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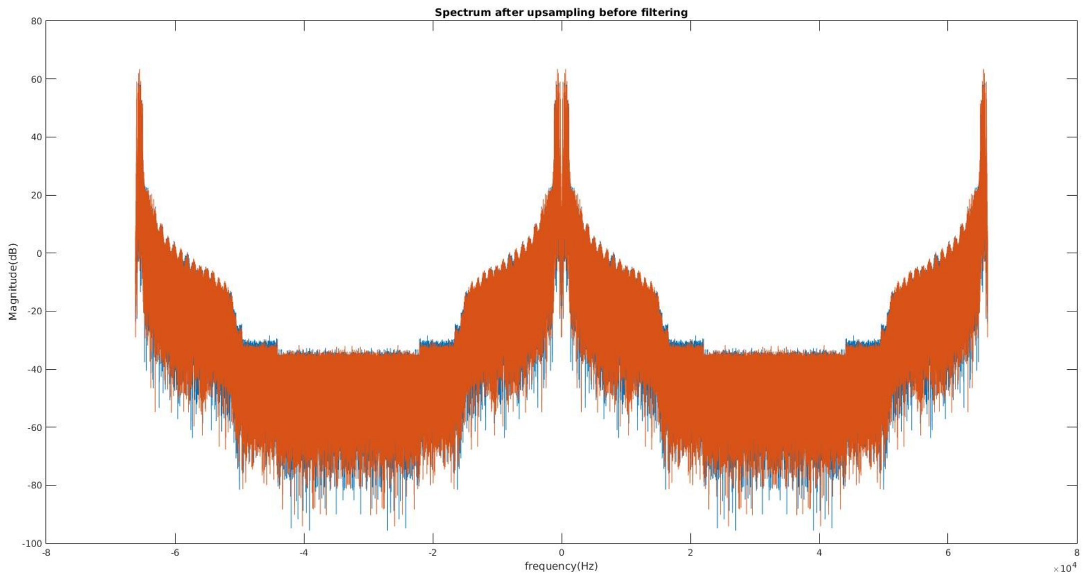
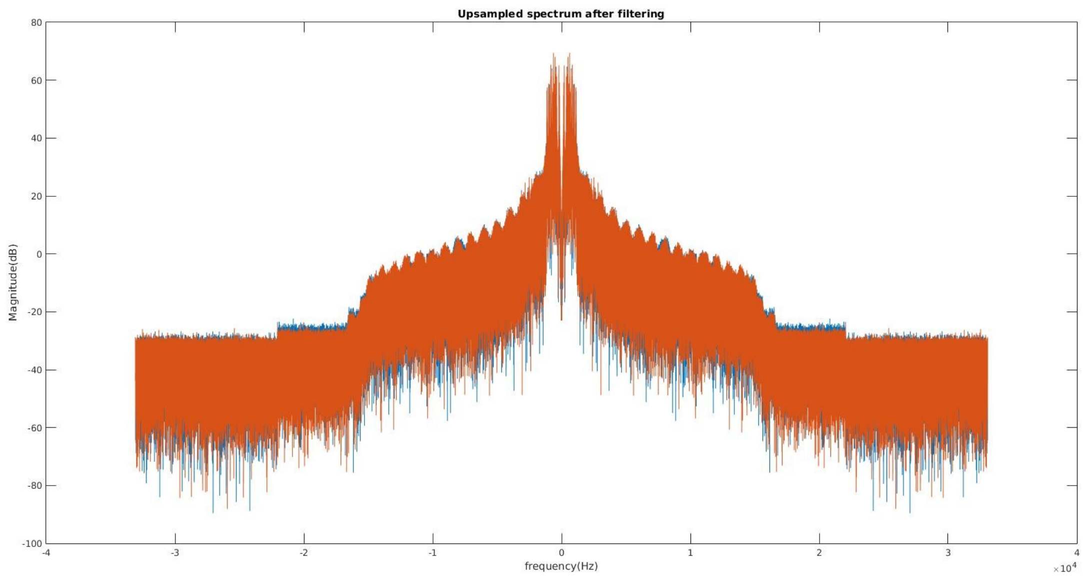
Report Item 1:

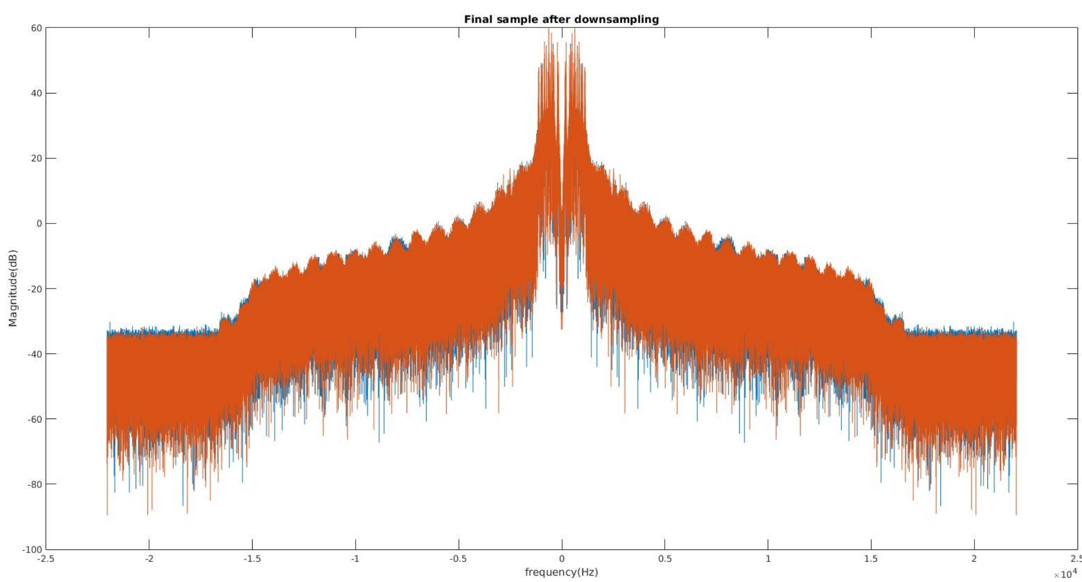
code:
```
[sound,fs] = audioread('audioclip.wav');
sizeO = length(sound);
SO = fftshift(fft(sound));
w = fftshift([0:sizeO-1]/sizeO*2*pi);
w(1:sizeO/2) = w(1:sizeO/2) - 2*pi;
freqO = fs*w/2/pi;
figure(6)
plot(freqO,mag2db(abs(SO)))



U = 2
D = 3
sound_up = upsample(sound,U);
sizeU = length(sound_up);
SU = fftshift(fft(sound_up));
wU = fftshift([0:sizeU-1]/sizeU*2*pi);
wU(1:sizeU/2) = wU(1:sizeU/2) - 2*pi;
fsU = 2*fs
freqU = fsU*wU/2/pi;
figure(1)
plot(freqU,mag2db(abs(SU)))
title('Spectrum after upsampling before filtering')
xlabel('frequency(Hz)')
ylabel('Magnitude(dB)')

%filtering
filtered = zeros(length(SU),3);
filtered(:,1) = freqU;
filtered(:,2) = (SU(:,1))';
filtered(:,3) = (SU(:,2))';
filtered(1:337495,2:3) = 0;
filtered(1012495:1350000,2:3) = 0;
figure(2)
filtered(:,2:3) = 2 * filtered(:,2:3);
plot(filtered(:,1),mag2db(abs(filtered(:,2:3))))
title('Upsampled spectrum after filtering')
xlabel('frequency(Hz)')
ylabel('Magnitude(dB)')

%go back to time domain
sound_up_filter = ifft(ifftshift((filtered(:,2:3))))
figure(3)
plot(real(sound_up_filter))
hold on
plot(sound_up)
```

```
sound_down = downsample(real(sound_up_filter),D);
figure(4)
plot(sound_down)
hold on
plot(sound)

sizeD = length(sound_down);
SD = fftshift(fft(sound_down));
wD = fftshift([0:sizeD-1]/sizeD*2*pi);
wD(1:sizeD/2) = wD(1:sizeD/2) - 2*pi;
fsD = fsU/D
freqD = fsD*wD/2/pi;
figure(5)
plot(freqD,mag2db(abs(SD)))
title('Final sample after downsampling')
xlabel('frequency(Hz)')
ylabel('Magnitude(dB)')
```

