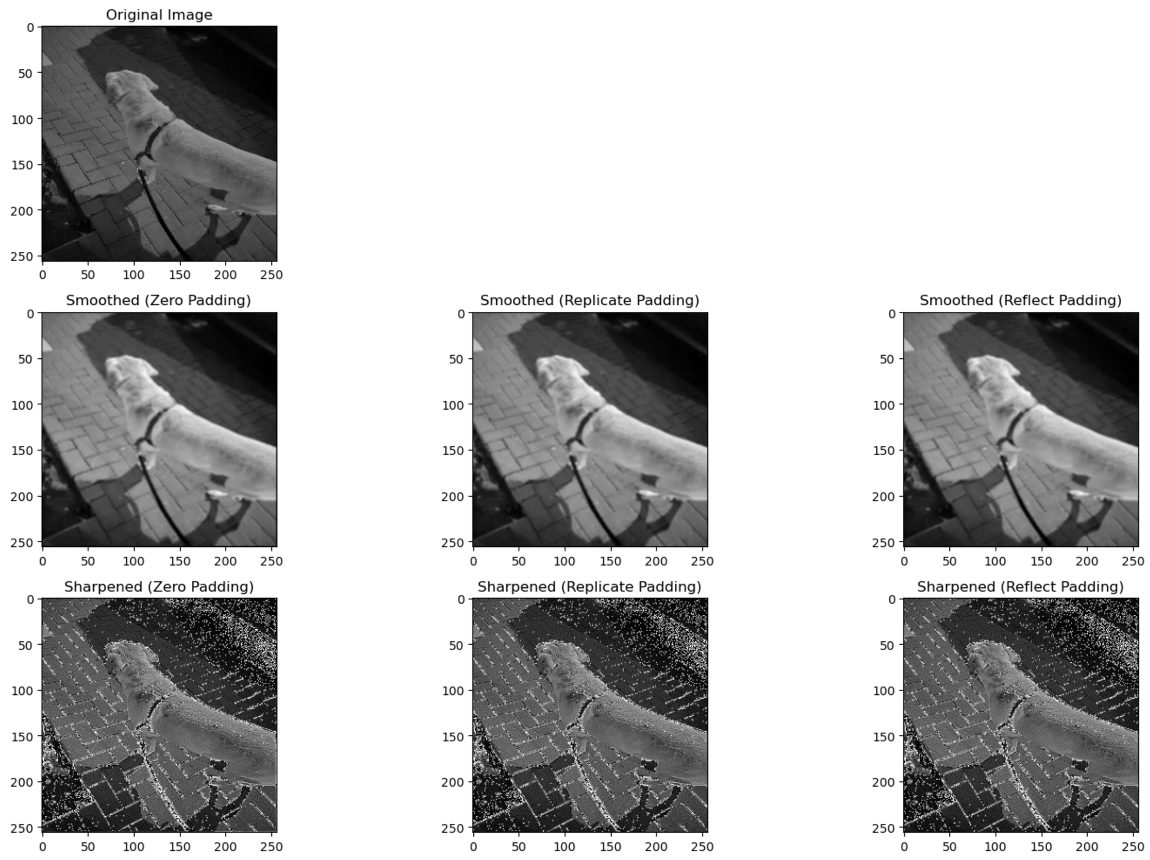
In [7]:

```
# Timing for my_imfilter
start_time = time.time()
result_sharpening = my_imfilter(gray_image, sharpening_filter, pad='zero')
end_time = time.time()
print("My filter execution time with sharpening:", end_time - start_time)

# Timing for OpenCV Laplacian
start_time = time.time()
# Applying unsharp mask for sharpening (there is no dedicated library fucntion for sharpe
# Applying a gaussian blur then substracting the blur from the original
blurred_image = cv.GaussianBlur(gray_image, (0, 0), 3)
sharpened_image = cv.addWeighted(gray_image, 1.5, blurred_image, -0.5, 0)
end_time = time.time()
print("OpenCV Laplacian execution time:", end_time - start_time)
```

```
My filter execution time with sharpening: 0.39992904663085094
OpenCV Laplacian execution time: 0.0009977817535400039
```

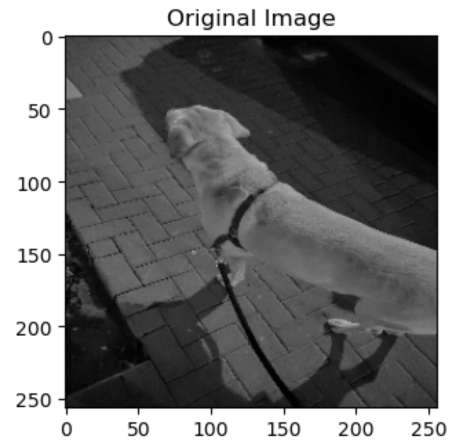
In [8]:

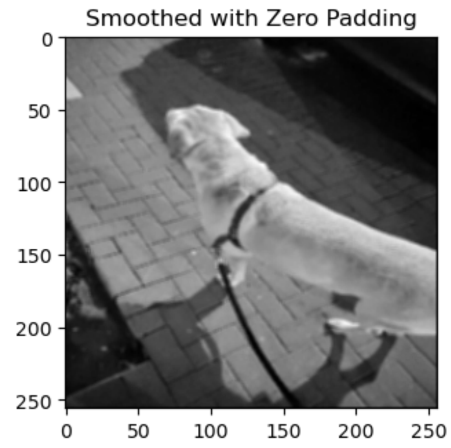
```
# Displaying the original image and the processed results with all the diffrent paddings
plt.figure(figsize=(15, 10))

plt.subplot(3, 3, 1)
plt.imshow(gray_image, cmap='gray')
plt.title('Original Image')

plt.subplot(3, 3, 4)
plt.imshow(smoothed_image_zero, cmap='gray')
plt.title('Smoothed (Zero Padding)')

plt.subplot(3, 3, 7)
plt.imshow(sharpened_image_zero, cmap='gray')
plt.title('Sharpened (Zero Padding)')

plt.subplot(3, 3, 5)
plt.imshow(smoothed_image_replicate, cmap='gray')
plt.title('Smoothed (Replicate Padding)')

plt.subplot(3, 3, 8)
plt.imshow(sharpened_image_replicate, cmap='gray')
plt.title('Sharpened (Replicate Padding)')

plt.subplot(3, 3, 6)
plt.imshow(smoothed_image_reflect, cmap='gray')
plt.title('Smoothed (Reflect Padding)')

plt.subplot(3, 3, 9)
plt.imshow(sharpened_image_reflect, cmap='gray')
plt.title('Sharpened (Reflect Padding)')

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

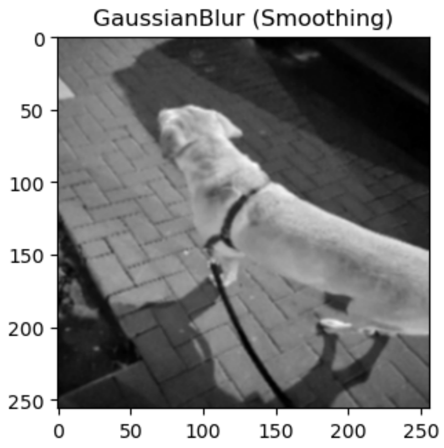

Original Image
Smoothed (Zero Padding)
Smoothed (Replicate Padding)
Smoothed (Reflect Padding)
Sharpened (Zero Padding)
Sharpened (Replicate Padding)
Sharpened (Reflect Padding)

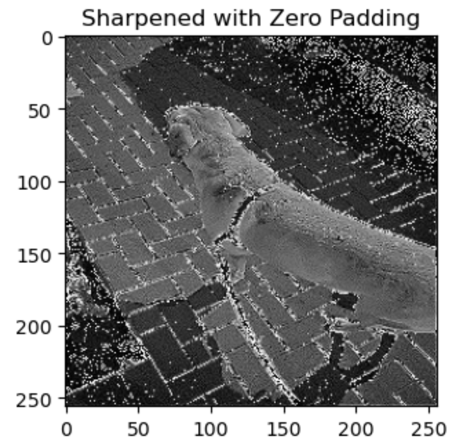
In [9]:

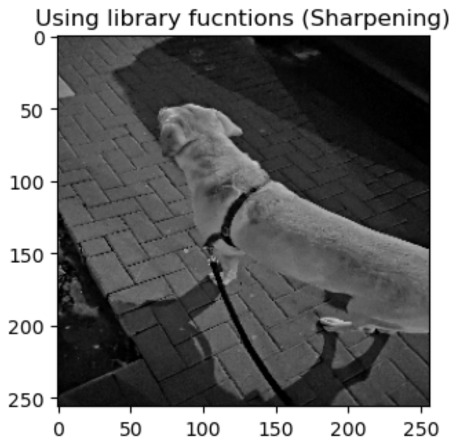
```
# Displaying the original image processed results with my padding compared with the libra
plt.figure(figsize=(15, 10))

plt.subplot(3, 3, 1)
plt.imshow(gray_image, cmap='gray')
plt.title('Original Image')

plt.subplot(3, 3, 4)
plt.imshow(result_smoothing, cmap='gray')
plt.title('Smoothed with Zero Padding')

plt.subplot(3, 3, 5)
plt.imshow(result_gaussian, cmap='gray')
plt.title('GaussianBlur (Smoothing)')

plt.subplot(3, 3, 7)
plt.imshow(result_sharpening, cmap='gray')
plt.title('Sharpened with Zero Padding')

plt.subplot(3, 3, 8)
plt.imshow(sharpened_image, cmap='gray')
plt.title('Using library fucntions (Sharpening)')

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











Part 2: Creating new function, my_compose.

