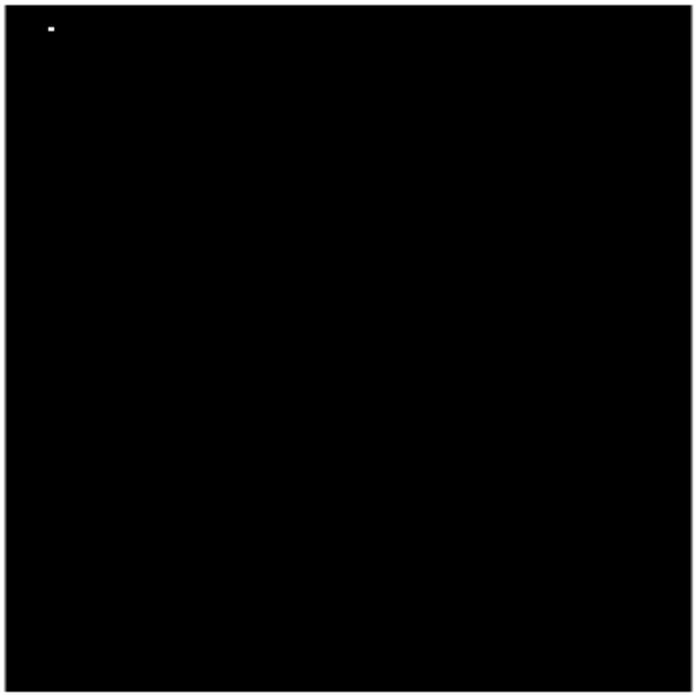
# lab1 - Pietro Alovisi

### Setup

```
% add path containing lab files
addpath('../LabFiles/Functions/');
addpath('../LabFiles/Images/');
addpath('../LabFiles/Images-m/');
```

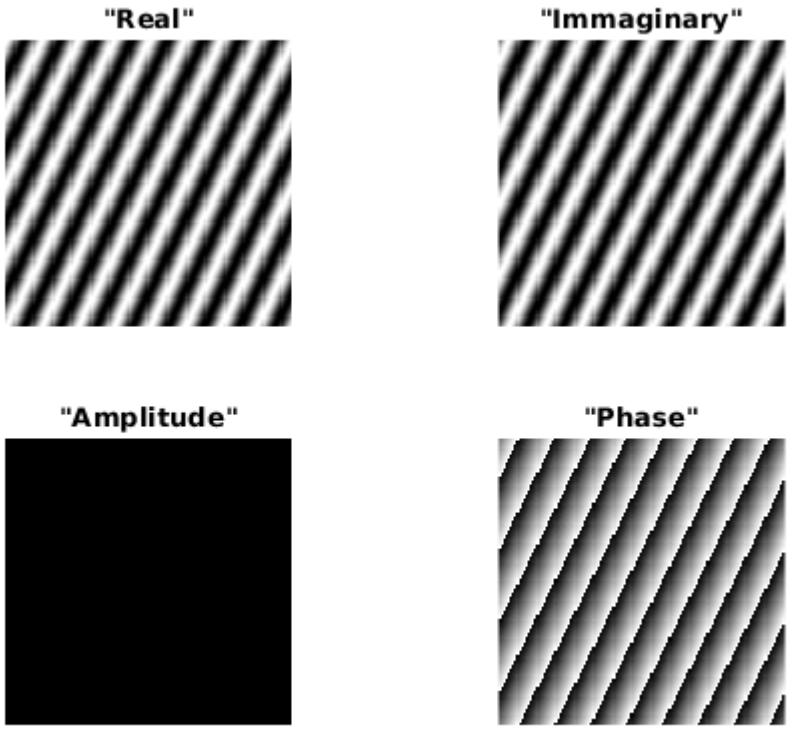
# Descrete Fourier transform

```
Fhat = zeros(128, 128);

p = 5;
q = 9;
Fhat(p , q ) = 1;
figure(1);
showgrey(Fhat);
```

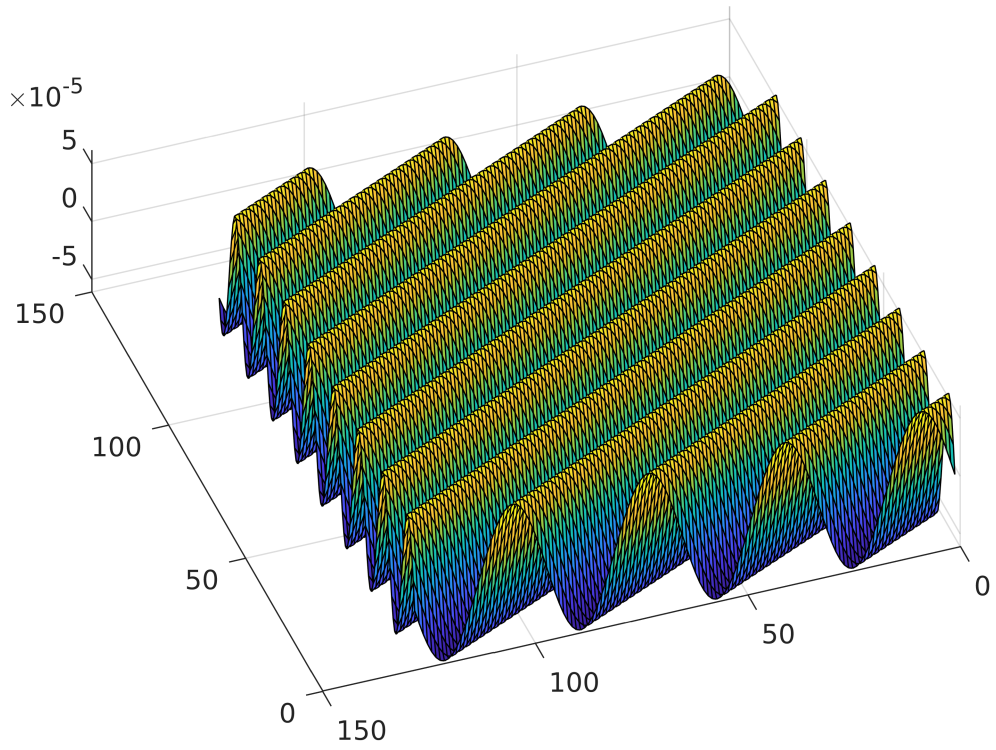


```


F = ifft2(Fhat);
Fabsmax = max(abs(F(:)));
figure(2);
subplot(2,2,1);
```

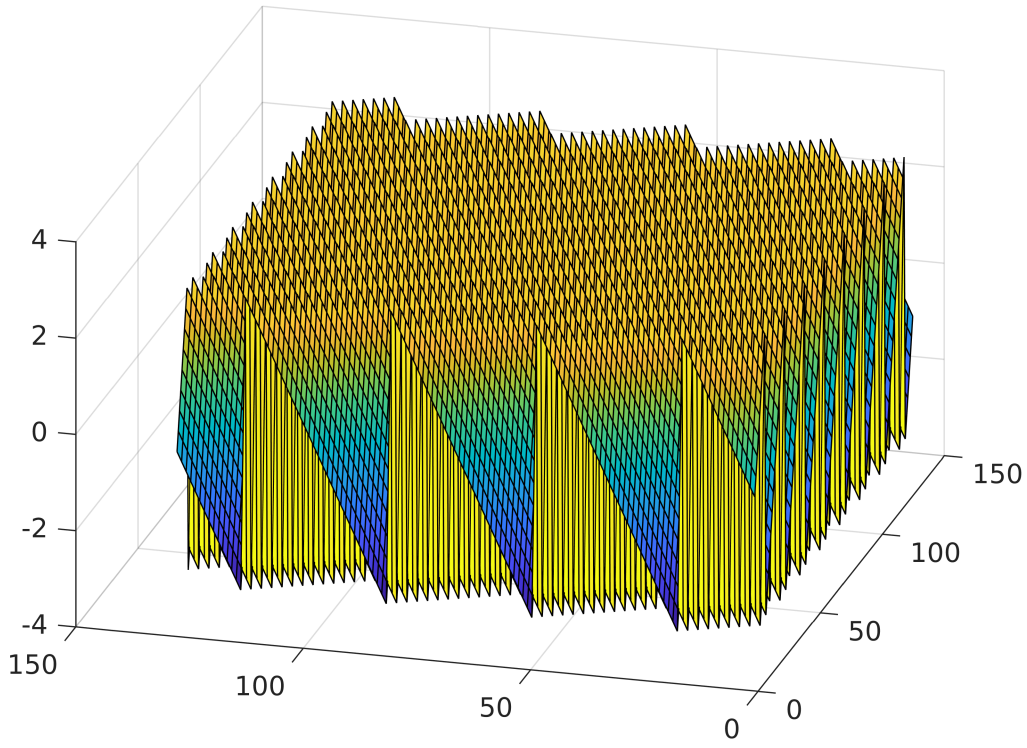
```
showgrey(real(F), 64, -Fabsmax, Fabsmax)
title "Real";

subplot(2,2,2);
showgrey(imag(F), 64, -Fabsmax, Fabsmax)
title "Immaginary";

subplot(2,2,3);
showgrey(log(abs(F)), 64, -Fabsmax, Fabsmax)
title "Amplitude";

subplot(2,2,4);
showgrey(angle(F), 64, -pi, pi)
title "Phase";
```




```
figure();
[X,Y]= meshgrid(1:128,1:128);
surf(X,Y,imag(F));

xlim([0 150])
ylim([0 150])
zlim([-0.0000610 0.0000610])
view([-109.9000000 71.6000000])
```