U = 2
D = 3





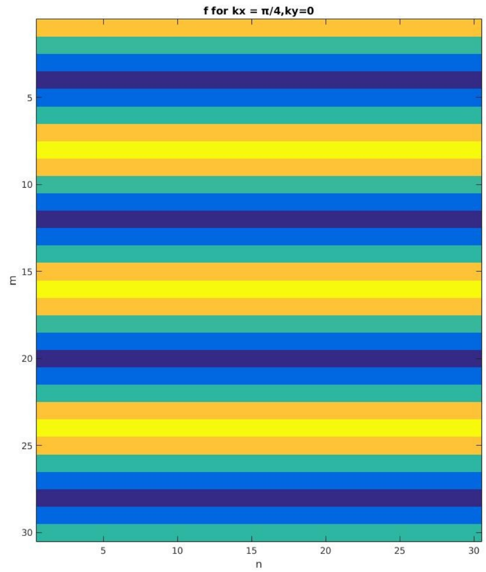


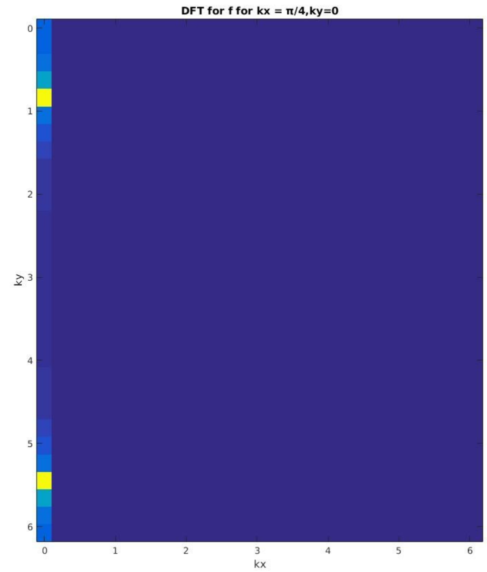
They sound the same

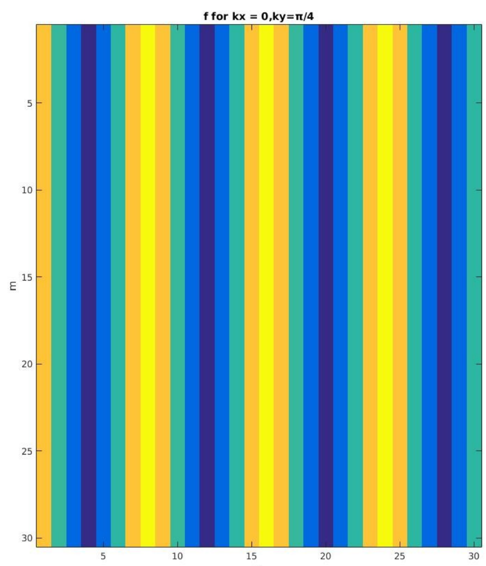
Report Item 2:

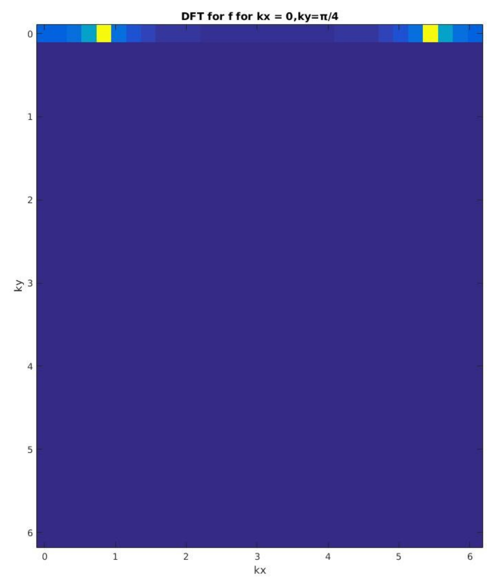
```
function  [dft2] = myDFT2(image)
[row,col] = size(image);

dft2 = zeros(row,col);
for m = 1:row
    dft2(m,:) = fft(image(m,:));
end

for n = 1:col
    dft2(:,n) = fft(dft2(:,n)) ;
end
end



M = 1:30;
N = 1:30;
[m,n] = meshgrid(M,N)
kx = pi/4
ky = 0
z = cos(ky*m + kx*n);
figure(1)
subplot(121)
imagesc(z)
title('f for kx = pi/4,ky=0')
xlabel('n')
ylabel('m')

Z = myDFT2(z)
Z1 = fft2(z)
subplot(122)
kX = ([0:length(N)-1]/length(N)*2*pi)
kY = ([0:length(M)-1]/length(M)*2*pi)
imagesc(kX,kY,abs((Z)))
title('DFT for f for kx = pi/4,ky=0')
xlabel('kx')
ylabel('ky')


kx = 0
ky = pi/4
z = cos(ky*m + kx*n);
figure(2)
subplot(121)
imagesc(z)
title('f for kx = 0,ky=pi/4')
xlabel('n')
ylabel('m')

Z = myDFT2(z)
Z1 = fft2(z)
```

