Original Article

Provide a new way to improve diagnostic performance in iris recognition systems in Ahwaz Pipe Manufacturing Company

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Abstract

The iris detection system consists of several stages for recording staff entry and exit, one of the most important of which is feature extraction. Most existing systems use a special method to extract the feature. In order to improve the performance of the system, we used the particle optimization algorithm to find the combined method extraction method. The proposed method uses a large number of filters and conversions in the extraction of features and finds the best combination of them during the repetition of the algorithm. Finally, a set of methods, including a number of wavelets, filter, and February conversions, was obtained as the most optimal combination feature extraction method. In experiments, improved performance of the proposed combination method compared to methods using only one filter was shown using ROC diagram. Was. Comparisons showed that the proposed method performed better in most situations than the newest methods. This method achieved FAR of zero and FRR of 0.92.

Keywords: Biometrics, iris, identity detection, feature extraction and particle optimization algorithm

Introduction

Today, there is a considerable need for reliable and fast tools for automatic identification of individuals. Computer techniques used to identify personality traits such as face, fingerprints, retina, voice, palm geometry, eyes, etc. have many applications in security, surveillance, and ownership; But many of the available methods have limited capabilities in identifying features in practical and real cases; Some methods require contact with a person's body, some use sampling, some require a final adjustment by one person, and some have high costs. A method that has recently received more attention than other methods is to identify people by the characteristics of their iris. Also, these methods must be both unique and easily measurable and do not change over time. Biometrics usually refers to the automatic or semi-automatic use of physiological or behavioral traits that depend on the human body. Physiological characteristics such as paralysis include fingerprints or facial images. Behavioral characteristics include actions or behaviors that occur from a person, such as a signature or speaking tone.

Ahvaz Pipe Manufacturing Company was established in 1346 in a large area of Ahvaz city using modern machinery and advanced equipment and using specialized manpower in order to produce steel pipes for oil, gas, petrochemical and water industries. The company currently has four pipe factories and three pipe cover factories; many employees and workers work in these factories with a wide range of tasks. Due to the specifications of the iris biometric method that we will discuss below, as well as the application that can be found in Ahwaz Pipe Company due to its high detection rate and non-touch, this method can be very useful in this organization.

Comparisons between different biometric methods are particularly popular due to their unique characteristics in complex iris tissues, including specific and abundant features such as grooves and protrusions, zigzag tissues, rings and spots [1], leading to better diagnostic performance than others. Methods. It is also easier to collect samples than some methods (eg DNA), and this feature is not easily variable (such as tone of voice) or by a fraudulent person (eg, burning fingerprints with acid).

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Feature extraction is the most important part of an identity recognition system; In addition to containing all the important information in the iris tissue, it should have even the smallest possible dimensions, because large-scale vectors, in addition to being large enough to store, also have a high computational volume in stages. Extraction and adaptation are imposed on the system.

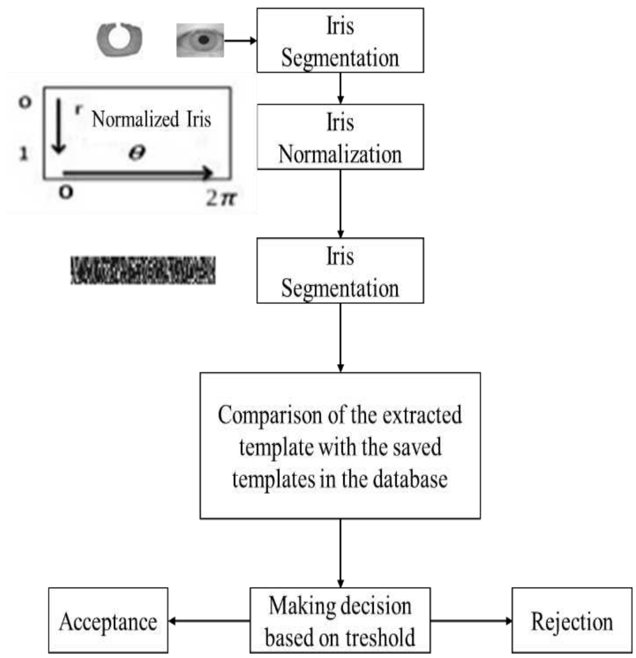

Figure 1: Identification process of the identification system using iris images

After finding the inner and outer boundaries of the iris and drawing this area on a rectangular strip with dimensions of 64 × 512, we must extract a feature vector from the obtained strip. This feature vector should be such that it uses the unique features of iris tissue. The resulting vector should only encode important information in the iris tissue so that a comparison between the input image and the stored code can be successfully performed. Most identity recognition systems generate appropriate code by analyzing the information of the middle band of iris tissue in the frequency domain. The first is the number of people who have been misdiagnosed and the second is equal to the number of people who were on the database but have not been authenticated.

