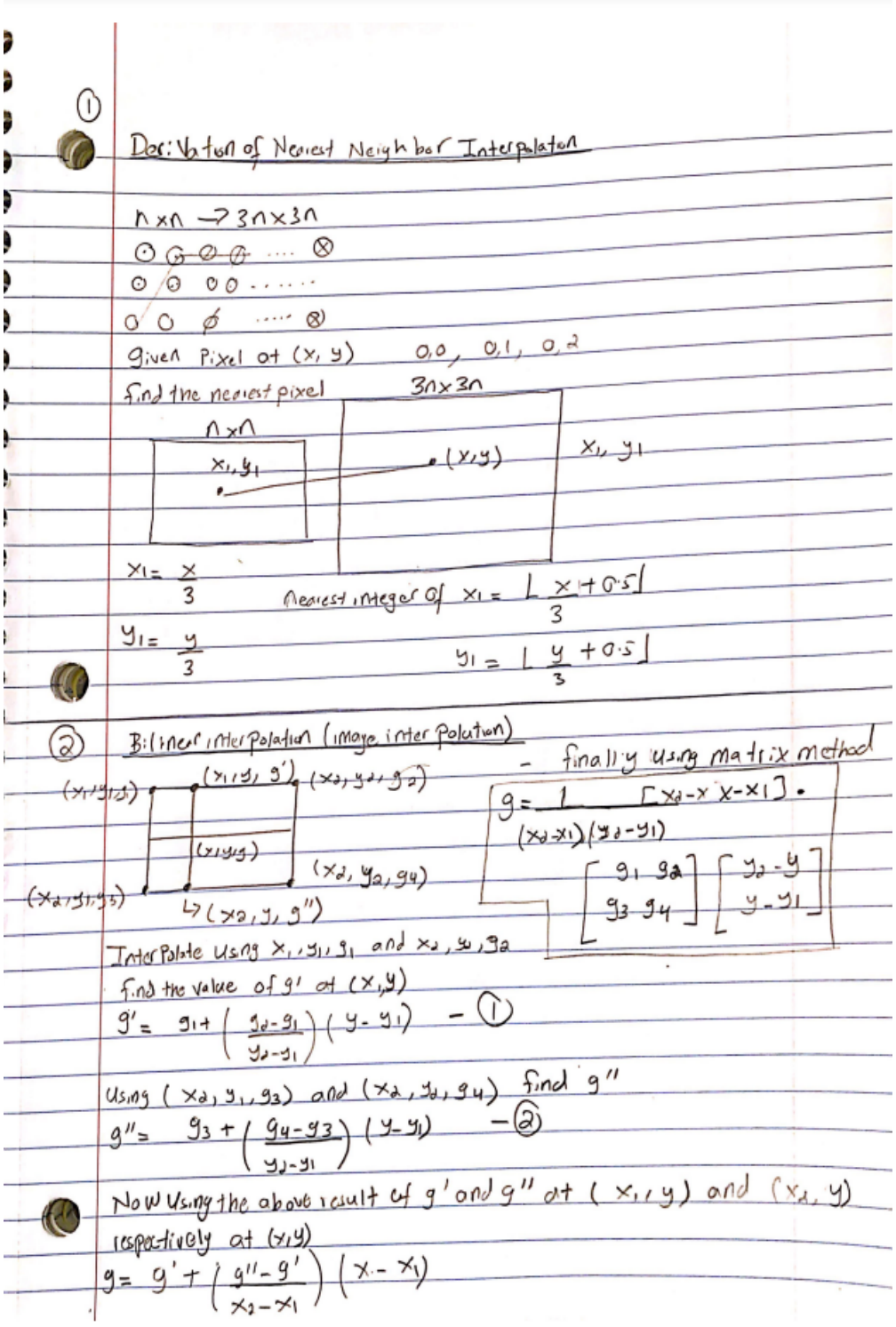
Problem Statement

Given the image of Lena, the goal of the assignment is to enlarge the image by a factor of k (where k = (k = 2, 2.5, 3.0,3.5, 4.0 along both dimensions) using the following interpolation techniques.