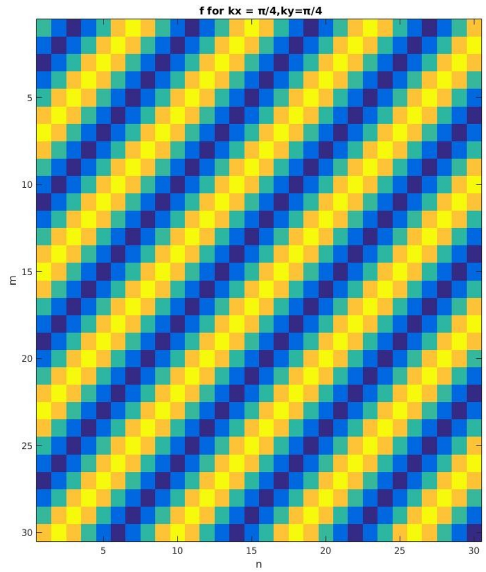
```
subplot(122)
kX = ([0:length(N)-1]/length(N)*2*pi)
kY = ([0:length(M)-1]/length(M)*2*pi)
imagesc(kX,kY,abs((Z)))

title('DFT for f for kx = 0,ky=pi/4')
xlabel('kx')
ylabel('ky')

kx = pi/4
ky = pi/4
z = cos(ky*m + kx*n);
figure(3)
subplot(121)
imagesc(z)
title(' f for kx = pi/4,ky=pi/4')
xlabel('n')
ylabel('m')

Z = myDFT2(z)
Z1 = fft2(z)
subplot(122)
kX = ([0:length(N)-1]/length(N)*2*pi)
kY = ([0:length(M)-1]/length(M)*2*pi)
imagesc(kX,kY,abs((Z)))

title('DFT for f for kx = pi/4,ky=pi/4')
xlabel('kx')
ylabel('ky')

kx = pi/4
ky = -pi/4
z = cos(ky*m + kx*n);
figure(4)
subplot(121)
imagesc(z)
title('f for kx = pi/4,ky=-pi/4')
xlabel('n')
ylabel('m')

Z = myDFT2(z)
Z1 = fft2(z)
subplot(122)
kX = ([0:length(N)-1]/length(N)*2*pi)
kY = ([0:length(M)-1]/length(M)*2*pi)
imagesc(kX,kY,abs((Z)))

title('DFT for f for kx = pi/4,ky=-pi/4')
xlabel('kx')
ylabel('ky')
```

