rpn2_mp0

January 24, 2019

1 MP0 : Image Demosaicing

Welcome to CS 543! This assignment is a warm-up assignment to get you back up working from the winter break! We will try to provide you an iPython Notebook (like this) for all the future assignments! The notebook will provide you some further instructions(implementation related mainly), in addition to the ones provided on class webpage.

1.0.1 Import statements

The following cell is only for import statements. You can use any of the 3 : cv2, matplotlib or skimage for image i/o and other functions. We will provide you the names of the relevant functions for each module. **{For convenience provided at the end of the class assignment webpage}**

```
In [1]: import numpy as np
        import cv2
        from scipy import ndimage, signal
        from matplotlib import pyplot as plt
        import matplotlib
```

```
In [2]: #Used to debug numpy array using print
        np.set_printoptions(threshold=np.nan)
```

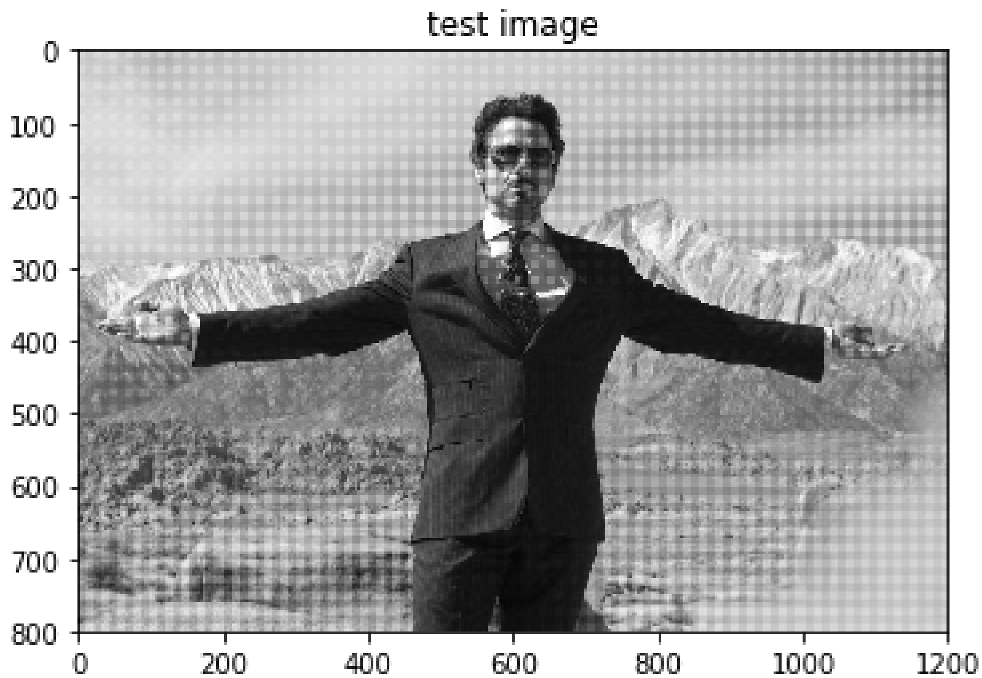
```
In [3]: IMG_DIR = 'images/'
```

1.0.2 Reading the Mosaic Image

```
In [4]: def read_image(IMG_NAME):
            img = cv2.imread(IMG_NAME)
            return img[:,:,::-1] # returns the image array in RGB order
```

```
In [5]: test_read_image = read_image(IMG_DIR+'tony.bmp')
        #Plot crayon solution
        plt.imshow(test_read_image)
        plt.title('test image')
```

```
Out[5]: Text(0.5,1,'test image')
```



1.0.3 Linear Interpolation

```
In [6]: def get_solution_image(mosaic_img):
            '''
            This function should return the soln image.
            Feel free to write helper functions in the above cells
            as well as change the parameters of this function.
            '''
            mosaic_shape = np.shape(mosaic_img)
            soln_image = np.zeros((mosaic_shape[0], mosaic_shape[1], 3))

            #Mask and retrieve red channel
            red_ch = mosaic_img[:,:,0]
            red_ch[1::2] = 0
            red_ch[:,1::2] = 0
            #Red  weights and convolution
            red_weights = np.array([[0.25,0.5,0.25],[0.5,1,0.5],[0.25,0.5,0.25]])
            red_conv    = ndimage.convolve(red_ch, red_weights, mode='constant', cval=0.0)

            ##Mask and retrieve blue channel
            blue_ch = mosaic_img[:,:,2]
            blue_ch[::2] = 0
            blue_ch[:,::2] = 0
            #Blue  weights and convolution
            blue_weights = np.array([[0.25,0.5,0.25],[0.5,1,0.5],[0.25,0.5,0.25]])
```

```
        blue_conv    = ndimage.convolve(blue_ch, blue_weights, mode='constant', cval=0.0)

        ###Mask and retrieve green channel
        green_ch = mosaic_img[:,:,1]
        green_ch[::2, 0::2] = 0
        green_ch[1::2, 1::2] = 0
        #green  and convolution
        green_weights = np.array([[0,0.25,0],[0.25,1,0.25],[0,0.25,0]])
        green_conv    = ndimage.convolve(green_ch, green_weights, mode='constant', cval=0.0

        #Construct solution image
        soln_image[:,:,0] = red_conv
        soln_image[:,:,1] = green_conv
        soln_image[:,:,2] = blue_conv

        return soln_image
```

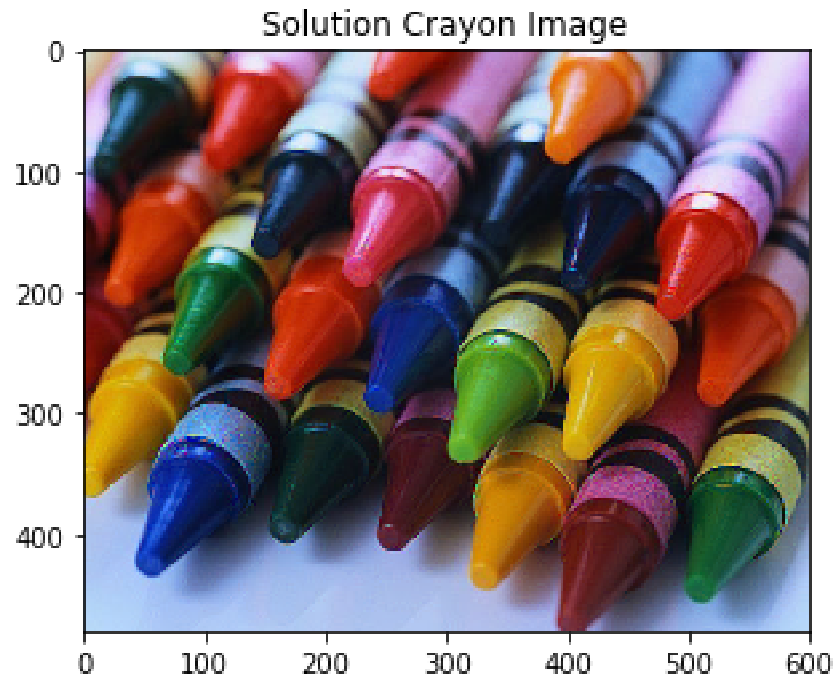
```
In [7]: def compute_errors(soln_image, original_image):
        '''
        Compute the Average and Maximum per-pixel error
        for the image.

        Also generate the map of pixel differences
        to visualize where the mistakes are made
        '''
        sq_diff = (soln_image-original_image)**2
        res_sum_diff = np.sum(sq_diff, axis = 2)
        max_err = np.amax(res_sum_diff)
        pp_err = np.mean(res_sum_diff)
        return res_sum_diff, pp_err, max_err
```