1. Nearest Neighbor interpolation
2. Bilinear interpolation

Derivation of NN Interpolation and Bilinear Interpolation



Code

Problem Statement

Given the image of Lena, the goal of the assignment is to enlarge the image by a factor of k (where k = (k = 2, 2.5, 3.0,3.5, 4.0 along both dimensions) using the following interpolation techniques:

1. Nearest Neighbor interpolation

2. Bilinear interpolation

0. Replicate the image

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
```

In [2]:
```
def replicate(x):
    m,n = x.shape
    x1 = np.zeros(shape=(2*m,2*n),dtype='uint8')
    for i in range(m):
        ii = 2*i
        for j in range(n):
            jj = 2*j
            x1[ii,jj] = x[i,j]
            x1[ii,jj+1] = x[i,j]
            x1[ii+1,jj] = x[i,j]
            x1[ii+1,jj+1] = x[i,j]
    return x1
```

1. NN interpolation

In [3]:
```
def nninterp(x,k):

    (m,n) = x.shape

    m1 = np.uint16(m*k)
    n1 = np.uint16(n*k)

    n1 = np.uint16(n*k)
    x1 = np.zeros(shape=(m1,n1),dtype = 'uint8')

    for i in range(0,m1):
        for j in range(0,n1):
            ii = np.uint16(np.floor(i*1.0/k+0.5))
            if(ii == m):
                ii = ii-1
            jj = np.uint16(np.floor(j*1.0/k+0.5))
            if(jj == n):
                jj = jj-1
```

```
            x1[i,j] = x[ii,jj]
    return x1
```

2. Bilinear Interpolation

In [4]:
```
def bilinear(x,i1,j1): #x input image i1 and j1 are floating point number where pixel v
    (m,n) = x.shape
    i0 = np.uint16(np.floor(i1))
    j0 = np.uint16(np.floor(j1))
    if(i0 == m-1):
        i0 = i0-1
    if(j0 == n-1):
        j0 = j0-1
    g1 = np.float(x[i0,j0])
    g2 = np.float(x[i0,j0+1])
    g3 = np.float(x[i0+1,j0])
    g4 = np.float(x[i0+1,j0+1])
    gp = g1+(g2-g1)*(j1-j0)
    gpp = g3+(g4-g3)*(j1-j0)
    g = gp+(gpp-gp)*(i1-i0)
    return np.uint8(g)
```

In [5]:
```
def bilinearinterp(x,k): # x is input image and k is zoom factor(float)
    (m,n) = x.shape
    m1 = np.uint16(m*k)
    n1 = np.uint16(n*k)
    x1 = np.ndarray(shape=(m1,n1),dtype='uint8')
    for i in range(0,m1):
        i1 = i*1.0/k
        for j in range(0,n1):
            j1 = j*1.0/k
            x1[i,j] = bilinear(x,i1,j1)
    return x1
```

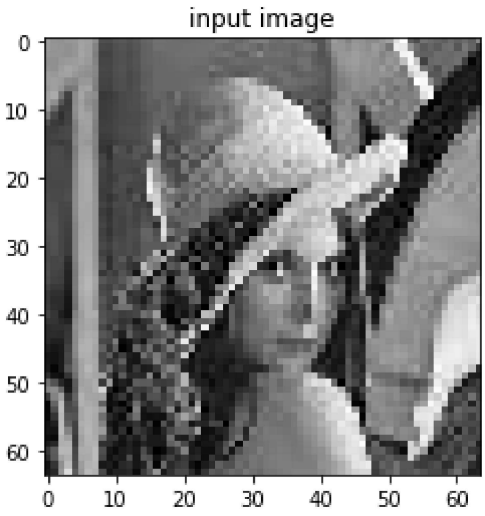
Main

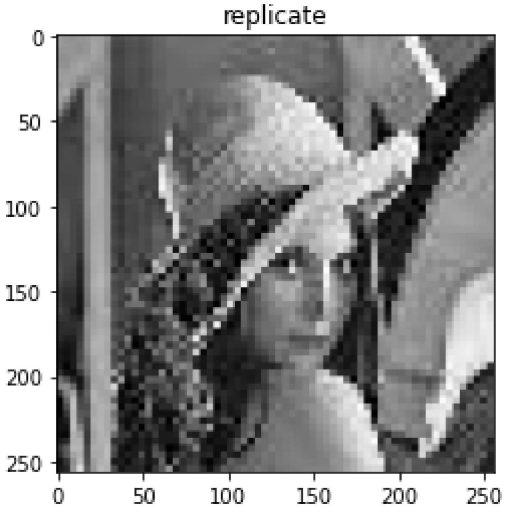
In [13]:
```
def main():

    xx = plt.imread('lena64.jpg')
    xx = xx[:,:,0]
    fig,ax0 = plt.subplots(1,1,figsize=(4,4))
    ax0.set_title('input image')
    ax0.imshow(xx,cmap='gray')


