作业三

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课堂遗留：

1、讨论 Q>0 处理胡椒噪声时为什么对暗区起到模糊效果？Q<0 处理盐噪声时为什么对亮区起到模糊效果？

对暗区模糊还是对亮区模糊可以大致理解为：对于在亮暗边界选定的子窗口 Sxy，经逆谐均值滤波器滤波后，返回的 Sxy 中心的值是偏向于灰度较小的值还是灰度较大的值，可以从数学上证明，灰度值差别较大的亮暗边界（比如相差 10 倍左右），当 Q>0 时，亮暗边界滤波后的返回灰度值偏大，即原先黑色的区域夹杂白色亮点，即暗区模糊。当 Q<0 时亮暗边界经滤波后返回的灰度值偏小，及边界的亮区域会有黑色扩展，暗区显得更宽，即暗区清晰，亮区模糊。

课后作业：

1、代码：

```
clc,clear;
close all;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
f0=zeros(256,256);%Produce original image.
[height,width]=size(f0);
f0(25:234,[25:31,49:55,73:79,97:103,...
    121:127,145:151,169:175,193:199,217:223])=255*ones(210,63);
f=double(uint8(f0));
figure,subplot(2,2,1),imshow(uint8(f)),title('Original image.');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
h3=fspecial('average',[3,3]);
h5=fspecial('average',[5,5]);
h9=fspecial('average',[9,9]);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
g3=imfilter(f,h3,'replicate','same','conv');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
g5=imfilter(f,h5,'replicate','same','conv');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
f_d_r99=[f(:,1:4),f,f(:,width-3:width)];
f_d_r9=[f_d_r99(1:4,:);f_d_r99;f_d_r99(height-3:height,:)];
N9=9;
f_L9=f_d_r9;
chip9=zeros(3,3);
```

```
for i=1:height%Convolution.
    for j=1:width
        for m=1:N9
            for n=1:N9
                chip9(m,n)=f_d_r9(i+m-1,j+n-1).*h9(N9+1-m,N9+1-n);
            end
        end
        s9=sum(sum(chip9));
        f_L9(i+(N9-1)/2,j+(N9-1)/2)=s9;
    end
end
f_Last9=f_L9(5:height+4,5:width+4);
f_L_u9=uint8(f_Last9);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
subplot(2,2,2),imshow(g3),title('h,[3*3]');
subplot(2,2,3),imshow(g5),title('h,[5*5]');
subplot(2,2,4),imshow(f_L_u9),title('h,[9*9]');
```

