

ant-CBIR: A New Method for Radial Furrow Extraction in Iris Biometric

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ABSTRACT

Iris recognition has evolved from first to second generation of biometric systems which capable of recognizing unique iris features such as crypts, collarette and pigment blotches. However, there are still ongoing researches on finding the best way to search unique iris features since iris image contains high noise. The high noise iris images (noisy iris); usually give the biometric systems to deliver erroneous results, leading to categorizations where the actual user is labeled as an impostor. Therefore, this study focuses on a novel method, targeted at overcoming the aforementioned challenge. We present the use of ant colony based image retrieval (ant-CBIR) technique as a successful method in recognizing the radial furrow in noisy iris. This method simulates the behavior of artificial ants, searching for pixel values of radial furrow based on an optimum pixel range. The evaluation of accuracy performance with and without the ant-CBIR application is measured using GAR parameter on UBIRIS.v1. Results show that the GAR is 79.9% with ant-CBIR implementation. The implication of this study contributes to a new feature extraction that has the ability of human-aided computing. Moreover, ant-CBIR helps to provide cost effective, easy maintenance and exploration of a long term data collection.

KEYWORDS

Iris Recognition, Iris Feature Ant Colony Optimization, and CBIR.

1 INTRODUCTION

Iris recognition remains as one of the most available, reliable and highly accurate method for human identification [1], [2], [3]. In fact, iris recognition system is a reliable method for identity authentication, such as access control, e-commerce, banking, online transactions and logistics. More than a decade ago, there are various methods used to reduce noise in the iris image and improving the system. All methods have its advantages and disadvantages depending on the acceptability, usability, modality, permanence, and user friendly.

However, a system of this nature has myriads of challenges that need to be dealt with prior to proper implementation. The challenges attributed to working with noisy images (noisy iris) still remains critical. Although noisy iris scenario is undoubtedly multifaceted, it can be generally defined as the presence of unwanted noise, leading to misrepresentation of iris information, primarily through causing occlusions and feature changes [4].

Occlusions caused by noisy iris leads to the obstruction of vital information present in the iris texture [5]. These occlusions may occur in the eyelids, eyelashes or eyebrows, strands of hair, contact lenses or may even affect the presence of specula highlights [6], [7]. The occlusion of information in the iris image obviously leads to the production of high error rates, resulting in lower performance accuracy. Feature changes in the iris refer to variations in color, shape, size and texture occurring in the unique iris features such as the crypt, collarette,

furrows and pigment blotches as shown in fig.1 [8].

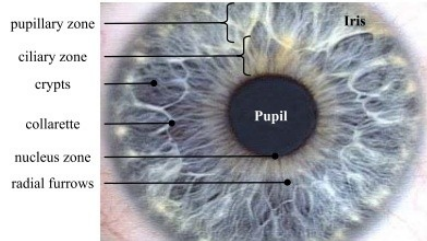


Figure 1: Human iris features[3]

The iris features, although may appear static; metamorphose significantly throughout the lifetime of a human being. Iris aging is a common factor affecting all human beings [9]. Besides iris aging, growth, various health conditions or pathologies, emotional status, diet factors and laser surgery may lead to changes in the iris [10], [11], [12], [13], [14] which lead to a primary challenge in using iris recognition as a successful form of biometrics for authentication purposes, often resulting in erroneous categorizations. Furthermore, the various anomalies in the matching process itself leads to the generation of noisy iris images, which in turn further increases the challenge. In order to evaluate the accuracy performance, the basic metric used to measure the high noise of an iris recognition system is based on the false rejected rate (FRR). The FRR represents the rate at which the system erroneously categorizes a genuine as an impostor user. Any iris recognition system will therefore try to minimize the FRR (type 1 error).

2 RELATED WORKS

Multiple publications exist with the primary goal of reducing FRR through addressing the noisy iris issue. Methods such as deblurring [15], [16], white noise insertion [17], [18], image enhancement [19], [16], multiple biometric modality analysis [20], [21], compression [22], [23] and the selection of unique iris features are popular [24]. The scope of this work corresponds to the selection of unique iris features. These

important features are extracted from the iris texture without changing the original information present within the image. It is important to highlight the fact that although the noisy iris image contains not useful information in many ways, the noise present within the iris texture is still vital. The success rate associated with the detection of best iris features in noisy iris images range between 30% - 50%. However, the selection of unique features for matching often leads to complications because some of the vital information present in the iris may be discarded and the next matching step may fail due to insufficient iris information. Rather than using hard-coded techniques, it was decided that bio-inspired techniques will work best for feature selection and extraction from iris images.

3 METHODOLOGY

In bio-inspired feature selection in extraction, particle swarm optimization (PSO) and ant colony optimization (ACO) are two common techniques used for recognition and segmentation tasks of iris images. However, both techniques deal with the texture of the iris, rather than focusing on the features. This work focuses on finding a unique iris feature, the radial furrow, during the extraction phase using the ant colony based image retrieval (ant-CBIR) technique. The proposed method is illustrated via fig. 2.

