数字图像处理综合作业

药 3 李宇晖 2013012470

实验目的：

了解图像的陷波阻断滤波器、低通滤波器原理，并使用 matlab 进行实验。

实验过程：

现场指纹的图像质量通常比较差，表现为背景纹理干扰严重，脊线模糊。请利用陷波阻断滤波器去除背景纹理，利用 Gabor 滤波器组对指纹脊线进行自适应增强（即对每个像素，选择适合的方向参数进行滤波）。输出陷波滤波结果、Gabor 滤波结果（实部图、虚部图、幅度图、相位图）。使用附件中的指纹图像进行实验。

提示：

1. 使用 MATLAB 中的 Gabor 滤波器函数。 Gabor 滤波器的波长可固定为 10 个像素；方向选 16 个，11.25k 度，k=0,1,2,3…,15；即滤波器组包含 16 个滤波器。
2. 对于一个像素，适合方向滤波的幅度最大。
3. 陷波滤波器的参数可手工指定。

首先，读取图像并做傅里叶变换、居中。而后根据显示出的频谱图像使用 ginput 函数选取需要进行滤波的坐标。代码如下：

```
I = imread('22.bmp');
[M,N] = size(I);
P = max(2*[M N]);% Padding size.
F = fftshift(fft2(I,P,P));
close all
figure(1),imshow(I,[]);
figure(2),imshow(log(1+abs(F)),[]);
[X,Y] = ginput;
```

根据上一步，得到 11 个巴特沃斯陷波阻断滤波器。由填充大小（图像长宽的较大值乘以 2）利用下述公式进行滤波。

$$\mathrm{H}_{NR}(u,v)=\prod_{k=1}^{Q}\frac{1}{1+[D_{0k}/D_k(u,v)]^{2n}}\frac{1}{1+[D_{0k}/D_{-k}(u,v)]^{2n}}$$

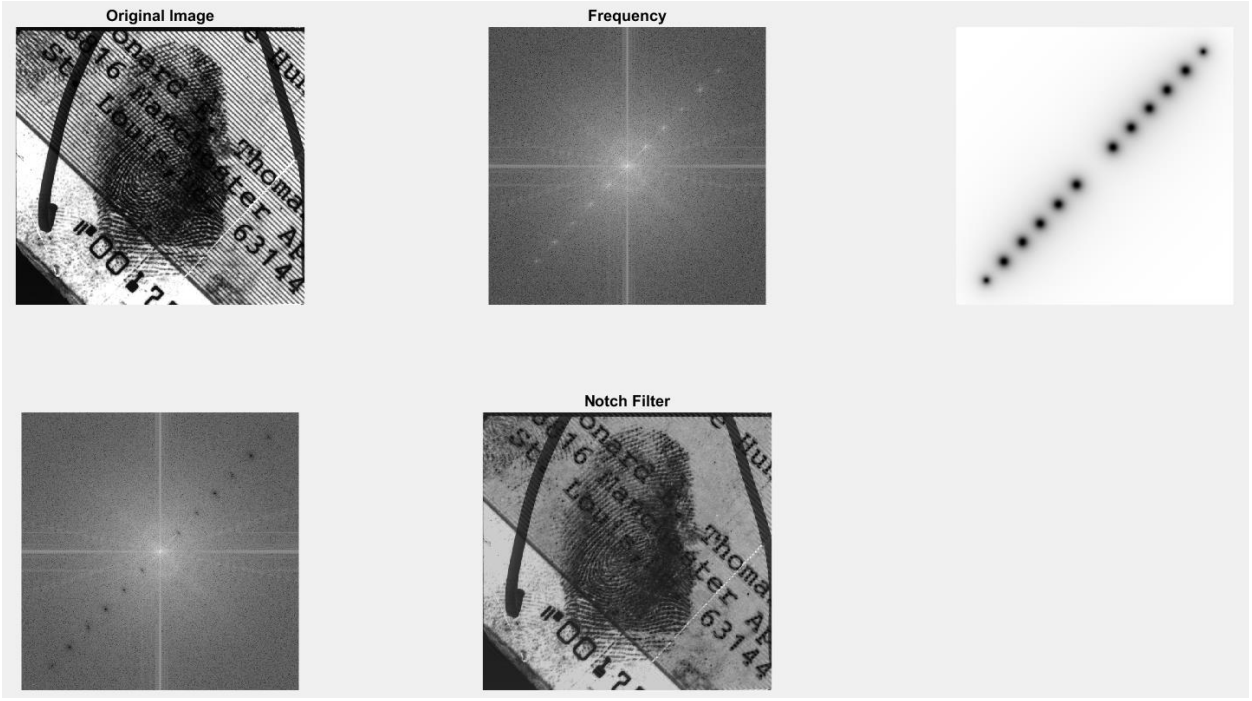
$$\mathrm{H}_{NR}(u,v)=1-\mathrm{H}_{NR}(u,v)$$

