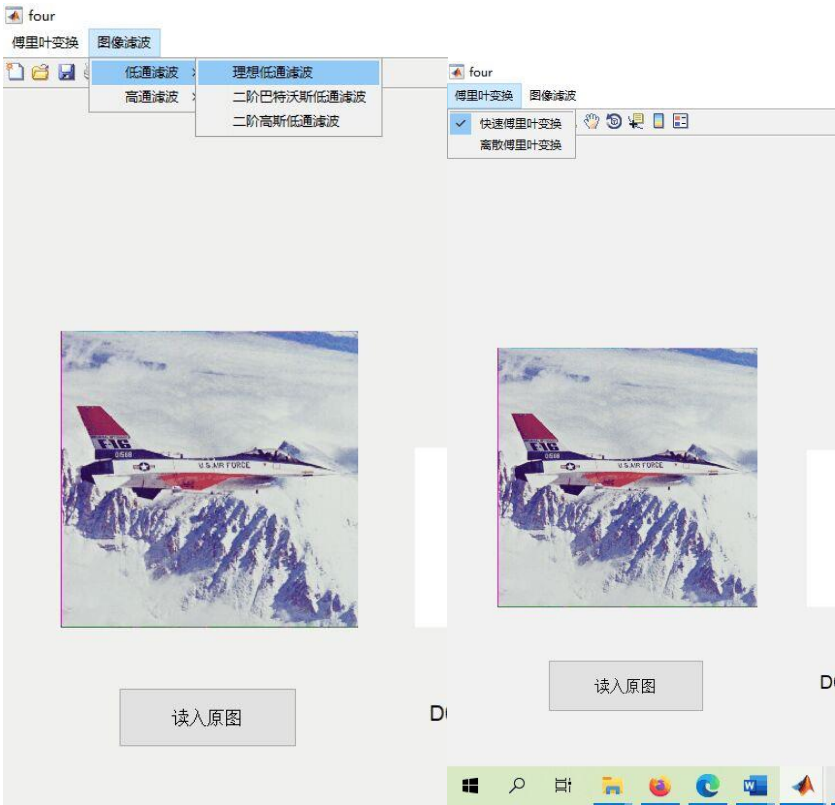


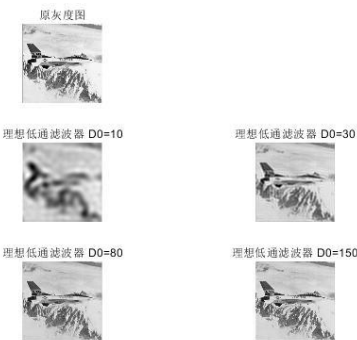
1、编程实现截止频率半径分别为 10、30、80、150 像素时，理想低通和高通滤波器、二阶巴特沃斯低通和高通滤波器、二阶高斯低通和高通滤波器对图像的滤波处理，并对结果进行分析。要求创建用户交互界面，能够实现图像读入、傅里叶变换、截止频率输入、输入输出图像输出等功能。

