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Signals and Systems Lab4 Report

Part 2

In this part it is desired to obtain 2D convolution of a 2D DS LSI system by following the similar steps previously demonstrated which are for obtaining convolution in a LTI system. 2D convolution for 2D DS LSI system can be observed in the following steps.

① 2D discrete impulse signal

$$\delta[m,n] = \begin{cases} 1, & m=n=0 \\ 0, & \text{otherwise} \end{cases}$$

② input signal is defined $x[m,n]$, input signal is represented as the superposition of shifted impulses:

$$x[m,n] = \sum_{k=-\infty}^{\infty} \sum_{\ell=-\infty}^{\infty} x[k,\ell]\, \delta[m-k, n-\ell]$$

③ Impulse response is $h[m,n]$. It is known that $\delta[m,n]$ has an impulse response which is $h[m,n]$. Due to being a space-invariant 2D DS LSI system, $\delta[m,n] = \delta[m-k, n-\ell]$ hence, $h[m,n] = h[m-k, n-\ell]$.

④ $y[m,n]$ denotes the output. The 2D convolution for 2D DS LSI is

$$y[m,n] = \sum_{k=-\infty}^{\infty} \sum_{\ell=-\infty}^{\infty} x[k,\ell] \cdot \delta[m-k,n-\ell] = \sum_{k=-\infty}^{\infty} \sum_{\ell=-\infty}^{\infty} h[k,\ell] \cdot x[m-k, n-\ell]$$

$$= x[m,n] ** h[m,n]$$

Part 3

After obtaining an analytical impression for the 2D convolution, now it is desired to implemt this anlytical experession to MATLAB. The code for 2D convolution is given below.'h' and 'x' matrices denote the test matrices which are indicated in lab report. The following hnd written part demonstrates how to obtain My and Ny in terms of Mx, Nx, Mh and Nh.

Code for 2D convolution

```
h=[1,-1;0,2]
x=[1,0,2;-1,3,1;-2,4,0]
y=DSLSI2D(h,x)
function [y]=DSLSI2D(h,x)
[Mx,Nx]=size(x);
[Mh,Nh]=size(h);
y=zeros(Mx+Mh-1,Nx+Nh-1);
for k=0:Mh-1
```

```
    for l=0:Nh-1
        y(k+1:k+Mx,l+1:l+Nx)=y(k+1:k+Mx,l+1:l+Nx)+h(k+1,l+1)*x;
    end
end
end
```

The 2D convolution function operates as desired and y is displayed as following.

```
y = 4×4
     1    -1     2    -2
    -1     6    -2     3
    -2     4     2     2
     0    -4     8     0
```

Part 4

Matlab for low pass filtering of the image is given below.

```
D7=rem(22101962,7);
Mh = 30+D7;
Nh = 30+D7;
B=0.7;
B1=0.4;
B2=0.1;
h=zeros(Mh,Nh);
h1=zeros(Mh,Nh);
h2=zeros(Mh,Nh);
for m=1:Mh-1;
    for n=1:Nh-1;
           h(m,n) = sinc(B * (m - (Mh-1) / 2)) * sinc(B * (n - (Nh-1) / 2));
           h1(m,n) = sinc(B1 * (m - (Mh-1) / 2)) * sinc(B1 * (n - (Nh-1) /2));
           h2(m,n) = sinc(B2 * (m - (Mh-1) / 2)) * sinc(B2 * (n - (Nh-1) /2));
    end
end
y=DSLSI2D(h,x);
y1=DSLSI2D(h1,x);
y2=DSLSI2D(h2,x);
x=ReadMyImage('Part4.bmp');
figure;
subplot(2,2,1);
DisplayMyImage(x);
title('noisy image')
subplot(2,2,2);
DisplayMyImage(y);
title('B=0.7')
subplot(2,2,3);
DisplayMyImage(y1);
title('B=0.4')
subplot(2,2,4);
DisplayMyImage(y2);
```

```
title('B=0.1')
```

