

An optimized Retina Recognition Technique Based on PSO Inspired Algorithm

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Abstract

Retina Recognition techniques capture and analyze the vascular patterns on the thin nerve on the backs of an eyeball which process light getting in the pupil. Retinal patterns are extremely distinguishing traits; it cannot be gotten or stolen since there are no two persons have similar patterns of retinal, as well as the features extracted from the retinal image are the most stable and reliable than other biometric features. Therefore, the retina is selected as a robust source in the proposed recognition techniques. In this paper, an optimized technique of retina recognition based on an inspired algorithm is proposed for the authentication purpose in which particle swarm optimization (PSO) inspired algorithm is utilized for extracting features from retinal images. The obtained results from this work declared that the PSO provides an optimized performance with 100% accuracy and 3.5 seconds time-consuming.

Keywords: *An Optimized Recognition Technique, Retina Patterns, PSO Inspired Algorithm.*

Introduction

The biometric recognition techniques for the purpose of authentication like face detection, retina, iris, and fingerprint scanning are more securely than other traditional authentication techniques like password, PIN, and etc. In these traditional authentication techniques, the users should remember the password unique combination. Furthermore, the password should be confidential since this is the main objective of the system to be secure. Additionally, the password and PIN-based techniques can be attacked by brute force dictionary or by guessing ¹. Unlike traditional techniques, Biometric authentication techniques give better usability and reliability since it need not be remembered. Generally, there are two types of biometric recognition techniques; physiological like retina scanning, and behavioral like voice, and Handwritten Signature ².

Retina authentication is the most promising biometric technique comparing to other biometric techniques. The retina remains unchangeable during the lifespan of the person. Furthermore, retina exists inside the eye that makes it cannot be forged owing to its internal protective position which prevents it from deformation ³. The blood vessels patterns in the retina have given a high level of security and uniqueness (even in identical twins) which is the foundation of retina recognition ⁴. In addition to

the blood vessels, the regions of the fovea and optical disk are two essential properties in the retina, figure 1 illustrates the retina regions.

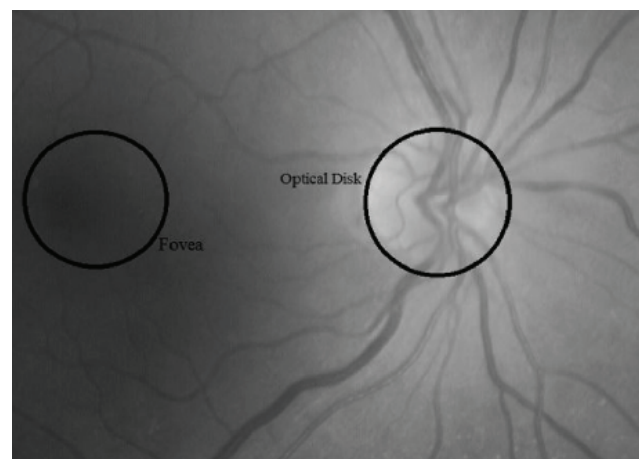


Figure 1: The image of retina regions.

The inspired algorithms have become an essential research field owing to intent to simulate nature for solving the complex real-life issues, especially in optimization ⁵. Particle swarm optimization (PSO) inspired algorithm has been utilized in this work for extracting optimal features from human retina image.

This paper is structured as follows; the related works are presented in the next section; Third section explains

the PSO inspired algorithm; Fourth Section presents the proposed optimized retina recognition technique; Fifth section explains the experimental results; The last section, presents the conclusions of this work, furthermore, it provides suggestions for future work. This technique provides an average identification rate of 92.50. Mahrokh Khakzar and Hossein Pourghassem ⁴, presented a retina authentication technique based on extracting the features from the spatial graph of the vessel pattern. The retina images were enhanced utilizing the preprocessing phase, and the retina vessel skeleton of this enhanced image was extracted utilizing the Isotropic undecimated wavelet transform algorithm. For generating a thin vessel and obtaining the bifurcations and vessel ends, the morphological operator has been utilized. The spatial graph adjacency matrix combining with the vessel patterns were generated automatically utilizing the relational mathematical graph (RMG) algorithm. After that, considerable features depending on the theory of spectral graph were used for developing the matching process. The obtained results showed that the proposed technique achieves a 97.14% accuracy rate. A. Saha et al. ⁹, presented a multi-modal individual authentication technique based on iris and retina recognition for providing a high degree of distinction, universality, and circumvention. To minimize the main issue related to feature level fusion, the Principal Component Analysis was used. The rate of recognition for this technique was 96.74% and 94.56% for iris and retina recognition respectively.

