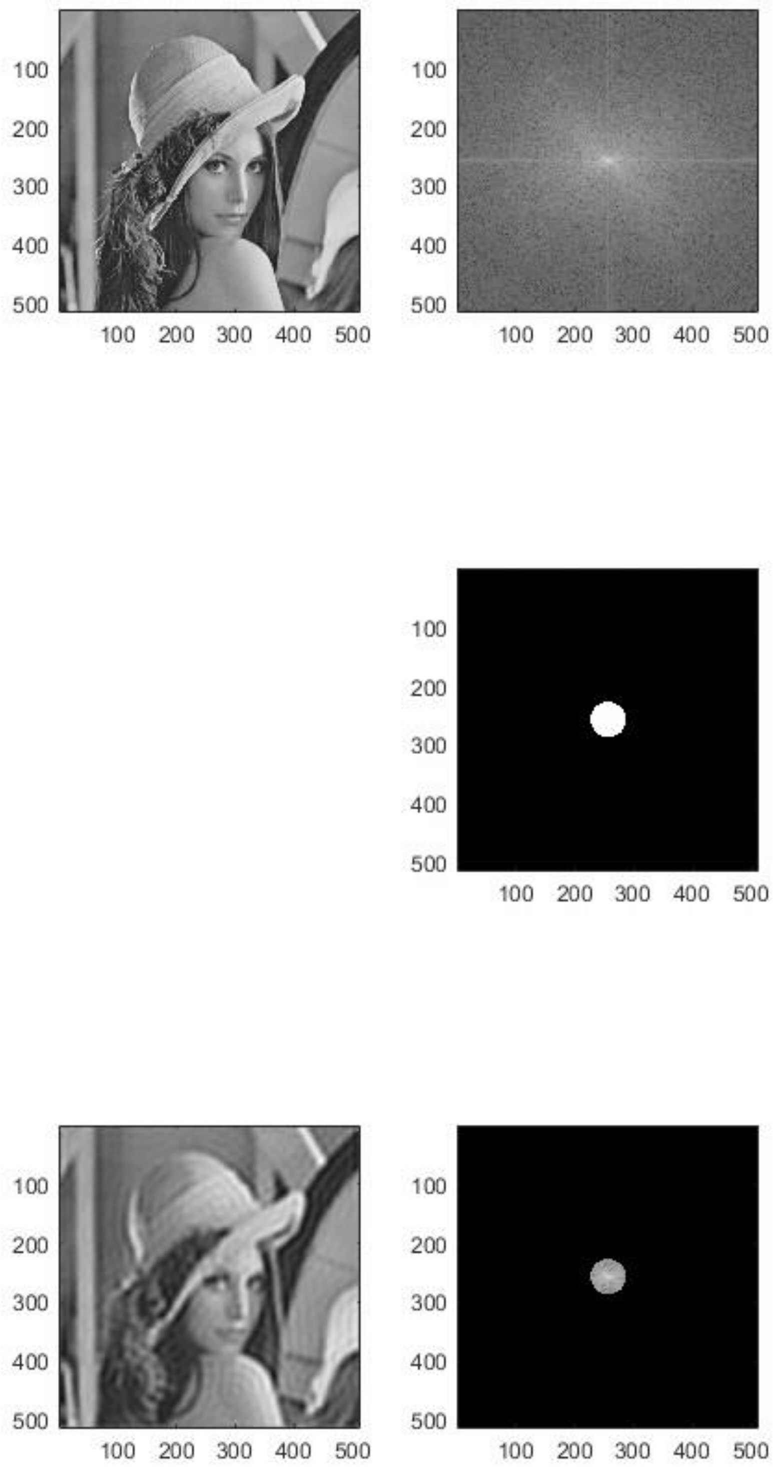
1. Ideal Low-pass filter

```
% change size of z to view the differences of low pass filter
[xLena, map]=imread('lena.bmp'); % xLena = imread('lena.bmp') -> [xLena, map] = imread('lena.bmp')
xLenaf=fftshift(fft2(xLena));
flog = log(1+abs(xLenaf));
fm = max(flog(:));
fig = figure();
fig.Position(3:4) = [1000, 1500];
subplot(3,2,1)
image(xLena);
colormap(map), axis('square')
subplot(3,2,2)
image(flog*255/fm);
colormap(map), axis('square')
[x,y]= meshgrid(-256:255,-256:255);
z = sqrt(x.^2+ y.^2);
% clf= (z<15);
clf = (z < 30); % set z < 30
subplot(3,2,4)
image(255*clf);
colormap(map), axis('square')
subplot(3,2,6)
yLenaf=xLenaf.*clf;
flog = log(1+abs(yLenaf));
fm = max(flog(:));
image(flog*255/fm);
colormap(map), axis('square')
yLena=ifft2(yLenaf);
subplot(3,2,5)
image(abs(yLena));
colormap(map), axis('square')

% If z goes larger, less high-frequency gets filtered out, the resulting
% image become sharper.
