Lab 5 Image Manipulation

November 16, 2019

1 Contrast Stretching

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

        from sklearn.cluster import KMeans
        from PIL import Image

        %matplotlib inline

        def originalImage(image):
            """
            Plot original image for the first part of the lab. Image is open using PIL package
            using imshow in matplotlib. Function returns vectorized image.
            """

            #open image using PIL package and convert to numpy array
            mona = np.array(Image.open(image))

            #show original image
            plt.imshow(mona, cmap='gray')
            plt.title('Original Image')
            plt.show()

            return mona

In [2]: def plotHist(image):
            """
            Function plots histogram given an image. Image is converted to float and then flat
            plotted on a histogram. Histogram is generated using matplotlib.
            """

            #convert pixels to float value
            img = image.astype(float)

            #flatten image so its dim is 90000x1
```

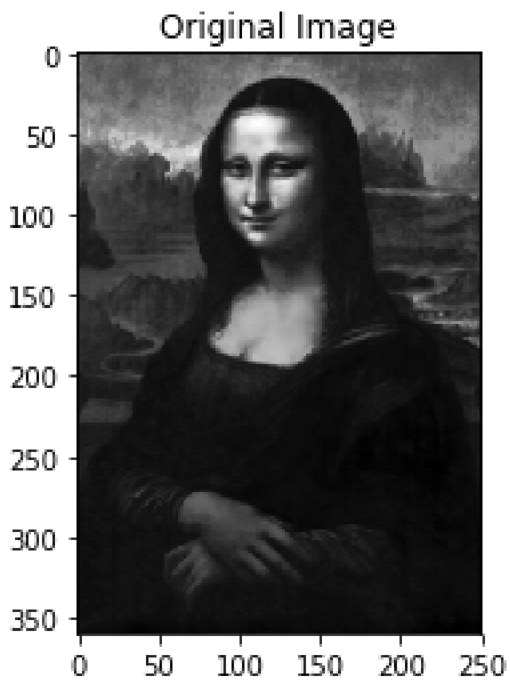
```
        flatten_img = img.ravel()

        #plot a histogram of the distripution of pixels
        hist = plt.hist(flatten_img, bins=256)
        plt.xlabel('grayscale 0 to 255')
        plt.ylabel('number of pixels')
        plt.title('Distribution of pixels')
        plt.show()

        return
```

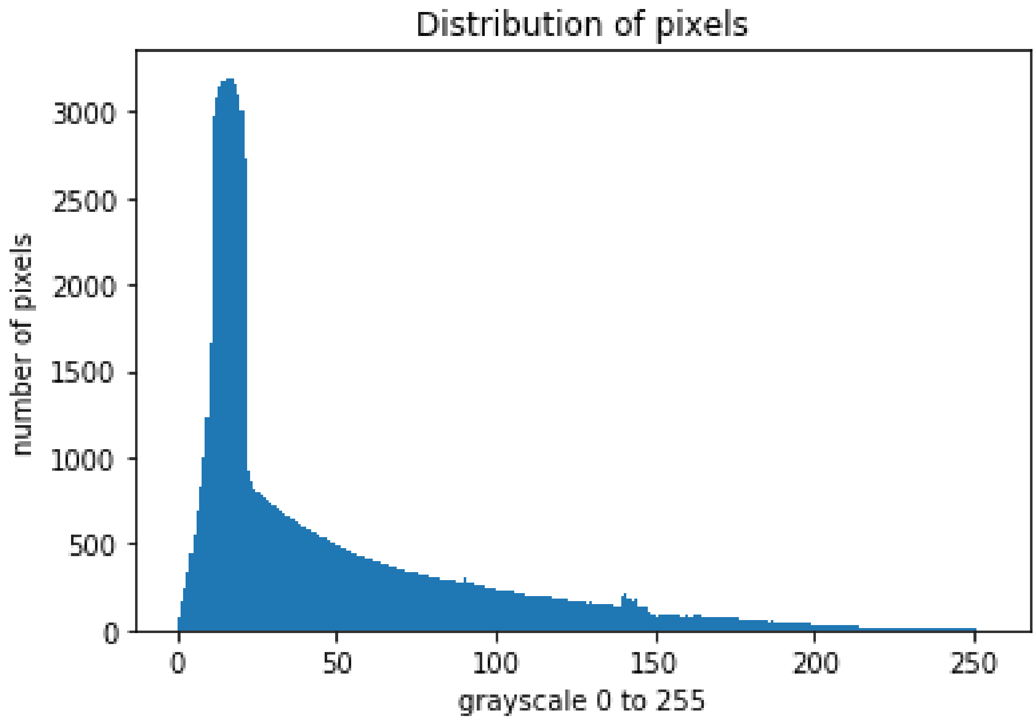
```
In [3]: def splitImage(img):
        """
        This function splits image into three equal sections and changes value of pixels d
        on the ranges the original pixels lie in. The function then plots the three level
        """

        img = img.astype(float)

        image = img.ravel()

        #sort pixels from desc to asc to split in 3
        sorted_img_vec = np.sort(image)

        #split images based on pixel distribution in histogram
        #since the image is now 90000x1 the first 3rd of pixels
        #can be chosen as sorted_img_vec[30000].
        for i in range(len(image)):
            #once image is split reassign sections of the flattened vector
            #to 0, 127, and 255
            #reset pixels in the first range to 0
            if image[i] < sorted_img_vec[30000]:
                image[i] = 0
            #reset pixels in the middle range to 127
            elif image[i] <= sorted_img_vec[60000]:
                image[i] = 127
            #reset pixels in the third range to 255
            else:
                image[i] = 255

