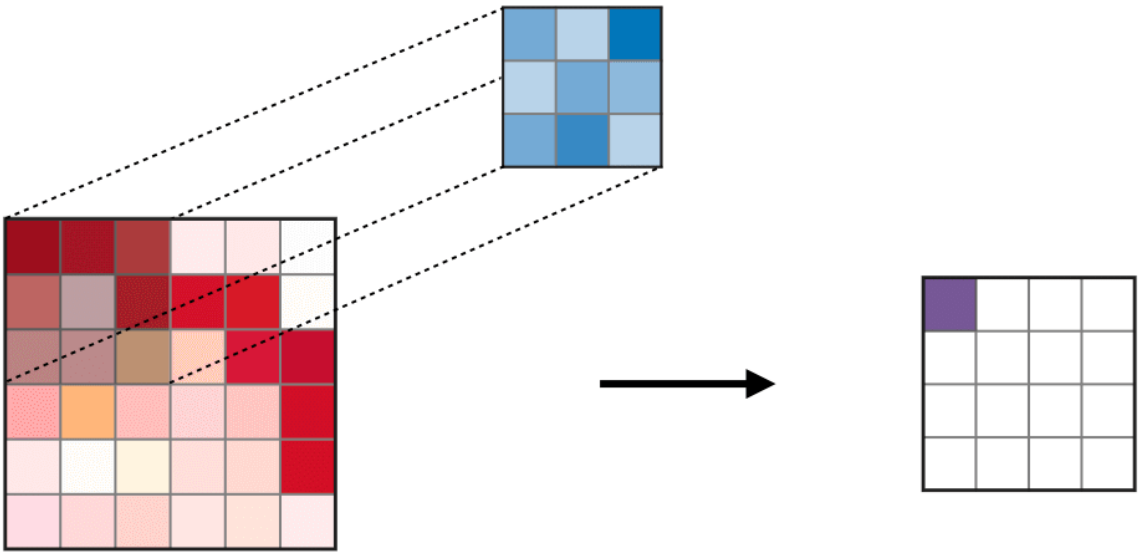
Assessment 2

Problem 2: Try different hyperparameters and perform convolution transform on an image

Convolution operation on an image

The convolution layer (CONV) uses filters that perform convolution operations as it is scanning the input *I* with respect to its dimensions. Its hyperparameters include the filter size *F* and stride *S*. The resulting output *O* is called feature map or activation map.



In [2]:

```
import cv2
import numpy as np
import matplotlib.pyplot as plt
import skimage.measure
```

Loading the image form local directory and checking the entropy of the image

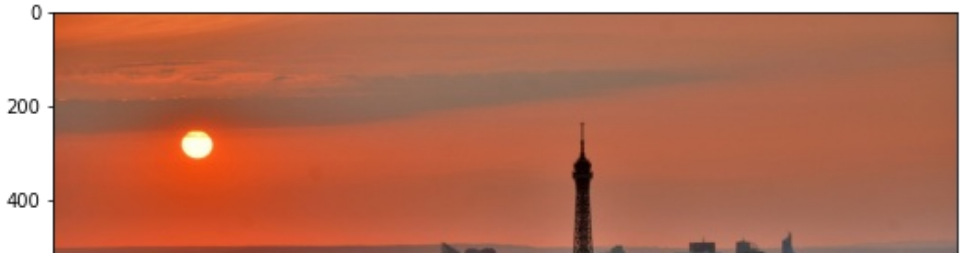
In [3]:

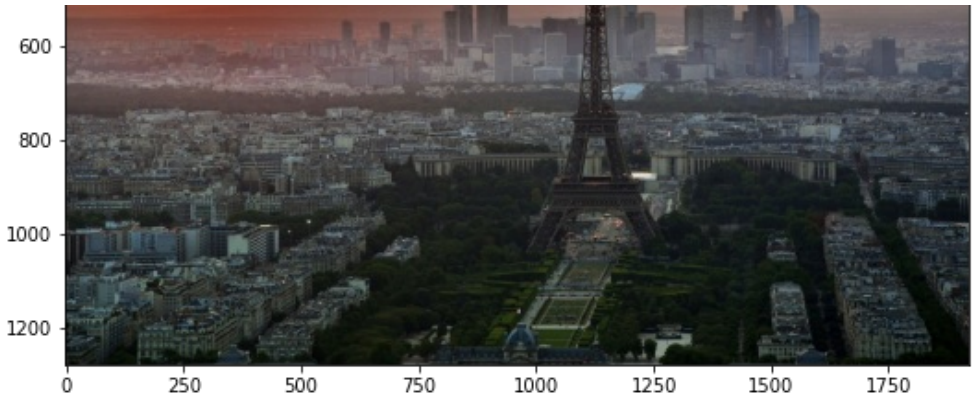
```
input_image = cv2.imread('/content/drive/MyDrive/DumpYard/paris-843229_1920.jpg')
input_image = cv2.cvtColor(input_image, cv2.COLOR_BGR2RGB)
fig, ax = plt.subplots(1, figsize=(9,6))
entropy1 = skimage.measure.shannon_entropy(input_image)
print("Entropy for the original image is:",entropy1)
plt.imshow(input_image)
```

```
Entropy for the original image is: 7.4473113904233825
```