代码如下：

```
p = 1.0e+03 * [0.1755 1.4595; 0.2775 1.3515; 0.3835 1.2435; 0.4875 1.1335; 0.5895 1.0235;
0.6975 0.9115; 0.9075 0.6955; 1.0095 0.5815; 1.1175 0.4695; 1.2175 0.3675; 1.3255
0.2515];% locations of maxima, found by ginput
H = ones(P,P);
[DX, DY] = meshgrid(1:P);
D0 = 20;
n=1;
for k = 1:11
    Dk1 = sqrt((DX-p(k,1)).^2+(DY-p(k,2)).^2);
    Dk2 = sqrt((DX-P-2+p(k,1)).^2+(DY-P-2+p(k,2)).^2);
    H1 = 1./(1+(D0./Dk1).^(2*n));
```

```
    H2 = 1./(1+(D0./Dk2).^(2*n));
    H = H.*H1.*H2;
end
close all;
figure(1),clf
subplot(2,3,1),imshow(I),title('Original Image');
subplot(2,3,2),imshow(log(1+abs(F)),[]),title('Frequency');
subplot(2,3,3),imshow(H,[]);
% Filtering
G = H.*F;
g = real(ifft2(ifftshift(G))); % reverse
g = g(1:M,1:N);
subplot(2,3,4),imshow(log(1+abs(G)),[]);
subplot(2,3,5),imshow(g,[]),title('Notch Filter');
```

结果如下：



可以发现，周期性的斜边纹理背景被滤波器有所消除。

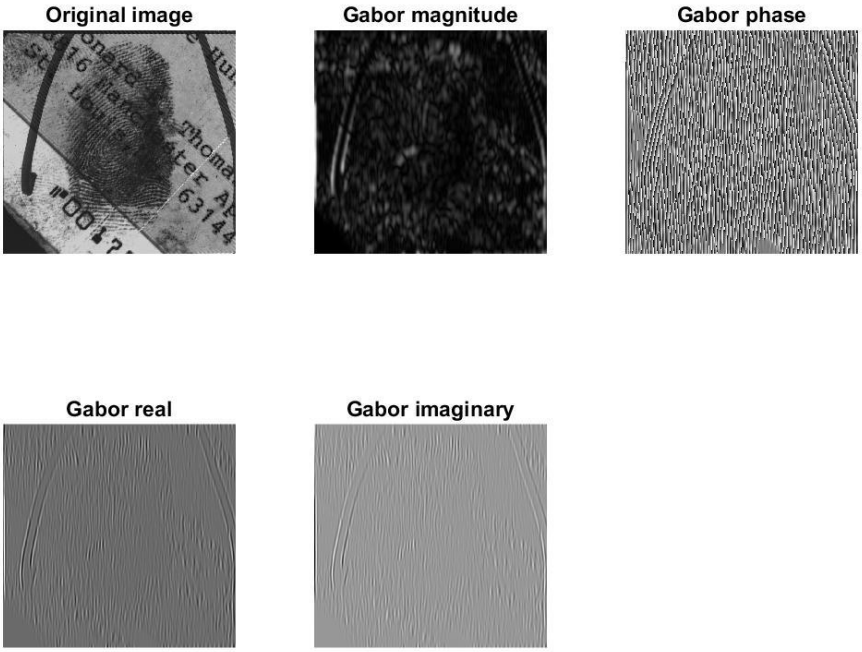
之后，利用 Gabor 滤波器组对指纹脊线进行自适应增强，使用 matlab 自带的 imgaborfilt() 即可实现。根据提示，方向选取 16 个，以循环形式给出，波长固定为 10 像素。代码如下：

```
%Gabor Filetering
close all;
wavelength = 10; %wavelength, parameter
orientation = 11.25;
for k = 0:15
    [mag,phase] = imgaborfilt(g,wavelength,k * orientation);
    figure(1),clf
```

```
    subplot(2,3,1),imshow(g,[]),title('Original image');
    subplot(2,3,2),imshow(mag,[]),title('Gabor magnitude');
    subplot(2,3,3),imshow(phase,[]),title('Gabor phase');
    subplot(2,3,4),imshow(mag.*cos(phase),[]),title('Gabor real');
    subplot(2,3,5),imshow(mag.*sin(phase),[]),title('Gabor imaginary');
    saveas(figure(1),[num2str(k) '.jpg']);
    close all;
end
```