        #reshape image to original dimensions, 360x250 to be able to plot
        three_level_img = image.reshape(360, 250)

        #show plot
        plt.imshow(three_level_img, cmap='gray')
        plt.title('3-level image')
        plt.show()
```

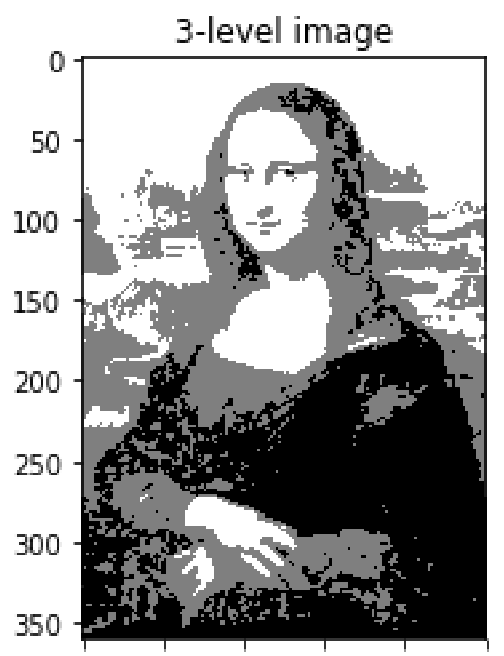
```
    return

In [4]: def kmeans(image):
            """
            This fucntion applies k-means with K = 8 representative gray levels. I use
            a built in kmeans method and display the new image
            """

            #apply k-means with k=8. fit with the original image
            kmeans = KMeans(n_clusters=8).fit(image.ravel().reshape(-1,1))

            img = kmeans.predict(image.ravel().reshape(-1,1))

            #plot reshaped image
            plt.imshow(img.reshape(360, 250), cmap='gray')
            plt.title('K-means clustering with K = 8')
            plt.show()

            return

In [5]: def brighterImage(im):
            """
            This functin doubles the value of each pixel with a value in [0, 127] and sets all
            other pixels to a value of 255. The function displays and returns the brighter ima
            """

            img = im.astype(float)
            image = img.ravel()

            sorted_image_vec = np.sort(image)

            #double the value of each pixel with a value in [0, 127]
            #and set all the other pixels to a value of 255
            for i in range(len(image)):
                if image[i] <= 127:
                    image[i] = 2 * image[i]
                else:
                    image[i] = 255

            #reshape brighter image
            brighter_img = image.reshape(360, 250)

            #show brighter image
            plt.imshow(brighter_img, cmap='gray')
            plt.title('Brighter image')
            plt.show()

            return brighter_img
```

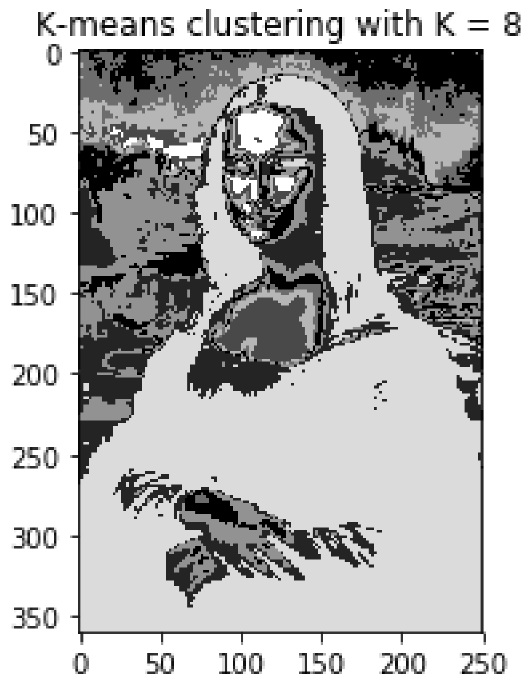
1.1 Trial 1

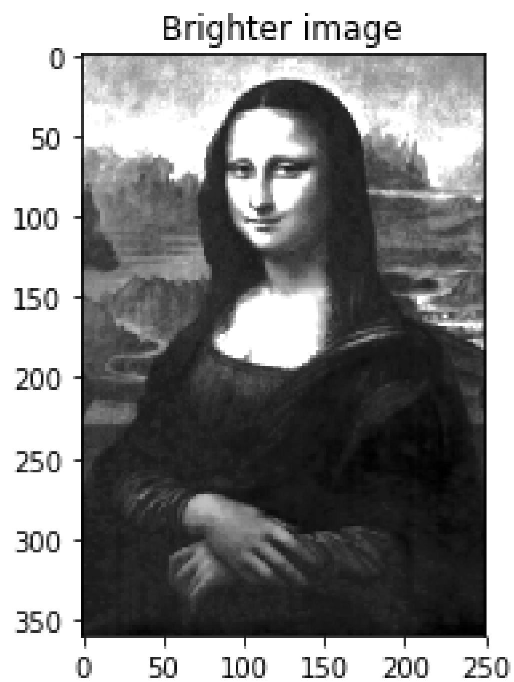
In [6]:
```
#driver code for contrast stretching run 1

#plot original image
mona = originalImage('mona_lisa.png')

#plot histogram
plotHist(mona)

#split image
splitImage(mona)

#apply k-means
kmeans(mona)