    k  = 2.0
    k2 = 2.5
    k3 = 3.0
    k4 = 3.5
    k5 = 4.0

    xx1 = replicate(replicate(xx))
    fig, ax1 = plt.subplots(1,1,figsize= (4,4))
    ax1.set_title('replicate')
    ax1.imshow(xx1,cmap='gray')
```

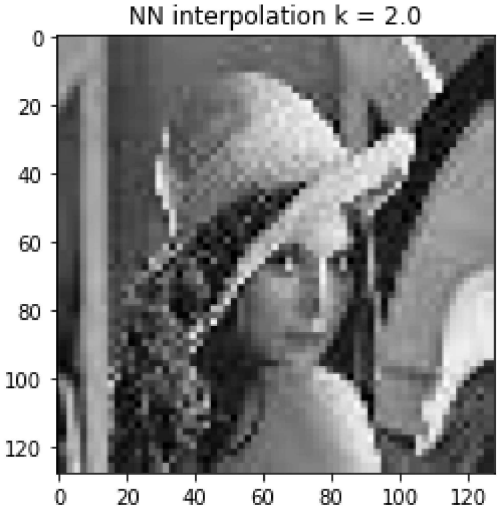
```
xx2 = nninterp(xx,k)
fig, ax2 = plt.subplots(1,1,figsize= (4,4))
ax2.set_title('NN interpolation k = 2.0')
ax2.imshow(xx2,cmap='gray')

xx3 = bilinearinterp(xx,k)
fig, ax3 = plt.subplots(1,1,figsize= (4,4))
ax3.set_title('Bi-linear interpolation k = 2.0')
ax3.imshow(xx3,cmap = 'gray')

xx22 = nninterp(xx,k2)
fig, ax22 = plt.subplots(1,1,figsize= (4,4))
ax22.set_title('NN interpolation k = 2.5')
ax22.imshow(xx22,cmap='gray')

xx32 = bilinearinterp(xx,k2)
fig, ax32 = plt.subplots(1,1,figsize= (4,4))
ax32.set_title('Bi-linear interpolation k= 2.5')
ax32.imshow(xx32,cmap = 'gray')

xx23 = nninterp(xx,k3)
fig, ax23 = plt.subplots(1,1,figsize= (4,4))
ax23.set_title('NN interpolation k = 3.0')
ax23.imshow(xx23,cmap='gray')

xx33 = bilinearinterp(xx,k3)
fig, ax33 = plt.subplots(1,1,figsize= (4,4))
ax33.set_title('Bi-linear interpolation k = 3.0')
ax33.imshow(xx33,cmap = 'gray')

xx24 = nninterp(xx,k4)
fig, ax24 = plt.subplots(1,1,figsize= (4,4))
ax24.set_title('NN interpolation k = 3.5')
ax24.imshow(xx24,cmap='gray')

xx34 = bilinearinterp(xx,k4)
fig, ax34 = plt.subplots(1,1,figsize= (4,4))
ax34.set_title('Bi-linear interpolation k = 3.5')
ax34.imshow(xx34,cmap = 'gray')

xx25 = nninterp(xx,k5)
fig, ax25 = plt.subplots(1,1,figsize= (4,4))
ax25.set_title('NN interpolation k = 4.0')
ax25.imshow(xx25,cmap='gray')

xx35 = bilinearinterp(xx,k5)
fig, ax35 = plt.subplots(1,1,figsize= (4,4))
ax35.set_title('Bi-linear interpolation k = 4.0')
ax35.imshow(xx35,cmap = 'gray')

