Gabor Filters in Fingerprint Application
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I. INTRODUCTION:
A filter is generally a frequency-selective device. Filter design is the process of designing a signal processing filter that satisfies a set of requirements, some of which are contradictory. The purpose is to find a realization of the filter that meets each of the requirements to a sufficient degree to make it useful. Some frequencies are passed through the filter and some frequencies are blocked by filter. Filtering is a class of signal processing, the defining feature of filters being the complete or partial suppression of some aspect of the signal. The frequencies of signals that are passed through the filter are called pass band frequencies and those frequencies that are stopped by the filter are called stop band frequencies. The magnitude of the system function is very large for pass band frequencies and constant for stop band frequencies. The magnitude is very small and ideally is zero. A filter selects important frequencies from the selected signal and removes unwanted frequencies and makes it good. Filter alters the relative amplitudes of the various frequency components and the phase characteristics and its ‘Gain’ depends entirely on the signal frequency.

II. THEORY:
Forensic scientists have used fingerprints in criminal investigations as a means of identification for centuries. The uniqueness of fingerprints makes it possible to use prints from a crime scene to either connect a suspect to the scene or eliminate a suspect from consideration. Both can occur with DNA traces and fingerprints, and therefore evidence should be collected, analyzed, and presented in accordance with established guidelines. Fingerprinting is one of the widest techniques which is presently used all over the world. It is the most convenient and most inexpensive method used from few years. It is the accurate way for security for storage of personal documents and files. Each and every individual has their own unique fingerprint because everyone has matchless edges on finger. Biometrics has its own pros of giving a control modified access to hidden areas and more important of all is identification of victims during the crime scene. Here, we use a unique design method of gabor filter to produce a final fingerprinting image quality.

III. DESIGN:
The main aim of this is to give a input fingerprint image by usage of gabor filtering techniques where there the the image is passed is gone through few important stages and later finally filtered to get an output image which is a clean image. Here gabor filter is used for edge detection. Here we use matlab and Verilog HDL for design of gabor filter mainly used for fingerprint applications worldwide. Gabor filters are basically bandpass filters which are mainly used in image processing, fingerprint application for a unique feature extraction when a gabor filter is given to an input image, it gives high response at the corners and at exactly on the point where texture changes. The impulse response of a gabor filter is usually given by convolution of a gaussian factor and a fourier transform.
Complex Portion: g(x,y,\lambda,\theta,\psi,\sigma) = \exp(-(x^2+y^2)/2 \sigma^2) \exp(i(2pix/\lambda+\psi))
The space domain representation of the complex 2d gabor filters is given by:
H(x,y)=s(x,y)g(x,y)
S(x,y) is complex sinusoid and g(x,y) is 2D gaussian shaped function known as envelope
Equivalent frequency representation of gabor filter is:
H(u,v)=\exp(-2*\pi^2*\sigma^2*(u-U)^2+(v-V)^2)}
The gabor filter tank is obtained by generating gabor filter for all directions from 0 to 360 degree.
Image processing is a form of signal processing where an input is an image signal and the output will be filtered and it gives the list of parameters depending on the requirement of the design.
The input image is segmented and then passed through different stages where different actions are performed. Initially, the input image is passed to normalization with the aim of obtaining a better contrast of the fingerprint image.

**The algorithm for normalization is:**
Detect the minimum and maximum gray value of the input fingerprint image $G_{(min)}$ and $G_{(max)}$.
Detect the range of gray values of the input fingerprint and compare the range of gray values in fingerprint image $G_{(range)}= G_{(max)}-G_{(min)}$. If the range is not zero, scale all the gray values of fingerprint image by:
$$\frac{\text{Grayoldvalue} - G_{(min)} \times 255}{G_{(range)}}.$$  

Segmentation is another method where the input image is segmented based on color, odor, and texture, and then the image is oriented in different directions and the image frequency is estimated. Finally, the most important step which is filtering, i.e., the removal of unwanted noise, is removed, and we get a proper output image. Resizing the image into a standard size is another part of conversion because we need a proper size to process.

**IV. ALGORITHM FOR GABOR FILTER DESIGN:**

```
Input image

Segmentation and normalization

Gabor Wavelet and feature extraction

F(x,y)  o(x,y)

Gaussian smooth kernel  Gaussian smooth kernel  Region mask estimation

F(x,y)  o(x,y)

Tuned Gabor Filter

Mask  o(x,y)

Enhanced image

Binarization

Binary image
```
The code:

```matlab
%Read the original RGB input image
image=imread('IMG_123.JPG');
%convert it to gray scale
    image_gray=rgb2gray(image);
%resize the image to 160x160 pixels
    image_resize=imresize(image_gray, [160 160]);
%apply im2double
    image_resize=im2double(image_resize);
%show the image
    figure(1);
    imshow(image_resize);
    title('Input Image');

%Gabor filter size 7x7 and orientation 90 degree
%declare the variables
    gamma=0.3; %aspect ratio
    psi=0; %phase
    theta=90; %orientation
    bw=2.8; %bandwidth or effective width
    lambda=3.5; % wavelength
    pi=180;

for x=1:160
    for y=1:160
        x_theta=image_resize(x,y)*cos(theta)+image_resize(x,y)*sin(theta);
        y_theta=-image_resize(x,y)*sin(theta)+image_resize(x,y)*cos(theta);
        gb(x,y)=exp(-(x_theta.^2/2*bw^2+gamma^2*y_theta.^2/2*bw^2))*cos(2*pi/lambda*x_theta+psi);
    end
end

figure(2);
imshow(gb);
title('filtered image');
```

The output:
V. CONCLUSION:
Filters serve a critical role in many common applications. Such applications include power supplies, audio electronics, and radio communications. Filters can be active or passive, and the four main types of filters are low-pass, high-pass, band-pass, and gabor filter design can be used for security as well as criminal investigation purposes. Gabor filters are a common model of simple cells found in the early stages of the visual cortex. Simple cells respond to the presence of oriented edges in the visual stimulus. Gabor filters with different frequencies and with orientations in different directions have been used to localize and extract text-only regions from complex document images (both gray and colour), since text is rich in high frequency components, whereas pictures are relatively smooth in nature.

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VI. REFERENCES:
[4]. "The Implementation of convolution" - Khader Mohammad and Sos Agaian in 2009