In the following, we will discuss the previous work done in the field of biometric identification systems and discuss them. In the next part of this research, it has been fully described by the data and methods used. Also, we will analyze and analyze the proposed method by mentioning the details in full. In the last part, we will evaluate the performance of the method and compare different methods with the proposed method and express the advantages and disadvantages of each, then conclude and discuss. The work to be done in the future can be done.

Research Background

Identifying images based on iris images involves analyzing and analyzing the features that are present in the colored tissue of the eye enclosed between the pupil and the iris. Complex iris tissues can include many specific features such as grooves and protrusions, zigzag textures, rings, and spots [1]. The iris scan uses a medium-sized camera that does not require close contact between the person and the camera. This advantage of the biometric system makes the user feel more comfortable than other systems that require physical contact of the camera with the person, such as a retinal scan. The iris is unique from one person to another because there are so many different tissues that surround the pupil [2].

Various image processing methods are used to extract the unique properties of iris images and convert the image into a biometric code. Biometric code is the result of applying mathematical operators to an image. The codes obtained from various images are stored in the system database after extraction, and when a person wants to be identified in the system, first a code of his iris image is extracted and then this code is compared with other codes in the database. At this stage, the system looks for the code that is the least different from the code obtained from the person; If the encoded distance is less than the threshold, the person will be given an identity card, otherwise it will not be recognized. The identity system has recently been taken into consideration by iris images, and the main discussion has been conducted by Professor John Dagman at the University of Cambridge in the United Kingdom. Another system that has shown high success rates is the Wilds system. This system did not show any errors on the 520 image [3]. Another system is the Lim system, which shows a success rate of 98.4% on 6000 images [4]. Based on the results obtained in different methods, it can be concluded that compared to other biometric methods such as fingerprint and face or sound, iris-based systems have higher reliability [5]. The main problem with this biometric test is the lack of large images of iris, which results in only low-resolution images. In addition, most experiments use high quality images.

In a study by Alvarez et al., They proposed a powerful method of extracting key point-based properties under variable quality conditions. Their method is based on the effective fusion of three sources of information from SIFT features at the same level. This method works by using the proposed fusion scheme, which is based on the three known units of measurement, AUC, EER, and CRR. This method has an innovation that uses the potential of SIFT features to describe key points and fuse them to improve performance on iris non-ideal images. Analysis and analysis show the high power of each resource in combining with each other. Also, the power to detect this method decreases with decreasing image resolution. Although the extraction of a feature with this algorithm is time consuming, it is very fast compared to other algorithms. As a result, this method can be used for the detection of real-time individuals [6].

In a study conducted by Abikoy et al., A new feature extraction method was proposed using fast wavelet conversion, which is used to extract iris characteristics. In this system, the attributes are encrypted to generate iris codes. This method first removes the iris from the Cartesian coordinate to the polar coordinate, and then the property extraction operation is performed by converting the FWT fast wave. This algorithm has a high speed and low complexity rate [7].

Another study by Sancar et al. Proposed a new method for extracting area-based traits for iris detection. In this study, a method called the three-band semiconductor filter bank (THFB) was used to perform multi-dimensional analysis and analysis. This analysis and analysis can be performed on any two-dimensional signal and extract its tissue characteristics. The study was conducted on three libraries, CASIv3, UBIRISv1 and IITD. The results indicate that the technique used in this study is more accurate than previous techniques [8]. Stuck et al. [9] have proposed a method in which the power of three classifications based on the nearest distance, thin display, and genetic algorithm is used simultaneously. Experiments show that the error rate in this method is almost zero.

A new algorithm has been proposed in [10] by Amir Azizi et al., Which uses the conversion and nonlinear approximation coefficients to detect iris. Dagman's methods have been used in this study to perform fragmentation and normalization of iris images. During the feature extraction phase, only the middle band of the normalized iris images is decomposed by contouring conversion. This method is more accurate than the wave conversion method. Because contour conversion is relatively capable of detecting richer directional information.

Methods Provided

The proposed algorithm uses the Libermusk iris detection system. The system includes an auto-segmentation based on the hoof conversion, as well as the ability to locate the iris ring and pupil area and the overlap of the eyelids, eyelashes, and light reflection. Separation, the inner boundary of the iris with the pupil and its outer boundary with the sclera is determined using a mineral edge (the specifications of these inner and outer circles) and then determined by converting the half-dot on the circular or border boundaries with a definite parametric equation.

