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Iris recognition based on 2D Gabor filter

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ABSTRACT

Iris recognition is a type of biometrics technology that is based on physiological features of the human body. The objective of this research is to recognize and identify iris among many irises that are stored in a visual database. This study employed a left and right iris biometric framework for inclusion decision processing by combining image processing and artificial bee colony. The proposed approach was evaluated on a visual database of 280 colored iris pictures. The database was then divided into 28 clusters. Images were preprocessed and texture features were extracted based Gabor filters to capture both local and global details within an iris. The technique begins by comparing the attributes of the online-obtained iris picture with those of the visual database. This technique either generates a reject or approve message. The consequences of the intended work reflect the output's accuracy and integrity. This is due to the careful selection of attributes, besides the deployment of an artificial bee colony and data clustering, which decreased complexity and eventually increased identification rate to 100%. We demonstrate that the proposed method achieves state-of-the-art performance and that our recommended procedures outperform existing iris recognition systems.

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1. INTRODUCTION

A biometric system allows for the automated recognition of an individual based on some form of distinguishing trait or characteristic. Fingerprints, facial traits, voice, hand geometry, handwriting, and the retina have all been used to construct biometric systems [1]. Because most existing authentication methods rely on passwords, they are vulnerable to issues such as password forgetting and password theft. Using biometrics (e.g., fingerprints, face, and iris pattern) for authentication is one technique to solve these issues [2].

When compared to other biometric traits, iris recognition for security purposes has become quite essential. This is owing to its precision, unchanging quality, and ease of use. The human iris is an annular space between the sclera (the darkest part of the eye) and the human (the darkest portion of the eye) [3]. It is a biometric technique that allows for safe human authentication. Dr. Frank presented the first iris recognition system in 1939, and Dr. Daugman executed it in 1990. Iris recognition system has recently improved its accuracy and reliability as a biometric identification system [4].

Iris recognition provides a number of advantages, including being unique, stable, collectible, and nonaggressive. Iris recognition has the lowest mistake rate of any biometric identification method [2]. The iris is a secure, visibly visible organ with a distinct a set epigenetic pattern that remains until adulthood. It is a strong candidate for use as a biometrics for identifying persons due to these properties [5]. The rich texture of the iris provides a powerful biometric indication for distinguishing individuals; hence iris recognition technologies are gaining popularity. An iris recognition system uses pattern matching to analyze two iris images and generate a match score that indicates how similar or different they are. In this score, a person's characteristics are utilized to identify them [5]. Table 1 shows the results of proposed work with the previous studies.

Table 1. Previous studies

Technique	Performance	Version
M parallel cat swarm optimization algorithm morphology, statistical	not mention	[6] 2015
Artificial intelligence	90,36%	[7] 2010
Artificial neural network	95%	[8] 2010
FFNNPSO*	94%	[9] 2016
FFNNGSA**	100%	[9] 2016
The proposed work	Right iris=90.90 Left iris=95.45	2021

* Particle Swarm Optimization Feed-forward Neural Network (FFNNPSO), **gravitational search algorithm Feed-forward Neural Network (FFNNGA)

The artificial bee colony (ABC) is a user-adapted and produced inquiry technique; it is a computational optimization well defined by Karaboga in 2005, and it is concerned with honeybee intelligence [10]. An ABC was strengthened by combining a number of traditional and evolutionary procedures. Hybridization is the name given to this approach. To decrease the issues of the processing operation and calculation time, this optimization approach combined feature selection (FS) with heuristic search. This reduction combined a large number of characteristics into a small number of features [10], [11].

The overall work of this paper is summarized as follows: section 2 describes basic concepts in proposed work in terms of describes the preprocessing steps of iris images, normalization, image segmentation, features extraction, and we have briefly explained the work of the Gabor filter. ABC algorithm is explained in section 3. Section 4 describes the iris recognition system in terms of build and enhancement method an iris database. Processing stage is discussed, proposed work and discussion of experimental results are presented in sections 5 and 6. Finally section 7 contains the conclusion and future outlook.