结果如下：

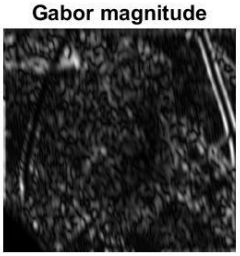
（Gabor 滤波器的方向为 11.25k 度）



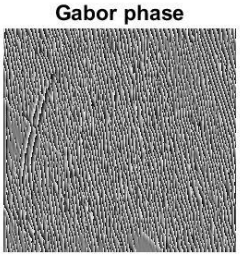
k=0

Original image

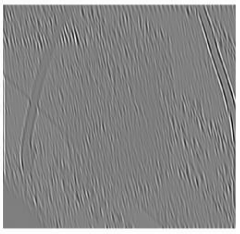
Gabor magnitude



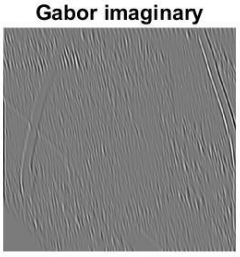
Gabor phase



Gabor real



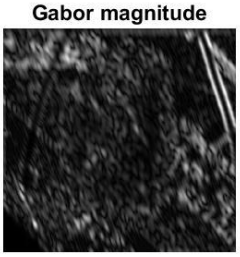
Gabor imaginary



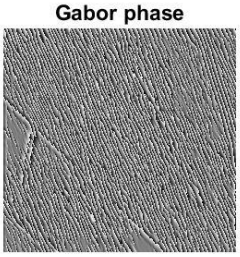
k=1

Original image

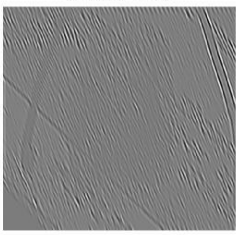
Gabor magnitude



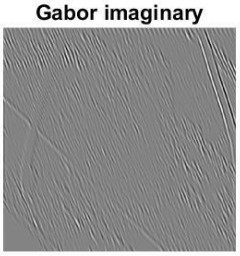
Gabor phase



Gabor real



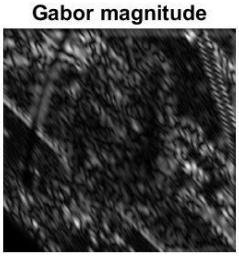
Gabor imaginary



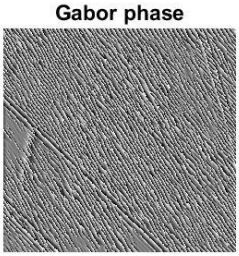
k=2

Original image

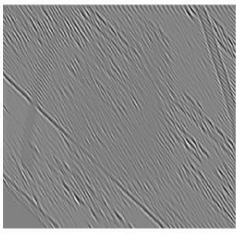
Gabor magnitude



Gabor phase



Gabor real

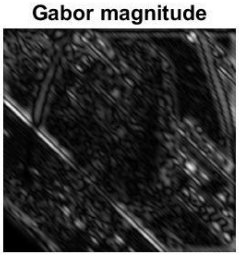


Gabor imaginary

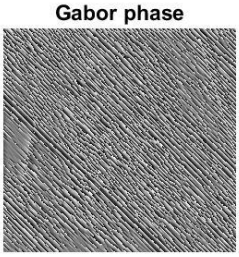
k=3

Original image

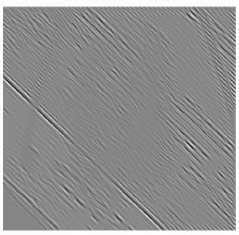
Gabor magnitude