Figure 2: Image of normalized iris ready to extract feature

The removed iris area is then normalized within a fixed rectangular block; So that we do not face the problem of different dimensions of iris size (Figure 2). In order to extract the feature in the Libmorsk system, the phase data is extracted from the one-dimensional filter of the Gabor logarithm and quantified at four levels.

01 00 00 10 11 11 01 01 00 10 10 11 11 01 01 00 10 10 11 01 01 01 01 01 00
10 10 01 11 00 01 11 10 11 10 10 00 10 01 10 00 11 01 10 11 00 01 01 11 10

Figure 3: Template feature extracted by Gabor filter [11]

In order to unify the iris pattern within a bit-based biometric template, the same distance is used to match the iris templates. The two molds are compatible if the distance between them is less than one threshold. By changing the threshold value, we see a change in the FAR and FRR values; By reducing each of them, we see an increase in the other; So we have to strike a balance between them. To balance this, we change the threshold value to the minimum value in FAR and FRR. In some systems, one of these two criteria (usually FAR) is more important; So the threshold value is adjusted according to this criterion; But usually our goal is to have at least both of them; Also, to draw the ROC diagram, different values of the criteria are obtained using the change of this threshold. In [11] it has been shown that the best threshold value for CASIA data is 0.38, in which we see a balance between the FAR and FRR values (something around zero for both criteria, Table 1).

Table 1: FAR and FRR values at different thresholds

FRR (%)	FAR (%)	threshold
99.047	0	0.20
82.787	0	0.25
37.88	0	0.30
5.181	0	0.35
0.238	0.005	0.40
0	7.599	0.45
0	99.499	0.50

In our proposed work, in addition to extracting the feature based on the Gabor filter, several other feature extraction methods have been used that have been used to extract effective properties of iris, and by combining some of them, we will achieve the most optimal feature extraction method; They can be used to achieve better performance. In the following, we will discuss the types of feature extraction methods and explain how to find the best combination of them using the PSO algorithm.

Combining filters in the proposed algorithm

We used four types of feature extraction in the proposed method; These methods include wave breakdown, laplasin mask, gabor conversion and February conversion. The filters used in this method are shown in Table 2.

Table 2: Different types of feature extraction in the proposed method

Details	Feature Extraction Type	No
Horizontal details of decomposition	Haar Wavelet	1
Vertical details of decomposition	Haar Wavelet	2
Diagonal details of decomposition	Haar Wavelet	3
Horizontal details of decomposition	Daubechies Wavelet 2	4
Vertical details of decomposition	Daubechies Wavelet 2	5
Diagonal details of decomposition	Daubechies Wavelet 2	6
Horizontal details of decomposition	Symlet Wavelet 1	7
Vertical details of decomposition	Symlet Wavelet 1	8
Diagonal details of decomposition	Symlet Wavelet 1	9
Horizontal details of decomposition	Coifflet Wavelet 1	10
Vertical details of decomposition	Coifflet Wavelet 1	11
Diagonal details of decomposition	Coifflet Wavelet 1	12
Horizontal details of decomposition	Biorthogonal Wavelet 1.1	13
Vertical details of decomposition	Biorthogonal Wavelet 1.1	14
Diagonal details of decomposition	Biorthogonal Wavelet 1.1	15
Horizontal details of decomposition	Reverse Biorthogonal Wavelet 1.1	16
Vertical details of decomposition	Reverse Biorthogonal Wavelet 1.1	17
Diagonal details of decomposition	Reverse Biorthogonal Wavelet 1.1	18
Horizontal details of decomposition	Meyer Wavelet	19
Vertical details of decomposition	Meyer Wavelet	20
Diagonal details of decomposition	Meyer Wavelet	21
Horizontal details of decomposition	Biorthogonal Wavelet 2.6	22
Vertical details of decomposition	Biorthogonal Wavelet 2.6	23
Diagonal details of decomposition	Biorthogonal Wavelet 2.6	24
Horizontal details of decomposition	Reverse Biorthogonal Wavelet 2.6	25
Vertical details of decomposition	Reverse Biorthogonal Wavelet 2.6	26
Diagonal details of decomposition	Reverse Biorthogonal Wavelet 2.6	27
real part of the filter output	Gabor Filter	28
imaginary part of the filter output	Gabor Filter	29
Filter output	Laplacian Filter	30
real part of the filter output	Fourier Transform	31
imaginary part of the filter output	Fourier Transform	32

