Image Denoising

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0.1 Image Denoising using MRFs

Two methods are implemented in this notebook: * Denoising Binary Images using MinCut (MRF) * Denoising Colored images using ICM (MRF)

[2]:
```
import numpy as np
import matplotlib.pyplot as plt
import cv2 as cv
import igraph as ig
```

1 Denoising Binary Images using MinCut

The chosen potentials are useful as the unary potentials represent the probability that the pixel was flipped and the inter-pixel weights represent the change in contrast with the pixels neighbors.

[45]:
```
class DeNoiser(object):

    def __init__(self, img, beta=0.3, p=0.2, n_iters=3):

        print("Initializing...")

        self.h = img.shape[0]
        self.w = img.shape[1]

        img = img.astype('float32')
        self.original_img = img.copy()
        self.img = img.reshape(-1)

        # Initializing parameters
        self.p=p
        self.beta=beta
        self.calculate_V()

        # Initializing Graph
        self.s = self.h*self.w
        self.t = self.h*self.w + 1

        self.n_iters = n_iters
```

```
def calculate_V(self):

    # Gets differences between pixels in the required directions
    self.l = np.abs(self.original_img[:, 1:] - self.original_img[:, :-1])
    self.u = np.abs(self.original_img[1:, :] - self.original_img[:-1, :])

    # Calculates the V term to add to the graph's edges capacity
    cap_l = self.beta*self.l
    cap_u = self.beta*self.u

    # Initializing variables
    self.edges_V = []
    self.capacity_V = []
    l_edges = []
    u_edges = []

    # Adds the edges in the required directions
    for i in range(self.h):
        for j in range(self.w):
            curr = i*self.w+j
            if i:
                u_edges += [((i-1)*self.w+j, curr)]
            if j:
                l_edges += [(i*self.w+j-1, curr)]

    # Updates edges and capacities
    self.edges_V = l_edges + u_edges
    self.capacity_V += cap_l.ravel().tolist() + cap_u.ravel().tolist()

def create_graph(self):

    self.graph = ig.Graph(self.h * self.w + 2)

    edges = self.edges_V.copy()
    self.capacity = self.capacity_V.copy()

    print("Adding Edges")
    for i in range(self.h*self.w):
        edges += [(self.s, i), (self.t, i)]
        if self.img[i] == 0:
            self.capacity += [-np.log(self.p), -np.log(1-self.p)]
        else:
            self.capacity += [-np.log(1-self.p), -np.log(self.p)]

    self.graph.add_edges(edges)
```

```
    def find_mincut(self):

        mincut = self.graph.st_mincut(self.s, self.t, self.capacity)
        self.img3 = self.img.copy()

        self.img3[mincut.partition[0][:-1]] = 0
        self.img3[mincut.partition[1][:-1]] = 255

        self.img3 = self.img3.reshape(self.h, self.w)

        self.original_img = self.img3.copy()
        self.img = self.img3.reshape(-1)

    def run(self):

        for i in range(self.n_iters):
            print("Creating Graph")
            self.create_graph()

            print("Finding MinCut")
            self.find_mincut()

        return self.img3.astype('uint8')
```

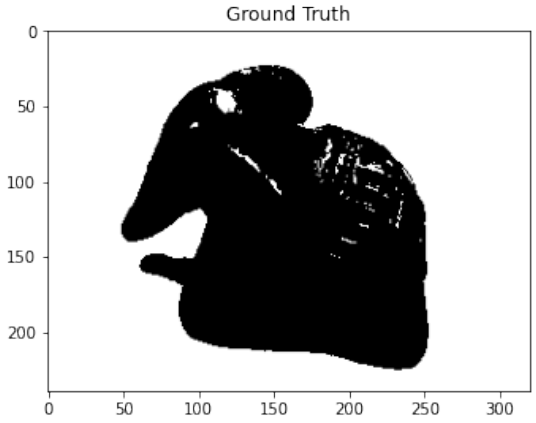
[360]:
```
def add_noise(img, p=0.2):

    op = img.copy()
    h,w = img.shape[:2]

    for i in range(h):
        for j in range(w):

            val = np.random.random()
            if val < p:
                op[i][j] = 1-op[i][j]

    return op

def run(img1, p=0.05, beta=2, sf=2, thres=127, g="v", show=True):

    h,w = img1.shape[:2]
    h/=sf
    w/=sf
    h,w = int(h), int(w)
    img1 = cv.resize(img1, (w,h))
```