实验结果：

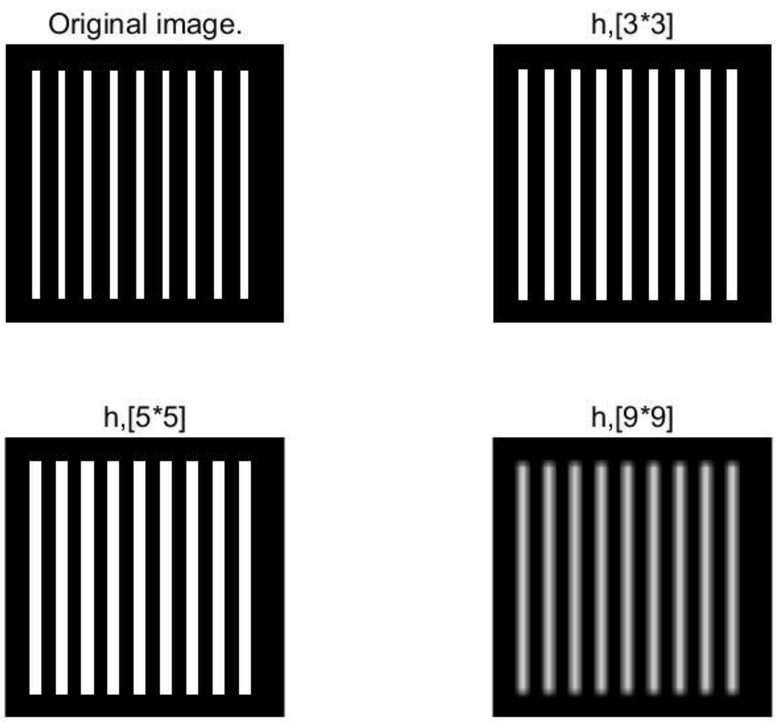


图 1

2.1、代码：

```
clc,clear;
close all;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
%%%%%
f0=zeros(256,256);%Produce original image.
[height,width]=size(f0);
f0(25:234,[25:31,49:55,73:79,97:103,...
    121:127,145:151,169:175,193:199,217:223])=255*ones(210,63);
f=double(uint8(f0));
figure,subplot(2,2,1),imshow(uint8(f)),title('Original image.');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r33=[f(:,1:4),f,f(:,width-3:width)];
f_d_r3=[f_d_r33(1:4,:);f_d_r33;f_d_r33(height-3:height,:)];
N3=3;
f_L3=f_d_r3;
for i=1:height
    for j=1:width
        s3=sum(sum(1./f_d_r3(i:i+2,j:j+2)));
        f_L3(i+(N3-1)/2,j+(N3-1)/2)=s3.*(N3*N3);
    end
end
f_Last3=f_L3(2:height+1,2:width+1);
f_L_u3=uint8(f_Last3);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r55=[f(:,1:4),f,f(:,width-3:width)];
f_d_r5=[f_d_r55(1:4,:);f_d_r55;f_d_r55(height-3:height,:)];
N5=5;
f_L5=f_d_r5;
for i=1:height
    for j=1:width
        s5=sum(sum(1./f_d_r5(i:i+4,j:j+4)));
        f_L5(i+(N5-1)/2,j+(N5-1)/2)=s5.*(N5*N5);
    end
end
f_Last5=f_L5(3:height+2,3:width+2);
f_L_u5=uint8(f_Last5);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r99=[f(:,1:4),f,f(:,width-3:width)];
f_d_r9=[f_d_r99(1:4,:);f_d_r99;f_d_r99(height-3:height,:)];
N9=9;
f_L9=f_d_r9;
for i=1:height
    for j=1:width
        s9=sum(sum(1./f_d_r9(i:i+8,j:j+8)));
```

```
        f_L9(i+(N9-1)/2,j+(N9-1)/2)=s9.*(N9*N9);
    end
end
f_Last9=f_L9(5:height+4,5:width+4);
f_L_u9=uint8(f_Last9);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
subplot(2,2,2),imshow(f_L_u3),title('3*3');
subplot(2,2,3),imshow(f_L_u5),title('5*5');
subplot(2,2,4),imshow(f_L_u9),title('9*9');
```