1. PSO Inspired Algorithm

PSO is presented by Kennedy and Elberhart ¹⁰, inspired by social behavior of bird flocking or fish schooling. The PSO algorithm searches the space of a fitness function by adjusting the individual agent's trajectories, named particles, as the piecewise paths created via positional vectors in a quasi-stochastic way. The swarming particle movement includes two main components: stochastic and deterministic components. Every particle is attracted toward the location of the current global best and its own best location in history, but, at the same time it has a tendency for moving randomly. If a particle gets a position which is best than any formerly found positions, updates that position as the new current best for particle ¹¹.

In every iteration, a loop in the program is determined to every agent that another agent was its nearest neighbor, then assigned that agent's X and Y velocities to the agent in focus. As it is predictable, it has been viewed that solely utilize such a strategy will quickly settle down the swarm on a unanimous, unchanging direction. For avoiding this, a stochastic variable named craziness was presented. In every iteration, several changes were added to randomly chosen X and Y velocities. This presented enough variation into the system to give the simulation a "life-like" appearance. The previous explanation illustrates the most needed features of PSO that refers to its seemingly unalterable nondeterministic nature: incorporation of randomness.

The conception was to allow the birds (agents) to get an unknown favorable location in the search space (food source) via capitalizing on one another's knowledge. Every agent could remember its best position and knowing the best position of the whole swarm. The extreme of the mathematical function to be optimized can be thought of as the food source. After a sequence of minor alterations and elimination of the ancillary variables, the rules of updating to calculate the next location of a particle were presented as Equation 1 and Equation 2.

$$v_{id} = w * v_{id} + c_1 * r_1 * (p_{id} - x_{id}) + c_2 * r_2 * (p_{gd} - x_{id}) \quad (1)$$

$$x_{id} = x_{id} + v_{id} \quad (2)$$

Where x_{id} and v_{id} are the i^{th} particle's position and velocity vector, respectively; r_1 and r_2 are two random numbers; p_{id} and p_{gd} represent the best positions experienced so far by the i^{th} particle and the whole swarm, respectively; and c_1 and c_2 are two parameters indicating the particle's confidence in itself (cognition) and in the swarm (social behavior), respectively. These two parameters are among the most important parameters of the algorithm in that they control the balance between exploration and exploration tendencies. A relatively high value of c_1 will encourage the particles to move toward their local best experiences, while higher values of c_2 will result in faster convergence to the global best position ¹². PSO inspired algorithm is shown in Algorithm 1.

```

Algorithm 1: PSO Inspired Algorithm
for p=1 to numbers of birds do
if M(ki) > M(si) then /* M ( ) evaluate strong*/
for f=1 to number x do
sid = Qid /*Qid is the strong find so far*/
ends
m=p /*arbitrary*/
for p=index neighborhood do
if M(pj) > M(pg) then
e=p
ends
ends
for p= 1 to num of dim do
refresh depend to Eq. (1)
refresh place depends to Eq. (2)
ends
ends
when stop
ends
    
```

2. The Proposed Retina Recognition Technique

This section describes the design and implementation of the proposed optimized retina authentication technique using PSO inspired algorithm. This proposed technique includes training and testing phases, every phase includes three processes; Firstly, the preprocessing; Secondly, the feature extraction; And thirdly, the matching. These phases include the same preprocessing and feature extraction processes but differ in the matching process. The general block diagram of the proposed technique for the training and testing sections are shown in figure 2 and figure 3.