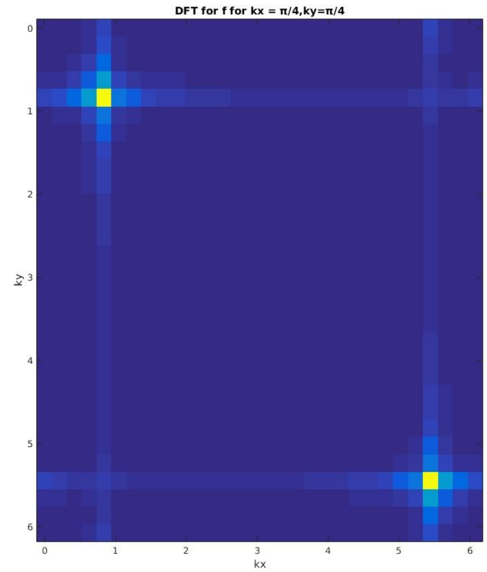

f for kx = π/4,ky=0
m
n

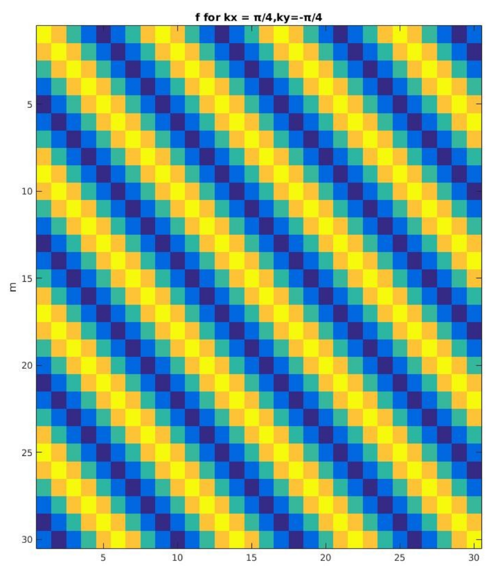

DFT for f for kx = π/4,ky=0
ky
kx

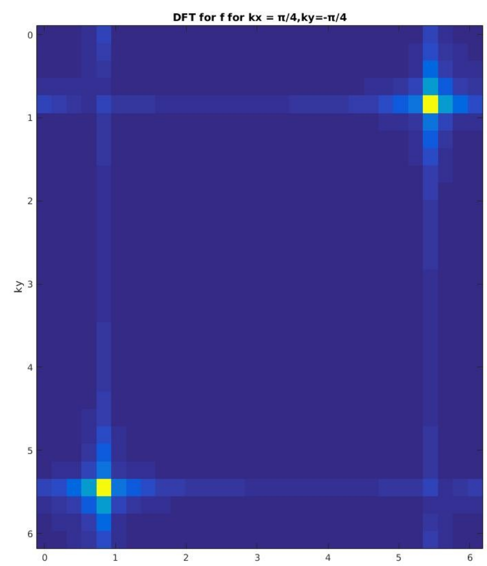

f for kx = 0,ky=π/4
m
n


DFT for f for kx = 0,ky=π/4
ky
kx


f for kx = π/4,ky=π/4
m
n

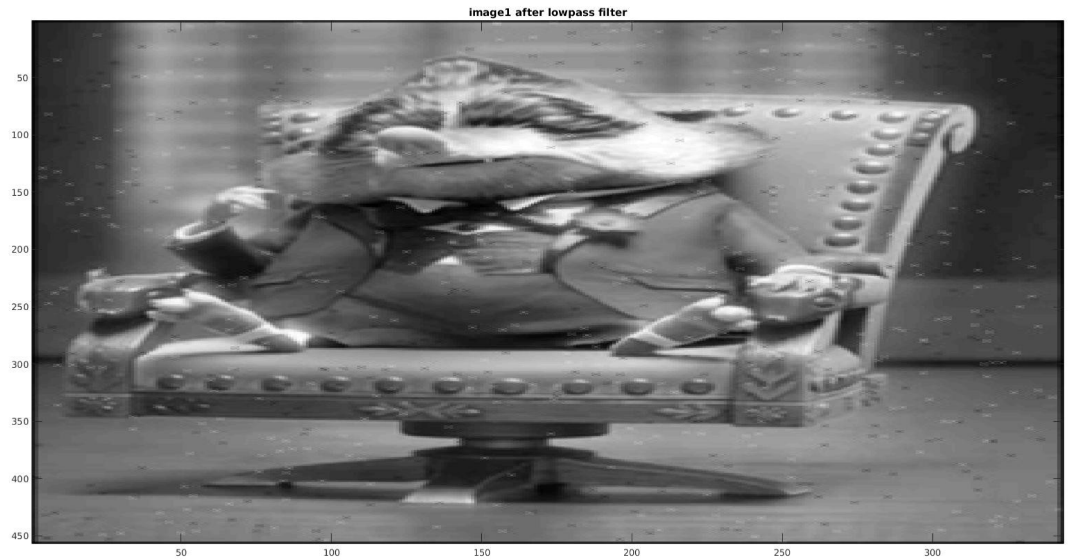

DFT for f for kx = π/4,ky=π/4
ky
kx


f for kx = π/4,ky=-π/4
m
n


DFT for f for kx = π/4,ky=-π/4
ky
kx

Report Item 3:

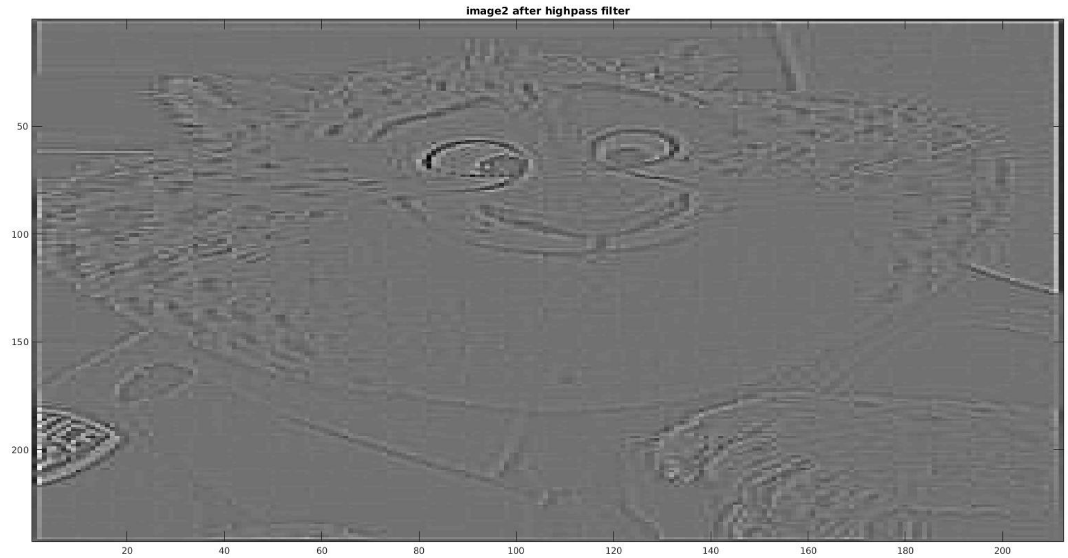
```
image1 = imread('image1.jpg')
image1 = double(image1)

h = [1/8,1/16,1/8;
    1/16,1/4,1/16;
    1/8,1/16,1/8]

c = conv2(h,image1)
colormap gray
imagesc(c)
title('image1 after lowpass filter')
```



Report Item 4:

code:

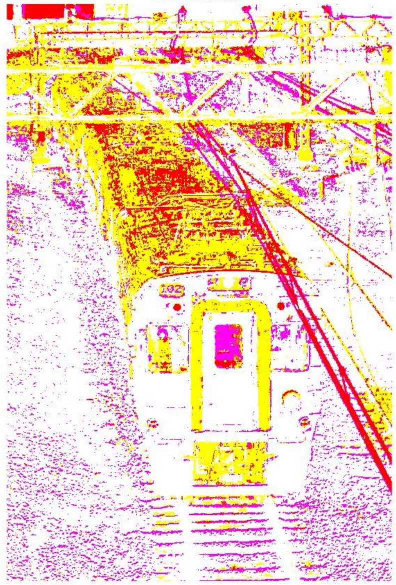
```
image2 = imread('image2.jpg')
image2 = double(image2)
h = [-1,-1,-1;
    -1,8,-1;
    -1,-1,-1]

c = conv2(h,image2)
colormap gray
imagesc(c)
title('image2 after highpass filter')
```



Report Item 5:

```
train = imread('train.jpg');
train = double(train);
%imshow(train)
train_lab = rgb2lab(train);

imshow(train_lab,[])
title('train in lab color')

figure;
subplot(131)
imshow(train_lab(:,:,1),[])
title('channel 1')
subplot(132)
imshow(train_lab(:,:,2),[])
title('channel 2')
subplot(133)
imshow(train_lab(:,:,3),[])
title('channel 3')

train_new = lab2rgb(train_lab)
figure
imshow(uint8(train_new),[])
title('from lab to rgb')
```

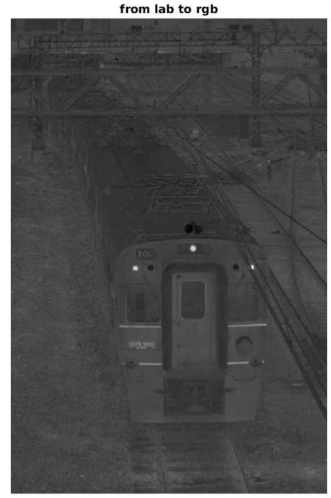
train in lab color



channel 1

channel 2

from lab to rgb



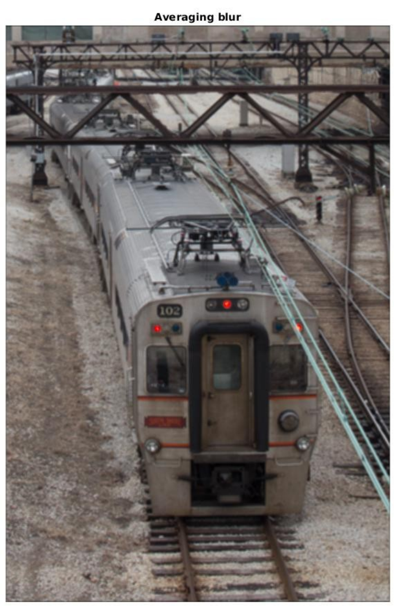
from lab to rgb

The converted image is the same as the input!!!

Report Item 6:

```
function [out_image] = meanFilter(image,kernelSize)
image_lab = rgb2lab(image);
kernel = 1/(kernelSize*kernelSize) * ones(kernelSize,kernelSize);
first = image_lab(:,:,1)
con = conv2(first,kernel,'same');
image_lab(:,:,1) = con;
out_image = lab2rgb(image_lab);
end
```

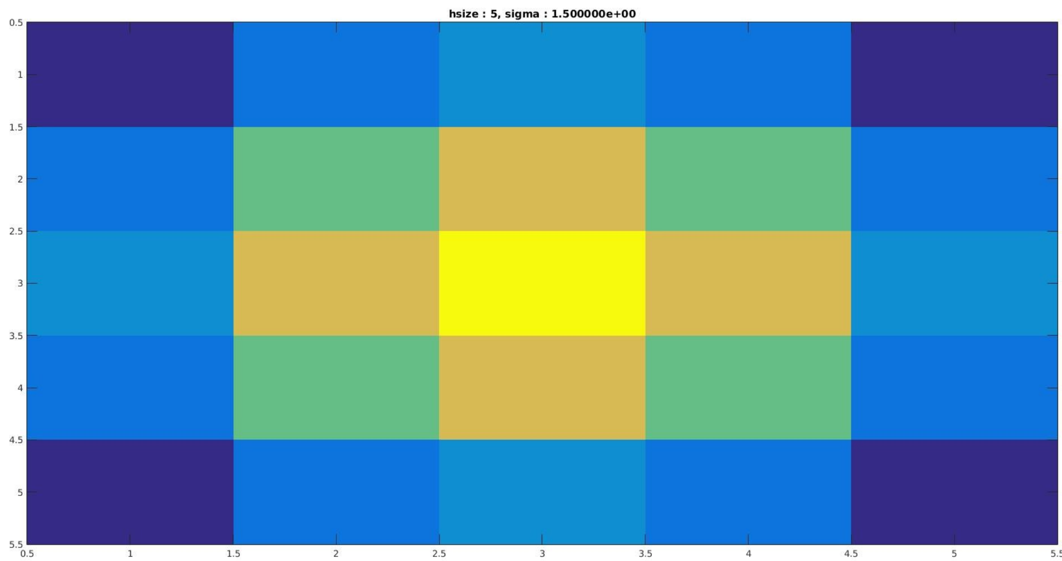
```
train = imread('train.jpg');
out = meanFilter(train,7);
imshow(out)
title('Averaging blur')
```