实验结果：

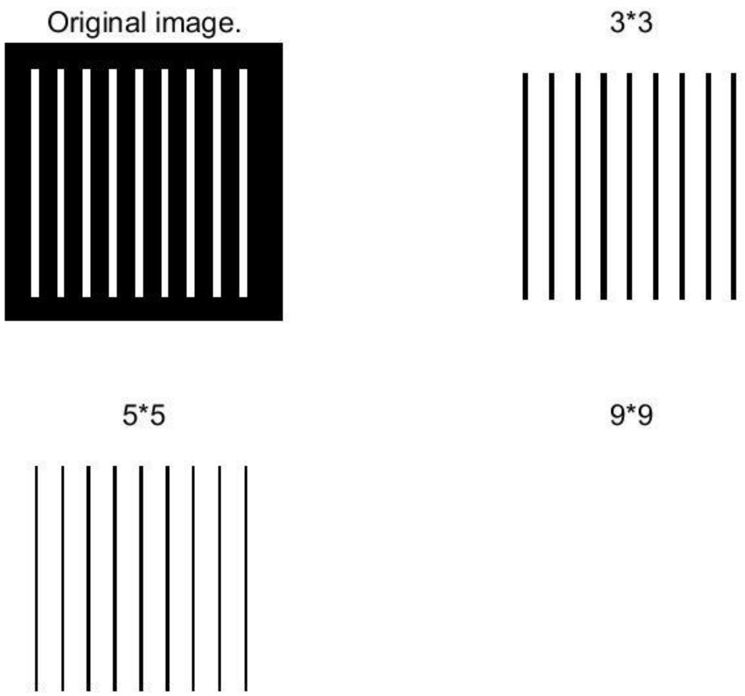


图 2

2.2、代码：

```
clc,clear;
close all;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f0=zeros(256,256);%Produce original image.
[height,width]=size(f0);
f0(25:234,[25:31,49:55,73:79,97:103,...
    121:127,145:151,169:175,193:199,217:223])=255*ones(210,63);
f=double(uint8(f0));
figure,subplot(2,2,1),imshow(uint8(f)),title('Original image.');
```

```
Q=-1.5;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r33=[f(:,1:4),f,f(:,width-3:width)];
f_d_r3=[f_d_r33(1:4,:);f_d_r33;f_d_r33(height-3:height,:)];
N3=3;
f_L3=f_d_r3;
for i=1:height
    for j=1:width
        s3=sum(sum(f_d_r3(i:i+2,j:j+2).^(Q+1)));
        s33=sum(sum(f_d_r3(i:i+2,j:j+2).^Q));
        f_L3(i+(N3-1)/2,j+(N3-1)/2)=s3/s33;
    end
end
f_Last3=f_L3(2:height+1,2:width+1);
f_L_u3=uint8(f_Last3);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r55=[f(:,1:4),f,f(:,width-3:width)];
f_d_r5=[f_d_r55(1:4,:);f_d_r55;f_d_r55(height-3:height,:)];
N5=5;
f_L5=f_d_r5;
for i=1:height
    for j=1:width
        s5=sum(sum(f_d_r5(i:i+4,j:j+4).^(Q+1)));
        s55=sum(sum(f_d_r5(i:i+4,j:j+4).^Q));
        f_L5(i+(N5-1)/2,j+(N5-1)/2)=s5/s55;
    end
end
f_Last5=f_L5(3:height+2,3:width+2);
f_L_u5=uint8(f_Last5);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r99=[f(:,1:4),f,f(:,width-3:width)];
f_d_r9=[f_d_r99(1:4,:);f_d_r99;f_d_r99(height-3:height,:)];
N9=9;
f_L9=f_d_r9;
for i=1:height
    for j=1:width
        s9=sum(sum(f_d_r9(i:i+8,j:j+8).^(Q+1)));
        s99=sum(sum(f_d_r9(i:i+8,j:j+8).^Q));
        f_L9(i+(N9-1)/2,j+(N9-1)/2)=s9/s99;
    end
end
```

```
f_Last9=f_L9(5:height+4,5:width+4);
f_L_u9=uint8(f_Last9);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
subplot(2,2,2),imshow(f_L_u3),title('3*3');
subplot(2,2,3),imshow(f_L_u5),title('5*5');
subplot(2,2,4),imshow(f_L_u9),title('9*9');
```

实验结果：

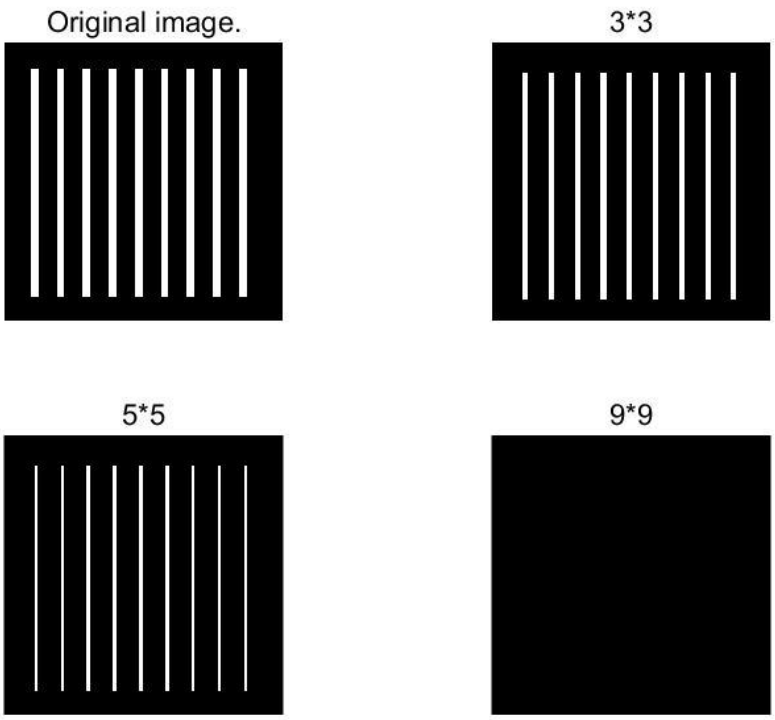


图 3

2.3、代码：

```
clc,clear;
close all;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f0=zeros(256,256);%Produce original image.
[height,width]=size(f0);
f0(25:234,[25:31,49:55,73:79,97:103,...
    121:127,145:151,169:175,193:199,217:223])=255*ones(210,63);
f=double(uint8(f0));
figure,subplot(2,2,1),imshow(uint8(f)),title('Original image.');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r33=[f(:,1:4),f,f(:,width-3:width)];
```

```
f_d_r3=[f_d_r33(1:4,:);f_d_r33;f_d_r33(height-3:height,:)];
N3=3;
f_L3=f_d_r3;
for i=1:height
    for j=1:width
        s3=max(max(f_d_r3(i:i+2,j:j+2)));
        f_L3(i+(N3-1)/2,j+(N3-1)/2)=s3;
    end
end
f_Last3=f_L3(2:height+1,2:width+1);
f_L_u3=uint8(f_Last3);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r55=[f(:,1:4),f,f(:,width-3:width)];
f_d_r5=[f_d_r55(1:4,:);f_d_r55;f_d_r55(height-3:height,:)];
N5=5;
f_L5=f_d_r5;
for i=1:height
    for j=1:width
        s5=max(max(f_d_r5(i:i+4,j:j+4)));
        f_L5(i+(N5-1)/2,j+(N5-1)/2)=s5;
    end
end
f_Last5=f_L5(3:height+2,3:width+2);
f_L_u5=uint8(f_Last5);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r99=[f(:,1:4),f,f(:,width-3:width)];
f_d_r9=[f_d_r99(1:4,:);f_d_r99;f_d_r99(height-3:height,:)];
N9=9;
f_L9=f_d_r9;
for i=1:height
    for j=1:width
        s9=sum(sum(f_d_r9(i:i+8,j:j+8)));
        f_L9(i+(N9-1)/2,j+(N9-1)/2)=s9;
    end
end
f_Last9=f_L9(5:height+4,5:width+4);
f_L_u9=uint8(f_Last9);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
subplot(2,2,2),imshow(f_L_u3),title('3*3');
subplot(2,2,3),imshow(f_L_u5),title('5*5');
subplot(2,2,4),imshow(f_L_u9),title('9*9');
```