2. PRIMARY CONCEPTS IN THE PROPOSED WORK

2.1. Iris preprocessing

For robustness of iris information, eyelashes, eyelids, light spots, also other sounds that are all caught in the human eye photographs [4], and in order to correctly capture iris information and reduce sounds, negative consequences [12], we built a preprocessing pipeline for iris pictures. This pipeline included outer edge localization, normalization, noise shield template building, as well as contrast enhancement.

The iris's outer border can be imagined as a circle. The center and radius of the circle are determined by locating the outside border and point in the center of the iris [12]. Rough localization should be done towards the center, and the radius of the iris outside border should be precisely localized. Using the circle detection equation, accurate localization for points in the middle of the iris and outside edge after calculating the parameters of outer edge rough localization is conducted. The iris picture following outer edge localization is shown in Figure 1.

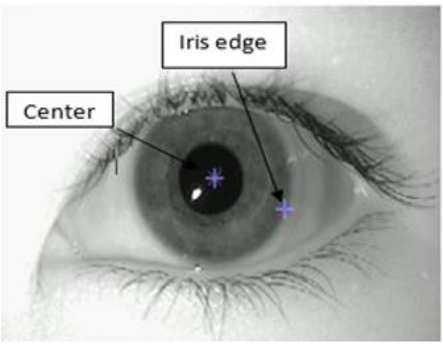


Figure 1. Iris picture with outer edge localization

2.2. Iris image normalization

After detecting the iris center coordinates, the iris picture was normalized, then the iris area was removed from the eye image as shown in Figure 2. After that, the iris picture is normalized to a predetermined size 150×150 pixel. In segmentation process, it is used for localizing the iris and pupil regions is done by circular only to perform iris recognition. Gabor filters are used to gain more accuracy and give the best results for optimal segmented iris [13]. Gabor filters were applied such as the normalization process was for iris region, and its phase was quantized to obtain the output.

2.3. Image segmentation

One of the major steps in biometric recognition system extraction is image segmentation. Image segmentation is a process of dividing the image into homogeneous regions or objects of interest. The process should be stopped when the isolated objects or areas have been created. In an earlier work, many image segmentation techniques have been applied to the gray level images. Recently, most research has been constrained on segmenting color images [14].

2.4. Features extraction

Feature is defined as any extractable measurement. It may be symbolic, numerical or both. Features may be represented by using different types of variables. These variables could be continuous, discrete-time, or even discrete binary variables. The image feature is a prominent distinctive aspect, quality, or characteristic of the image. Feature extraction is the basis of any image recognition systems [15].

2.5. Gabor filter

It is a linear filter that is used to identify edges. A 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave in the spatial domain. A real and an imaginary component indicate orthogonal orientations in the filter. The two elements can be combined to make a complex number or utilized separately [16]. According to the psychological findings, the human visual system interprets textural pictures by breaking them down into many filtered images. Each of these pictures has intensity fluctuations across a restricted frequency and orientation range [17]. Gabor filters have been used in several image analysis applications including texture segmentation, defect detection and automatic system recognition [15]. From local image regions, the resulting Gabor functions extract the most information. This information evaluates features which are invariant against translation, rotation, and scale [18].

3. ARTIFICIAL BEE COLONIES

Any effort to devise processes or distribute problem-solving solutions is sparked by the collective behaviors of insect colonies and other animal organizations. This organization is referred to as swarm intelligence. Animal and insect behavior has been studied and turned into mathematical algorithms, which have been employed in a variety of applications [19]. It is a sort of artificial colony that is founded on the principle of collaboration, and it is one of several types of artificial colonies. Cooperation allows bees to be more efficient, and in certain cases, to attain goals that they would not have been able to achieve on their own [20]. It is a recursive elegance that has been employed recently based on population, and the food source is the headache solution (nectar). Fitting nectar signifies fitness [21]. There are three categories of bees in the colony: scout bees, observer bees, and paid bees. The bee rate quantity have two halfs at the commencement point: one for the hired bee and the other for the spectator bee. The following processes were repeated until [22] was achieved as the optimal solution: i) worked (active) bees search for food sources and replace meals when the new source's nectar supply is higher; ii) the food location is chosen by the onlooker (observer) bee; and iii) when the food slots expire, the hired bee becomes a scout.