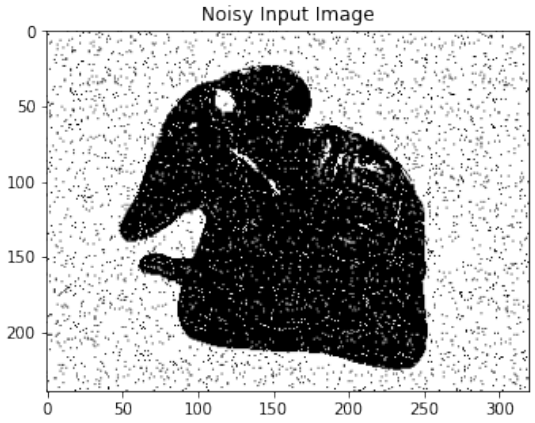
```
    img1[img1 < thres] = 0
    img1[img1 >= thres] = 1

    noisy = add_noise(img1, p)

    dn = DeNoiser(noisy, beta, p, 1)
    denoised = dn.run()

    if not show:
        return noisy, denoised

    if show:
        fig = plt.figure(figsize=(12,10))
        if g == "v":
            plt.subplot(221)
            plt.imshow(img1, cmap="gray")
            plt.title("Ground Truth")
            plt.subplot(222)
            plt.imshow(noisy, cmap="gray")
            plt.title("Noisy Input Image")
            plt.subplot(223)
            plt.imshow(denoised, cmap="gray")
            plt.title("De-Noised Output Image")
        else:
            plt.subplot(131)
            plt.imshow(img1, cmap="gray")
            plt.title("Ground Truth")
            plt.subplot(133)
            plt.imshow(noisy, cmap="gray")
            plt.title("Noisy Input Image")
            plt.subplot(132)
            plt.imshow(denoised, cmap="gray")
            plt.title("De-Noised Output Image")
```

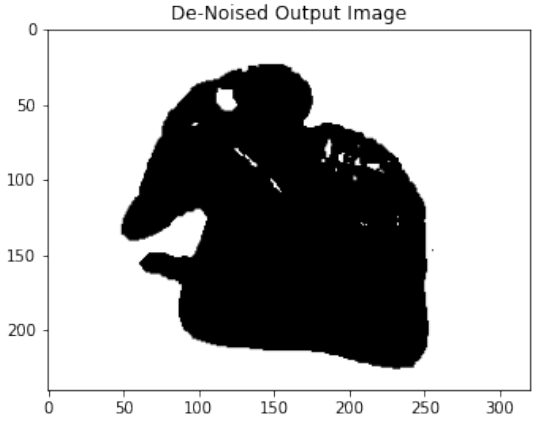
1.1 Example 1

[361]:
```
img1 = cv.imread("../../images/elefant.jpg", 0)
run(img1, 0.05, 2, sf=2, thres=127)
```

```
Initializing…
Creating Graph
Adding Edges
Finding MinCut
```



