ECE415 -- Homework 4

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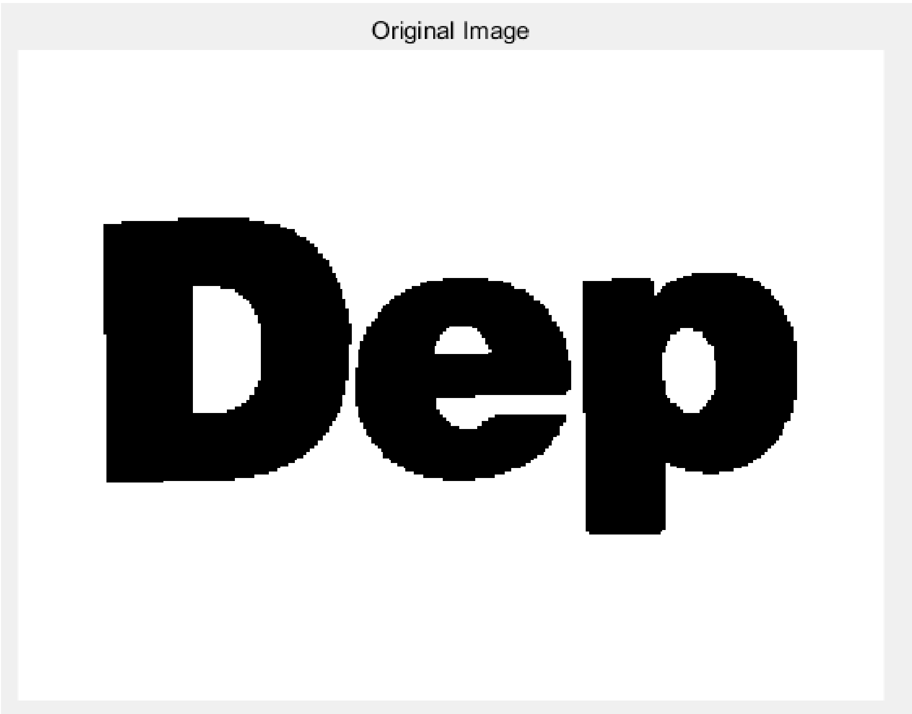
Problem 1

Find the connected components in the image Connected.bmp.

1) Display the image

Load the grayscale image Image.bmp into MATLAB and display the image. The picture is shown as follows.

```
im=imread('Connected.bmp');
imshow(im);
title('Original Image');
```



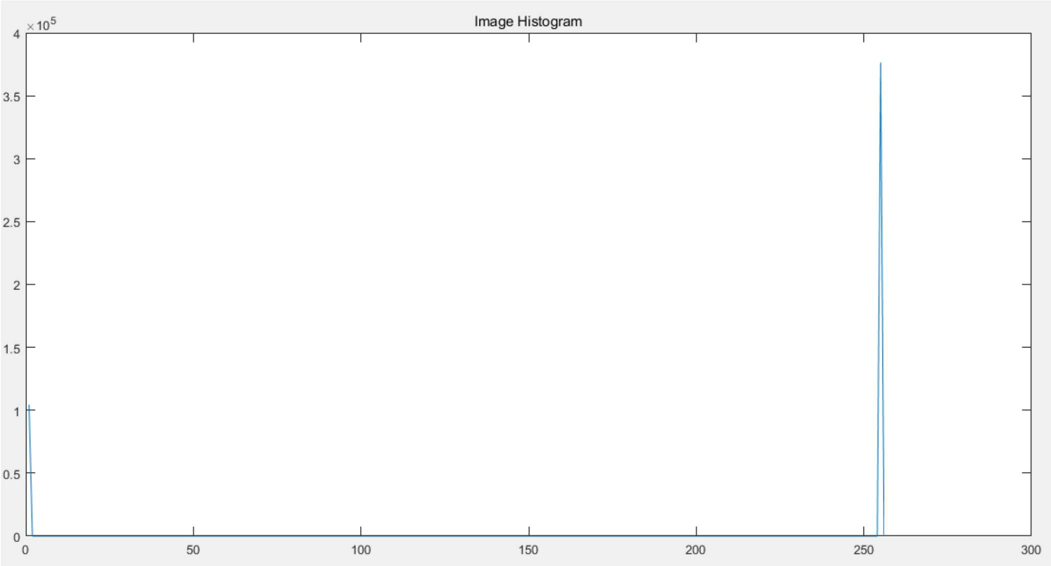
2) Perform thresholding if necessary, to create binary image. Describe the method and threshold used. Display the image.