% If z goes smaller, more high-frequency get filter out, the resulting
% image become smoother.
```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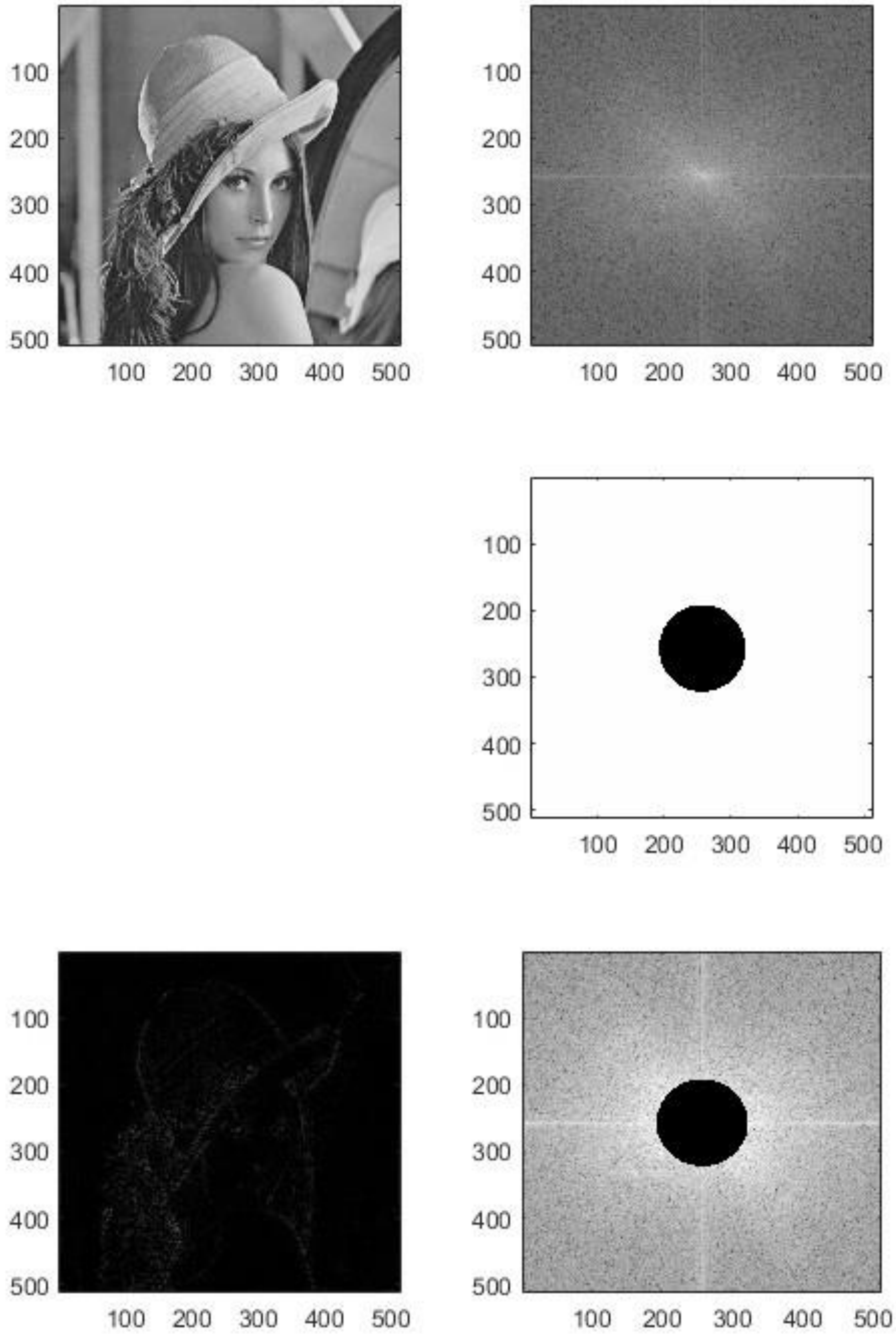
2. Ideal High-pass filter

```
% change size of z to view the differences of high pass filter
% ======== new =========
[xLena, map]=imread('lena.bmp');
xLenaf=fftshift(fft2(xLena));
% ======================
fig = figure();
fig.Position(3:4) = [1000, 1500];
subplot(3,2,1)
image(xLena);
colormap(map), axis('square')
subplot(3,2,2)
flog = log(1+abs(xLenaf));
fm = max(flog(:));
image(flog*255/fm);
colormap(map), axis('square')
[x,y]=meshgrid(-256:255,-256:255);
z=sqrt(x.^2+y.^2);
% chf=(z>15);
chf = (z > 65); % set z > 65
subplot(3,2,4)
image(255*chf);
colormap(map), axis('square')
yLenaf=xLenaf.*chf;
flog = log(1+abs(yLenaf));
fm = max(flog(:));
subplot(3,2,6)
image(flog*255/fm);
colormap(map)
yLena=ifft2(yLenaf);
subplot(3,2,5)
image(abs(yLena));
