Comparison of Iris Recognition Algorithms

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Abstract

In this paper, we have studied various well known algorithms for iris recognition. Four algorithms due to Avila [5], Li Ma [9], Tisse [13] and Daugman [15] are implemented and compared on the CASIA iris image database. The results show that the Daugman's algorithm gave the highest accuracy of 99.9%.

Keywords

Biometrics, Iris Recognition, Iris Code, Wavelets.

INTRODUCTION

Person authentication has always been an attractive goal in computer vision. Authentication systems based on human characteristics such as face, finger, iris, voice are known as Biometric Systems. Such types of systems are based on signal and image processing based techniques. The basis of every biometric trait is to get the input signal/image and apply some algorithms like neural network, fuzzy logic, wavelet transform, etc to extract the prominent features.

Biometrics include fingerprints, facial features, retina, iris, voice, gait, fingerprint, palm-prints, handwritten signatures and hand geometry. Among the various traits, iris recognition has attracted a lot of attention because it has various advantageous factors like greater speed, simplicity and accuracy compared to other biometric traits. Iris recognition relies on the unique patterns of the human iris to identify or verify the identity of an individual.

In this paper we have made a survey of various existing iris recognition algorithms. We have also implemented four algorithms [5, 9, 13, 15] and comparison of the results obtained is given in the paper. The comparison has been done on the CASIA image database [22] provided by Prof. T. Tan. In the next section we have discussed the structure of iris and its importance as a biometric trait. In the third section various approaches of iris recognition have been described. Fourth section shows the experimental comparison of the implemented algorithms. Last section is the conclusion and future work.

STRUCTURE OF IRIS

Iris is distinct for every person, even the twins have different iris patterns and it remains same for whole of the life. Thus this technology is now considered as providing positive identification of an individual without contact and at very high confidence levels. Sample iris images are shown in Figure 1.

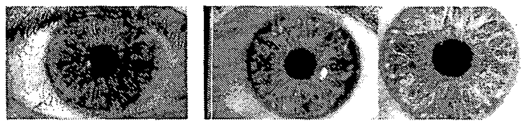

Figure 1. Example of Human Iris (from [12]).

The very front of the eye is essentially made up of two parts: the sclera or "white" portion of the eye, and cornea. The sclera consists of closely interwoven fibers and a small section in the front and center known as the cornea. The cornea consists of fibers arranged in regular fashion. Conveniently this makes the cornea transparent, allowing light to filter in. Behind the cornea is the anterior chamber filled with a fluid known as the aqueous humor. A spongy tissue, the ciliary bodies, arranged around the edge of the cornea, constantly produces the aqueous humor. Immersed in the aqueous humor is a ring of muscles commonly referred to as iris. The word iris is most likely derived from the Latin word for rainbow. It appears that the term was first applied in the sixteenth century, making reference to this multicolored portion of the eye [1]. The iris itself extends out in front of the lens, forming a circular array, with a variable opening in the center, otherwise known as the pupil [2]. The pupil is not located exactly in the center of the iris, but rather slightly nasally and inferiorly (below the center) [3]. The iris, which is made up of two bands of muscles, controls the pupil, the dilator, which contracts to enlarge the pupil, and the sphincter, which contracts to reduce the size of the pupil. The visual appearance of the iris is directly related to its multi-layered construction. The anterior layer is divided into two basic regions, the central pupillary zone and the surrounding ciliary zone. The border between these areas is known as the collarette. The collarette appears as a zigzag circumferential ridge, where the anterior border layer begins to drop into the pupil. The ciliary zone is characterized by interlacing ridges resulting from stromal support. The ridges tend to vary with the state of the pupil (contracted or dilated). Other striations can be seen as an effect of the blood vessels beneath the surface. Crypts, nevi and freckles make up the other main source of variation on the iris. A crypt is an irregular atrophy of the border layer. Nevi are small elevations in the border layer. Freckles are local collections of chromataphores. The pupillary zone, on the other hand tends to be relatively flat. It occasionally features radiating spoke-like processes and a pigment frill where the posterior layer's heavily pigmented tissue shows at the pupil boundary [1].

The iris has been found to be incredibly unique from person to person, in both color and structure. In fact, it has been discovered by both ophthalmologists and anatomists, examining large numbers of eyes, that even the left and right eye of and individual exhibit differences in their iris pattern. Also, the patterns appear to vary little after childhood. Developmental biology further suggests that, while the general structure of the iris is genetically determined, the particular aspects of its details are dependent upon circumstance, like the conditions in the embryonic precursor to the iris. Developmental biology also supports the lack of variance through life idea, noting that the iris is most fully developed and grows little after childhood. The only marked exceptions are the pigmentation, which does not fully mature until adolescence, and the size of the pupil, which is also not fully determined until puberty. However, once out of the teenage years, it is likely a person's iris variations will likely remain the same for the rest of their life. Thus there is enormous interest in utilizing iris variation in a biometric system.