I first write a function *histogram* to calculate the histogram for the intensity image, which can implement the built-in function of *imhist*. The MATLAB code is as follows.

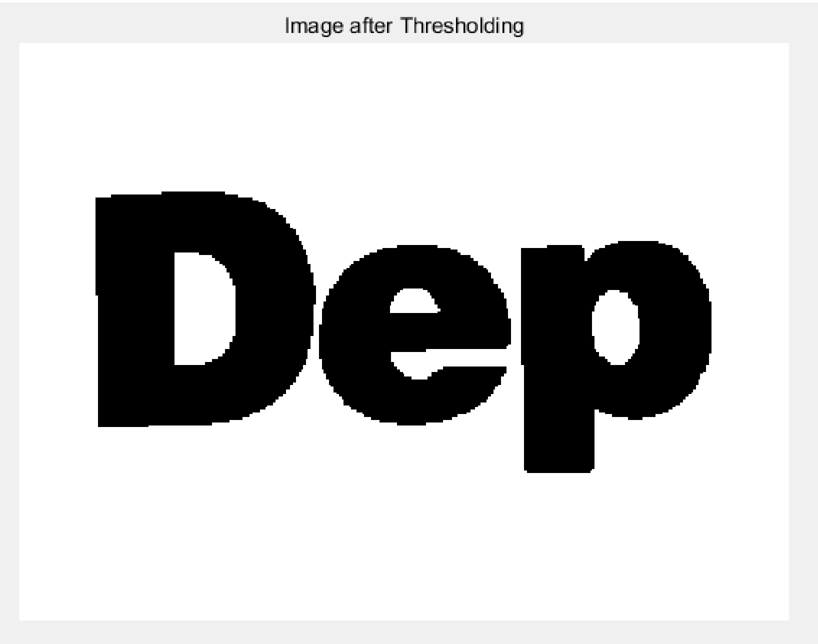
```
function y=histogram(I)
[row col]=size(I);
h=zeros(1,256);
for i=1:row
    for j=1:col
```

```
        h(I(i,j)+1)=h(I(i,j)+1)+1;
    end
end
y=h;
end
```

Then I use function *histogram* I have write above to display the histogram of picture.



We can easily find out the pixel value basically either 0 or 255. We just choose 100 to create the binary image.



3) Find the connected components using the component labeling two-pass algorithm assuming 4 connectivity. How many components are there?

I find **three** components.

First pass:

Iterate the image from top left to bottom right. Each time if the pixel (x, y) is black, do the following thing:

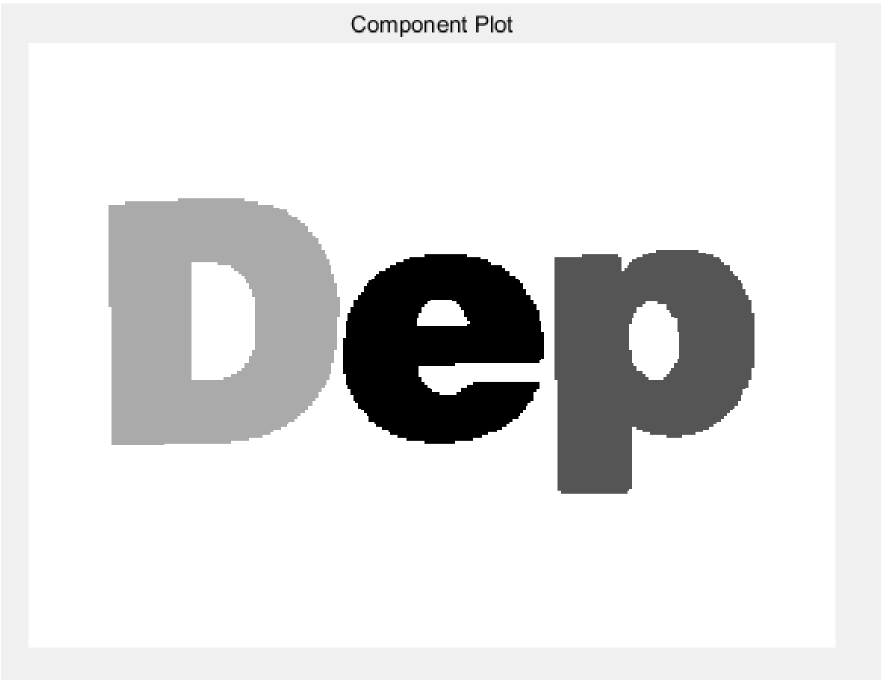
1. If both pixel (x, y-1) and (x-1, y) are white, give this pixel a new label.
2. If either pixel (x, y-1) or (x-1, y) is black, give this pixel the same label as the black pixel next to it.
3. If both pixel (x, y-1) and (x-1, y) are black, give this pixel the same label as either of the neighbor pixel and record that the label of pixel (x, y-1) and (x-1, y) are equivalent.

