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Iris Image Recognition Based on Independent Component Analysis and Support Vector Machine

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Abstract

The iris has a very unique texture and pattern, different for each individual and the pattern will remain stable, making possible what biometric technology call iris recognition. In this paper, 150 iris images from the Department of Computer Science, Palacky University in Olomouc iris database are used for iris recognition based on independent component analysis and support vector machine. There are three steps for developing this research namely, image preprocessing, feature extraction and recognition. The first step is image preprocessing in order to get the iris region from the eye image. The second is feature extraction by using independent component analysis in order to get the feature from the iris image. Support vector machine (SVM) is used for iris classification and recognition. In the end of this experiment, the implement method will be evaluated based upon Genuine Acceptance Rate (GAR). Experimental results show that the recognised rate from the variation of training data is 52% with one data train, 73% with two data trains and 90% three data trains. From the experimental result, it also shows that this technique produces a good performance.

Keywords*: Iris Recognition, Biometric, Independent Component Analysis, Support Vector Machine, Iris Processing*

1. Introduction

Humans have unique and distinctive characteristics such as face, fingerprint, voice, iris and gestures, with these characteristics able to be used as recognition or classifying of humans, this is known as biometric recognition [1]. The method of identification based on biometric characteristics is preferred over traditional passwords and PIN based methods for various reasons such as the fact that the person to be identified is required to be physically present at the time-of-identification. Identification based on biometric techniques obviates the need to remember a password or carry a token. A biometric system is essentially a pattern recognition system which makes a personal identification by determining the authenticity of a specific physiological or behavioural characteristic possessed by the user [2]. Biometric technologies are thus defined as the "automated methods of identifying or authenticating the identity of a living person based on a physiological or behavioural characteristic" [3].

Eyes are one of the important human senses. Stimulation of light-sensitive receptors in the eye (photoreceptors) raises the sense of sight [4]. As shown in Figure 1 the eye structure consists of eye sclera, iris, pupil and eyelid. In biometric systems used for the identification and detection in a case study, the structure of the eye most often used is the iris.

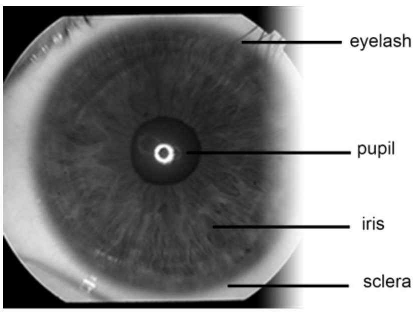

Figure 1. Eye anatomy

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The iris has a unique pattern and texture in the human eye and cannot be transferred or faked which makes the iris more secure than other biometric systems. The iris pattern also has a marvellous and great structure and multiplies the texture to recognise personal identification. This paper implements the combination between independent component analysis (ICA) as feature extraction and support vector machines (SVMs) as the classification method to evaluate the performance of the GAR. This paper also consists of three steps: image preprocessing, feature extraction by using independent component analysis then the support vector machine is used for iris classification and recognition.

2. Research Method

Iris recognition is an automated method of biometric identification that uses mathematical pattern-recognition techniques on video images of the irides of an individual's eyes: these, complex random patterns are unique and can be seen from some distance [5].

Millions of people from several countries have been enrolled in an iris recognition systems with a variety of purposes, such as passport-free automated border-crossing, and some national ID system based on iris recognition. Therefore, the development of iris recognition is a biometric technology that has the potential to be developed. Figure 2 shows the structure of an iris image recognition system.