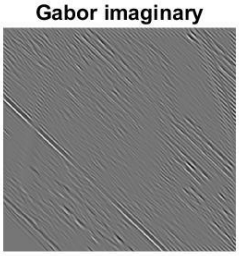
Gabor phase



Gabor real



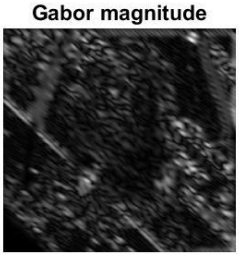
Gabor imaginary



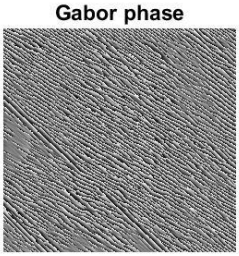
k=4

Original image

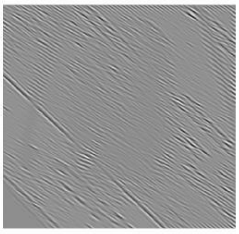
Gabor magnitude



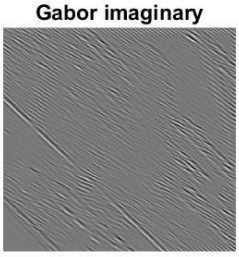
Gabor phase



Gabor real



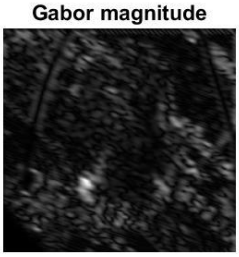
Gabor imaginary



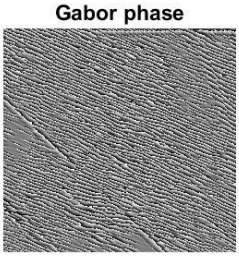
k=5

Original image

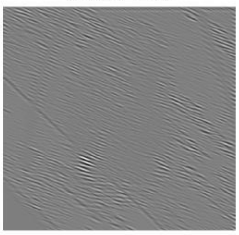
Gabor magnitude



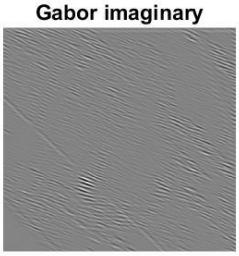
Gabor phase



Gabor real



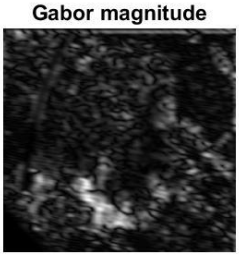
Gabor imaginary



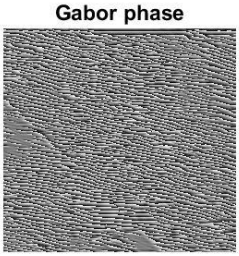
k=6

Original image

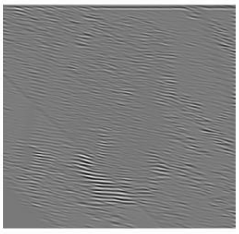
Gabor magnitude



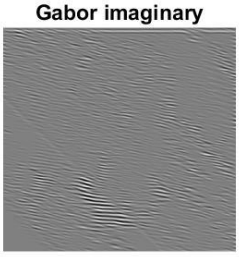
Gabor phase



Gabor real



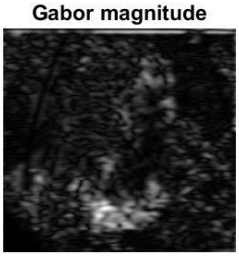
Gabor imaginary



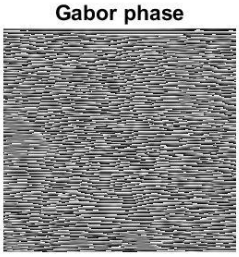