Second pass:

Assign same label to all the pixel with equivalent labels.

4) Substituting the pixel values in binary image with the component number they belong to, and mapping the component numbers to the full dynamic range of 8 bits display the image to demonstrate the found connected components. Comment!

According to the picture, there are three different colors, which means we find out three components.



MATLAB code:

```
%% find connected component
flag=1;
count=[];
label=zeros(row,col);
x=0;
```

```
for i=1:row
    for j=1:col
        if im(i,j)==0
            if im(i,j-1)==255&&im(i-1,j)==255
                count=[count,flag];
                label(i,j)=count(x+1);
                flag=flag+1;
                x=x+1;
                continue;
            end
            if im(i,j-1)==255&&im(i-1,j)==0
                label(i,j)=count(label(i-1,j));
                continue;
            end
            if im(i,j-1)==0&&im(i-1,j)==255
                label(i,j)=count(label(i,j-1));
                continue;
            end
            if im(i,j-1)==0&&im(i-1,j)==0
                label(i,j)=label(i-1,j);
                for k=1:x
                    if count(k)==count(label(i,j-1))
                        count(k)=count(label(i-1,j));
                    end
                end
                continue;
            end
        end
    end
end
component=unique(count)
len=size(component)
output=zeros(row,col);
for i=1:row
    for j=1:col
        if label(i,j)==0
            output(i,j)=0;
        else
        output(i,j)=count(label(i,j));
        end
    end
end
for i=1:row
    for j=1:col
```

```
        if label(i,j)==0
            output(i,j)=0;
        else
        output(i,j)=count(label(i,j));
        end
    end
end
for i=1:row
    for j=1:col
        for k=1:len(2)
            if output(i,j)==component(k)
                output(i,j)=k;
            end
        end
    end
end
for k=0:len(2)
    for i=1:row
        for j=1:col
            if output(i,j)==k
                output(i,j)=-255/len(2)*(k-3);
            end
        end
    end
end
output=uint8(output);
subplot(2,2,3);
imshow(output);
title('Component Plot');
```

