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HAAR Wavelet Transform and Gabor Features Fusion Based Iris Recognition

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Abstract: ***Iris recognition is used for identifying people based on unique patterns within the ring-shaped region surrounding the pupil of the eye. Since it makes use of biological characteristic, it is considered a form of biometric verification. Currently the iris recognition techniques allow very high recognition performances in controlled settings and with cooperating users. This provides iris an edge over other biometric traits like fingerprints. Most of the existing approaches for iris recognition are designed for images acquired in Near Infrared or Hyper-spectral regions, which are not much affected by changes in surrounding light conditions. Current research is focused on designing new techniques which aim to ensure high accuracy even on images that are captured in visible light. Iris classification aims to recognize and identify iris among many that are stored in database. Image registration for database includes-image pre-processing and feature extraction based on the texture. Feature extraction is done using fusion of haar wavelet transform and texton representation. The query image is processed using the same technique and iris matching process is done.***

Keywords: Iris recognition, Biometric identification, Feature vector, Haar wavelet transform, Gabor filter, Squared Euclidean distance

1. Introduction

Iris is formed 10 months after the birth and remains stable throughout thereafter. Irises are complex structures which have a unique texture pattern for every individual. Hence verification based on iris can be a secure biometric identification technique.

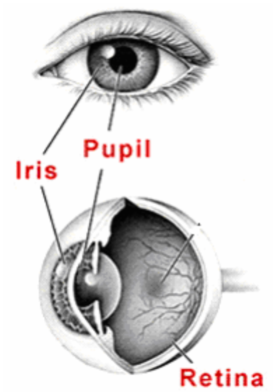

Figure 1: Iris of the eye

2. HAAR Wavelet Transform

In the Haar wavelet transformation method, low-pass filtering is done by finding the average of two adjacent pixel values, whereas the difference of two adjacent pixel values is found out to perform high-pass filtering. The Haar wavelet transform applies a pair of low-pass and high-pass filters to image decomposition.[1] First they are applied in image columns and then in image rows one by one. As a result, the output of first level Haar wavelet transform consists of four sub-bands. The four sub-bands are LL1, HL1, LH1, and HH1. Up to four levels of decomposition are done to get the detailed image.[2] The WT separates an image into a lower resolution approximation image component (LL) as well as horizontal component (HL), vertical component (LH) and diagonal (HH) component. This process is repeated to compute multi-scale wavelet decomposition of the image.

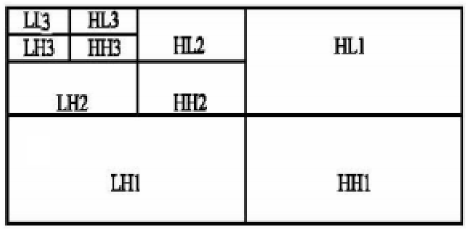

Figure 2: Haar wavelet transform

3. Texture Features

Textons are basic patterns in a texture. Textons can be obtained by convolving an image with a filter bank. For this purpose we have used Gabor filter bank.

Gabor filter

In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for edge detection. Gabor filters have frequency and orientation representations which are similar to the human visual system, and they are particularly appropriate for texture representation and discrimination of the images. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave. [4]

The impulse response of Gabor filter is defined by a sinusoidal plane wave which is multiplied by a Gaussian function. Because of the Convolution theorem, the Fourier transform of a Gabor filter's impulse response is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian function. The filter output has two components a real and an imaginary component which are orthogonal to each other. The two components form a complex function as shown below. The output of the real part of the filter is similar to the human visual system and is therefore commonly used. [3]

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma)=\exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\exp\left(i\left(2\pi\frac{x'}{\lambda}+\psi\right)\right)$$

Real

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma)=\exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\cos\left(2\pi\frac{x'}{\lambda}+\psi\right)$$

Imaginary

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma)=\exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\sin\left(2\pi\frac{x'}{\lambda}+\psi\right)$$

where

$$x'=x\cos\theta+y\sin\theta$$

and

$$y'=-x\sin\theta+y\cos\theta$$

Figure 3: 2-D Gabor filter equations

In this equation, λ represents the wavelength of the sinusoidal factor,θ theta represents the orientation of the normal to the parallel stripes of a Gabor function,Ψ psi is the phase offset, σ sigma is standard deviation of the Gaussian envelope and γ gamma is the spatial aspect ratio, and specifies the ellipticity of the support of the Gabor function.

4. Working

There are four steps to iris recognition, iris acquisition, iris localization and normalization, iris feature extraction and matching verification.

Image preprocessing

Image preprocessing includes Image acquisition, Iris Localization and Normalization. The first processing step consists in capturing the image of the eye and locating the inner and outer boundaries of the iris. Iris normalization is done in order to rectify the orientation of the image.