colormap(map), axis('square')

% If z goes larger, more frequency gets filtered out, the resulting image become sharper (more edge detail).
% However, if z goes too large, the high frequency would also be filter out, resulting a dark image.
```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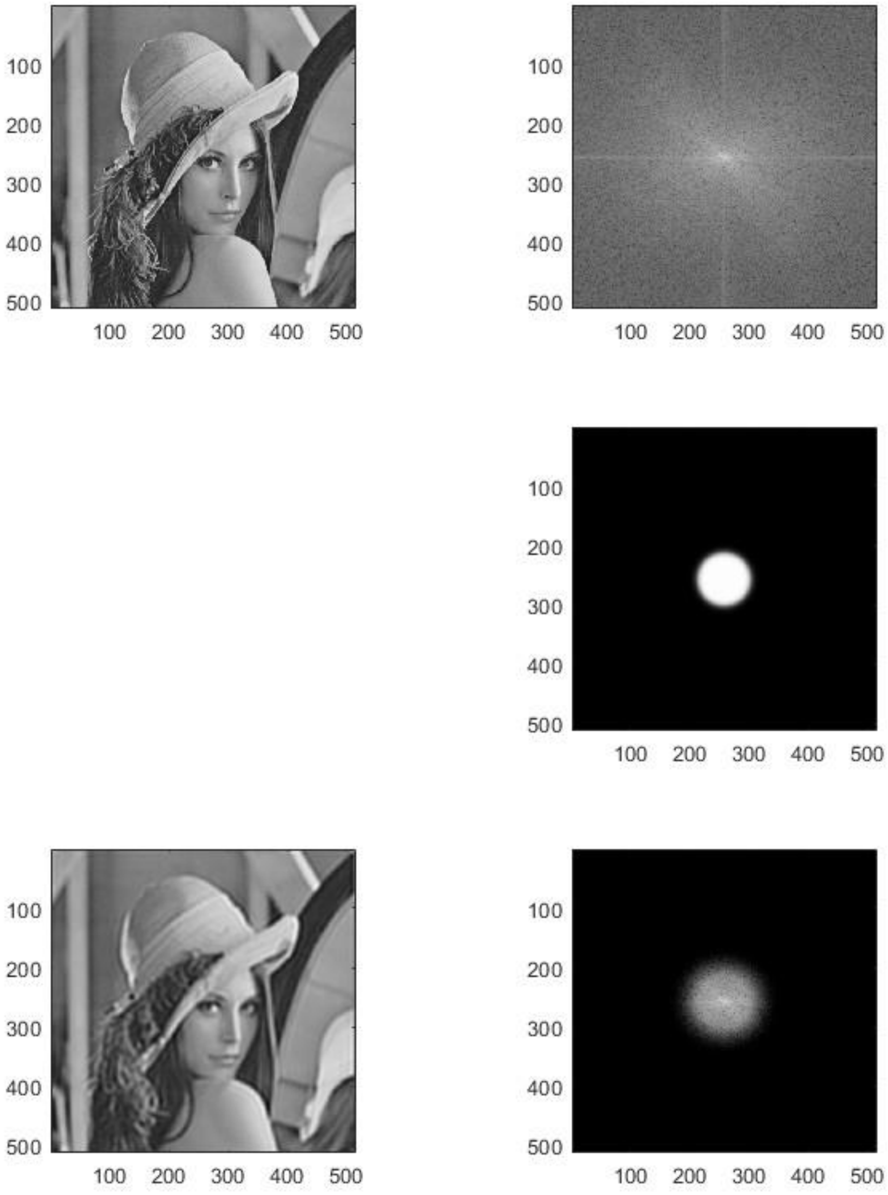
3. Butterworth low-pass filter (blf)

```
% change size of D and n to view the differences of Butterworth low-pass filter
% ======== new =========
[xLena, map]=imread('lena.bmp');
xLenaf=fftshift(fft2(xLena));
% ======================
fig = figure();
fig.Position(3:4) = [1000, 1500];
subplot(3,2,1)
image(xLena);
colormap(map), axis('square')

subplot(3,2,2)
flog = log(1+abs(xLenaf));
fm = max(flog(:));
image(flog*255/fm);
colormap(map), axis('square')

%D=15, n=2
D=2048; % set D = 2048
n=8;    % set n = 8
[x,y]=meshgrid(-256:255,-256:255);
blf=1./(1+((x.^2+y.^2)/D).^n);
subplot(3,2,4)
image(255*blf);
colormap(map), axis('square')