实验结果：

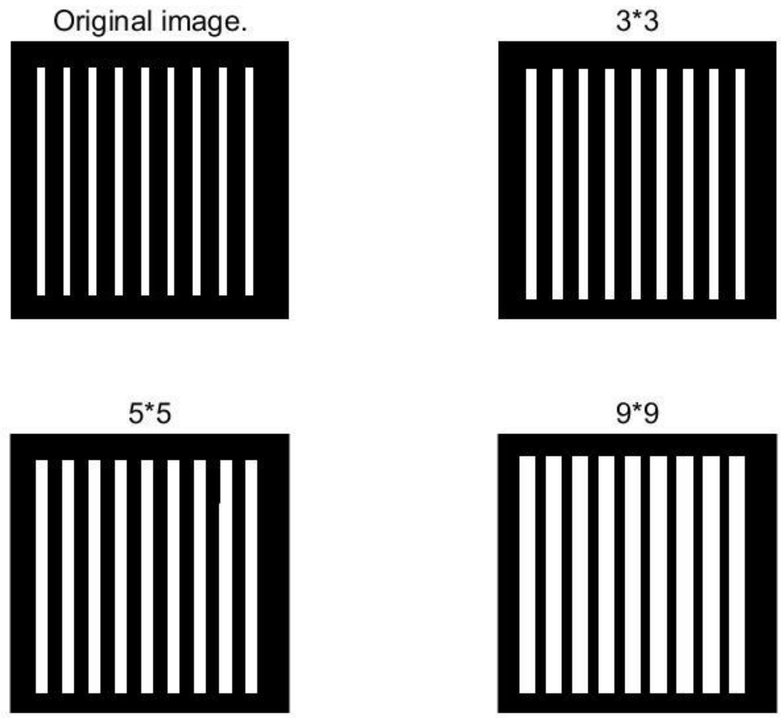


图 4

2.4、代码：

```
clc,clear;
close all;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f0=zeros(256,256);%Produce original image.
[height,width]=size(f0);
f0(25:234,[25:31,49:55,73:79,97:103,...
    121:127,145:151,169:175,193:199,217:223])=255*ones(210,63);
f=double(uint8(f0));
figure,subplot(2,2,1),imshow(uint8(f)),title('Original image.');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r33=[f(:,1:4),f,f(:,width-3:width)];
f_d_r3=[f_d_r33(1:4,:);f_d_r33;f_d_r33(height-3:height,:)];
N3=3;
f_L3=f_d_r3;
for i=1:height
    for j=1:width
        s3=max(max(f_d_r3(i:i+2,j:j+2)));
        s33=min(min(f_d_r3(i:i+2,j:j+2)));
```

```
        f_L3(i+(N3-1)/2,j+(N3-1)/2)=1/2*(s3+s33);
    end
end
f_Last3=f_L3(2:height+1,2:width+1);
f_L_u3=uint8(f_Last3);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r55=[f(:,1:4),f,f(:,width-3:width)];
f_d_r5=[f_d_r55(1:4,:);f_d_r55;f_d_r55(height-3:height,:)];
N5=5;
f_L5=f_d_r5;
for i=1:height
    for j=1:width
        s5=max(max(f_d_r5(i:i+4,j:j+4)));
        s55=min(min(f_d_r5(i:i+4,j:j+4)));
        f_L5(i+(N5-1)/2,j+(N5-1)/2)=1/2*(s5+s55);
    end
end
f_Last5=f_L5(3:height+2,3:width+2);
f_L_u5=uint8(f_Last5);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_d_r99=[f(:,1:4),f,f(:,width-3:width)];
f_d_r9=[f_d_r99(1:4,:);f_d_r99;f_d_r99(height-3:height,:)];
N9=9;
f_L9=f_d_r9;
for i=1:height
    for j=1:width
        s9=sum(sum(f_d_r9(i:i+8,j:j+8)));
        s99=sum(sum(f_d_r9(i:i+8,j:j+8)));
        f_L9(i+(N9-1)/2,j+(N9-1)/2)=1/2*(s9+s99);
    end
end
f_Last9=f_L9(5:height+4,5:width+4);
f_L_u9=uint8(f_Last9);%8 bit image data.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
subplot(2,2,2),imshow(f_L_u3),title('3*3');
subplot(2,2,3),imshow(f_L_u5),title('5*5');
subplot(2,2,4),imshow(f_L_u9),title('9*9');
```