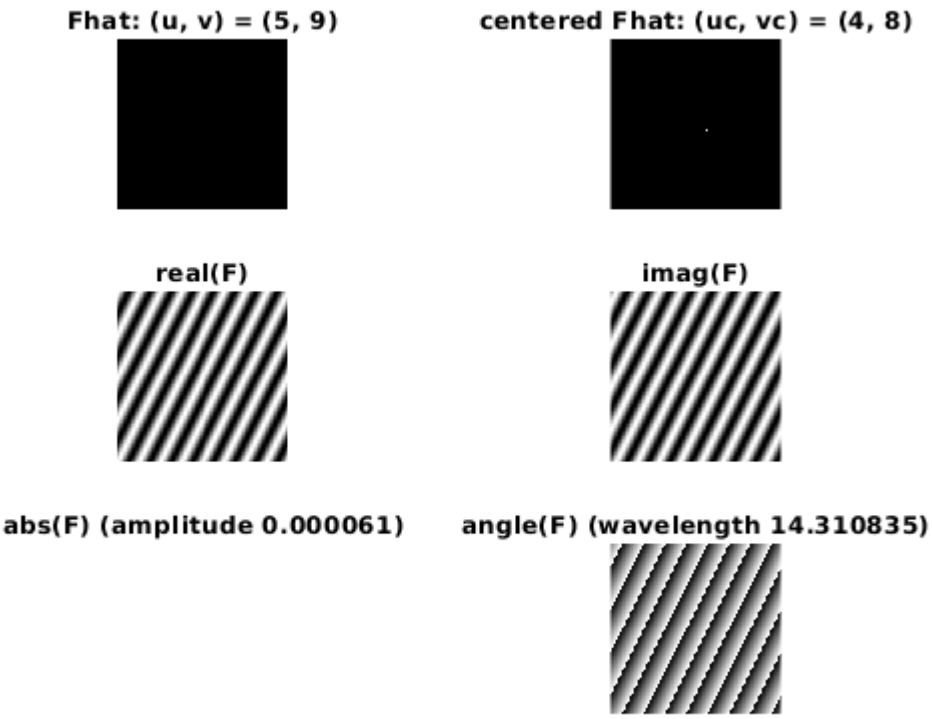



```
figure();
[X,Y]= meshgrid(1:128,1:128);
surf(X,Y,angle(F));

view([-74.70 32.40])
```




### Question 1

```
fftwave(5,9,128);
```

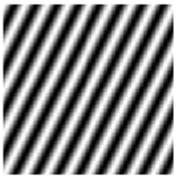



```
points = [5, 9; 9, 5; 17, 9; 17, 121;5, 1;125, 1];


for c =  1:size(points,1)
    figure();
    title(sprintf("Point %d, %d",points(c,1),points(c,2)));
    fftwave(points(c,1),points(c,2));
end
```

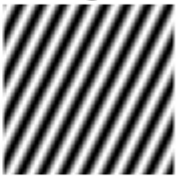
Fhat: (u, v) = (5, 9)

centered Fhat: (uc, vc) = (4, 8)

real(F)

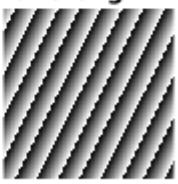


imag(F)



abs(F) (amplitude 0.000061)

angle(F) (wavelength 14.310835)



Fhat: (u, v) = (9, 5)

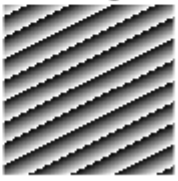
centered Fhat: (uc, vc) = (8, 4)

real(F)

imag(F)

abs(F) (amplitude 0.000061)

angle(F) (wavelength 14.310835)

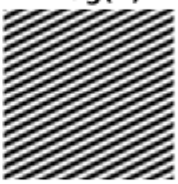


Fhat: (u, v) = (17, 9)

centered Fhat: (uc, vc) = (16, 8)

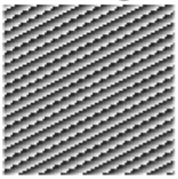
real(F)

imag(F)



abs(F) (amplitude 0.000061)

angle(F) (wavelength 7.155418)



Fhat: (u, v) = (17, 121)

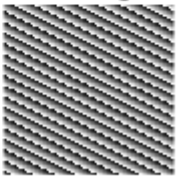
centered Fhat: (uc, vc) = (16, -8)

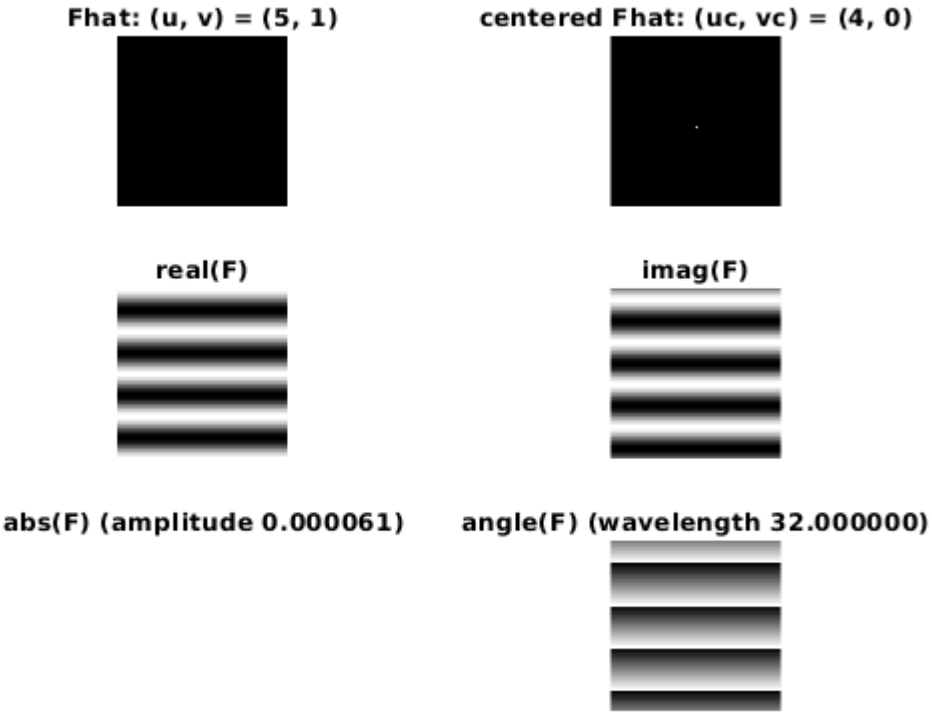
real(F)

imag(F)

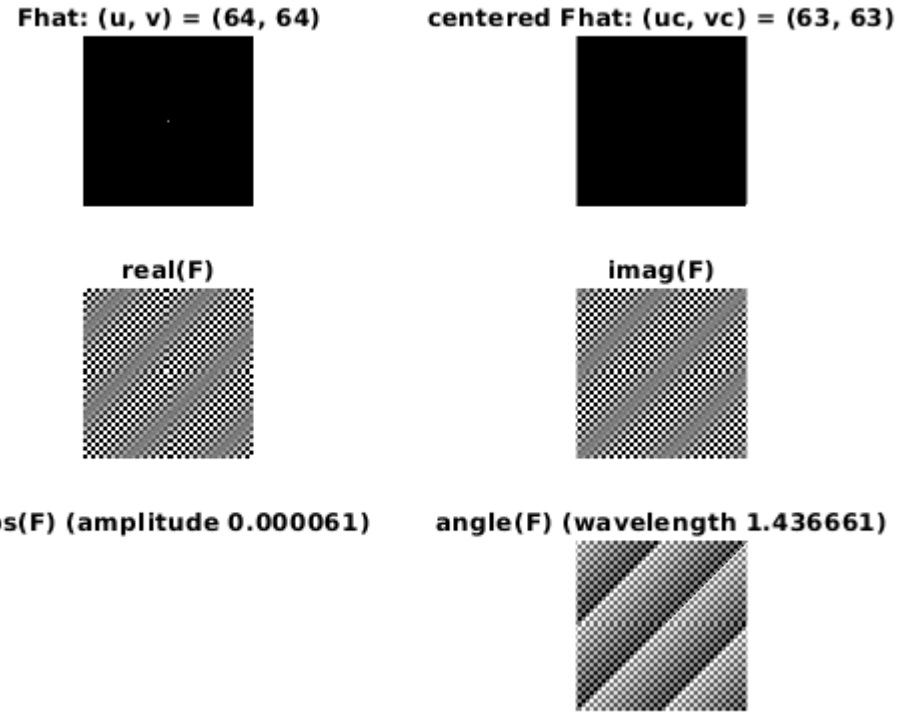
abs(F) (amplitude 0.000061)

angle(F) (wavelength 7.155418)






```
p = 64;
q = 64;
fftwave(p,q,128);
```

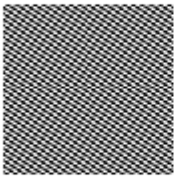



```
p = 100;
q = 20;
fftwave(p,q,128);
```

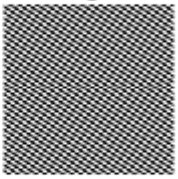
Fhat: (u, v) = (100, 20)

centered Fhat: (uc, vc) = (-29, 19)

real(F)

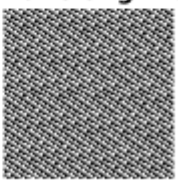


imag(F)



abs(F) (amplitude 0.000061)