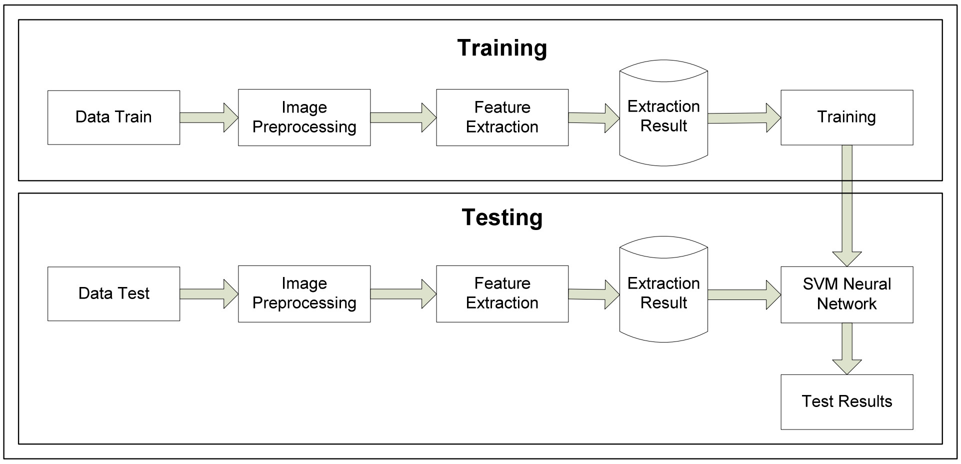

Figure 2. The structure of iris image recognition system

Based on Figure 2, there are three main steps for this research namely, images preprocessing, feature extraction and recognition.

2.1. Image Preprocessing

Image processing is a form of treatment or processing the image as input and transforming it into another image as output with certain techniques. Image processing is conducted to fix the image signal data errors caused by signal acquisition and transmission, as well as to improve the quality of the appearance of the image to be more easily interpreted by the human visual system to perform well and also analysing the manipulation of the image.

In order to get the best part of the iris image, image processing is necessary to separate the image of the iris from the information that is not needed. Various methods for separating the image of the iris from the eye image have been conducted. In this study, there are four steps for image preprocessing in order to get the best iris region for the best recognition result:

1) Convert to grayscale: converting RGB image to grayscale in order to facilitate the next stage.
2) Histogram equalisation: a technique for adjusting the image intensities to enhance contrast. The purpose of this technique is to produce a uniform image histogram.

3) Edge detection using Prewitt operator: a discreet differentiation operator to compute an approximation of the gradient of the image intensity function.
4) Convert to Cartesian polar: to get a proper iris area. Cartesian into polar coordinate conversion is required.

2.2. Feature Extraction using Independent Component Analysis (ICA)

Feature extraction is the process of extracting information or important features of an image. As mentioned above, independent component analysis (ICA) is applied as a feature extraction method. One of the ICA algorithm will be used in this research, namely FastICA.

FastICA is a popular algorithm for independent component analysis created by Aapo Hyvärinen, Helsinki University of Technology. The algorithm is based on a fixed-point iteration scheme maximising non-Gaussian as a measure of statistical independence. It can also be derived as an approximatively Newton iteration.

.Here is the algorithm of fastICA based Fast and Robust Fixed-Point Algorithms for Independent Component Analysis [6]:

1) *Centering:* centering of the input data *x* is done by calculating the average of each component of *x* then *x* is reduced by the mean. This has the effect of making each component having a zero mean.

$$x = x - E\{x\} \quad (1)$$

2) *Whitening:* Whitening data involves a linear transformation of the data so that the new components are uncorrelated and have variance one.

$$z = \Lambda^{1/2} U^T x' \quad (2)$$

   In this equation, x' is the centralised observation signal, *z* is observation signal after whitening treatment, *Λ* and *U* are eigenvalue matrix and eigenvector matrix of *x* covariance matrix $C_x = E\{xx^T\}$, respectively. Eigenvalue matrix and eigenvector matrix is obtained according to PCA method.
3) Randomly generated orthogonal matrix w-w is directed toward normalised *z.*
4) Perform the calculation*:*

$$w^+ \leftarrow E\{xg(w^T x)\} - E\{g'(w^T x)\}x \quad (3)$$

   Where, E {...} is the average of all column vectors *x* matrix.
5) Perform normalisation:

$$w \leftarrow \frac{w^+}{\|w^+\|} \quad (4)$$

6) If not converged, repeat step 4.