In the wild, bees hunt for food by wandering the fields around their colony. They gather and store the food for subsequent consumption by other bees. Typically, some scouts search the area as a first step scout bees return to the hive after finishing their search and inform their hive mates of the locations, quantities, and other information they uncovered.

They looked at the number and quality of food sources available in the areas they visited. If they locate nectar in previously investigated sites, scout bees dance on the hive's so-called "dance floor region," in an attempt to "advertise" food locations and entice the colony's remaining members to follow their lead. The amount of food available is communicated by a "waggle dance." A bee will follow one of the dancing scout bees to the previously discovered flower patch if it leaves the hive in search of nectar. When the foraging bee comes, it brings back a cargo of nectar to the hive, where it is sold to a food store [20]. This approach [21] is depicted in Figure 2.

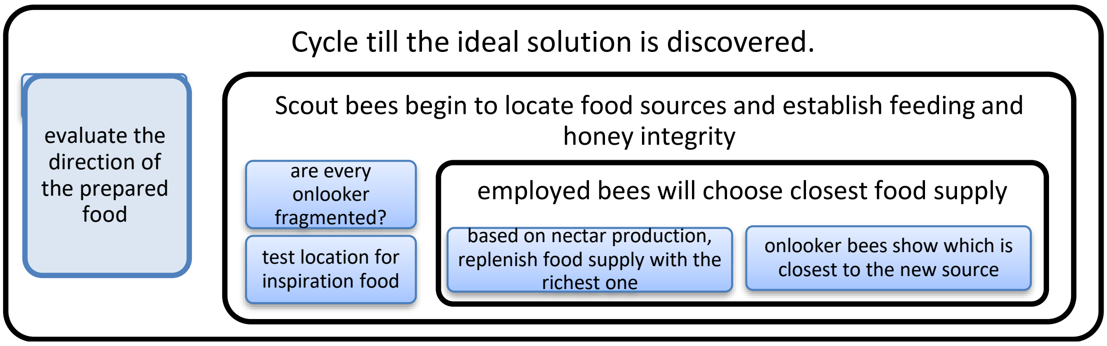


Figure 2. Bee colony system

4. IRIS RECOGNITION SYSTEM
4.1. Iris database
The proposed system requires an eye visual image database, which will be used to perform the features evaluation. This iris database is arranged for twenty-eight people in the form of a class of ten images per person. Five images for each right and left eye, the total number is two hundred and eighty iris images. This paper relied on the eye images database taken from Multimedia University (MMU) iris database. Figure 3 shows a sample from this database.

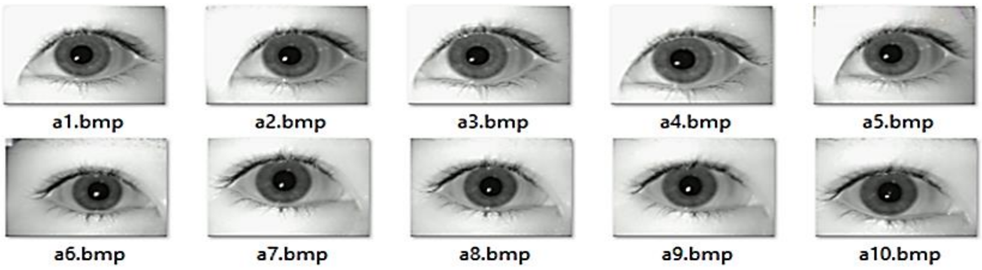
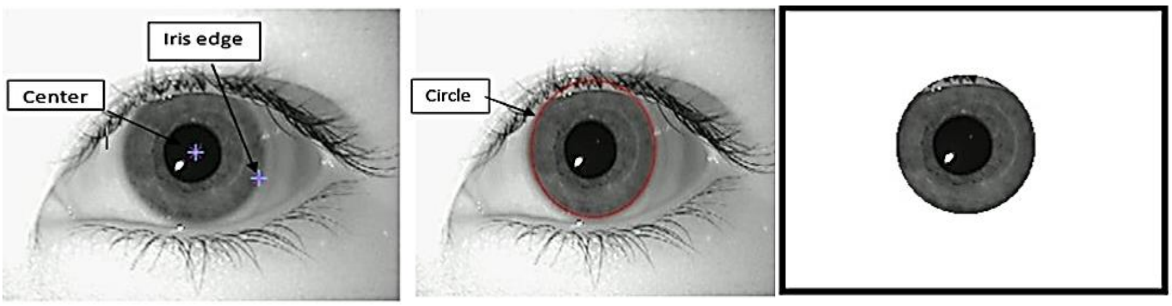