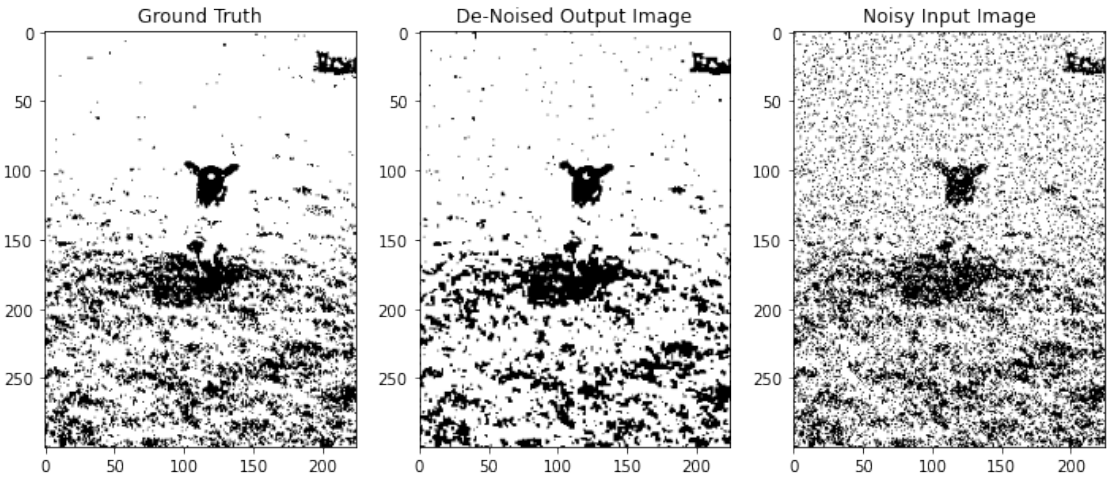




1.2 Example 2

[82]:
```
img1 = cv.imread("../../images/sheep.jpg", 0)
run(img1, 0.1, 1, sf=2, thres=120, g="h")
```

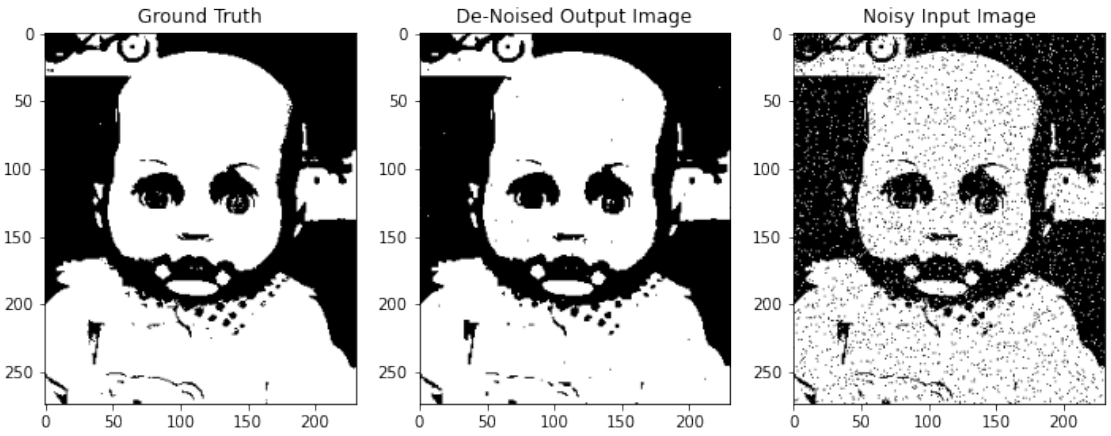
```
Initializing…
Creating Graph
Adding Edges
Finding MinCut
```



1.3 Example 3

[83]:
```
img1 = cv.imread("../../images/doll.jpg", 0)
run(img1, 0.05, 1.3, sf=2, g="h")
```