Out[3]:

```
<matplotlib.image.AxesImage at 0x7f257706e150>
```





Use a simple 3x3 filter on the image and demonstrate the transformed image with its entropy

Filter

A filter of size $F \times F$ applied to an input containing C channels is a $F \times F \times C$ volume that performs convolutions on an input of size $I \times I \times C$ and produces an output feature map (also called activation map) of size $O \times O \times 1$.

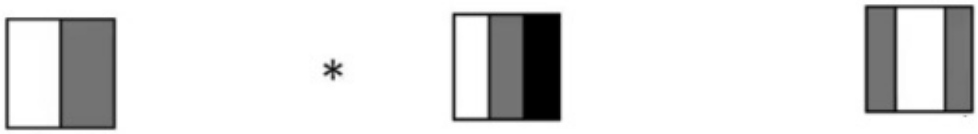
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

1	0	-1
1	0	-1
1	0	-1

=

0	30	30	0
0	30	30	0
0	30	30	0
0	30	30	0



Kernel

In [4]:

```
sharpenfilter = np.array(([[0, -1, 0], [-1, 9, -1], [0, -1, 0]]), np.float32)/9
sharpenfilter
```

Out[4]:

```
array([[ 0.        , -0.11111111,  0.        ],
       [-0.11111111,  1.        , -0.11111111],
       [ 0.        , -0.11111111,  0.        ]], dtype=float32)
```

Transformation and output image with its Entropy

In [5]:

```
sharpen = cv2.filter2D(src=input_image, kernel=sharpenfilter, ddepth=-1)
fig, ax = plt.subplots(1, figsize=(9,6))
entropy2 = skimage.measure.shannon_entropy(sharpen)
print("Entropy for the sharpened image is:",entropy2)
plt.imshow(sharpen)
```

```
Entropy for the sharpened image is: 6.647542774487621
```

Entropy for the sharpened image is: 8.017512771107021

Out[5]:

```
<matplotlib.image.AxesImage at 0x7f25762e1190>
```

Use a simple 5x5 filter on the image and demonstrate the transformed image with its entropy

Filter or Kernel

In [6]:

```
gaussian_blur_filter = np.array(([[1,4,6,4,1], [4,16,24,16,4], [6,24,36,24,6], [4,16,24
,16,4], [1,4,6,4,1]]), np.float32)/256
gaussian_blur_filter
```

Out[6]:

```
array([[0.00390625, 0.015625  , 0.0234375 , 0.015625  , 0.00390625],
       [0.015625  , 0.0625    , 0.09375   , 0.0625    , 0.015625  ],
       [0.0234375 , 0.09375   , 0.140625  , 0.09375   , 0.0234375 ],
       [0.015625  , 0.0625    , 0.09375   , 0.0625    , 0.015625  ],
       [0.00390625, 0.015625  , 0.0234375 , 0.015625  , 0.00390625]],
      dtype=float32)
```

Transformation and Output image with Entropy

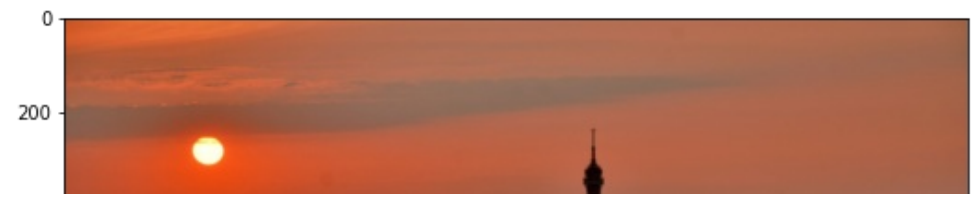
In [7]:

```
gaussianBlur = cv2.filter2D(src=input_image, kernel=gaussian_blur_filter, ddepth=-1)
entropy3 = skimage.measure.shannon_entropy(gaussianBlur)
print("Entropy for the blurred image is:",entropy3)
fig, ax = plt.subplots(1, figsize=(9,6))
plt.imshow(gaussianBlur)
```

```
Entropy for the blurred image is: 7.395531620068165
```