Here we examine the reason for using these filters. The February conversion is a low-cost filter that allows the use of phase-phase information. This premise has also been widely used in iris recognition [12, 13]. Laplace filters are more detailed than many filters and have sharpening properties, and in some cases have been used to identify identities using irises [14]. Gabor filters can be used as directional and scalable detectors to detect lines and edges in images. Also, the statistical characteristics of this conversion can be used to determine the structure and visual content of images. Gabor's conversion features are used in image analysis, texture segmentation, and image recognition. In the Limborsk system, only this filter is used to extract the feature [11]. Waves are a group of mathematical functions used to break down a continuous signal into its frequency components. In these functions, the resolution of each component is equal to its scale. The conversion of the analysis wave of a function is defined based on its functions. Waves (known as girl waves) are the transmitted and scaled samples of a function (mother wave) with finite length and highly oscillating damping. Compared to the February conversion, it can be said that the wave conversion has a very good localization feature. These filters have been widely used in the recognition of iris, especially in recent years [15-17].

Finding a combination filter among the filters listed to extract the work feature is very difficult; So we have a complicated search problem. In the proposed method, particle density optimization (PSO) algorithm is used to achieve the best combination of filters to achieve a near-optimal response. In the proposed algorithm, each particle consists of a number of numbers between zero and one. Extracting the feature from the database images is evaluated (Figure 4).

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
0.5	0.9	0.1	0.6	0.8	0.1	0.2	0.7	0.5	0.6	0.3	0.1	0.7	0.3	0.6	0.8	0.2	0.0	0.6	0.7	0.2	0.4	0.0	0.7	0.9	0.4	0.1	0.3	0.9	0.5	0.8	0.3

Figure 4 is an example of a particle in the proposed PSO algorithm.

For the particle shown in Figure 4, which is an example of the particle in the proposed PSO algorithm, the corresponding filter with a value of one is selected from Table 2 and used to extract the property. Because the output of the extraction feature for the match must be binary, we consider the result of the filter to be one if it is greater than zero, and otherwise zero. The matching process is as follows: First, for both images in the training phase, which are compared with each other, using the filters that have a value of 1 in the particle, the extraction of the feature is performed and then the comparison is made if the amount of Heming distance obtained is less than the threshold value. For that filter, it is accepted as a correct match, and finally, if more than 50% of the filters have accepted the desired comparison (as a correct claim), that comparison is accepted as a correct match, otherwise it is rejected as a false match. This process applies to all photos in both databases. This procedure is applied to all particles of society and finally the value of the fitness function for each particle is calculated. Because the lower the FAR and FRR errors, the better the feature extraction method and finally the iris detection system; Therefore, relation (1) is used for the fitness function, and finally the search algorithm seeks to reduce this value; And then in the next step, the PSO algorithm produces the next population to look for answers that have the least amount of fitness function.

(1) $$FAR = \frac{Number\ of\ \ False\ Accepted\ Matches}{Total\ Matches}$$

(2) $$FRR = \frac{Number\ of\ \ False\ Rejected\ Matches}{Total\ Matches}$$

(3) $$Fitness = \alpha \times FAR + \beta \times FRR$$

In relation (3), there are values and rewards that are determined manually, and the size of each indicates the importance of the corresponding error rate. Figure 5 shows the flowchart for calculating the fitness function.

