CV_HW1_Notebook_Hamed-Mohammadzadeh_9812762418

April 18, 2022

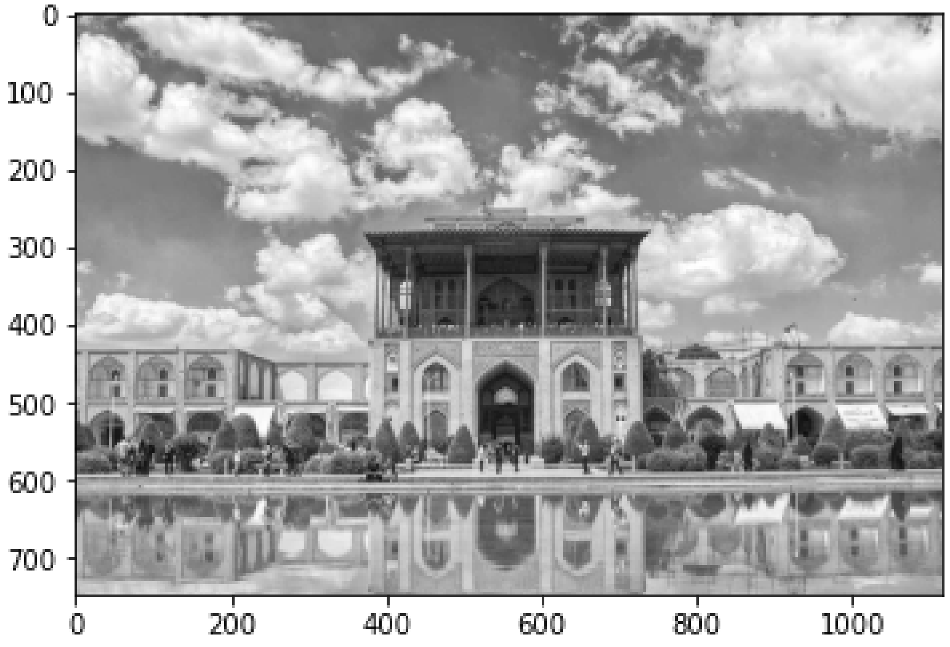
[29]:
```
from PIL import Image
import numpy as np
from numpy import asarray
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
import random
import math
from numpy.linalg import inv
import matplotlib
```

1 Exercise 1

1.1 Q-1.1

[30]:
```
rgb_im = Image.open("assignment1/assignment1/images/alighapoo.jpg")
rgb_arr = asarray(rgb_im)

# The RGB values are converted to grayscale using the NTSC formula:
# 0.299  Red + 0.587  Green + 0.114  Blue.
# This formula closely represents the average person's relative
# perception of the brightness of red, green, and blue light.

if len(rgb_arr.shape)==3:
    img_arr = np.floor(rgb_arr[:,:,0]*0.299 + rgb_arr[:,:,1]*0.587 + rgb_arr[:,:
↪,2]*0.114).astype(int)
else:
    img_arr = rgb_arr

imgplot = plt.imshow(img_arr , cmap="gray")

img_arr, img_arr.shape,  max(img_arr.flatten()), min(img_arr.flatten())
```

[30]:
```
(array([[108, 111, 116, …, 212, 212, 212],
        [110, 111, 112, …, 214, 213, 213],
        [117, 113, 108, …, 214, 214, 213],
        …,
        [169, 168, 169, …, 158, 157, 157],
        [169, 168, 169, …, 156, 155, 156],
        [169, 168, 169, …, 154, 155, 154]]),
 (748, 1116),
 255,
 0)
```



1.2 Q-1.2

[31]:
```
max_lum = max(img_arr.flatten())
min_lum = min(img_arr.flatten())
max_lum, min_lum
```

[31]:
```
(255, 0)
```

1.3 Q-1.3

[32]:
```
mean_lum = img_arr.flatten().sum()/(len(img_arr.flatten()))
mean_lum
```

[32]:
```
155.98711258697028
```

1.4 Q-1.4

```
[33]: lum_var = ((img_arr.flatten() - mean_lum)**2).sum() / (len(img_arr.flatten()))
      lum_var
```

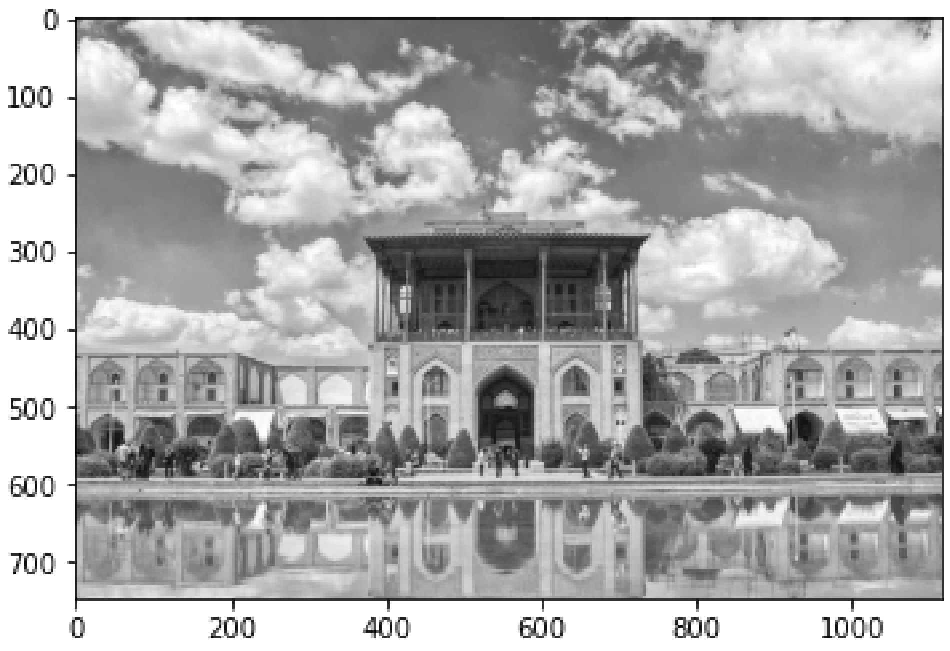
```
[33]: 2716.2002225255524
```

2 Exercise 2

.

```
[80]: im = Image.open("assignment1/assignment1/images/alighapoo.jpg").convert('L')
      # im.show()

      img_arr = asarray(im)
      imgplot = plt.imshow(img_arr , cmap="gray")

      img_arr, img_arr.var(), img_arr.shape
```

```
[80]: (array([[108, 112, 116, …, 213, 213, 213],
              [111, 112, 113, …, 214, 214, 214],
              [117, 113, 109, …, 214, 214, 214],
              …,
              [170, 169, 169, …, 158, 158, 158],
              [170, 169, 169, …, 156, 156, 156],
              [170, 169, 169, …, 155, 155, 155]], dtype=uint8),
       2716.427558555292,
       (748, 1116))
```

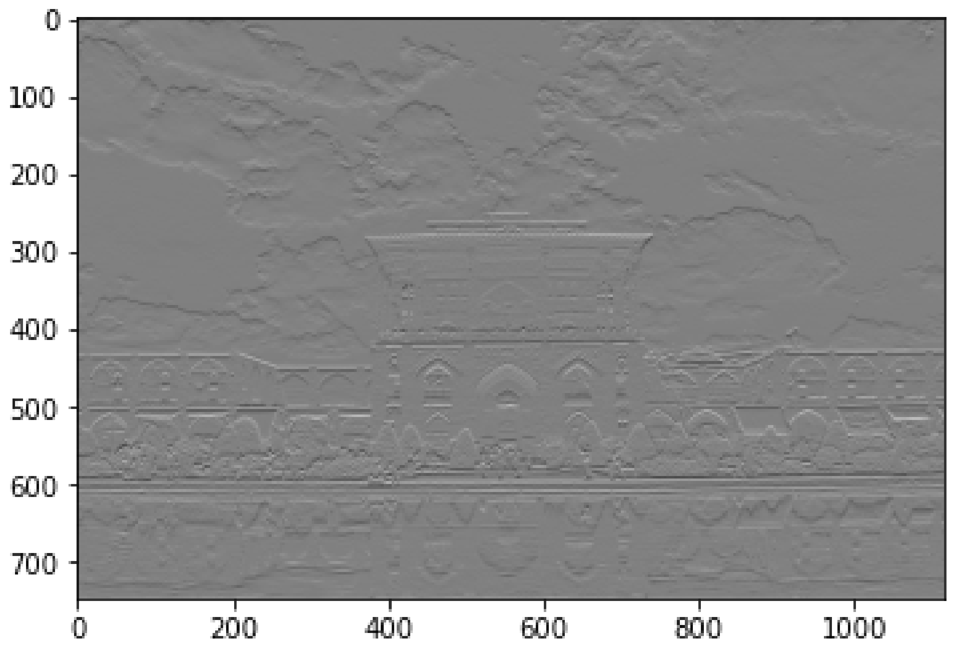


[81]:
```
def edge_detect(edge_filter, img_arr):
    filter_size = edge_filter.shape[0]
    # shape = same

    # (x-1, y-1) (x-1, y) (x-1, y+1)
    # (x,   y-1) (x,   y) (x,   y+1)
    # (x+1, y-1) (x+1, y) (x+1, y+1)
    out = np.zeros(img_arr.shape)
    for x in range(img_arr.shape[0]):
        for y in range(img_arr.shape[1]):

            new_val = 0
            count = 0 ####
            for f_i in range(-int(filter_size/2), int(filter_size/2)+1):
                for f_j in range(-int(filter_size/2), int(filter_size/2)+1):
                    if not (x+f_i < 0 or x+f_i >= img_arr.shape[0] or y+f_j<0␣
 ↪or y+f_j >=img_arr.shape[1]):
                        new_val += img_arr[x+f_i][y+f_j] *␣
 ↪edge_filter[int(filter_size/2)+f_i][int(filter_size/2)+f_j]
                        count += edge_filter[int(filter_size/
 ↪2)+f_i][int(filter_size/2)+f_j] ####
                    else:
                        new_val += 0
                        count += 0
            if count == 0: out[x][y] = int(new_val)
            else: out[x][y] = int(new_val/count)

    out_test = np.array(out)
    out_test += -(min(out.flatten()))
    out_test = ((out_test - min(out_test.flatten())) * ((255 - 0) /␣
 ↪max(out_test.flatten())-min(out_test.flatten()))) + 0
    out_test = out_test.astype(int)
    print(out_test)

    imgplot = plt.imshow(out_test , cmap="gray")
    return out_test
```

2.1 Q-2.1

[82]:
```
hor_filter = np.array([[1, 2, 1],
                      [0, 0, 0],
                      [-1, -2, -1]])
temp_test_hor_edge = edge_detect(hor_filter, img_arr)
```

