Digital Image Processing EECS 740

Assignment 1

LohithReddy Nanuvala

2790468

Oct 25^{th} ,2015

Abstract:

This assignment is meant to get familiar with programming for image processing. Fundamentals like image filtering and enhancement algorithms were emphasized. Power law transformation, Histogram equalization, Gaussian noise and its removal, Laplacian enhancement technique are some of the concepts demonstrated. I have considered two images, one with underexposure and other with overexpose. The transformations discussed above have been applied on these images and results analysed.

Power law transformation:

- Power law transformation is one of the intensity transformation techniques.
- The transformation is given by the equation $s=cr^{\gamma}$ where r is the intensity of the input image, $^{\gamma}$ is the power of the transform, c is a constant, s is the intensity of the output image.
- When $^{\gamma}$ value is larger, the lower intensities are stretched and vice versa.
- Power law transform is mainly used for contrast enhancement.

Histogram:

- Histogram of an image gives the distribution of # of times an intensity occurs.
- Histogram can be useful to understand the over and under exposure in the image, the brightness, contrast and dynamic range.
- Histogram only provides statistical information, it does not give any information about the spatial distribution of intensities, and thus we cannot use histogram to reconstruct an image.
- Matlab syntax: imhist(I), I is the input image.

Histogram Equalization:

- Histogram equalization is the method of contrast adjustment using the image's histogram.
- We use a monotonic function to transform the input intensities into the output intensities which will be evenly distributed.
- Matlab syntax: histeq(I, N), Where I is the input image, N is the maximum intensity value.

Gaussian Noise:

- Gaussian noise is statistical noise having a probability density function (PDF) equal to that of the normal distribution.
- Principal sources of Gaussian noise in digital images arise during acquisition e.g. sensor noise caused by poor illumination and/or high temperature, and/or transmission e.g. electronic circuit noise.
- Gaussian noise can be reduced using a spatial filter, though when smoothing an image, an undesirable outcome may result in the blurring of fine-scaled image edges.

Filtering using average filter is obtained by convolving filter with the image.

Ex:

1	1	1
1	1	1
1	1	1

Is a 3x3 averaging filter.

A Gaussian filter is obtained by

$$h(x,y)=\frac{1}{2\pi\sigma^2}e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Laplacian Enhancement:

- ❖ Laplacian is a derivative operator, which highlights grey-level discontinuities in an image and deemphasizes regions with slowly varying grey levels.
- ❖ It is used for image sharpening.

Laplacian derivate operator is given by,

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}.$$

$$\frac{\partial^2 f}{\partial^2 x^2} = f(x+1, y) + f(x-1, y) - 2f(x, y)$$

$$\frac{\partial^2 f}{\partial^2 y^2} = f(x, y+1) + f(x, y-1) - 2f(x, y)$$

$$\nabla^2 f = \left[f(x+1, y) + f(x-1, y) + f(x, y+1) + f(x, y-1)\right] - 4f(x, y).$$

Some laplacian filter masks are,

0	1	0
1	−4	1
0	1	0

1	1	1
1	−8	1
1	1	1

0	−1	0
−1	4	−1
0	−1	0

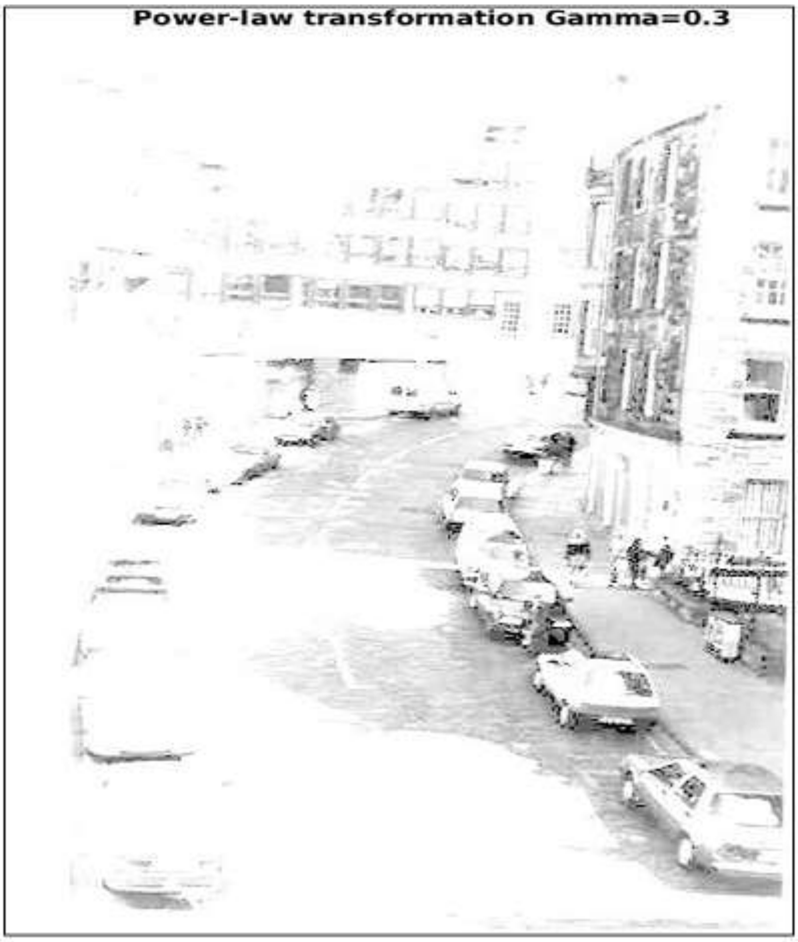
−1	−1	−1
−1	8	−1
−1	−1	−1

RESULTS:

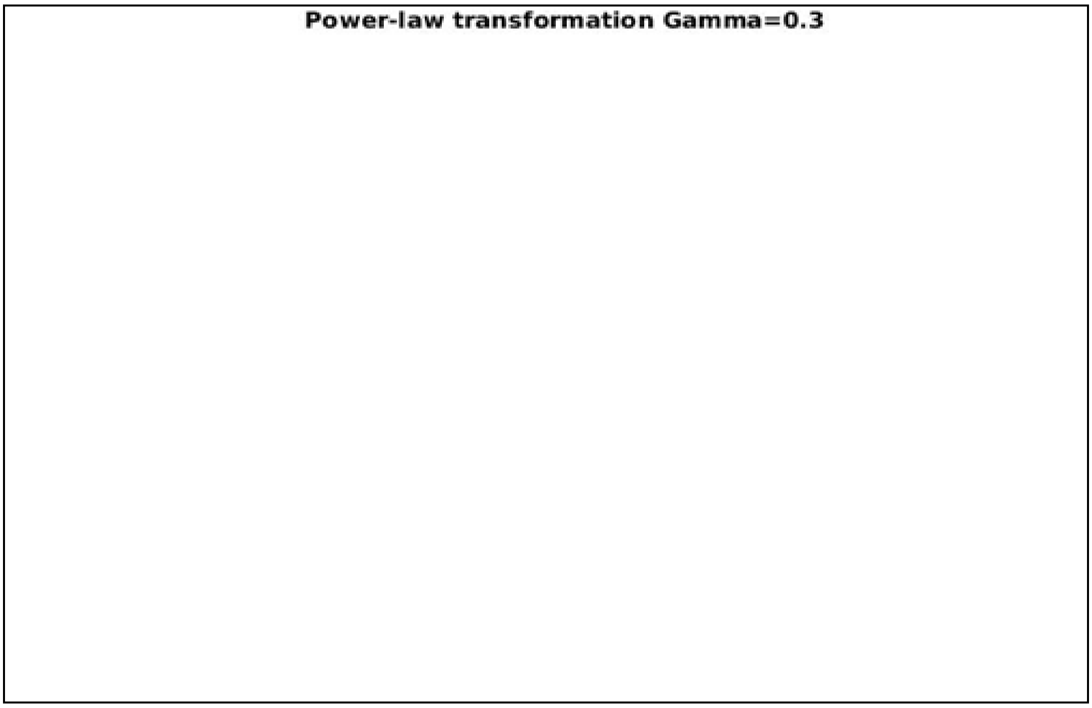
Over exposed image Original:

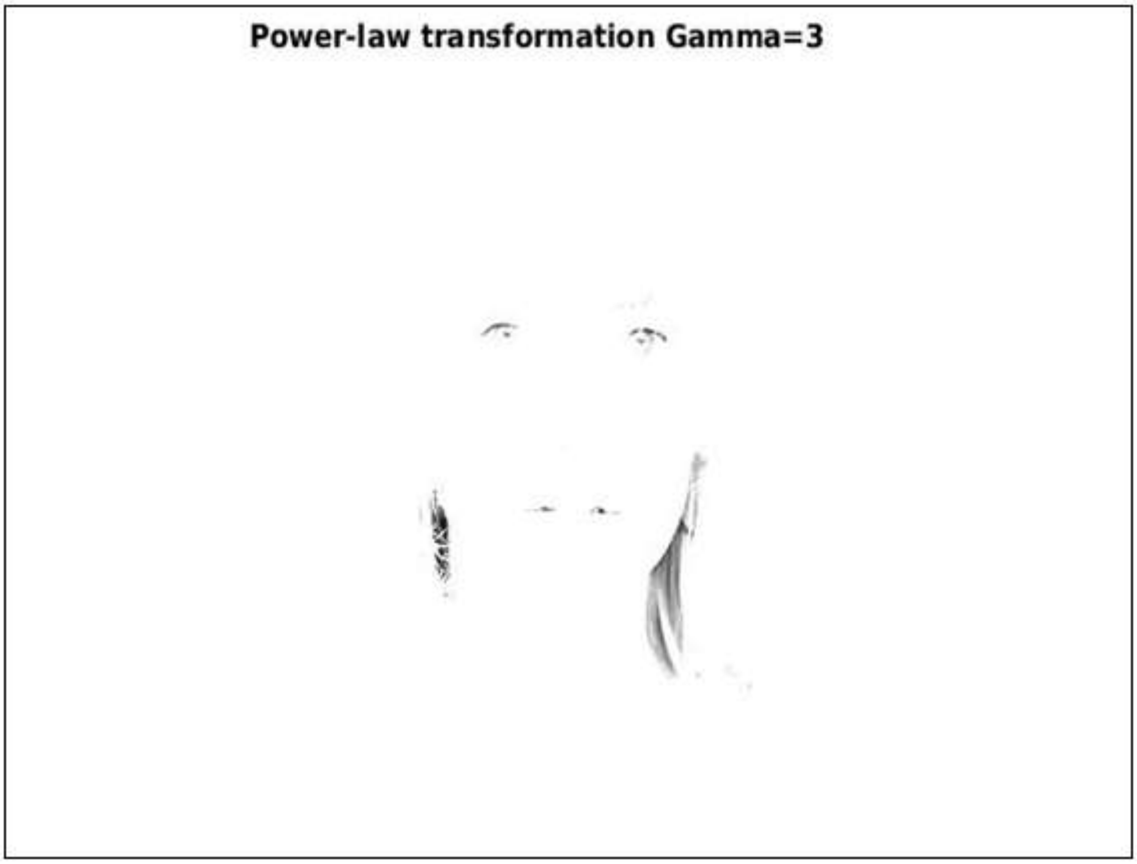
Under exposed image Original:

Under exposed image with power law transformation:

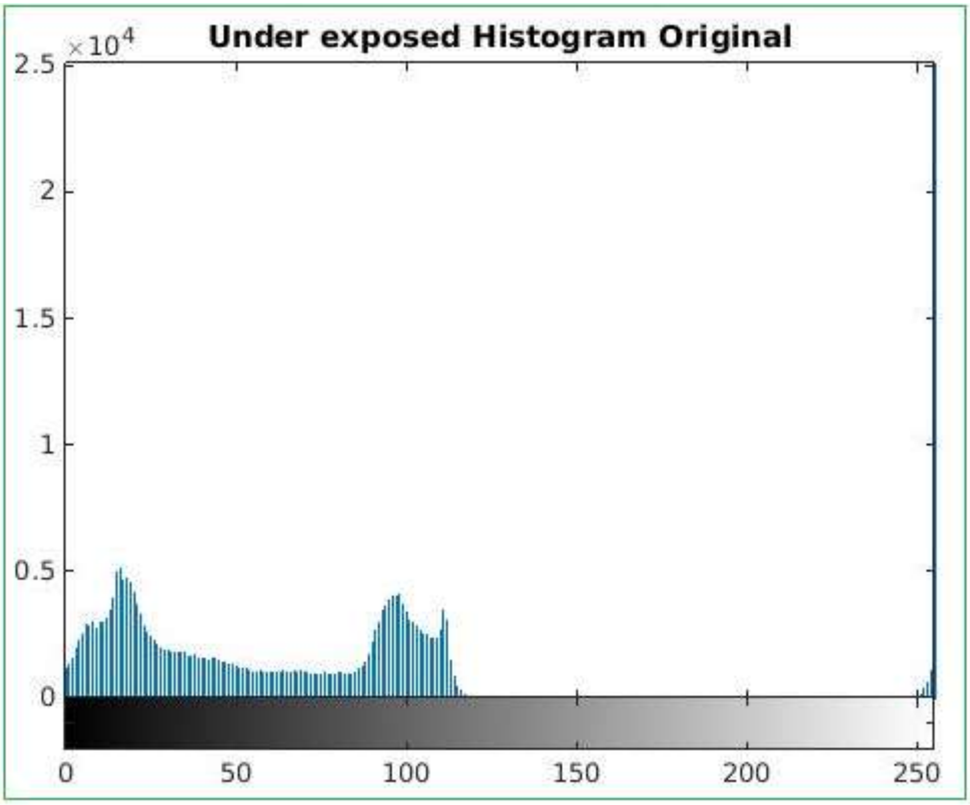


Over exposed image with power law transformation:

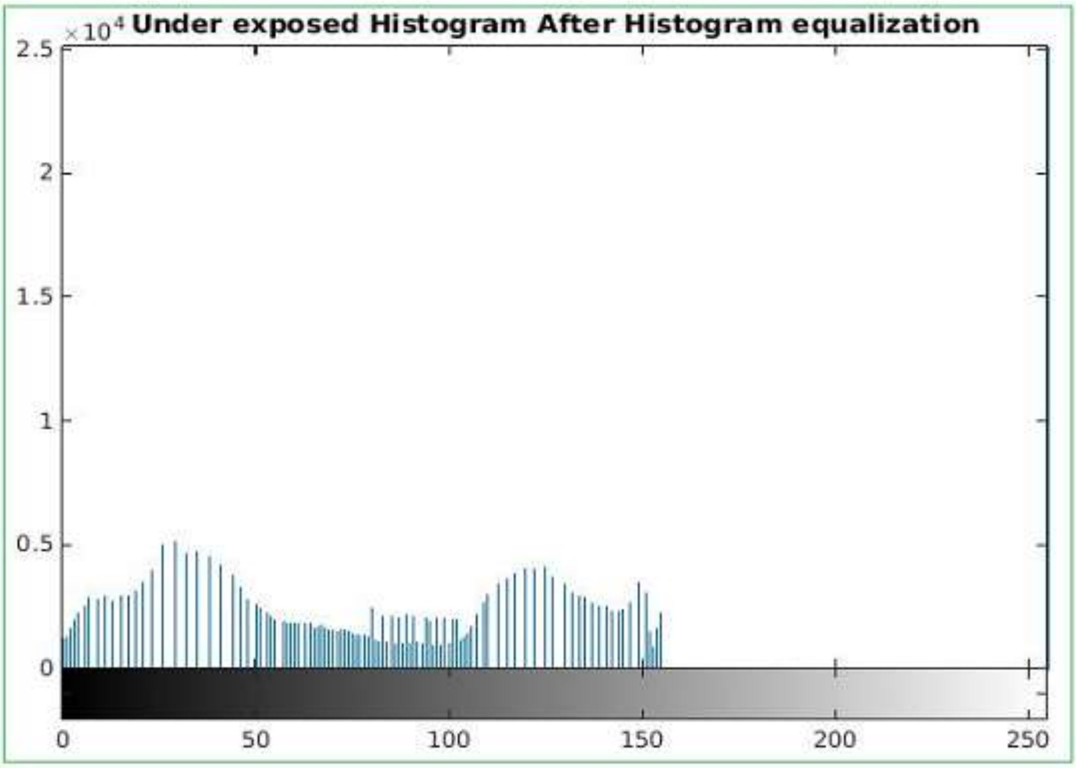




Histogram of under exposed image before Histogram Equalization:

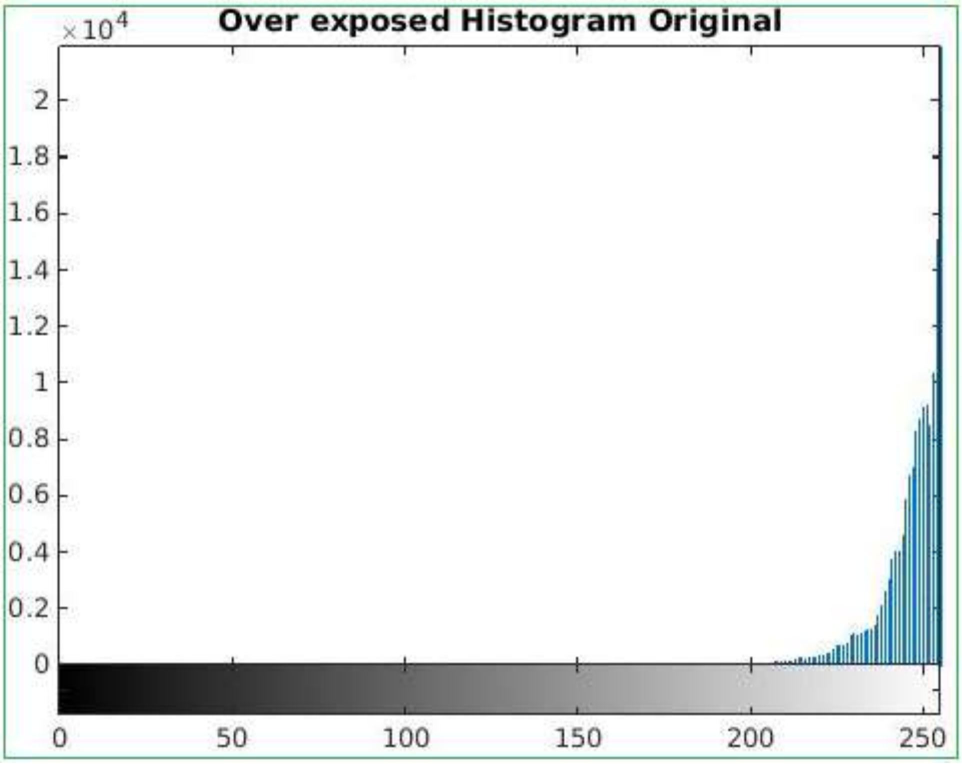


Histogram of under exposed image after Histogram Equalization:

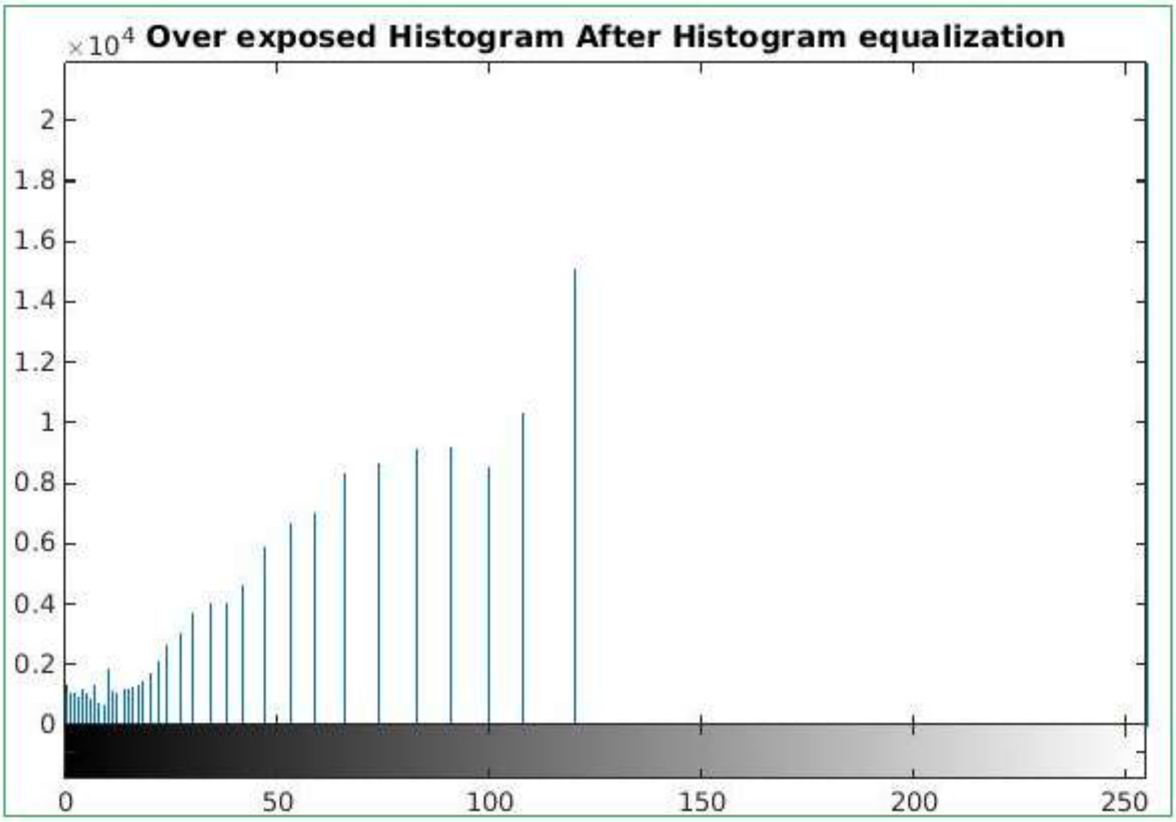


Under exposed image after Histogram Equalization:

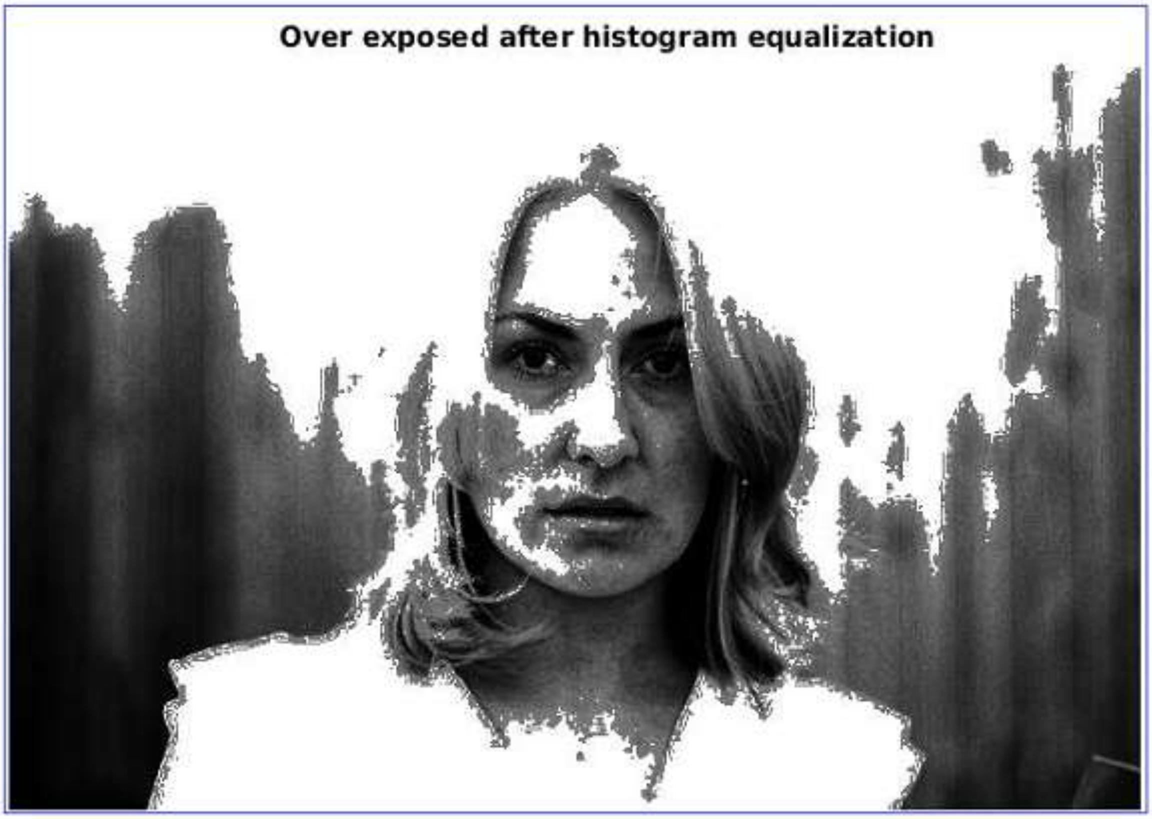
Histogram of over exposed image before Histogram Equalization:



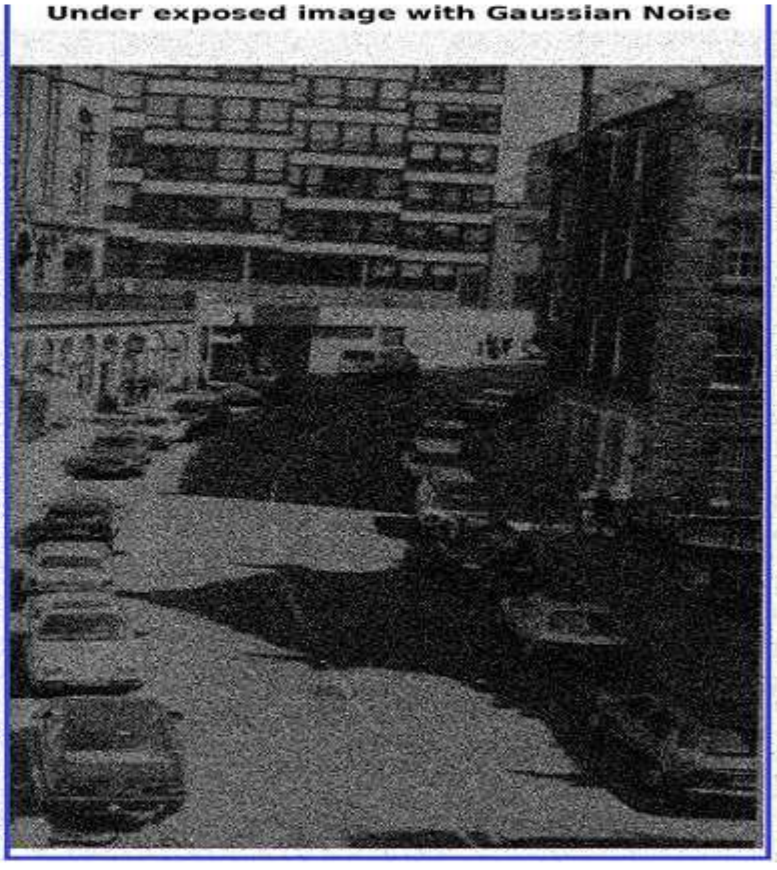
Histogram of over exposed image after Histogram Equalization:



Over exposed image after Histogram Equalization:



Under exposed image with Gaussian noise:



Under exposed image with 3x3 averaging filter:

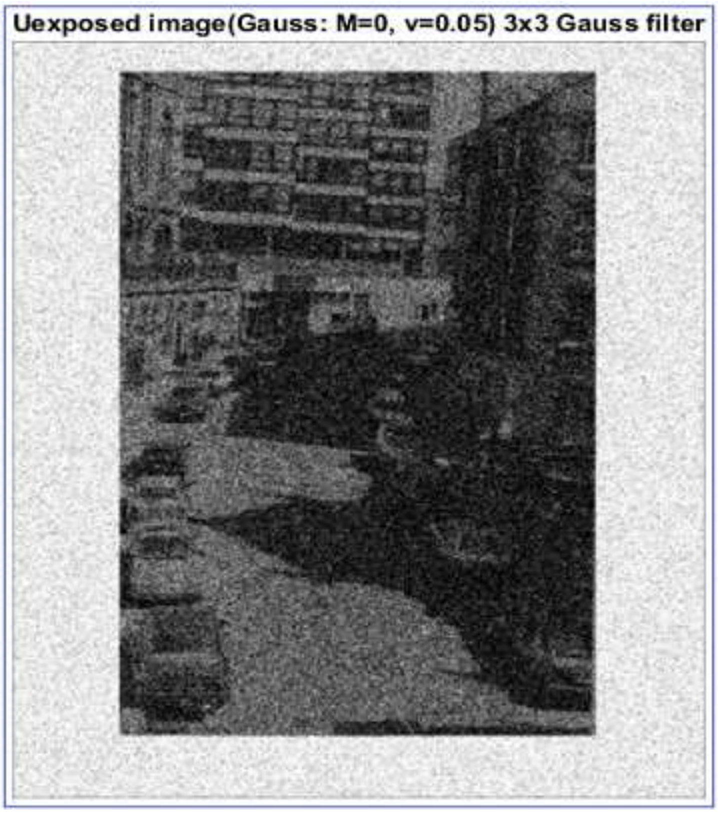
Under exposed image with 5x5 filter:

Under exposed image with Gaussian Noise (mean=0, variance=0.05)

Under exposed image with 3x3 averaging filter:

Under exposed image with 5x5 averaging filter:

Under exposed image with Gaussian 3x3 filter:

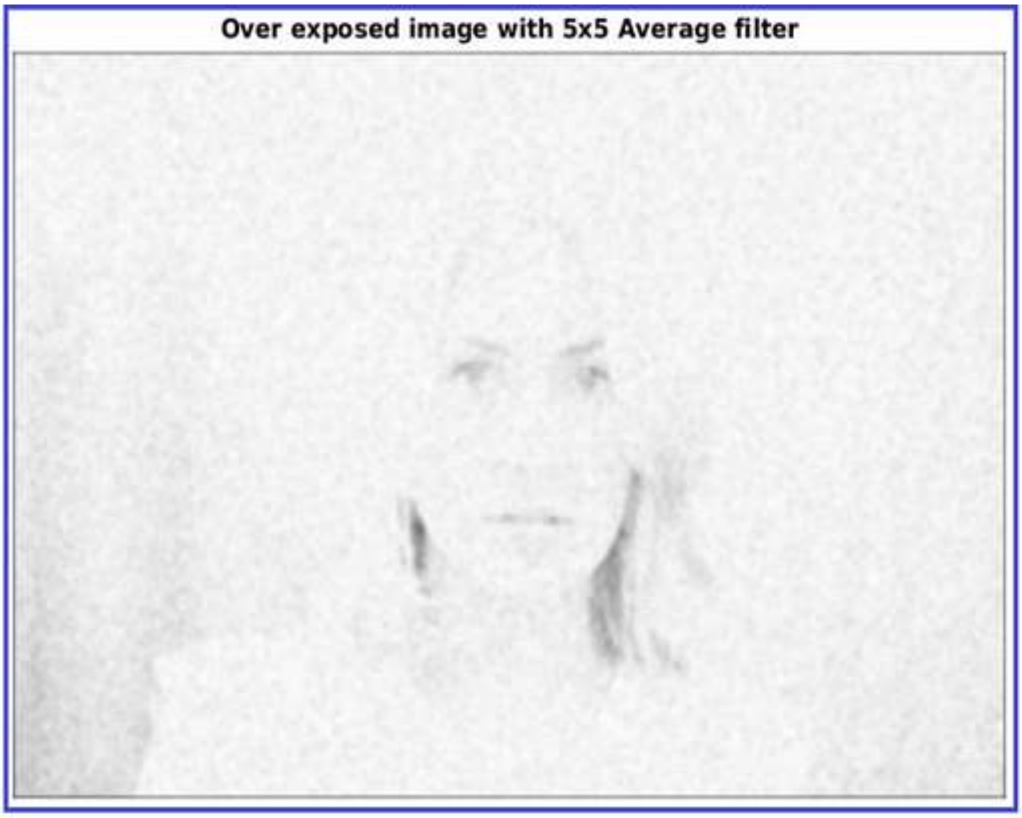


Under exposed image with Gaussian 5x5 filter:

Over exposed image with Gaussian noise:

Over exposed image with 3x3 average filter:

Over exposed image with 5x5 average filter:



Over exposed image with Gaussian noise (m=0, v=0.05):

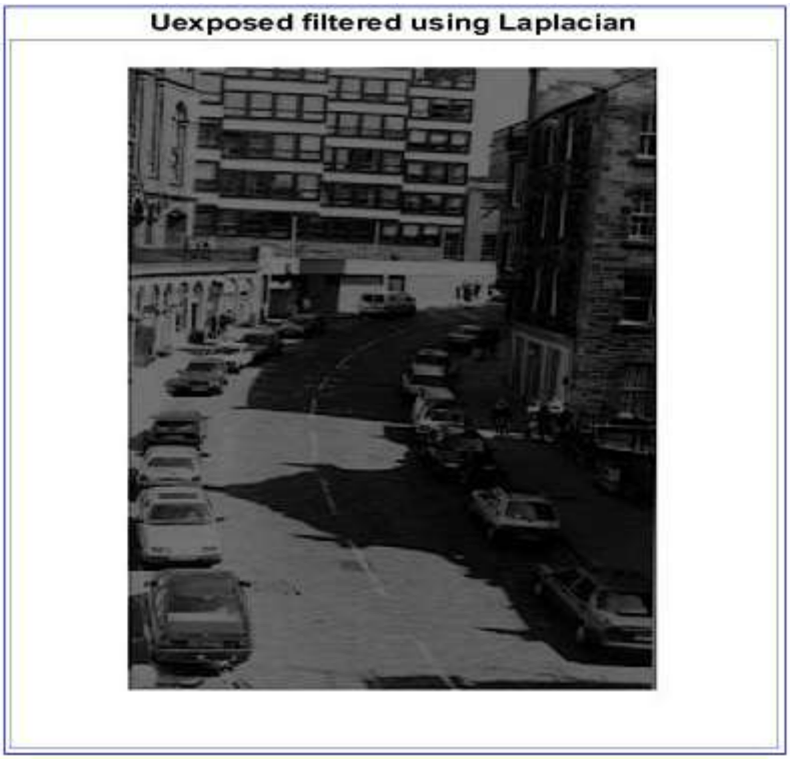
Over exposed image with 3x3 averaging filter:

Over exposed image with 5x5 averaging filter:

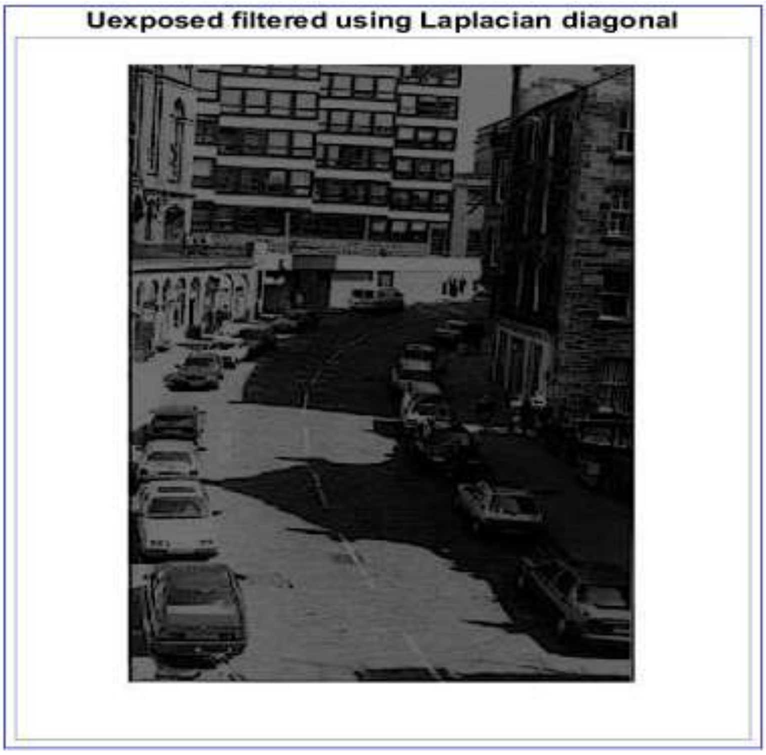
Over exposed image with Gaussian 3x3 filter:

Over exposed image with Gaussian 5x5 filter:

Under exposed image with Laplacian filter:



Under exposed image with laplacian diagonal filter:



Over exposed image with Laplacian filter:

Over exposed image with laplacian diagonal filter:

Analysis:

Power law transformation:

As discussed, for a higher gamma value, the low intensity of the under exposed image have been stretched and image became darker. For the lower gamma values, the higher intensity has been stretched and the image became brighter. For the over exposed image; for a lower gamma value, the higher intensities have been stretched and the image is also invisible. For higher gamma value, very few details are visible.

Histogram Equalization:

Under exposed image- We can clearly see the stretch in the intensities after plotting the histogram. The image becomes brighter and more details are visible.

Over exposed image- For the over exposed image, the intensities have been shifted to lower values, the image is less bright and difference can be clearly observed between the original image and final image.

Gaussian Noise:

Under exposed image- We can observe a blurring effect when we apply the Gaussian 3x3 filter. We can observe more blurring effect with a 5x5 filter. The blurring effect can also be observed with averaging filter. When we add Gaussian noise with mean=0 and variance=0.05, the noise is more than what can be observed in normal noise. We can observe the blurring effect with Gaussian filters also.

Over exposed image- We can observe a blurring effect when we apply the Gaussian 3x3 filter. We can observe more blurring effect with a 5x5 filter. When we add Gaussian noise with mean=0 and variance=0.05, the noise is more than what can be observed in normal noise. Upon comparing averaging filter with Gaussian filter for 3x3 filters, the difference was very little, but for 5x5 filters, we can observe a difference.

Laplacian enhancement:

Under exposed image- I have used two types of laplacian filters, normal and diagonal. When we apply the normal laplacian enhancement, the image is sharpened as expected. With a diagonal laplacian enhancement, the sharpening is more clear and the image looks very neat.

Over exposed image- The same effect as observed in under exposed image can be observed here also.

Appendix:

Program for problem 1:

```
% Program demonstrates the power law transformation.
Ue = imread('Uexposed.jpg');
Oe = imread('Oexposed.jpg');
% RGB to gray
I = rgb2gray(Ue);
J = rgb2gray(Oe);
% Change to double
I = im2double(I);
J = im2double(J);
% computing size m,n
[m1 n1] = size(I);
[m2 n2] = size(J);
% Computing s = c * (r ^ gamma) where r and gamma are positive constants
c = 2;
```

```
% gamma values
g1=0.3;
g2=3.0;
for p = 1 : m1
    for q = 1 : n1
        I3(p,q) = c * I(p,q).^g1;
        I4(p,q) = c * I(p,q).^g2;
    end
end
figure, imshow(I3);title('Under exposed,Powerlaw transformation
Gamma=0.3');
figure, imshow(I4);title('Under exposed,Power-law transformation
Gamma=3');
for p = 1 : m2
    for q = 1 : n2
        J3(p,q) = c * J(p,q).^g1;
        J4(p,q) = c * J(p,q).^g2;
    end
end
figure, imshow(J3);title('Over exposed,Powerlaw transformation
Gamma=0.3');
figure, imshow(J4);title('Over exposed,Power-law transformation Gamma=3');
% end
```

Program for problem 2:

```
%Program for problem 2:
%reading the under exposed image
Ue = imread('Uexposed.jpg');
% converting to gray scale image
I = rgb2gray(Ue);
% displaying the histogram of the image
imhist(I);
title('Under exposed Histogram Original');
% histogram equalization
I1 = histeq(I,256);
% histogram of output image
imhist(I1);
title('Under exposed Histogram After Histogram equalization');
figure, imshow(I);
title('Original under exposed image');
figure, imshow(I1);
title('Under exposed image after histogram equalization');
% reading the over exposed image
```

```
Oe = imread('Oexposed.jpg');
% converting color image to grey scale
A = rgb2gray(Oe);
% displaying the histogram of the image
imhist(A);
title('Over exposed Histogram Original');
% histogram equalization
A1 = histeq(A,256);
% histogram of output image
imhist(A1);
title('Over exposed Histogram After Histogram equalization');
figure, imshow(A);
title('Original over exposed image');
figure, imshow(A1);
title('Over exposed after histogram equalization');
%end
```

