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Palm print recognition based on harmony search algorithm

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ABSTRACT

Due to its stabilized and distinctive properties, the palmprint is considered a physiological biometric. Recently, palm print recognition has become one of the foremost desired identification methods. This manuscript presents a new recognition palm print scheme based on a harmony search algorithm by computing the Gaussian distribution. The first step in this scheme is preprocessing, which comprises the segmentation, according to the characteristics of the geometric shape of palmprint, the region of interest (ROI) of palmprint was cut off. After the processing of the ROI image is taken as input related to the harmony search algorithm for extracting the features of the palmprint images through using many parameters for the harmony search algorithm, Finally, Gaussian distribution has been used for computing distance between features for region palm print images, in order to recognize the palm print images for persons by training and testing a set of images, The scheme which has been proposed using palmprint databases, was provided by College of Engineering Pune (COEP), the Hong Kong Polytechnic University (HKPU), Experimental results have shown the effectiveness of the suggested recognition system for palm print with regards to the rate of recognition that reached approximately 92.60%.

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1. INTRODUCTION

Recently, there has been a growing interest in biometric solutions for palmprint recognition and security systems. Where the biometric method is considered comparatively new but promising. Palm prints (palm's interior superficies) carrying many distinguishing similarity characteristics with regard to authoritative and precise individual recognition. Such as fingerprints, palm prints have persistent distinguishing characteristics, comprehensive patterns of ridges and valleys, minutiae, in addition to high-resolution pores (more than >1000 dpi) images. Regardless of fingerprint characteristics, palm prints furthermore carry another specific distinguishing characteristic, comprising wrinkles and principal lines [1]-[5].

Recently, there were numerous methods in terms of biometric recognition using harmony search algorithm has been studied. Such as Tamrakar and Khanna [6] who have presented a technique for palmprint recognition by combining various texture extraction methods with high precision. In this paper, the study has been conducted using two-level wavelet transform that decomposed into various frequency-time sub-bands and selection of approximate image is called as approximate image-region of interest (AI-ROI), that contain information related to vital palm lines, while the competitive indicator was utilized as palmprint's characteristics, where 6 Gabor filters with many directions convolving with the palmprint image for the extraction of the direction information from the images. In addition, PCA was used for selecting the un-correlated competitive indicator features, for the purpose of decreasing the dimensions related to a feature vector (FV), and to system properties on eigenspace, while the resemblance regarding 2 palmprints was metrical via Euclidean distance metrics. Also, the algorithm was studied using the database Hong Kong PolyU palmprint. A lot of AI-ROI with different wavelet filter families were investigated with competitive indicator and PCA, via using a palm database of Hong Kong Polytechnic University (PolyU) AIROI on daubechies-7 (DB-7) wavelet filter attaining genuine acceptance rate (GAR) of 99.67% and equal error rate (EER) of 0.0152%. A study conducted by Parekh and Karar [7] proposed a system to recognize palmprints for the individual's biometric matching. Complicated Zernike moments (ZM) have been structured with the use of many complicated polynomials forming the whole orthogonal base series and determining unit disc. In addition, the palmprint images were considered as presentations onto the base series leading to a series of complicated signals. Furthermore, the complication value extent was evaluated, while the scalar value was derived from it via estimating the mean of the vector element (VE). The classification might be done via discounting test specimens regarding the average value of the training series. A data-set includes 80 images discordant to four classes, the gained precision was similar to the results that have been provided in the literature.