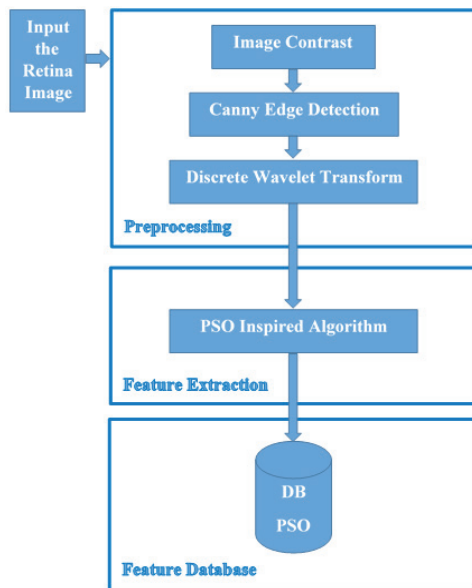


Figure 2: Block diagram of the proposed technique training section.

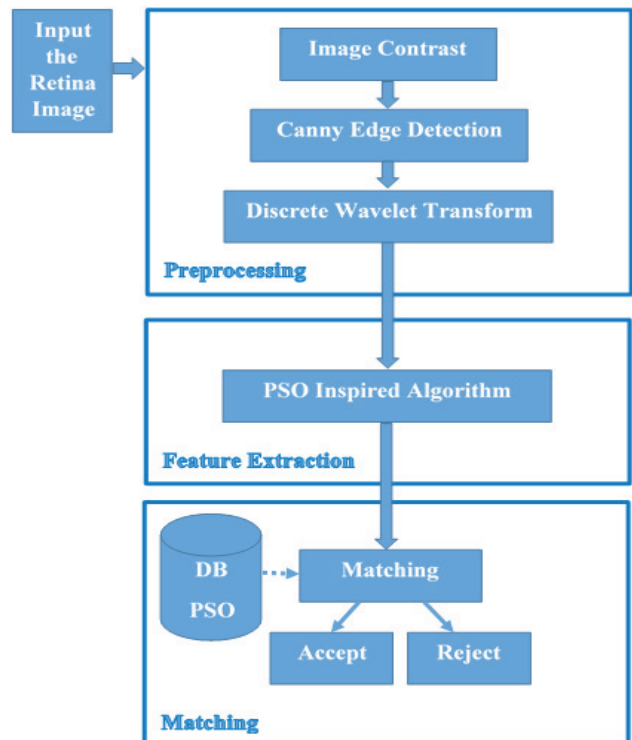


Figure 3: Block diagram of the proposed technique testing section.

2.1 Preprocessing

This process includes several steps as follows;

Step1: Apply the contrast image enhancement process to the input retina image (as in Algorithm 2) for enhancing the retina image and obtaining additional specifics to the vessel edges. This step improves the objects perceptibility via enhancing the brightness difference between the object and their background.

```

Algorithm 2: Contrast Image Enhancement Algorithm

Input: Mean_Img ///Image after local mean compensation process
Mask_Img///Mask image, H, W /// The image Height & Width, respectively
Output: Con_Img ///Resulting image [0,1]
    
```

Cont... Algorithm 2: Contrast Image Enhancement Algorithm

```

Step1: ///Calculate mean and standard deviation values (STD)
Set Mean ← 0: STD ← 0: N ← 0 /// Initial values
If Mask_i Then Set Mean ← Mean + Mean_Img(x,y)
Set N ← N+1
End If
End For
Set Mean ← Mean/N
If Mask_1 Then
Set STD ←STD+Power((Mean_Img(x,y)- Mean),2)
End For
Set STD ← Sqrt((1/ N) *STD)
Step2: ///Calculate minimum (Min) and maximum values (Max)
Set alpha1←1.1///Predefined value used for computing minimum value
Set alpha2← 0.3///Predefined value used for computing maximum value
Set Min ← Mean - (alpha1×STD)
If Min<0 Then Set Min ← 0
Set Max ← Mean +(alpha2×STD)
If Max>255 Then
Set Max ← 255
Set Gam ← 6.5///Predefined value
Step3: ///Calculate new values from old values
For all y,x Do
If Mask = 1 Then
If Mean_Img(x,y) ← Min Then Set Con
Else If n← Max Then Set
Else Set × ((Mean_Img(x,y) - Min)/(Max - Min))
End If
Else Set Con_Img(x,y) ← 0
End For
For all y,x Do {where m} //Normalization values
If Con >0 Then Set Con_Img(x,y) ←1
End For
Step4: End
    
```

Step2: Apply the canny filter for detecting and recognizing the vessel edges.