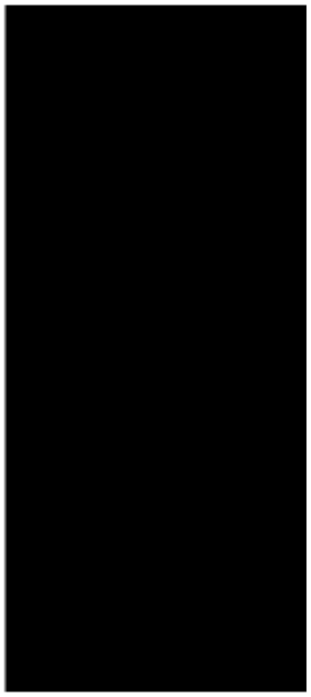
angle(F) (wavelength 3.691966)

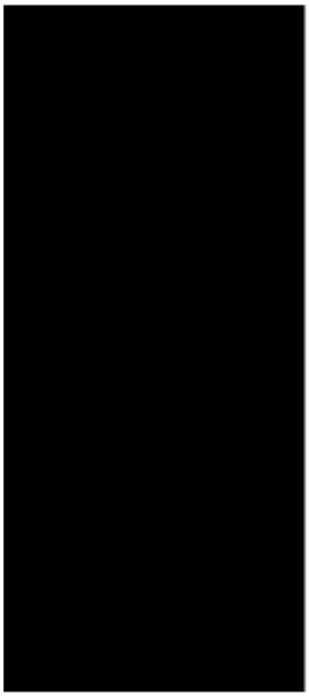


## Lienarity

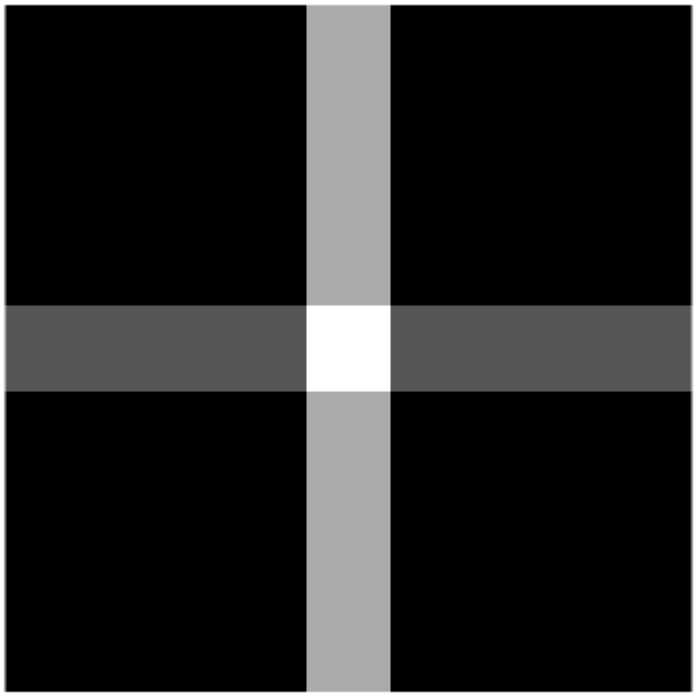
```
F = [ zeros(56, 128); ones(16, 128); zeros(56, 128)];
G = F';
H = F + 2 * G;

figure();
showgrey(F);
```

```
showgrey(G);
```

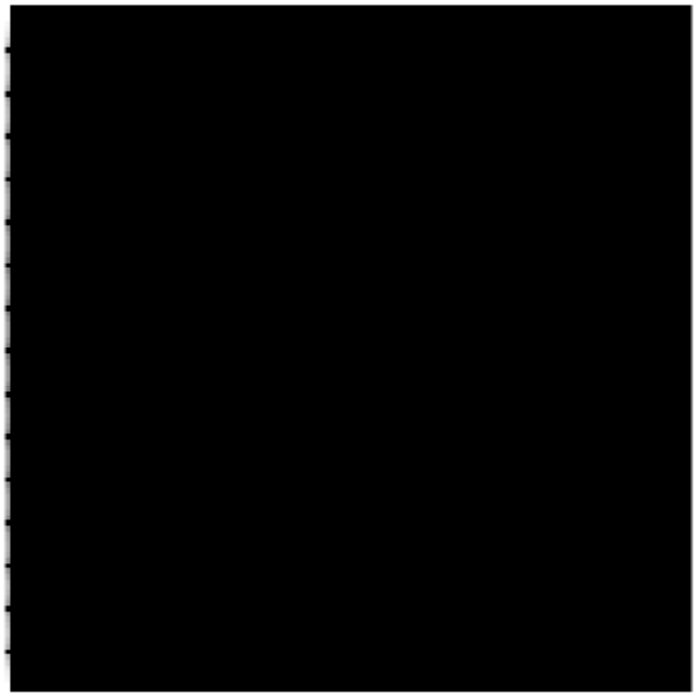




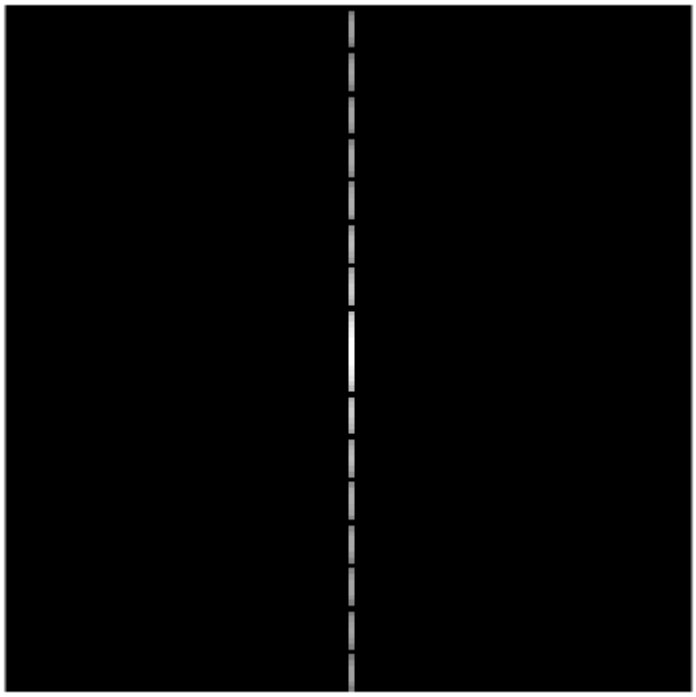
```
showgrey(H);
```



```
Fhat = fft2(F);
Ghat = fft2(G);
Hhat = fft2(H);

showgrey(log(1 + abs(Fhat)));
```

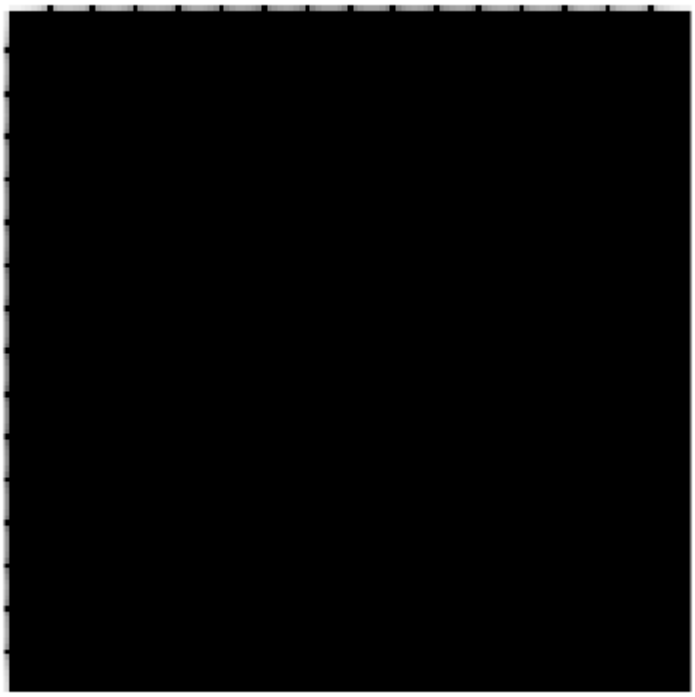


```
showgrey(log(1 + abs(fftshift(Fhat))));
```

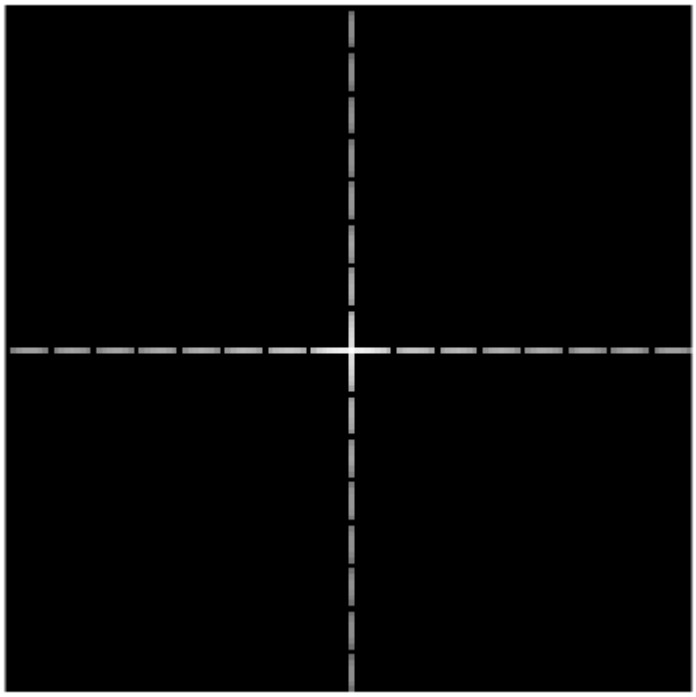


```
showgrey(log(1 + abs(fftshift(Ghat))));
```

```
showgrey(log(1 + abs(Hhat)));
```