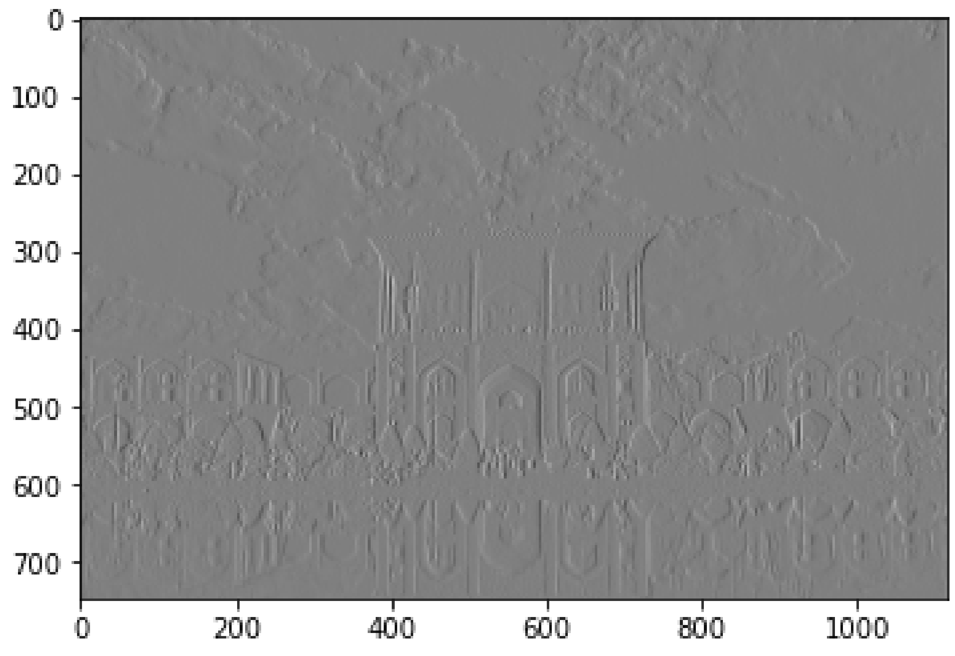
```
[[145 145 145 … 161 161 161]
 [125 127 130 … 127 127 127]
 [125 126 129 … 127 127 127]
 …
 [128 128 128 … 130 130 130]
 [128 128 128 … 130 130 129]
 [154 154 154 … 152 152 152]]
```



2.2 Q-2.2

```
[83]: ver_filter = np.array([[1, 0, -1],
                             [2, 0, -2],
                             [1, 0, -1]])
      temp_test_ver_edge = edge_detect(ver_filter, img_arr)
```

```
[[144 125 127 … 127 127 159]
 [144 127 127 … 127 127 159]
 [144 131 128 … 127 127 159]
 …
 [153 128 126 … 127 127 151]
 [153 128 126 … 127 127 151]
 [153 128 126 … 127 127 151]]
```

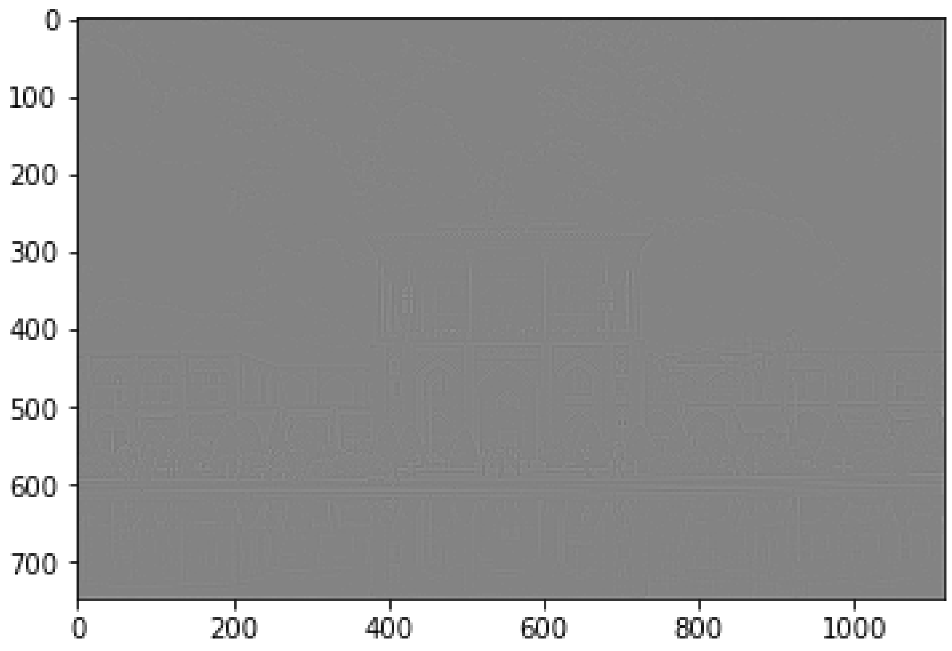


2.3 Q-2.3

[84]:
```
ver_hor_filter = np.array([[0, -1, 0],
                           [-1, 4, -1],
                           [0, -1, 0]])
edge_detect(ver_hor_filter, img_arr)
```

```
[[161 163 167 … 192 192 192]
 [162 131 132 … 132 132 192]
 [167 132 128 … 131 131 192]
 …
 [180 131 131 … 132 132 176]
 [180 131 131 … 131 131 175]
 [180 179 179 … 175 175 175]]
```

[84]:
```
array([[161, 163, 167, …, 192, 192, 192],
       [162, 131, 132, …, 132, 132, 192],
       [167, 132, 128, …, 131, 131, 192],
       …,
       [180, 131, 131, …, 132, 132, 176],
       [180, 131, 131, …, 131, 131, 175],
       [180, 179, 179, …, 175, 175, 175]])
```

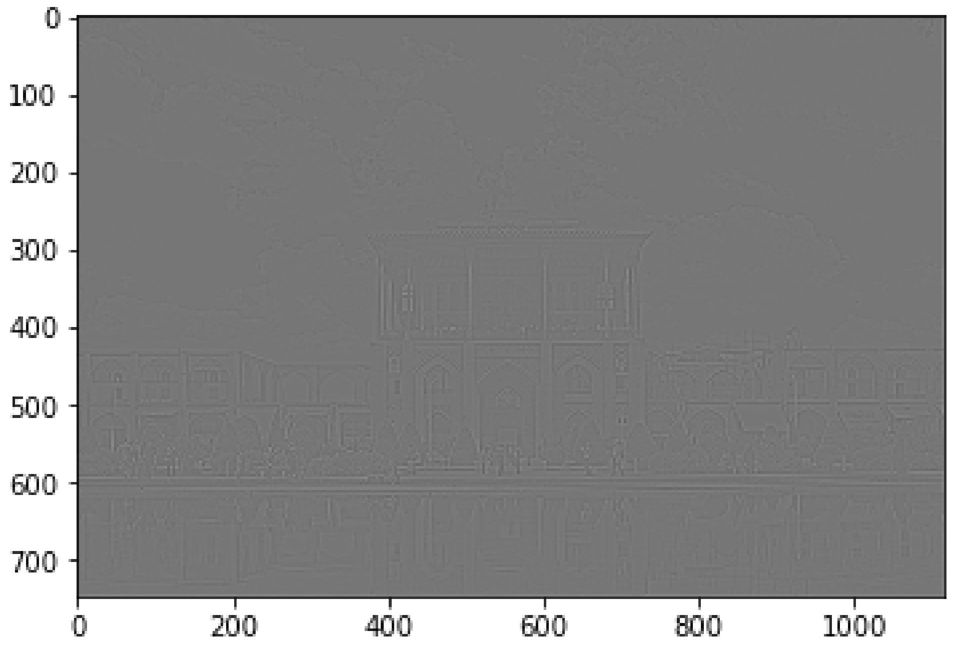


2.4 Q-2.4

[85]:
```
all_diag_filter = np.array([[-1, 0, -1],
                            [0, 4, 0],
                            [-1, 0, -1]])
edge_detect(all_diag_filter, img_arr)
```

```
[[143 145 146 … 168 168 168]
 [144 118 119 … 119 119 169]
 [147 118 115 … 118 118 169]
 …
 [159 118 117 … 118 118 156]
 [159 118 117 … 118 118 155]
 [158 158 158 … 155 155 155]]
```

[85]:
```
array([[143, 145, 146, …, 168, 168, 168],
       [144, 118, 119, …, 119, 119, 169],
       [147, 118, 115, …, 118, 118, 169],
       …,
       [159, 118, 117, …, 118, 118, 156],
       [159, 118, 117, …, 118, 118, 155],
       [158, 158, 158, …, 155, 155, 155]])
```



2.5 Q-2.5

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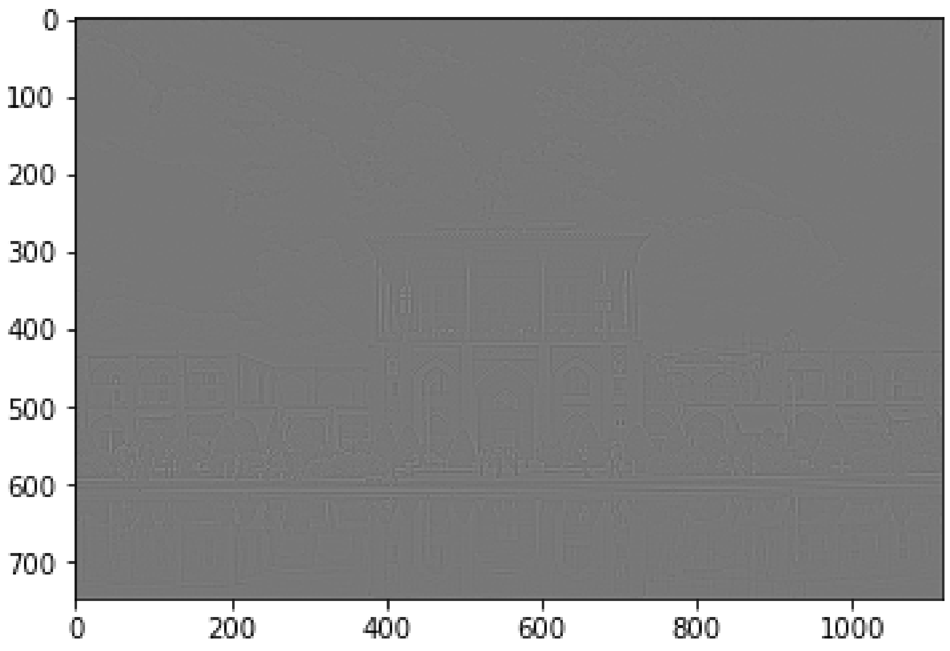
```
[40]: lap = np.array([[-1, -1, -1],
                      [-1, 8, -1],
                      [-1, -1, -1]])
      lap_edge = edge_detect(lap, img_arr)
```

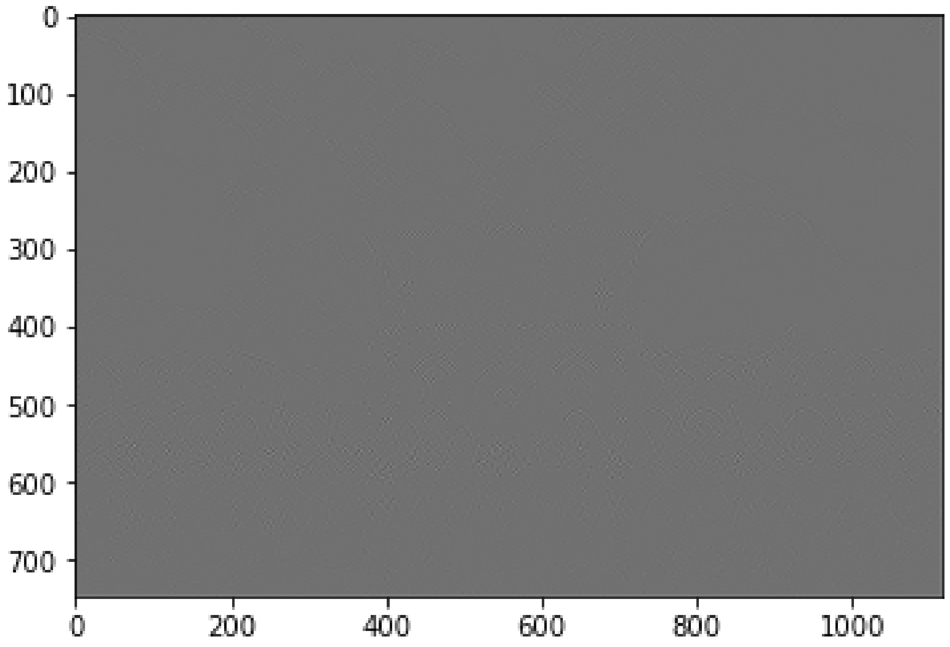
```
[[134 134 136 … 148 148 148]
 [134 119 120 … 120 120 148]
 [136 119 116 … 119 119 148]
 …
 [143 119 118 … 119 119 141]
 [143 119 118 … 119 119 140]
 [142 142 142 … 140 140 140]]
```



