An Efficient Iris Recognition System using Phase Based Technique

T.Manickam, A.Sharmila, A.K.Sowmithra

Department Of Electronics and Communications Engineering, Nandha Engineering College, Erode Tamilnadu, India.

*Corresponding Author: T.Manickam
E-mail: manickam1976@gmail.com
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Abstract

A major approach for iris recognition today is to generate feature vectors corresponding to individual iris images and to perform iris matching based on some distance metrics. One of the difficult problems in feature-based iris recognition is that the matching performance is significantly influenced by many parameters in feature extraction process, which may vary depending on environmental factors of image acquisition. This paper presents an efficient algorithm for iris recognition using phase-based image matching. The use of phase components in 2D (two-dimensional) discrete Fourier transforms of iris images makes possible to achieve highly robust iris recognition in a unified fashion with a simple matching algorithm. Experimental evaluation using an iris image database clearly demonstrates an efficient matching performance of the proposed algorithm.

Keywords: Phase-based matching, Phase only correlation, Band limited phase-only correlation, Iris Recognition, image processing.

1. Introduction

1.1 Overview

Biometrics refers to the identification and verification of human identity based on certain physiological traits of a person. The commonly used biometric features include speech, fingerprint, face, handwriting, gait, hand geometry etc. The face and speech techniques have been used for over 25 years, while iris method is a newly emergent technique.

The iris is the colored part of the eye behind the eyelids, and in front of the lens. It is the only internal organ of the body which is normally externally visible. These visible patterns are unique to all individuals and it has been found that the probability of finding two individuals with identical iris patterns is almost zero. Though there lies a problem in capturing the image, the great pattern variability and the stability over time, makes this a reliable security recognition system.
1.2 Background

Ophthalmologists Alphonse Bertillon and Frank Burch were one among the first to propose that iris patterns can be used for identification systems. In 1992, John Daugman was the first to develop the iris identification software. Other important contribution was by R.Wildes et al. Their method differed in the process of iris code generation and also in the pattern matching technique. The Daugman system has been tested for a billion

This paper consists of six main parts, which are Introduction, image acquisition, preprocessing, Matching, Simulation, Results and discussions. Each section describes the theoretical approach and is followed by how it is implemented.

2. Image Acquisitions

This step is one of the most important and deciding factors for obtaining a good result. A good and clear image eliminates the process of noise removal and also helps in avoiding errors in calculation. In this case, computational errors are avoided due to absence of reflections, and because the images have been taken from close proximity. This project uses the image provided by CASIA (Institute of Automation, Chinese Academy of Sciences, these images were taken solely for the purpose of iris recognition software research and implementation. Infra-red light was used for illuminating the eye, and hence they do not involve any specular reflections. Some part of the computation which involves removal of errors due to reflections in the image was hence not implemented.

Figure 1: Image of the eye

2.1 Image localization

Due to computational case, the image was scaled down by 60%, the image was tilled using Gaussian filter, which blurs the image and reduces effects due to noise. The degree of smoothening is decided by the standard deviation, \( \sigma \) and

The part of the eye carrying information is only the iris part. It lies between the scleral and the pupil. Hence the next step is separating die iris pan from the eye image. The iris inner and outer boundaries are located by finding the edge image using tire canny edge detector,

The Canny detector mainly involves three steps, viz. finding the gradient, non-maximum suppression and the hysteresis thresholding. As proposed by Wildes, the thresholding for the eye image is performed in a vertical
direction only, so that the influence due to the eyelids can be reduced. This reduces (the pixels on the circle boundary, but with the use of Hough transform, successful localizations of the boundary can be obtained even with the absence or few pixels. It is also computationally faster since the boundary pixels are lesser for calculation.

Using the gradient image, the peaks are located using non-maximum suppression. It works in the following manner. For a pixel midgrade (x, y) in the gradient image, and given the orientation theta(x, y), the edge intersects two of its 8 connected neighbors. The point al (x, y) is a maximum if its value is not smaller than the values at the two intersection points.