We provide you with 3 images to test if your solution works. Once it works, you should generate the solution for test image provided to you.

```
In [8]: mosaic_img = read_image(IMG_DIR+'crayons.bmp')
        soln_image = get_solution_image(mosaic_img)
        original_image = read_image(IMG_DIR+'crayons.jpg')
```

```
In [9]: #Plot crayon solution
        plt.imshow(soln_image/255)
        plt.title('Solution Crayon Image')
```

```
Out[9]: Text(0.5,1,'Solution Crayon Image')
```




```
In [10]: #Write solution image to disk
         cv2.imwrite('solution_crayon.jpg',soln_image[:,:,::-1])
```

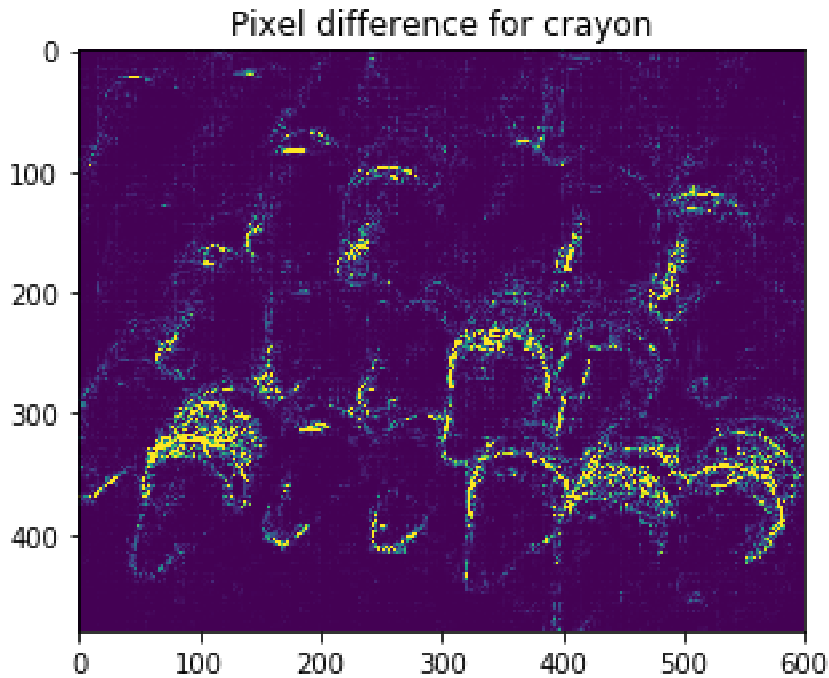
```
Out[10]: True
```

```
In [11]: res_pixel_diff, pp_err, max_err = compute_errors(soln_image, original_image)
         print("The average per-pixel error for crayons is: "+str(pp_err))
         print("The maximum per-pixel error for crayons is: "+str(max_err))
```

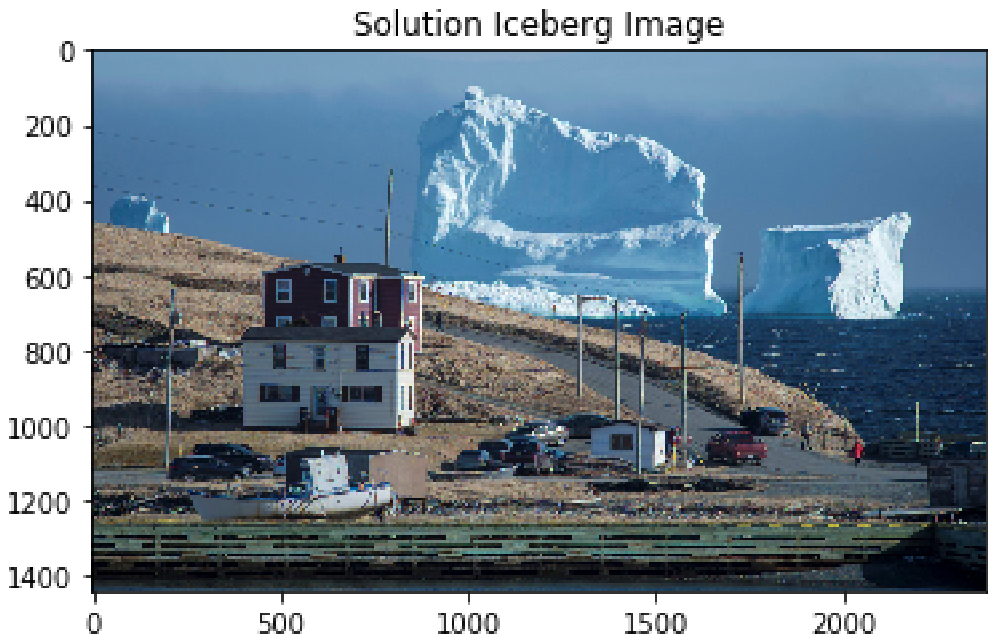
```
The average per-pixel error for crayons is: 212.75303819444446
The maximum per-pixel error for crayons is: 53765.0
```

```
In [12]: #Plot pixel difference
         plt.imshow(res_pixel_diff, vmin = 0, vmax = 2048)
         plt.title('Pixel difference for crayon')
```

```
Out[12]: Text(0.5,1,'Pixel difference for crayon')
```




```
In [13]: mosaic_img = read_image(IMG_DIR+'iceberg.bmp')
         soln_image = get_solution_image(mosaic_img)
         original_image = read_image(IMG_DIR+'iceberg.jpg')
         # For sanity check display your solution image here
         ### YOUR CODE

In [14]: #Plot iceberg solution
         plt.imshow(soln_image/255)
         plt.title('Solution Iceberg Image')

Out[14]: Text(0.5,1,'Solution Iceberg Image')
```




```
In [15]: #display_image('Iceberg solution', soln_image/255)
         #Write solution image to disk
         cv2.imwrite('solution_iceberg.jpg',soln_image[:,:,::-1])
```