#brighten image
brighter_img = brighterImage(mona)
```




Distribution of pixels
number of pixels
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250
grayscale 0 to 255

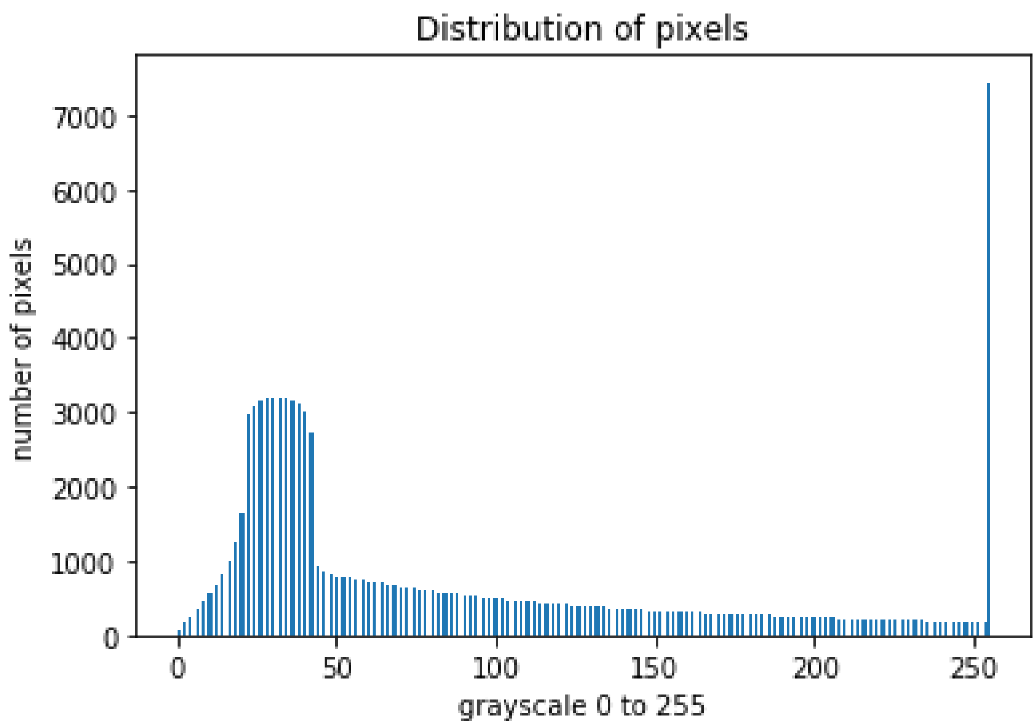

3-level image
0
50
100
150
200
250
300
350
0
50
100
150
200
250

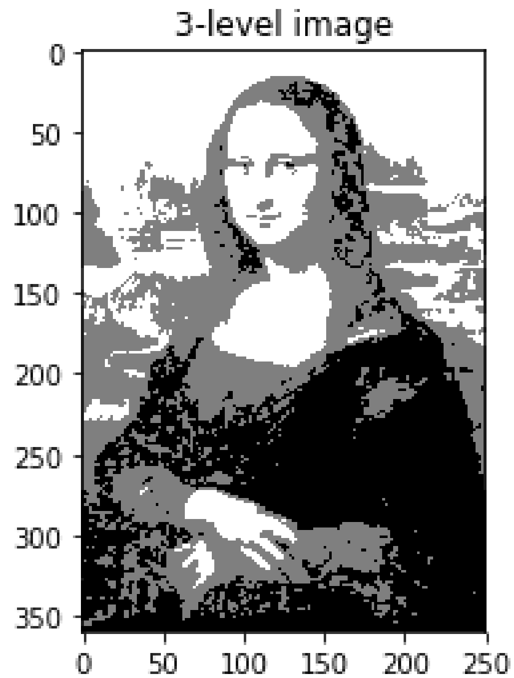

K-means clustering with K = 8
0
50
100
150
200
250
300
350
0
50
100
150
200
250

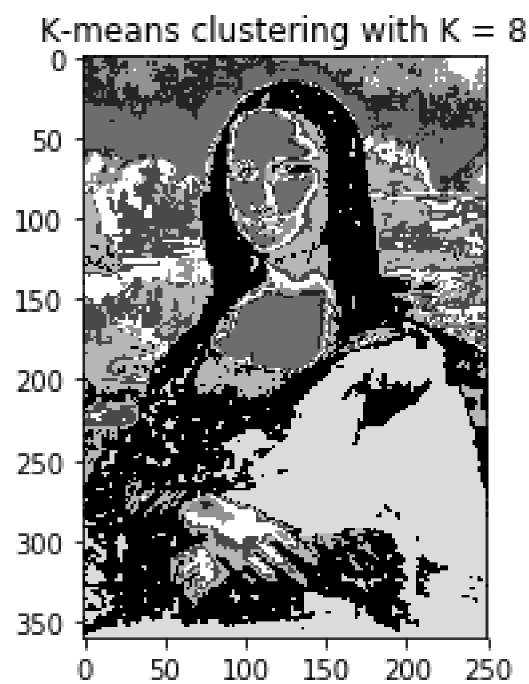

Brighter image
0
50
100
150
200
250
300
350
0
50
100
150
200
250

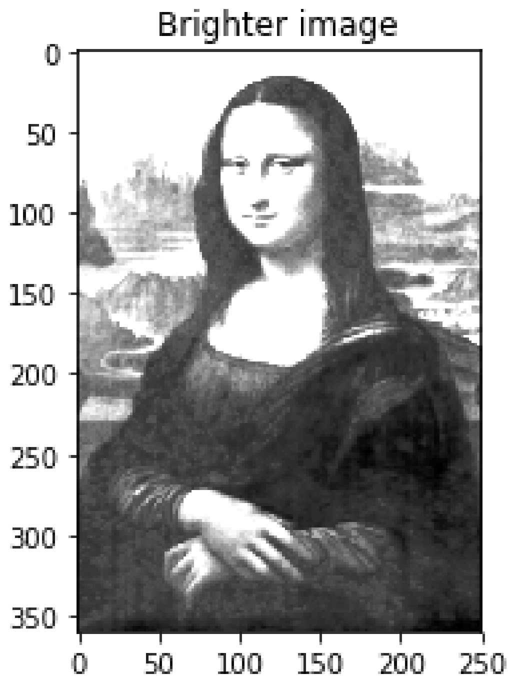
1.2 Trial 2

In [7]:
```
#driver code for contrast stretching run 2