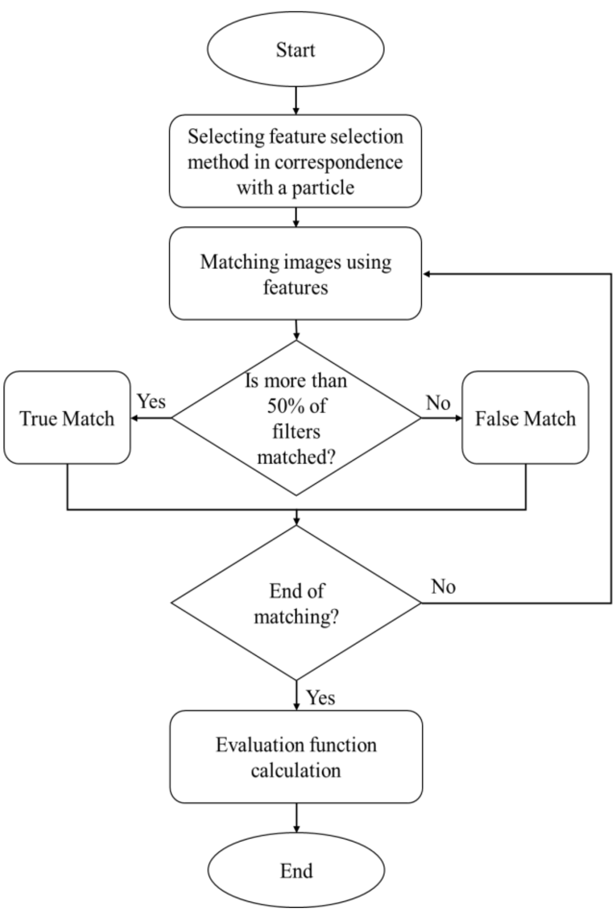

Figure 5: Flowchart Calculates the fitness function for each particle.

To save on calculations, features are first extracted from all images and stored in a four-dimensional matrix (first dimension for image number, second dimension for feature extraction, and third and fourth dimension for feature matrix); Then, using a particle from among the various features of the operation, the selection is made. In calculating the fit, the database images are matched in two ways and are calculated using Equations (1) and (2), FAR and FRR. We get the feature. Figure 6 shows the proposed flowchart algorithm:

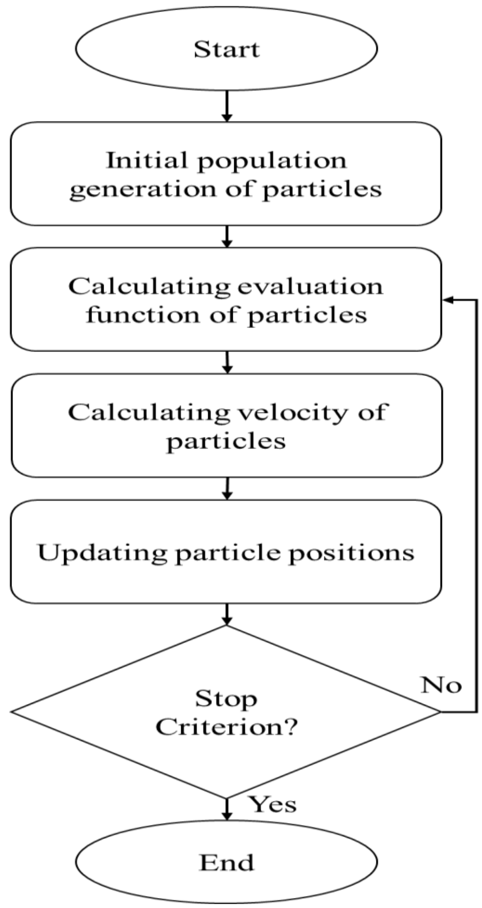

Figure 6: Fluctuation of the proposed algorithm

Data and Performance Analysis

In this section, first, the specifications of the database used in this research are introduced. The method of recognizing the iris is then fully explained. All the steps in the iris recognition algorithm are given in detail, as well as explanations of similar methods in each section. A brief description of the Libermusk iris detection system is also provided. Since this study uses the PSO algorithm to obtain near-optimal answers; Therefore, we have fully described this algorithm.

The database used in this study

Unlike other biometric methods such as fingerprint and face detection, there are many databases available for testing. There are limited databases for iris. In this study, the iris database CASIA V.1 (Chinese Academy of Sciences) was used for experiments due to the good image quality. The images were taken by infrared light and stored in BMP format with a resolution of 280 x 320 [6, 18]. In this study, 30 images were used to obtain the best filters to extract the characteristics of the iris image (in order to maximize the detection capability) from the eye images of 30 people and five images per person; So we have 150 images; We have a total of 15 × 150=750 correct comparisons and 150 × 145=21750 wrong comparisons.

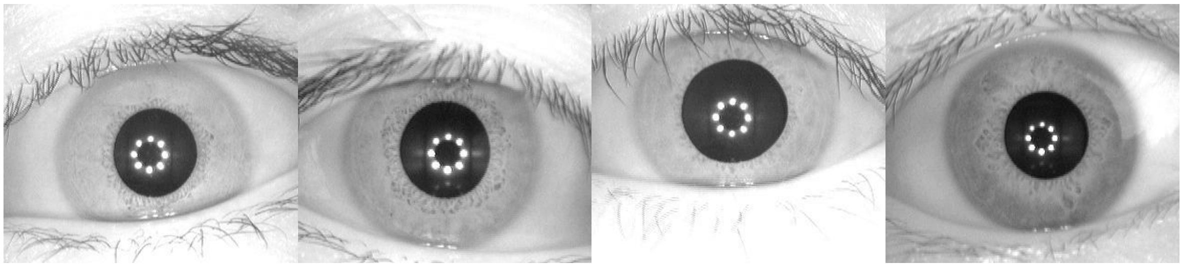

Figure 7: Examples from the CASIA V-1.0 database.