实验结果：

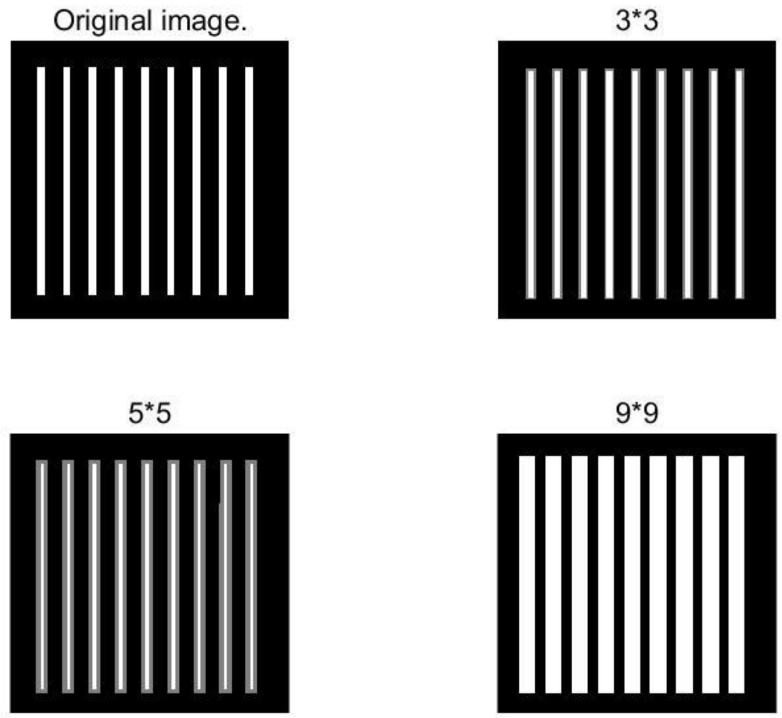


图 5

3、代码：

```
clc,clear;
close all;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
f_u=imread('cameraman.tif');
[height,width]=size(f_u);
f_d=double(f_u);
figure,subplot(2,2,2),imshow(f_u),title('Original image.');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
h=fspecial('motion',100,-45);
h_d=mat2gray(h).*255;
h_u=uint8(mat2gray(h_d)*255);
f_motion=imfilter(f_d,h,'replicate','same');
subplot(2,2,[1,3]),imshow(h_u),title('h');
subplot(2,2,4),imshow(uint8(mat2gray(f_motion)*255)),...
    title('Filtering result.');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
a=50*sqrt(2);%50*sqrt(2)
b=50*sqrt(2);
T=1;
```

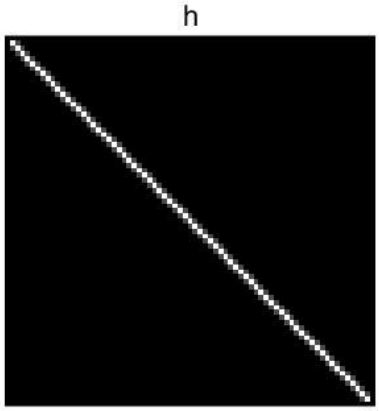
```
[U,V]=dftuv(height,width,height,width);
H=T.*sin(pi*(U*a+V*b))./...
          (pi.*(U*a+V*b)).*exp(complex(0,-1).*pi.*(U*a+V*b));
H_shift=fftshift(H);
H_u=uint8(mat2gray(abs(H_shift))*255);
[m,n]=find(isnan(H_shift)==1);
H_shift(isnan(H_shift)==1)=zeros(size(m));
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
%H_text=fft2(h,256,256);
%H_shift=fftshift(H_text);
%H_text_u=uint8(mat2gray(abs(H_text))*255);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
F=fft2(f_d,height,width);
F_shift=fftshift(F);
G=F_shift.*H_shift;
G_ifftshift=ifftshift(G);
g_d=real(ifft2(G_ifftshift));
g_u=uint8(mat2gray(g_d)*255);
figure,subplot(2,2,2),imshow(f_u),title('Original image.');
subplot(2,2,[1,3]),imshow(H_u),title('H_u');
subplot(2,2,4),imshow(g_u),title('Filtering result.');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
```

dtfuv:

```
function [U,V]=dftuv(M,N,height,width)

u = 0:(M - 1);
v = 0:(N - 1);
idx = find(u > M/2); %找大于 M/2 的数据
u(idx) = u(idx) - M; %将大于 M/2 的数据减去 M
idy = find(v > N/2);
v(idy) = v(idy) - N;
[V, U] = meshgrid(1/height.*v,1/width.* u);
end
```