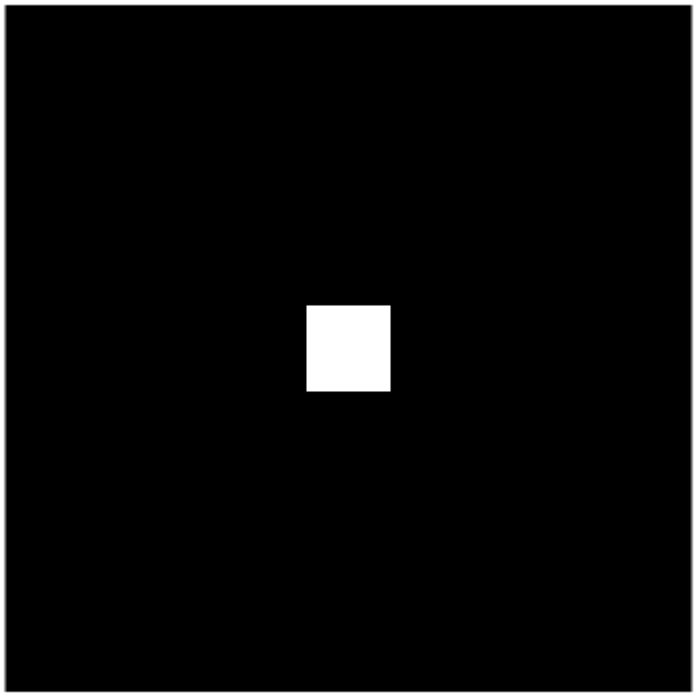


```
showgrey(log(1 + abs(fftshift(Hhat))));
```

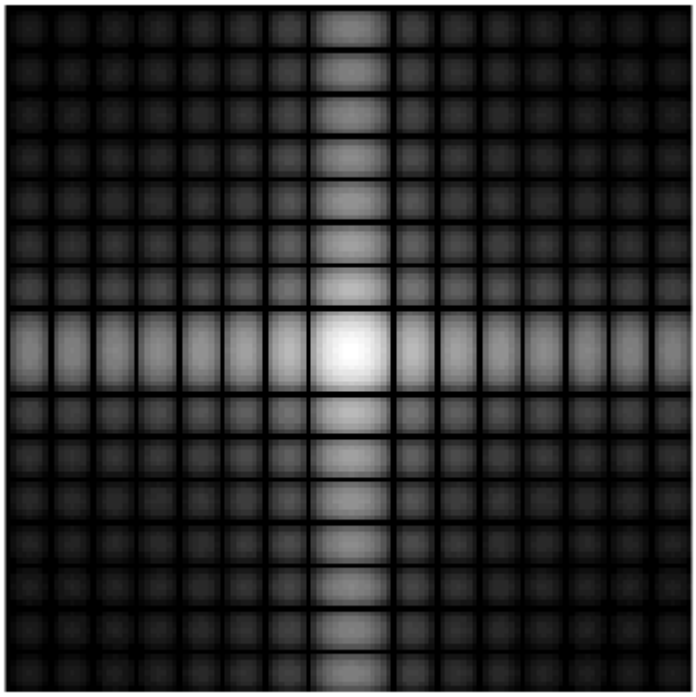


## Multiplication

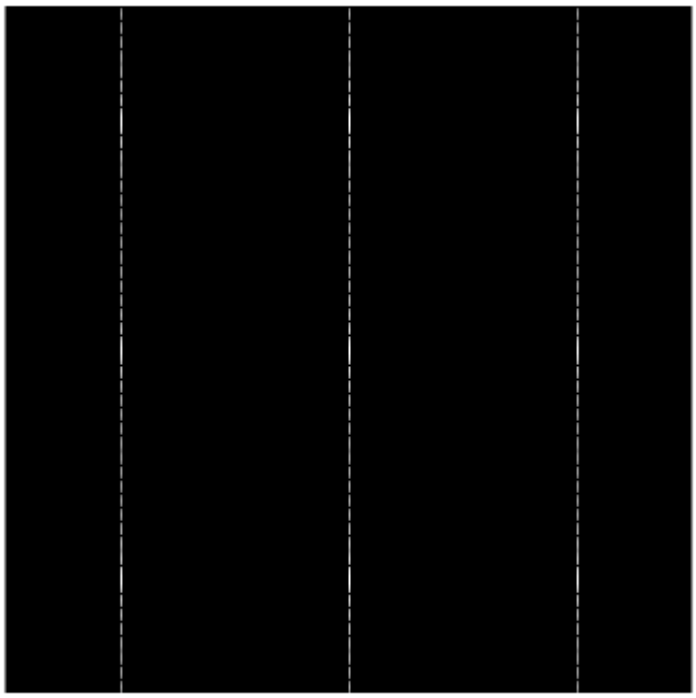
```
figure();
%With F and G as previously defined
F = [ zeros(56, 128); ones(16, 128); zeros(56, 128)];
G = F';
%Try the following commands
showgrey(F .* G);
```



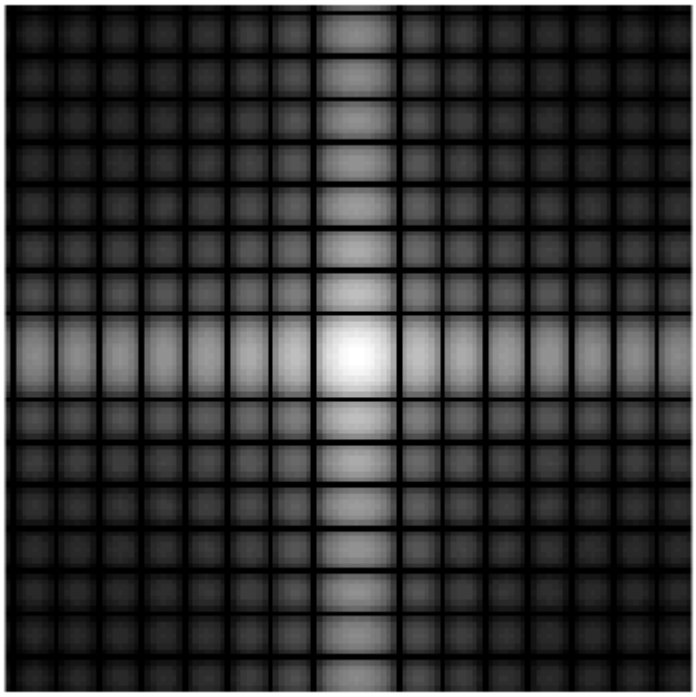
```
showfs(fft2(F .* G));
```



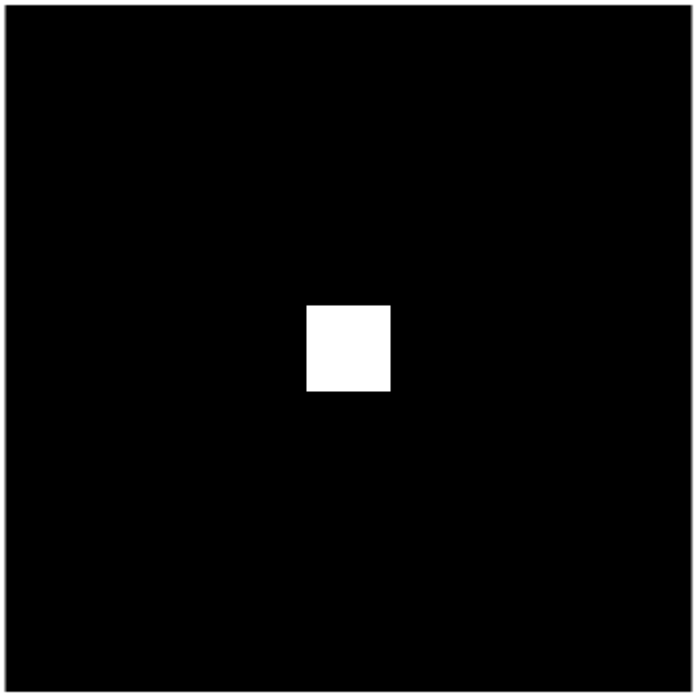
```
Fhat = fft2(F);
Ghat = fft2(G);

Fhat = [Fhat Fhat Fhat;
        Fhat Fhat Fhat;
        Fhat Fhat Fhat];

showfs(Fhat);
```



```
C = conv2(Fhat,Ghat,'valid');
% divide by a multiplicative factor to highlight the similarities
% betwee C and the original fourier transform
C = C(129:256,129:256)/10000;

showfs(C);
```

