Project 1 Gabor Filter

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MATLAB Code:

```
clear all
close all
fv=[0.25,0.18,0.13,0.09,0.06];
theta=[0,pi/8,pi/4,3*pi/8,pi/2,5*pi/8,3*pi/4,7*pi/8];
phi=0;
a=1;
b=1;
[X,Y] = meshgrid(-50:50,-50:50);
for i=1:8
    for j=1:5;
    Xprime = X .*cos(theta(i)) - Y .*sin(theta(i));
    Yprime = X .*sin(theta(i)) + Y .*cos(theta(i));
    hGaussian(:,:,(j-1)*8+i) = exp( -1/2*fv(j)*fv(j)*( Xprime.^2 ./a^2    + Yprime.^2 ./b^2));
    hGaborEven(:,:,(j-1)*8+i)    =fv(j)*fv(j)/pi/a/b*hGaussian(:,:,(j-1)*8+i) .*cos(2*pi*fv(j).*Xprime+phi);
    hGaborOdd(:,:,(j-1)*8+i)     =fv(j)*fv(j)/pi/a/b*hGaussian(:,:,(j-1)*8+i) .*sin(2*pi*fv(j).*Xprime+phi);
    h(:,:,(j-1)*8+i)    = complex(hGaborEven(:,:,(j-1)*8+i) ,hGaborOdd(:,:,(j-1)*8+i));
    end
end
for i=1:40
    subplot(5,8,i);
    imshow(h(:,:,i),[]);
end
```

Description:

A 2D Gabor filter can be viewed as a complex sinusoidal plane of particular frequency and orientation, modulated by a Gaussian envelope(Kamarainen et al.).

$$h(x,y) = s(x,y)g(x,y)$$

where $s(x,y)$ is the complex sinusoidal plane and the $g(x,y)$ is the Gaussian envelope.

. In this project the obtained function $h(x,y)$ could be written in the form

$$h(x,y,f_v,a,b,\varphi,\theta) = \frac{{f_v}^2}{\pi ab} e^{(-(\frac{{f_v}^2}{a^2}x'^2+\frac{{f_v}^2}{b^2}y'^2))} e^{j(2\pi f_v x'+\varphi)}$$

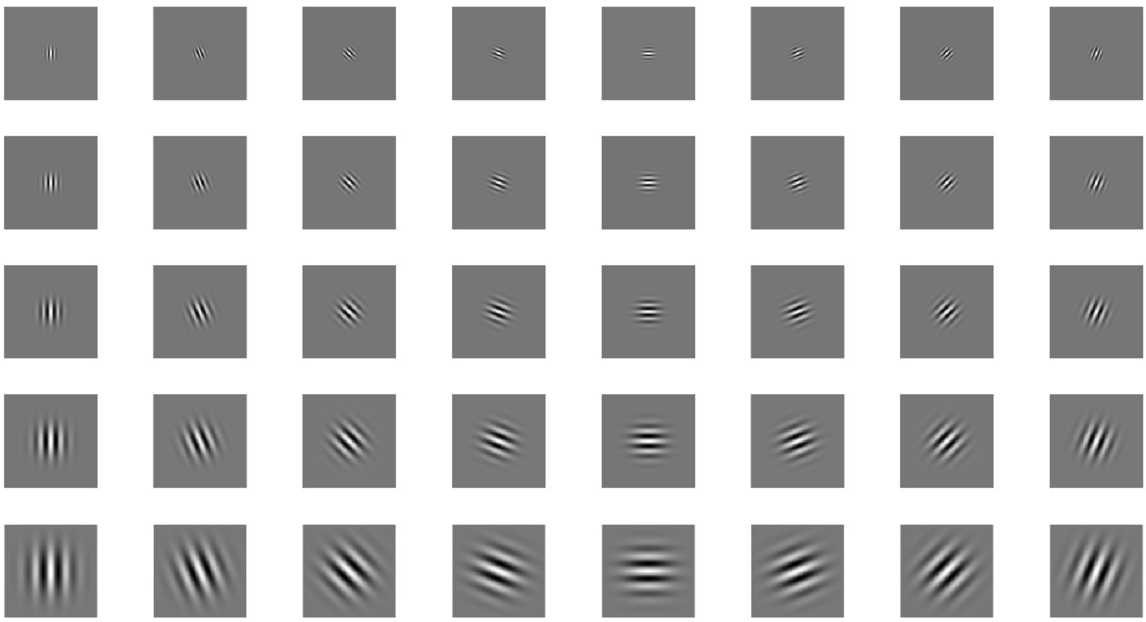
with $x' = x\cos\theta + y\sin\theta, y' = -x\sin\theta + y\cos\theta$ where x and y represent the spatial coordinates of the considered filter, f_v central frequency of the considered filter, θ rotation angle for the particular orientation of the filter, a sharpness of the Gaussian along the major axis, b

sharpness of the Gaussian along the minor one, and φ is the phase offset which can affect the distribution and magnitude of the filter. (G. D. Licciardo et al.)

In this project, I choose $f_v = 2^{-\frac{n+2}{2}}, n = 2, 3, 4, 5, 6.$ f_v retains two decimal places. Let the $\theta = m\frac{\pi}{8}$ $m = 1,2 \dots .7.$ I also set $a = b = 1, \varphi = 0$. We can get $5 \times 8 = 40$ gabor filters called gabor bank.

First, we need to get coordinate matrices of x and y using the meshgrid function. I choose x and y from -50 to 50 because it is not only large enough but can center the filter image. Then we need to get x' and y'. It is like rotating all the coordinates to the particular orientation. In the MATLAB, if we want to anticlockwise rotate θ, we will need to compute $x' = xcos\theta - ysin\theta, y' = xsin\theta + ycos\theta$. Then we can first compute the component of Gaussian and then decompose the component of sinusoidal with Euler's formula. Finally using complex function to bring them together to get the h. We use the for loop function to get all 40 kernals in one figure. Here is the result below.

θ \ f_v	0	$\frac{\pi}{8}$	$\frac{2\pi}{8}$	$\frac{3\pi}{8}$	$\frac{4\pi}{8}$	$\frac{5\pi}{8}$	$\frac{6\pi}{8}$	$\frac{7\pi}{8}$
0.25								
0.18								
0.13								
0.09								
0.06								



Bibliography

G. D. Licciardo, et al. "Design of a Gabor Filter HW Accelerator for Applications in Medical Imaging." *IEEE Transactions on Components, Packaging and Manufacturing Technology*, vol. 8, no. 7, July 2018, pp. 1187–94, doi:10.1109/TCPMT.2018.2818947.

Kamarainen, Joni-Kristian, et al. *Robustness of Gabor Feature Parameter Selection.* 2002, pp. 132–35.