ALGORITHMS

Since 1990s, many researchers have worked on this problem. In this section the various algorithms for iris recognition has been discussed. Human iris identification process is basically divided into four steps,

- Localization – The inner and the outer boundaries of the iris are calculated.
- Normalization – Iris of different people may be captured in different size, for the same person also size may vary because of the variation in illumination and other factors.
- Feature extraction – Iris provides abundant texture information, a feature vector is formed which consists of the ordered sequence of features extracted from the various representation of the iris images.
- Matching – The feature vectors are classified through different thresholding techniques like Hamming Distance, weight vector and winner selection, dissimilarity function, etc.

Daugman [2, 15] is the first one to give an algorithm for iris recognition. His algorithm is based on Iris Codes. For the preprocessing step i.e., inner and outer boundaries of the iris are located. Integro-differential operators are then used to detect the centre and diameter of the iris, then the pupil is also detected using the differential operators, for conversion from Cartesian to polar transform, rectangular representation of the required area is made. Feature extraction algorithm uses the modified complex valued 2-D Gabor wavelets [2, 15]. For matching, Hamming Distance has been calculated by the use of simple Boolean Exclusive – OR operator and for the perfect match give the hamming distance equal to zero is obtained. The algorithm gives the accuracy of more than 99.9%. Also the time required for iris identification is less than one second.

Wildes has made use of an isotropic band-pass decomposition derived from application of Laplacian of Gaussian filters to the image data [1]. Like Daugman Wildes also used the first derivative of image intensity to find the location of edges corresponding to the borders of the iris. The Wildes system explicitly models the upper and lower eyelids with parabolic arcs whereas Daugman excludes the upper and the lower portions of the image. The results of this system were good enough to recognize the individuals in minimum time period.

Boashash and Boles [3] have given a new approach based on zero-crossings [4]. They first localized and normalized the iris by using edge detection and other well known computer vision algorithms. The zero-crossings of the wavelet transform are then calculated at various resolution levels over concentric circles on the iris. The resulting one dimensional (1D) signals are then compared with the model features using different dissimilarity function. This system can handle noisy conditions as well as variations in illumination. This algorithm is also translation, rotation and scale invariant. A similar type of system has been presented in [5] which is based on zero-crossing discrete dyadic wavelet transform representation and has shown a high level of accuracy.

In [6], a new algorithm has been proposed to extract the features of iris signals by Multi-resolution Independent Component Identification (M-ICA). It provides good properties to represent signals with time frequency. This extracts the iris features which are used for matching using conventional algorithms. The accuracy obtained is low because the M-ICA does not give good performance on class-separability.

There are some other researchers who have used different algorithms for feature extraction. Dargham et. al. [8] used thresholding to detect iris from pupil and the surroundings. The detected iris is then reconstructed into a rectangular format. Self organizing map networks are then used for recognizing the iris patterns. The accuracy obtained by the network is around 83%. In another approach by Li Ma et. al. [7, 9], circular symmetry filters are used to capture local texture information of the iris, which are then used to construct a fixed length feature vector. Nearest feature line method is used for iris matching. The results obtained were 0.01% for false match and 2.17% for false non-match rate. In [11], Chen and Yuan developed the algorithm for extracting the iris features based on fractal dimension. The iris zone is partitioned into small blocks in which the local fractal dimension features are computed as the iris code. And finally the patterns are matched using the k-means and neural networks. The results obtained are 91.8% acceptance for authentic person and 100% rejection rate for fakers. Wang *et. al.* [12] used Gabor filters and 2-D wavelet transforms for feature extraction. For identification weighted Euclidean distance classification has been used. This method is invariant to translation and rotation and tolerant to illumination. The classification rate on using Gabor is 98.3% and the accuracy with wavelets 82.51%. Robert et. al. [13] introduced new algorithm for localization and extraction of iris. For localization a combination of the integro-differential operators with a Hough Transform is used and for feature extraction the concept of instantaneous phase or emergent frequency is used. Iris code is generated by thresholding both the models of emergent frequency and the real and imaginary parts of the instantaneous phase. Finally the matching is performed using Hamming distance. Results gave 11% of the false reject rate was obtained. Lim et. al. [14] used Haar Wavelet transform to extract features from iris images. By applying the transform four times on image of size 450X60 and combining the features 87 bit feature vector was obtained. This feature vector is the compact representation of the iris image. Finally for classification of feature vectors, weight vector initialization and winner selection strategy has been used. The recognition rate obtained is around 98.4%. In [16] two new methods of the statistical and computer evaluations of the iris structure of a human eye in view of personal identification have been proposed which are based partly on the correlation analysis and partly on the median binary code of commensurable regions of digitized iris image. Similarly method of eye-iris structure characterization using statistical and spectral analysis of color iris images is considered in [17]. Gurianov et.al. [17] used Wiener spectra for characterization of iris patterns. In [18, 20] human iris structure is explained and classified using coherent Fourier spectra of the optical transmission.