#show distribution of pixels
plotHist(brighter_img)

#divide image into three ranges
splitImage(brighter_img)

#apply k-means
kmeans(brighter_img)

#brighten image
brighter_img2 = brighterImage(brighter_img)
```




3-level image
0
50
100
150
200
250
300
350
0
50
100
150
200
250


K-means clustering with K = 8
0
50
100
150
200
250
300
350
0
50
100
150
200
250

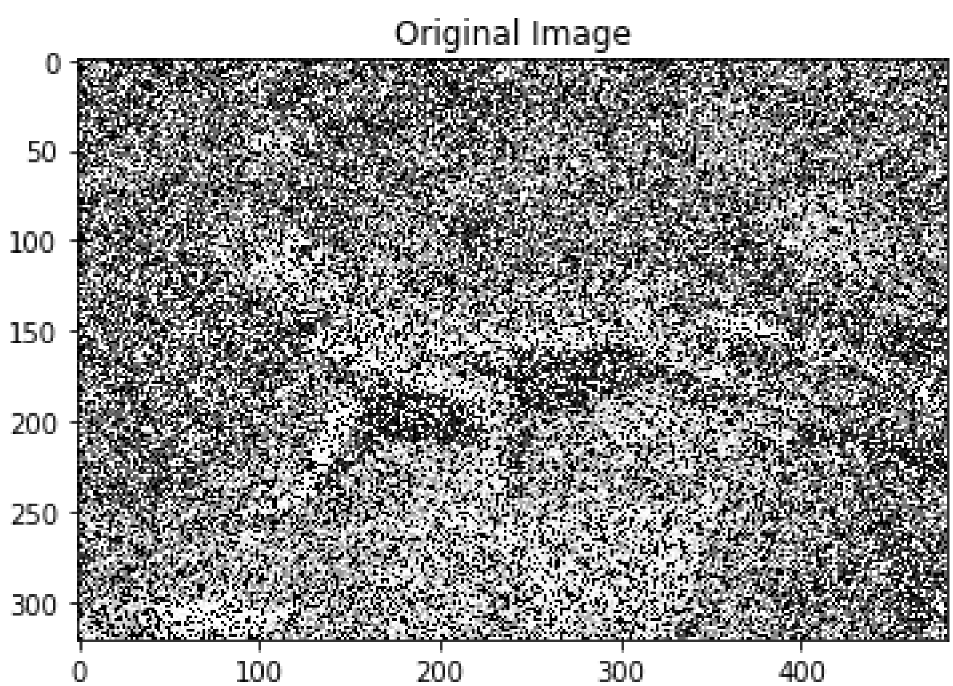


2 Noise Removal

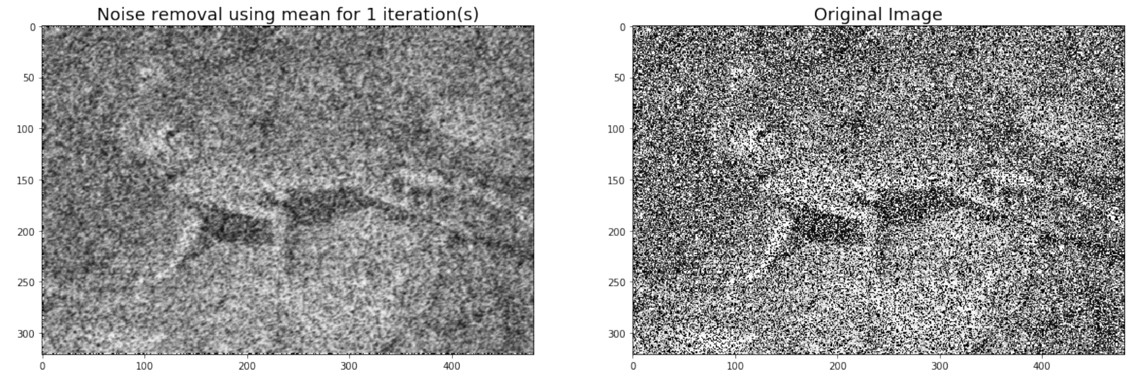
```
In [8]: def noiseRemoval(image, avg_type, n_iter):
            """
            This function denoises the image by replacing each pixel with the average value of
            its 3x3 neighborhood. The averaging technique can be either mean or median
            """

            #read in image
            lizard = np.array(Image.open(image))

            #convert image to double
            p = lizard.astype(float)