Selvy *et al.* [8] suggested a system that implements palm print recognition scheme utilizing gray level co-occurrence matrix (GLCM) for extracting the features and utilizing support vector machine (SVM) method for classification. The Suggested approach not only utilizes the direction features, but also comprises second-order features such as contrast, correlation, energy and homogeneity for recognition and comparison. It demonstrated robustness to rotation and noise. It has an effective and simple balancing system to progress the accuracy of the direction feature of the palm print. Experience which has been conducted on the dataset showed that the suggested approach gives the optimal results compared to the existing direction methods. The suggested approach reinforces precision and also it decreases the mean error rate in classification. Khokher *et al*. [9] suggested an algorithm for biometric palm recognition of a person, utilizing the texture and geometrical properties. The material dimensions related to the human's palm include information that has the ability to authenticate the person's identity. The algorithm was proposed to extract finger length (FL) as a geometrical characteristic as well as the essential lines as texture characteristics. Emulation results showed that the false accept rate (FAR) was 25%, half total error rate (HTER) was 21.87%, false reject rate (FRR) was 18.75%, GAR was 81.25%, and accuracy was 78.12% in geometrical features while precision was 92.3% with regard to texture feature. Ahmadi and Soleimani [10] designed a novel approach to increase the speed of the palmprint identification speed. Utilizing generalized Hough transform (GHT) and convolutional neural networks (CNNs), a novel procedure has been suggested for registration, alignment of the palmprint images thoroughly. This procedure detects the identical displacement and rotation (in jointly x and y orientations) among the palmprint and an indicated image. The suggested procedure is preferrable for automatically distinguishing between the right and the left palmprints which assists to speed up the identification procedure. Moreover, designing a framework which is related to CNN in the registration phase is providing a segmented palmprint image that was considered as a pre-processing phase for the minutia extraction. Also, the proposed procedure of recording followed by the minutia cylinder code (MCC) identification algorithm which was evaluated on THUPALMLAB database, also the results indicated that the algorithm suggested in this research can do 166 palmprint identifications in each second with an EER=0:04%.

Lavanya and Inbarani [11] proposed a palmprint recognition system that relies on a probabilistic rough set (PRST). The proposed system consists of three phases: The first phase is preprocessing, which is performed by applying the region of interest (ROI) detection for palmprint image. The second phase is feature extraction using principal component analysis (PCA) for palmprint image. Finally, a PRST for palmprint identification. The probabilistic rough set model (PRST) is subedited through utilizing a conditional probability, which leads to robustness and flexibility while applying classification. The proposed PRST system for palmprint identification generated increased precision when compared with a standard method such as Euclidean distance. various databases are utilized for this experiment and the results of the suggested PRST gives the best result at FRR and FAR as compared to other techniques. Gong *et al.* [12] indicated that the palmprint recognition system has been conducted on the basis of CNN structure Alexnet. First, the ROI area of the palmprint was cut out. After processing ROI area is taken as the input of the convolutional neural network (CNN). Next, the parametric rectified linear unit (PRLU) activation function is utilized to train the network to choose the better super parameters and learning rate. Lastly, the palmprint was identified and classified. The system has utilized the database called PolyU Multi-Spectral and PolyU 2D+3D Palmprint, and the system has achieved a recognition rate equal to 99.99%. Ata *et al.* [13] provided palmprint recognition with the use of 7 different algorithms of machine learning (ML). Initially, extracting ROI. Secondly, they have applied several image enhancement techniques like edge detection (ED) and a set of morphological operations to make the ROI image more appropriate for the Hough transformation (HT). In addition, they have extracted all the possible principle lines on ROI images via applying HT. This work extracted the major prominent morphological features which are related to lines, length, and slope, also the presented work used a 7-moment invariant algorithm with adequate hues of interest. Finally, following using whole hybrid feature vectors, this study used many algorithms of ML for the recognition of palmprints. Recognition precision has been tested through calculating accuracy, dice, specificity, precision, sensitivity, correlation coefficients, training time, and jaccard coefficients. Seven various supervised algorithms of ML were used. The effect of creating the proposed hybrid feature vectors (FV) between Hough transform and Invariant moment were tested and used. Also, the experimental results showed that a back-propagation with feed-forward neural network (NN) reached recognition accuracy of approximately 99.99% between each tested ML method.

The presented study suggested a harmony search algorithm (HAS) for recognition of color palm print based on computing Gaussian distribution. This algorithm increases security and efficiency for the proposed system. The remaining sections of this study will be proved is being as. The suggested algorithm and scheme are provided in section 2. The suggested scheme will be thoroughly indicated in section 3. Section 4 will provide the results and discussion. The scheme analysis will be presented in section 5. Lastly, section 6 will provide the conclusions.

2. HARMONY SEARCH ALGORITHM

Nowadays, due to several advantages for harmony search (HS) such as the fact that it is simple to apply, converges fast to the optimum resolution and obtain a good adequate resolution in a sensible quantity of computational time. Also, harmony search (HS) has received a considerable deal of interest by computer scientists who have found an important relation between music and the process, to look for optimal resolution. It is a novel type a meta-heuristic algorithm which attempts to mimic musicians' procedure to finding harmony during playing music [14], [15]. There are many potential techniques that are utilized for generating musical improvisations, by musicians: i) operating original segment, ii) operating in a method which is identical to the original segment, and iii) generating a segment by random notes [15]-[18]. Figure 1 in this research paper concentrates on colorings a map by means of HSA [15], [19].