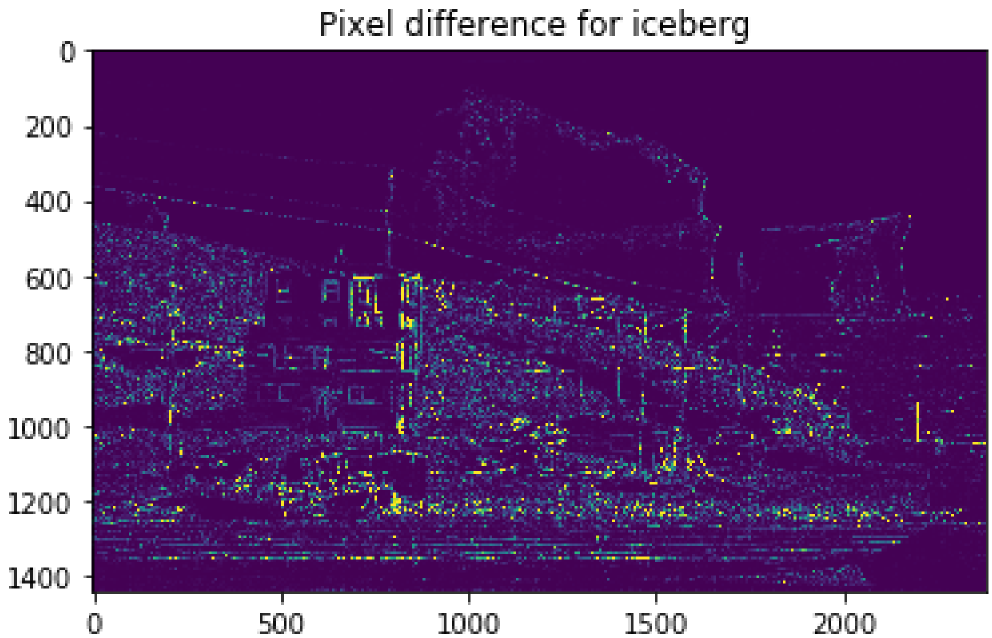
```
Out[15]: True
```

```
In [16]: res_pixel_diff, pp_err, max_err = compute_errors(soln_image, original_image)
         print("The average per-pixel error for iceberg is: "+str(pp_err))
         print("The maximum per-pixel error for iceberg is: "+str(max_err))
         #print(original_image[10:20,10:20,0])
```

```
The average per-pixel error for iceberg is: 114.97222338837578
The maximum per-pixel error for iceberg is: 30553.0
```

```
In [17]: #Plot pixel difference
         plt.imshow(res_pixel_diff, vmin = 0, vmax = 2048)
         plt.title('Pixel difference for iceberg ')
```

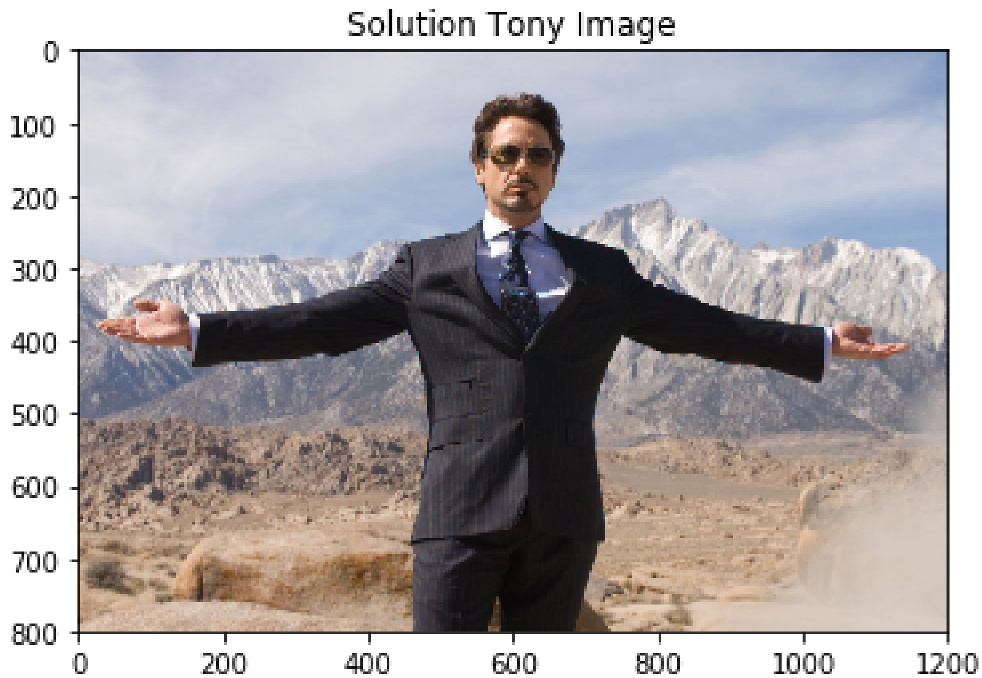
```
Out[17]: Text(0.5,1,'Pixel difference for iceberg ')
```




```
In [18]: mosaic_img = read_image(IMG_DIR+'tony.bmp')
         soln_image = get_solution_image(mosaic_img)
         original_image = read_image(IMG_DIR+'tony.jpg')
         # For sanity check display your solution image here
         ### YOUR CODE
```

```
In [19]: #Plot Tony solution
         plt.imshow(soln_image/255)
         plt.title('Solution Tony Image')
```

```
Out[19]: Text(0.5,1,'Solution Tony Image')
```



In [20]:
```
cv2.imwrite('solution_tony.jpg',soln_image[:,:,::-1])
```

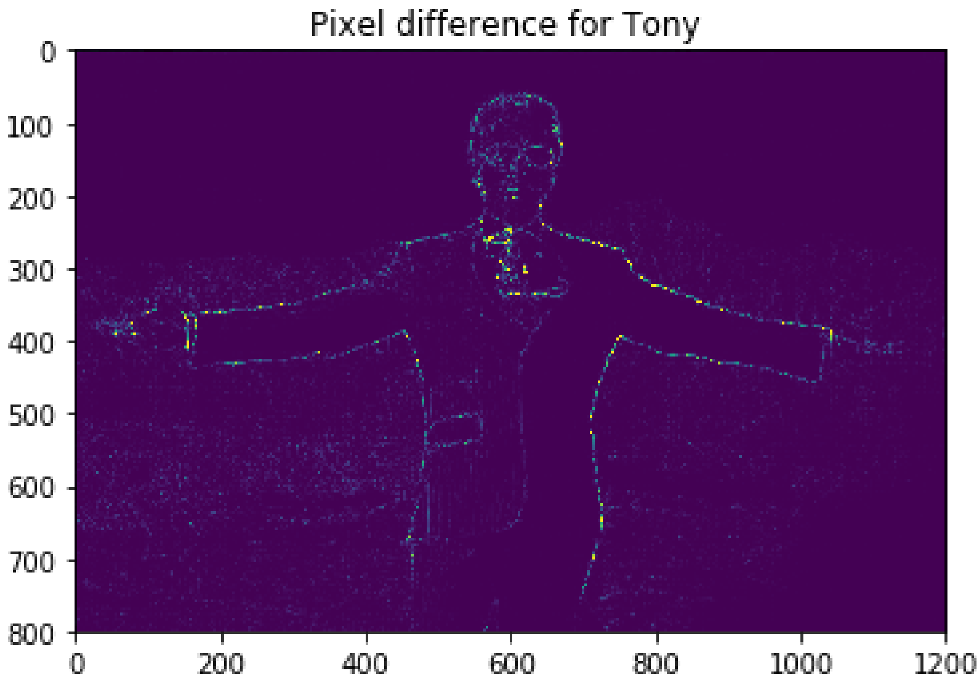
Out[20]:
```
True
```

In [21]:
```
res_pixel_diff, pp_err, max_err = compute_errors(soln_image, original_image)
print("The average per-pixel error for tony is: "+str(pp_err))
print("The maximum per-pixel error for tony is: "+str(max_err))
```

```
The average per-pixel error for tony is: 58.208590625
The maximum per-pixel error for tony is: 36973.0
```

In [22]:
```
#Plot pixel difference
plt.imshow(res_pixel_diff, vmin = 0, vmax = 2048)
plt.title('Pixel difference for Tony ')
```

Out[22]:
```
Text(0.5,1,'Pixel difference for Tony ')
```




```
In [23]: mosaic_img = read_image(IMG_DIR+'hope.bmp')
         soln_image = get_solution_image(mosaic_img)
         # Generate your solution image here and show it

In [24]: #Plot Hope solution
         plt.imshow(soln_image/255)
         plt.title('Solution Hope Image')

Out[24]: Text(0.5,1,'Solution Hope Image')
```


```
In [25]: cv2.imwrite('solution_hope.jpg',soln_image[:,:,::-1])
```

```
Out[25]: True
```

1.0.4 Freeman's Method

For details of the freeman's method refer to the class assignment webpage.