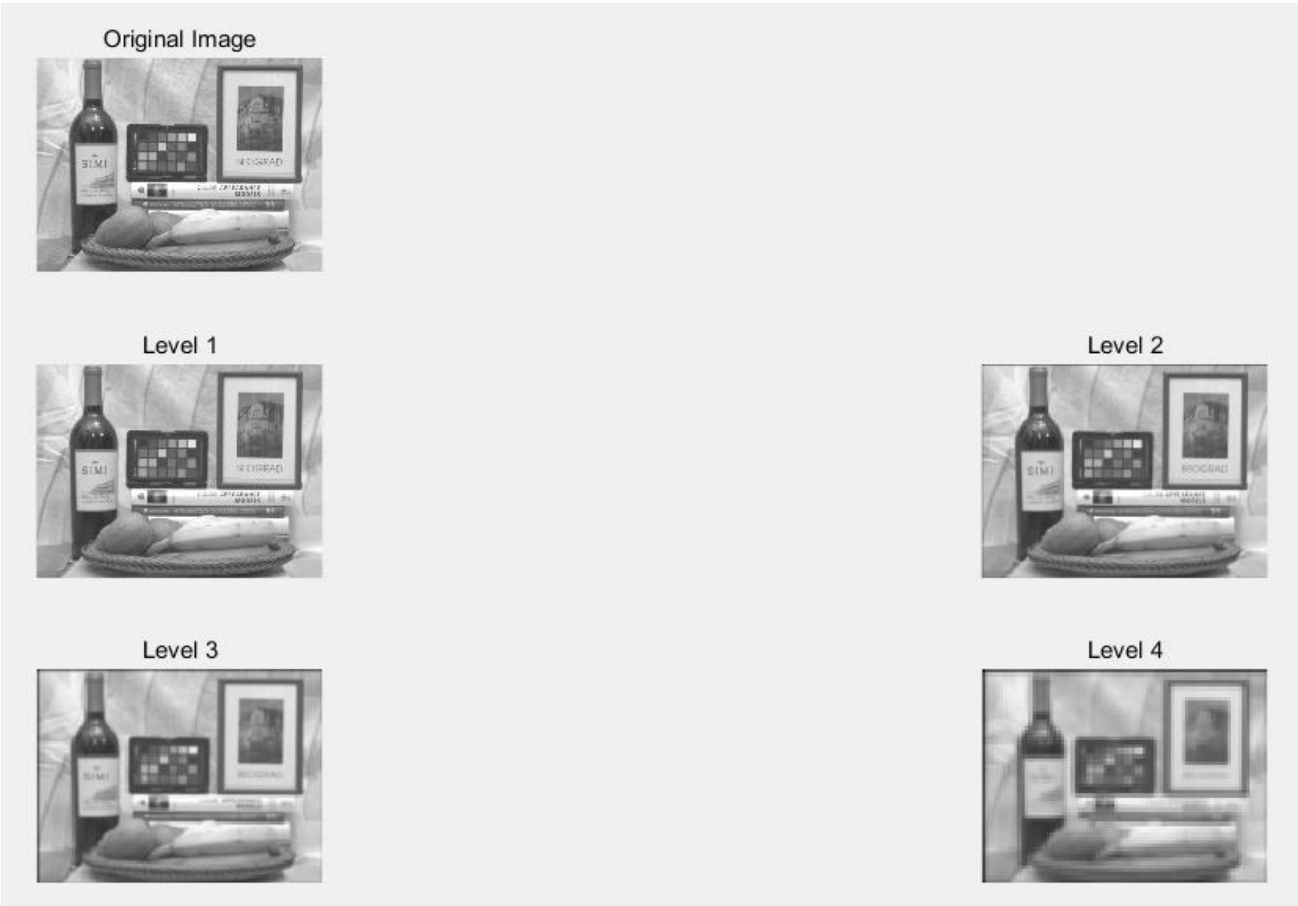
Problem 2

Load the image Image.bmp.

1) Display the image.

```
im=imread('Image.bmp');
imshow(im);
title('Original Image');
```

2) Create a Gaussian pyramid for the Image.bmp. The pyramid should have the original image and four more levels. Display all five levels of the pyramid.



MATLAB code:

```
clear;clc;
im=imread('Image.bmp');
```

```
subplot(3,2,1);
imshow(im);
title('Original Image');
[row, col]=size(im);
im1=double(im);
output1=zeros(row,col);
outputmid1=zeros(row+4,col);
im1=[zeros(2,col);im1;zeros(2,col)];
im1=[zeros(row+4,2) im1 zeros(row+4,2)];
for i=3:row+2
    for j=1:col
outputmid1(i,j)=round(im1(i,j)/16+im1(i,j+1)/4+6*im1(i,j+2)/16+im1(i,j+3)/4+im1(i
,j+4)/16);
    end
end
for i=1:col
    for j=1:row
output1(j,i)=round(outputmid1(j,i)/16+outputmid1(j+1,i)/4+6*outputmid1(j+2,i)/16+
outputmid1(j+3,i)/4+outputmid1(j+4,i)/16);
    end
end
for j=col:-2:2
    output1(:,j)=[];
end
for i=row:-2:2
    output1(i,:)=[];
end
output1=uint8(output1);
subplot(3,2,3);
imshow(output1);
title('Level 1');

[row1, col1]=size(output1);
im2=double(output1);
output2=zeros(row1,col1);
outputmid2=zeros(row1+4,col1);
im2=[zeros(2,col1);im2;zeros(2,col1)];
im2=[zeros(row1+4,2) im2 zeros(row1+4,2)];
for i=3:row1+2
    for j=1:col1
outputmid2(i,j)=round(im2(i,j)/16+im2(i,j+1)/4+6*im2(i,j+2)/16+im2(i,j+3)/4+im2(i
,j+4)/16);
    end
end
```