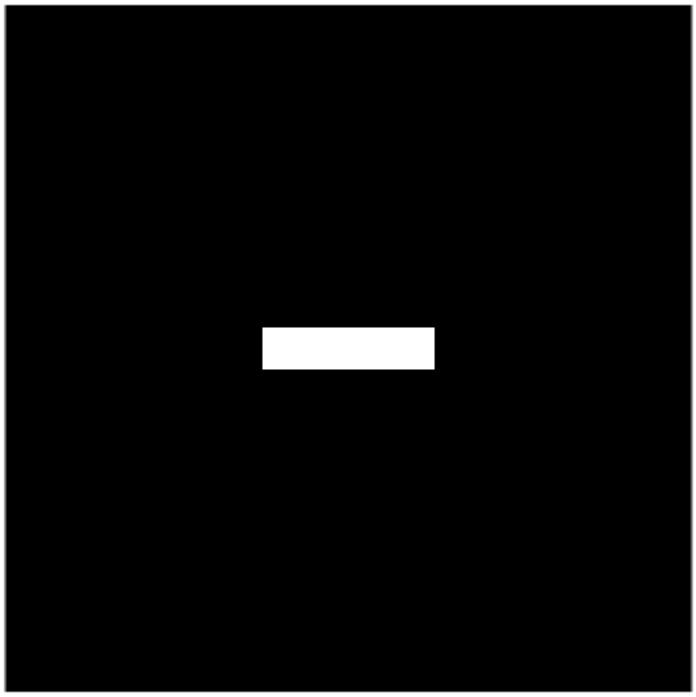


```
showgrey(abs(ifft2(C)));
```

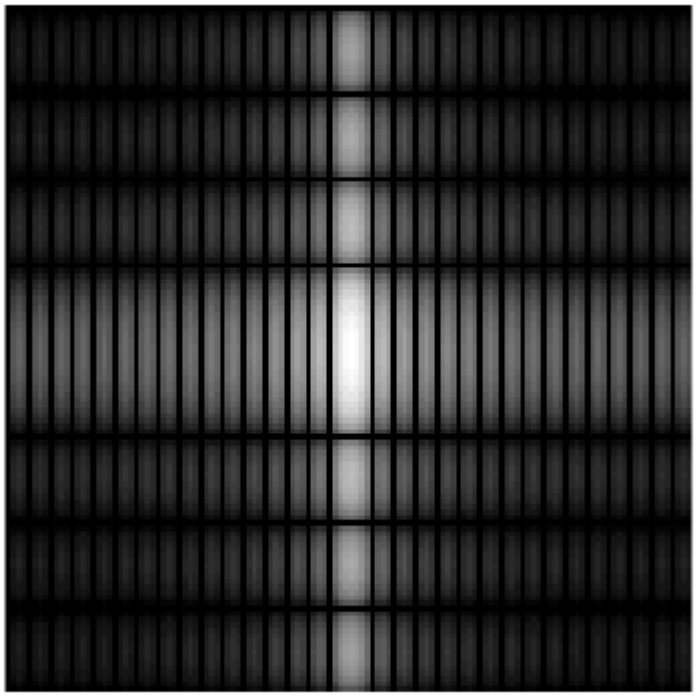


## Scaling

```
F = [zeros(60, 128); ones(8, 128); zeros(60, 128)] .* ...
[zeros(128, 48) ones(128, 32) zeros(128, 48)];

showgrey(F);
```

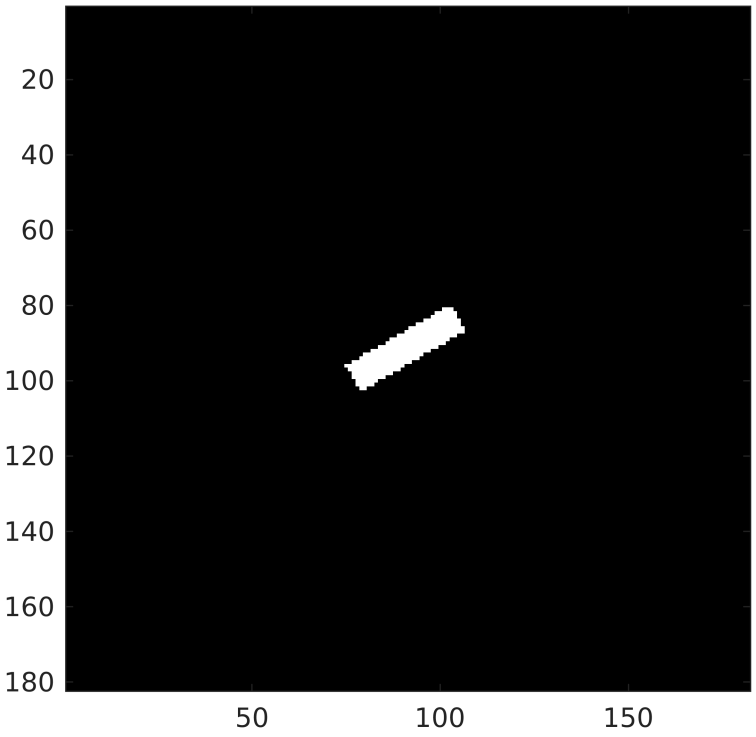


```
Fhat = fft2(F);
showfs(Fhat);
```

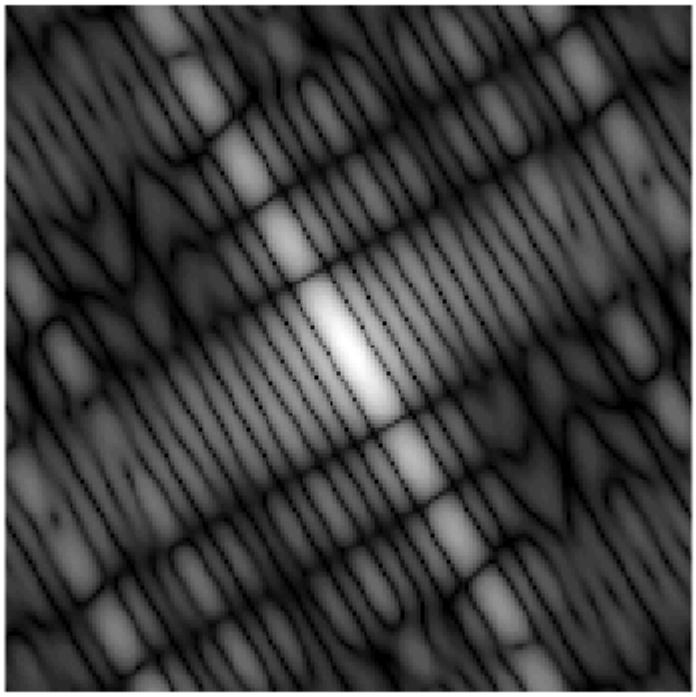


## Rotation

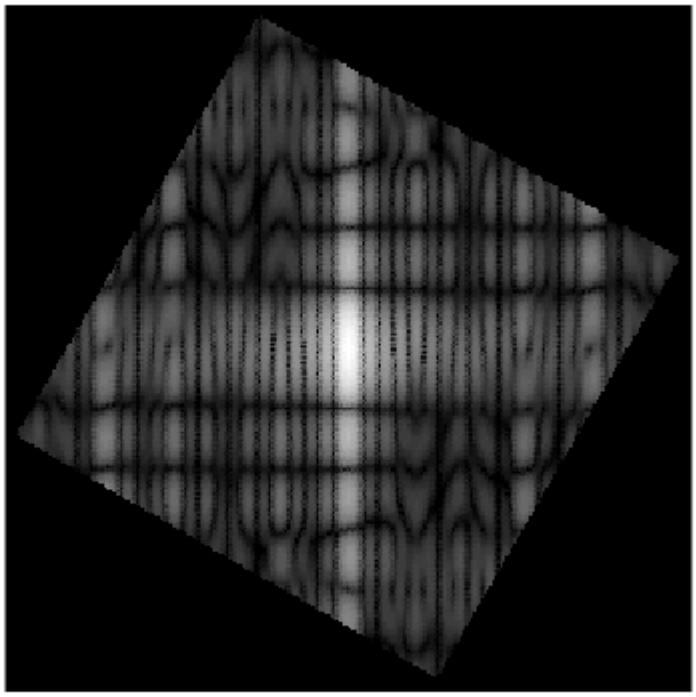
```
alpha = 30;

G = rot(F, alpha);
showgrey(G)
axis on
```




```
Ghat = fft2(G);
showfs(Ghat);
```



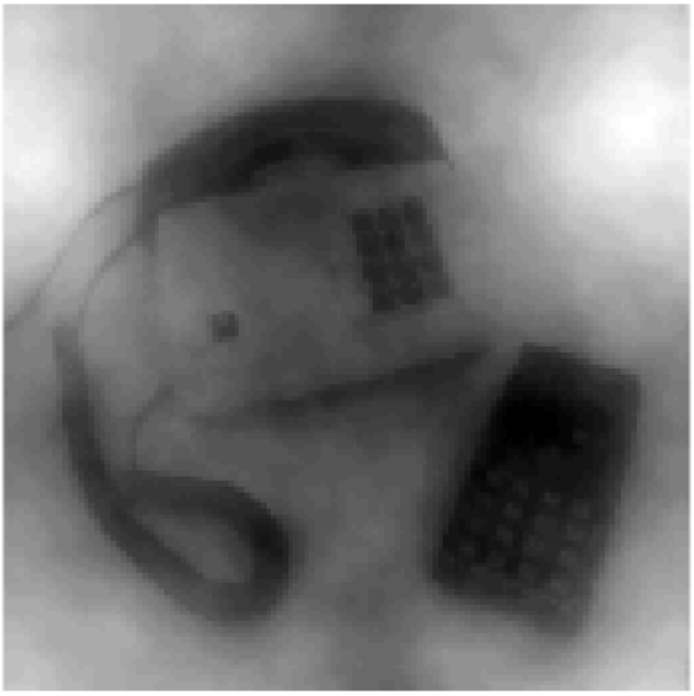
```
Hhat = rot(fftshift(Ghat), -alpha );
showgrey(log(1 + abs(Hhat)));
```