k=7

Original image

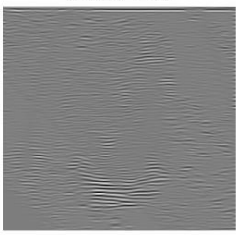
Gabor magnitude



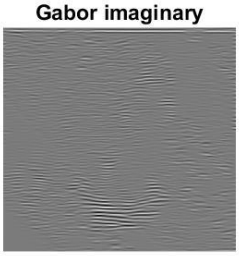
Gabor phase



Gabor real



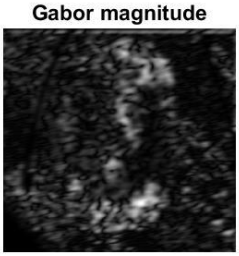
Gabor imaginary



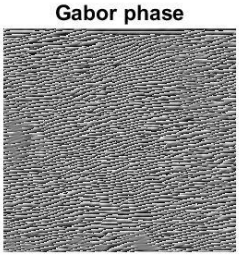
k=8

Original image

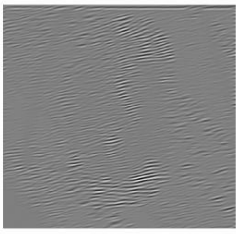
Gabor magnitude



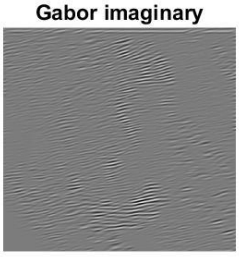
Gabor phase



Gabor real



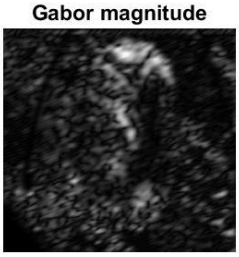
Gabor imaginary



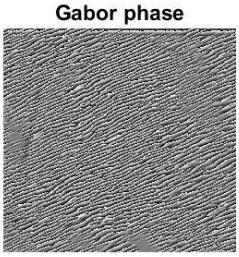
k=9

Original image

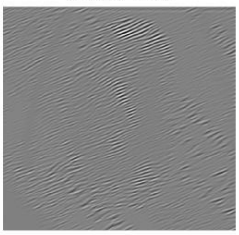
Gabor magnitude



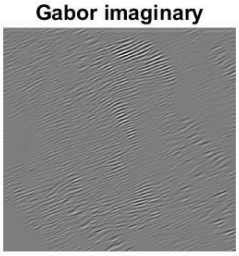
Gabor phase



Gabor real



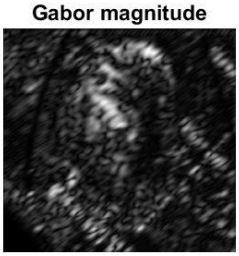
Gabor imaginary



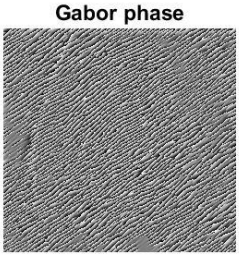
k=10

Original image

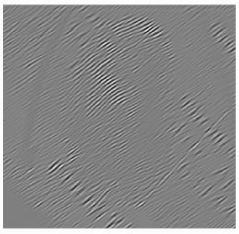
Gabor magnitude



Gabor phase



Gabor real

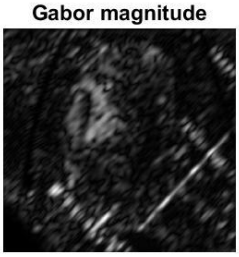


Gabor imaginary