Step3: Transform the obtained image from the canny filter using the discrete wavelet transform to get four sub-images (LL, HL, LH, HH). LL is selected to be used in the next process.

2.2 Feature Extraction Process

In this process, a set of distinguished information is extracted from the resulted preprocessed image. This information refers to the required features vector for distinguishing among persons. In the proposed

recognition technique, the PSO inspired algorithm is utilized for extracting the features from the retina image.

Feature in the PSO inspired algorithm was extracted according to the movement of bird’s direction. The implemented PSO algorithm for features extraction is explained in the following steps:

Step1: Choose the number of iterations.

Step2: Choose the number of particles.

Step3: Detect the center of the retina to detect the distance of the particle from the center.

Step4: Release the particle to the retina image to find the best position.

Step5: Find the best position by using guide particle.

Step6: Make the guide is the best particle.

Step7: Repeat the process with another iteration.

Step8: Collect all the features with (position (i,j), and the distance of the features from the center of the retina.

Step9: Save the features vector in the PSO database.

Note that for each iteration in the PSO algorithm, there is a new best position will be found by the particle, so, the guide particle will modify itself depending on the new best position. Then the feature will be saved in the PSO database.

2.3 Matching Process

The matching is an essential process for any biometric recognition technique which is utilized for finding the similarity degree between two patterns of the retina, where the distance between the features vector of the template stored in the Database and the tested image is computed. The measure utilized in this proposed technique is the Sum of Squared Difference (SSD).

3. The Experimental Results and Tests

The proposed retina recognition technique was implemented using VB.NET programming language. For testing the performance of the optimized technique, the Digital Retinal Images for Optic Nerve Segmentation Database (DIRONS-DB) has been utilized. This dataset includes 110 images, 100 for training and 10 for testing, each image of size 565×584 of (24 bit/pixel). Figure 4

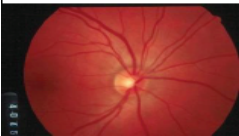
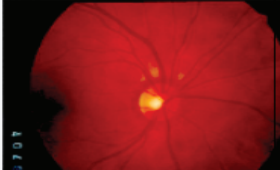
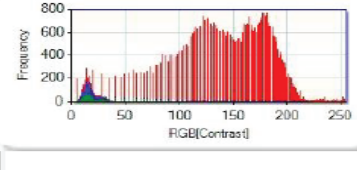
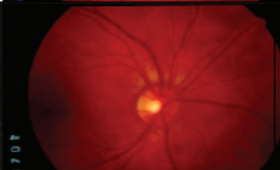
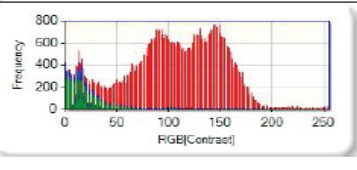
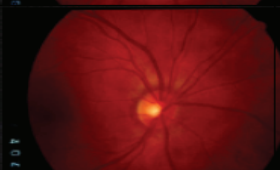
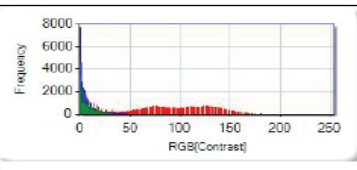
shows some of the retina image samples belong to the used dataset.



Figure 4: Some samples of retina images from DIRONS-DB.

The preprocessing gives a certain result that deal with enhancement of the retina image to find the best clear resolution of the blood vessels and optic disc that prepare for feature extraction. In order to detect the blood vessels with high clarity, the contrast filtering must be done. Table 1 shows the effect of contrast filter on retina images.

Table 1: The effect of Alpha Contrast on some retina images.

Image	α	Contrast Filter	Histogram
	0.5		
	1		
	1.5		

The parameter of the main contrast is (α Alpha contrast), therefore, table 1 shows the obtained results at different values of (α Alpha contrast parameter) with contrast image and histogram image for each value. The best contrast is attained when choosing the parameter ($\alpha=0.5$).