2.3. Recognition using Support Vector Machine

SVM will be used as a technique for iris image classification or recognition. The working principle of SVM is essentially only able to handle two-class classification [7]. However, techniques have been developed and multiclass support vector machines are able to classify two or more classes. Therefore, in this thesis will use the multiclass SVM as classifiers for the iris image.

There are two options for implementing the multiclass SVM by combining several binary SVM or combining all of the data that consists of multiple classes into an optimal form of problems. However, the second approach for the optimisation problem to be solved is much more complicated. Here is a common method used to implement the multiclass SVM with the first approach:

1) One-against-all method: By using this method, SVM models build binary k (k is the number of classes).
2) One-against-one method: By using this method, build k (k-1) / 2 pieces of binary classification model (k is the number of classes). There are several methods to perform the test after the whole k (k-1) / 2 classification model is built. One is the method of voting [8].

The steps of the multi-class SVM is used to classify iris images in this research are as follows:

1) Available data denoted as $\vec{x}_i \in \Re^d$ whereas each label denoted $y_i \in \{-1,+1\}$ for $i = 1,2,\dots,l$, where *l* is the number of data. Assumed two classes -1 and +1 can be completely separated by the hyper plane dimension *d*, which is defined:

$$\vec{w}.\vec{x} + b = 0 \quad (5)$$

2) If all the training data satisfy the constraints, then:

$$\vec{w}.\vec{x} + b \le -1 \quad (6)$$

$$\vec{w}.\vec{x} + b \ge +1 \quad (7)$$

and the distance between the two hyperplanes is expressed as:

$$2d = \frac{2}{\|w\|} \quad (8)$$

3) Now, by combining (6) and (7) into a single constraint, we get:

$$y_i(\vec{x}_i.\vec{w} + b) \ge 1 \quad \forall_i = 1,\dots N \quad (9)$$

In the training phase, the main goal is to find the SV that maximises the margin of separation, *d*. The largest margin could be found by maximising the value of the distance between the hyperplane and the closest point, which is $1/\|\vec{w}\|$.

$$\min_{w} \tau(w) = \frac{1}{2}\|\vec{w}\|^2 \quad (10)$$

This problem can be solved by a variety of computational techniques, including the Lagrange Multiplier.

$$L_p(w,b,\alpha) = \frac{1}{2}\|\vec{w}\|^2 - \sum_{i=1}^{l} \alpha_i(y_i((w.x_i + b) - 1)) \quad (11)$$

where $L_p(w,b,\alpha)$ is simultaneously minimised with respect to *w* and *b* and maximised with respect to α_i.

4) Finally, the decision boundary can be derived as follows:

$$f(x) = w.x + b = \sum_{i=1}^{N} \alpha_i y_i(x.x_i) + b = 0 \quad (12)$$

5) If the data points are not separable by a linear separating hyper plane, a set of slack or relaxation variables $\{\xi = \xi_1,\dots,\xi_n\}$ is introduced with $\xi_i(\xi > 0)$ such that (9) become:

$$y_i(w.x_i + b) \ge 1 - \xi_i \forall_i \quad (13)$$

The slack variables measure the deviation of the data points from the marginal hyper plane. The new objective function to be minimised becomes:

$$\min_{w} \tau(w,\xi) = \frac{1}{2}\|\vec{w}\|^2 + C\sum_{i=1}^{l}\xi_i \quad (14)$$

where C is the user-defined penalty parameter that penalises any violation of the safety margin for all the training data.

6) In order to obtain a nonlinear decision boundary, we replace the inner product (x, x_i) of (12) with a nonlinear kernel $K(x, x_i)$ and get:

$$f(x) = \sum_{i=1}^{N} \alpha_i y_i K(x, x_i) + b \quad (15)$$

There are three types of kernels that can be used to deal with cases which are not linear, it can use the help of a wide variety of kernel functions as shown in Table I.