In [21], an efficient biometric security algorithm for iris recognition system with high performance and high confidence has been described. The system is based on an empirical analysis of the iris image and it is split in several steps using local image properties. The various steps are capturing iris patterns; determining the location of iris boundaries; converting the iris boundary to the stretched polar coordinate system; extracting the iris code based on texture analysis using wavelet transforms and classification of the iris code. The proposed system use the wavelet transforms for texture analysis, and it depends heavily on the knowledge of general structure of human iris. The system has been implemented and tested using a dataset of 240 samples of iris data with different contrast quality.

COMPARISON

We have implemented four algorithms [5, 9, 13, 15] based on Iris Code. The algorithms are implemented in MATLAB 6.5. These algorithms have been tested on the CASIA Iris Image Database [22] as this is the only database available in public domain. The database includes 756 iris images from 108 individuals. For each eye, 7 images are there which have been captured in two sessions; three samples are collected in the first session and four in the second session. We have taken three images for training purpose and rest of the four for testing. The performance results are based on error rates: False Acceptance Rate (FAR) and False Rejection Rate (FRR); and the overall accuracy. The percentage accuracy based on FAR and FRR of the implemented algorithms is shown in Table 1. This table shows that the Daugman's algorithm [15] gives the maximum accuracy among the four.

Table 1. Performance of Algorithms

Algorithm [Reference]	FAR/FRR	Overall % Accuracy
Avila [5]	0.03/ 2.08	97.89
Li Ma [9]	0.02/ 1.98	98.00
Tisse [13]	1.84/ 8.79	89.37
Daugman [15]	0.01/ 0.09	99.90

Figure 2 shows a comparison among the algorithms. In this experiment we have compared the FAR, FRR and overall accuracy of the algorithms to each other, i.e. FAR for 1 is compared to FAR of 2, 3 and 4 and in all [15] gives the best performance.

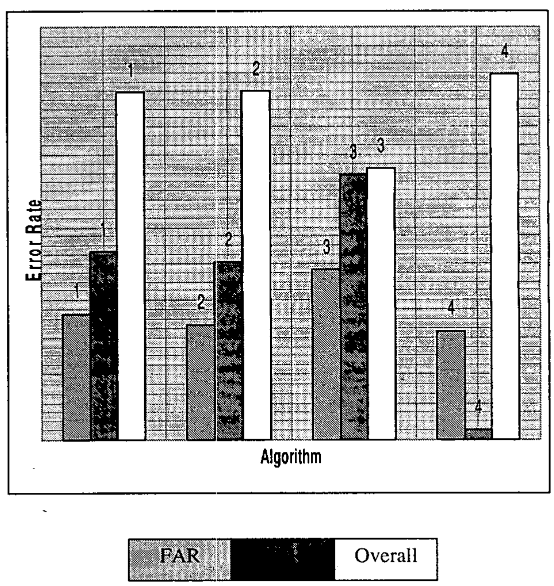

Figure 2. Comparison of Error Rates and Accuracy of Algorithms.

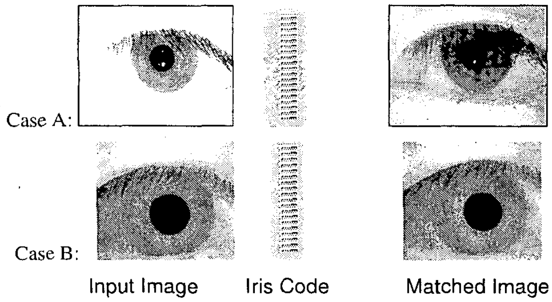

Figure 3. Results of Iris Recognition.

Figure 3 shows sample results on Daugman's algorithm [15]. The iris image along with their iris codes and matched results are shown in different cases. In Case A, the image with varying illumination is shown and Case B shows the results with noise added to it.

CONCLUSION

This paper presents a review of the existing algorithms available for iris recognition. The algorithms are generally divided into four steps, viz. Localization, Normalization, Feature Extraction and Matching. Iris recognition technology is able to give highly accurate results for human identification. But this technology needs more attention to overcome the disadvantages of the existing algorithms. This paper also shows an experimental comparison of four algorithms [5, 9, 13, 15] which shows that Daugman's [15] algorithm gives maximum accuracy. Future work would be to make a database of large number of people which includes a large number of variations for illumination and size. We are working to develop an efficient algorithm for iris recognition using less expensive cameras and other hardware so that the cost can be reduced upto some extent.

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