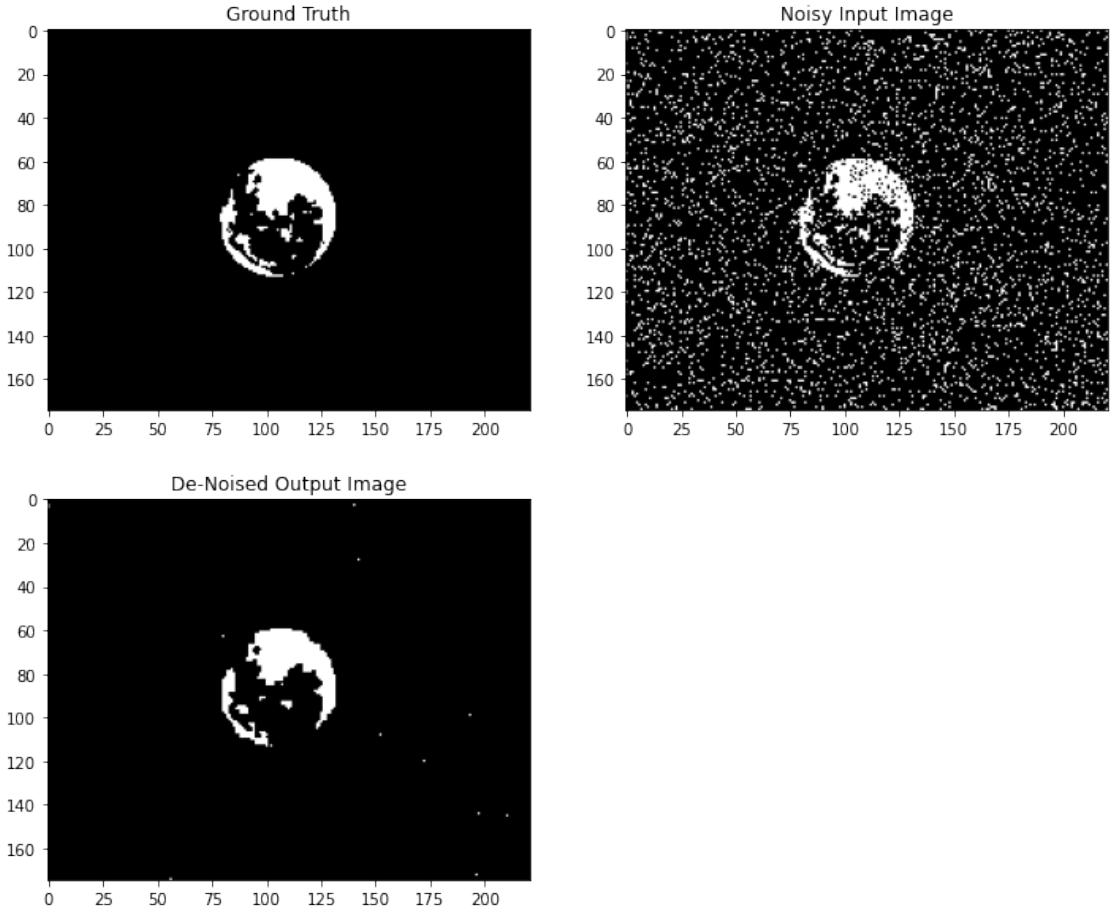
```
Initializing…
Creating Graph
Adding Edges
Finding MinCut
```



1.4 Example 4

[87]:
```
img1 = cv.imread("../../images/fullmoon.jpg", 0)
run(img1, 0.1, 1.5, sf=2, thres=120)
```

```
Initializing…
Creating Graph
Adding Edges
Finding MinCut
```