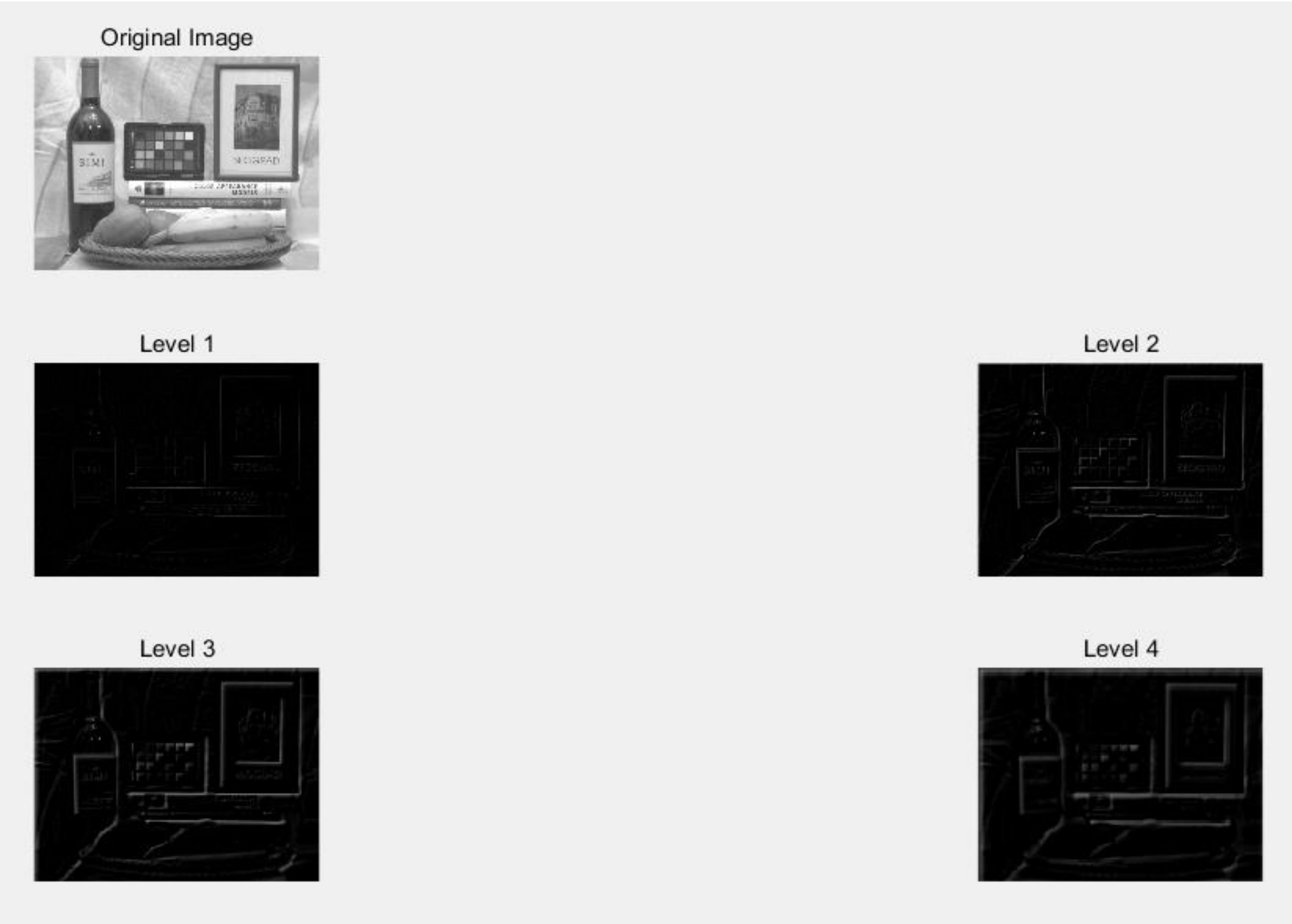
```
for i=1:col1
    for j=1:row1
output2(j,i)=round(outputmid2(j,i)/16+outputmid2(j+1,i)/4+6*outputmid2(j+2,i)/16+
outputmid2(j+3,i)/4+outputmid2(j+4,i)/16);
    end
end
for j=col1:-2:2
    output2(:,j)=[];
end
for i=row1:-2:2
    output2(i,:)=[];
end
output2=uint8(output2);
subplot(3,2,4);
imshow(output2);
title('Level 2');

[row2, col2]=size(output2);
im3=double(output2);
output3=zeros(row2,col2);
outputmid3=zeros(row2+4,col2);
im3=[zeros(2,col2);im3;zeros(2,col2)];
im3=[zeros(row2+4,2) im3 zeros(row2+4,2)];
for i=3:row2+2
    for j=1:col2
outputmid3(i,j)=round(im3(i,j)/16+im3(i,j+1)/4+6*im3(i,j+2)/16+im3(i,j+3)/4+im3(i
,j+4)/16);
    end
end
for i=1:col2
    for j=1:row2
output3(j,i)=round(outputmid3(j,i)/16+outputmid3(j+1,i)/4+6*outputmid3(j+2,i)/16+
outputmid3(j+3,i)/4+outputmid3(j+4,i)/16);
    end
end
for j=col2:-2:2
    output3(:,j)=[];
end
for i=row2:-2:2
    output3(i,:)=[];
end
output3=uint8(output3);
subplot(3,2,5);
imshow(output3);
```

```
title('Level 3');

[row3, col3]=size(output3);
im4=double(output3);
output4=zeros(row3,col3);
outputmid4=zeros(row3+4,col3);
im4=[zeros(2,col3);im4;zeros(2,col3)];
im4=[zeros(row3+4,2) im4 zeros(row3+4,2)];
for i=3:row3+2
    for j=1:col3
outputmid4(i,j)=round(im4(i,j)/16+im4(i,j+1)/4+6*im4(i,j+2)/16+im4(i,j+3)/4+im4(i
,j+4)/16);
    end
end
for i=1:col3
    for j=1:row3
output4(j,i)=round(outputmid4(j,i)/16+outputmid4(j+1,i)/4+6*outputmid4(j+2,i)/16+
outputmid4(j+3,i)/4+outputmid4(j+4,i)/16);
    end
end
for j=col3:-2:2
    output4(:,j)=[];
end
for i=row3:-2:2
    output4(i,:)=[];
end
output4=uint8(output4);
subplot(3,2,6);
imshow(output4);
title('Level 4');
```