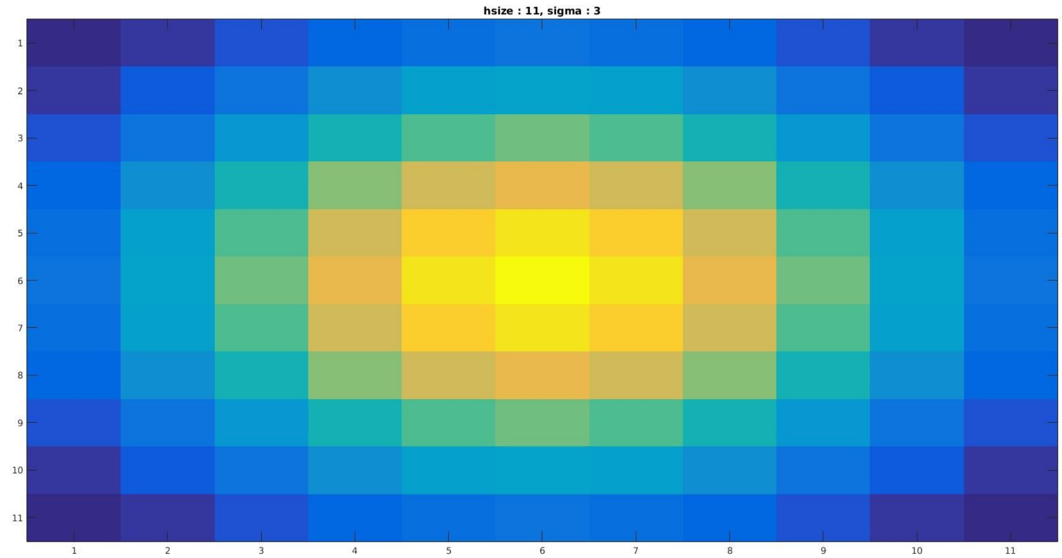


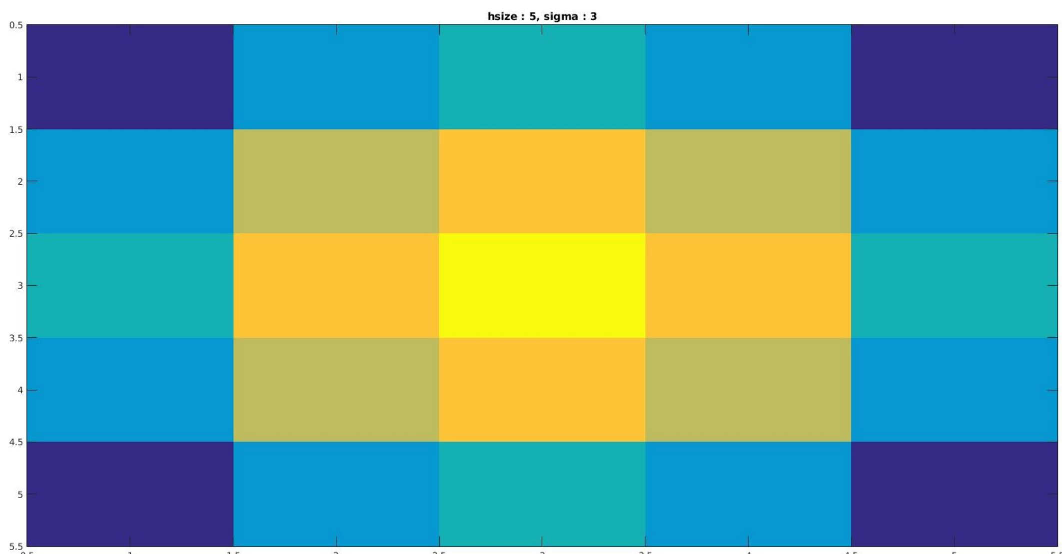
This kernel gives the same weight to both the nearer pixels and the further pixels;therefore it's called a meanfilter.