The next step, hysteresis thresholding, eliminates the weak edges below a low threshold, but not if they are connected to an edge above a high threshold through a chain of pixels all above the low threshold. In other words, the pixels above a threshold TJ are separated. Then, these points are marked as edge points only if all its surrounding pixels are greater than another threshold T2. The threshold values were found by trial mid error, and were obtained as 0.2 and 0.19.

Hough transforms. Firstly, the threshold values are to be found by trial Secondly, it is computationally intensive. This is improved by just having eight-way it is taken to be 2 in this case.

![Figure 2: Canny edge image](image)

Edge detection is followed by finding the boundaries of the iris and the pupil Datigman proposed the use of the Integra-differential operator to detect the boundaries and the radii. It is given by max

\[
(r, x_0, y_0)
\]

This behaves as a circular edge detector by searching the gradient image along the boundary of circles of increasing radii from the likelihood of all circles, the maximum sum is calculated and is used to find the circle centers and radii.
The Hough transform is another way of detecting the parameters of geometric objects, and in this case, has been used to find the circles in the edge image. For every edge pixel, the points on the circles surrounding it at different radii are taken, and their weights are increased if they are edge points too. These weights are added to the accumulator array. Thus, after all radii and edge pixels have been searched, the maximum from the accumulator array is used to find the center of the circle and its radius. The Hough transform is performed for the iris outer boundary using the whole image, and then is performed for the pupil only, instead of the whole eye, because the pupil is always inside the iris. There are a few problems with symmetric points on the circle for every search point and radius. The eyelashes were separated by thresholding, and those pixels were removed.

2.2 Image Normalization

Once the iris region is segmented, the pixel stage is to normalize this part, to enable generation of the iris templates and their comparisons; Since variations in the eye, like optical size of the iris, position of pupil in the iris, and the iris orientation change person to person, it is required to normalize the iris image, so that the representation is common to all, with similar dimensions.

Normalization process involves unwrapping the iris and converting it into its polar equivalent. It is done using Daugman’s Rubber sheet model. The center of the pupil is considered as the reference point and a remapping formula, used to convert the points on the Cartesian scale to the polar scale. Theomeddled form of the model is shown below.
The radial resolution was set to 100 and the angular resolution to 2400 pixels. For every pixel in the iris, an equivalent position is found out on polar axes. The normalized image was then interpolated into the size of the original image, by using the interp2 function. The parts in the normalized image which yield a NaN, are divided by the sum to get a normalized value.

2.3 Effective region extraction

This step is performed to avoid certain problems, which occurs when the extracted effective region becomes too small to perform image matching. Given a pair of normalized iris images \((nl, nl)\) and \(g\)
to extract from the two images, the effective regions $f(n_l, n_l)$ and $g(n_l, n_l)$ of same size, which do not contain irrelevant regions, lire index range is assumed in any specified matrix where amplitude and phase is detected and evaluated. The diverse DFT is calculated. When two images are not similar, the peak drops and the height of tire peak gives the good similarity measure for image matching and the localization of the peak shows the translation displacement of the image.

### 3. Phase-Based Image Matching

Before discussing the image alignment and the matching score calculation, we introduce the principle of phase-based image matching using Phase-Only Correlation (POC) function [5]. Consider two $N_l \times \sqrt{2}$-pixel images, $f(n_1, n_l)$ and $g(n_1, n_l)$, where we assume that the index ranges are $n_1 = -M_1 \ldots M_1$ ($M_1 > 0$) and $n_2 = -M_2 \ldots M_2$ ($M_2 > 0$) for mathematical simplicity, and hence $M = 2M_1 + 1$ and $\sqrt{2} = 21/2 + 1$. Let $F(k_1, k_2)$ and $G(k_1, k_2)$ denote the 2D DFTs of the two images. $F(k_1, k_2)$ is given by:

$$
F(k_1, k_2) = \sum_{n_1, n_2} f(n_1, n_2) e^{-j2\pi (k_1 n_1 + k_2 n_2)}.
$$

The cross-phase spectrum $R_{FG}(k_1, k_2)$ is given by:

$$
R_{FG}(k_1, k_2) = \frac{F(k_1, k_2) G^*(k_1, k_2)}{|F(k_1, k_2)||G(k_1, k_2)|} = e^{j\theta(k_1, k_2)}.
$$