(1) 交互界面

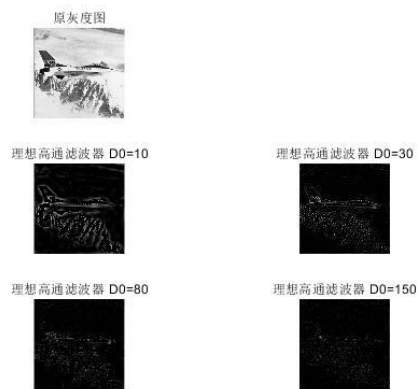


(2) 滤波结果

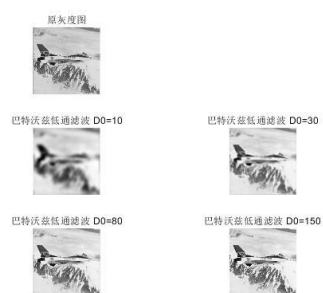
1) 理想低通



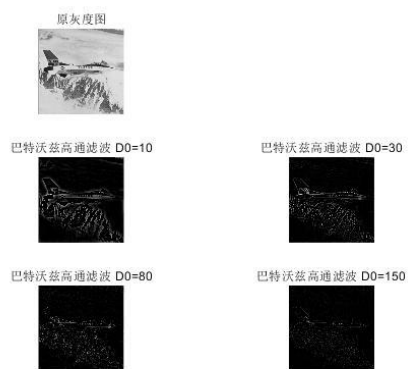
2) 理想高通



3) 二阶巴特沃斯低通



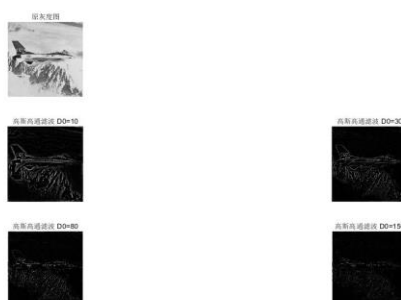
4) 二阶巴特沃斯高通



5) 二阶高斯低通



6) 二阶高斯高通



(3) 结果分析

低通滤波器滤除了高频成分，使得图像模糊。由于理想低通滤波器的过度特性过于急峻，所以会产生了振铃现象，巴特沃斯低通滤波随着次数的增加，振铃现象越来越明显。高斯滤波器的过度特性非常平坦，可有效消除振铃效应，高斯滤波比巴特沃斯滤波更光滑，在三种滤波器里，高斯低通滤波的效果最好，且截止频率越大，得到的图像越清晰。

高通滤波器滤除了低频成分，使得图像锐化，突出边缘和轮廓。由于理想高通滤波器的过度特性过于急峻，所以滤波结果使得轮廓比较模糊，巴特沃斯高通滤波随着次数的增加，振铃现象会越来越明显。高斯滤波器的过度特性非常平坦，可有效消除振铃效应，高斯滤波比巴特沃斯滤波更锐化，三种滤波器里，高斯高通滤波的效果最好，且截止频率越大，得到的图像越模糊。

(4) 编程代码

```
function varargout = four(varargin)
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                  'gui_Singleton',   gui_Singleton, ...
                  'gui_OpeningFcn', @four_OpeningFcn, ...
                  'gui_OutputFcn',  @four_OutputFcn, ...
                  'gui_LayoutFcn',  [] , ...
```

```

        'gui_Callback', []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end
if nargin
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
function four_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);
if strcmp(get(hObject, 'Visible'), 'off')
    plot(rand(5));
end
function varargout = four_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;
function pushbutton1_Callback(hObject, eventdata, handles)
axes(handles.axes1);
cla;
popup_sel_index = get(handles.popupmenu1, 'Value');
switch popup_sel_index
    case 1
        plot(rand(5));
    case 2
        plot(sin(1:0.01:25.99));
    case 3
        bar(1:.5:10);
    case 4
        plot(membrane);
    case 5
        surf(peaks);
end
function FileMenu_Callback(hObject, eventdata, handles)
function OpenMenuItem_Callback(hObject, eventdata, handles)
file = uigetfile('*.fig');
if ~isequal(file, 0)
    open(file);
end
function PrintMenuItem_Callback(hObject, eventdata, handles)
prindlg(handles.figure1)
function CloseMenuItem_Callback(hObject, eventdata, handles)
selection = questdlg(['Close ' get(handles.figure1, 'Name') '?'], ...
    ['Close ' get(handles.figure1, 'Name') '...'], ...

