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Research Article

Optimizing the Genetic Algorithm to resynthesize iris Patterns from iris Code Template

Rajwinder Kaur[†*] and Prabhpreet Kaur[†]

[†]School of Computer Engineering and Technology, Guru Nanak Dev University, Amritsar, Punjab, India

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Abstract

Human iris is considered to be the most reliable biometric trait. Iris recognition system stores the discriminant and complete information of a particular iris in a compact form known as iris code, because of security reasons. Earlier it was conceived that resynthesizing the original information from the biometric template is not feasible, but later scrutinization proved this notion wrong. Different types of approaches were propounded for resynthesizing biometric data from their corresponding template representations. In this paper, different crossover techniques are used to optimize the genetic algorithm to synthesize iris images from similar iris codes and their performance is evaluated through a commercial matcher by estimating the probability of successfully matching the synthetic iris images with its corresponding real images.

Keywords: *Image Processing, Image Reconstruction, Biometrics, Genetic Algorithms, Selection, Crossover, Iris code, Security*

1. Introduction

Biometrics refers to the science that includes identifiers such as fingerprints, face, iris or voice, which are distinctive measurable characteristics use to label or describe a person. As the biometric traits are hereditary factors so they are unique to an individual and hence proved to be more accurate than traditional human authentication schemes. The biometric system gathers the biometric traits of a person, elicit-ate the features from the collected biometric characteristics and matches the elicited features with those stored in the database, to validate the claimed identity. The raw biometric data may reveal critical information about an individual's personal identity, so for security sake instead of raw biometric data, the feature set extracted from biometric data is stored as a biometric template into the database.

Among various available biometric traits human iris is regarded as the most authentic, precise and veracious, and also, it was assumed that iris patterns remain uniformly unique throughout a person's life (however it was proved wrong later on). Because of these reasons, the iris recognition system was employed in various private and critical systems' authentication. John Dougman proposed first iris recognition system, later on, many other approaches were proposed for improving this biometric system. The process of iris recognition involves certain pre-processing steps like localization, segmentation and normalization and then some filtering techniques are used to generate iris templates. The final binary template (iris code) is constructed by quantizing the phase information contained in the filtered normalized image. The obtained binary template is then stored in the database. Bit-based metrics like hamming distance are used for comparison of iris codes during iris recognition

For a long time, it was perceived that reversibility of iris code is not feasible however many researchers get victorious in resynthesizing biometric information from their corresponding compact representations and hence proved this notion wrong.

Inverse Biometrics refers to the process of reconstructing or re-engineering the biometric template to obtain information about the identity corresponding to the template.

In the current scenario where the biometric systems are overtaking the classic authentication schemes, inverse biometrics acts as a serious security threat. As iris recognition is employed in providing authentication or personal identification for highly confidential or secure systems such as at airports, for forensic purposes, etc. so the security is essential than ever.

In this paper, the work done by (J. Galbally *et al.*, 2013) is carried forward. In this referenced paper a genetic algorithms based template reconstruction technique is proposed. With the help of this method, a large number of synthetic iris images can be

*Corresponding author: **Rajwinder Kaur**

constructed which look somewhat similar to the original iris patterns and could easily deceive human analyst as well as commercial iris matchers.

The work is done not to generate spoofed images that could fool the system rather the work is done from computer perspective i.e. to create iris patterns that could be successfully matched against their physical counterparts. In this paper, different selection techniques are used in the genetic algorithm for resynthesizing the iris code. A fundamental genetic algorithm mainly consists of three operators i.e. selection, crossover, and mutation. The selection techniques that are used in this paper for performance comparison are proportionate selection, ranking selection, and tournament selection. Analyse system's performance for each of the used selection technique in terms of the values of the performance metrics such as false acceptance rate, false real rate, etc.

2. Related Work

Latest research trends in the field of inverse biometrics encouraged the involvement of many researchers to re-engineer the biometric templates. Earlier it was considered that biometric templates cannot be re-engineered, but this belief was challenged by an experiment proposed by (Christopher John Hill, 2001). The experiment mainly focused on the reversibility of fingerprint minutiae template.

Many researchers contributed towards resynthesizing the binary iris code templates. In (J. Cui *et al*., 2004) iris synthesis technique based on principal component analysis and a super resolution was proposed. This technique involved the synthesis of a vast number of synthetic iris images by adjusting the values of the given coefficients and then the visual enhancement of these images through super-resolution. In (S. Makthal *et al*., 2005), iris images were resynthesized using Markov Random Field, in which single or multiple primitives are used to generate iris like patterns. The generated images are then validated through clustering process for differentiating iris like patterns from non-iris patterns and through match score distribution of real and synthetic iris images. (Z. Wei *et al*., 2008) Proposed a patch-based sampling method for synthesizing a large database consisting of realistic iris images. In this method firstly the visual characteristics are analyzed through a small iris patch and then an iris prototype is formed using patch-based sampling.