Figure 3. A sample from the database

4.2. Database enhancement method
The enhancement process starts by isolating the selected part of the iris only by determining the center and outer limits of the iris. The selected part is deducted from the iris, in order to obtain the biometric characteristics of the iris without any noise or distortion. After obtaining an image of the iris, it is stored in a new database as formatted joint photographic expert group (JPEG). To be dealt with in the next stage of processing, Figure 4(a)-(c) shows sequentially this process, the output of this process is shown in Figure 5 which describes the iris image.



(a) (b) (c)

Figure 4. Enhancement process steps: (a) center and iris edge, (b) cutting circle, and (c) after cutting

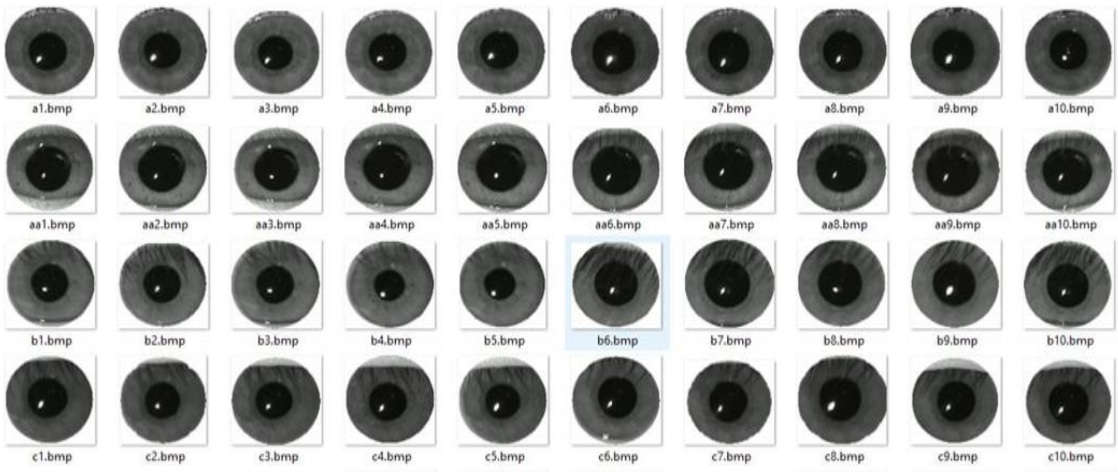


Figure 5. The iris images

5. PROCESSING STAGE

At this stage, the image was read from the iris database and the image size is determined (150×150). The colored iris image has been converted to a gray image and processed through a sequential morphological process to create a template that could be worked on in later stages. The output image was resized to a common required size. The importance of image resizing is to make all the images database of the same size. Then these images could be processed by the same parameters using the system software. The proposed paper applies a 2-D Gabor filter to iris images. This filter extracts tissue features by analyzing the frequency field of the image using different frequencies and directions. This operation identifies and shows the inner and outer edges of the iris as shown in Figure 6.

5.1. Iris edge detection

Edge detection is one of the most important stages in digital image processing and medical image processing. The iris image was processed by canny filter after the Gabor filter to obtain the best edges then to extract the biometric feature from it, as shown in Figure 7. Simply, a clever edge detector is used to spot abrupt intensity fluctuations and iris boundaries in a picture. The Canny edge detector operation classifies a pixel as an edge. When its gradient magnitude is larger than that of pixels on both sides in the direction [23].