            #get shape of image
            m, n = lizard.shape

            p2 = p

            #og count
            count = n_iter

            #denoise the image by replacing each pixel with
            #the average value of its 3x3 neighbors
```

```
    for i in range(2, m-1):
        for j in range(2, n-1):
            p2[i,j] = avg_type((p[i+1, j-1], p[i+1, j], p[i+1, j+1],
                               p[i, j-1], p[i, j], p[i, j+1], p[i-1, j-1],
                               p[i-1, j], p[i-1, j+1]))

    #convert back to uint8
    g = p2.astype(np.uint8)

    #plot images
    atype = 'mean' if avg_type == np.mean else 'median'
    fig, ax = plt.subplots(1, 2, figsize=(20,20))
    ax[0].imshow(g, cmap='gray')
    ax[0].set_title('Noise removal using {} for {} iteration(s)'.format(atype, count),
    ax[1].imshow(lizard, cmap='gray')
    ax[1].set_title('Original Image', fontsize=18)
    plt.show()

    return
```

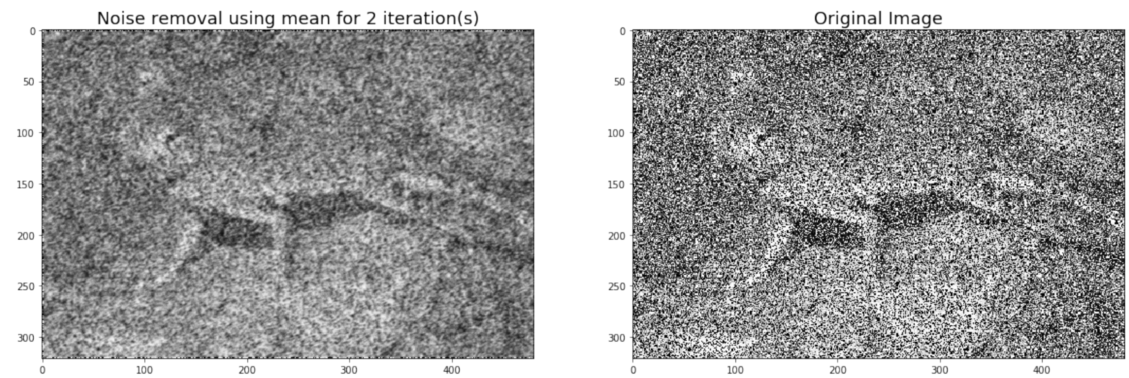
In [9]:
```
#Read in the image file and display the image
lizard = np.array(Image.open('lizard_noisy.png'))
og_image = plt.imshow(lizard, cmap='gray')
plt.title('Original Image')
plt.show()
```



```
In [10]: noiseRemoval('lizard_noisy.png', np.mean, 1)
```

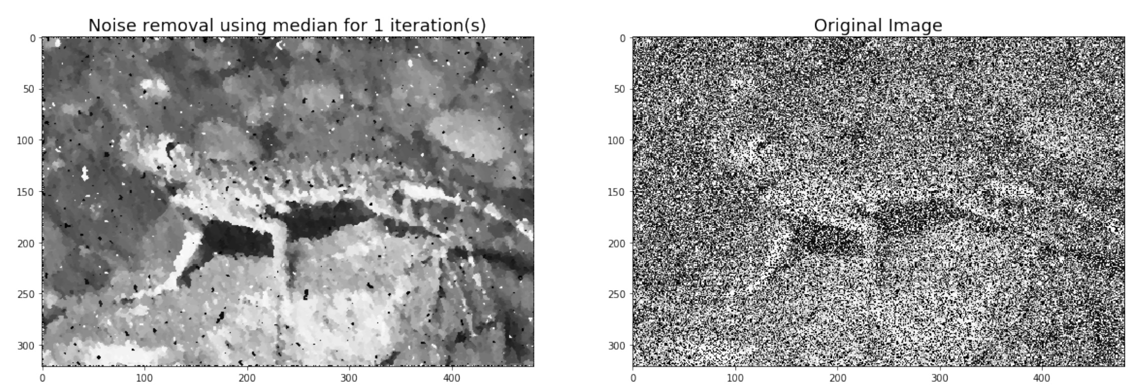



```
In [11]: noiseRemoval('lizard_noisy.png', np.mean, 2)
```

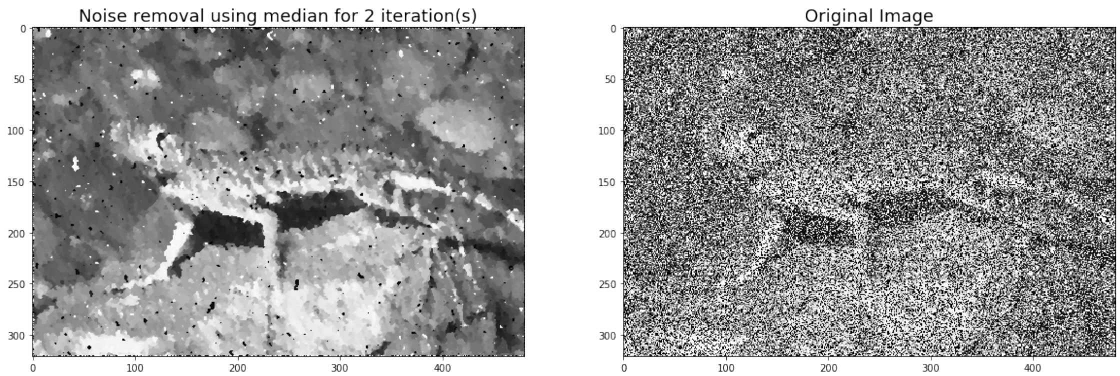


The image does not approve when the iterations are increased to 2. In fact, noise removal two using the mean for two iterations makes the image more noisy then when using the mean for 1 iteration.