<u>Program for problem 3:</u>

```
% Matlab code for problem 3-Noise Addition and removal
% defining 3x3 averaging filter
h = ones(3,3)/9;
% defining 5x5 averaging filter
h5 = ones(5,5)/25;
% Creating the gaussian filter with size = [3 3] and sigma = 1
Gauss3 = fspecial('gaussian',[3 3],1);
% Creating the gaussian filter with size = [5 5] and sigma = 1
Gauss5 = fspecial('gaussian',[5 5],1);
%-------------------------------------------------------------------------------------%
% reading the input image
Oe = imread('Oexposed.jpg');
% converting to gray image
I = rgb2gray(Oe);
% adding Gaussian noise with default mean values
I1 = imnoise(I,'gaussian');
% figure, imshow(I1); title('Oexposed image with Gaussian Noise');

% filtering using 3x3 filter
 I2 = imfilter(I1,h);
 figure, imshow(I2); title('Oexposed image(Gauss Noise) 3x3 Average filter');

% filtering using 5x5 filter
 I3 = imfilter(I1,h5);
 figure, imshow(I3); title('Oexposed image(Gauss Noise) 5x5 Average filter');
```

```
% filtering using 3x3 Gaussian filter
 I4 = imfilter(I1,Gauss3,'same');
 figure, imshow(I4); title('Oexposed image(Gauss Noise) 3x3 Gauss filter');

% filtering using 5x5 Gaussian filter
 I5 = imfilter(I1, Gauss5,'same');
 figure, imshow(I5); title('Oexposed image(Gauss Noise) 5x5 Gauss filter');
%--------------------------------------------------------------------%
% adding Gaussian noise with mean=50 and variance 0.05
 J = imnoise(I,'gaussian',0,0.05);
 figure, imshow(J); title('Oexposed image with Gaussian Noise:M=0, sigma=0.05');

% filtering using 3x3 averaging filter
 J1 = imfilter(J,h);
 figure, imshow(J1); title('Oexposed image(Gauss:M=0, v=0.05) 3x3 Average filter');

% filtering using 5x5 averaging filter
 J2 = imfilter(J,h5);
 figure, imshow(J2); title('Oexposed image(Gauss:M=0, v=0.05) 5x5 Average filter');

% filtering using 3x3 Gaussian filter
 J3 = imfilter(J,Gauss3,'same');
 figure, imshow(J3); title('Oexposed image(Gauss:M=0, v=0.05) 3x3 Gauss filter');

% filtering using 5x5 Gaussian filter
 J4 = imfilter(J, Gauss5, 'same');
 figure, imshow(J4); title('Oexposed image(Gauss: M=0, v=0.05) 5x5 Gauss filter');
%-----------------------------------------------------------------------------------%
% reading the image
Ue = imread('Uexposed.jpg');
A = rgb2gray(Ue);
% adding Gaussian noise with default mean values
 A1 = imnoise(A,'gaussian');
 figure, imshow(A1); title('Uexposed image with Gaussian Noise');
% filtering using 3x3 averaging filter
 A2=imfilter(A1,h);
 figure, imshow(A2); title('Uexposed image(Gauss noise) with 3x3 Average filter');
% filtering using 5x5 averaging filter
 A3=imfilter(A1,h5);
 figure, imshow(A3); title('Uexposed image(Gauss noise) with 5x5 Average filter');
```

```
% Filtering using Gauss 3x3
 A4 = imfilter(A1,Gauss3,'same');
 imshow(A4); title('Uexposed image(Gauss noise) with 3x3 Gaussian filter');

% Filtering using Gauss 5x5
 A5 = imfilter(A1,Gauss5,'same');
 imshow(A5); title('Uexposed image(Gauss noise) with 5x5 Gaussian filter');
%-----------------------------------------------------------------------------------%
% adding Gaussian noise with mean=0 and variance 0.05
 B = imnoise(A,'gaussian',0,0.05);
 figure, imshow(B); title('Uexposed image with Gaussian Noise:M=0, sigma=0.05');

% filtering using 3x3 averaging filter
 B1 = imfilter(B,h);
 figure, imshow(B1); title('Uexposed image(Gauss: M=0, v=0.05) 3x3 Average
filter');

% filtering using 5x5 averaging filter
 B2 = imfilter(B,h5);
 figure, imshow(B2); title('Uexposed image(Gauss: M=0, v=0.05) 5x5 Average
filter');

% filtering using 3x3 Gaussian filter
 B3 = imfilter(B,Gauss3,'same');
 figure, imshow(B3); title('Uexposed image(Gauss: M=0, v=0.05) 3x3 Gauss filter');

% filtering using 5x5 Gaussian filter
 B4 = imfilter(B, Gauss5, 'same');
 figure, imshow(B4); title('Uexposed image(Gauss: M=0, v=0.05) 5x5 Gauss filter');
%------------------------------------------------------------------------------------%
% end
%I6 = imnoise(I,'salt & pepper',0.05);
%figure, imshow(I6); title('Oexposed image with Salt & pepper Noise');

% filtering using 3x3 filter
%I7 = imfilter(I6,h);
%figure, imshow(I7); title('Oexposed image(salt & pepper) 3x3 Average filter');

% filtering using 5x5 filter
%I8 = imfilter(I6,h5);
%figure, imshow(I8); title('Oexposed image(salt & pepper) 5x5 Average filter');
```

```
% filtering using 3x3 Gaussian filter
%I9 = imfilter(I6,Gauss3,'same');
%figure, imshow(I9); title('Oexposed image(salt & pepper) 3x3 Gauss filter');

% filtering using 5x5 Gaussian filter
%%figure, imshow(I10); title('Oexposed image(salt & pepper) 5x5 Gauss filter');
```

Program for Problem 4:

```
% Matlab code for problem 4-Laplacian Enhancement
% defining the simple laplacian filter
lap1 = [0 1 0; 1 -4 1; 0 1 0];
% laplacian filter involving the diagonal pixels as well
lap2 = [1 1 1; 1 -8 1; 1 1 1];
% Creating the gaussian filter with size = [3 3] and sigma = 1
Gauss3 = fspecial('gaussian',[3 3],1);
% lap2 with negation
lap3 = [-1 -1 -1; -1 8 -1; -1 -1 -1];
Ue = imread('Uexposed.jpg');
I = rgb2gray(Ue);
% filtering using gaussian filter
I = imfilter(I,Gauss3,'same');
% applying the Laplacian operator
I1 = imfilter(I,lap1,'conv');
I1 = I - I1;
I2 = imfilter(I,lap2,'conv');
I2 = I - I2;
%I3 = imfilter(I,lap3);
figure, imshow(I); title('Uexposed Original');
figure, imshow(I1); title('Uexposed filtered using Laplacian');
figure, imshow(I2); title('Uexposed filtered using Laplacian diagonal');
%figure, imshow(I3); title('Uexposed filtered using Laplacian diagonal
inverse');
Oe = imread('Oexposed.jpg');
A = rgb2gray(Oe);
A = imfilter(A,Gauss3,'same');
A1 = imfilter(A,lap1,'conv');
A1 = A - A1;
A2 = imfilter(A,lap2,'conv');
A2 = A - A2;
figure, imshow(A); title('Over exposed Original');
figure, imshow(A1); title('Over exposed using Laplacian filter');
figure, imshow(A2); title('Oexposed using Laplacian filter diagonal');
%end
```