MAKE SURE YOU FINISH LINEAR INTERPOLATION BEFORE STARTING THIS PART!!!

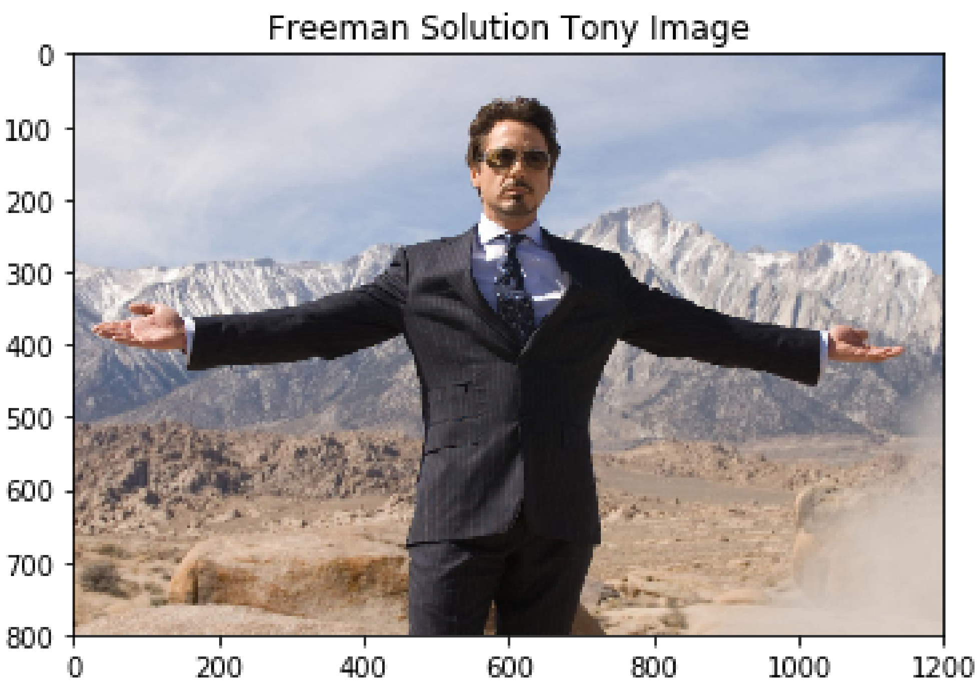
```
In [26]: def get_freeman_solution_image(mosaic_img, kernel_size = 3):
             '''
             This function should return the freeman soln image.
             Feel free to write helper functions in the above cells
             as well as change the parameters of this function.

             HINT : Use the above get_solution_image function.
             '''
             ### YOUR CODE HERE ###
             linear_sol_image = get_solution_image(mosaic_img)
             freeman_soln_image = linear_sol_image
             red_conv = signal.medfilt2d(linear_sol_image[:,:,0] - linear_sol_image[:,:,1], ke
             blue_conv = signal.medfilt2d(linear_sol_image[:,:,2] - linear_sol_image[:,:,1],ke
             freeman_soln_image[:,:,0] = red_conv
             freeman_soln_image[:,:,2] = blue_conv
```

```
        return np.clip(freeman_soln_image, a_min = 0, a_max = 255)
```

```
In [27]: mosaic_img = read_image(IMG_DIR+'tony.bmp')
         soln_image = get_freeman_solution_image(mosaic_img)
         original_image = read_image(IMG_DIR+'tony.jpg')
         # For sanity check display your solution image here
         ### YOUR CODE
```

```
In [28]: #Plot Tony solution
         plt.imshow(soln_image/255)
         plt.title('Freeman Solution Tony Image')
```

```
Out[28]: Text(0.5,1,'Freeman Solution Tony Image')
```



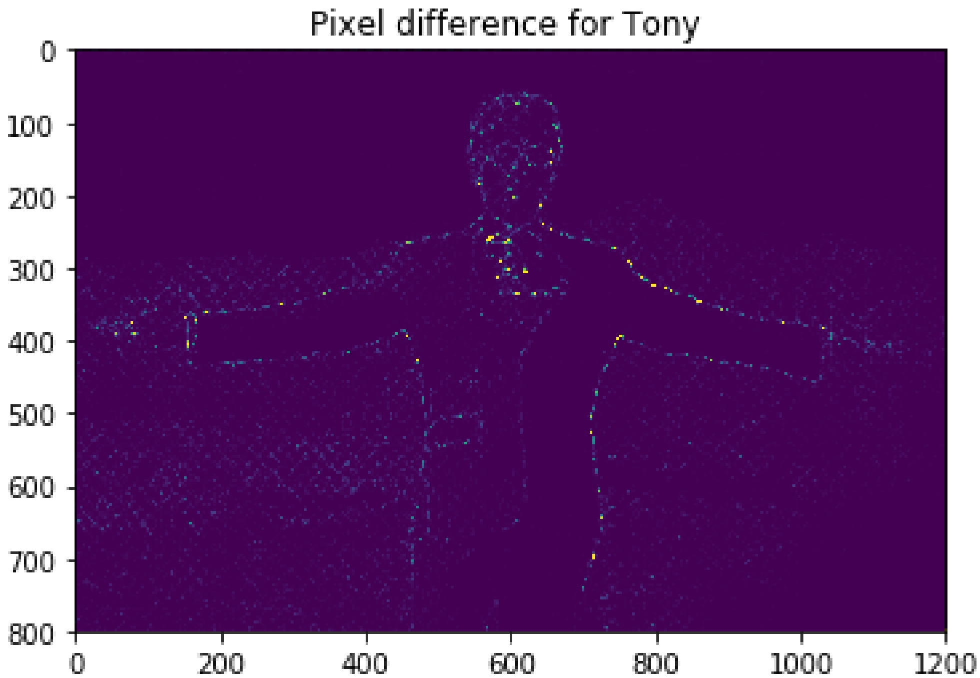

```
In [29]: res_pixel_diff,pp_err, max_err = compute_errors(soln_image, original_image)
         print("The average per-pixel error for tony is: "+str(pp_err))
         print("The maximum per-pixel error for tony is: "+str(max_err))
```

```
The average per-pixel error for tony is: 29.502977083333334
The maximum per-pixel error for tony is: 32278.0
```