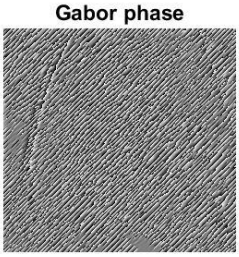
k=11

Original image

Gabor magnitude

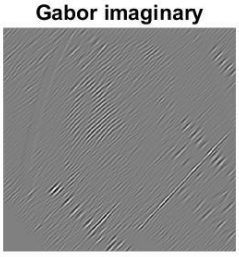


Gabor phase



Gabor real

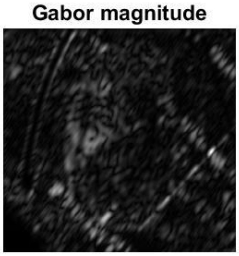
Gabor imaginary



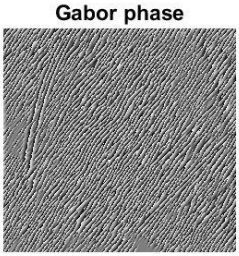
k=12

Original image

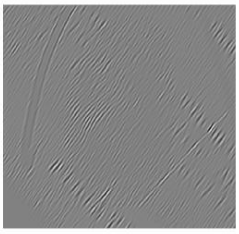
Gabor magnitude



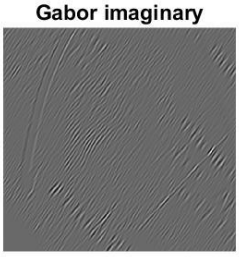
Gabor phase



Gabor real



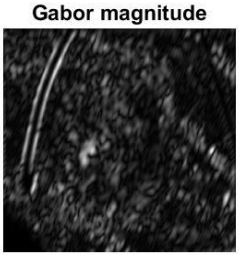
Gabor imaginary



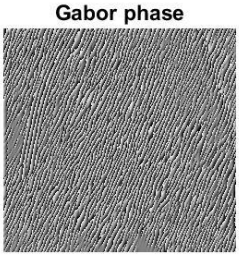
k=13

Original image

Gabor magnitude



Gabor phase



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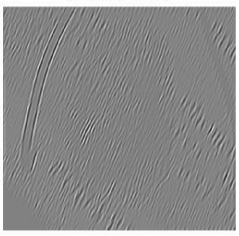
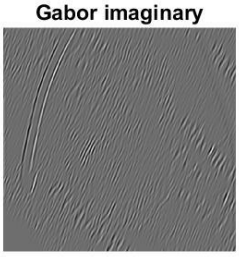
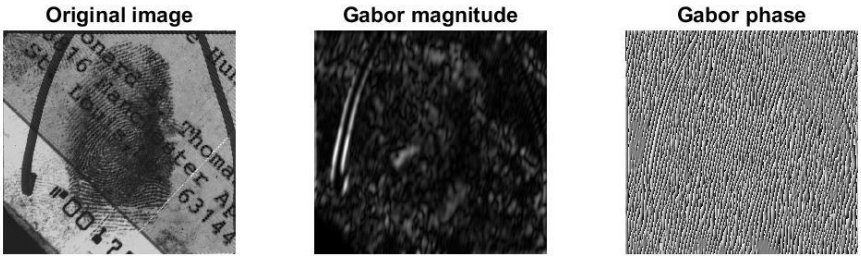
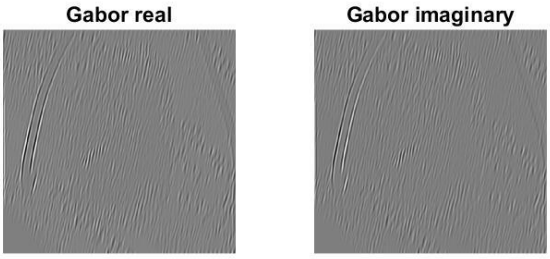


Gabor imaginary



k=14





k=15

可以看出，Gabor 滤波器十分适合纹理表达和分离。对于一个像素，适合方向滤波的幅度最大。而在这张图片中，一些不规则的噪声也会对 Gabor 滤波器的结果造成影响。如左右两边的墨汁样带状线条等。