yLenaf=xLenaf.*blf;
flog = log(1+abs(yLenaf));
fm = max(flog(:));
subplot(3,2,6)
image(flog*255/fm);
colormap(map), axis('square')

yLena=ifft2(yLenaf);
subplot(3,2,5)
image(abs(yLena));
colormap(map), axis('square')
```

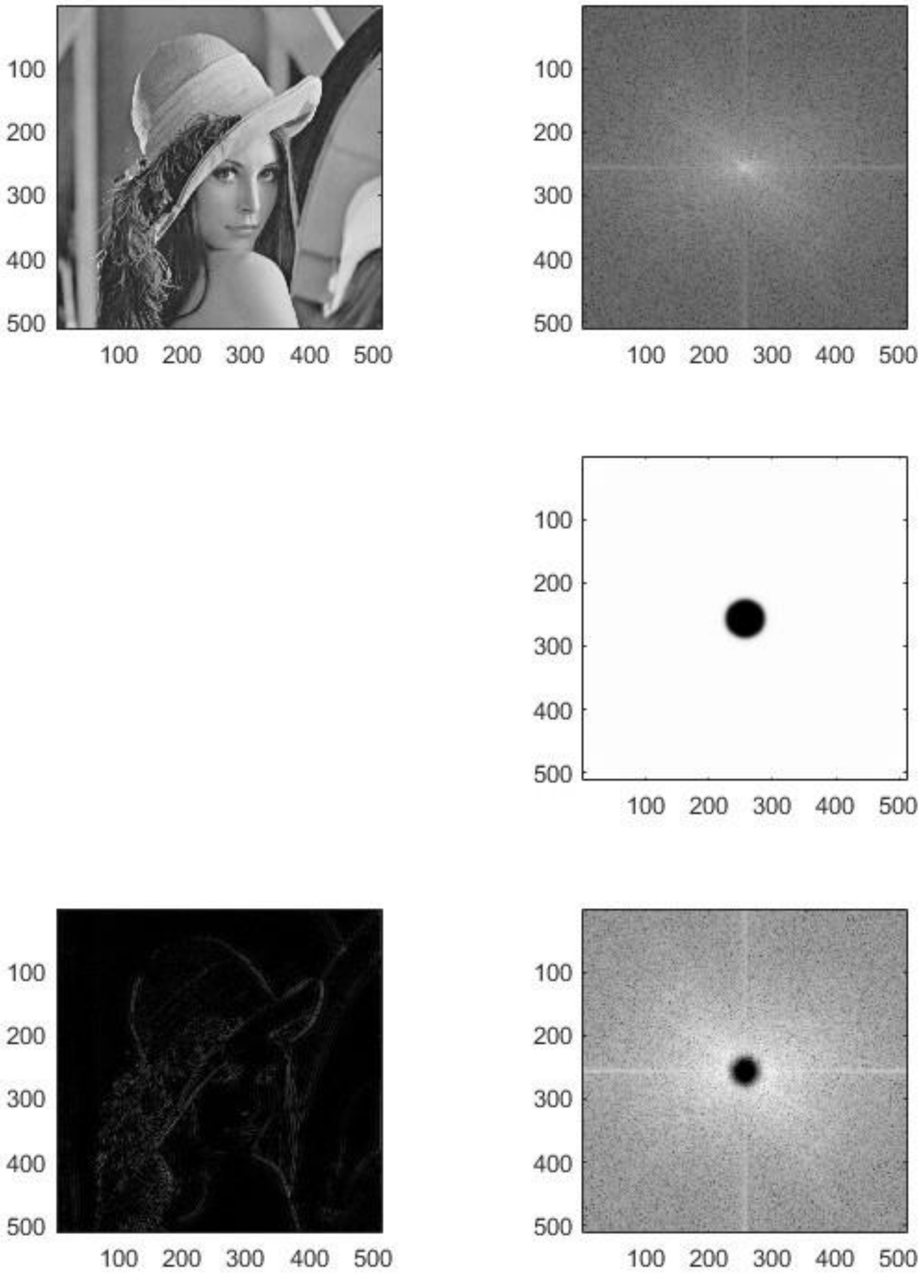
```
% if D goes larger, more frequency would be covered/retained, resulting a clearer(less blur) image.
% if n goes larger, more frequency would be filtered out, resulting a blurer image, and when n reach a certain value, the effect becomes no longer significant.
```



4. Butterworth high-pass filter (bhf)

```
% change size of D and n to view the differences of Butterworth high-pass
filter
% ======== new =========
[xLena, map]=imread('lena.bmp');
xLenaf=fftshift(fft2(xLena));
% ======================
fig = figure();
fig.Position(3:4) = [1000, 1500];
subplot(3,2,1)
image(xLena);
colormap(map), axis('square')

subplot(3,2,2)
flog = log(1+abs(xLenaf));
fm = max(flog(:));