[41]:
```
# hor_filter, ver_filter, all_diag_filter
edge_detect(all_diag_filter, edge_detect(ver_filter, edge_detect(hor_filter,␣
 ↪img_arr)))
```

```
[[145 145 145 … 161 161 161]
 [125 127 130 … 127 127 127]
 [125 126 129 … 127 127 127]
 …
 [128 128 128 … 130 130 130]
 [128 128 128 … 130 130 129]
 [154 154 154 … 152 152 152]]
[[161 115 116 … 116 117 164]
 [158 112 115 … 116 117 160]
 [157 113 116 … 116 117 157]
 …
 [157 116 117 … 118 118 158]
 [159 117 117 … 117 117 160]
 [163 117 117 … 117 117 162]]
[[174 145 153 … 153 146 175]
 [183  77 111 … 112  83 183]
 [182  79 111 … 112  84 181]
 …
 [182  83 114 … 113  84 181]
 [183  83 113 … 113  82 183]
 [175 146 153 … 153 146 174]]
```

```
[41]: array([[174, 145, 153, …, 153, 146, 175],
              [183,  77, 111, …, 112,  83, 183],
              [182,  79, 111, …, 112,  84, 181],
              …,
              [182,  83, 114, …, 113,  84, 181],
              [183,  83, 113, …, 113,  82, 183],
              [175, 146, 153, …, 153, 146, 174]])
```



3 Exercise 3

```
[42]: im = Image.open("assignment1/assignment1/images/charli.jpeg").convert('L')
      # im.show()

      img_arr = asarray(im)
      imgplot = plt.imshow(img_arr , cmap="gray")

      img_arr, img_arr.shape
```

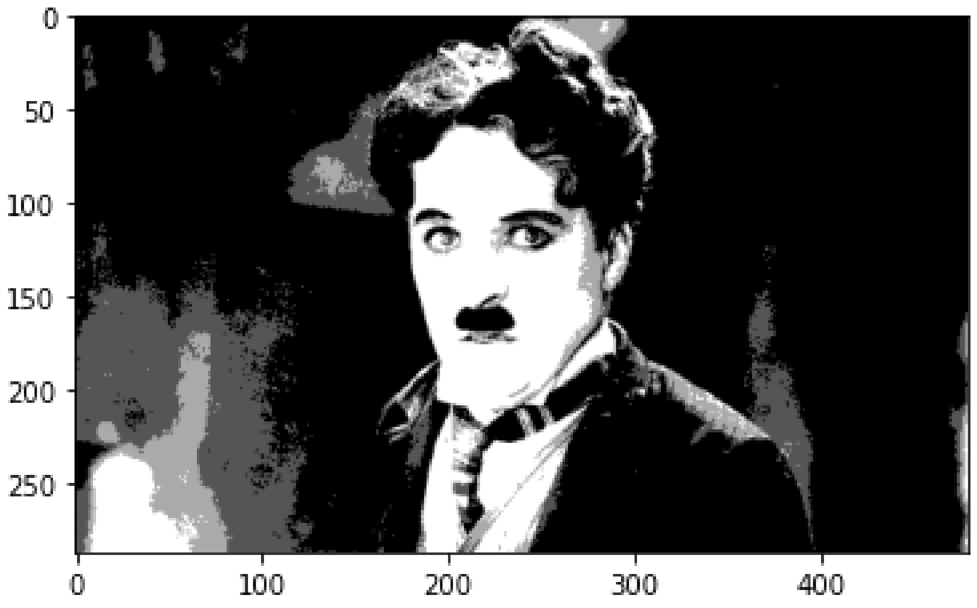
```
[42]: (array([[ 71,  65,  56, …,   5,   0,  41],
               [ 51,  47,  43, …,   5,   0,  41],
               [ 37,  33,  30, …,   5,   0,  41],
               …,
               [ 85,  83, 102, …, 119, 150, 184],
               [ 88,  95, 106, …, 118, 149, 186],
               [ 90, 105, 110, …, 110, 142, 182]], dtype=uint8),
        (288, 480))
```

[43]:
```
def bit_slicing(img_arr, bit_list):
    img_arr_bin = np.zeros((img_arr.shape[0], img_arr.shape[1], 8))
    # msb(8) = img_arr_bin[][][0]
    # lsb(1) = img_arr_bin[][][7]
    out = np.zeros(img_arr.shape)

    temp_num = 0
    for bit in bit_list:
        temp_num += 2 ** (bit-1)

    # print('power num(temp_num): ', temp_num)
    out = img_arr & temp_num
    plt.imshow(out, cmap="gray")

    return out
```

3.1 Q-3.1

[44]:
```
bit_slicing(img_arr, [7, 8])
```

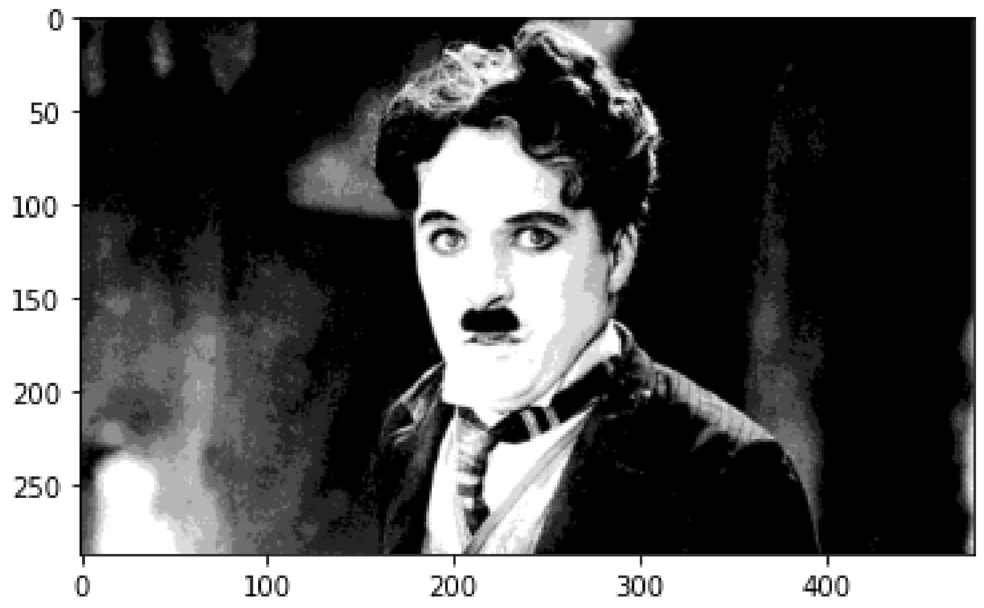
```
[44]: array([[ 64,  64,   0, …,   0,   0,   0],
             [  0,   0,   0, …,   0,   0,   0],
             [  0,   0,   0, …,   0,   0,   0],
             …,
             [ 64,  64,  64, …,  64, 128, 128],
             [ 64,  64,  64, …,  64, 128, 128],
             [ 64,  64,  64, …,  64, 128, 128]], dtype=uint8)
```



3.2 Q-3.2

```
[45]: bit_slicing(img_arr, [6, 7, 8])
```

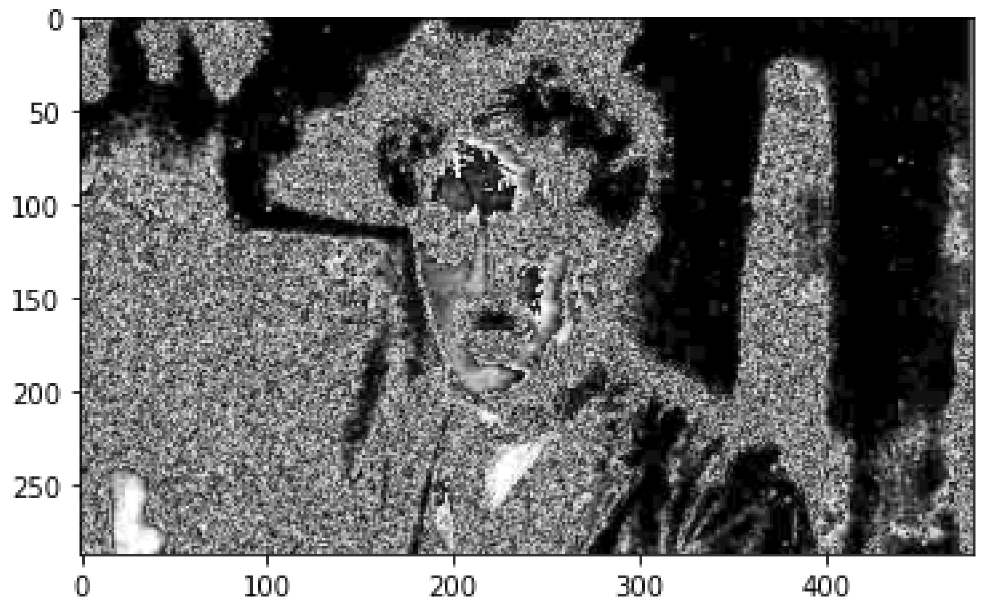
```
[45]: array([[ 64,  64,  32, …,   0,   0,  32],
             [ 32,  32,  32, …,   0,   0,  32],
             [ 32,  32,   0, …,   0,   0,  32],
             …,
             [ 64,  64,  96, …,  96, 128, 160],
             [ 64,  64,  96, …,  96, 128, 160],
             [ 64,  96,  96, …,  96, 128, 160]], dtype=uint8)
```



3.3 Q-3.3

```
[46]: bit_slicing(img_arr, [1, 2, 3, 4])
```

```
[46]: array([[ 7,  1,  8, …,  5,  0,  9],
             [ 3, 15, 11, …,  5,  0,  9],
             [ 5,  1, 14, …,  5,  0,  9],
             …,
             [ 5,  3,  6, …,  7,  6,  8],
             [ 8, 15, 10, …,  6,  5, 10],
             [10,  9, 14, …, 14, 14,  6]], dtype=uint8)
```

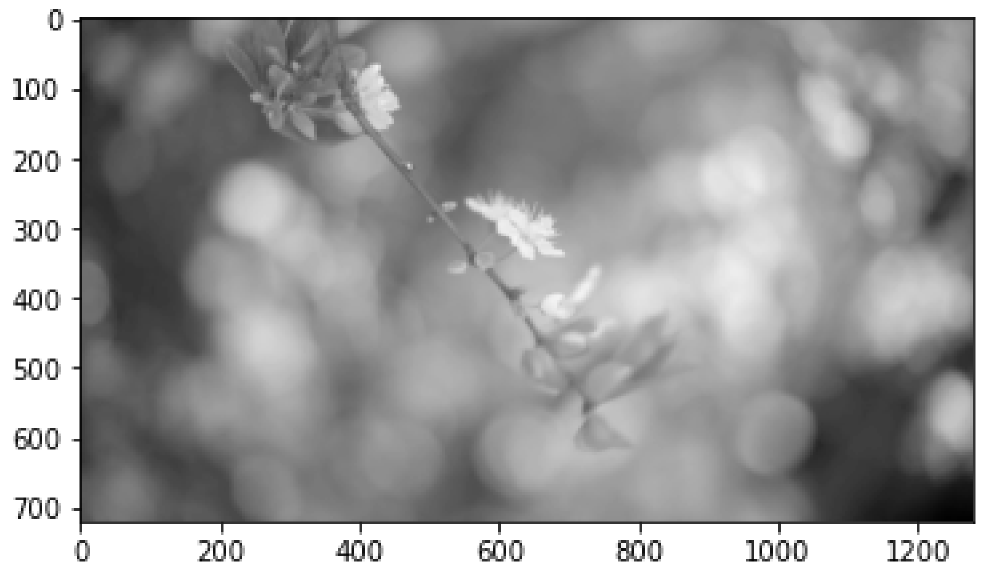


4 Exercise 4

jpg.histogram

```
[47]: im = Image.open("assignment1/assignment1/images/histogram.jpeg").convert('L')
      # im.show()

      img_arr = asarray(im)
      imgplot = plt.imshow(img_arr , cmap="gray")

      img_arr, img_arr.shape
```

```
[47]: (array([[ 84,  89,  90, …, 146, 148, 138],
              [ 89,  93,  95, …, 155, 158, 148],
              [ 92,  96,  98, …, 153, 155, 146],
              …,
              [ 94,  99, 103, …,  35,  35,  35],
              [ 93,  98, 102, …,  35,  35,  35],
              [ 87,  93,  96, …,  35,  35,  35]], dtype=uint8),
       (720, 1280))
```