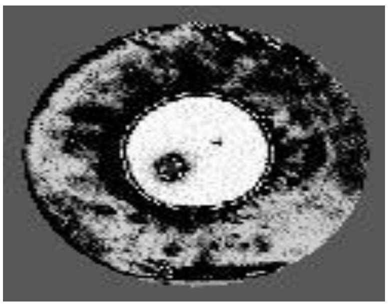


Figure 6. The inner and outer edge

Figure 7. Canny edge

5.2. Iris feature extraction stage

In every biometric system, feature mining is the most important phase. Statistical moments have been utilized to determine the most appropriate attributes. Moments were considered for inclusion in the system based on the following. They provide memory storage space, resilience, computing speed, and accurate results [24] in every biometric system, the extraction of iris features is critical. We used the iris geometry characteristics through the region property [25]. This function is one of the most used tools related to morphological image processing. In general terms this function measures a set of properties for each region labeled within a binaries image. The implementation of this function can be carried out in contiguous and discontinuous regions, applying a wide variety of properties [26]. As demonstrated below, analysis and tests were used to choose the most accurate attributes. Centroid determines the white pixel region's center. It yields two coordinates as a result. The center's horizontal coordinate (or x-coordinate) is the first element, while the center's vertical coordinate (or y-coordinate) is the second (or y-coordinate). The number of pixels that make up the area is referred to as area. Orientation [25] is the angle between the x-axis and the principal axis of the region (in degrees ranging from -90 to 90 degrees). Perimeter calculates the distance around the region's perimeter [27].

In this approach, eleven characteristics relating to the left and right iris segments are retrieved. They are perimeter, centroid1, centroid2, area, orientation, major axis length, solidity, extent, eccentricity, as well as the minor axis length. We have 10 images per individual and ten features each image, therefore we will collect one hundred features for each of the 28 participants. Furthermore, 2,800 features are gathered and recorded in an Excel file, which is used to create a feature database that will be used during the test phase of the recognition stage. Table 2 shows a sample from the features database.

Table 2. Features database

Perimeter	Centroid1	Centroid2	Area	Orientation	Mxaxis	Solidity	Extent	Eccentricity	Mnaxis
513.46	154.71	149.98	330.00	30.71	179.52	0.03	0.02	0.77	115.44
517.79	142.73	144.64	311.00	-37.52	170.72	0.06	0.04	0.78	122.28
551.17	128.54	142.14	330.00	-40.80	175.41	0.04	0.02	0.72	120.93
490.75	98.07	163.60	45.00	-49.49	142.54	0.47	0.07	1.00	122.68
493.23	145.12	141.21	300.00	-33.08	163.19	0.04	0.03	0.75	115.81
251.48	118.61	103.27	47.00	-66.26	120.16	0.06	0.03	0.93	4.55
224.80	101.93	107.50	14.00	-77.98	115.63	0.05	0.03	0.99	2.40
248.50	109.84	124.00	25.00	-72.38	129.12	0.05	0.03	1.00	2.31
296.15	112.28	105.82	57.00	-70.38	134.95	0.03	0.01	0.96	10.17
292.00	113.09	107.58	13.00	-76.26	92.02	0.08	0.06	0.95	2.84

5.3. Recognition evaluation

This is an important stage in any biometric application. Once a query image has been submitted into the system, it is examined on-line. The ABC algorithm [10] was used to extract its features and compare them to the feature database. The ABC approach is used to do a comparison between the query image and all the 8 clusters images. The ABC, which is based on a feature algorithm that lowers the vast function set, improves accuracy. The suggested paper-based software and its criteria include rigidity, correctness, clarity, and the ability to differentiate hundreds of people. The iris image's natural homes were converted into statistical functions using the template [28] Gabor filter. The system is reliable and enhances enactment. The planned work is depicted in Figure 8. MATLAB 2018b is used to implement all the methods.