image(flog*255/fm);
colormap(map), axis('square')

%D=15, n=2
D=960;
n=8;
[x,y]=meshgrid(-256:255,-256:255);
blf=1./(1+((x.^2+y.^2)/D).^n);
bhf=1-blf; subplot(3,2,4)
image(255*bhf);
colormap(map), axis('square')

yLenaf=xLenaf.*bhf;
flog = log(1+abs(yLenaf));
fm = max(flog(:));
subplot(3,2,6)
image(flog*255/fm);
colormap(map), axis('square')

yLena=ifft2(yLenaf);
subplot(3,2,5)
image(abs(yLena));
colormap(map), axis('square')
```

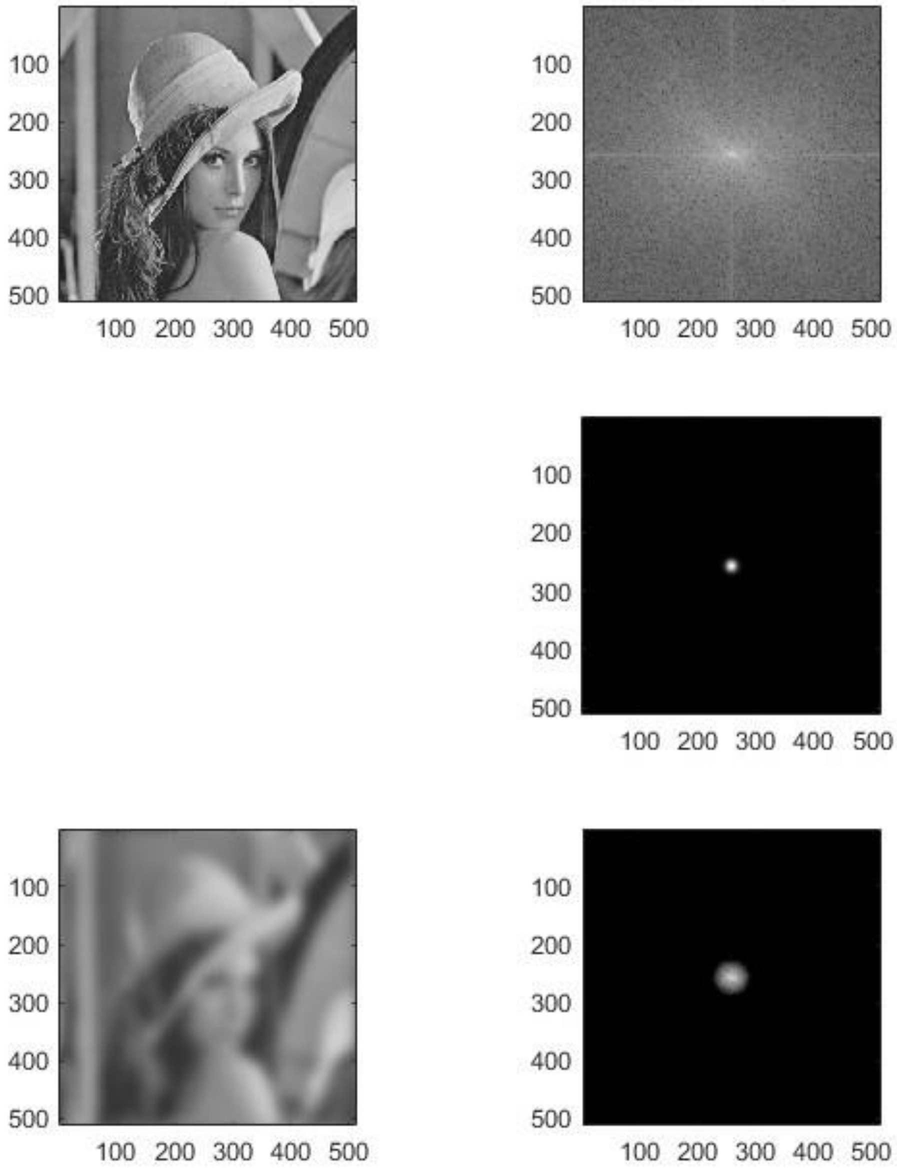
```
% If D goes larger, more low-frequency would be filtered out, resulting a sharper image, vice versa.
% IF N goes larger, more low-frequency would be filtered out, resulting a sharper image, vice versa.
```



5. Gaussian Low-Pass Filter (glf)

```
% change size of std (standard deviation)
% ======== new =========
[xLena, map]=imread('lena.bmp');
xLenaf=fftshift(fft2(xLena));
% ======================
fig = figure();
fig.Position(3:4) = [1000, 1500];
subplot(3,2,1)
image(xLena);