The method of recognizing the iris

Image processing steps include image capture, iris separation, normalization, feature extraction, and adaptation. Images taken from iris include not only the iris area, but also the pupil, eyelids, eyelashes, and reflections; In order for the iris recognition system to function properly, the above-mentioned areas must be separated from the main iris tissue (which is used in the diagnosis process).

- ### Shredding

Dagman used a differential integral operator in his method to identify iris boundaries and separated the upper and lower stairs by two arcs. The differential integral method can be considered as a change of hoof conversion because it uses the first derivative of the image to search. [19].

- ### Sobel edge finder algorithm

The Subel algorithm is obtained by combining a derivative function and a Gaussian function, and applies both vertical and horizontal forms with a negative coefficient of previous pixels, a positive coefficient of subsequent pixels, as well as vertical neighbors of value two on the image. Sobel's algorithm is suitable for vertical and horizontal edge detection [20].

Turning a circular hoof to mark the inner and outer border of the iris and eyelids and separating the eyelashes

Huff Conversion is a way to extract features in image analysis, machine vision, and image processing. In one image, this method looks for examples of a pattern. These specimens may not be complete and may have been partially distorted [21]. An example of the application of this method is the presence of a straight line in an image; Huff conversion is therefore an algorithm that can be used to identify and separate certain shapes in an image; To find a particular shape with a Huff conversion, that shape needs to have a certain parametric form, so the Huff conversion is usually used to find shapes such as lines, circles, and quotas. To find the circle in the image, we first find the edges of the image using an edge finder algorithm such as Connie or Sobel, then use the circular hoof conversion to find the radius and center of convergence of the pupil and iris areas [11].

Normalization

Since the size of the iris varies according to the intensity of the light entering the eye; Therefore, in order to facilitate the calculations and independence from this change in the size of the circle, including the iris texture, it is normalized in a rectangular shape.

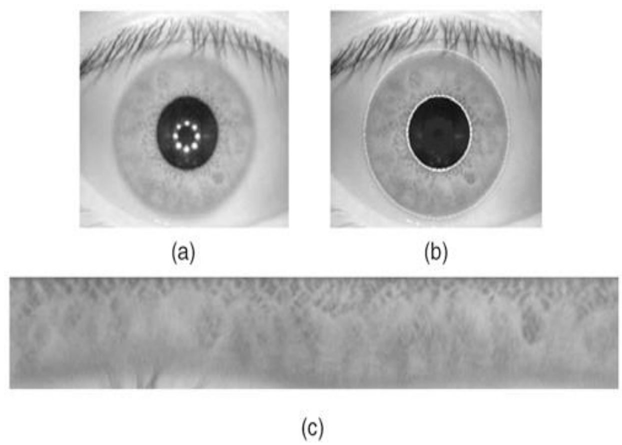

Figure 8. (a) shows the iris image, (b) the result of the circular hoof conversion, and (c) the normalized image sample [11].

Extraction of iris features

At this stage, features are extracted from the iris tissue to compare individuals, and the extracted characteristics will be used to create a biometric sample. Here are some common ways to extract the feature from the normalized iris image below:

- ### wave conversion

Wave conversion displays an image as a collection of wave functions with different locations and scales. Each image analysis consists of a pair of waveforms; One of them is for displaying high frequencies related to the details of an image (wave function) and the other is for displaying low frequencies or smooth parts of the image (scale function). The result is a set of wave coefficients; Which measure wavelengths in these locations and scales [22].

The waveform decomposes the image into images with different resolution. Clarity is determined by a threshold; Where the details are ignored and the difference between the two different resolutions shows the details. Therefore, an image can be displayed by a low resolution image (approximate or middle limit) and details relative to higher resolution.

- Gabor filters

In various applications of computer vision, such as tissue analysis and edge detection, Gabor functions have been widely used. The Gabor filter is a linear and local filter. The core of the Gabor Filter Conversion is the product of a mixed representation of Gusin. Gabor filters, if properly and accurately adjusted, perform very well in identifying the characteristics of the tissue and the edge of the tissue. Another feature of Gabor filters is their high degree of common separation. This means that their response is quite local and adjustable both in the field and in the frequency domain [23].

matching

In the previous step, the molds obtained from the iris tissue were compared with each other by a scale called the mean distance of Heminge fraction, and in the normalized state, it gave a (numerical) score between zero and half; If this value is less than the set threshold, the iris pattern can be accepted as authorized person, otherwise it will not be accepted as unauthorized person. In Heming's information theory, the distance between two strings of equal length is equal to the number of places where the corresponding symbols differ. Because the output of the feature extraction in the previous step is a matrix consisting of zeros and ones, the distance between the two images of the iris and one type of extraction of a particular feature is equal to the number of drives that have different bits.