Report Item 7:

```
hsize = [5,11,5]
sigma = [1.5,3,3]

for i = 1:3
    figure(i)
    imagesc(fspecial('gaussian',hsize(i),sigma(i)))
    title(sprintf('hsize : %d, sigma : %d',hsize(i),sigma(i)))
end
```





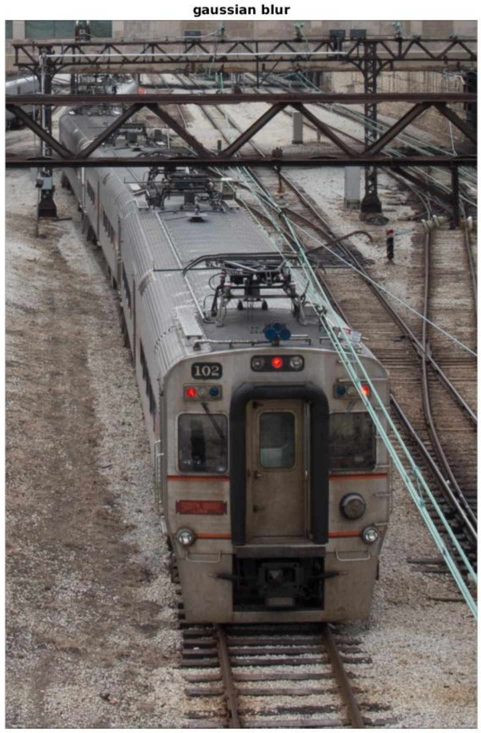


When hsize is small and sigma is really large, all cells on the image will almost have the same color, as the gaussian function changes more slowly with large standard deviation.

Report Item 8:

```
function [out_image] = gaussianFilter(image,kernelSize,std)
image_lab = rgb2lab(image)
kernel = fspecial('gaussian',kernelSize,std)
first = image_lab(:,:,1)
con = conv2(first,kernel,'same');
image_lab(:,:,1) = con;
out_image = lab2rgb(image_lab);
end

train = imread('train.jpg');
out = gaussianFilter(train,7,1);
imshow(out)
title('gaussian blur')
```

gaussian blur

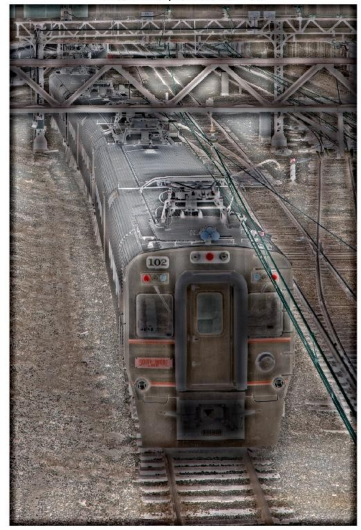


Report Item 9:

```
function [sharpened] = unsharpMask(original,lowpass,alpha)
ori_L = rgb2lab(original);
low_L = rgb2lab(lowpass);
lab_sharp = ori_L;
lab_sharp(:,:,1) = ori_L(:,:,1) - alpha*(ori_L(:,:,1)-low_L(:,:,1));
sharpened = lab2rgb(lab_sharp);

end


train = imread('train.jpg');
meanK_first = unsharpMask(train,meanFilter(train,7),2);
meanK_second= unsharpMask(train,meanFilter(train,50),2);
gaussian_first=unsharpMask(train,gaussianFilter(train,7,1),2);
gaussian_second=unsharpMask(train,gaussianFilter(train,50,1),2);

figure(1)
subplot(121)
imshow(meanK_first);
title('mean filter, kernelsize= 7');
subplot(122)
imshow(meanK_second);
title('mean filter,kernelsize = 50');
figure(2)
subplot(121)
imshow(gaussian_first);
title('gaussian filter kernel size = 7');
subplot(122)
imshow(gaussian_second);
title('gaussian filter kernel size = 50')
```

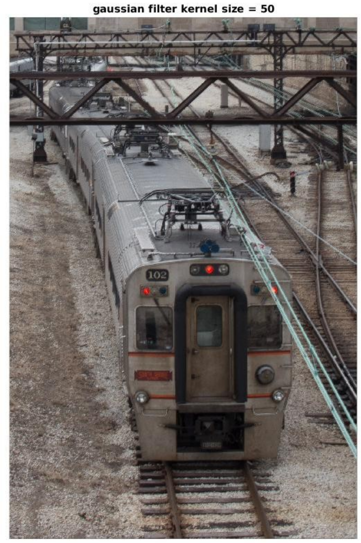
mean filter, kernelsize= 7

mean filter,kernelsize = 50



gaussian filter kernel size = 7

gaussian filter kernel size = 50



When the filters are of the same size but different type, the result generated by the meanFilter tends to sharpen the image more, as the contour is more emphasized. When the images are both generated by the same type of filter, there is huge difference the image gets sharpened, as the one with larger kernel size gets sharpened more. When the gaussian filter is used,difference between the results are little harder to see.