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Efficient Biometric for Human Identification and Verification through Iris Recognition

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ABSTRACT

A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual. Iris recognition is regarded as the most reliable and accurate biometric identification system available. Most commercial iris recognition systems use patented algorithms developed by Daugman, and these algorithms are able to produce perfect recognition rates. However, published results have usually been produced under favorable conditions. The work presented in this paper involved developing an iris recognition system in order to verify both the uniqueness of the human iris and also its performance as a biometric. For determining the recognition performance of the system one databases of digitized grayscale eye images were used. The iris recognition system consists of an automatic segmentation system that is based on the Hough transform, and is able to localize the circular iris and pupil region, occluding eyelids and eyelashes, and reflections. The extracted iris region was then normalized into a rectangular block with constant dimensions to account for imaging inconsistencies. The Hamming distance was employed for classification of iris templates, and two templates were found to match if a test of statistical independence was failed. The system performed with perfect recognition on a set of 450 eye images; however, tests on another set of 340 images resulted in false accept and false reject rates of 0.005% and 0.238% respectively. Therefore, iris recognition is shown to be a reliable and accurate biometric technology.

Introduction

The purpose of 'Iris Recognition', a biometrical based technology for personal identification and verification, is to recognize a person from his/her iris prints. The objective will be to implement an iris recognition system in order to verify the claimed performance of the technology. We implemented 'Iris Recognition' used will be MATLAB, and emphasis will be only on the software for performing recognition, and not hardware for capturing an eye image. A rapid application development (RAD) approach will be employed in order to produce results quickly. MATLAB provides an excellent RAD environment, with its image processing toolbox, and high level programming methodology (Ashish Dewangan, 2012). To test the system, data sets of eye images will be used as inputs; a database of 756 grayscale eye images courtesy. (CASIA,2003).The system is to be composed of a number of sub-systems, which correspond to each stage of iris recognition. These stages are segmentation – locating the iris region in an eye image, normalization – creating a dimensionally consistent representation of the iris region, and feature encoding – creating a template containing only the most discriminating features of the iris. The input to the system will be an eye image, and the output will be an iris template, which will provide a mathematical representation of the iris region.

Materials and Methods

The process of iris recognition typically involves the following stages :(a) an algorithm to automatically segment the iris region from an eye image. This will require research into many different techniques such as Daugman's integro-differential operator, circular Hough transform, and active contour models(Ma L.,2002).(b) normalize the iris region in order to counteract imaging inconsistencies such as pupil dilation. An implementation of Daugman's polar representation (Daugman,2002) will be used for this purpose, as this is the most documented method for iris normalization.

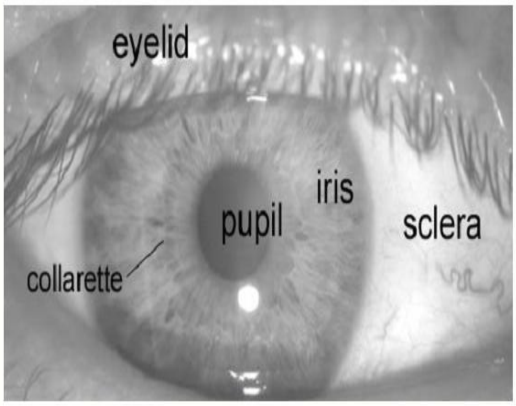

Figure 1. A front-on view of the human eye

Once a normalized iris pattern has been obtained, it will be convolved with 2D Gabor wavelets in order to extract features.(Daugman,2002) , and also Boles(Boles, 1998) and a MATLAB function (Kovesi,2004) is available to perform Gabor wavelet analysis.(c) matching and statistical analysis will be performed in order to test how well iris patterns can be identified against a database of pre-registered iris patterns again this is well documented in the open literature. In the early stages of the project, the primary objective will be to get results.

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Once results are obtained and analyzed, the different parts of the software will be optimized, corrected and matching re-run. This iterative cycle will proceed until satisfactory results are obtained.

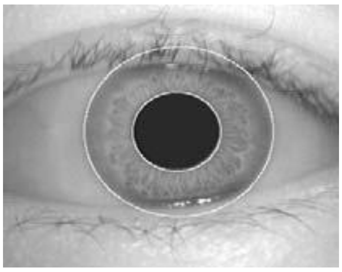
Implementation details

Iris Localization and Normalization

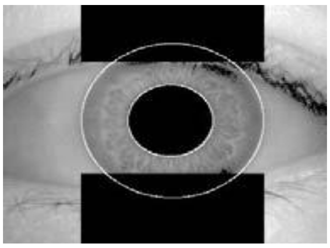
Iris localization mainly involves two basic operations, one is to detect eye lids and the other is boundary detection. The first step involves extraction of circular shaped iris rim by removing the noisy regions. Eyelids and eyelashes occlude upper and lower parts of the iris. Thus these regions must be segmented. The second step is to detect the inner and outer boundaries of iris. One is at the transition region of iris and sclera and the other is at the iris and pupil. Canny edge detection is performed both in vertical direction and horizontal directions.(Wildes,1999).The iris images in CASIA database has iris radius 80 to 150 and pupil radius from 30 to 75 pixels, which were found manually and were given to the Hough transform. If we apply Hough transform first for iris/sclera boundary and then to iris/pupil boundary then the results are accurate. The output of this step results in storing the radius and x, y parameters of inner and outer circles.