Evaluation and Laboratories

In this section, the best combination filter is described using the proposed method and also the appropriate form of the process of achieving the best answer (particle) is given. Then, after achieving the best combination method (same as the combined filter), the performance of the filter obtained by the proposed method is compared with other filters that already have the best performance in the field of iris detection system. This comparison is performed by the ROC diagram. The biometric system performs best, with the maximum area under the ROC diagram being the maximum value (maximum one). In the diagram description, it is shown that the obtained filter with the proposed algorithm performs better than the previous filters.

To test the filter obtained by the proposed method with the best filters that have already performed very well on iris detection. Eye images of 50 different people (for testing on the number of sufficient samples) and 5 images for each person have been considered, which leads to the production of 1250 correct adaptations and 61250 incorrect adaptations, which is a suitable number for testing.

As we have seen in Equation (3), there are two constants in the fitness function; Which must be adjusted; However, since the FAR value is very small compared to the rejection rate (at the standard threshold used with a value of 0.37) (approximately 1000 times) and the FAR value is of great importance in the overall performance of the iris detection system, in other words because The small FAR relative to the FRR in total adaptations, as well as the very high FAR importance of these parameters, are considered $\beta = 1$ and $\alpha = 1000$ (an iris detection system is expected to have a FAR close to zero because this measure indicates the wrong admission rate). And in most applications it is more important than FRR).

The proposed algorithm first calculates the initial population fitness function. Thus, the value of the fit function of each particle is equal to the error rate on the iris images used to access the best filter. In each iteration, the best filters are selected to produce the next generation, and if up to 10 consecutive iterations of the filter that performed better than the best filter obtained in the previous step are not produced, the optimization algorithm stops. Another condition is to stop passing a certain amount of repetition, which we considered to be 1000. Obviously, the minimum fit is zero, and if a particle with this fit can be found, the continuation of the algorithm is meaningless and must end.

Performance Evaluation

Figure 9 shows the process of achieving the best filter using the proposed algorithm. It is important to note that in the implementation of the PSO algorithm,

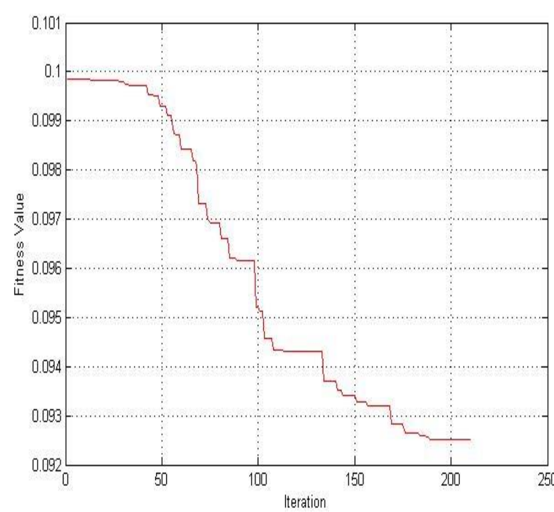

Figure 9: Processes to access the near-optimal answer using the proposed algorithm

As shown in Figure 9, the proposed algorithm goes through a very good process of accessing the most appropriate answer, and in the last 195 to 205 iterations the value of the fit function for the best member remains unchanged, and as a result the algorithm stops.

In the course of these performances, the best particle found in Figure 10 is shown. This particle with the value of fitness function 092517006802721/0 had the lowest fit compared to others; This value was obtained with FAR equal to zero and FRR equal to 0.252517006802721, which shows that the system has no erroneous admissions and out of the non-admissions, only 400 errors have been applied out of 4410 (less than 10% error).