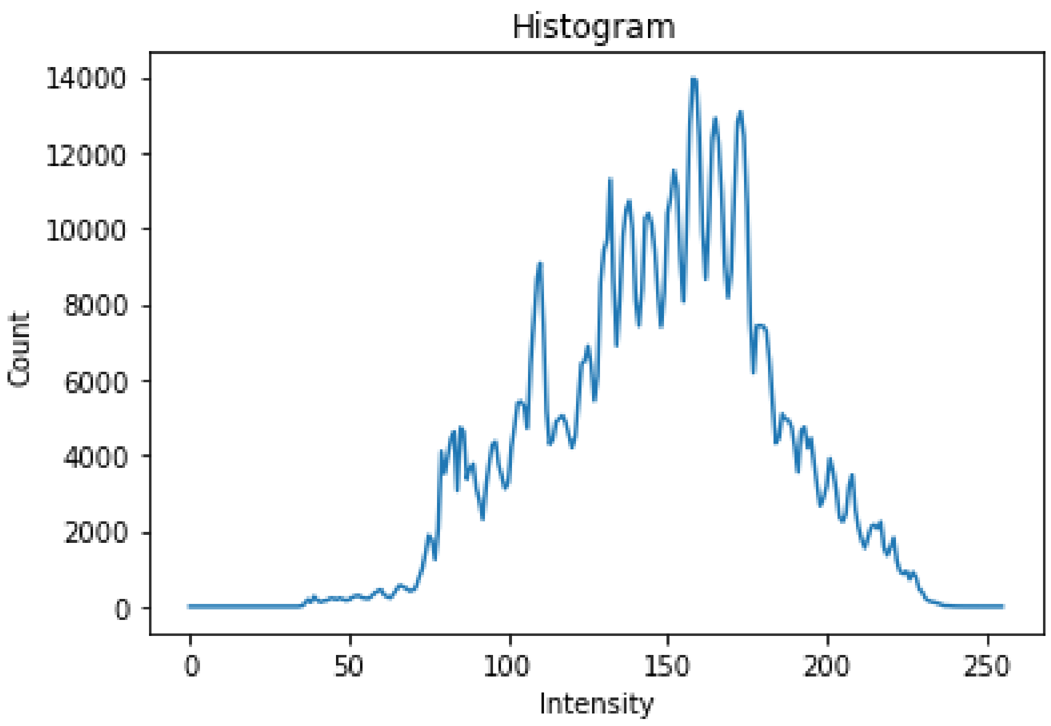


[48]:
```
def histogram(img_arr):
    intensity = np.zeros(256)
    for i in img_arr:
        for j in i:
            intensity[j] += 1
    intensity = intensity.astype(int)
    plt.plot(intensity, aa=True)

    plt.title("Histogram")
    plt.xlabel("Intensity")
    plt.ylabel("Count")

    plt.show()
```

4.1 Q-4.1

. .

[49]:
```
histogram(img_arr)
```



```
[50]: img_arr.var()
```

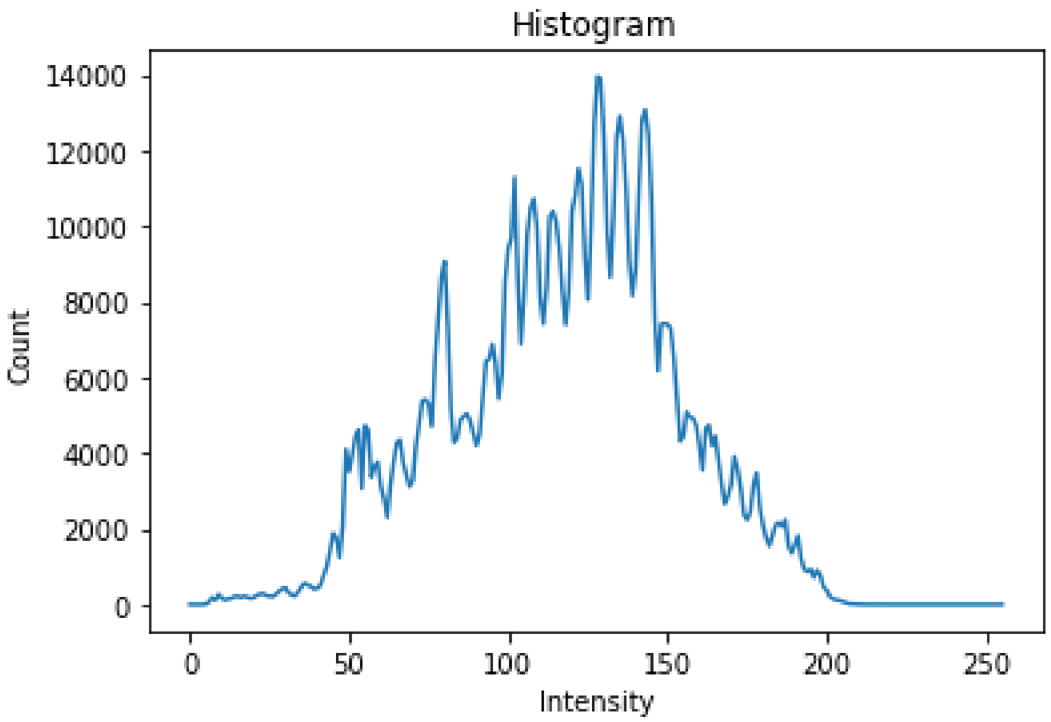
```
[50]: 1229.8413434992176
```

4.2 Q-4.2

. .

30 .

```
[51]: out1 = img_arr - 30
      out1[out1<0] = 0
      histogram(out1)

      # histogram shifts 30 units to left
```



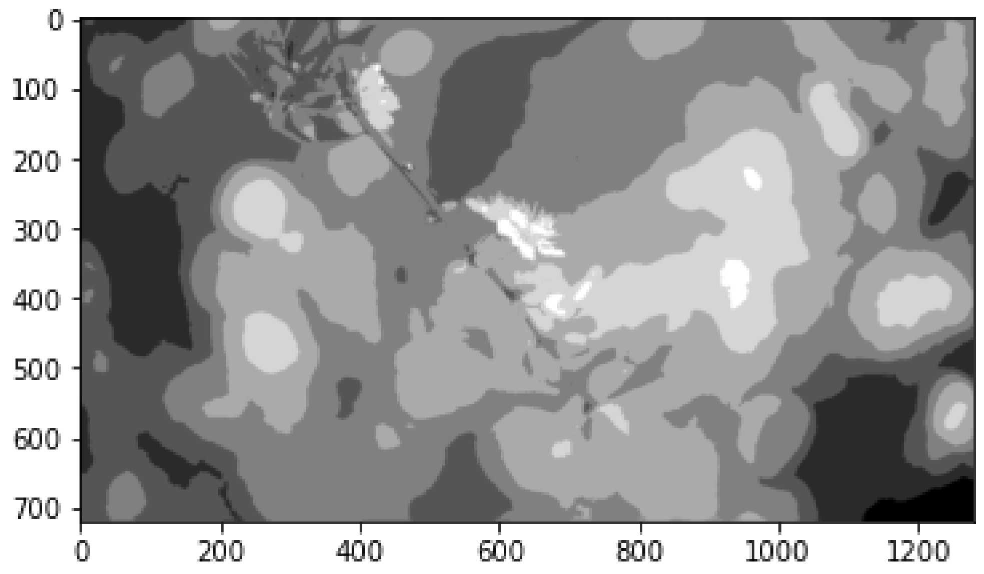
4.3 Q-4.3

.

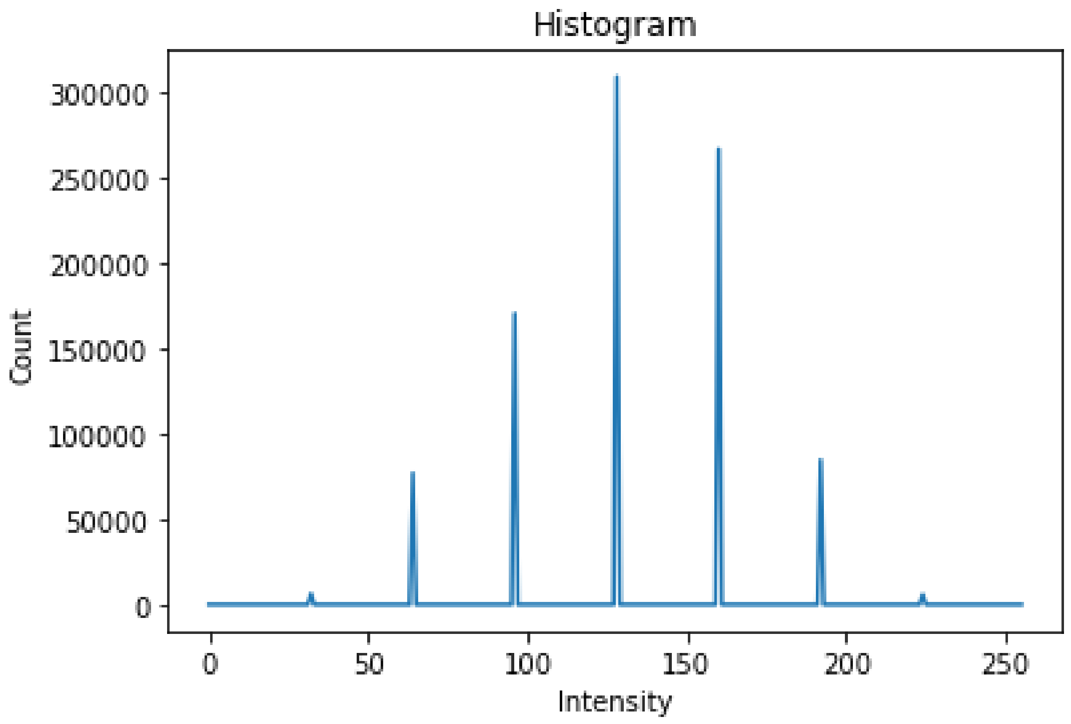
. 2

2 . ,32 64, 32+64, 128, ...