```

```

        'Yes', 'No', 'Yes');
if strcmp(selection, 'No')
    return;
end

delete(handles.figure1)
function popupmenu1_Callback(hObject, eventdata, handles)
function popupmenu1_CreateFcn(hObject, eventdata, handles)

if ispc && isequal(get(hObject, 'BackgroundColor'),
get(0, 'defaultUiControlBackgroundColor'))
    set(hObject, 'BackgroundColor', 'white');
end
set(hObject, 'String', {'plot(rand(5))', 'plot(sin(1:0.01:25))', 'bar(1:.5:10)',
'plot(membrane)', 'surf(peaks)'});

%理想高通
function Untitled_8_Callback(hObject, eventdata, handles)
color_pic=imread('airplane.tiff');
gray_pic=rgb2gray(color_pic);
double_gray_pic=im2double(gray_pic);
[width,height]=size(double_gray_pic);
mid_w=width/2;
mid_h=height/2;
fourier_pic=fft2(double_gray_pic);
fourier_shift=fftshift(fourier_pic);

end_radius=[10,30,80,150];
Result=zeros(width,height);
subplot(3,2,1);imshow(double_gray_pic,[]);title('原灰度图');
for k=1:4
    Result=fourier_shift;
    for i=1:width
        for j=1:height
            distance=sqrt((i-mid_w)^2+(j-mid_h)^2);
            if distance<end_radius(k)
                Result(i,j)=0;
            end
        end
    end
    output1=im2uint8(real(ifft2(ifftshift(Result))));
    subplot(3,2,k+2);imshow(output,[]);title(['理想高通滤波'
D0=',num2str(end_radius(k))]);
end

```

% 波特沃斯高通

```
function Unt_9_Callback(hObject, eventdata, handles)
color_pic=imread('airplane.tiff');
gray_pic=rgb2gray(color_pic);
double_gray_pic=im2double(gray_pic);
[width,height]=size(double_gray_pic);
mid_w=width/2;
mid_h=height/2;
fourier_pic=fft2(double_gray_pic);
fourier_shift=fftshift(fourier_pic);
level=2;
end_radius=[10,30,80,150];
for i=1:width
    for j=1:height
        distance=sqrt((i-mid_w)^2+(j-mid_h)^2);
        h1=1./(1+(end_radius(1)/distance).^(2*level));
        h2=1./(1+(end_radius(2)/distance).^(2*level));
        h3=1./(1+(end_radius(3)/distance).^(2*level));
        h4=1./(1+(end_radius(4)/distance).^(2*level));
        result1(i,j)=fourier_shift(i,j)*h1;
        result2(i,j)=fourier_shift(i,j)*h2;
        result3(i,j)=fourier_shift(i,j)*h3;
        result4(i,j)=fourier_shift(i,j)*h4;
    end
end
output1=im2uint8(real(ifft2(ifftshift(result1))));
output2=im2uint8(real(ifft2(ifftshift(result2))));
output3=im2uint8(real(ifft2(ifftshift(result3))));
output4=im2uint8(real(ifft2(ifftshift(result4))));
subplot(3,2,1);imshow(double_gray_pic);title('原灰度图');
subplot(3,2,3);imshow(output1,[]);title(['巴特沃斯高通滤波'
    D0=',num2str(end_radius(1))]);
subplot(3,2,4);imshow(output2,[]);title(['巴特沃斯高通滤波'
    D0=',num2str(end_radius(2))]);
subplot(3,2,5);imshow(output3,[]);title(['巴特沃斯高通滤波'
    D0=',num2str(end_radius(3))]);
%subplot(3,2,6);imshow(output4,[]);title(['巴特沃斯高通滤波'
    D0=',num2str(end_radius(4))]);
```