```
In [12]: noiseRemoval('lizard_noisy.png', np.median, 1)
```



```
In [13]: noiseRemoval('lizard_noisy.png', np.median, 2)
```



The image does not improve when taking the meadian for 2 iterations. Looking at the comparison between the two images it looks like the first iteration when taking the mean is clearer then the image when 2 iterations were applied.

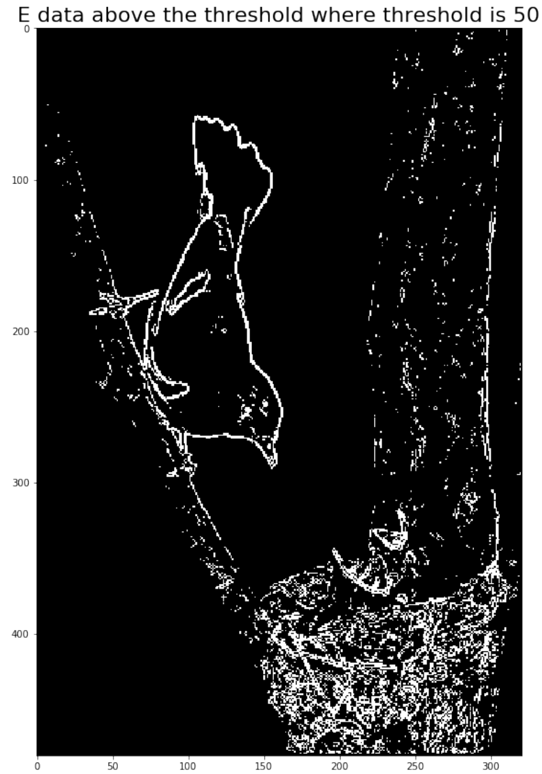
3 Edge Detection

```
In [14]: def edgeDetection (img, threshold):
             """
             This function takes an image and implements the NEWS algorithm to detect edges.
             The threshold is taken as a parameter to enable the user to experiment with the
             level of thresholding.
             """

             #read in image
             a = np.array(Image.open(img))

             #get the dimensions of the image
             m, n = a.shape

             #convert to a float
             b = a.astype(float)

             #edge matrix
             e = np.zeros((m, n))
             e[2:m-1, 2:n-1] = (abs(b[3:m, 2:n-1] - b[1:m-2, 2:n-1]) +
                                abs(b[2:m-1, 3:n] - b[2:m-1, 1:n-2]))

             #scale E to [0, 255]
             emin = np.min(np.min(e))
```

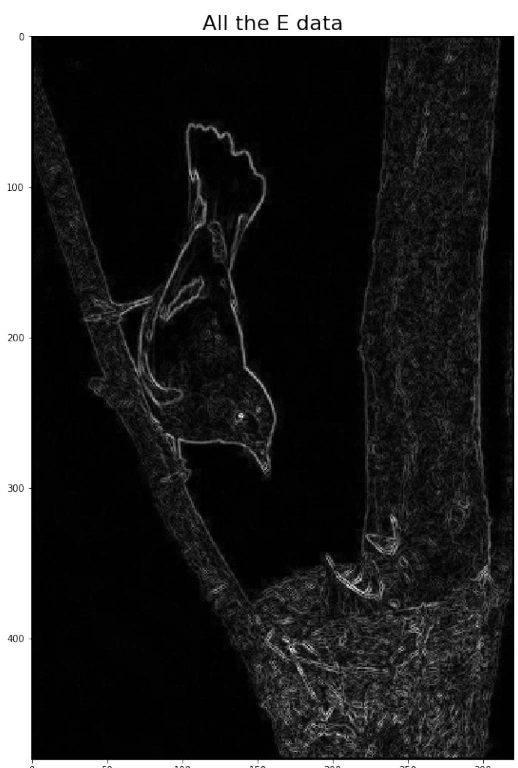
```
        emax = np.max(np.max(e))

        #plot it
        e = np.round(255 * (e - emin) / (emax - emin))

        #using a threshold
        e_thresh = 255 * (threshold < e)

        #reverse image
        e_reverse = 255 - e_thresh

        #plot edge results
        plotEdgeDetection(e, e_thresh, e_reverse, threshold)

        return
```

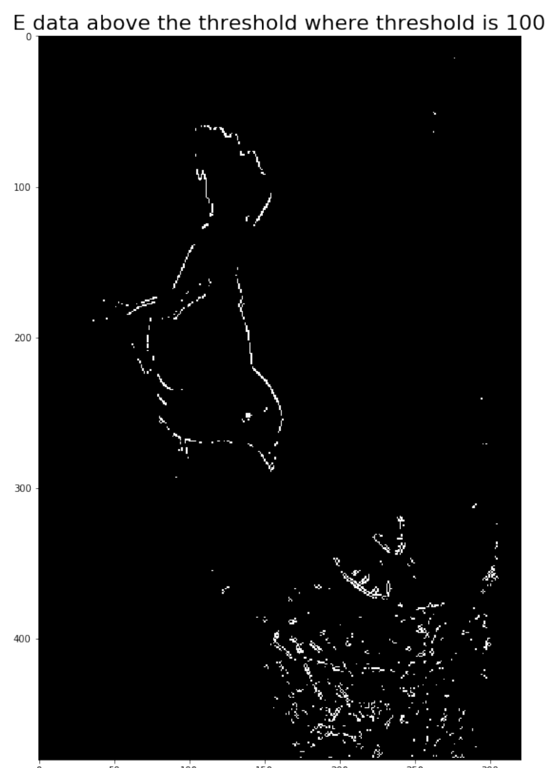
In [15]:
```
def plotEdgeDetection(e, e_thresh, e_reverse, threshold):
    """
    Function plots edge detection image with threshold.
    """