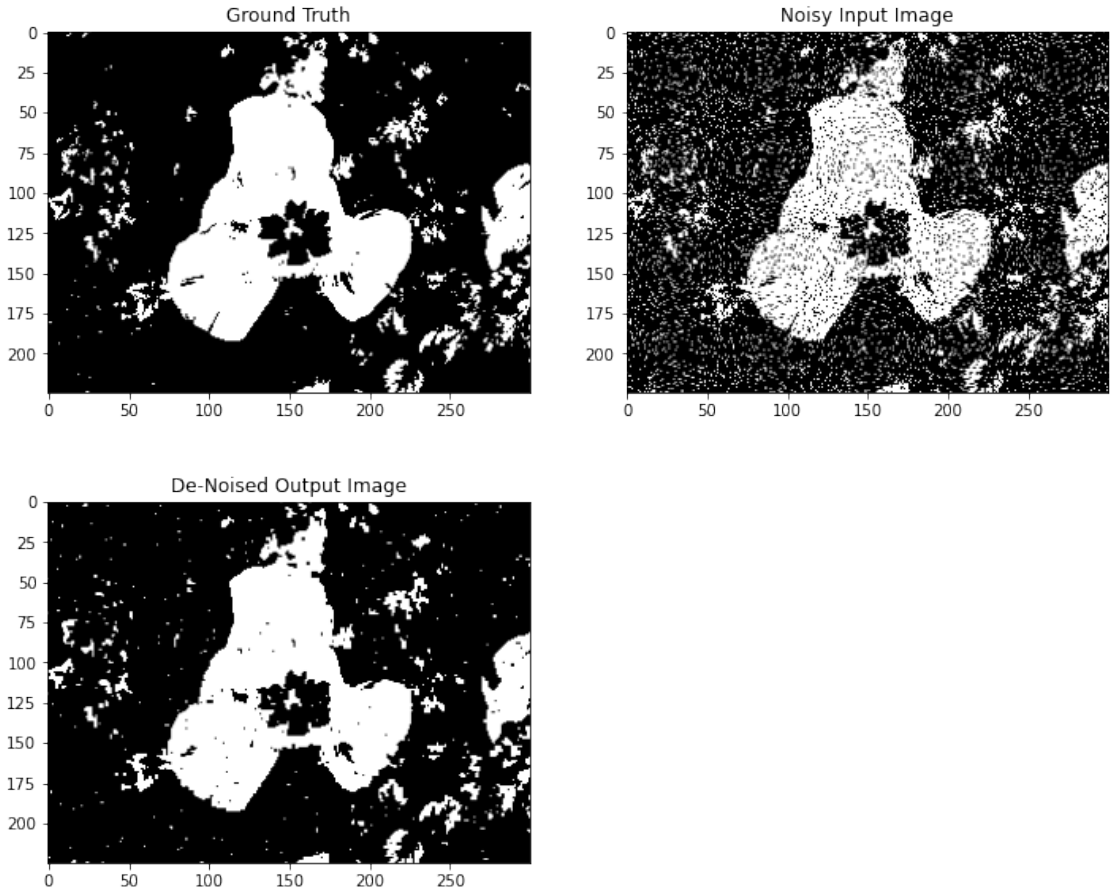


1.5 Example 5

[91]:
```
img1 = cv.imread("../../images/flower.jpg", 0)

run(img1, 0.1, 1, sf=2, thres=120)
```

```
Initializing…
Creating Graph
Adding Edges
```

```
Finding MinCut
```