%高斯高通

```
function Untitled_10_Callback(hObject, eventdata, handles)
imgrgb = imread('airplane.tiff');
axes(handles.axes1);
```

```

imshow(imgrgb);
handles.img=imgrgb;
guidata(hObject,handles);
f = rgb2gray(imgrgb);
I = double(f);
g = fft2(I);
g = fftshift(g);
[M, N] = size(g);
D0 = [10,30,80,150];
m = fix(M / 2); n = fix(N / 2);
for i = 1:M
    for j = 1:N
        D = sqrt((i - m)^2 + (j - n)^2);
        H1 = exp(-(D.^2) ./ (2 * (D0(1)^2)));
        result1(i, j) = (1- H1) * g(i, j);
    end
end
result1 = ifftshift(result1);
J1 = ifft2(result1);
J2 = uint8(real(J1));
subplot(3, 2, 3);
imshow(J2)
title('高斯高通滤波 D0=10')
for i = 1:M
    for j = 1:N
        D = sqrt((i - m)^2 + (j - n)^2);
        H2 = (exp(-(D.^2) ./ (2 * (D0(2)^2))));
        result2(i, j) = (1- H2) * g(i, j);
    end
end
result2 = ifftshift(result2);
J1 = ifft2(result2);
J2 = uint8(real(J1));
subplot(3, 2, 4);
imshow(J2)
title('高斯高通滤波 D0=30')
for i = 1:M
    for j = 1:N
        D = sqrt((i - m)^2 + (j - n)^2);
        H3 = exp(-(D.^2) ./ (2 * (D0(3)^2)));
        result3(i, j) = (1- H3) * g(i, j);
    end
end
result3 = ifftshift(result3);

```

```

J1 = ifft2(result3);
J2 = uint8(real(J1));
subplot(3, 2, 5);
imshow(J2)
title('高斯高通滤波 D0=80')
for i = 1:M
    for j = 1:N
        D = sqrt((i - m)^2 + (j - n)^2);
        H4 = exp(-(D.^2) ./ (2 * (D0(4)^2)));
        result4(i, j) = (1 - H4) * g(i, j);
    end
end
result4 = ifftshift(result4);
J1 = ifft2(result4);
J2 = uint8(real(J1));
subplot(3, 2, 6);
imshow(J2)
title('高斯高通滤波 D0=150')

```

%理想低通

```

function U_3_Callback(hObject, eventdata, handles)
color_pic=imread('airplane.tiff');
gray_pic=rgb2gray(color_pic);
double_gray_pic=im2double(gray_pic);
[width,height]=size(double_gray_pic);
mid_w=width/2;
mid_h=height/2;
fourier_pic=fft2(double_gray_pic);
fourier_shift=fftshift(fourier_pic);

end_radius=[10,30,80,150];
Result=zeros(width,height);
subplot(3,2,1);imshow(double_gray_pic,[]);title('原灰度图');
for k=1:4
    Result=fourier_shift;
    for i=1:width
        for j=1:height
            distance=sqrt((i-mid_w)^2+(j-mid_h)^2);
            if distance<end_radius(k)
                Result(i,j)=0;
            end
        end
    end
    output1=im2uint8(real(ifft2(ifftshift(Result))));

```



```

        subplot(3,2,k+2);imshow(output,[]);title(['理想低通滤波
D0=',num2str(end_radius(k))]);
end

```

%巴特沃斯低通

```

function Untitled_5_Callback(hObject, eventdata, handles)
color_pic=imread('airplane.tiff');
gray_pic=rgb2gray(color_pic);
double_gray_pic=im2double(gray_pic);
[width,height]=size(double_gray_pic);
mid_w=width/2;
mid_h=height/2;
fourier_pic=fft2(double_gray_pic);
fourier_shift=fftshift(fourier_pic);
level=2;
end_radius=[10,30,80,150];
for i=1:width
    for j=1:height
        distance=sqrt((i-mid_w)^2+(j-mid_h)^2);
        h1=1./(1+(distance/end_radius(1)).^(2*level));
        h2=1./(1+(distance/end_radius(2)).^(2*level));
        h3=1./(1+(distance/end_radius(3)).^(2*level));
        h4=1./(1+(distance/end_radius(4)).^(2*level));
        result1(i,j)=fourier_shift(i,j)*h1;
        result2(i,j)=fourier_shift(i,j)*h2;
        result3(i,j)=fourier_shift(i,j)*h3;
        result4(i,j)=fourier_shift(i,j)*h4;
    end
end
output1=im2uint8(real(ifft2(ifftshift(result1))));
output2=im2uint8(real(ifft2(ifftshift(result2))));
output3=im2uint8(real(ifft2(ifftshift(result3))));
output4=im2uint8(real(ifft2(ifftshift(result4))));
subplot(3,2,1);imshow(double_gray_pic);title('原图');
subplot(3,2,3);imshow(output1,[]);title(['巴特沃斯低通滤波
D0=',num2str(end_radius(1))]);
subplot(3,2,4);imshow(output2,[]);title(['巴特沃斯低通滤波
D0=',num2str(end_radius(2))]);
subplot(3,2,5);imshow(output3,[]);title(['巴特沃斯低通滤波
D0=',num2str(end_radius(3))]);
subplot(3,2,6);imshow(output4,[]);title(['巴特沃斯低通滤波
D0=',num2str(end_radius(4))]);