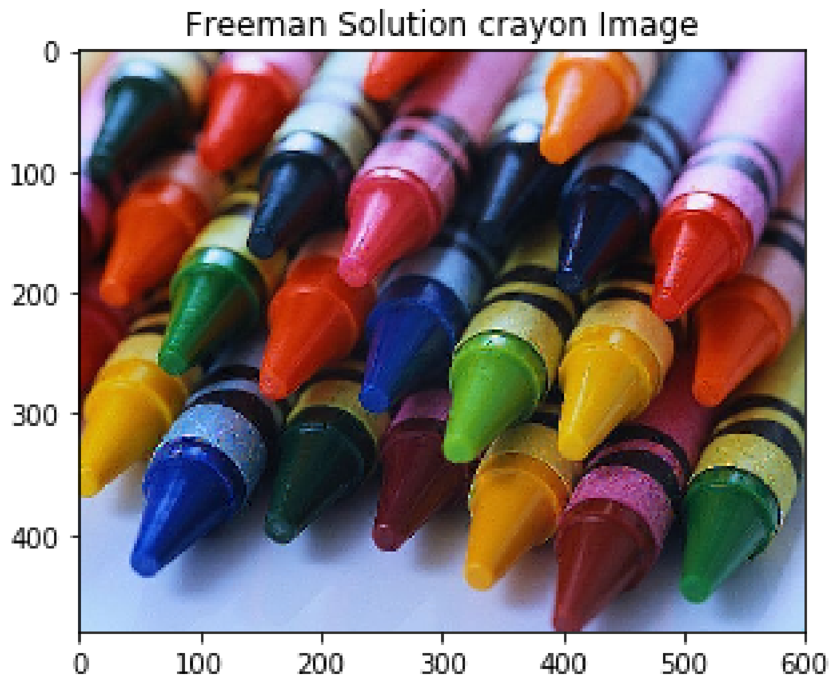
```
In [30]: cv2.imwrite('solution_freeman_tony.jpg',soln_image[:,:,::-1])
```

```
Out[30]: True
```

```
In [31]: #Plot pixel difference
         plt.imshow(res_pixel_diff, vmin = 0, vmax = 2048)
         plt.title('Pixel difference for Tony ')

Out[31]: Text(0.5,1,'Pixel difference for Tony ')
```




```
In [32]: mosaic_img = read_image(IMG_DIR+'crayons.bmp')
         soln_image = get_freeman_solution_image(mosaic_img)
         original_image = read_image(IMG_DIR+'crayons.jpg')

In [33]: #Plot Crayon solution
         plt.imshow(soln_image/255)
         plt.title('Freeman Solution crayon Image')

Out[33]: Text(0.5,1,'Freeman Solution crayon Image')
```




```
In [34]: res_pixel_diff,pp_err, max_err = compute_errors(soln_image, original_image)
         print("The average per-pixel error for crayons is: "+str(pp_err))
         print("The maximum per-pixel error for crayons is: "+str(max_err))
```

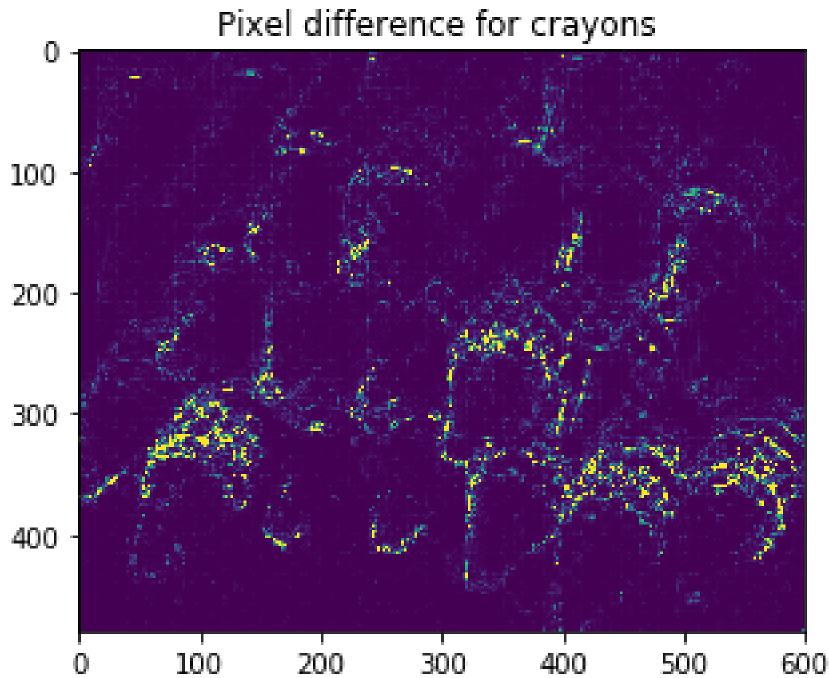
```
The average per-pixel error for crayons is: 142.27091319444443
The maximum per-pixel error for crayons is: 48173.0
```

```
In [35]: cv2.imwrite('solution_freeman_crayon.jpg',soln_image[:,:,::-1])
```

```
Out[35]: True
```

```
In [36]: #Plot pixel difference
         plt.imshow(res_pixel_diff, vmin = 0, vmax = 2048)
         plt.title('Pixel difference for crayons ')
```

```
Out[36]: Text(0.5,1,'Pixel difference for crayons ')
```




```
In [37]: mosaic_img = read_image(IMG_DIR+'iceberg.bmp')
         soln_image = get_freeman_solution_image(mosaic_img)
         original_image = read_image(IMG_DIR+'iceberg.jpg')

In [38]: #Plot iceberg solution
         plt.imshow(soln_image/255)
         plt.title('Freeman Solution iceberg Image')

Out[38]: Text(0.5,1,'Freeman Solution iceberg Image')
```


```
In [39]: res_pixel_diff,pp_err, max_err = compute_errors(soln_image, original_image)
         print("The average per-pixel error for iceberg is: "+str(pp_err))
         print("The maximum per-pixel error for iceberg is: "+str(max_err))
```

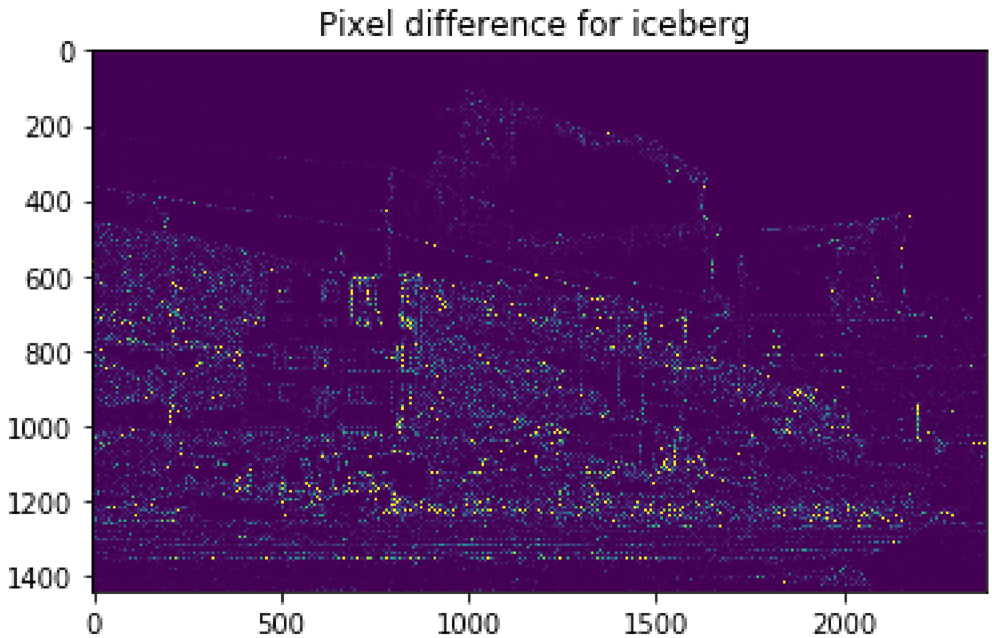
```
The average per-pixel error for iceberg is: 73.44045270081165
The maximum per-pixel error for iceberg is: 33989.0
```

```
In [42]: cv2.imwrite('solution_freeman_iceberg.jpg',soln_image[:,:,::-1])
```

```
Out[42]: True
```

```
In [40]: #Plot pixel difference
         plt.imshow(res_pixel_diff, vmin = 0, vmax = 2048)
         plt.title('Pixel difference for iceberg ')
```

```
Out[40]: Text(0.5,1,'Pixel difference for iceberg ')
```




```
In [41]: mosaic_img = read_image(IMG_DIR+'hope.bmp')
         soln_image = get_freeman_solution_image(mosaic_img)
```

```
In [42]: #Plot iceberg solution
         plt.imshow(soln_image/255)
         plt.title('Freeman Solution Hope Image')
```

```
Out[42]: Text(0.5,1,'Freeman Solution Hope Image')
```


```
In [43]: cv2.imwrite('solution_freeman_hope.jpg',soln_image[:,:,::-1])
```

```
Out[43]: True
```

1.0.5 Mosaicing an Image

Now lets take a step backwards and mosaic an image.