    fig, ax = plt.subplots(1, 2, figsize=(20,20))
    ax[0].imshow(e.astype(np.uint8), cmap='gray')
    ax[0].set_title('All the E data', fontsize=22)
    ax[1].imshow(e_thresh.astype(np.uint8), cmap='gray')
    ax[1].set_title('E data above the threshold where threshold is {}'.format(thresho
    plt.show()
```

In [16]:
```
edgeDetection('bird.png', 50)
```

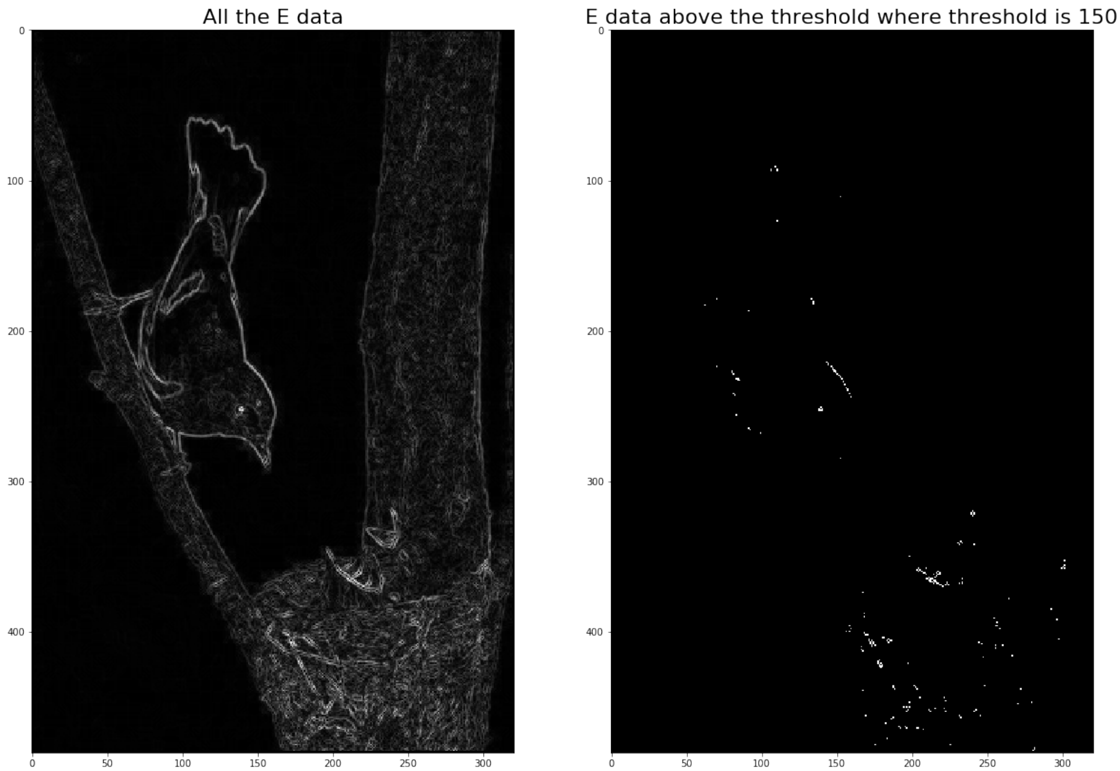



```
In [17]: edgeDetection('bird.png', 100)
```





```
In [18]: edgeDetection('bird.png', 150)
```



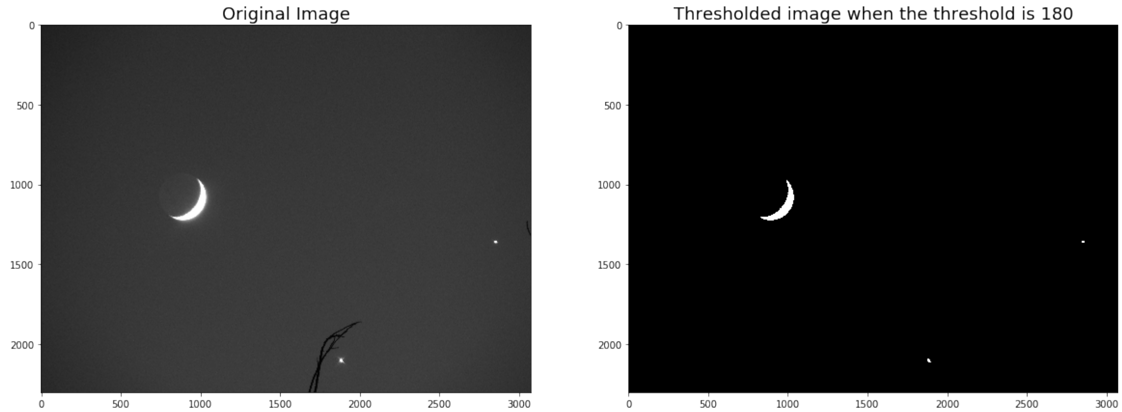
4 Component Identification