Write a function r=my_compose(s,s1,m2) that receives 2 images and creates "combined" image where the m high bits (msb) of the result are from the first image, and the lower 8-m are the high bits (msb) of the second image.

• Also, write a function that checks whether the image is "fake". Explain what you did (what is the algorithem).

• If m is not given, the default is 3

• Work on photos you took (move them to gray level 256X256)

In [10]:

```
def my_compose(s1, s2, m=3):
    # Resize both images to 256x256
    s1 = cv.cvtColor(cv.resize(s1, (256, 256)), cv.COLOR_BGR2GRAY)
    s2 = cv.cvtColor(cv.resize(s2, (256, 256)), cv.COLOR_BGR2GRAY)

    # If m is outside of the valid values change it to 3
    if m < 0 or m > 8:
        m=3

    # Combine the images based on the amount of m given
    combined_image = (s1 >> (8 - m)) << (8 - m)  # Seperating the m high bits from s1
    combined_image += ((s2 << m) >> m)  # Seperating the (8-m) low bits from s2 and combi



    return combined_image.astype(np.uint8)
```

Fake image fucntion detection, compares the combined image with the original (image1)

In [15]:

```
def is_faked_image(combined_image, original_image):
    # Performing bitwise AND operation for each pixel to take its LSB 1 and MSB 1
    # both from the combined image and original image

    # Extracting the LSB 1 from the combined image
    lsb_combined = combined_image & 0b01

    # Extracting the LSB 1 from original
    lsb_original = original_image & 0b01

    # Extracting the MSB 1 from the combined image
    msb_combined = combined_image & 0b10000000

    # Extracting the MSB 1 from original
    msb_original = original_image & 0b10000000

    # Checking if all LSB 1 bits dont match and MSB 1 match

    return (not np.all(lsb_combined == lsb_original)) and np.all(msb_combined == msb_orig
```

Demonstration of the functions

In [12]:

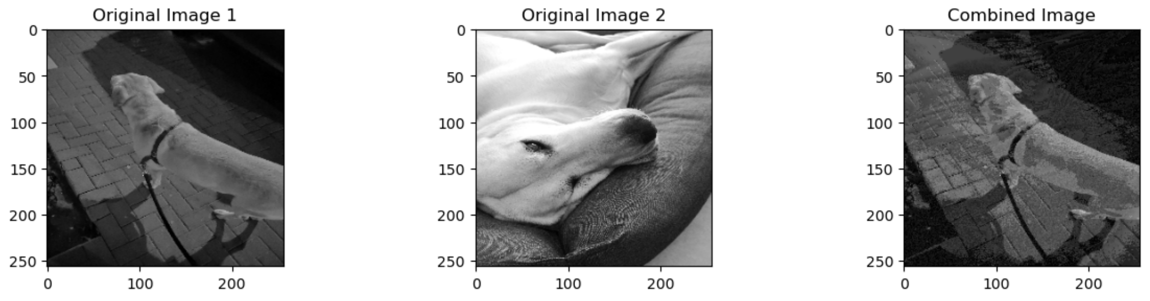
```
# Grabbing 2 images
image1 = cv.imread('my_dog.jpg')
image2 = cv.imread('my_dog2.jpg')
image1_GRAY = cv.cvtColor(cv.resize(image1, (256, 256)), cv.COLOR_BGR2GRAY)
image2_GRAY = cv.cvtColor(cv.resize(image2, (256, 256)), cv.COLOR_BGR2GRAY)

# Combinining the images
combined_image = my_compose(image1, image2, m=3)
```

In [13]:

```
plt.figure(figsize=(15, 10))

plt.subplot(3, 3, 1)
plt.imshow(image1_GRAY, cmap='gray')
plt.title('Original Image 1')
plt.subplot(3, 3, 2)
plt.imshow(image2_GRAY, cmap='gray')
plt.title('Original Image 2')
plt.subplot(3, 3, 3)
plt.imshow(combined_image, cmap='gray')
plt.title('Combined Image')
```

Out[13]:

```
Text(0.5, 1.0, 'Combined Image')
```



Comparing the combined with the original(in gray scale)

In [14]:

```
is_faked_image(combined_image,image1_GRAY)
```

Out[14]:

```
True
```