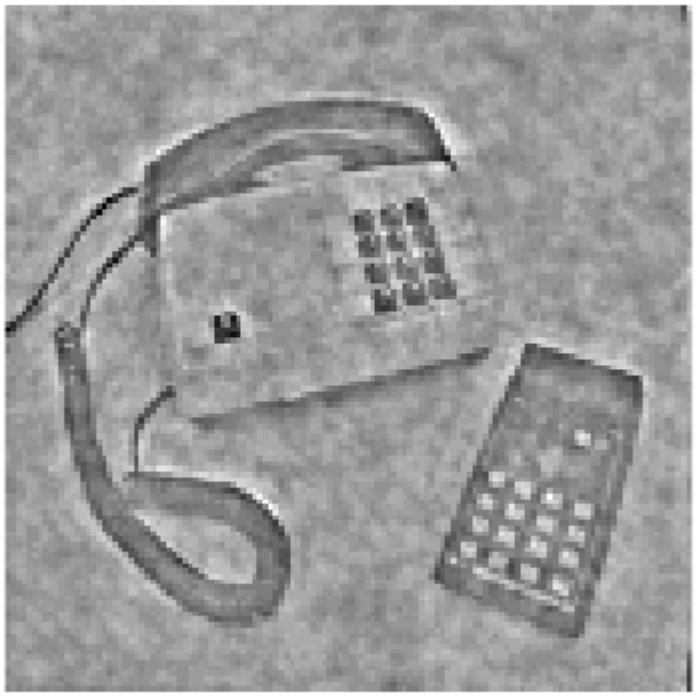
## Information in Fourier phase and magnitude

```
img = phonecalc128;
figure();
showgrey(img)
```

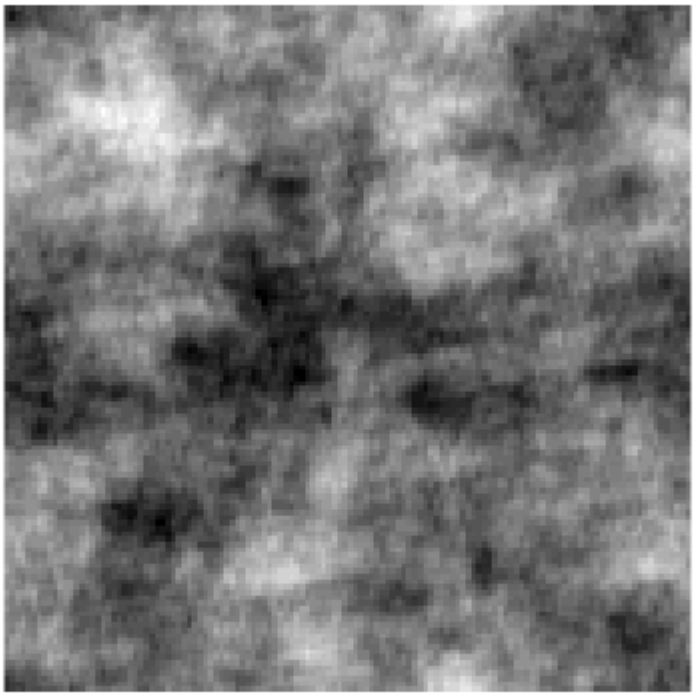
```
t_img = pow2image(img, 10e-10);
showgrey(t_img);
```



```
t_img = pow2image(img, 1);
showgrey(t_img);
```

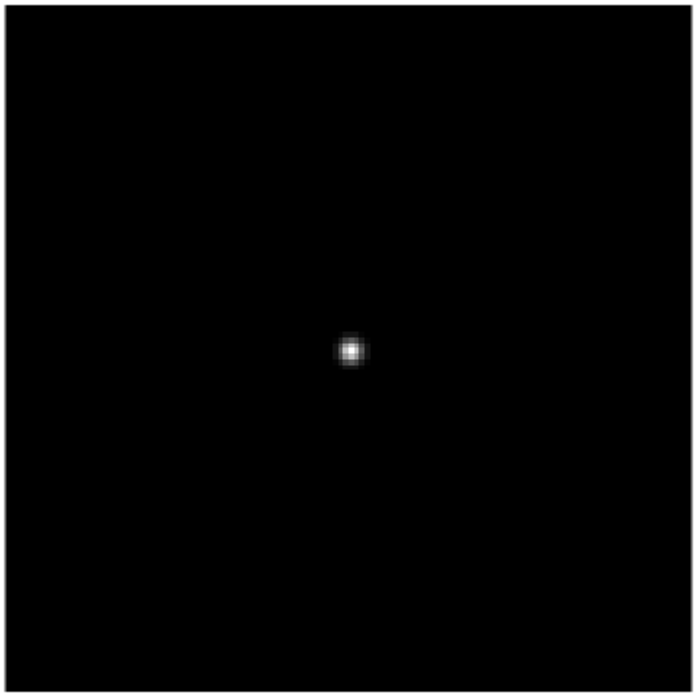


```
t_img = randphaseimage(img);
showgrey(t_img);
```



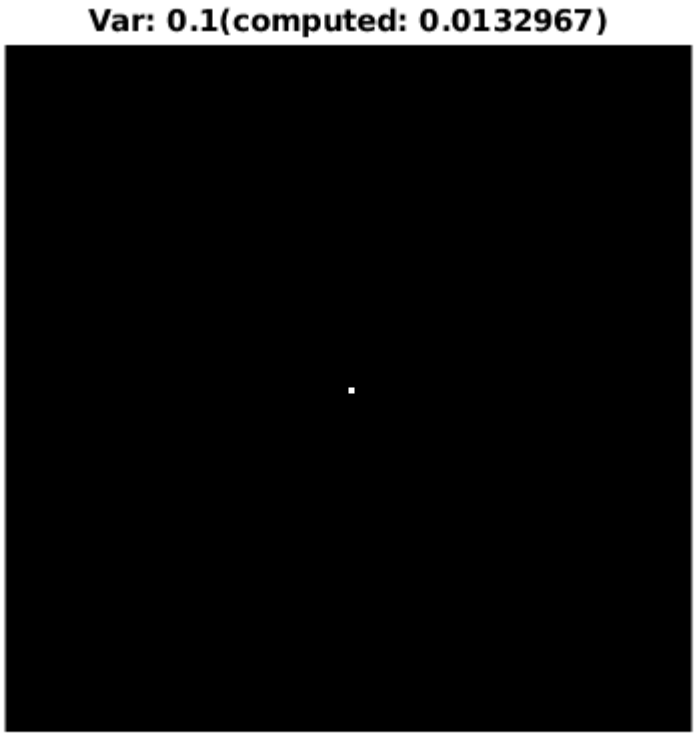
## Gaussian convolution implemented via FFT

```
figure();
psf = gaussfft(deltafcn(128, 128), 2);
showgrey(psf);
```

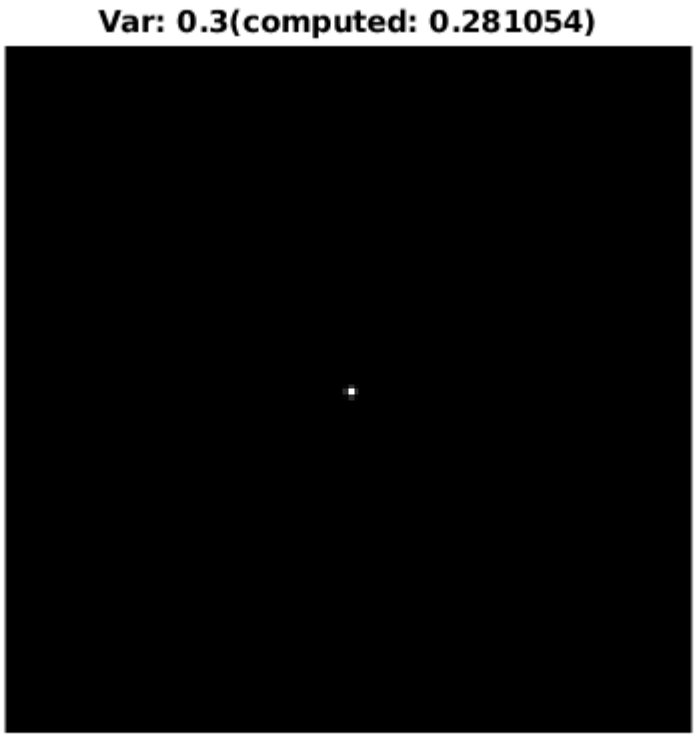


```
figure();
for t = [0.1,0.3,1.0,10.0]
    psf = gaussfft(deltafcn(128, 128), t);
    figure();
    showgrey(psf);
    v = variance(psf)
    title(sprintf('Var: %g(computed: %g)',t,v(1,1)));

end
```

```
v = 2×2
    0.0133    0.0000
    0.0000    0.0133
```

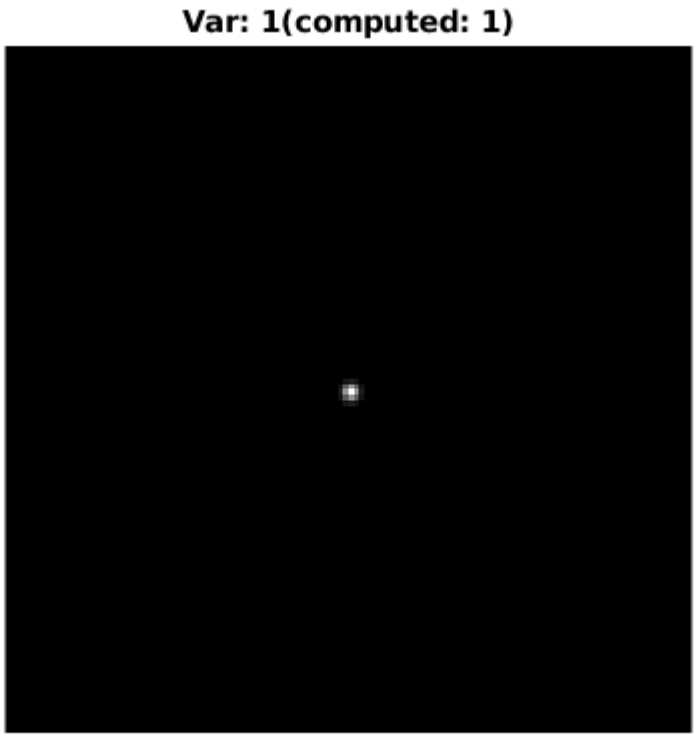



```
v = 2×2
    0.2811    0.0000
    0.0000    0.2811
```