3) **Create a Laplacian pyramid for the Image.bmp. The pyramid should have the original image and four more levels. Display all five levels of the pyramid.**



MATLAB code:

```
upoutput1=double(output1);
for j=col1:-1:1
    upoutput1=[upoutput1(:,1:j-1) zeros(row1,1) upoutput1(:,j:end)];
end
for i=row1:-1:1
    upoutput1=[upoutput1(1:i-1,:); zeros(1,2*col1); upoutput1(i:end,:)];
end
upoutput1=[zeros(2,2*col1);upoutput1;zeros(2,2*col1)];
upoutput1=[zeros(2*row1+4,2) upoutput1 zeros(2*row1+4,2)];
upoutputmid1=zeros(2*row1+4,2*col1);
lapout1=zeros(2*row1,2*col1);
for i=1:2*row1+4
    for j=1:2*col1
upoutputmid1(i,j)=round(upoutput1(i,j)/8+upoutput1(i,j+1)/2+6*upoutput1(i,j+2)/8+
upoutput1(i,j+3)/2+upoutput1(i,j+4)/8);
    end
end
for i=1:2*col1
    for j=1:2*row1
lapout1(j,i)=round(upoutputmid1(j,i)/8+upoutputmid1(j+1,i)/2+6*upoutputmid1(j+2,i
```

```
)/8+upoutputmid1(j+3,i)/2+upoutputmid1(j+4,i)/8);
    end
end
laplace1=uint8(double(im)-lapout1(1:row,1:col));
subplot(3,2,3);
imshow(laplace1);
title('Level 1');

upoutput2=double(output2);
for j=col2:-1:1
    upoutput2=[upoutput2(:,1:j-1) zeros(row2,1) upoutput2(:,j:end)];
end
for i=row2:-1:1
    upoutput2=[upoutput2(1:i-1,:); zeros(1,2*col2); upoutput2(i:end,:)];
end
upoutput2=[zeros(2,2*col2);upoutput2;zeros(2,2*col2)];
upoutput2=[zeros(2*row2+4,2) upoutput2 zeros(2*row2+4,2)];
upoutputmid2=zeros(2*row2+4,2*col2);
lapout2=zeros(2*row2,2*col2);
for i=1:2*row2+4
    for j=1:2*col2
upoutputmid2(i,j)=round(upoutput2(i,j)/8+upoutput2(i,j+1)/2+6*upoutput2(i,j+2)/8+
upoutput2(i,j+3)/2+upoutput2(i,j+4)/8);
    end
end
for i=1:2*col2
    for j=1:2*row2
lapout2(j,i)=round(upoutputmid2(j,i)/8+upoutputmid2(j+1,i)/2+6*upoutputmid2(j+2,i
)/8+upoutputmid2(j+3,i)/2+upoutputmid2(j+4,i)/8);
    end
end
laplace2=uint8(double(output1)-lapout2(1:row1,1:col1));
subplot(3,2,4);
imshow(laplace2);
title('Level 2');

upoutput3=double(output3);
for j=col3:-1:1
    upoutput3=[upoutput3(:,1:j-1) zeros(row3,1) upoutput3(:,j:end)];
end
for i=row3:-1:1
    upoutput3=[upoutput3(1:i-1,:); zeros(1,2*col3); upoutput3(i:end,:)];
end
upoutput3=[zeros(2,2*col3);upoutput3;zeros(2,2*col3)];
```

```
upoutput3=[zeros(2*row3+4,2) upoutput3 zeros(2*row3+4,2)];
upoutputmid3=zeros(2*row3+4,2*col3);
lapout3=zeros(2*row3,2*col3);
for i=1:2*row3+4
    for j=1:2*col3
upoutputmid3(i,j)=round(upoutput3(i,j)/8+upoutput3(i,j+1)/2+6*upoutput3(i,j+2)/8+
upoutput3(i,j+3)/2+upoutput3(i,j+4)/8);
    end
end
for i=1:2*col3
    for j=1:2*row3
lapout3(j,i)=round(upoutputmid3(j,i)/8+upoutputmid3(j+1,i)/2+6*upoutputmid3(j+2,i
)/8+upoutputmid3(j+3,i)/2+upoutputmid3(j+4,i)/8);
    end
end
laplace3=uint8(double(output2)-lapout3(1:row2,1:col2));
subplot(3,2,5);
imshow(laplace3);

title('Level 3');
[row4, col4]=size(output4);
upoutput4=double(output4);
for j=col4:-1:1
    upoutput4=[upoutput4(:,1:j-1) zeros(row4,1) upoutput4(:,j:end)];
end
for i=row4:-1:1
    upoutput4=[upoutput4(1:i-1,:); zeros(1,2*col4); upoutput4(i:end,:)];
end
upoutput4=[zeros(2,2*col4);upoutput4;zeros(2,2*col4)];
upoutput4=[zeros(2*row4+4,2) upoutput4 zeros(2*row4+4,2)];
upoutputmid4=zeros(2*row4+4,2*col4);
lapout4=zeros(2*row4,2*col4);
for i=1:2*row4+4
    for j=1:2*col4
upoutputmid4(i,j)=round(upoutput4(i,j)/8+upoutput4(i,j+1)/2+6*upoutput4(i,j+2)/8+
upoutput4(i,j+3)/2+upoutput4(i,j+4)/8);
    end
end
for i=1:2*col4
    for j=1:2*row4
lapout4(j,i)=round(upoutputmid4(j,i)/8+upoutputmid4(j+1,i)/2+6*upoutputmid4(j+2,i
)/8+upoutputmid4(j+3,i)/2+upoutputmid4(j+4,i)/8);
    end
end
```

```
laplace4=uint8(double(output3)-lapout4(1:row3,1:col3));
subplot(3,2,6);
imshow(laplace4);
title('Level 4');
```

4) Comment on the difference between the Gaussian and Laplacian pyramid of the image.

The Laplace pyramid can be calculated by subtracting interpolated filtering pyramid from Gaussian pyramid. With level increase, the picture is more blur in Gaussian pyramid because we down sample more information. As a result, with level increase, the edges in Laplacian pyramid is thicker.