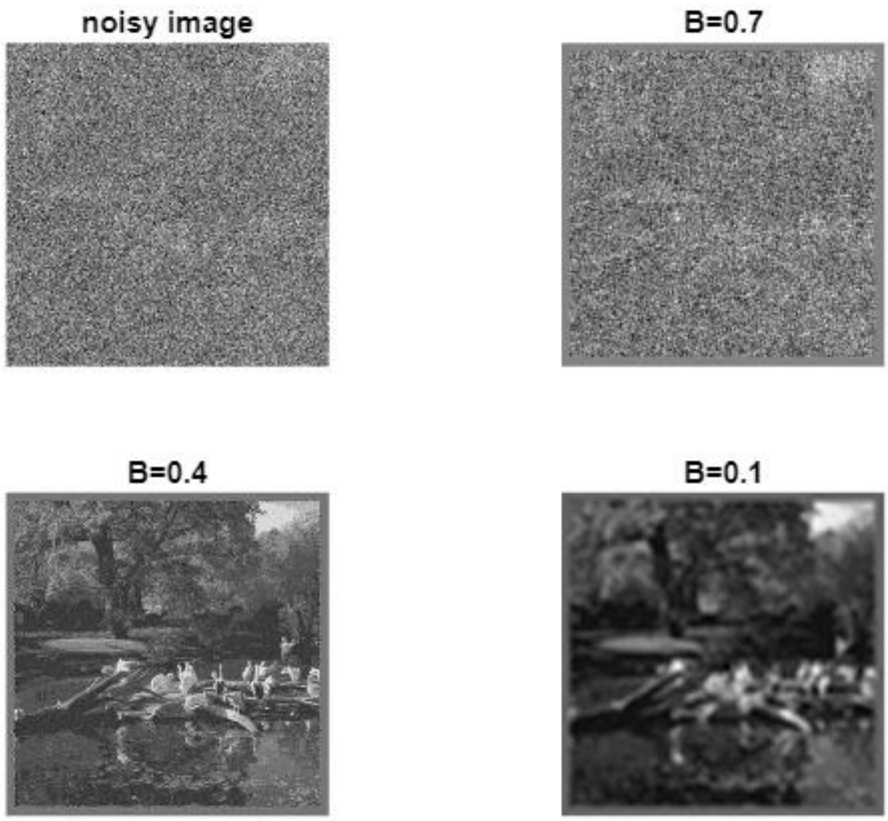

Fig4.1 demonstration of low pass filtering

As the low pass filter parameter B approaches to 0 the removal of high frequency content increases. However there is a value of B such that if the present value of B is lower than mentioned value of B filtering of high frequency content is increased such that the edges dissappear ad the image becames blurry. It can be interpreted that B denotes the bandwith of the filter.

Part 5

Code for high pass filtering in order to detect edges.

```
x=ReadMyImage('Part5.bmp');
```

```
h1=[0.5 -0.5;0 0];

h2=[0.5 0;-0.5 0];
h3=0.5*h1 + 0.5*h2
y=DSLSI2D(h3,x);
s1=y.*y;
DisplayMyImage(s1)
```

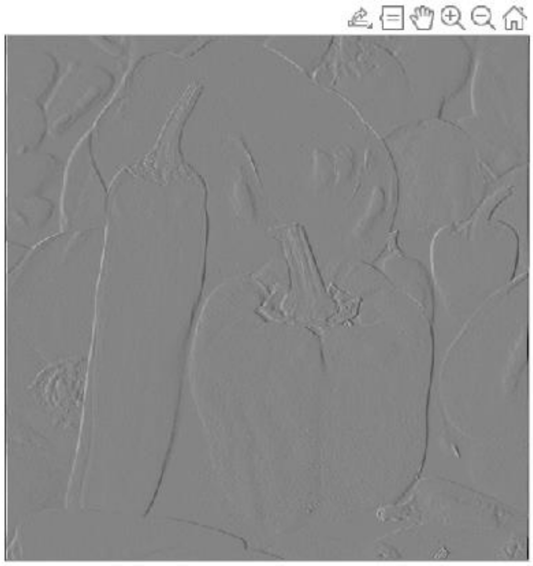

Fig5.1 y1[m,n]

Fig5.2 y1[m,n]*y1[m,n]=s1[m,n]

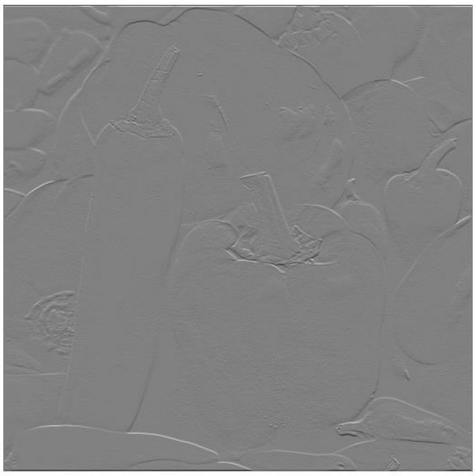

Fig5.3 y2[m,n]

Fig5.4 y2[m,n]*y2[m,n]=s2[m,n]

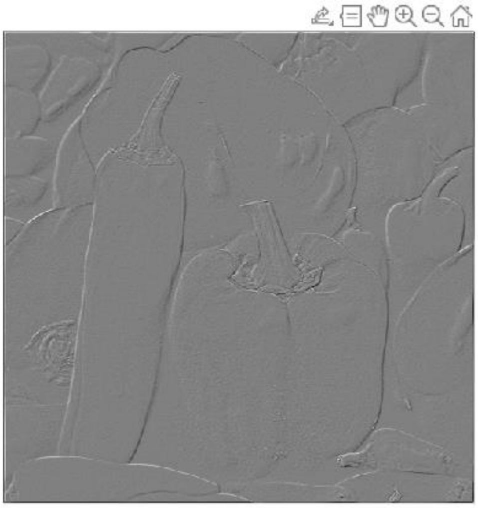

Fig5.5 y3[m,n]

Fig5.6 y3[m,n]*y3[m,n]=s3[m,n]

In this part edge detection is done. When the impulse response is h1 the vertical edges are detected as it can be seen in Fig5.2. When the impulse response is h2 the hrizontal edges are detected as it can be seen in Fig5.3. h3 is the sum of h1 and h2 therefore the edgesa are not direction specific in Fig5.6, both horizontal and vertical edges are detected.

Part 6

Fig6.1 magnitude of y[m,n]

Fig6.2 third power of the magnitude of y[m,n]

Fig6.3 fifth power of the magnitude of y[m,n]

It can be observed that when the power of the magnitude of y[m,n] increases the brightnesses more likely located in the faces of the players meaning that pattern recognition becomes more successful when the the power of the magnitude of y[m,n] is increased. It is important to note that the face detection is done by 2D convolution of original image and the impulse response where impulse response is given as upside down since the operation is done by flipping and shifting the impulse response.