The POC function $r_{FG}(n_1, n_2)$ is the 2D Inverse DFT (IDFT) of $R_{FG}(k_1, k_2)$ and is given by:

$$
r_{FG}(n_1, n_2) = \frac{1}{N_1 N_2} \sum_{k_1, k_2} R_{FG}(k_1, k_2) W_{n_1}^{k_1} W_{n_2}^{k_2}.
$$

Band Limited phase only correlation (BLPOC) is given by:

$$
r_{BLPOC}(n_1, n_2) = \frac{1}{L_1 L_2} \sum_{k_1, k_2} R_{FG}(k_1, k_2) W_{n_1}^{k_1} W_{n_2}^{k_2}.
$$

Note that the maximum value of the correlation peak of the BLPOC function is always normalized to 1 and does not depend on $L_1$ and $L_2$. Figure 5 shows an example of genuine matching using the original POC function and the BLPOC function. The BLPOC function provides better discrimination capability than that of the original POC function.
3.1 Displacement alignment

This step is performed to align die translational displacement between the extracted images. Various factors like rotation of camera; head tilt etc might cause displacement of the normalized images. The displacement parameter can be obtained as die peak location of the Phase only Correlation (POC) Function. The obtained parameters are used to align the images.

3.2 Matching score calculation

Band limited phase only correlation is calculated in this step between the aligned images and evaluated the matching score. In the case of genuine matching, if the displacement between the tiro images is aligned, tire correlation peak of BLPOC function should appear in the origin. If the matching score is close to the threshold value to separate genuine and imposters, we calculate the matching score with scale correction.(see figure 7)

4. Simulation

Simulation model:

The proposed model has been simulated on a Pentium core2duo processor by using MATLAB 2009 programming language with image processing tool box for the performance and effectiveness of tite approach.

The flow graph of our simulation work is as shown below figure 7.

Simulation Procedure:

1) The MATLAB program saved in nr file.
2) File can be executed by using simulator tool in editor Window
3) Add person's image to the data base.
4) Take one input image and performs preprocesing algorithm.
5) Comparing input image with data base image.

If input image matches with data base image
Figure 7: process of flow diagram

Algorithm:
Begin:
    Take input image
    If input image f
    F1 = conv [H1 (f)]
    For all database 20 people
        For all samples per person G1
            Matches F1 and G1
            POC = store to peak
            BLPOC = store to peak
        End
    End
    // TO find the maximum peak //
    If peak > Th
        % T1 = Threshold%
        Match
    Else
        Not Match
    End
End

Figure 8: Genuine matching using (A) & (B) The original POC Function and (C) & (D) The Band Limited POC function.

Figure 9: Distributions of matching score
5. Results and Discussion

This section describes a set of experiments using CASIA iris image database [6] for evaluating the proposed algorithm. This database contains 756 eye images (108 eyes and 7 images of each eye). We evaluate the genuine matching scores and the impostor matching scores for all possible combinations (genuine: 2.268 attempts, impostor: 283.122 attempts).

The score between minimum genuine value and maximum impostor values can be chosen as a threshold. Our observation shows that this performance degradation is mainly caused by the elimination of the eyelid masking and the effective region extraction steps. Note that CASIA iris image database contains many iris images whose irises are heavily occluded by eyelids. Thus, the eyelid masking and the effective region extraction steps have a significant impact on the performance. In a practical system, however, such a difficult condition does not happen so often. On the other hand, the processing time could be greatly reduced by the simplification which allows the system to perform multiple matching within a short time. This leads to better GAR (Genuine Accept Rate) for users. The number of iris images in the database available at [7] is smaller than the complete database. The result demonstrates a potential possibility of phase-based image matching for creating an efficient iris recognition system.

6. Conclusion

The personal identification technique developed by John Daugman was implemented, with a few modifications involving due to processing speed. It has been tested only for the CASIA database image. Due to computational efficiency, the search area in a couple of parts has been reduced, and the elimination of errors due to reflections in the eye image has not been implemented.

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References