Table 1. Kernel Function for SVM

Kernel	K (x_i, x_j)
Linear	$x^T . x_j$
Polynomial	$(x^T . x_j + 1)^d$
Radial Basis Function	exp $(-\|x - x_j\|2/2\sigma^2)$

3. Results and Discussion

Before we describe the experiments performed to assess our proposed methods, first, the database employed in the assessment is briefly introduced and then the actual experiments with the corresponding results are presented.

3.1. Iris Database

The human iris images that are used in this study are not taken directly but use secondary data that is obtained from http://phoenix.inf.upol.cz Dept. Computer Science, Palacky University in Olomouc [8]. Iris image data is offline with size 200 x 200 pixels and RGB (red, green, blue) format consisting of 25 people with six photos for each individual. The images were taken at different hours and days. The image format used is PNG (Portable Network Graphics). Figure 3 shows one example of an eye image that is used as input data.

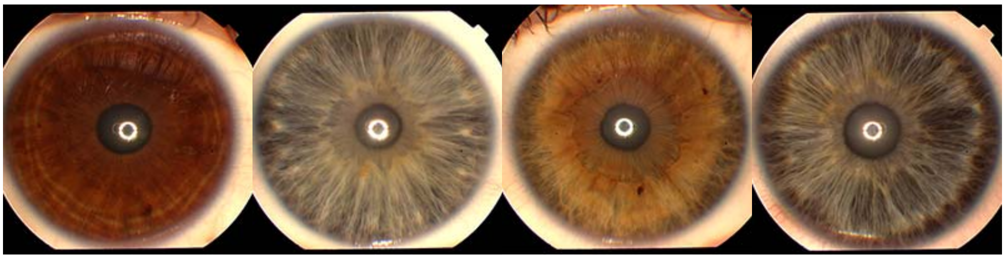

Figure 3. Sample image from iris database

3.2. Experimental Settings

Iris images that are already input will go through the image preprocessing stage in order to separate the iris image from the eye image. The image preprocessing process will produce a normalised iris image with size 580 x 35 pixels. Figure 4 shows the result of the image preprocessing stage. After that, the pixel values from normalized iris image will be used to obtain the characteristics by using FastICA algorithm, and the last stage is iris image recognition by using SVM. The experiment is done by using a variation on the number of images of different trainers. The first test will use one training data with three data tests, the second test will use two training data with three data tests, and the last testing will be three training data with three data tests.

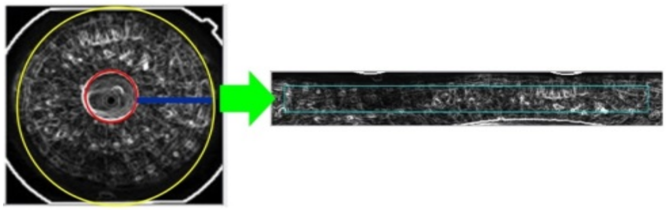

Figure 4. Iris normalized into polar coordinates.

To evaluate the algorithm, the performance can be measured by calculating GAR (Genuine Acceptance Rate). The GAR stated success rate of verification of a system with all the training data and test data is used. The higher value indicates the higher GAR system verification success rate. The equation for calculating the value of GAR can be seen in equation (16).

$$GAR = \frac{recognized\ data}{total\ testing\ data} x\ 100\% \quad (16)$$

3.3. Experimental Result

The result of these experiments has been conducted using six iris images from 25 different people, where in such an experiment has been carried out using three variations on the amount of training data to the test data. The first test will use one training image with three test images, the second test will use two training images with three test images, and the final test will use a three training image with three test images. Figure 5 shows the result of the experiment where we obtained 52%, 73% and 90% genuine acceptance rate (GAR) respectively.