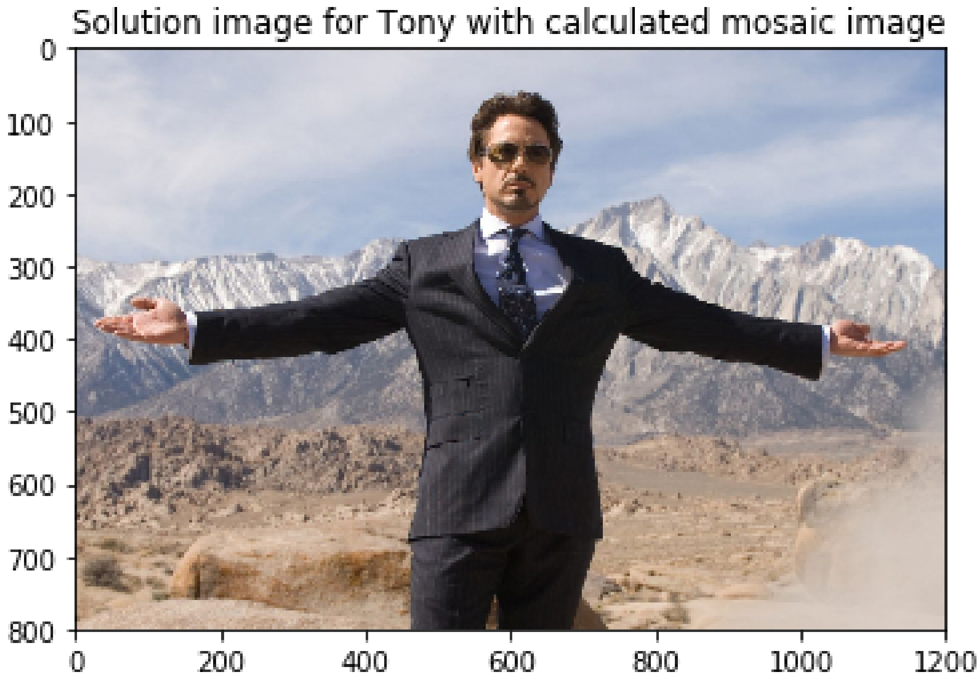
```
In [44]: def get_mosaic_image(original_image):
             '''
             Generate the mosaic image using the Bayer Pattern.
             '''

             mosaic_shape = np.shape(original_image)
             mosaic_img = np.zeros((mosaic_shape[0], mosaic_shape[1], 3))

             ##Mask and retrieve red channel
             red_ch = original_image[:,:,0]
             red_ch[1::2] = 0
             red_ch[:,1::2] = 0

             ##Mask and retrieve blue channel
             blue_ch = original_image[:,:,2]
             blue_ch[::2] = 0
             blue_ch[:,::2] = 0
```

```
        ##Mask and retrieve green channel
        green_ch = original_image[:,:,1]
        green_ch[::2, 0::2] = 0
        green_ch[1::2, 1::2] = 0

        #Construct mosaic image
        mosaic_img[:,:,0] = red_ch + blue_ch + green_ch
        mosaic_img[:,:,1] = red_ch + blue_ch + green_ch
        mosaic_img[:,:,2] = red_ch + blue_ch + green_ch


        return mosaic_img
```

In [45]:
```
### YOU CAN USE ANY OF THE PROVIDED IMAGES TO CHECK YOUR get_mosaic_function
original_image = read_image(IMG_DIR+'tony.jpg')
given_mosaic_img = read_image(IMG_DIR+'tony.bmp')
calc_mosaic_img = get_mosaic_image(original_image.copy())
diff = calc_mosaic_img-given_mosaic_img
print(np.amax(diff))
print(np.amin(diff))
soln_image = get_freeman_solution_image(calc_mosaic_img)
res_pixel_diff,pp_err, max_err = compute_errors(soln_image, original_image)
print("The average per-pixel error for Tony with calculated mosaic is: "+str(pp_err))
print("The maximum per-pixel error for for Tony with calculated mosaic is: "+str(max_e
plt.imshow(soln_image/255)
plt.title('Solution image for Tony with calculated mosaic image')
```

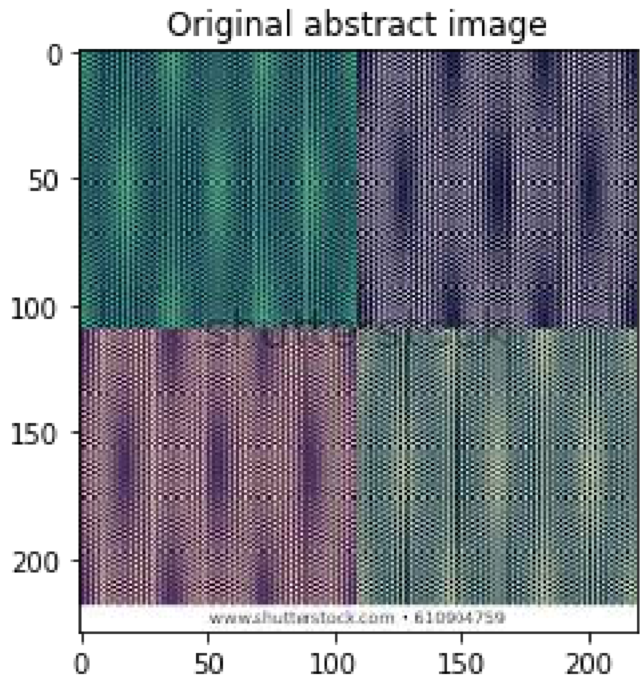
```
0.0
0.0
The average per-pixel error for Tony with calculated mosaic is: 28.821133984375
The maximum per-pixel error for for Tony with calculated mosaic is: 32278.0
```

Out[45]: Text(0.5,1,'Solution image for Tony with calculated mosaic image')



Use any 3 images you find interesting and generate their mosaics as well as their demosaics. Try to find images that break your demosaicing function.