```
In [19]: def componentThreshold(image, threshold):
             """
             This function determines a threshold between 0 and 255 so that when the image is
             thresholded, everythint is black except the white pixels. Threshold is a paramete
             so the user can experiment with different thresholds.
             """

             #read in image
             a = np.array(Image.open(image))

             #convert image to a float
             y = a.astype(float)

             #capture dim of image to easily reshape later
             m, n = y.shape
```

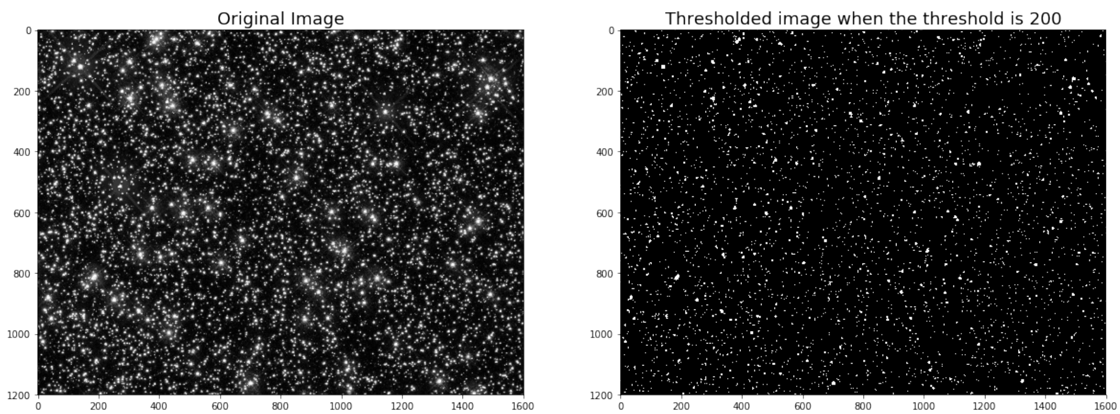
```
    #flatten and sort pixels for easier threshold
    t = y.ravel()
    b = np.sort(t)

    #find min index where threshold is equal
    x = np.min(np.where(b == threshold))

    #set pixels less than threshold to 0
    #else set to 1
    for i in range(len(t)):
        if t[i] <= b[x]:
            t[i] = 0
        else:
            t[i] = 1

    #reshape threshold image
    thresh_img = t.reshape(m, n)

    return thresh_img, threshold, a
```

```
In [20]: def plotThreshImage(threshold_image, threshold, original_image):
    """
    This function plots the thresholded image against the original image. The thresho
    is displayed with the image.
    """

    #show plots
    fig, ax = plt.subplots(1, 2, figsize=(20,20))
    ax[0].imshow(original_image, cmap='gray')
    ax[0].set_title('Original Image', fontsize=18)
    ax[1].imshow(threshold_image.astype(np.uint8), cmap='gray')
    ax[1].set_title('Thresholded image when the threshold is {}'.format(threshold), fo
    plt.show()
```

```
In [21]: #threshold and plot moon image
         moon, threshold, original_image = componentThreshold('conjunction_gray.png', 180)
         plotThreshImage(moon, threshold, original_image)
```




```
In [22]: #threshold and plot stars image
         stars, threshold, original_image = componentThreshold('star_field_gray.png', 200)
         plotThreshImage(stars, threshold, original_image)
```




```
In [23]: def connectedComponent(p):
             """
             This function applies a connected component identification algorithm to the a
             thresholded image to count the numeber of white pixels.
             """

             #set component counter to 0
             l = 0
             #initialize label vector
             label = np.zeros_like(p, dtype=int)
             m, n = p.shape
             #loop through pixels
             for i in range(2, m-1):
```

```
        for j in range(2, n-1):
            #check left and above across array
            if (p[i, j] == 0):
                label[i, j] = 0
            elif (p[i-1, j] == 0 and p[i, j-1] == 0):
                l = l + 1
                label[i, j] = l
            elif (p[i-1, j] == 0):
                label[i, j] = label[i, j-1]
            elif (p[i, j-1] == 0):
                label[i, j] = label[i-1, j]
            else:
                label[i, j] = np.min([label[i-1, j],label[i,j-1]])

    #second pass
    index = np.arange(0, l+1, dtype=int)

    #loop through pixels
    for i in range(2,m-1):
        for j in range(2,n-1):
            #check right and above
            if label[i, j] != 0:
                lst = [label[i, j]]
                if label[i+1, j] != 0:
                    lst.append(label[i+1,j])
                if label[i, j+1] != 0:
                    lst.append(label[i, j+1])
                if np.min(lst) < index[label[i,j]]:
                    index[label[i,j]] = np.min(lst)

    for i in range(l+1):
        index[i] = index[index[i]]

    #convert to set
    index_uniq = set(index)

    #dont include 0
    text = 'The number of connected components is ' + str(len(index_uniq)-1)

    return text
```

In [24]:
```
#Connected components for the moon image
connectedComponent(moon)
```

Out[24]: 'The number of connected components is 5'

In [25]:
```
#connected components for the stars image
connectedComponent(stars)
```

```
Out[25]: 'The number of connected components is 5148'
```