Out[7]:

```
<matplotlib.image.AxesImage at 0x7f25746579d0>
```



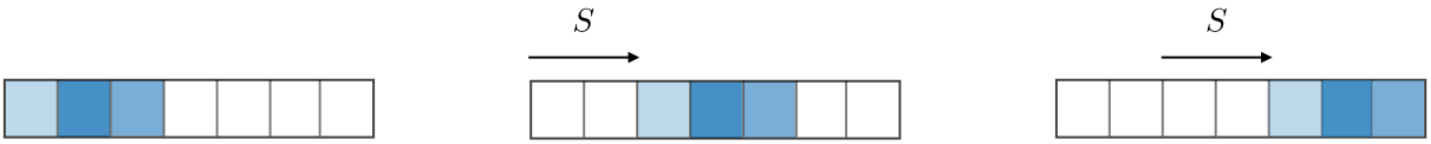
In [8]:

```
grey_image = cv2.cvtColor(input_image, cv2.COLOR_BGR2GRAY)
```

Filtering an image with 3x3 filter with a stride = 2 and then calculate its Entropy

Stride

For a convolutional or a pooling operation, the stride *S* denotes the number of pixels by which the window moves after each operation.



In [9]:

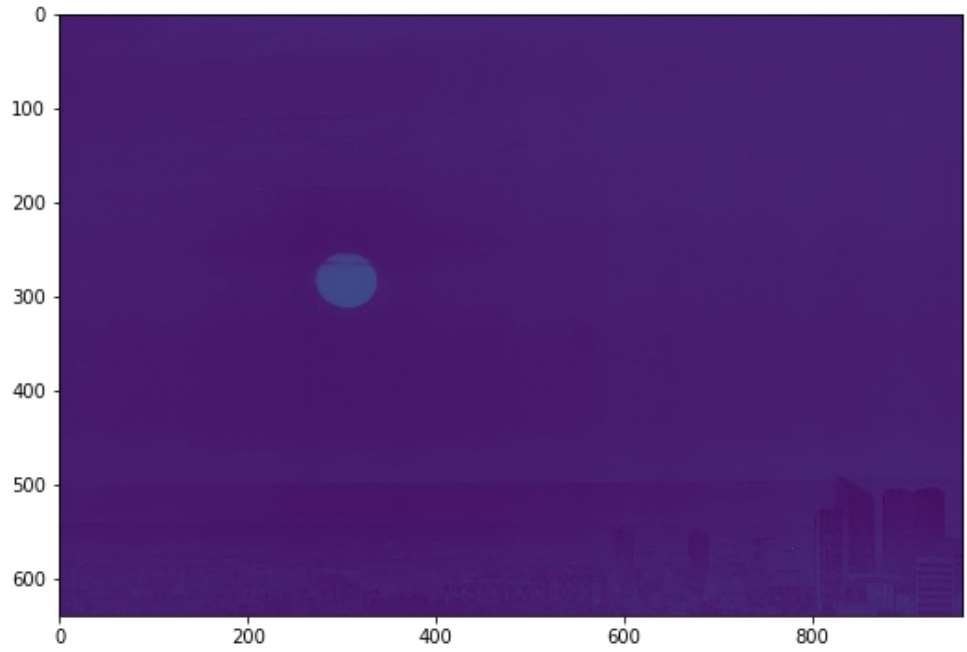
```
def convolve2D(image, kernel, strides):
    kernel = np.flipud(np.fliplr(kernel))
    xKernShape = kernel.shape[0]
    yKernShape = kernel.shape[1]
    xImgShape = image.shape[0]
    yImgShape = image.shape[1]
    xOutput = int(((xImgShape - xKernShape + 2) / strides) + 1)
    yOutput = int(((yImgShape - yKernShape + 2) / strides) + 1)
    output = np.zeros((xOutput, yOutput))
    for y in range(image.shape[1]):
        if y > image.shape[1] - yKernShape:
            break
        if y % strides == 0:
            for x in range(image.shape[0]):
                if x > image.shape[0] - xKernShape:
                    break
                try:
                    if x % strides == 0:
                        output[x, y] = (kernel * image[x: x + xKernShape, y: y + yKernS
hape]).sum()
                except:
                    break
    return output

kernel = np.array(([[0, -1, 0], [-1, 9, -1], [0, -1, 0]]), np.float32)/9
optimg = convolve2D(grey_image, kernel, strides = 2)
entropy6 = skimage.measure.shannon_entropy(optimg)
print("Entropy for an image with kernel = 3x3 and stride = 2 is:",entropy6)
fig, ax = plt.subplots(1, figsize=(9,6))
plt.imshow(optimg)
```

```
Entropy for an image with kernel = 3x3 and stride = 2 is: 3.222862544247595
```