Figure 1. The adjacency of regions

According to the facts that have been stated above, this study suggested equations which will assist to search for solutions of the optimal workable ranges, HM only has been utilized, which has given the best solutions due to the fact that HM involves better resolutions acquired through previous generations. The suggested expressions are specified together exponential and linear [20], [21]. Linear in (1) and (2):

$$\mathrm{PAR}(gn) = PAR_{\min} + \frac{(\mathrm{PAR}_{\max} - \mathrm{PAR}_{\min})}{NI} \times (NI - gn) \tag{1}$$

$$\mathrm{HMCR}(gn) = \mathrm{HMCR}_{\min} + \frac{(\mathrm{HMCR}_{\max} - \mathrm{HMCR}_{\min})}{NI} \times gn \tag{2}$$

Exponential in (3) and (4):

$$\mathrm{PAR}(gn) = \mathrm{PAR}_{\max} \cdot e^{\left(\frac{\ln(\mathrm{PAR}_{\min}/\mathrm{PAR}_{\max})}{NI} \times gn\right)} \tag{3}$$

$$\mathrm{HMCR}(gn) = \mathrm{HMCR}_{\min} \cdot e\left(-\frac{\ln(\mathrm{HMCR}_{\min}/\mathrm{HMCR}_{\max})}{NI} \times gn\right) \quad (4)$$

3. PROPOSED SCHEME

The proposed scheme comprises three main phases (training, testing, and recognition), the training phases consist of two phases: the first phases is pre-processing, that consist of many sub-phases (segmentation, region of interest (ROI), and edge detector). The second phase is extraction of the features for color palm print images through utilizing harmony search algorithm (HSA) and storing features for all classes for all samples of the color palm print images for a person in training database features (TRDBF). The testing phase also participates in the essential phases of the scheme (preprocessing phase and feature extraction phase). Finally, the recognition phase computes distance among all classes for all samples of the color palm print images through utilizing Gaussian distribution. Figure 2 shows the framework of the proposed scheme.

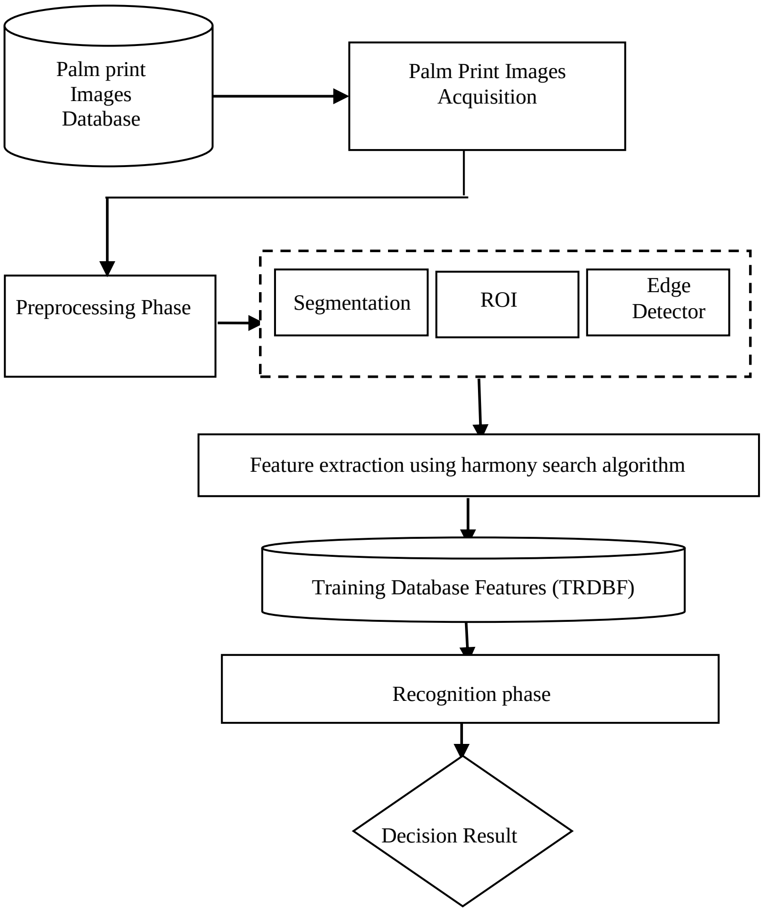


Figure 2. General framework of the suggested scheme

4. RESULTS AND DISCUSSION

The presented section is providing the results related to the recognition of the palm print system as well as a comprehensive discussion.