colormap(map), axis('square')

subplot(3,2,2)
flog = log(1+abs(xLenaf));
fm = max(flog(:)); image(flog*255/fm);
colormap(map), axis('square')

gsize=512;
std = 7;
[x,y] = meshgrid(-256:255,-256:255);
arg = -(x.*x + y.*y)/(2*std*std);
glf = exp(arg);
glf(glf<eps*max(glf(:))) = 0;
%sumh = sum(glf(:));
%if sumh ~= 0,
%glf =glf/sumh;
%end;

subplot(3,2,4)
image(255*glf);
colormap(map), axis('square')

yLenaf=xLenaf.*glf;
flog = log(1+abs(yLenaf));
fm = max(flog(:));
subplot(3,2,6)
image(flog*255/fm);
colormap(map), axis("square")
```

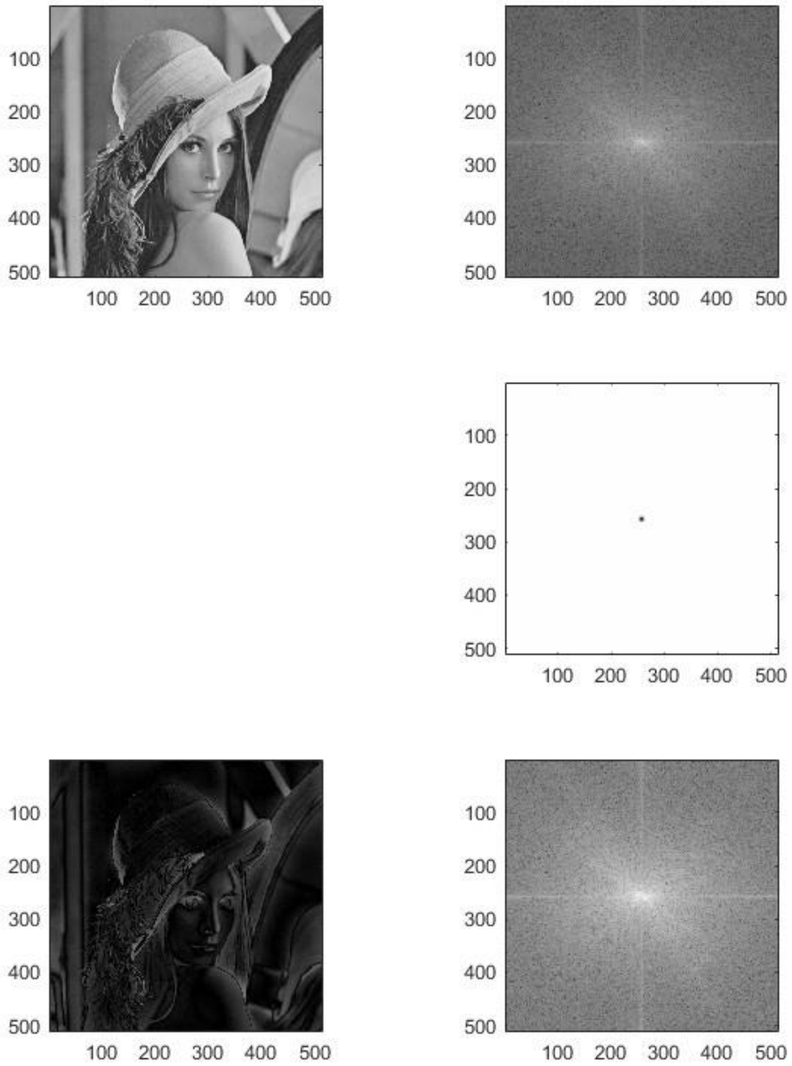
```
yLena=ifft2(yLenaf);
subplot(3,2,5)
image(abs(yLena));
colormap(map),axis('square')

% If std goes smaller, more high-frequency will be flitered out, resulting a smoother image, vice versa.
```



6. Gaussian High-Pass Filter (ghf)

```
% change size of std (standard deviation)
% ======== new =========
[xLena, map]=imread('lena.bmp');
xLenaf=fftshift(fft2(xLena));
% ======================
fig = figure();
fig.Position(3:4) = [1000, 1500];
subplot(3,2,1)
image(xLena);
colormap(map), axis('square')

subplot(3,2,2)
flog = log(1+abs(xLenaf));
fm = max(flog(:)); image(flog*255/fm);
colormap(map), axis('square')

gsize=512;
std = 3;
[x,y] = meshgrid(-256:255,-256:255);
arg = -(x.*x + y.*y)/(2*std*std);
glf = exp(arg);
glf(glf<eps*max(glf(:))) = 0;
sumh = sum(glf(:));
%if sumh ~= 0
%glf =glf/sumh;
%end

% ====== new ======
ghf = 1 - glf;
% ================

subplot(3,2,4)
image(255*ghf); % glf -> ghf
colormap(map), axis('square')

yLenaf=xLenaf.*ghf; % glf -> ghf
flog = log(1+abs(yLenaf));
fm = max(flog(:));
```

```
subplot(3,2,6)
image(flog*255/fm);
colormap(map), axis("square")

yLena=ifft2(yLenaf);
subplot(3,2,5)
image(abs(yLena));
colormap(map),axis('square')

% If std goes larger, more low-frequency will be flitered out, resulting a sharper image, vice versa.
```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