The parameters of canny filter process (α , kernel, high threshold, and low threshold). These parameters have been preprocessed on the retina image in order to find a clear Gaussian image. Table 2 shows the obtained results at different values of (α , kernel, high threshold, and low threshold). Table 3 shows the effect of parameters (α , kernel, high threshold, and low threshold) on the contrasted image by using histogram for Gaussian image.

Table 2: The Effect of Parameters (α , kernel, high threshold, and low threshold) on the Contrasted Image to find Gaussian image.

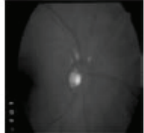
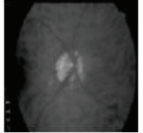
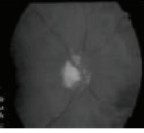
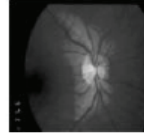
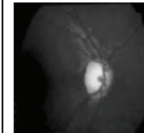
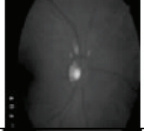
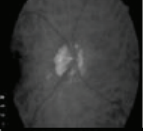
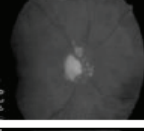
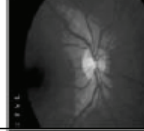
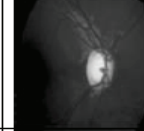

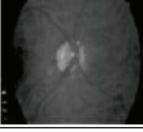
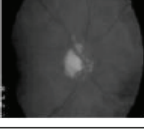
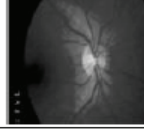
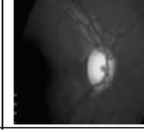
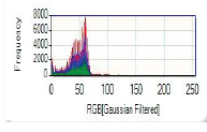
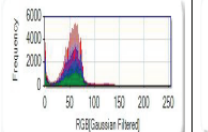
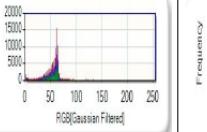
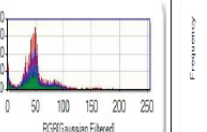

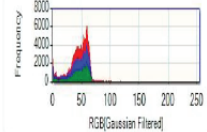
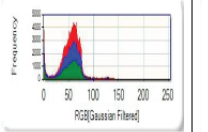
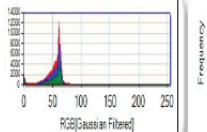
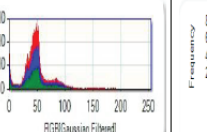

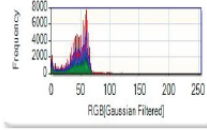
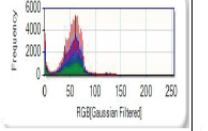
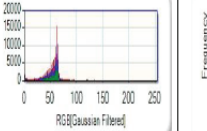
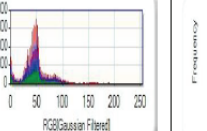
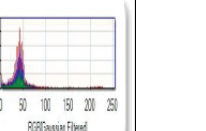
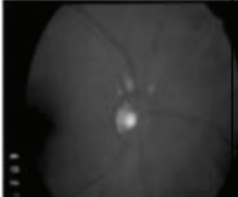
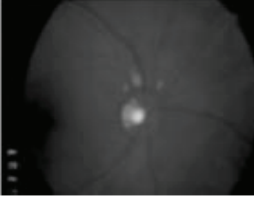
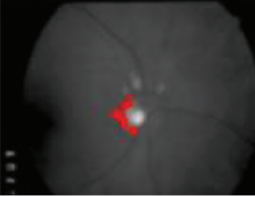
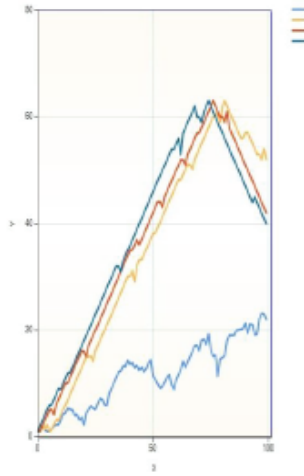