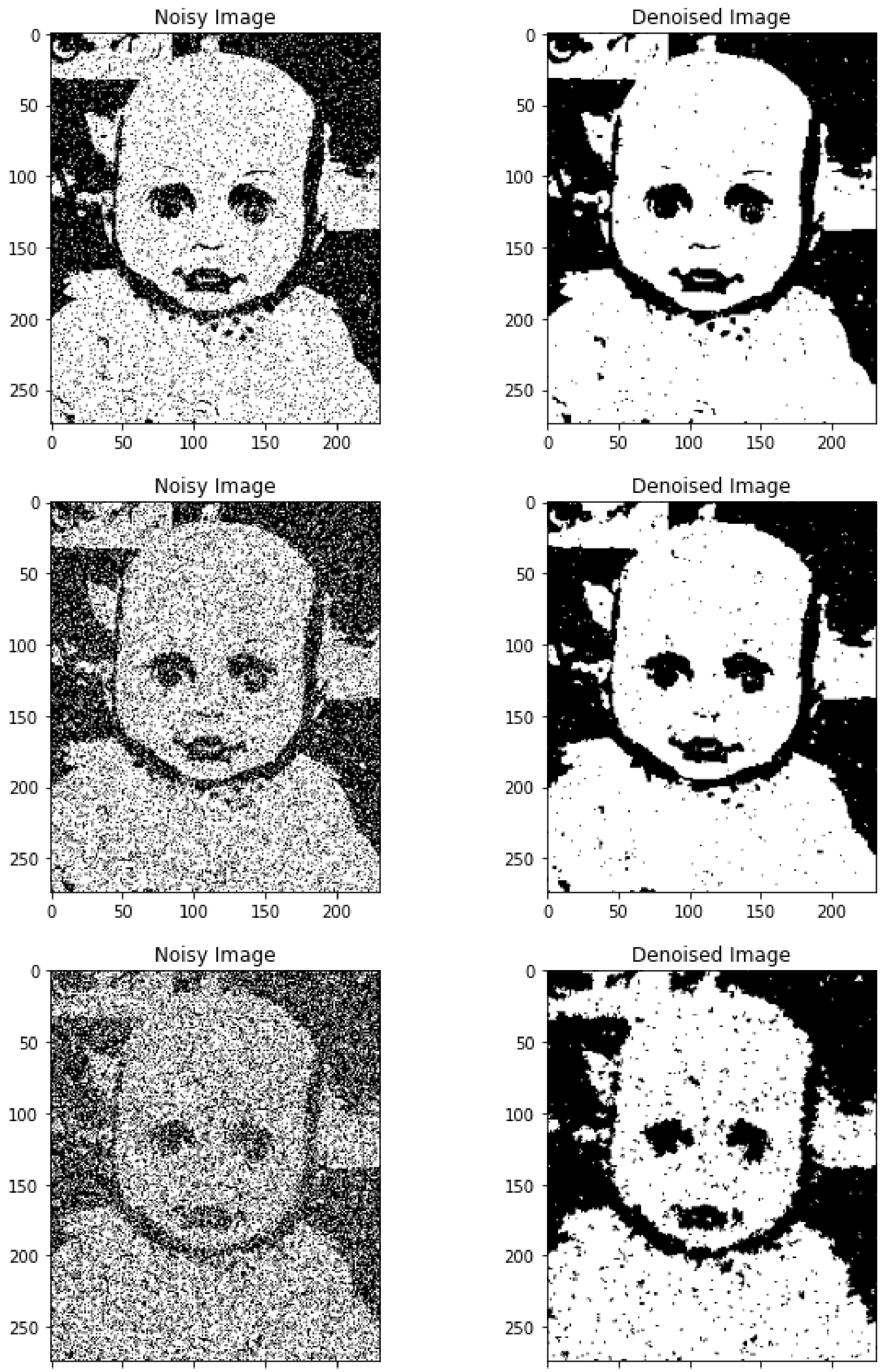
1.6 Comparison of Results with Varying amount of Noise

[368]:
```
img = cv.imread("../../images/doll.jpg", 0)
n1,o1 = run(img, 0.09, 1, sf=2, thres=120, show=False)
n2,o2 = run(img, 0.2, 1, sf=2, thres=120, show=False)
n3,o3 = run(img, 0.3, 1, sf=2, thres=120, show=False)

plt.figure(figsize=(10,15))
plt.subplot(321)
plt.title("Noisy Image")
plt.imshow(n1, cmap="gray")
plt.subplot(323)
plt.title("Noisy Image")
plt.imshow(n2, cmap="gray")
plt.subplot(325)
plt.title("Noisy Image")
plt.imshow(n3, cmap="gray")
```

```
plt.subplot(322)
plt.title("Denoised Image")
plt.imshow(o1, cmap="gray")
plt.subplot(324)
plt.title("Denoised Image")
plt.imshow(o2, cmap="gray")
plt.subplot(326)
plt.title("Denoised Image")
plt.imshow(o3, cmap="gray")
```

```
Initializing…
Creating Graph
Adding Edges
Finding MinCut
Initializing…
Creating Graph
Adding Edges
Finding MinCut
Initializing…
Creating Graph
Adding Edges
Finding MinCut
```

[368]: <matplotlib.image.AxesImage at 0x7ffa945952d0>


Noisy Image
Denoised Image
Noisy Image
Denoised Image
Noisy Image
Denoised Image
0
50
100
150
200
250
0
50
100
150
200

2 Denoising Colored Images using ICM

The unary potentials in this case represent the deviation from the current pixel value and the inter-pixel potentials represent the smoothness in intensity with respect to the neigboring pixels.