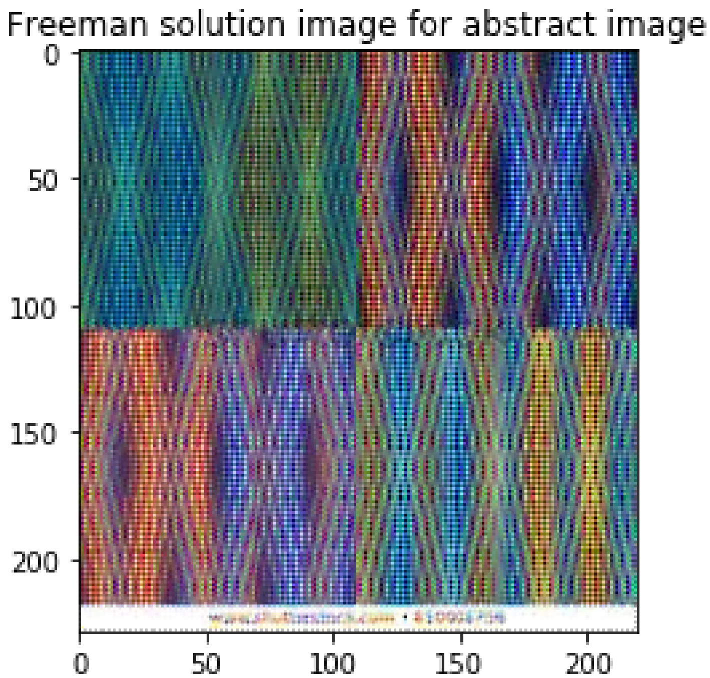
```
In [46]: #Test image that breaks demosaic + interpolation
         original_image = read_image(IMG_DIR+'abstract.jpg')
         plt.imshow(original_image)
         plt.title('Original abstract image')
         calc_mosaic_img = get_mosaic_image(original_image.copy())
         soln_image = get_freeman_solution_image(calc_mosaic_img)
```



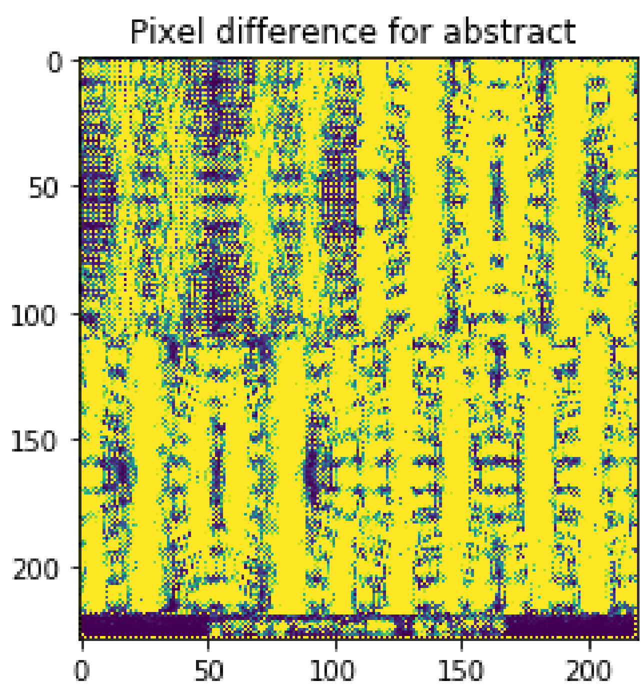

```
In [47]: res_pixel_diff,pp_err, max_err = compute_errors(soln_image, original_image)
         print("The average per-pixel error for abstract is: "+str(pp_err))
         print("The maximum per-pixel error for abstract is: "+str(max_err))
         plt.imshow(soln_image/255)
         plt.title('Freeman solution image for abstract image')
```

```
The average per-pixel error for abstract is: 6485.304662068281
The maximum per-pixel error for abstract is: 101803.25
```

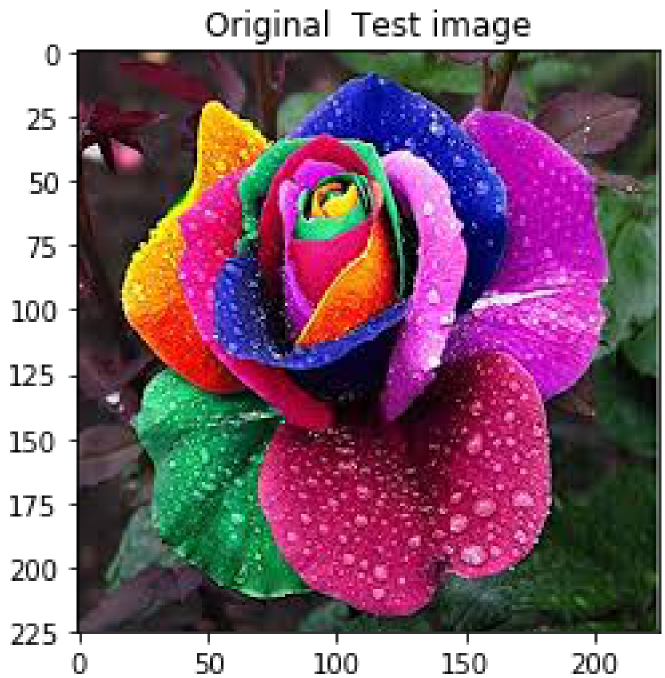
```
Out[47]: Text(0.5,1,'Freeman solution image for abstract image')
```




```
In [48]: #Plot pixel difference
         plt.imshow(res_pixel_diff, vmin = 0, vmax = 2048)
         plt.title('Pixel difference for abstract ')

Out[48]: Text(0.5,1,'Pixel difference for abstract ')
```



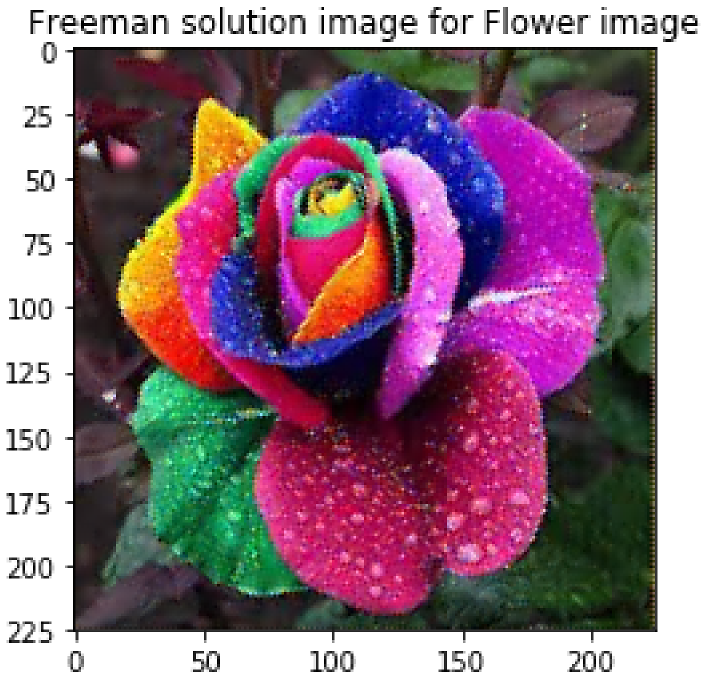
```python
In [49]: #Flower image that works for demosaic + interpolation
         original_image = read_image(IMG_DIR +'flower.jpg')
         plt.imshow(original_image)
         plt.title('Original  Test image')
         calc_mosaic_img = get_mosaic_image(original_image.copy())
         soln_image = get_freeman_solution_image(calc_mosaic_img)
```