实验结果：



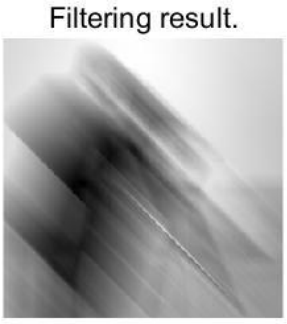
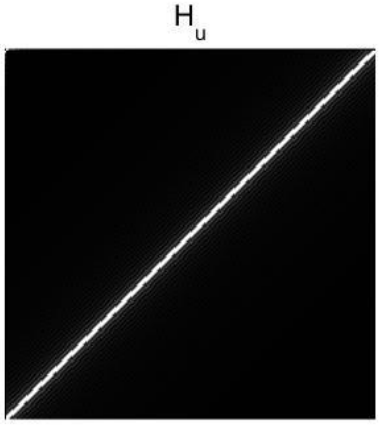


图 6 h



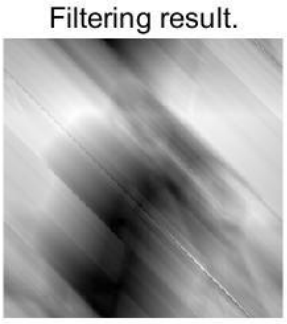


图 7 H

4、代码：

```
clc,clear;
```

```
close all;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
f_u=imread('cameraman.tif');
[height,width]=size(f_u);
f_d=double(f_u);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Produce degraded image.
T=1;
a=50*sqrt(2);%50*sqrt(2)
b=50*sqrt(2);
[U,V]=dftuv(height,width,height,width);
H=T.*sin(pi*(U*a+V*b))./...
            (pi.*(U*a+V*b)).*exp(complex(0,-1).*pi.*(U*a+V*b));
H_shift=fftshift(H);
H_u=uint8(mat2gray(abs(H_shift))*255);
[m,n]=find(isnan(H_shift)==1);
H_shift(isnan(H_shift)==1)=ones(size(m));
H_shift_u=uint8(mat2gray(abs(H_shift))*255);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
F=fft2(f_d);
F_shift=fftshift(F);
G=F_shift.*H_shift;
G_ifftshift=ifftshift(G);
g_d=real(ifft2(G_ifftshift));
g_u=uint8(mat2gray(g_d)*255);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Produce noise&superposition.
r=normrnd(0.01,0.02,height,width).*255;%Produce gaussian white noise.
g_d_noise=g_d+r;
g_u_noise=uint8(mat2gray(g_d_noise)*255);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
figure,subplot(2,2,1),imshow(f_u),title('Original image.');
subplot(2,2,2),imshow(H_shift_u),title('Filter,H.');
subplot(2,2,3),imshow(g_u),title('Degrade image.');
subplot(2,2,4),imshow(g_u_noise),title('Degraded image with noise.');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%The recover of degraded image with noise.
G2=fft2(g_d_noise);
G2_fftshift=fftshift(G2);
F2_shift=G2_fftshift./H_shift;
F2_ifftshift=ifftshift(F2_shift);
f2_d=real(ifft2(F2_ifftshift));
f2_u=uint8(mat2gray(f2_d)*255);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
figure,subplot(2,2,1),imshow(f_u),title('Original image.');
subplot(2,2,2),imshow(H_shift_u),title('Filter,H.');
subplot(2,2,3),imshow(g_u_noise),title('Degrade image with noise.');
subplot(2,2,4),imshow(f2_u),title({'The recover of degraded image',...
    'with noise.'});
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Produce frequency limited inverse filter.
H_shift_inverse_limited=zeros(height,width);
R=height/4;
centre=(height+1)/2;
H_shift_min=sqrt(min(min(abs(H_shift))));
for u=1:height
    for v=1:width
        if (u-centre)^2+(v-centre)^2<=R^2
            H_shift_inverse_limited(u,v)=H_shift(u,v);
        else
            H_shift_inverse_limited(u,v)=H_shift_min;
        end
    end
end
H_shift_inverse_limited_u=...
    uint8(mat2gray(abs(H_shift_inverse_limited))*255);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%The recover of degraded image with noise.
G3=fft2(g_d_noise);
G3_fftshift=fftshift(G3);
F3_shift=G3_fftshift./H_shift_inverse_limited;
F3_ifftshift=ifftshift(F3_shift);
f3_d=real(ifft2(F3_ifftshift));
f3_u=uint8(mat2gray(f3_d)*255);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
figure,subplot(2,2,1),imshow(f_u),title('Original image.');
subplot(2,2,2),imshow(H_shift_inverse_limited_u),title('Filter,H.');
subplot(2,2,3),imshow(g_u_noise),title('Degrade image with noise.');
subplot(2,2,4),imshow(f3_u),title({'The recover of degraded image',...
    'with noise.'});
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
G4=fft2(g_d_noise);
G4_fftshift=fftshift(G4);
H_shift_conj=conj(H_shift);
H_shift_abs=abs(H_shift);
K1=0.01;
F4_shift=(H_shift_conj./(H_shift_abs.^2+K1)).*G4_fftshift;
F4_ifftshift=ifftshift(F4_shift);
```

```
f4_d=real(ifft2(F4_ifftshift));
f4_u=uint8(mat2gray(f4_d)*255);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
G5=fft2(g_d_noise);
G5_fftshift=fftshift(G5);
K2=0.02;
F5_shift=(H_shift_conj./(H_shift_abs.^2+K2)).*G5_fftshift;
F5_ifftshift=ifftshift(F5_shift);
f5_d=real(ifft2(F5_ifftshift));
f5_u=uint8(mat2gray(f5_d)*255);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
figure,subplot(2,2,1),imshow(f_u),title('Original image.');
subplot(2,2,2),imshow(g_u_noise),title('Degrade image with noise.');
subplot(2,2,3),imshow(f4_u),title({'The recover of degraded image',...
    'with noise.','K=0.01'});
subplot(2,2,4),imshow(f5_u),title({'The recover of degraded image',...
    'with noise.','K=0.02'});
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

dtfuv:

```
function [U,V]=dftuv(M,N,height,width)

u = 0:(M - 1);
v = 0:(N - 1);
idx = find(u > M/2); %找大于 M/2 的数据
u(idx) = u(idx) - M; %将大于 M/2 的数据减去 M
idy = find(v > N/2);
v(idy) = v(idy) - N;
[V, U] = meshgrid(1/height.*v,1/width.* u);
end
```

实验结果：

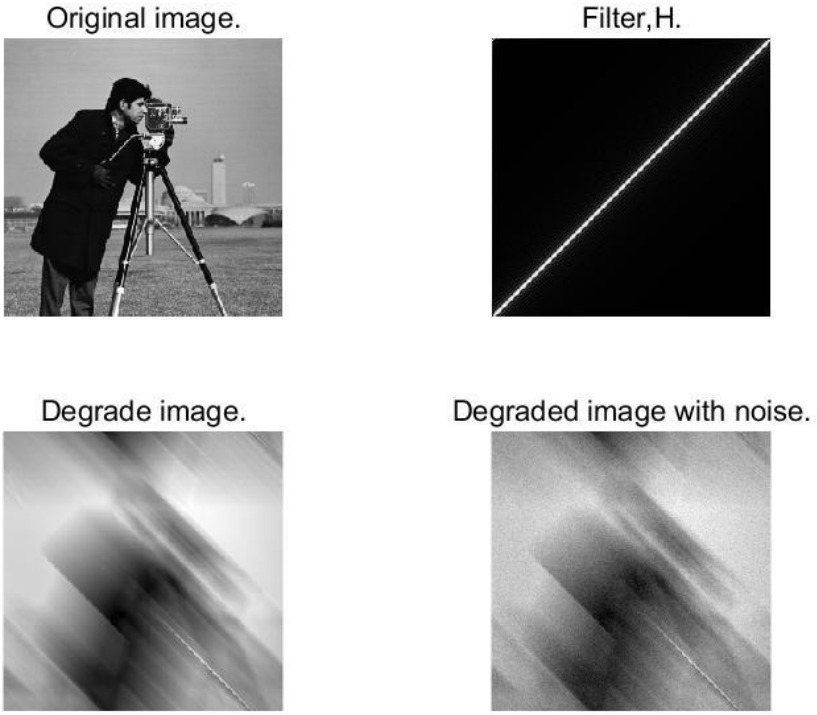


图 8

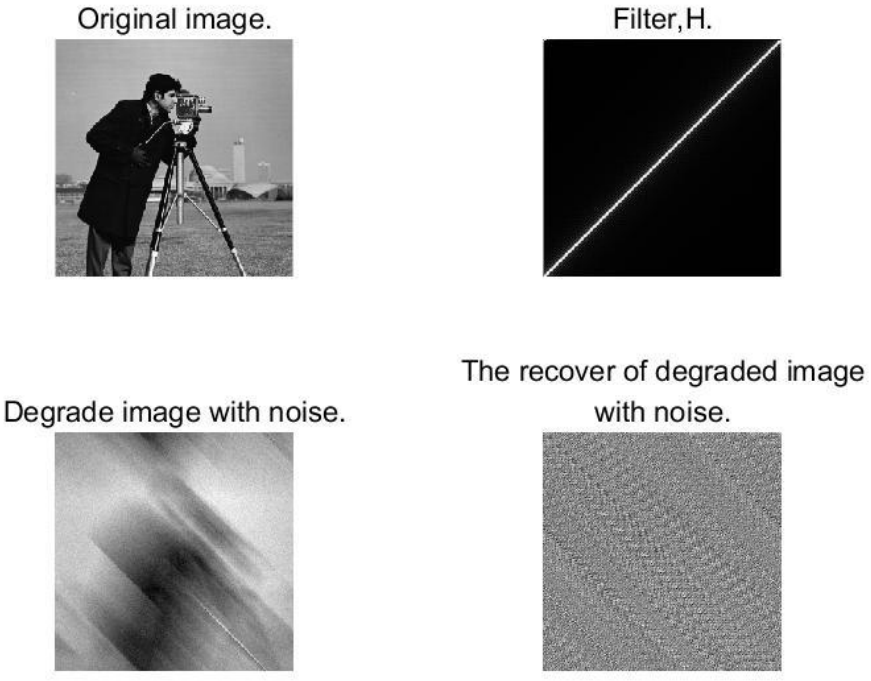


图 9 Inverse filter

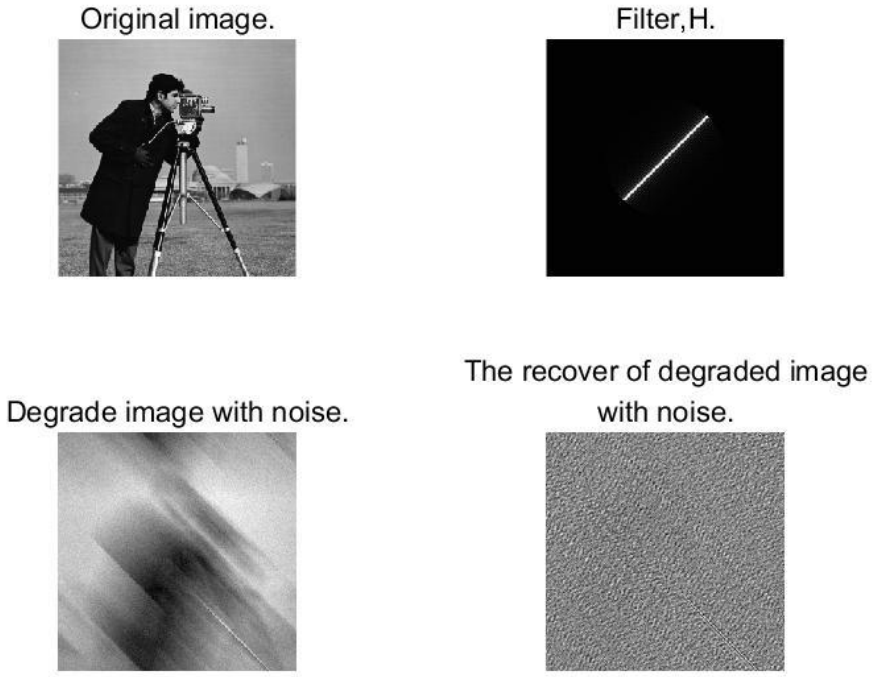


图 10 Frequency limited inverse filter

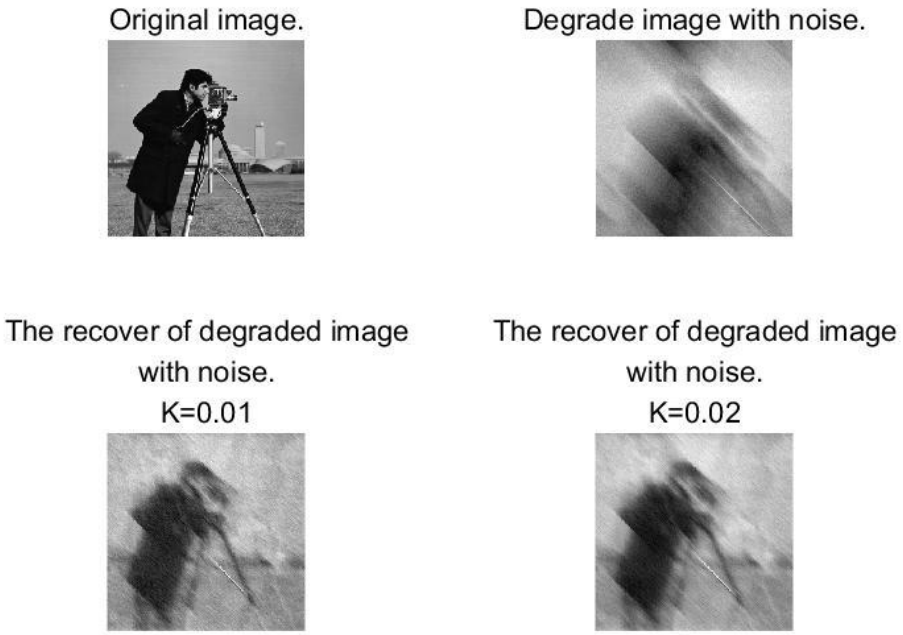


图 11 Wiener filtering