Various techniques for generating spoofed iris images by making use of iris code templates or match score data were proposed in (S. Shah *et al*., 2006), (J. Zuo *et al*., 2007), (Andy Adler, 2004) and (S. Venugopalan *et al*., 2011)

A recent technique for resynthesizing the iris images has been proposed in (J. Galbally *et al*., 2013). This method is based on genetic algorithms and addresses the problem of generating some synthetic iris images that look somewhat similar to original iris images and could easily deceive human analysts and commercial matchers. The methodology used in (J. Galbally *et al*., 2013) (Genetic Approach) helps in enhancing the security of biometric systems by protecting it against the vulnerability of spoofing attacks. In (J. Galbally *et al*., 2013), only output scores of an iris image are required, and no prior knowledge of the feature extraction scheme is needed while resynthesizing the synthetic images. Also, there is no need to use original images to give a realistic look to the images.

3. Basic Techniques followed

3.1. Iris Recognition Process

Iris Recognition system mainly consists of some pre-processing steps like Acquisition, Segmentation, and Normalization and then the encoded normalized images are matched against the claimed identity. The steps involved in iris recognition system are:-

3.1.1 Image Acquisition: -An eye's image is acquired with the help of a sensor or camera or some other image acquisition tool.
3.1.2 Image Segmentation: - The captured image of an eye is then segmented to distinguish the iris region from rest of the area of the eye.
3.1.3 Normalization: -The annular-like iris images of the eye are then converted into rectangular normalized images which are the representation of the segmented iris image from Cartesian coordinates to pseudo-polar coordinates.

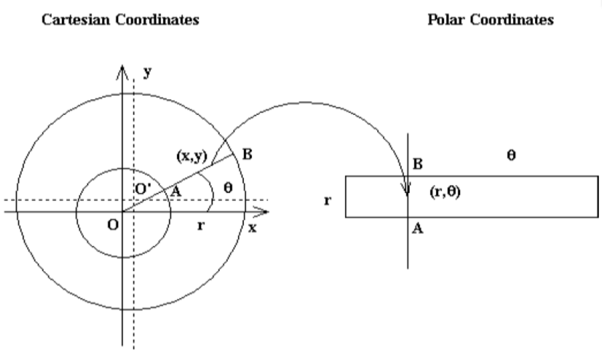

Figure 3.1: Normalization of annular-like segmented iris image from Cartesian coordinates to polar coordinates

3.1.4 Encoding: -A large number of encoding techniques, most of which use some filtering techniques, are available to encode the normalized images.

The normalized images are mapped to binary templates through encoding, and then these binary. The whole iris recognition process can be summarized using figure 3.2.

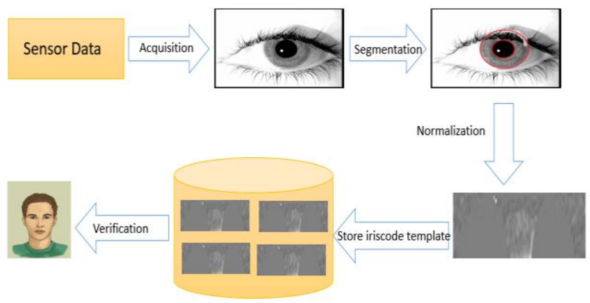

Figure 3.2: Iris recognition process

3.2. Genetic Algorithms

A basic genetic algorithm mainly consists of three operators; Selection, Crossover, and Mutation. The algorithm starts by considering a set of chromosomes (usually the elements or units on which we want to apply genetic algorithms), called population. The chromosomes of the current population are used to create offspring that can be passed on to the next generation or population in the hope that newly generated offspring chromosomes will be better than their parent chromosomes.
Fitness Evaluation: - In the process of creating offspring chromosomes, first of all, the fitness of all the chromosomes under consideration, is calculated through a predefined fitness function.
Selection: - The selection operator facilitates the selection of parent chromosomes based on their corresponding fitness values. The chromosomes possessing the best fitness values are directly passed on to the next generations; this type of selection is known as elitism. There are many types of selection operators available for use, out of these possible types three main selection operators that are used in this paper are:

- Rank Selection: In rank-based selection, the population is sorted according to the fitness values. The fitness assigned to each chromosome depends only on its position in the individual's rank and not on the actual fitness value. The probability of each chromosome being selected for mating is its fitness normalized by the total fitness of the population.
- Roulette wheel selection: The chromosomes are mapped to contiguous segments of a line, such that each's portion is equal in size to its fitness. A random number is generated, and the chromosome whose section spans the random number is selected. Until the desired number of chromosomes is obtained (called mating population), the process is repeated over again and again.
- Stochastic Universal Sampling: The chromosomes are mapped to continous segments of a line, such that each chromosomes' portion of the segment is equal to its fitness value. Equally spaced pointers equal to the number of chromosomes to be selected are placed over the line. Consider N to be the number of chromosomes to be selected, and 1/N be the distance between the pointers, and the position of the first pointer is given by a randomly generated number in the range [0, 1/N]. This selection technique ensures a selection of offspring that is closer to what is deserved then roulette wheel selection.

Crossover: - After selecting the parent chromosomes, crossover operator is applied to the parent chromosomes to create offspring chromosomes. The crossover operator combines the characteristics of parent chromosomes into the children chromosomes or just passes over the best features of parent chromosomes to the offspring chromosomes.
Mutation: - The mutation operator works after the crossover operator, over the newly created offspring chromosomes. The mutation operator is analogous to biological evolution. It mainly alters one or more genes of the chromosomes in order to maintain and introduce genetic diversity. A predefined probability value is used to control the rate of mutation in the newly generated population of chromosomes.

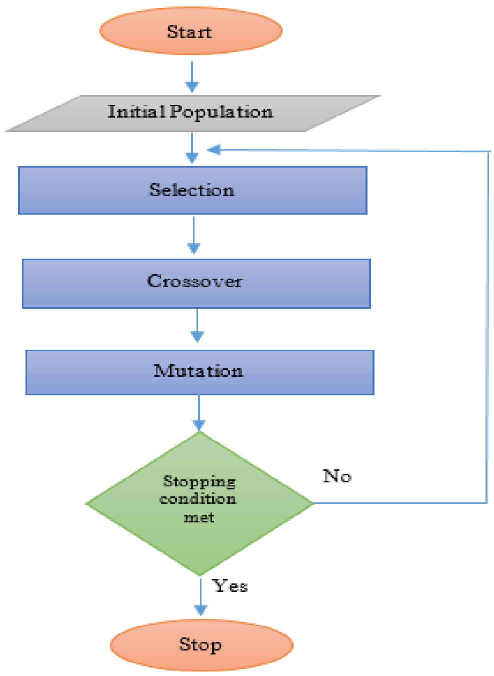

Figure 3.3: Flowchart of basic Genetic Algorithm

4. Proposed Methodology

4.1 Image Pre-processing

The iris image pre-processing include following steps:

- Image Acquisition: - Eye images are acquired through sensors or cameras.
- Image Segmentation: -The iris part of the eye is segmented from the rest of the eye areas like eyelids, eyelashes, etc. and shown with the help of a thick circle.

- Image Normalization: - The normalized iris images are stored in the database for further identification and verification purposes.

4.2 Encoding and Matching

- Encoding: - Encoding process maps the normalized iris image to binary representation. Many encoding methods are available and most of these use filtering techniques (typically Log Gabor filtering technique) before quantizing the phasor response of the filtered output and thus representing the iris images to binary form.
- Matching: - In this process the two iriscodes i.e. the iriscode of target iris image and that stored in the database are compared using bitwise operators such as hamming distance.

The encoding and matching processes can be summarized using figure 4.1.

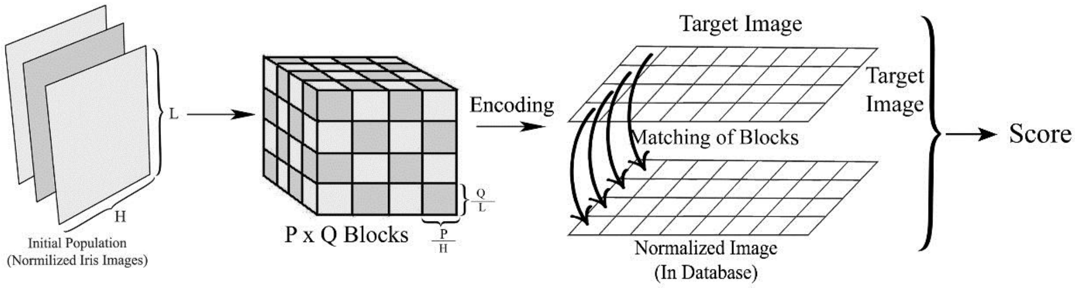

Figure 4.1: Encoding and matching process

4.3 Reconstruction Technique

Let us assume that the normalized image is of size HxL and this image is divided into PxQ blocks of size P/H x Q/L. Each of these PxQ blocks acts as genes of the chromosomes and these chromosomes are used to form the initial population. The fitness value of the chromosomes is equal to the matching score value. The reconstruction technique follows the following steps:

1. Initial population (p_0) with size (HxL) is generated with N individuals and then divide each individual into (P x Q) rectangular blocks.
2. Similarity scores s^i of the chromosomes $(I_r)^i$ from the initial population are computed.
3. Next generation of the population p_n is created using four operations of genetic algorithm:

a) Elitism:-In the next generation individuals with maximum similarity score are retained.

b) Selection: Three types of selection operators are applied independently over the initial population to find parent chromosomes. The types of selection operator used are:

- Rank Selection
- Roulette Wheel Selection
- Stochastic Universal Sampling

c) Crossover: - Uniform crossover technique is applied. In this crossover technique, a mask equal to the size of individual chromosome is chosen randomly and the value of first parent bit is assigned to child chromosome if value of corresponding mask bit is 1 and if value of mask bit is 0 then value of second parent bit is assigned to child chromosome.

d) Mutation: - Random changes are applied to the blocks of the new children with mutation probability p_m.

4. Redefine $p_0 = p_n$ and return to step 2.

Stopping Criteria:

a) When the best fitness score in the population increases the threshold value.

b) When the variations in the successive populations are almost negligible.

c) When the maximum limit population generation is reached.

Conclusion

This paper primarily focuses on the concept of inverse biometric from a computer perspective. In this paper, an optimization technique for the method given by (J. Galbally *et al.*, 2013) is proposed. (J. Galbally *et al.*, 2013) proposed a probabilistic approach to reconstruct iris images from binary iris code template. This paper optimizes the genetic algorithm (used to reconstruct iris images from iris code), firstly by using different types of selection operators in the genetic algorithm, after that the results of the algorithm are analysed and then based on the results the selection technique is used to optimize the ideal reconstruction method.

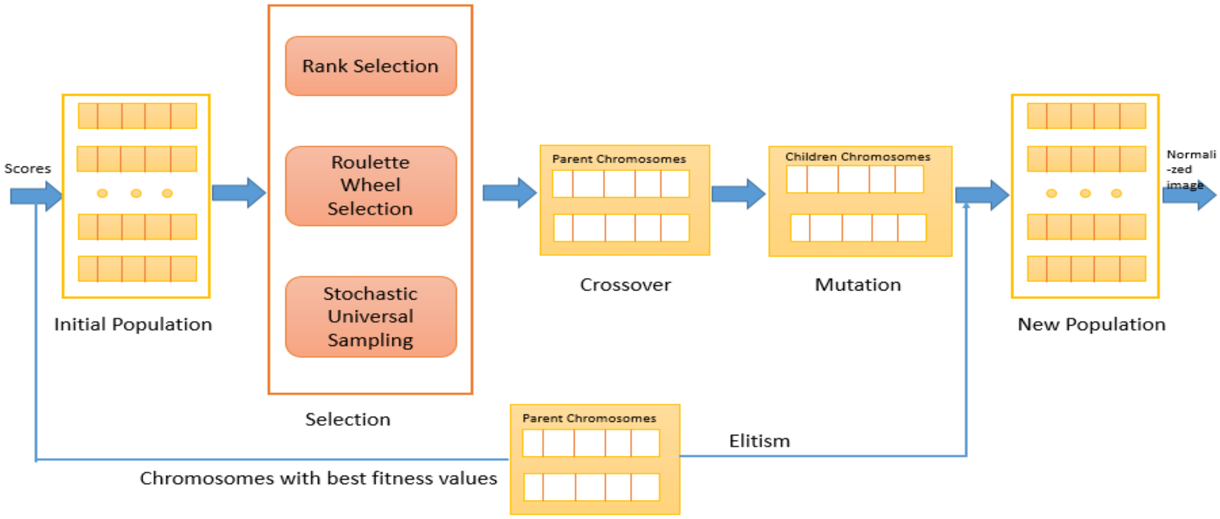

Figure 4.2: Iris Reconstruction Technique Based on Genetic Algorithm

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