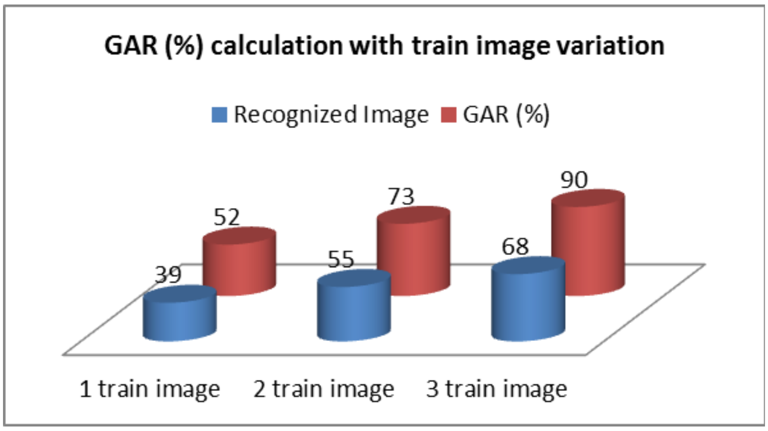

Figure 5. Experimental result with GAR calculation

In order to compare our method with other existing methods, several methods listed in published papers are implemented under the same method in feature extraction or the recognition method. These methods include Roy [9], Wang [10], Mirdawati [11], Muslim [12] and proposed ICA. From this data, we obtained 98.54%, 97.25%, 87.50%, 80.00% and 90.00%

identification success rates respectively. Table 2 shows the comparison of the proposed method with some methods in iris recognition. These comparisons indicate our algorithm is effective and has an emerging performance in iris recognition.

Table 2. Methods performance comparison in iris recognition

Methods	Recognition Rate
Roy [9]	98.54%
Wang [10]	97.25%
Mirdawati [11]	87.50%
Muslim [12]	80.00%
Proposed	90.00%

4. Conclusion

The paper has examined the development of an iris-based recognition system. The Independent Component Analysis was implemented as a feature extraction method while Support Vector Machine was adopted as a classifier in order to develop an iris-based recognition system. An experimental study using the iris image database from the Departement.of Computer Science, Palacky University in Olomouc [4] was carried out to evaluate the effectiveness of the proposed system. Based on obtained results, the ICA and SVM classifier produces good recognize result that can be measured by calculating GAR (Genuine Acceptance Rate). The results show that the combination of ICA and SVM is a promising and effective in iris-based recognition.

References

[1] Liu S, Mark S. A practical guide to biometric security technology. *IT Professional 3*. 2001; 1: 27-32.
[2] Delac K, Mislav G. *A survey of biometric recognition methods. In Electronics in Marine, 2004*. Proceedings Elmar 2004. 46th International Symposium. IEEE. 2004: 184-193.
[3] Santosa B. Feature Selection with Support Vector Machines Applied on Tornado Detection. *IPTEK The Journal for Technology and Science 18*. 2007; 1.
[4] Corwin EJ. *Buku Saku Patofisiologi Corwin*. EGC. 2006.
[5] Daugman J. How iris recognition works. *Circuits and Systems for Video Technology, IEEE Transactions*. 2004; 14(1): 21-30.
[6] Hyvärinen A, Erkki O. Independent component analysis: algorithms and applications. *Neural networks*. 2000; 13(4): 411-430.
[7] Boswell D. *Introduction to Support Vector Machines*. 2002.
[8] Departement Computer Science, Palacky University in Olomouc – http://phoenix.inf.upol.cz.
[9] Roy K, Prabir B. *Iris recognition with support vector machines*. Advances in Biometrics. Springer Berlin Heidelberg. 2005: 486-492.
[10] Wang Y, Jiu QH. *Iris recognition using independent component analysis*. Machine Learning and Cybernetics, 2005. Proceedings of 2005 International Conference on. IEEE. 2005: 7.
[11] Muslim L. *Pengenalan Individu Melalui Iris Mata menggunakan kombinasi Independent Component Analysis dan Support Vector Machine*. Institut Teknologi Telkom. Bandung. 2009.
[12] Mirdawati S. *Ektraksi Ciri Iris Mata menggunakan Metode Independent Component Analysis (ICA)*. Universitas Sriwijaya. Palembang. 2012.