[52]:
```
out2 = bit_slicing(img_arr, [6, 7, 8])
```



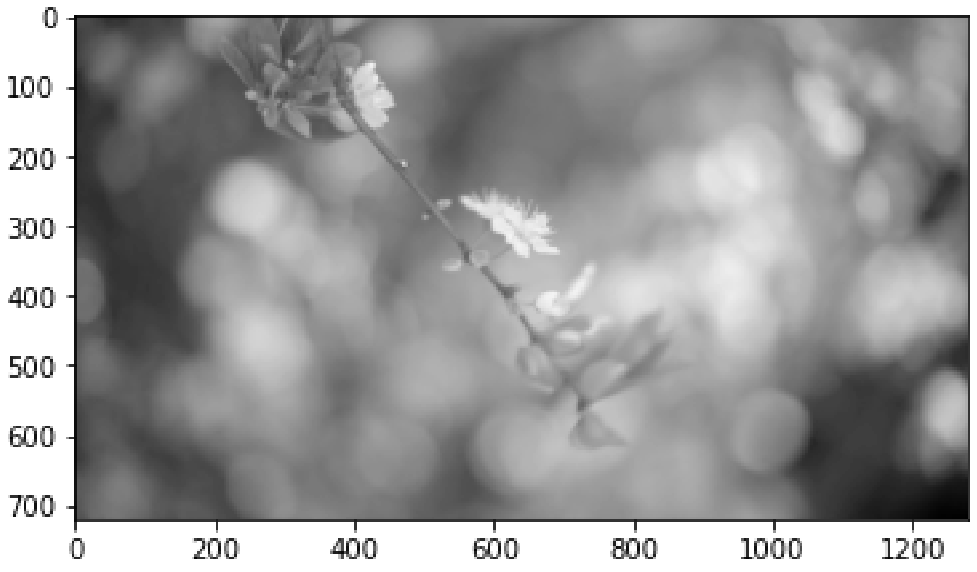
[53]:
```
histogram(out2)
```



5 Exercise 5

[54]:
```
im = Image.open("assignment1/assignment1/images/histogram.jpeg").convert('L')
# im.show()

img_arr = asarray(im)
imgplot = plt.imshow(img_arr , cmap="gray")

img_arr, img_arr.shape
```

[54]:
```
(array([[ 84,  89,  90, …, 146, 148, 138],
        [ 89,  93,  95, …, 155, 158, 148],
        [ 92,  96,  98, …, 153, 155, 146],
        …,
        [ 94,  99, 103, …,  35,  35,  35],
        [ 93,  98, 102, …,  35,  35,  35],
        [ 87,  93,  96, …,  35,  35,  35]], dtype=uint8),
 (720, 1280))
```

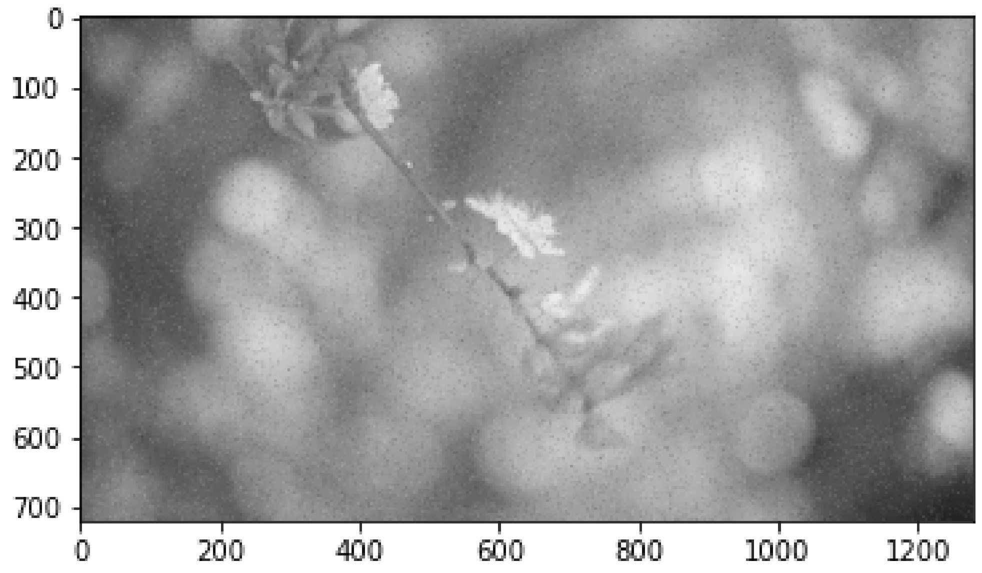


5.1 Q-5.1

[55]:
```
sp_intensity = 3 # 0-100
sp_img = np.array(img_arr)

sp_count = int((sp_intensity/100) * (img_arr.shape[0]*img_arr.shape[1]))
```

```
for count in range(sp_count):
    x = random.randint(0, img_arr.shape[0]-1)
    y = random.randint(0, img_arr.shape[1]-1)
    b_or_w = random.randint(0, 1)
    sp_img[x][y] = b_or_w * 255


plt.imshow(sp_img , cmap="gray"),len(sp_img[sp_img == 0]), sp_count, img_arr.
↪shape[0]*img_arr.shape[1]
```

[55]:
```
(<matplotlib.image.AxesImage at 0x1b80830c948>, 13646, 27648, 921600)
```

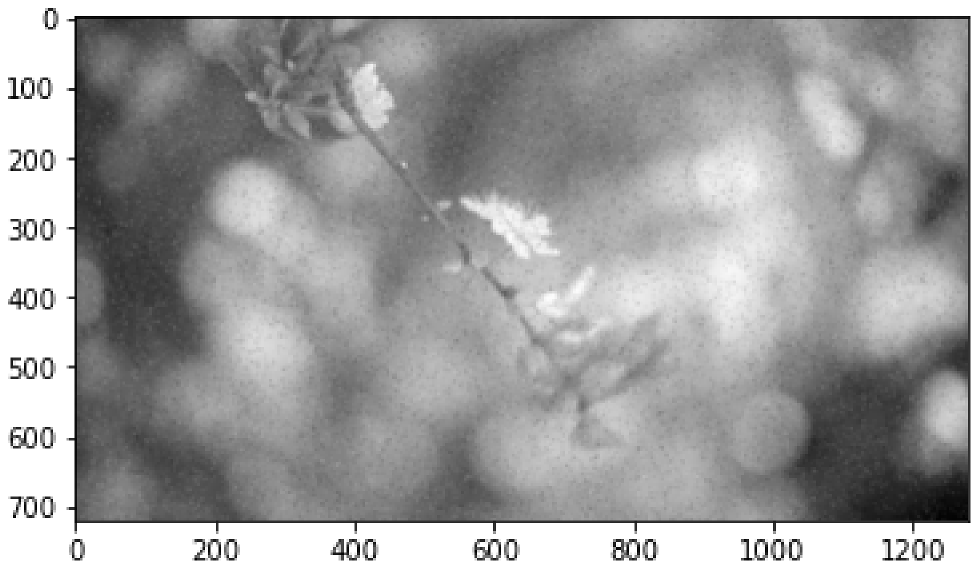


5.2 Q-5.2

[56]:
```
def box_filter(filter_size, img_arr):
    # (x-1, y-1) (x-1, y) (x-1, y+1)
    # (x,   y-1) (x,   y) (x,   y+1)
    # (x+1, y-1) (x+1, y) (x+1, y+1)
    out = np.zeros(img_arr.shape)
    for x in range(img_arr.shape[0]):
        for y in range(img_arr.shape[1]):

            new_val = 0
            count = 0
            for f_i in range(-int(filter_size/2), int(filter_size/2)+1):
                for f_j in range(-int(filter_size/2), int(filter_size/2)+1):
                    if not (x+f_i < 0 or x+f_i >= img_arr.shape[0] or y+f_j<0␣
↪or y+f_j >=img_arr.shape[1]):
                        new_val += img_arr[x+f_i][y+f_j]
                        count+=1
                    else:
                        new_val += 0

            out[x][y] = int(new_val/count)

    imgplot = plt.imshow(out , cmap="gray")
    return out.astype(int)
```

[57]:
```
box_filter(5, sp_img)
```

[57]:
```
array([[ 91,  91,  91, …, 150, 149, 149],
       [ 92,  92,  91, …, 150, 150, 150],
       [ 92,  92,  91, …, 151, 150, 150],
       …,
       [ 97,  98,  98, …,  35,  35,  35],
       [ 96,  97,  97, …,  35,  35,  35],
       [ 96,  96,  97, …,  35,  35,  35]])
```



5.3 Q-5.3

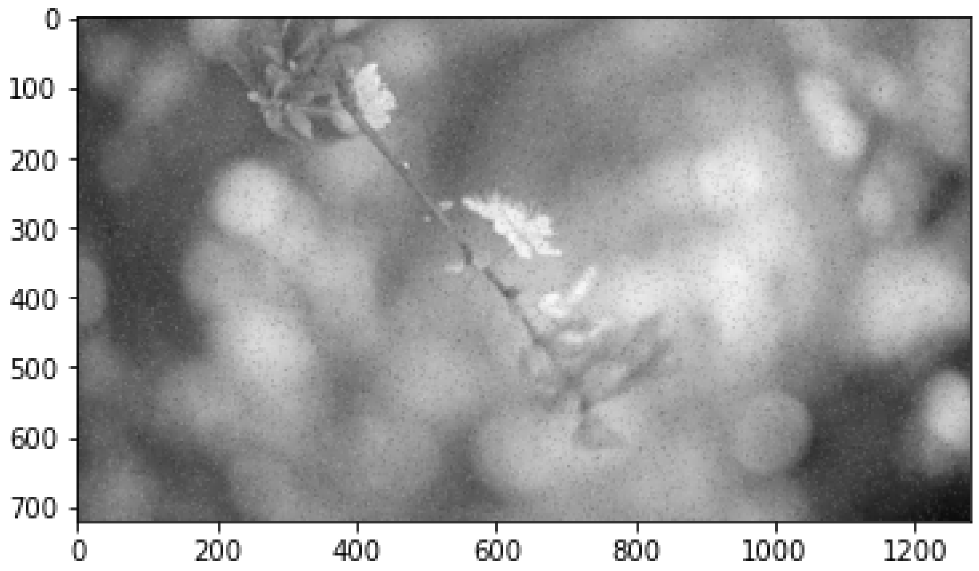
[58]:
```
# G(s,t) = K exp(- (s2+t2) / 2 sgima2)
def gauss_kernel(k_param, sigma, filter_size):
    out = np.zeros((filter_size, filter_size))
    for f_i in range(-int(filter_size/2), int(filter_size/2)+1):
        for f_j in range(-int(filter_size/2), int(filter_size/2)+1):
            out[int(filter_size/2)+f_i][int(filter_size/2)+f_j] = k_param * np.
 ↪exp(-((f_i**2+f_j**2)/2*(sigma**2)))

    return out
```

[59]:
```
def gaussian_filter(k_param, sigma, filter_size, img_arr):

    # (x-1, y-1) (x-1, y) (x-1, y+1)
    # (x,   y-1) (x,   y) (x,   y+1)
    # (x+1, y-1) (x+1, y) (x+1, y+1)
    # kernel = gauss_kernel(k_param, sigma, filter_size)
    gk= gauss_kernel(k_param, sigma, filter_size)
    gk = gk*(gk.sum())
    kernel = np.floor(gk)
    print("kernel: ", kernel)

    out = np.zeros(img_arr.shape)
    for x in range(img_arr.shape[0]):
        for y in range(img_arr.shape[1]):

            new_val = 0
            sum_coeff = 0
            for f_i in range(-int(filter_size/2), int(filter_size/2)+1):
                for f_j in range(-int(filter_size/2), int(filter_size/2)+1):
                    if not (x+f_i < 0 or x+f_i >= img_arr.shape[0] or y+f_j<0␣
 ↪or y+f_j >=img_arr.shape[1]):
                        new_val += img_arr[x+f_i][y+f_j] *␣
 ↪kernel[int(filter_size/2)+f_i][int(filter_size/2)+f_j]
                        sum_coeff += kernel[int(filter_size/
 ↪2)+f_i][int(filter_size/2)+f_j]
                    else:
                        new_val += 0
                        sum_coeff += 0

            # if x==0 and y==0: print(sum_coeff, img_arr[x][y], new_val)
            out[x][y] = int(new_val/sum_coeff)

    imgplot = plt.imshow(out , cmap="gray")
    return out
```

[60]:
```
gaussian_filter(1, 1, 5, sp_img)
```

```
kernel:  [[0. 0. 0. 0. 0.]
 [0. 2. 3. 2. 0.]
 [0. 3. 6. 3. 0.]
 [0. 2. 3. 2. 0.]
 [0. 0. 0. 0. 0.]]
```

```
[60]: array([[ 87.,  89.,  90., …, 149., 148., 145.],
             [ 90.,  92.,  93., …, 152., 151., 148.],
             [ 92.,  94.,  95., …, 153., 152., 149.],
             …,
             [ 95.,  98., 101., …,  35.,  35.,  35.],
             [ 93.,  96.,  99., …,  35.,  35.,  35.],
             [ 91.,  94.,  96., …,  35.,  35.,  35.]])
```