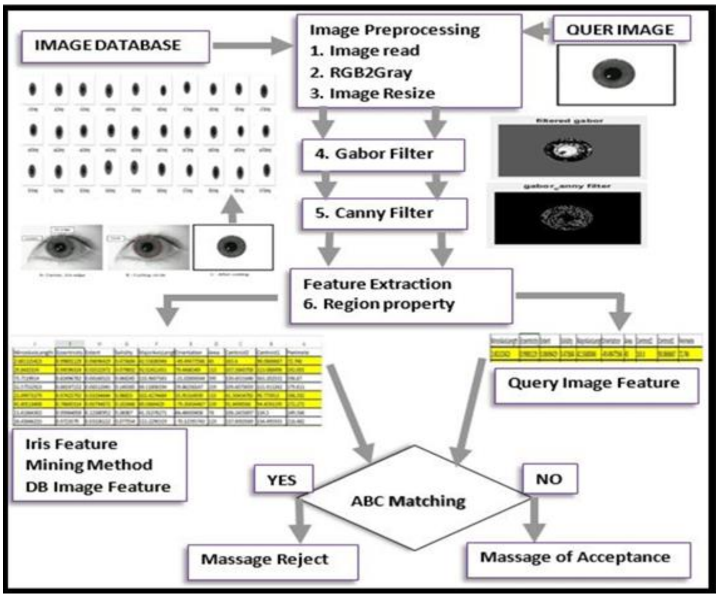


Figure 8. The proposed work procedure

5.4. The recognition techniques

The characteristics of each person’s right and left iris were calculated and recovered from 120 photos, and their values were stored in an Excel file. For the duration of the system’s operation, the query image was submitted to the system and its characteristics were mined online. ABC is utilized to compare query features to all database attributes in order to estimate the fitness task that is concerned with the least dissimilarity (min) between inquiry and dataset attributes.

As shown in Figure 8, the entry is the ABC parameters in our recommended approach application. Unless a rejection note was issued, the granted image was presented in the databank along with its identification number. The picture iris properties are stored in an Excel file (new iris) and passed to the ABC function. This job presents the best solution and the most direct approach from 120 compared addresses corresponding to the footprints numbered one through ten.

Proposed program-code

```
Involvement: ABC’s features
Production: correct iris image and its identification
gbo1 = edge (Gabor, ‘canny’, 0.2, 2);
s= regionprops (gbo1,’all’);
Per(h,1)=cat(1, s(1).Perimeter);Per(h,2)=cat(1, s(1).Centroid(1));
Per(h,3)=cat(1, s(1).Centroid(2));Per(h,4)=cat(1, s(1).Area);
Per(h,5)= cat(1,s(1).Orientation);Per(h,6)=cat(1, s(1).MajorAxisLength(1));
Per(h,7)=cat(1, s(1).Solidity);Per(h,8)=cat(1, s(1).Extent);
Per(h,9)=cat(1, s(1).Eccentricity(1));Per(h,10)=cat(1,s(1).MinorAxisLength);
    Label = Per (h, :);
[r1, addDB]=ADDDBUSER (label);
Xlswrite (‘newiris.xlsx’, addDB);
If isempty (label) ~=1
[Data, header]=xlsread (newiris.xlsx’); % ABC Function
    [bestInd, gbst] =ABCCG (Data, label);
    If (gbst<0.4) seq1=floor (bestInd-1/11) +1;
    Else seq1=0; End
    End if sq1~=0 mssg “acceptance message”
    Else mssg”rejected message”;
    End
```

ABC algorithm is a swarm-based meta-heuristic for numerical problem optimization. Honeybees’ clever foraging activity served as inspiration. In ABC, a colony of artificial forager bees (agents) looks for plentiful artificial food sources (good solutions for a given problem). The problem at hand is first turned into a problem of obtaining the optimum parameter vector that minimizes an objective function before using ABC. The artificial bees then select a population of starting solution vectors at random and improve them periodically using tactics such as migrating toward better solutions via a neighbor search mechanism while discarding poor solutions [6], [7].

6. EXPERIMENTAL RESULTS DISCUSSION

As talk over earlier, the system was created in a way to find the edges of the left and right iris, with five images per side using the Gabor filter. Ten features were extracted from the left and the right iris and saved in an Excel template. The total data was 110 features for 11 people.