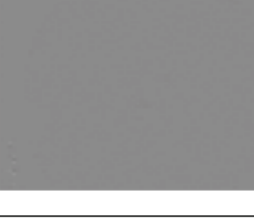
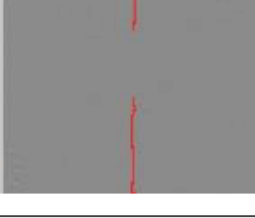
Gaussian Filter									
No.	Parameters				Image Samples				
	Alpha	K	h	L	Imag1	Imag2	Imag3	Imag4	Image5
1	0.5	3	9	4	Gaussian	Gaussian	Gaussian	Gaussian	Gaussian
									
2	0.8	3	10	3					
3	0.5	5	12	2					

Table 3: The Effect of Parameters (α , kernel, high threshold, and low threshold) by using Histogram for Gaussian.

Gaussian Histogram									
No.	Parameter				Image sample				
	Sigma	k	h	L	Imag1	Imag2	Imag3	Imag4	Image5
1	0.5	3	9	4	Gaussian histogram	Gaussian histogram	Gaussian histogram	Gaussian histogram	Gaussian histogram
									
2	0.8	3	10	3					
3	0.5	5	12	2					

The extracted features of the PSO inspired algorithm are shown in table 4, as red dots. However, table 4 shows the results of the histogram for the extracted features depend on the best parameter in the technique (contrast $\alpha=0.5$, $H=9$, $L=4$, canny $\alpha=0.5$).

Table 4: Results of Features Extraction for PSO Inspired Algorithms, and the Histogram.

Gaussian Image	Wavelet Transform	PSO	Histogram
			
			
			
			

The vector set of features that extracted from the retina image will have 100 iterations so that all sections of wavelet possess (LL, LH, HL, and HH) will extract 100 feature with its distance from the center as shown in table 5.

Table 5: the features vector of PSO algorithm.