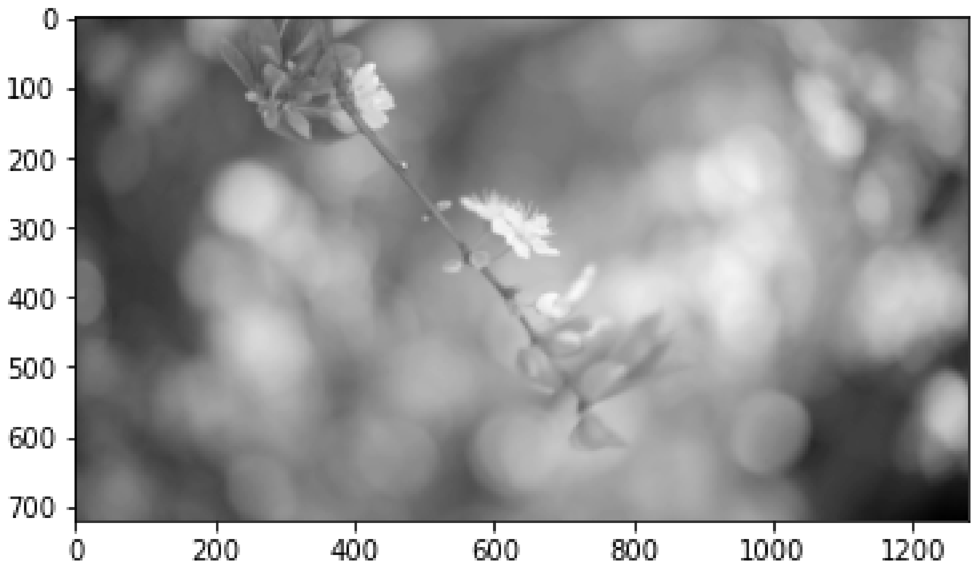
5.4 Q-5.4

```
[61]: def median_filter(filter_size, img_arr):
          # (x-1, y-1) (x-1, y) (x-1, y+1)
          # (x,   y-1) (x,   y) (x,   y+1)
          # (x+1, y-1) (x+1, y) (x+1, y+1)
          out = np.zeros(img_arr.shape)
          for x in range(img_arr.shape[0]):
              for y in range(img_arr.shape[1]):

                  list = []
                  for f_i in range(-int(filter_size/2), int(filter_size/2)+1):
```

```
                for f_j in range(-int(filter_size/2), int(filter_size/2)+1):
                    if not (x+f_i < 0 or x+f_i >= img_arr.shape[0] or y+f_j<0␣
↪or y+f_j >=img_arr.shape[1]):
                        list.append(img_arr[x+f_i][y+f_j])

            out[x][y] = np.median(np.array(list))


    imgplot = plt.imshow(out , cmap="gray")
    return out.astype(int)
```

[62]:
```
median_filter(3, sp_img)
```

[62]:
```
array([[ 89,  89,  91, …, 151, 148, 148],
       [ 90,  92,  93, …, 153, 148, 148],
       [ 92,  95,  95, …, 155, 153, 151],
       …,
       [ 96,  99, 101, …,  35,  35,  35],
       [ 93,  96,  99, …,  35,  35,  35],
       [ 93,  94,  97, …,  35,  35,  35]])
```

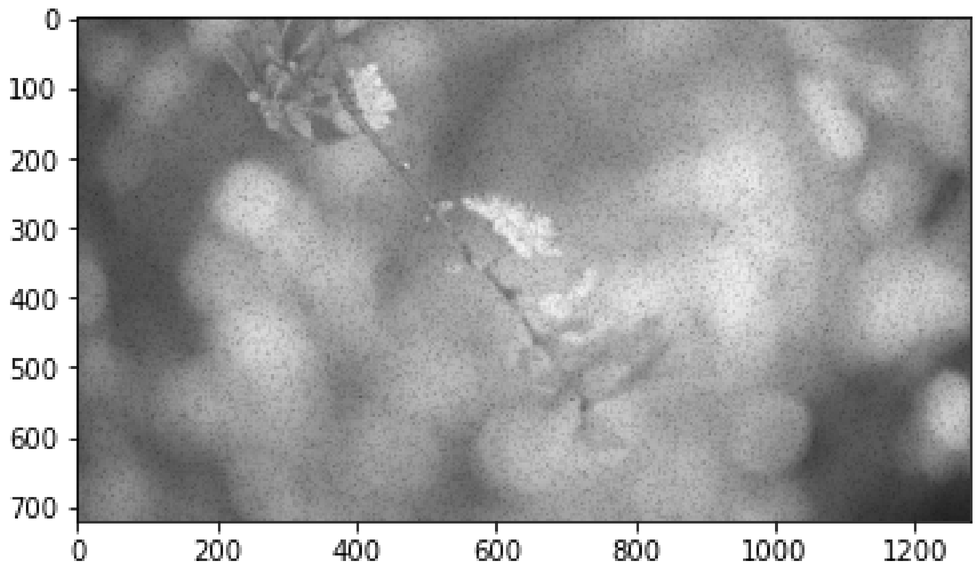


5.5 Q-5.5

In order for max filter to have positive effect on noisy picture, noises must be dark. if noises are lighter (intensity = 255) the max filter would pick noise as value for pixels near a noise.

[63]:
```python
sp_intensity = 5 # 0-100
sp_img = np.array(img_arr)

sp_count = int((sp_intensity/100) * (img_arr.shape[0]*img_arr.shape[1]))

for count in range(sp_count):
    x = random.randint(0, img_arr.shape[0]-1)
    y = random.randint(0, img_arr.shape[1]-1)
    sp_img[x][y] = 0

plt.imshow(sp_img , cmap="gray"),len(sp_img[sp_img == 0]), sp_count, img_arr.
 ↪shape[0]*img_arr.shape[1]
```

[63]:
```
(<matplotlib.image.AxesImage at 0x1b808350108>, 44921, 46080, 921600)
```

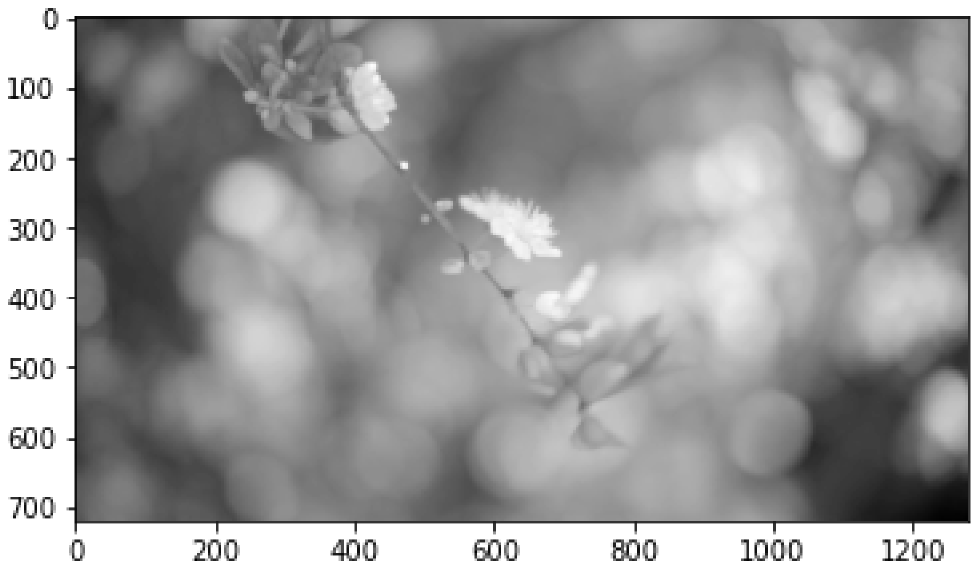


[64]:
```python
def max_filter(filter_size, img_arr):
    # (x-1, y-1) (x-1, y) (x-1, y+1)
    # (x,   y-1) (x,   y) (x,   y+1)
    # (x+1, y-1) (x+1, y) (x+1, y+1)
    out = np.zeros(img_arr.shape)
    for x in range(img_arr.shape[0]):
        for y in range(img_arr.shape[1]):

            list = []
            for f_i in range(-int(filter_size/2), int(filter_size/2)+1):
                for f_j in range(-int(filter_size/2), int(filter_size/2)+1):
                    if not (x+f_i < 0 or x+f_i >= img_arr.shape[0] or y+f_j<0␣
 ↪or y+f_j >=img_arr.shape[1]):
```

```
                        list.append(img_arr[x+f_i][y+f_j])

            out[x][y] = max(np.array(list))


    imgplot = plt.imshow(out , cmap="gray")
    return out.astype(int)
```

[65]:
```
max_filter(5, sp_img)
```

[65]:
```
array([[ 98,  98,  98, …, 158, 158, 158],
       [ 98,  98,  98, …, 158, 158, 158],
       [ 98,  98,  98, …, 158, 158, 158],
       …,
       [105, 105, 105, …,  36,  36,  36],
       [103, 103, 103, …,  36,  36,  36],
       [103, 103, 103, …,  36,  36,  35]])
```



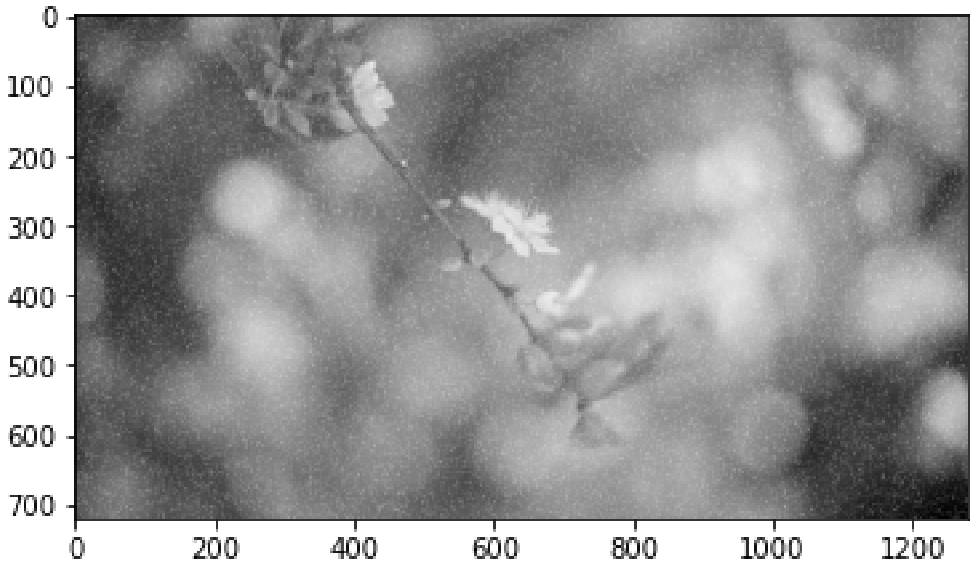
5.6 Q-5.6

Same as Max filter, input for Min filter must have lighter noises, if noises are black(intensity = 0) Min filter would pick noise as value for pixels nearby.