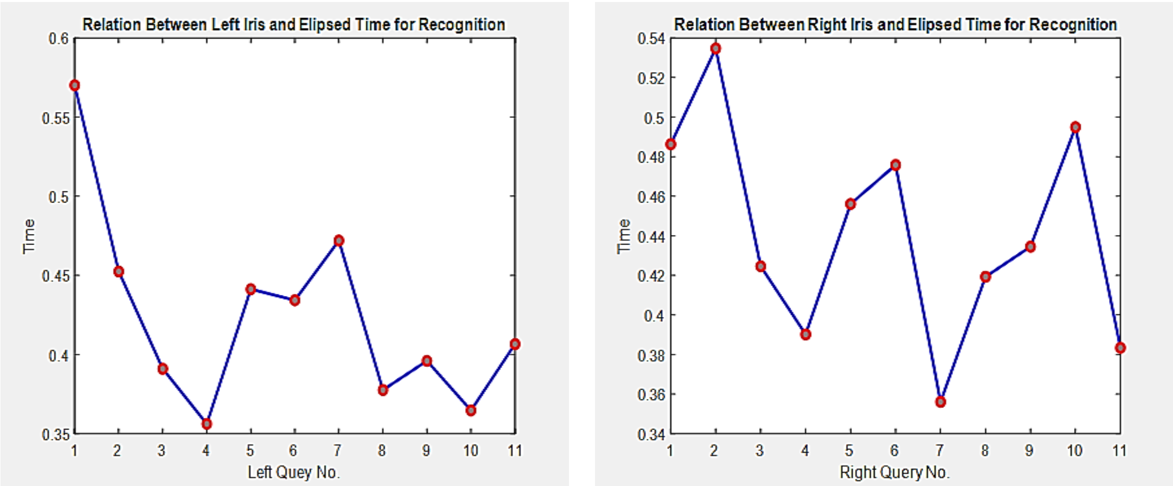
The process of differentiation to find the desired person by comparing the iris of his eye with the data of the irises stored in the database. We used the ABC algorithm to speed up the solution, in addition to recording the ideal results. After extracting the biometric characteristics of the iris image, it was compared with the biometric characteristics extracted offline previously and stored in the database as shown in Figure 7. The system output was arranged as a table but described as figures shown in follows. Each column contains the left and right iris characteristics. The first column contains the query image number, the second shows the cluster number, and the third describes the image frequency within the database. The fourth column described the elapsed time, indeed the best (shortest) path to the solution. The third column shows the fault recognition of the fifth and ninth query for the left and the seventh for the right. The fault recognition was labeled with red color.

The second method in the process of differentiation is not to enter the biometric data of the iris (right, left) in the database. The test was applied on 22 images and the data previously stored 88 characteristics. The prevalence (accuracy) was evaluated based on (1) [29] for the left iris is 90.90% and 95.45% for the right iris.

$$Prevalence = (correctly\ predicted\ observation/total\ observations) \times 100 \quad (1)$$
$$Prevalence\ for\ left\ iris = 20/22x100 = 90.90\%$$
$$Prevalence\ for\ right\ iris = 21/22x100 = 95.45\%$$

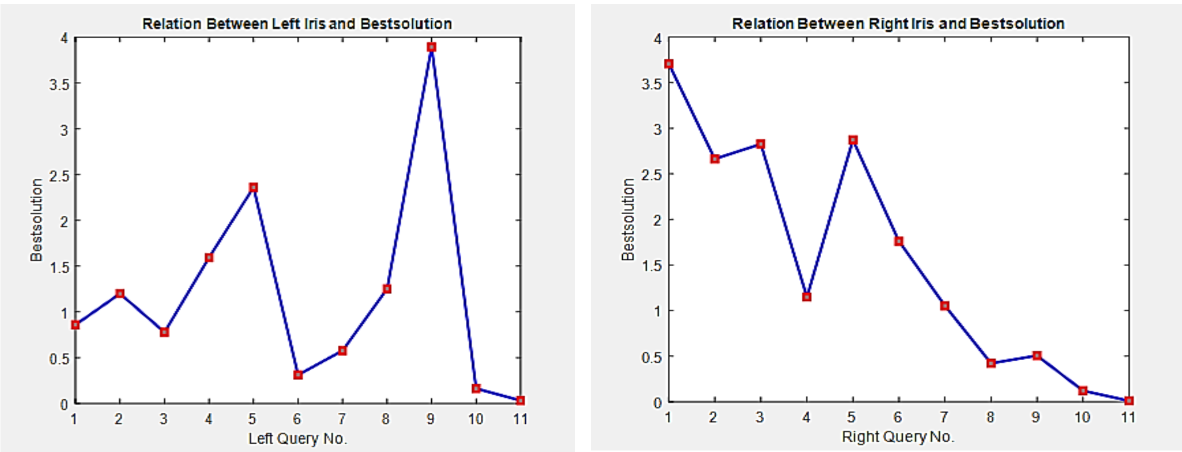
Figures 9(a) and 9(b) show the relation between the left and the right iris with the time consumed for recognition were (0.3562) second for left iris and (0.0324) second for the right iris. Figures 10(a) and 10(b) show the relation between the left and the right iris with the shortest path to solution or the best solution for the left iris is equal (0.0324) corresponds to image number eleven while for the right iris equals (0.0103) denotes image eleven. Figure 11 describes the system outcome. Figure 11(a) shows the relation between bee colony best path and system time consumed for the left iris, while Figure 11(b) shows the same relation but for the right iris.