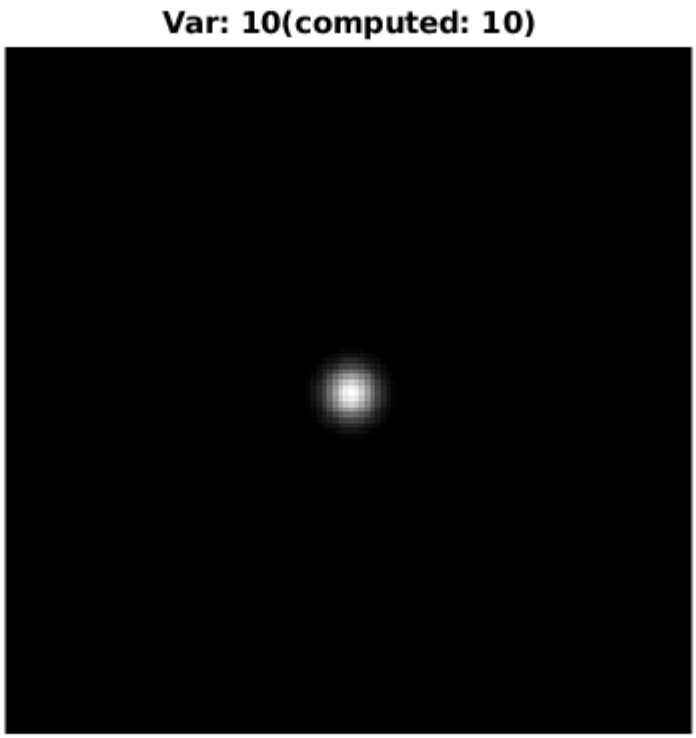



```
v = 2×2
    1.0000    0.0000
```

```
    0.0000    1.0000
```




```
v = 2×2
   10.0000    0.0000
    0.0000   10.0000
```



## Smoothing

```
figure();

office = office256;
add = gaussnoise(office, 16);
sap = sapnoise(office, 0.1, 255);

showgrey(office);
```

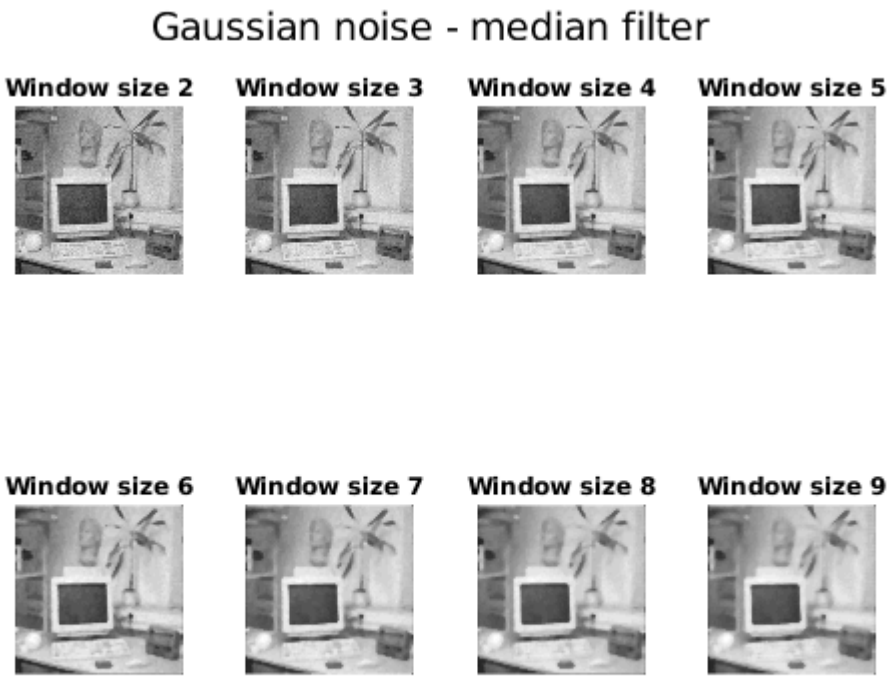
```
showgrey(add);
```

```
showgrey(sap);
```

### Gaussian noise

### Median filter

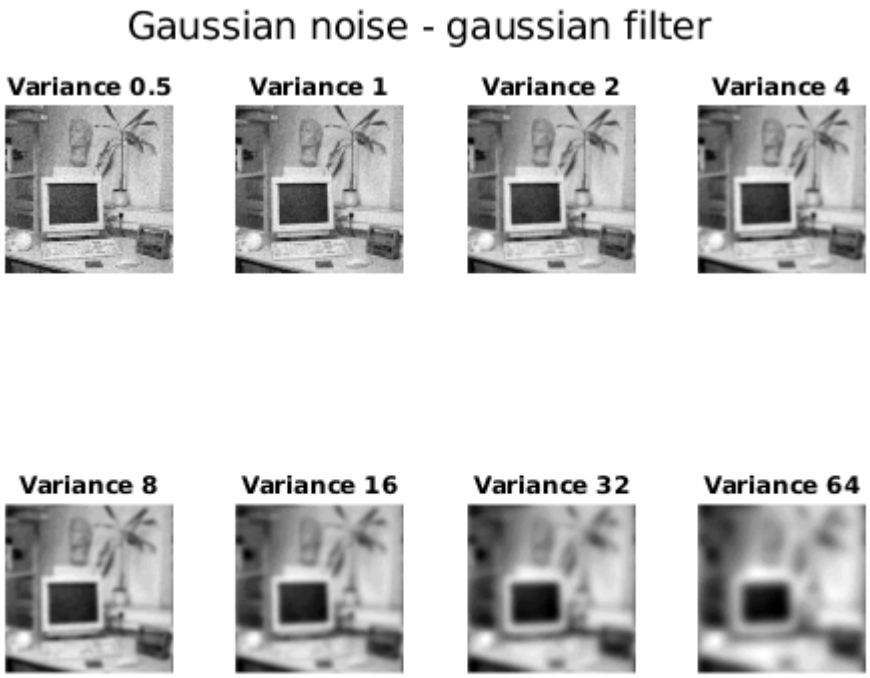
```
figure();
suptitle('Gaussian noise - median filter');
t = [2,3,4,5,6,7,8,9];

for j = 1:8
    subplot(2,4,j);
    out = medfilt(add,t(j));
    showgrey(out);
    title(sprintf("Window size %g",t(j)));
end
```




### Gaussian filter

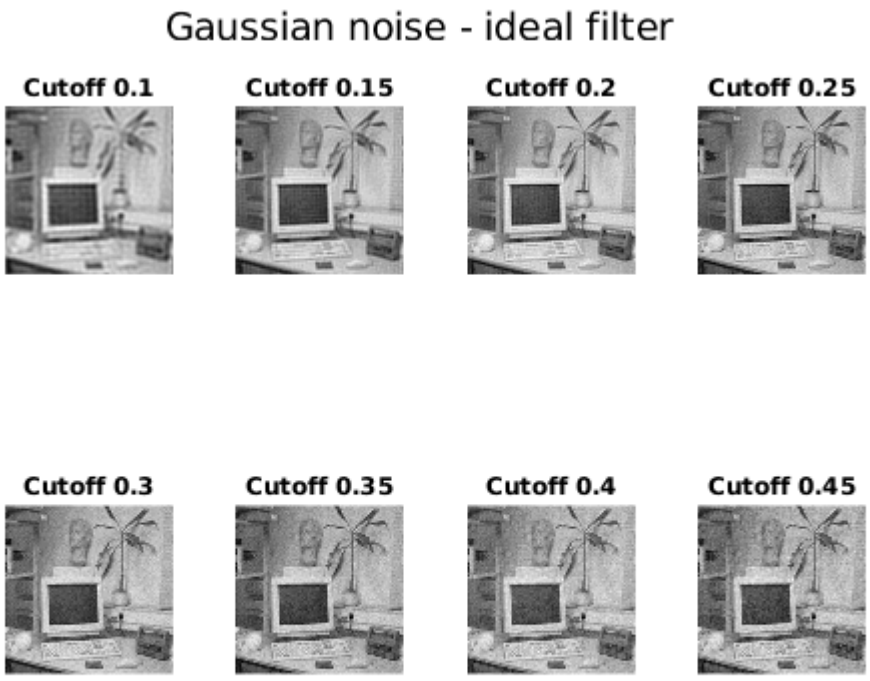
```
figure();
suptitle('Gaussian noise - gaussian filter');
t = [0.5,1.0,2,4,8,16,32,64];

for j = 1:8
    subplot(2,4,j);
    out = gaussfft(add,t(j));
    showgrey(out);
```

```
    title(sprintf("Variance %g",t(j)));
end
```