[66]:
```
sp_intensity = 5 # 0-100
sp_img = np.array(img_arr)
```

```
sp_count = int((sp_intensity/100) * (img_arr.shape[0]*img_arr.shape[1]))

for count in range(sp_count):
    x = random.randint(0, img_arr.shape[0]-1)
    y = random.randint(0, img_arr.shape[1]-1)
    sp_img[x][y] = 255

plt.imshow(sp_img , cmap="gray"),len(sp_img[sp_img == 0]), sp_count, img_arr.
 ↪shape[0]*img_arr.shape[1]
```

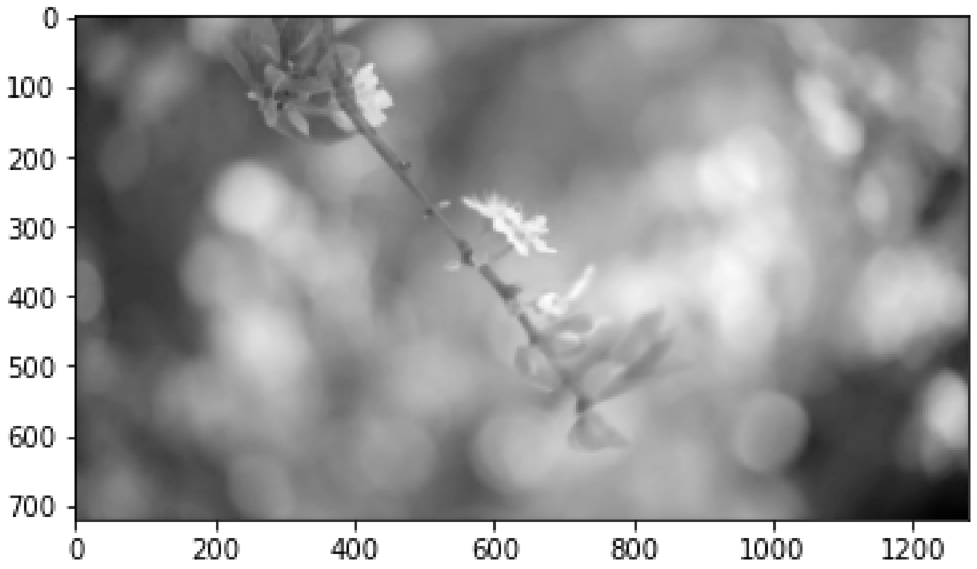
[66]:
```
(<matplotlib.image.AxesImage at 0x1b809ed3088>, 0, 46080, 921600)
```



[67]:
```
def min_filter(filter_size, img_arr):
    # (x-1, y-1) (x-1, y) (x-1, y+1)
    # (x,   y-1) (x,   y) (x,   y+1)
    # (x+1, y-1) (x+1, y) (x+1, y+1)
    out = np.zeros(img_arr.shape)
    for x in range(img_arr.shape[0]):
        for y in range(img_arr.shape[1]):

            list = []
            for f_i in range(-int(filter_size/2), int(filter_size/2)+1):
                for f_j in range(-int(filter_size/2), int(filter_size/2)+1):
                    if not (x+f_i < 0 or x+f_i >= img_arr.shape[0] or y+f_j<0␣
 ↪or y+f_j >=img_arr.shape[1]):
                        list.append(img_arr[x+f_i][y+f_j])
                out[x][y] = min(np.array(list))


    imgplot = plt.imshow(out , cmap="gray")
    return out.astype(int)
```

[68]:
```
min_filter(5, sp_img)
```

[68]:
```
array([[ 84,  84,  84, …, 138, 138, 138],
       [ 84,  84,  84, …, 138, 138, 138],
       [ 84,  84,  84, …, 138, 138, 138],
       …,
       [ 87,  87,  87, …,  35,  35,  35],
       [ 87,  87,  87, …,  35,  35,  35],
       [ 87,  87,  87, …,  35,  35,  35]])
```



5.7 Q-5.7

Box filter(Average): if filter_size is big enough, Box filter eliminates noises but it also blurs the image.

Gaussian filter(weighted average): increasing Sigma would result in more blured image, also eliminates noises. (smoother edges)

Median filter: Best performance for eliminating noises.

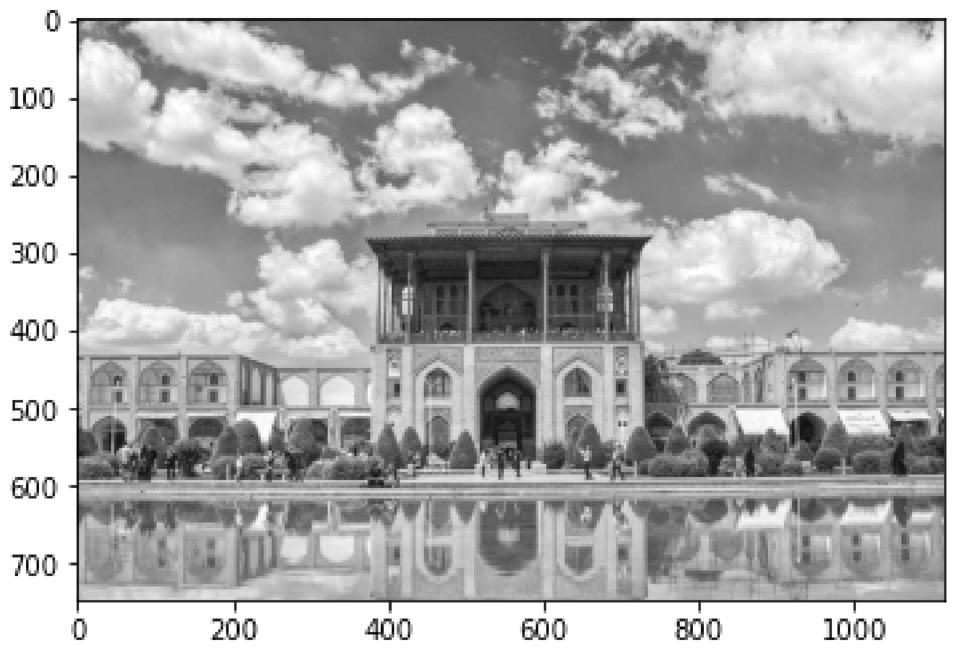
Maximum Filter: if noises are white, it picks noises for nearby pixels and expands white noises, but if noises are darker and black($I = 0$) it works pretty well because it replaces nearby pixel's intensity for noises.

Minimum Filter: works for White noises(I = 255). (in the same way as Maximum Filter)

6 Exercise 6

[69]:
```
im = Image.open("assignment1/assignment1/images/alighapoo.jpg").convert('L')
# im.show()

img_arr = asarray(im)
imgplot = plt.imshow(img_arr , cmap="gray")

img_arr, img_arr.shape
```

[69]:
```
(array([[108, 112, 116, …, 213, 213, 213],
        [111, 112, 113, …, 214, 214, 214],
        [117, 113, 109, …, 214, 214, 214],
        …,
        [170, 169, 169, …, 158, 158, 158],
        [170, 169, 169, …, 156, 156, 156],
        [170, 169, 169, …, 155, 155, 155]], dtype=uint8),
 (748, 1116))
```



[70]:
```
import numpy as np
from scipy import ndimage

# exchange x and y when using
def GetBilinearPixel(imArr, posX, posY):
    out = 0

    #Get integer and fractional parts of numbers
    modXi = int(posX)
    modYi = int(posY)
    modXf = posX - modXi
    modYf = posY - modYi
    modXiPlusOneLim = min(modXi+1,imArr.shape[1]-1)
    modYiPlusOneLim = min(modYi+1,imArr.shape[0]-1)

    #if (modYi==10 and modXi == 500) or (modYi==10 and modXiPlusOneLim==500) or␣
 ↪(modYiPlusOneLim==10 and modXi==500) or (modYiPlusOneLim==10 and␣
 ↪modXiPlusOneLim==500):
    #    print(posX , posY)

    #if (modYi==500 and modXi == 10) or (modYi==500 and modXiPlusOneLim==10) or␣
 ↪(modYiPlusOneLim==500 and modXi==10) or (modYiPlusOneLim==500 and␣
 ↪modXiPlusOneLim==10):
     #   print(posX , posY)

    #Get pixels in four corners
    bl = imArr[modYi, modXi]
    br = imArr[modYi, modXiPlusOneLim]
    tl = imArr[modYiPlusOneLim, modXi]
    tr = imArr[modYiPlusOneLim, modXiPlusOneLim]

    #Calculate interpolation
    b = modXf * br + (1. - modXf) * bl
    t = modXf * tr + (1. - modXf) * tl
    pxf = modYf * t + (1. - modYf) * b
    out = (int(pxf+0.5))

    return out
```

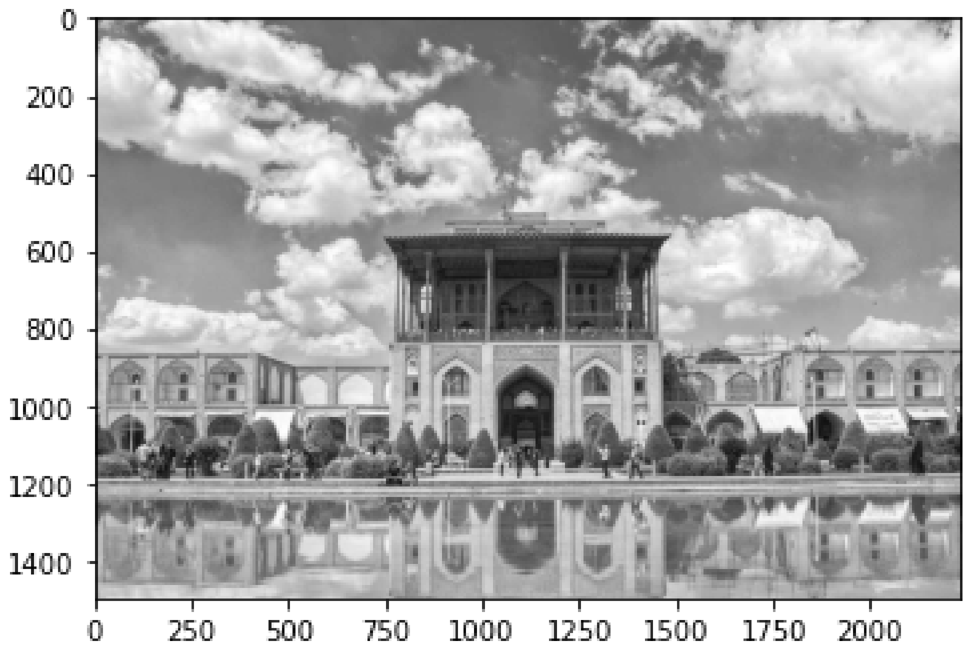
6.1 Q-6.1

[71]:
```
def scaling(k, img_arr):
    new_height = img_arr.shape[0]*k
    new_width = img_arr.shape[1]*k
    out = np.zeros((new_height, new_width))

    T = np.array([[k, 0, 0],
                  [0, k, 0],
                  [0, 0, 1]])

    T_inv = inv(T)

    for x_p in range(new_height):
        for y_p in range(new_width):
            res = T_inv @ np.array([x_p, y_p, 1])
            x_orig = res[0]
            y_orig = res[1]

            intensity = GetBilinearPixel(img_arr, y_orig, x_orig)
            out[x_p][y_p] = intensity
            #break
        #break

    print(out)
    imgplot = plt.imshow(out , cmap="gray")
    return out
```

[72]:
```
scaling(2, img_arr)
```

```
[[108. 110. 112. … 213. 213. 213.]
 [110. 111. 112. … 214. 214. 214.]
 [111. 112. 112. … 214. 214. 214.]
 …
 [170. 170. 169. … 156. 156. 156.]
 [170. 170. 169. … 155. 155. 155.]
 [170. 170. 169. … 155. 155. 155.]]
```

[72]:
```
array([[108., 110., 112., …, 213., 213., 213.],
       [110., 111., 112., …, 214., 214., 214.],
       [111., 112., 112., …, 214., 214., 214.],
       …,
       [170., 170., 169., …, 156., 156., 156.],
       [170., 170., 169., …, 155., 155., 155.],
       [170., 170., 169., …, 155., 155., 155.]])
```