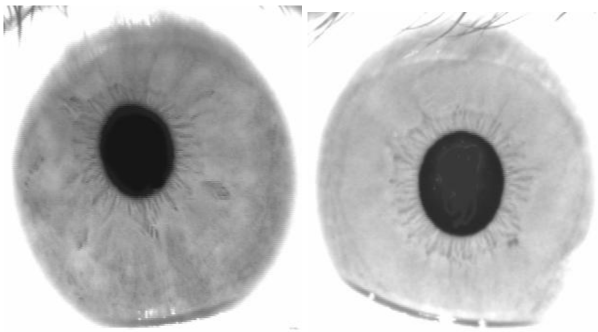

Figure 4: Sample iris images after preprocessing

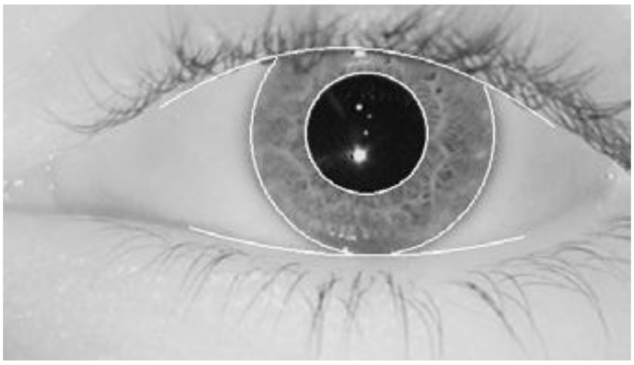

Figure 5: Iris localization and normalization

Block Diagram

The features of the pre-processed image are extracted and those feature vectors are stored in the database. When a query image is given, it undergoes same preprocessing and same method of feature extraction. These feature vectors of query image are then compared with the existing feature vectors in the database. The feature vector with which the query feature vector has less difference is selected. Thus the person is identified based on the matching of feature vectors.

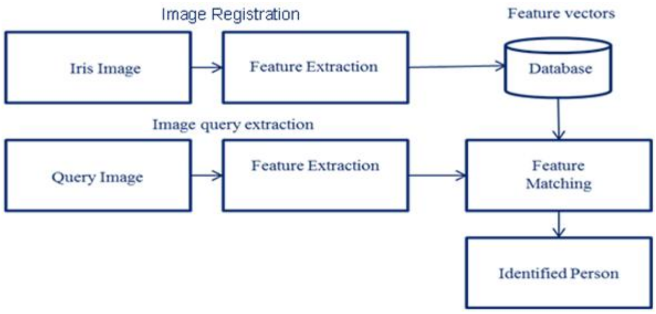

Figure 6: General Block Diagram

Proposed System for Fusion

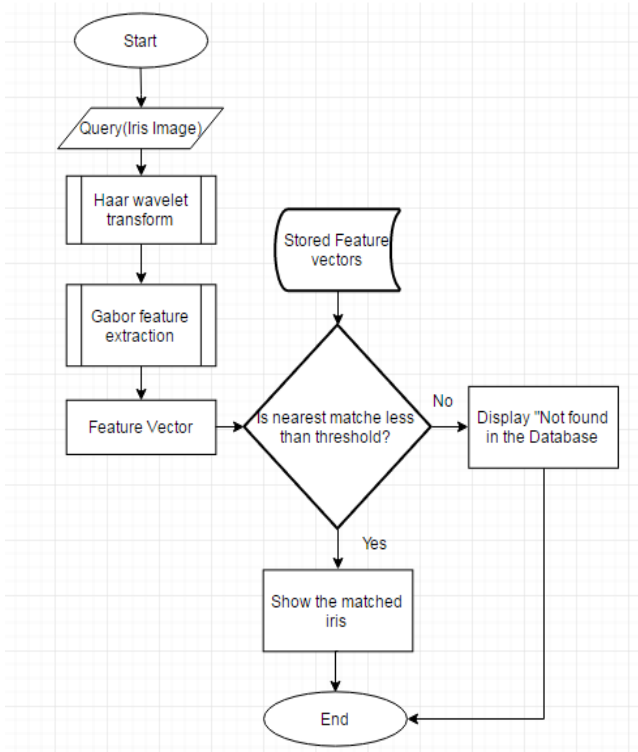

Figure 7: Flowchart of the proposed technique

The query image undergoes Haar wavelet transform. Features of the transformed iris image are extracted by applying the gabor filter bank. The feature vector after applying gabor filter is then compared with all the Feature vectors stored in the database. The nearest match of the image is considered by using the squared Euclidean distance.

The standard Euclidean distance is squared in order to place progressively greater weight on objects that are farther apart. In this case, the equation becomes

$$d^2(p,q) = (p_1 - q_1)^2 + (p_2 - q_2)^2 + \cdots + (p_i - q_i)^2 + \cdots + (p_n - q_n)^2.$$

If the matched image is less than a threshold value then the matched image is shown. If it is greater than the threshold, it displays that a match for the query image was not found in the database.

5. Conclusion

Haar wavelet transform and Gabor filter bank for Iris recognition output good result when applied individually on images that are taken in UV light spectrum. But when they are applied individually on visible light they do not output the expected results as with UV light spectrum. So we use fusion of both these methods to obtain a better result in visible light.

6. Future Scope

Further analysis will be focused on the Iris recognition of the image of eye with contact lenses, image that are clicked on low megapixel camera, poor contrast images. Even images clicked on smart phones can be used for recognition which in turn gives chance for developing applications based on iris lock.

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