Canny edge detection is used to create edges in horizontal direction and then Hough transform is implemented on it. If the maximum Hough space is less than the threshold it represents non occlusion of eyelids. For isolating eyelashes it is easier by using thresholding, since they are darker when compared with other elements in eye. The eye images collected are of gray scale and their contrast is enhanced using histogram equalization.

Daugman suggested normal Cartesian to polar transformation that maps each pixel in the iris area into a pair of polar coordinates(r, θ), where r and θ are on the intervals of [0 1] and [0 2π] .



(a) Iris after boundaries detected



(b) Iris image after noise removal

Figure 2. Iris Localization

This unwrapping can be formulated as

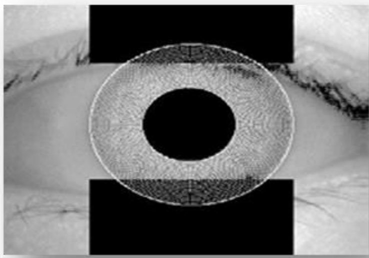
$I(x(r,\ \theta), y(r, \theta)) \rightarrow I(r,\ \theta)$ (1)

Such that

$x(r,\ \theta) = (1-r)\ xp(\theta) + r\ x(\theta)$

$y(r, \theta) = (1-r)\ yp(\theta) + r\ y(\theta)$ (2)

where I(x, y), (x, y), (r, θ), (xp, yp), (xi, yi) represent the iris region, Cartesian coordinates, polar coordinates, coordinates of the pupil and iris boundaries along θ direction respectively(Patnala S,2009).Thus this representation often called as rubber sheet model. Rotational inconsistencies are not considered in this representation. In the Daugman system, rotation is accounted for during matching by shifting the iris templates in the direction until two iris templates are aligned



(a)Polar form of Flower iris image

(b) Normalized form of Flower iris

Figure 3. Normalised image.

Matching (Hamming Distance)

For matching, the Hamming distance was chosen as a metric for recognition, since bit-wise comparisons were necessary. The Hamming distance algorithm employed also incorporates noise masking, so that only significant bits are used in calculating the Hamming distance between two iris templates. Now when taking the Hamming distance, only those bits in the iris pattern that corresponds to '0' bits in noise masks of both iris patterns will be used in the calculation. The Hamming distance will be calculated using only the bits generated from the true iris region, and this modified Hamming distance formula is given as

$$HD = \frac{1}{N - \sum_{k=1}^{N} Xn_k (OR) Yn_k} \sum_{j=1}^{N} X_j (XOR) Y_j (AND) Xn'_j (AND) Yn'_j$$

Where Xj and Yj are the two bit-wise templates to compare, Xnj and Ynj are the corresponding noise masks for Xj and Yj, and N is the number of bits represented by each template. Although, in theory, two iris templates generated from the same iris will have a Hamming distance of 0.0, in practice this will not occur. Normalisation is not perfect, and also there will be some noise that goes undetected, so some variation will be present when comparing two intra-class iris emplates. In order to account for rotational inconsistencies, when the Hamming distance of two templates is calculated, one template is shifted left and right bit-wise and a number of Hamming distance values are calculated from successive shifts. This bit-wise shifting in the horizontal direction corresponds to rotation of the original iris region by an angle given by the angular resolution used. If an angular resolution of 180 is used, each shift will correspond to a rotation of 2 degrees in the iris region.(Daugman,2002) and corrects for misalignments in the normalised iris pattern caused by rotational differences during imaging. From the calculated Hamming distance values, only the lowest is taken, since this corresponds to the best match between two templates. The number of bits moved during each shift is given by two times the number of filters used, since each filter will generate two bits of information from one pixel of the normalised region. The actual number of shifts required to normalise rotational inconsistencies will be determined by the maximum angle difference between two images of the same eye, and one shift is defined as one shift to the left, followed by one shift to the right. The shifting process for one shift is illustrated in Figure.