### Ideal filter

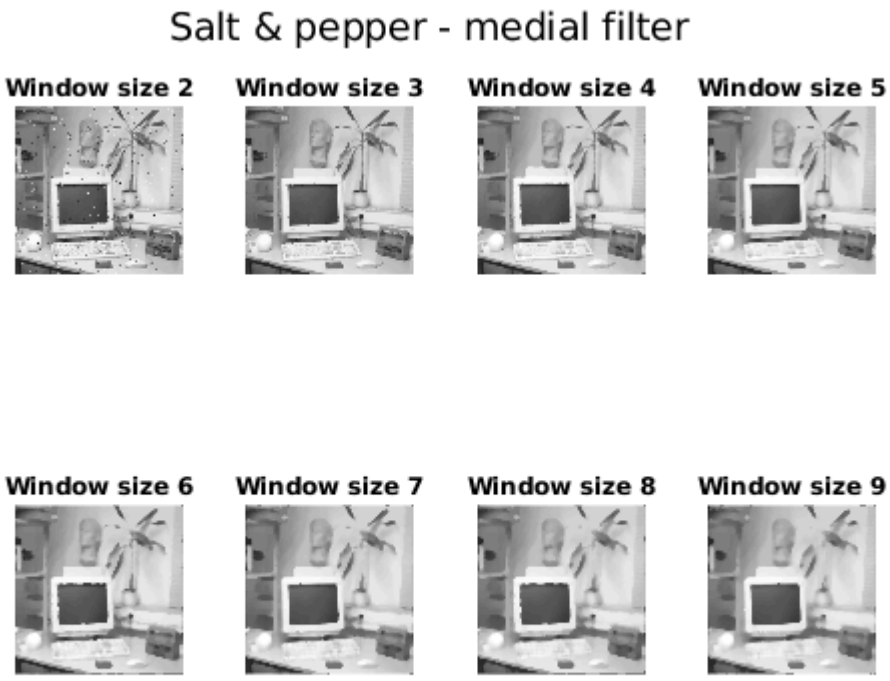
```
figure();
suptitle('Gaussian noise - ideal filter');
t = 0.1:0.05:0.5;

for j = 1:8
    subplot(2,4,j);
    out = ideal(add,t(j));
    showgrey(out);
    title(sprintf("Cutoff %g",t(j)));
end
```




### Salt and pepper

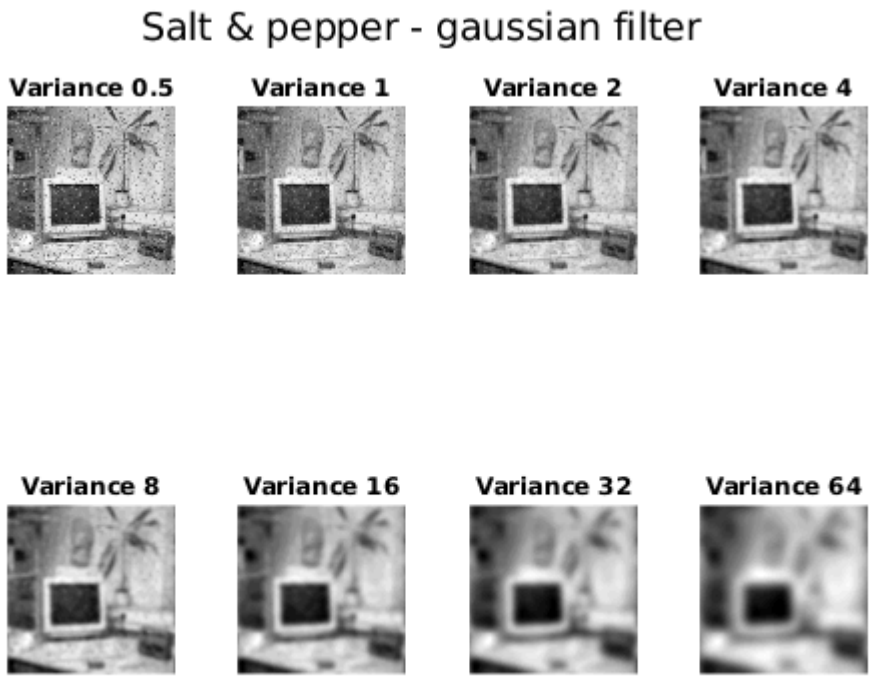
### Median filter

```
figure();
suptitle('Salt & pepper - medial filter');
t = [2,3,4,5,6,7,8,9];

for j = 1:8
    subplot(2,4,j);
    out = medfilt(sap,t(j));
    showgrey(out);
    title(sprintf("Window size %g",t(j)));
end
```



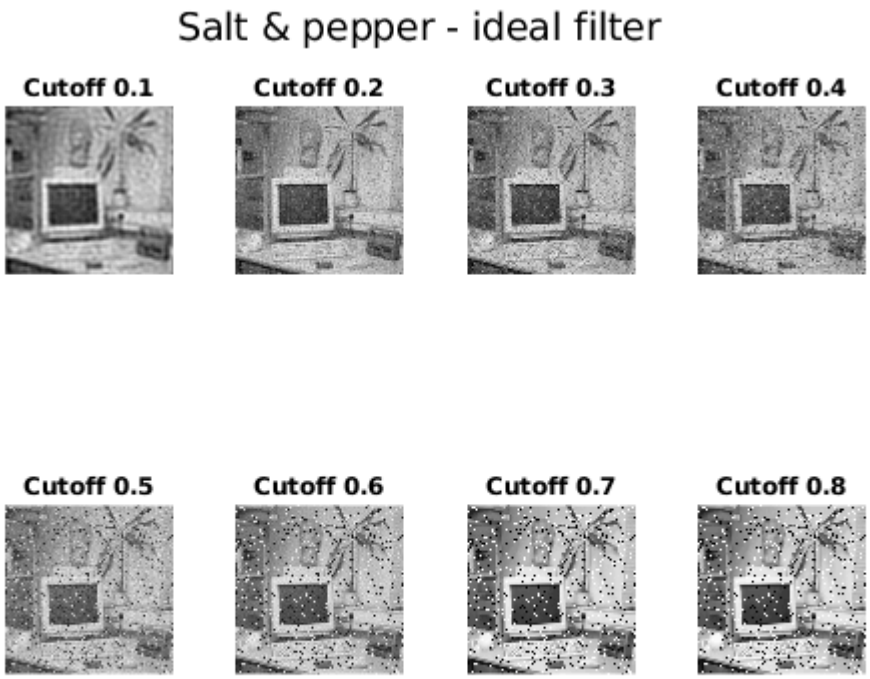

### Gaussian filter

```
figure();
suptitle('Salt & pepper - gaussian filter');
t = [0.5,1.0,2,4,8,16,32,64];

for j = 1:8
    subplot(2,4,j);
    out = gaussfft(sap,t(j));
    showgrey(out);
    title(sprintf("Variance %g",t(j)));
end
```



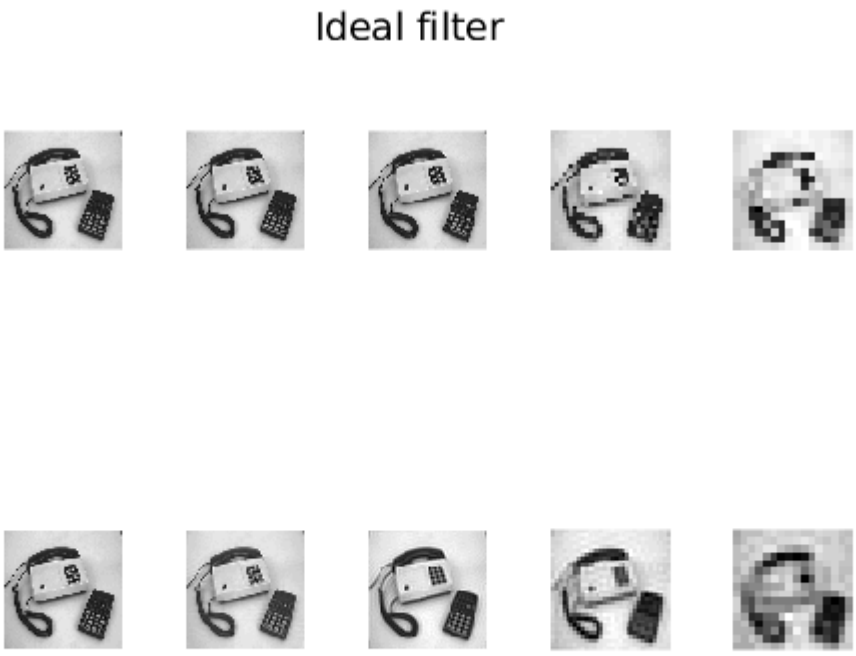

### Ideal filter

```
figure();
suptitle('Salt & pepper - ideal filter');
t = 0.1:0.1:0.8;

for j = 1:8
    subplot(2,4,j);
    out = ideal(sap,t(j));
    showgrey(out);
    title(sprintf("Cutoff %g",t(j)));
end
```




## Subsampling

```
figure();
suptitle('Ideal filter');
img = phonecalc256;
smoothimg = img;
N=5;
for i=1:N
        if i>1
            % generate subsampled versions
            img = rawsubsample(img);
            smoothimg = ideal(smoothimg, 0.25);
            smoothimg = rawsubsample(smoothimg);
        end
    subplot(2, N, i)
    showgrey(img)
    subplot(2, N, i+N)
    showgrey(smoothimg)
end
```




```
figure();
suptitle('Gaussian filter');
img = phonecalc256;
smoothimg = img;
N=5;
for i=1:N
        if i>1
            % generate subsampled versions
            img = rawsubsample(img);
            smoothimg = gaussfft(smoothimg, 0.4);
            smoothimg = rawsubsample(smoothimg);
        end
    subplot(2, N, i)
    showgrey(img)
    subplot(2, N, i+N)
    showgrey(smoothimg)
end
```

Gaussian filter