Out[9]:

```
<matplotlib.image.AxesImage at 0x7f25745ac690>
```

<matplotlib.image.AxesImage at 0x7f25745ac690>



Filtering an image with 5x5 filter with a stride = 2 and then calculate its Entropy

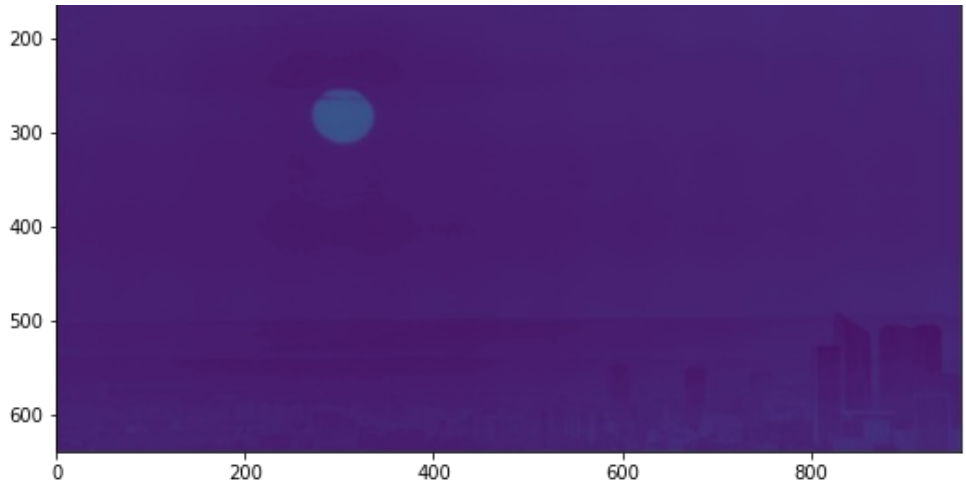
In [10]:

```
def convolve2D(image, kernel, strides):
    kernel = np.flipud(np.fliplr(kernel))
    xKernShape = kernel.shape[0]
    yKernShape = kernel.shape[1]
    xImgShape = image.shape[0]
    yImgShape = image.shape[1]
    xOutput = int(((xImgShape - xKernShape + 2 ) / strides) + 1)
    yOutput = int(((yImgShape - yKernShape + 2 ) / strides) + 1)
    output = np.zeros((xOutput, yOutput))
    for y in range(image.shape[1]):
        if y > image.shape[1] - yKernShape:
            break
        if y % strides == 0:
            for x in range(image.shape[0]):
                if x > image.shape[0] - xKernShape:
                    break
                try:
                    if x % strides == 0:
                        output[x, y] = (kernel * image[x: x + xKernShape, y: y + yKernS
hape]).sum()
                except:
                    break
    return output

kernel = np.array(([[1,4,6,4,1], [4,16,24,16,4], [6,24,36,24,6], [4,16,24,16,4], [1,4,6
,4,1]]), np.float32)/256
optimg = convolve2D(grey_image, kernel, strides = 2)
entropy7 = skimage.measure.shannon_entropy(optimg)
print("Entropy for an image with kernel = 5x5 and stride = 2 is:",entropy7)
fig, ax = plt.subplots(1, figsize=(9,6))
plt.imshow(optimg)
```

```
Entropy for an image with kernel = 5x5 and stride = 2 is: 4.189303058746414
```

Out[10]:

```
<matplotlib.image.AxesImage at 0x7f2574581b90>
```



Filtering an image with 3x3 filter with stride = 1 and zero padding, then calculate its Entropy

Zero Padding

Zero-padding denotes the process of adding *P* zeroes to each side of the boundaries of the input.