In compared to prior works using the various methodologies listed in Table 1, our results are reasonable. The effectiveness of this system depends on presentation and obligations, which include strictness, accuracy, authentication power, and the likelihood of usage to distinguish a large number of people. Moreover, lessen the system's solution honesty and complication in terms of time.



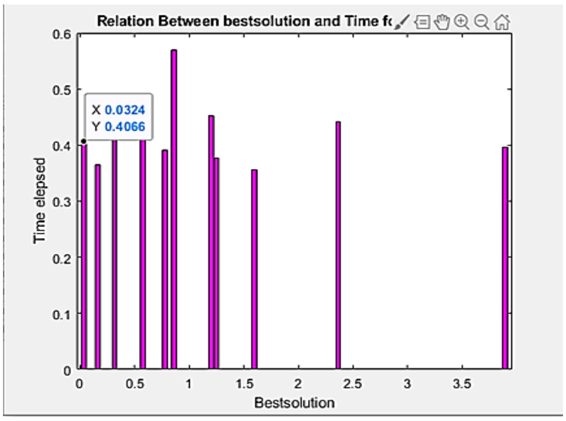
(a) (b)

Figure 9. Results for the relation between system time consumed and the iris recognition process in (a) for left iris, and (b) for right iris

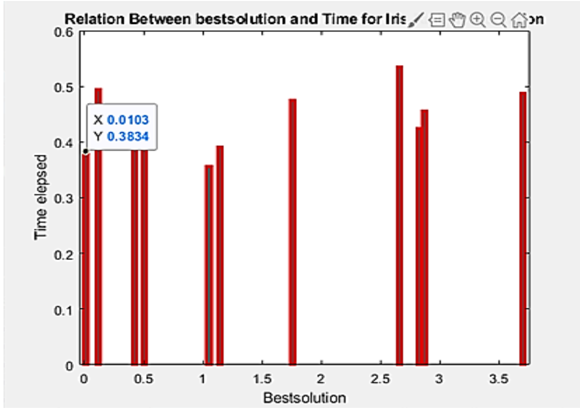


(a) (b)

Figure 10. Results for the relation between bee colony best path and the iris recognition process in (a) for left iris, and (b) for right iris



(a)



(b)

Figure 11. Results for the relation between bee colony best path and system time consumed in (a) for left iris, and (b) for right

7. CONCLUSION AND FUTURE OUTLOOK

We reviewed solutions for fixing biometric identification applications briefly, emphasizing the necessity of intelligent techniques. The focus is on resolving and developing challenges that have arisen with biometric authentication, such as overriding time and authentication errors. Our summaries are as follows: we propose a method of hybridization that combines image processing with ABC. The results indicate that integrating is preferable to splitting up. For feature selection, we estimate the ABC approach for attribute matching using a met heuristic search technique. In comparison to previous studies in the biometric authentication sector, the experimental software of image processing and ABC methods hybridization exhibits robustness in an ideal outcome. The discrimination ratios are all equal to one hundred percent. The results suggest that using the ABC approach reduces the number of fired functions in the statistics set, which improves accuracy. Furthermore, from a temporal perspective, it minimizes the processing complexity. We will investigate the following concept in the near future: we will use the ABC-k approach, which provides supervised learning via clustering and regression, to try to speed and progress our method. Controlling parameters to obtain the best answer is a difficult process. A good algorithm should be able to reorganize, tweak, and adapt on its own.

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