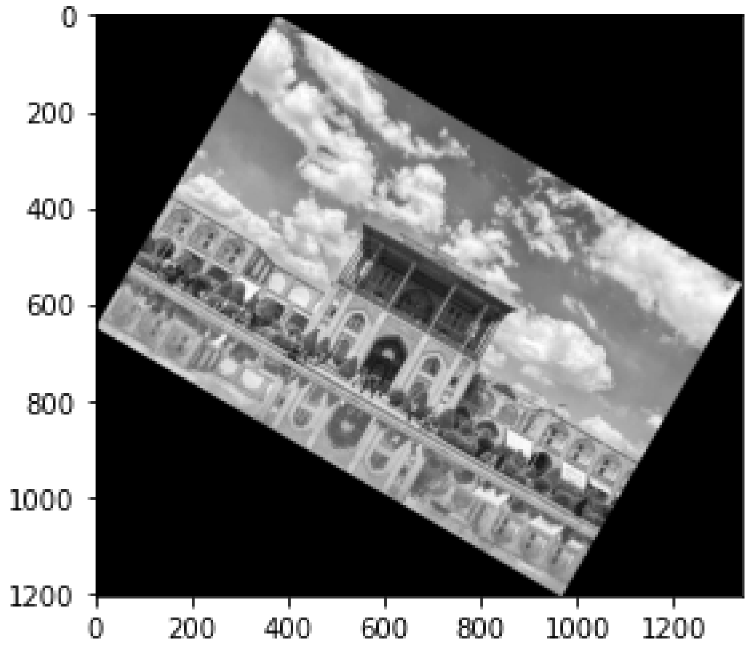


6.2 Q-6.2

[73]:
```
def rotate_and_scale(theta, img_arr):
    new_height = int(img_arr.shape[0] * math.cos(math.radians(theta))+ img_arr.
 ↪shape[1] * math.sin(math.radians(theta)))
    new_width =  int(img_arr.shape[0] * math.sin(math.radians(theta))+ img_arr.
 ↪shape[1] * math.cos(math.radians(theta)))
    print(new_height, new_width)
    out = np.zeros((new_height, new_width))

    temp = math.ceil(img_arr.shape[0] * math.sin(math.radians(theta)))-1

    T = np.array([[math.cos(math.radians(theta)), math.sin(math.
 ↪radians(theta)), 0],
                  [-math.sin(math.radians(theta)), math.cos(math.
 ↪radians(theta)), 0],
                  [0, 0, 1]])

    T_inv = inv(T)

    for x_p in range(new_height):
        for y_p in range(-temp, new_width-temp):
            res = T_inv @ np.array([x_p, y_p, 1])
            x_orig = res[0]
            y_orig = res[1]


            if x_orig < 0 or x_orig >= img_arr.shape[0] or y_orig < 0 or y_orig␣
↪>= img_arr.shape[1]:
                continue


            intensity = GetBilinearPixel(img_arr, y_orig, x_orig)
            out[x_p][y_p+temp] = intensity
            #out[x_p][y_p] = intensity

    print(out)
    imgplot = plt.imshow(out , cmap="gray")
    return out
```

[74]:
```
out = rotate_and_scale(30,  img_arr) #600, 1000
```

```
1205 1340
[[0. 0. 0. … 0. 0. 0.]
 [0. 0. 0. … 0. 0. 0.]
 [0. 0. 0. … 0. 0. 0.]
 …
 [0. 0. 0. … 0. 0. 0.]
 [0. 0. 0. … 0. 0. 0.]
 [0. 0. 0. … 0. 0. 0.]]
```



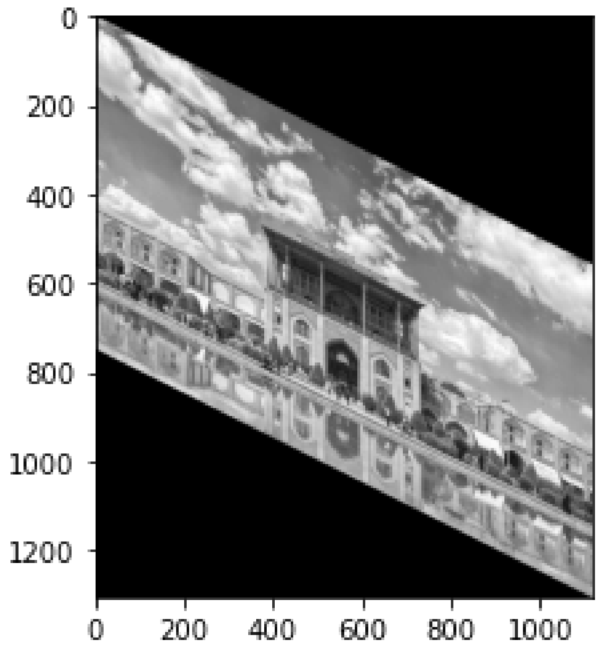
6.3 Q-6.3

[76]:
```
def custom_shearing(k_hor_shear, k_ver_shear, img_arr):
    new_height = int(img_arr.shape[1]*k_hor_shear+img_arr.shape[0])
    new_width = int(img_arr.shape[0]*k_ver_shear+img_arr.shape[1])

    out = np.zeros((new_height, new_width))

    T = np.array([[1, k_hor_shear, 0],
                  [k_ver_shear, 1, 0],
                  [0, 0, 1]])

    T_inv = inv(T)

    for x_p in range(new_height):
        for y_p in range(new_width):
            res = T_inv @ np.array([x_p, y_p, 1])
            x_orig = res[0]
            y_orig = res[1]

            if x_orig < 0 or x_orig >= img_arr.shape[0] or y_orig < 0 or y_orig␣
 ↪>= img_arr.shape[1]:
                continue

            intensity = GetBilinearPixel(img_arr, y_orig, x_orig)
            out[x_p][y_p] = intensity
            #break
        #break

    print(out)
    imgplot = plt.imshow(out , cmap="gray")
    return out
```

[77]:
```
custom_shearing(0.5, 0, img_arr)
```

```
[[108.   0.   0. …   0.   0.   0.]
 [111. 112. 116. …   0.   0.   0.]
 [117. 113. 113. …   0.   0.   0.]
 …
 [  0.   0.   0. … 156. 156. 157.]
 [  0.   0.   0. … 155. 155. 156.]
 [  0.   0.   0. …   0.   0. 155.]]
```

```
[77]: array([[108.,   0.,   0., …,   0.,   0.,   0.],
              [111., 112., 116., …,   0.,   0.,   0.],
              [117., 113., 113., …,   0.,   0.,   0.],
              …,
              [  0.,   0.,   0., …, 156., 156., 157.],
              [  0.,   0.,   0., …, 155., 155., 156.],
              [  0.,   0.,   0., …,   0.,   0., 155.]])
```

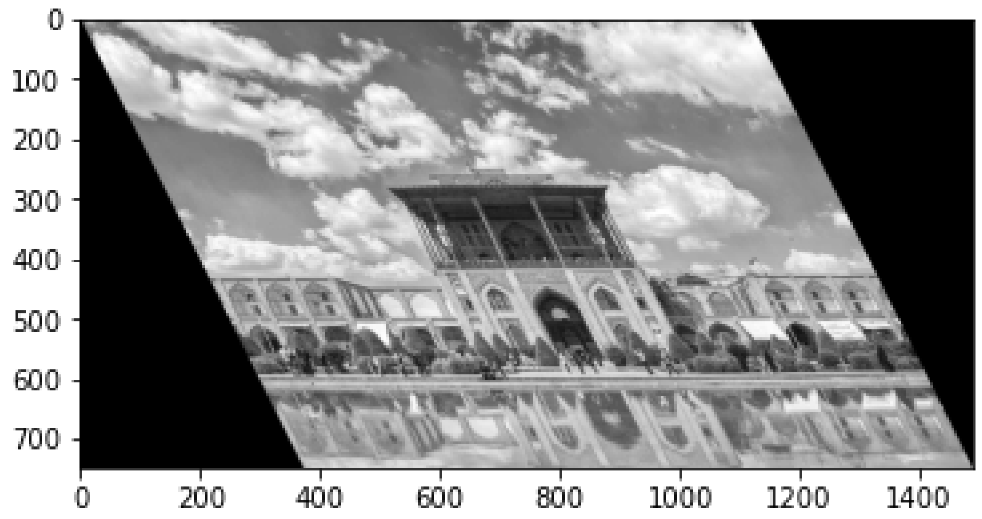


6.4 Q-6.4

```
[78]: custom_shearing(0, 0.5, img_arr)
```

```
[[108. 112. 116. …   0.   0.   0.]
 [  0. 112. 113. …   0.   0.   0.]
 [  0. 117. 113. …   0.   0.   0.]
 …
 [  0.   0.   0. … 158. 158.   0.]
 [  0.   0.   0. … 156. 156.   0.]
 [  0.   0.   0. … 155. 155. 155.]]
```

```
[78]: array([[108., 112., 116., …,   0.,   0.,   0.],
              [  0., 112., 113., …,   0.,   0.,   0.],
              [  0., 117., 113., …,   0.,   0.,   0.],
              …,
              [  0.,   0.,   0., …, 158., 158.,   0.],
              [  0.,   0.,   0., …, 156., 156.,   0.],
              [  0.,   0.,   0., …, 155., 155., 155.]])
```

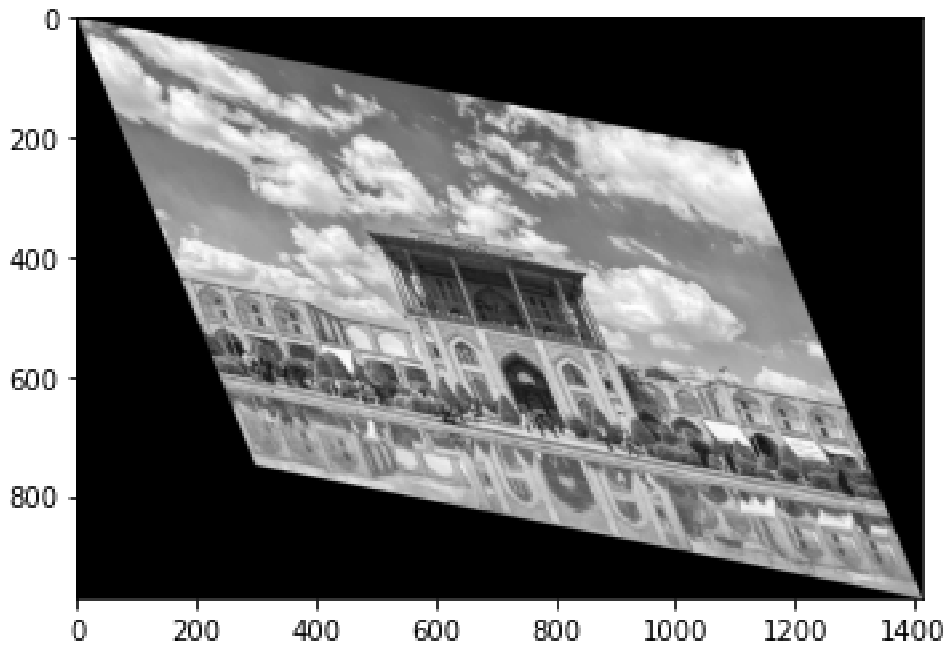


6.5 Q-6.5

[79]:
```
custom_shearing(0.2, 0.4, img_arr)
```

```
[[108.   0.   0. …   0.   0.   0.]
 [  0. 112. 114. …   0.   0.   0.]
 [  0. 116. 112. …   0.   0.   0.]
 …
 [  0.   0.   0. … 158. 158.   0.]
 [  0.   0.   0. … 156. 156. 156.]
 [  0.   0.   0. … 155. 155. 155.]]
```

[79]:
```
array([[108.,   0.,   0., …,   0.,   0.,   0.],
       [  0., 112., 114., …,   0.,   0.,   0.],
       [  0., 116., 112., …,   0.,   0.,   0.],
       …,
       [  0.,   0.,   0., …, 158., 158.,   0.],
       [  0.,   0.,   0., …, 156., 156., 156.],
       [  0.,   0.,   0., …, 155., 155., 155.]])
```


0
200
400
600
800
0
200
400
600
800
1000
1200
1400