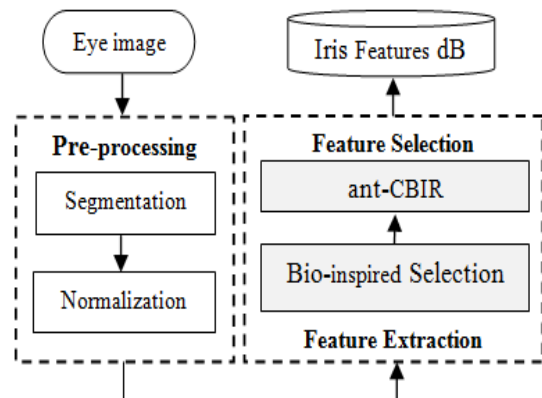


Figure 2: Feature Selection using ant-CBIR

3.1 ant-CBIR based Iris Feature Selection

Ant colony optimization technique was first algorithm was first presented by Dorigo et al. in 1994 with the primary idea of solving optimization problems [25]. Dorigo et al. further extended the work by applying ACO to solve the travelling salesman problem [26]. The proposed method is entirely inspired by the behavior of ants in colonies. Ants, when travelling, deposit a certain amount of pheromones along the path they travel. The ants that use the optimum path is obviously reach the target before the ants that take other paths. The ants that follow will soon join the shorter path and continue to saturate the path with more pheromones, resulting in a positive feedback, leading the rest of the colony to follow the same path.

This behavior provides a meta-heuristic method, capable of auto-tuning during semi-optimal solution points. This self-searching behavior makes ant-CBIR a suitable candidate for finding the important iris features in noisy iris images.

The ants are first initialized randomly, with a positive pheromone level, represented by a small number, between pixels so as to identify the possible paths. The movement of an ant can be mathematically modeled using equation (1). For each ant k , there are 8 possible cells around to travel. The probability of travelling from node i to node j is given by $p_{ij}^k(t)$ where t corresponds to the given instance. The factor N_i^k corresponds to the set of nodes yet to be visited by the particular ant and η_{ij}^β denotes the heuristic function used, such as the inverse pixel values between points i and j . The purpose of α and β is to balance the effects of the heuristic and pheromone quantity.

$$p_{ij}^k(t) = \begin{cases} \frac{\xi_{ij}^\alpha(t)\eta_{ij}^\beta(t)}{\sum_{r \in N_i^k} \xi_{ir}^\alpha(t)\eta_{ir}^\beta(t)} & \text{if } j \in N_i^k \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

A value of α equal to 0 will yield the method to perform entirely in the fashion of a classical stochastic greedy algorithm, whereas a value of β equal to 0 will resulting in an algorithm completely based on the effects of pheromones [27].

In terms of the application for this particular task, the implementation is as follows. During the initialization, the iris texture is divided into two parts, and the pixel values are read from the upper leftmost point to locate the radial furrow pixel values within the 10×240 matrix. The movements of the ants are based on the number of iterations in both the backward and forward directions.

The ant starts moving from point i in a direction ranging between 0° to 45° , by comparing the pixel intensity range between the two pixels. A predefined threshold is set for the intensity, ranging from 80 to 110 in terms of 8-bit gray of pixel values. If the pixel value falls within the range, the ant saves the particular pixel into a memory buffer. The next iteration compares the direction ranging between 45° to 90° , and followed by 90° to 135° . The continuation of the iterations can be highlighted using equation 2. Let $(x_1, y_1), (x_2, y_2)$ be coordinates of pixels belonging to the xy neighborhood. Let i and j show the intensities of the pixels derived using function $f(\cdot)$, then the value $C(i, j)$ corresponds to the cardinality of the set of pixels fulfilling the requirement of the predefined threshold.

$$C(i, j) = \text{card} \left\{ \begin{array}{l} ((x_1, y_1), (x_2, y_2)) \in (XY) \times (XY) \\ \text{for } f(x_1, y_1) = i, f(x_2, y_2) = j \\ (x_2, y_2) = (x_1, y_1) + (d \cos \theta, d \sin \theta); \\ \text{for } 0 < i, j < N \end{array} \right\} \quad (2)$$

In equation 3, P_d corresponds to the probability for creating a mediator between points d and s . The parameter f_{sd} corresponds to a measure of the points' value variation when travelling from s to d .

$$P_d = \frac{f_{sd}}{\sum_{d'} f_{sd}} \quad (3)$$

In the case of a pairwise blurring or damaging of points in the noisy iris, the ant will use equation (1) and learn a new point to pair with by applying equation (2) to determine the path using the angular method defined above. Once the pheromone update trail ends, the system will determine that the iteration has converged. Once the convergence is complete, the radial furrow feature is indexed using CBIR method and stored in the database.

3 EXPERIMENTS AND FINDINGS

The ant-CBIR method was implemented on the ant movements of forward and backward that is based on the number of ants' iteration. These iterations are based on the precision parameter with 10 cycles starting with 2,4,6,8 and 10 using 10th cross validation with the goal of increasing the classifier learning in order to yield better accuracy performance. Each training and testing datasets are tested at different iteration cycles, with lengths 2, 4, 6, 8 and 10. Table 1 shows the precision of searching radial furrow without ant-CBIR application. Meanwhile, table 2 shows the precision in FAR and FRR using ant-CBIR.