LL					LH				HL				HH			
no.	I	J	Val	Dis	i	j	val	Dis	I	J	val	Dis	I	J	Val	Dis
2	64	63	63	1	63	62	128	1	63	62	128	1	63	64	128	1
3	64	62	61	1.414	63	64	126	1	64	62	128	1.414	63	65	128	2
4	64	61	61	2.236	63	65	126	2	64	61	128	2.236	63	66	126	3
5	64	64	68	1.414	63	66	126	3	62	62	128	1.414	63	67	126	4
6	63	64	62	1	63	67	126	4	62	61	128	2.236	63	68	128	5
7	63	62	62	1	63	68	124	5	62	63	127	1	64	69	127	6.083
8	62	62	62	1.414	64	68	123	5.099	62	64	127	1.414	64	70	128	7.071
9	63	61	62	2	64	67	128	4.123	62	65	126	2.236	64	71	128	8.062
10	65	62	61	2.236	64	69	123	6.083	62	66	123	3.162	64	72	126	9.055
11	64	65	76	2.236	64	70	127	7.071	63	66	123	3	63	72	128	9
12	64	66	86	3.162	64	71	127	8.062	63	67	125	4	63	73	128	10
13	64	67	90	4.123	64	72	126	9.055	63	68	128	5	63	74	128	11
14	65	67	98	4.472	64	73	126	10.050	63	69	128	6	63	75	128	12
15	65	68	98	5.385	65	73	125	10.198	63	70	126	7	62	75	128	12.042
16	64	68	91	5.099	65	74	125	11.180	63	71	127	8	62	76	127	13.038
17	63	68	89	5	65	75	125	12.166	63	72	127	9	62	77	127	14.036
18	63	67	75	4	65	76	129	13.153	63	73	127	10	62	78	128	15.033
19	62	67	71	4.123	65	77	129	14.142	63	74	126	11	62	79	128	16.031
20	62	66	64	3.162	65	78	134	15.133	63	75	126	12	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	64	4	128	59.008
-	-	-	-	-	-	-	-	-	-	-	-	-	64	5	128	58.009
80	60	74	93	11.402	65	2	125	61.033	65	124	127	61.033	64	6	127	57.009
81	59	77	64	14.560	65	3	125	60.033	65	122	127	59.034	64	7	127	56.009
82	58	77	61	14.866	64	3	126	60.008	65	125	127	62.032	64	8	128	55.009
83	57	77	60	15.232	64	4	128	59.008	65	126	127	63.032	64	9	128	54.009
84	62	81	103	18.028	64	2	126	61.008	65	1	128	62.032	64	10	128	53.009
85	62	82	98	19.026	64	5	128	58.009	65	2	127	61.033	64	11	128	52.010
86	63	82	92	19	64	6	127	57.009	65	3	127	60.033	64	12	128	51.010
87	64	82	85	19.026	64	7	127	56.009	65	4	128	59.034	64	13	128	50.01
88	64	83	76	20.025	64	8	127	55.009	65	5	128	58.034	64	14	128	49.010
89	65	83	74	20.100	64	9	127	54.009	65	6	127	57.035	64	15	128	48.010
90	66	83	72	20.224	64	10	127	53.009	65	7	127	56.036	64	16	128	47.011
91	67	83	68	20.396	64	11	127	52.010	66	7	128	56.080	64	17	128	46.011
92	67	84	68	21.378	64	12	127	51.010	66	6	127	57.079	64	18	127	45.011
93	67	82	74	19.416	64	13	127	50.010	67	6	127	57.140	63	18	127	45
94	66	84	68	21.213	64	14	128	49.010	67	7	128	56.143	63	19	127	44
95	65	84	72	21.095	64	15	128	48.010	66	8	128	55.082	63	20	128	43
96	65	82	83	19.105	64	16	128	47.011	66	9	128	54.083	63	21	128	42
97	66	82	80	19.235	64	17	128	46.011	66	10	128	53.085	63	22	127	41
98	66	85	66	22.204	64	18	128	45.011	65	10	128	53.038	63	23	127	40
99	66	86	65	23.195	64	19	128	44.011	65	11	128	52.038	64	4	128	59.008
100	65	86	69	23.087	64	20	128	43.012	65	9	128	54.037	64	5	128	58.009
101	65	85	70	22.091	64	21	128	42.012	66	11	128	52.086	64	6	127	57.009
													64	7	127	56.009
													64	8	128	55.009

The extracted features for PSO inspired algorithm are translated into two values: mean, and standard deviation (STD). Then, these two values are being to deal with instead of a large number of features, as shown in the table 6. Table 7 shows the time consuming in different No. iteration for the PSO algorithm.

Table 6: Mean and STD values for the extracted features to three test images.

No.	Mean	STD
1	30.2509387042607	19.9936404193108
2	31.2063811829574	18.2332000661934
3	33.8934603909775	7.9964399484224

Table 7: Time consume in different No. iteration for the PSO algorithm.

No. iteration	Time min	Time max	Time mean
100	00:00:2.4	00:00:4.6	00:00:3.5
200	00:00:4.6	00:00:6.6	00:00:5.5
300	00:00:7.4	00:00:9.4	00:00:8.4

For the purpose of evaluating the performance of the optimized authentication technique, the verification accuracy was analyzed using the false rejection rate (FRR) and false acceptance rate (FAR). Table 8 shows the FAR and FRR and Accuracy for the PSO algorithm depending on the parameter α , so, the best sigma is (0.5).

Table 8: FAR, FRR and the accuracy versus different threshold values.

Parameter α	FAR	FRR	Accuracy
0.5	0.033	0.0	100
1	0.067	0.053	99.94
1.5	0.080	0.067	99.93
2	0.083	0.093	99.91

Conclusion

Among different existing biometric techniques, retina recognition is a very secure and stable since the vascular patterns are unique and it is hard to modify or copying it. In this paper, an effective optimized technique is proposed for individual recognition depending on retinal blood vessels. The tests results conducted on the Drions dataset indicated that the performance of the proposed technique is very high with 100% recognition rate.

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Conflict of Interest: None to declare.

Ethical Clearance: All experimental protocols were approved under the Ababil high school-AI-resaffa education and all experiments were carried out in accordance with approved guidelines.

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