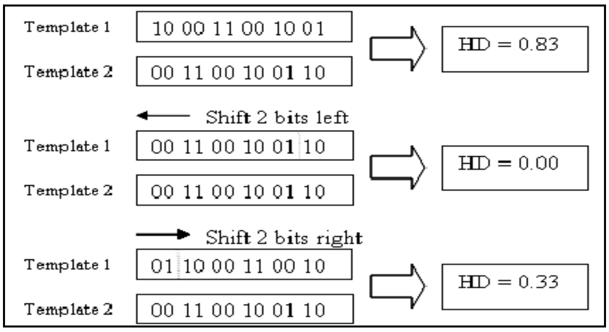


Figure 4. An illustration of the shifting process.

One shift is defined as one shift left, and one shift right of a reference template. In this example one filter is used to encode the templates, so only two bits are moved during a shift. The lowest Hamming distance, in this case zero, is then used since this corresponds to the best match between the two templates.

Results and discussion

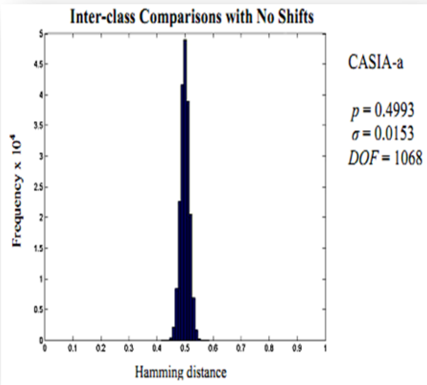


Figure 5. Inter-class Hamming distance distribution

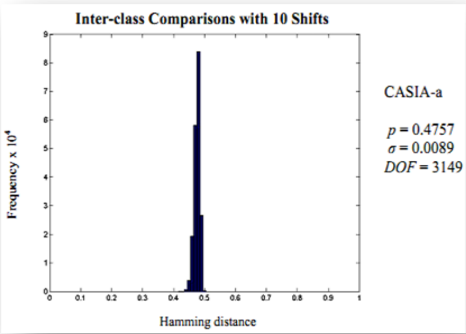


Figure 6. Inter-class Hamming distance distribution with 10 shifts left and right when comparing templates. Encoded with one filter

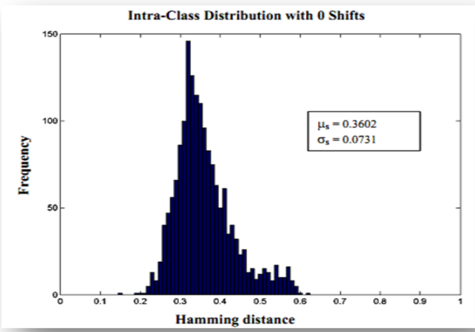


Figure 7. Intra class distribution with no shifts.

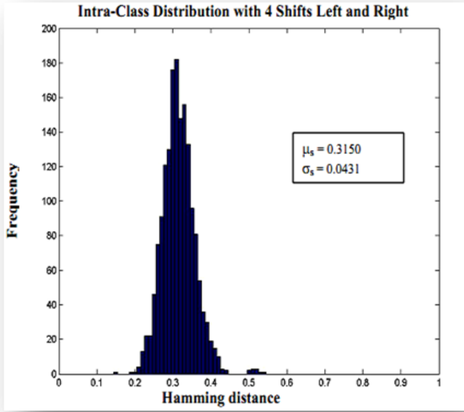


Figure 8. Intra-class distribution with 4 shifts left and right.

As above figure shows, the inter-class Hamming distance distributions conform to the theory of statistical independence, since the mean of the distribution equals 0.5. Therefore it can be stated that for 'CASIA-a', iris templates generated are highly unique, in that comparing any two templates generated from different irises is equivalent to comparing two random bit patterns. Also, the number of degrees calculated for data sets shows the complexity of the iris, with1068 degrees of freedom represented by the 'CASIA-a' data set.

Table 1. False accept and false reject rates for the 'CASIA-a' data set with different separation points using the optimum parameters

Threshold	FAR(%)	FRR(%)
0.20	0.0000	99.047
0.25	0.0000	82.787
0.30	0.0000	37.880
0.35	0.0000	5.181
0.40	0.0000	0.238
0.45	7.599	0.000
0.50	99.499	0.000

As shifting was introduced, so that intra-class templates were properly lined up, the mean inter-class Hamming distance value decreased as expected. With 10 shifts the mean decreased to 0.47 for both as shown in Figure. The standard deviation of inter-class distribution was also reduced, this was because the lowest value from a collection was selected, which reduced outliers and spurious values. The shifting also caused a reduction in the number of degrees of freedom, DOF. This reduction in DOF is an anomaly caused by a smaller standard deviation, which itself is caused by taking the lowest Hamming distance from 10 calculated values. This shows that, due to shifting, the distribution is not merely shifted towards the left, but the characteristics of the distribution are changed. Therefore the degrees of freedom formula is not very useful with shifting introduced, since it relies on the distribution approximating a binomial.

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