```

%高斯高通

```

function Untitled_6_Callback(hObject, eventdata, handles)
imgrgb = imread('airplane.tiff'); %读取图像
axes(handles.axes1);
imshow(imgrgb);
handles.img=imgrgb;
guidata(hObject,handles);
f = rgb2gray(imgrgb);
I = double(f);
g = fft2(I);
g = fftshift(g);
[M, N] = size(g);
D0 = [10,30,80,150];
m = fix(M / 2); n = fix(N / 2);
for i = 1:M
    for j = 1:N
        D = sqrt((i - m)^2 + (j - n)^2);
        H1 = exp(-(D.^2) ./ (2 * (D0(1)^2)));
        result1(i, j) = H1 * g(i, j);
    end
end
result1 = ifftshift(result1);
J1 = ifft2(result1);
J2 = uint8(real(J1));
subplot(3, 2, 3);
imshow(J2)
title('高斯低通滤波 D0=10')
for i = 1:M
    for j = 1:N
        D = sqrt((i - m)^2 + (j - n)^2);
        H2 = (exp(-(D.^2) ./ (2 * (D0(2)^2))));
        result2(i, j) = H2 * g(i, j);
    end
end
result2 = ifftshift(result2);
J1 = ifft2(result2);
J2 = uint8(real(J1));
subplot(3, 2, 4);
imshow(J2)
title('高斯低通滤波 D0=30')
for i = 1:M
    for j = 1:N
        D = sqrt((i - m)^2 + (j - n)^2);
        H3 = exp(-(D.^2) ./ (2 * (D0(3)^2)));
        result3(i, j) = H3 * g(i, j);
    end
end

```

```

        end
    end
    result3 = ifftshift(result3);
    J1 = ifft2(result3);
    J2 = uint8(real(J1));
    subplot(3, 2, 5);
    imshow(J2)
    title('高斯低通滤波` D0=80')

    for i = 1:M
        for j = 1:N
            D = sqrt((i - m)^2 + (j - n)^2);
            H4 = exp(-(D.^2) ./ (2 * (D0(4)^2)));
            result4(i, j) = H4 * g(i, j);
        end
    end
    result4 = ifftshift(result4);
    J1 = ifft2(result4);
    J2 = uint8(real(J1));
    subplot(3, 2, 6);
    imshow(J2)
    title('高斯低通滤波` D0=150')
    axes(handles.axes5);

% 傅里叶变换
function Untitled_16_Callback(hObject, eventdata, handles)
    open('GUI2.fig');

% 傅里叶变换界面
function Untitled_17_Callback(hObject, eventdata, handles)
    structure with handles and user data (see GUIDATA)
    GUI2;

%页面关闭按钮
function pushbutton6_Callback(hObject, eventdata, handles)
    clc;
    clear ;
    close all;

%低通滤波按钮
function Untitled_2_Callback(hObject, eventdata, handles)

% 高通滤波按钮
function Untitled_7_Callback(hObject, eventdata, handles)

% 图像滤波菜单
function Untitled_1_Callback(hObject, eventdata, handles)

```

%傅里叶变换菜单按钮

```
function Untitled_13_Callback(hObject, eventdata, handles)
```