[369]:
```
def get_min(img, ch, i,j, beta=50):

    h,w = img.shape[:2]
    c = img[i,j,ch]
    n1, n2, n3, n4 = 0,0,0,0

    n1 = img[i-1,j][ch]
    n2 = img[i,j-1][ch]
    n3 = img[(i+1)%h,j][ch]
    n4 = img[i,(j+1)%w][ch]

    vals = np.array([i for i in range(256)]).reshape(-1,1)

    costs = ((1/beta)*(vals - c)**2 + ((vals - n1)**2 + (vals - n2)**2 + (vals␣
 ↪- n3)**2 + (vals - n4)**2)).ravel()
    return np.argmin(costs)

def denoise_img(img, n_iters=1, beta=1):

    img = img.copy()
    h,w = img.shape[:2]

    for i in range(h):
        for j in range(w):
            img[i,j,0] = get_min(img, 0, i, j, beta)
            img[i,j,1] = get_min(img, 1, i, j, beta)
            img[i,j,2] = get_min(img, 2, i, j, beta)

    if n_iters > 0:
        return denoise_img(img, n_iters-1)
    return img

def add_colored_noise(img, p=0.1):

    gaussian = np.abs(np.random.normal(0, p, img.shape))
    gaussian = np.random.normal(0, p, img.shape)
    print(gaussian.max())
```

```
    return (img + gaussian).astype('uint8')
    return (np.clip(img.astype('float32') + gaussian.astype('float32'), 0,␣
↪255)).astype('uint8')
```

2.1 Example 1

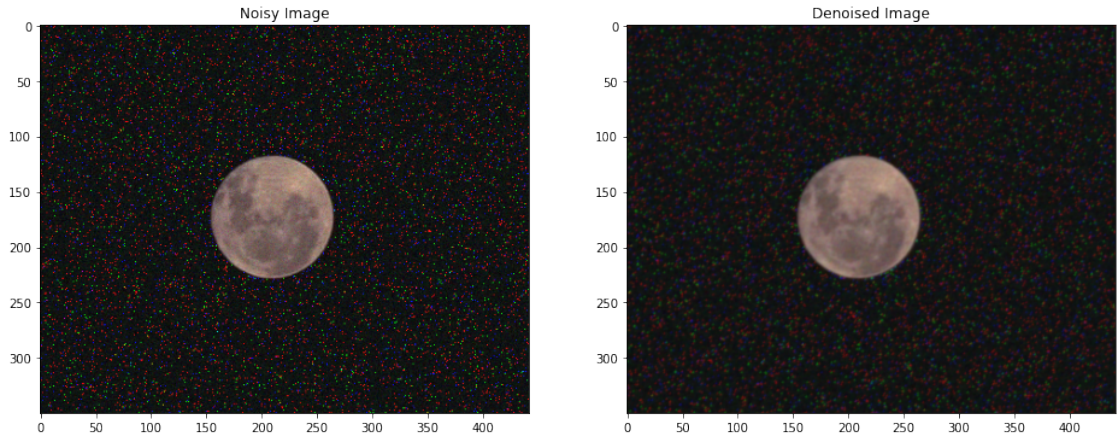
[370]:
```
img = cv.imread("../../images/fullmoon.jpg")[:,:,::-1]
noisy = add_colored_noise(img, 9)
```

```
42.32323477442015
```

[355]:
```
out = denoise_img(noisy,1,0.2)
```

[375]:
```
plt.figure(figsize=(16,10))
plt.subplot(121)
plt.title("Noisy Image")
plt.imshow(noisy)
plt.subplot(122)
plt.title("Denoised Image")
plt.imshow(out)
```