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
0.6	0.1	0.2	0.1	0.8	0.1	0.2	0.7	0.9	0.4	0.3	0.1	0.2	0.1	0.3	0.3	0.1	0.5	0.2	0.1	0.8	0.4	0.6	0.2	0.1	0.4	0.9	0.0	0.6	0.2	0.1	0.7

Figure 10: the best particle found

According to particle 10 and the filters in Table 2, the combination of horizontal details of HARG wave breakdown, vertical details of Dabishz 2 wave breakdown, vertical details of SIMTL2 wave breakdown, diameter details of SIMTL2 wave breakdown, vertical details of Mir wave wave breakdown breakdown, details 2.6 byte signal, vertical details of riveting analysis of Bioart signal 6.2, imaginary part of Gabor filter and imaginary part of February conversion are considered as the proposed feature extraction method and all charts are drawn using this feature extraction method.

Continuing the performance, the two waveguide filters and the Gabor filter, which have performed well in the past in the field of iris detection in the Limborsk system, are compared with the combined filter obtained by the proposed method. The performance is compared with the drawing of the ROC diagram to evaluate the performance of these filters on the iris detection system; As we have seen before, this diagram is obtained for different values of the threshold in the matching section; By changing this threshold, different values of TAR and FAR criteria are calculated and the corresponding graph is drawn using these values. Figure 11 shows the ROC diagram of these three filters to compare their performance on the iris detection system.

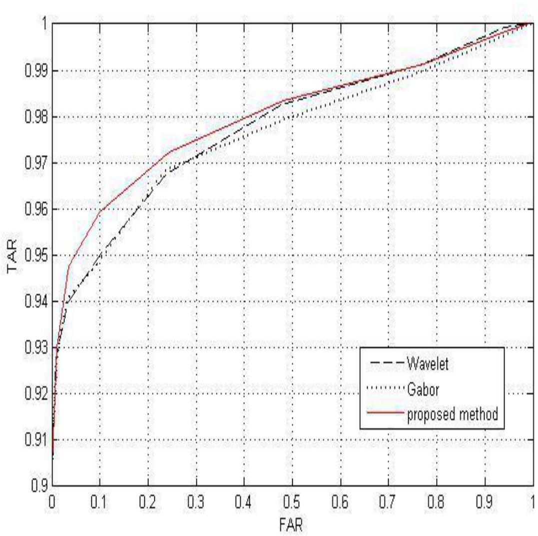

Figure 11: shows the ROC diagram for the three Gabor, Wave, and Combined Filters filters

As shown in Figure 11. In most cases, the proposed filter performs better than other filters and only performs worse at FAR = 0.02 than the Gabor filter. Finally, it can be concluded that the combined filter obtained by the proposed method is superior to other filters in the field of iris detection in the LiberMusk system.

In the following, we intend to compare the created system with other methods in [6].

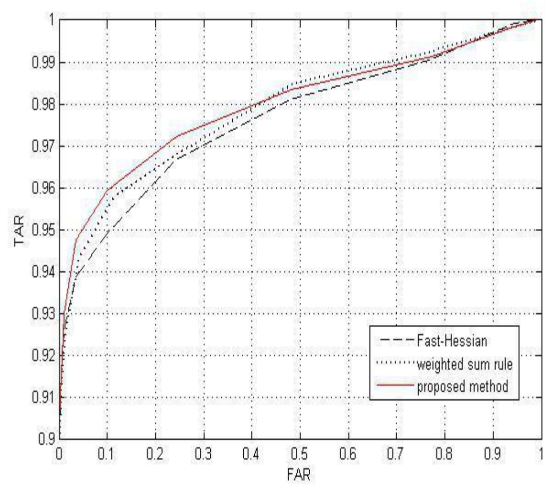

Figure 12: ROC diagram of the three Fast-Hessian iris detection systems, Weighted sum rule, and proposed method

Figure 12 shows the proper performance of the proposed method compared to recent methods, and even in most places the proposed method performs better than other methods.

Final Conclusions and Suggestions

In the proposed method, we intended to obtain a combination of filters that would improve the overall performance of the system. To do this, we used the PSO algorithm to be able to choose the best combination from the types of wave transforms, February conversions and Gabor filters. Comparisons and evaluations have shown that the proposed method has advantages over other methods of extracting feature and iris detection systems. With these interpretations, the proposed method can be used as an identification system used in Ahwaz Pipe Manufacturing Company.

Suggestions and future work

From the appropriate trend of decreasing the error rate by increasing the repetition in the proposed algorithm, it can be concluded that by increasing the repetition and constantly changing the setting of the initial parameters used in the PSO algorithm, better results can be achieved in future work; Therefore, the following are suggested to researchers as future work:

1. Change the PSO algorithm parameters and improve the method.
2. Use other types of PSO algorithms and other evolutionary methods.
3. Using filters and other conversions in addition to the methods mentioned.
4. Using parallel processing methods in extracting and selecting properties.

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