0	0	0	0	0	0
0	35	19	25	6	0
0	13	22	16	53	0
0	4	3	7	10	0
0	9	8	1	3	0
0	0	0	0	0	0

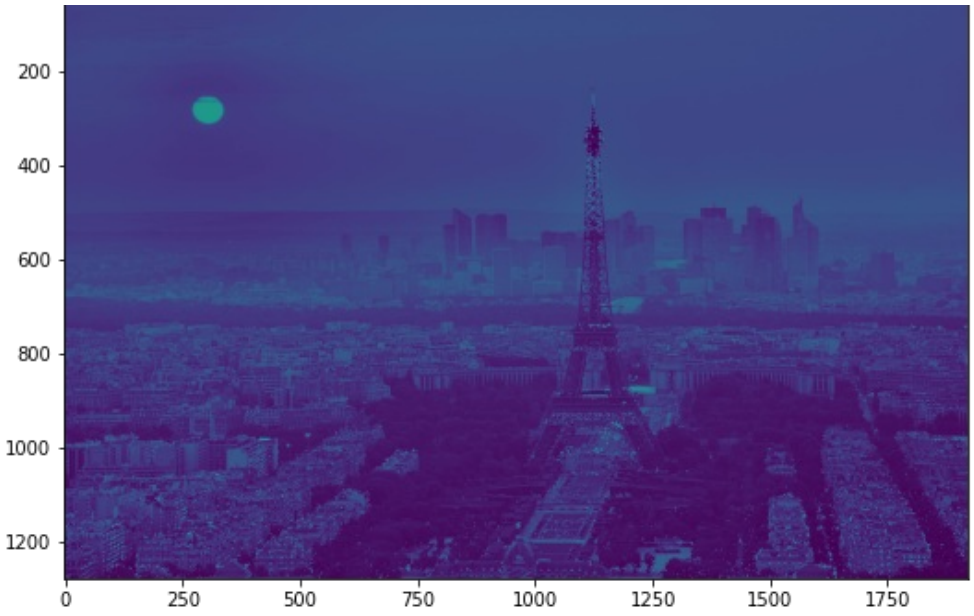
In [11]:

```
def convolve2d(image, kernel):
    output = np.zeros_like(image)
    image_padded = np.zeros((image.shape[0] + 2, image.shape[1] + 2))
    image_padded[1:-1, 1:-1] = image
    for x in range(image.shape[1]):
        for y in range(image.shape[0]):
            output[y, x]=(kernel * image_padded[y: y+3, x: x+3]).sum()
    return output
# For a 3x3 Kernel and stride = 1 and Zero_padding
KERNEL = np.array(([[0, -1, 0], [-1, 9, -1], [0, -1, 0]]), np.float32)/9
stride_1_3x3 = convolve2d(grey_image, kernel=KERNEL)
entropy4 = skimage.measure.shannon_entropy(stride_1_3x3)
print("Entropy for the 3x3 image with zero padding and stride = 1 is:",entropy4)
fig, ax = plt.subplots(1, figsize=(9,6))
plt.imshow(stride_1_3x3)
```

```
Entropy for the 3x3 image with zero padding and stride = 1 is: 6.055754583579611
```

Out[11]:

```
<matplotlib.image.AxesImage at 0x7f25745972d0>
```



Filtering an image with 5x5 filter with stride = 1 and zero padding, then calculate its Entropy

In [12]:

```
def convolve2d(image, kernel):
    output = np.zeros_like(image)
    image_padded = np.zeros((image.shape[0] + 4, image.shape[1] + 4))
    image_padded[2:-2, 2:-2] = image
    for x in range(image.shape[1]):
        for y in range(image.shape[0]):
            output[y, x]=(kernel * image_padded[y: y+5, x: x+5]).sum()
    return output
# For a 5x5 Kernel and stride = 1 and Zero_padding
KERNEL = np.array(([[1,4,6,4,1], [4,16,24,16,4], [6,24,36,24,6], [4,16,24,16,4], [1,4,6
,4,1]]), np.float32)/256
opimg = convolve2d(grey_image, kernel=KERNEL)
entropy5 = skimage.measure.shannon_entropy(opimg)
print("Entropy for the 5x5 image with zero padding and stride = 1 is:",entropy5)
fig, ax = plt.subplots(1, figsize=(9,6))
plt.imshow(opimg)
```

```
Entropy for the 5x5 image with zero padding and stride = 1 is: 6.715918610760809
```

Out[12]:

```
<matplotlib.image.AxesImage at 0x7f257459bc50>
```