[375]:
```
<matplotlib.image.AxesImage at 0x7ffa914972d0>
```



2.2 Example 2

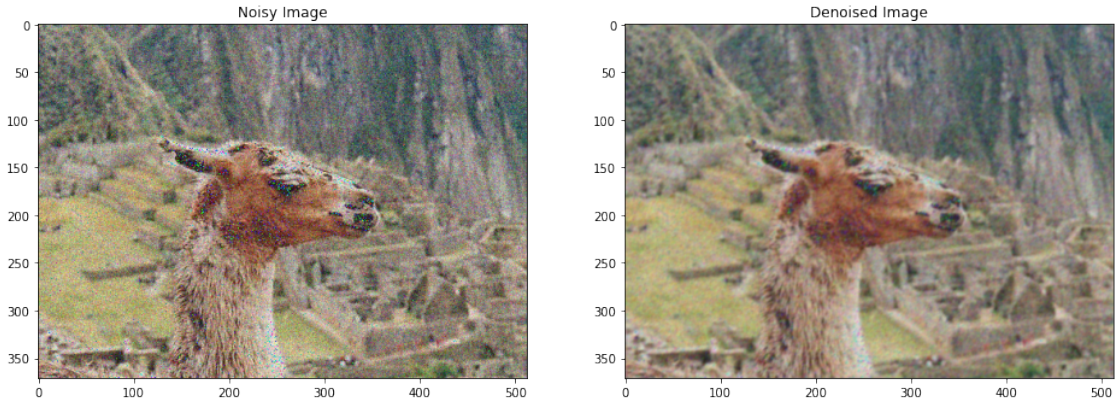
[376]:
```
img = cv.imread("../../images/llama.jpg")[:,:,::-1]
noisy = add_colored_noise(img, 25)
```

```
114.08607858453222
```

[377]:
```
out = denoise_img(noisy)
```

[378]:
```
plt.figure(figsize=(16,10))
plt.subplot(121)
plt.title("Noisy Image")
plt.imshow(noisy)
plt.subplot(122)
plt.title("Denoised Image")
plt.imshow(out)
```

[378]: <matplotlib.image.AxesImage at 0x7ffa921aef90>



2.3 Example 3

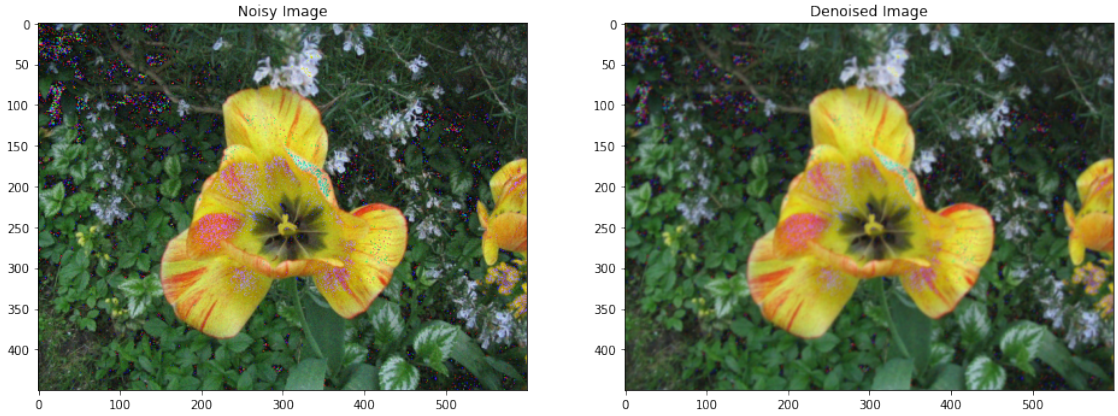
[386]:
```
img = cv.imread("../../images/flower.jpg")[:,:,::-1]
noisy = add_colored_noise(img, 10)
```

46.20454189650994

[387]:
```
out = denoise_img(noisy)
```

[388]:
```
plt.figure(figsize=(16,10))
plt.subplot(121)
plt.title("Noisy Image")
plt.imshow(noisy)
plt.subplot(122)
plt.title("Denoised Image")
plt.imshow(out)
```

[388]: <matplotlib.image.AxesImage at 0x7ffa915dce10>


Noisy Image
Denoised Image
0
50
100
150
200
250
300
350
400
0
100
200
300
400
500