plt.show()
```

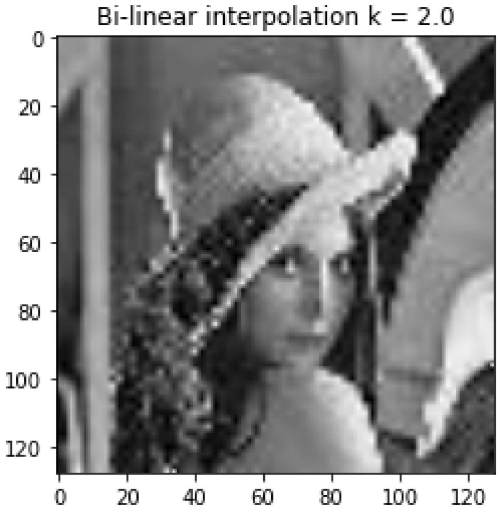
Results

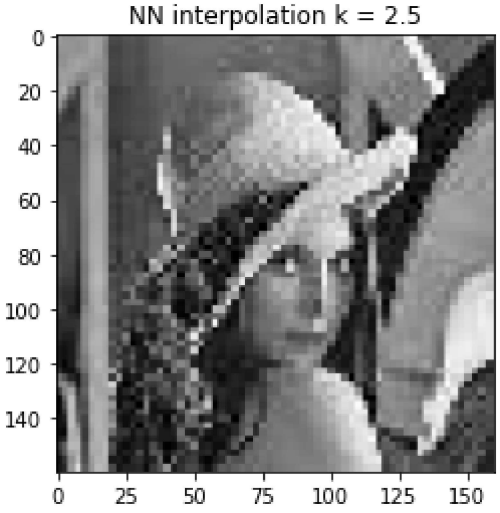
In [14]:
```
if __name__=='__main__':
    main()
```

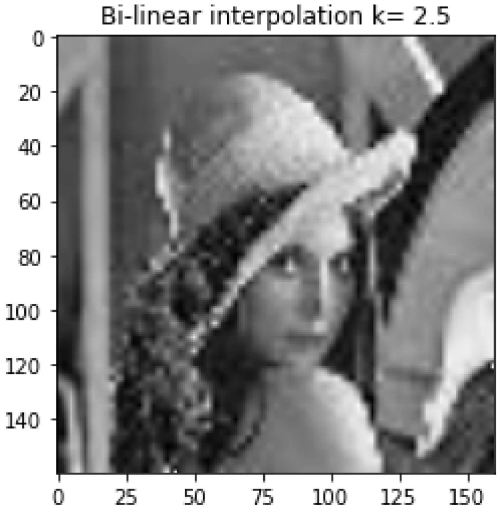

input image
0
10
20
30
40
50
60
0
10
20
30
40
50
60

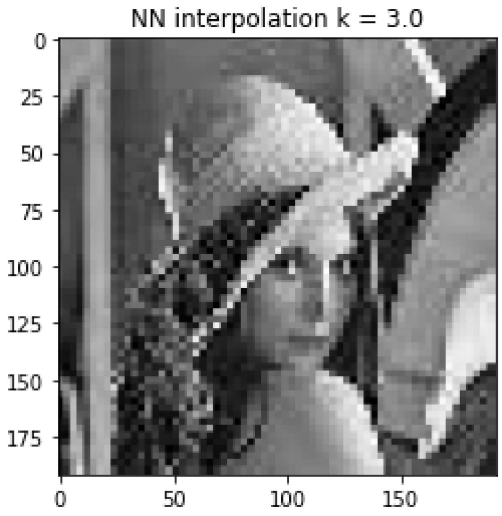

replicate
0
50
100
150
200
250
0
50
100
150
200
250

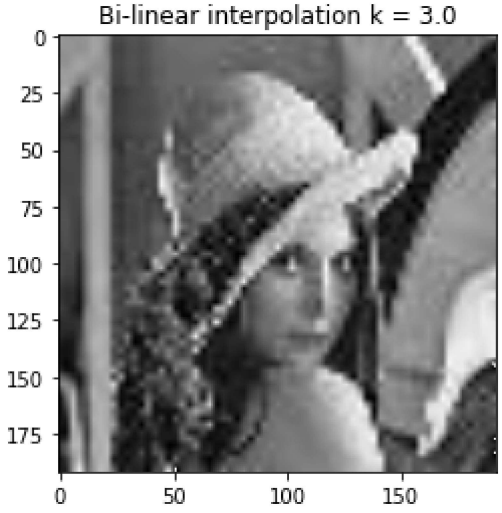

NN interpolation k = 2.0
0
20
40
60
80
100
120
0
20
40
60
80
100
120

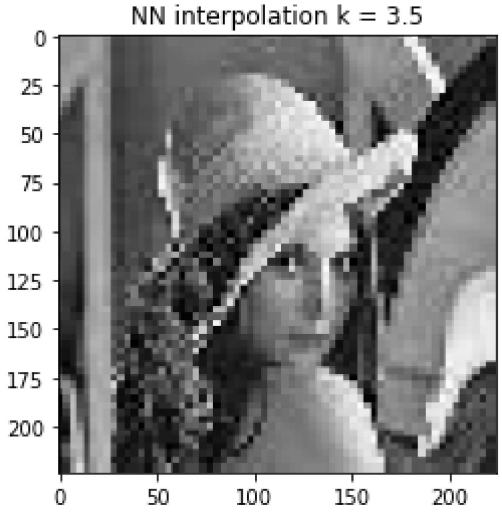

Bi-linear interpolation k = 2.0
0
20
40
60
80
100
120
0
20
40
60
80
100
120

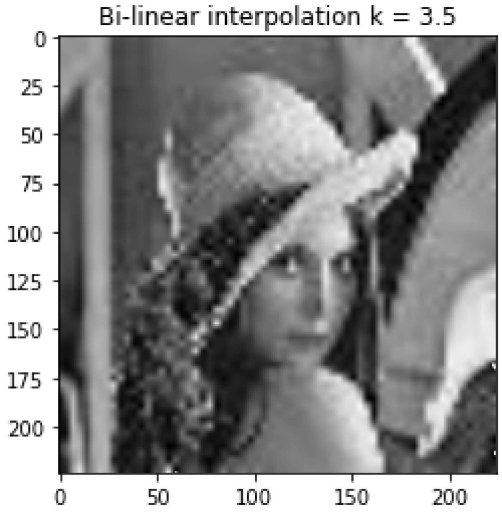

NN interpolation k = 2.5
0
20
40
60
80
100
120
140
0
25
50
75
100
125
150

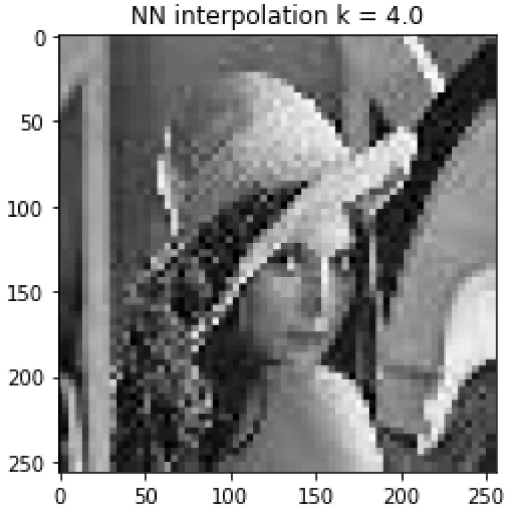

Bi-linear interpolation k= 2.5
0
20
40
60
80
100
120
140
0
25
50
75
100
125
150

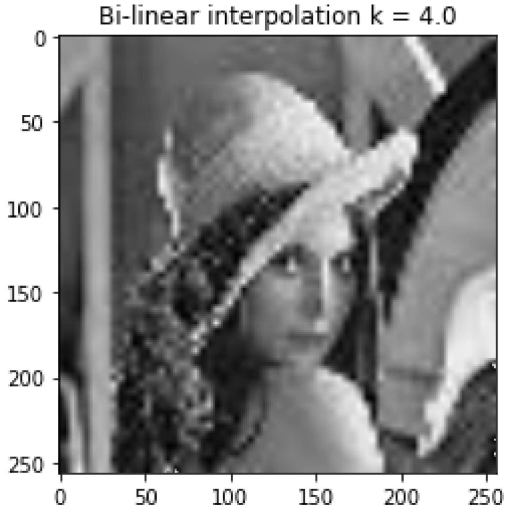

NN interpolation k = 3.0
0
25
50
75
100
125
150
175
0
50
100
150


Bi-linear interpolation k = 3.0
0
25
50
75
100
125
150
175
0
50
100
150


NN interpolation k = 3.5
0
25
50
75
100
125
150
175
200
0
50
100
150
200


Bi-linear interpolation k = 3.5
0
25
50
75
100
125
150
175
200
0
50
100
150
200


NN interpolation k = 4.0
0
50
100
150
200
250
0
50
100
150
200
250


Bi-linear interpolation k = 4.0
0
50
100
150
200
250
0
50
100
150
200
250

In [ ]:

Concluding Remarks

So based on the images provided in the previous page we can see that after implementing the NN interpolation and Bilinear interpolation we can see that with NN interpolation the image looks less pixelated (or blocky) and is clearer when compared with the original image, and the quality of the image increases with successive values of k. With bilinear interpolation the image becomes significantly better when compared with the original and with NN interpolation, and with successive of values k the image quality becomes slightly clearer. When comparing NN and bilinear interpolation with the replicated image, we see that implementing either of the interpolation techniques the image becomes better in quality especially with bilinear interpolation.