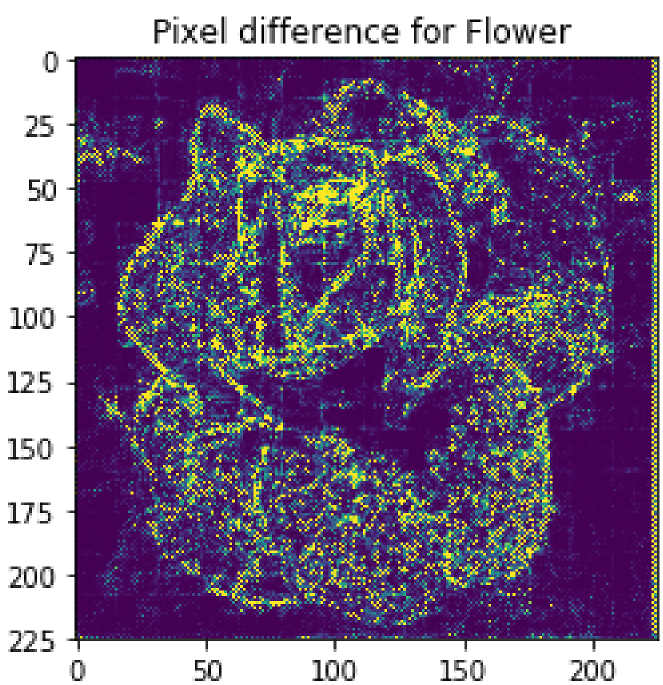

```python
In [50]: res_pixel_diff,pp_err, max_err = compute_errors(soln_image, original_image)
         print("The average per-pixel error for Flower is: "+str(pp_err))
         print("The maximum per-pixel error for Flower is: "+str(max_err))
         plt.imshow(soln_image/255)
         plt.title('Freeman solution image for Flower image')
```

```
The average per-pixel error for Flower is: 636.3399395061729
The maximum per-pixel error for Flower is: 47289.8125
```

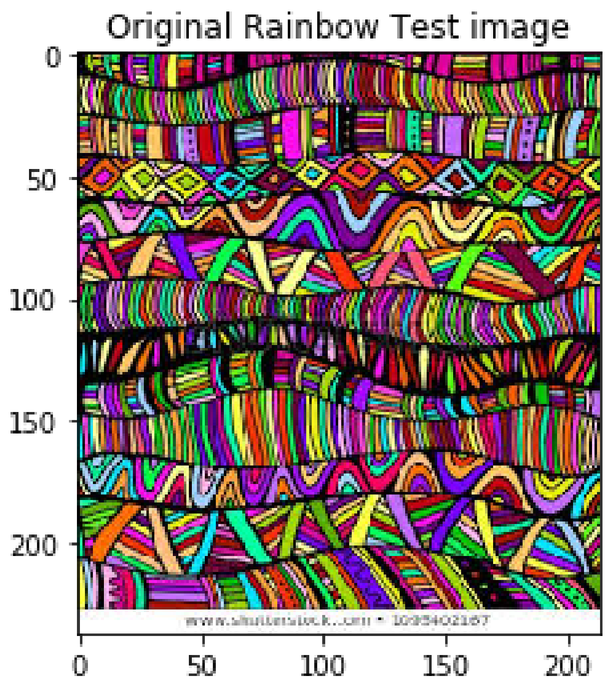
```
Out[50]: Text(0.5,1,'Freeman solution image for Flower image')
```




```
In [51]: #Plot pixel difference
         plt.imshow(res_pixel_diff, vmin = 0, vmax = 2048)
         plt.title('Pixel difference for Flower ')

Out[51]: Text(0.5,1,'Pixel difference for Flower ')
```



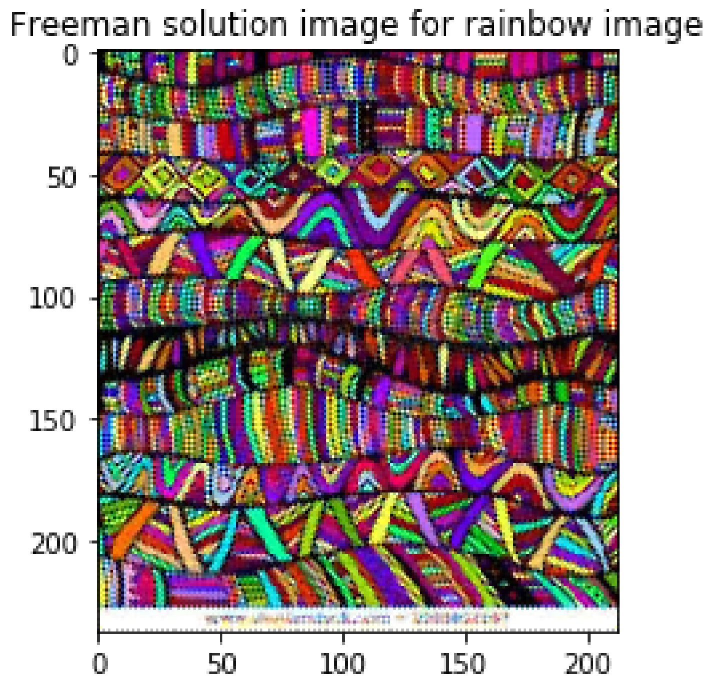
```
In [52]: #Maze image that works for demosaic + interpolation
         original_image = read_image(IMG_DIR +'rainbow.jpg')
         plt.imshow(original_image)
         plt.title('Original Rainbow Test image')
         calc_mosaic_img = get_mosaic_image(original_image.copy())
         soln_image = get_freeman_solution_image(calc_mosaic_img)
```




```
In [53]: res_pixel_diff,pp_err, max_err = compute_errors(soln_image, original_image)
         print("The average per-pixel error for rainbow is: "+str(pp_err))
         print("The maximum per-pixel error for rainbow is: "+str(max_err))
         plt.imshow(soln_image/255)
         plt.title('Freeman solution image for rainbow image')
```

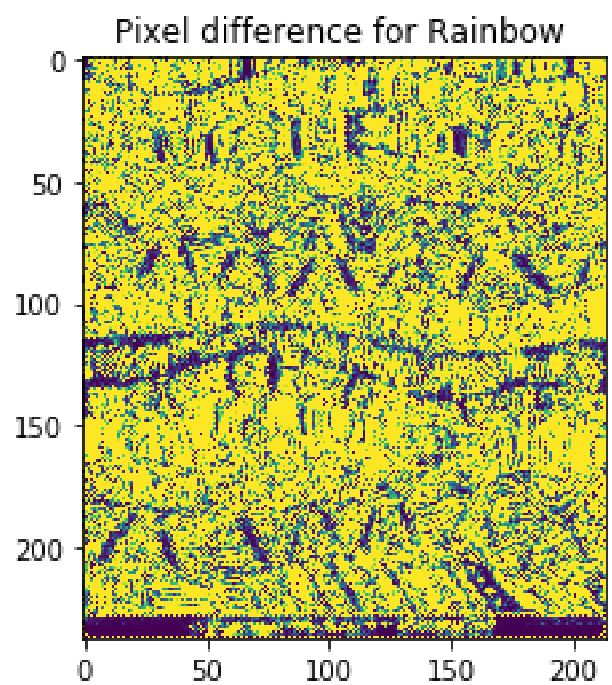
```
The average per-pixel error for rainbow is: 5080.670696648244
The maximum per-pixel error for rainbow is: 112696.8125
```

```
Out[53]: Text(0.5,1,'Freeman solution image for rainbow image')
```



In [54]:
```
#Plot pixel difference
plt.imshow(res_pixel_diff, vmin = 0, vmax = 2048)
plt.title('Pixel difference for Rainbow ')
```

Out[54]:
```
Text(0.5,1,'Pixel difference for Rainbow ')
```



1.0.6 Bonus Points

```
In [4]: ### YOUR CODE HERE ###
        ### YOU ARE ON YOUR OWN :) ####
```