Table1. Precision of Training and Testing Radial Furrow without ant-CBIR

No. of Iteration	FAR (%)	FRR (%)
2 nd	0	100
4 th	0	100
6 th	0	100
8 th	0	100
10 th	0	100

Table2. Precision of Training and Testing Radial Furrow with ant-CBIR

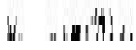
No. of Iteration	FAR (%)	FRR (%)
2 nd	27.27	72.72
4 th	0	100
6 th	22.33	77.67
8 th	40	60
10 th	25.00	75

The precision of training and testing using ant-CBIR in searching for radial furrow shows some variation of FAR and FRR values

according to the number of iterations of ants' movements which indicates that ants have detected some points of unique features inside the radial furrow. Meanwhile, if not using ant-CBIR method, the value of precision designates zero value in FAR which represents non unique points are able to be identified in the radial furrow iris feature. This experiment has proven that using ant-CBIR, the unique feature points of radial furrow can be achieved.

The overall process of ant movements (forward and backward) according to iterations and degree of angle is measured based on FAR and FRR as summarized as in table 3.

Table 3. ant-CBIR Pheromone Table

Radial Furrow	Angle	1 – Forward	2 – Backward
	$\theta = 0^0$	Q1(i, j) = 121	Q1(i, j) = 111
	$\theta = 45^0$	Q2(i, j) = 120	Q2(i, j) = 111
	$\theta = 90^0$	Q3(i, j) = 109	Q3(i, j) = 109
	$\theta = 135^0$	Q4(i, j) = 111	Q4(i, j) = 120
	$\theta = 180^0$	Q5(i, j) = 111	Q5(i, j) = 121

The overall process of ant movements according to iterations and degree of angle is measured using FRR and false acceptance rate (FAR). The accuracy and performance is further analyzed using the genuine acceptance rate (GAR) parameter.

$$GAR = 1 - FRR \tag{4}$$

Table 4: Comparison of FAR, FRR and GAR using classifier with and without ant-CBIR

	Without ant-CBIR	With ant-CBIR
FAR (%)	0	78.99
FRR (%)	100	20.3
GAR (%)	0	79.7

Results shown in table 4 highlight the fact that regardless of the method used, GAR values remain zero without the use of ant-CBIR. This signifies that the system, regardless of the method used, rejects the genuine user, and classifies him or her as an impostor. The classifier used with ant colony is Adaboost.

The experiment results show the graph of ant-CBIR implementation in the extraction process produces the significant results of GAR value which is 79.7%. Figure 3 shows the comparison in bar graph between the extraction processes that using ant-CBIR and without ant-CBIR for finding radial furrows feature in noisy iris.

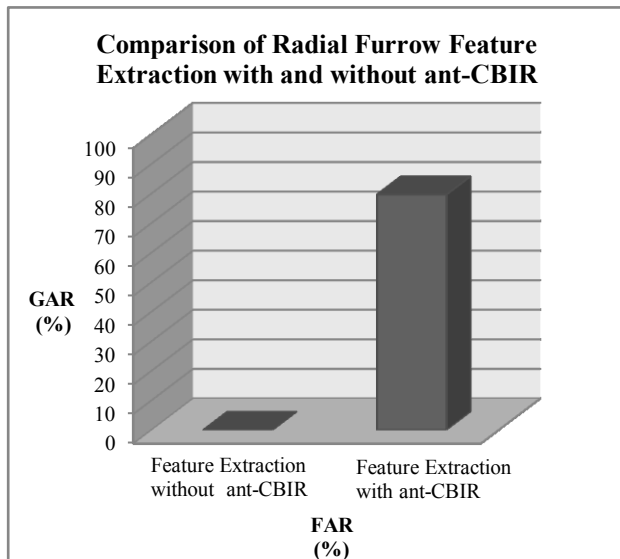


Figure 3. Comparison of Radial Furrow Feature Extraction Process with and without ant-CBIR

4 CONCLUSIONS

This paper presented a study on the iris feature extraction using bio-inspired algorithms and proposed method called as ant-CBIR for evaluating the GAR values to determine the genuineness of the unique feature (radial furrow) from the iris texture. The evaluation is conducted using iris database (UBIRIS) that has been pre-processed previously. During the evaluation, the movements of ants are based on precision that is measured with FAR and FRR values. Once the radial furrow has been obtained, it is indexed and the most optimal points in the radial furrow are stored into the database. In addition, the impact of the new method produces a better accuracy performance to iris recognition. Subsequently, the benefits of the ant-CBIR from a new perspective method provide cost effective, easy

maintenance, robustness in exploration of human-aided recognition and long term stability in iris database which at the end contribute to the biometric society.

In future it is recommended to continue this work using other bio-inspired algorithm such as water drop in order to evaluate the accuracy performance.

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