4.1. Load images phase

This phase of the suggested scheme is conducted to load an image into the suggested recognition scheme and then it is presented for the following stages. The proposed scheme could read an image with every stretching (image format), it utilized a BMP image format, also it used the color images for the palm print. Figure 3 explain the array.

No Pixels	Row/ Column (x,y)	Z (Preprocessing on x and y)							
		Value			HSV			SkinHSV	Contrast
		Red	Green	Blue	H	S	V		
1	1,1								
	1,2								
	…								
2	2,1								
	2,2								
	…								

Figure 3. Example of 3D array contents

4.2. Preprocessing phase

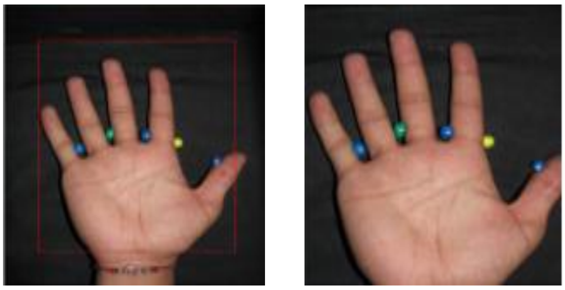
In this phase, the proposed scheme includes three sub-phases is:

a. Segmentation Sub-phase: In this sub-phase, there are many steps is being as:

1) Rotate image: rotates the palm print image 90 degrees. Figure 4 illustrates palmprint image rotation.
2) Image cropping: cropping of the palm print. Where, unimportant parts were removed by placing a rectangle around the hand. Figure 5 illustrates cropping of palmprint image.
3) Determination of the checkpoint: used to determine the distance among the fingers by utilizing the checkpoint. Figure 6 illustrates determine checkpoint of palmprint image.
4) Convert to binary: In this step is used to convert the determined check point to binary for the purpose of determining the rectangle object for fingers. Figure 7 shows conversion to the binary. Table 1 illustrates some of the values for x and y for conversion to the binary.
5) Rectangle object: in this step, a rectangle is placed around the determined checkpoint for the purpose of determining the important part of the palmprint image. Figure 8 shows the rectangle of the important object. Table 2 shows the values of the distance between the checkpoints.

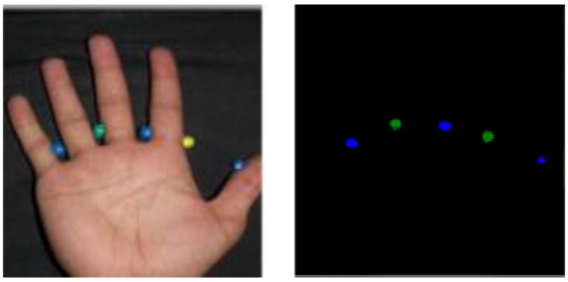
(a) (b)

Figure 4. Palmprint image rotation; (a) original image, (b) rotate image 90



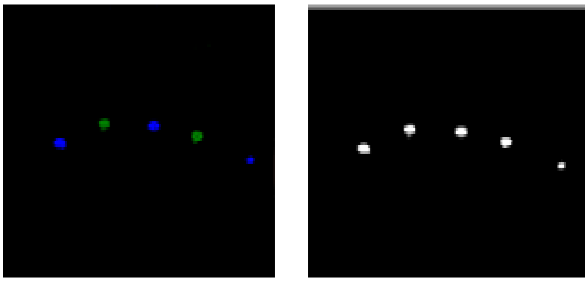
(a) (b)

Figure 5. Cropping of palmprint image; (a) rectangle image, (b) image cropping



(a) (b)

Figure 6. determine checkpoint of palmprint image; (a) image cropping, (b) determine check point

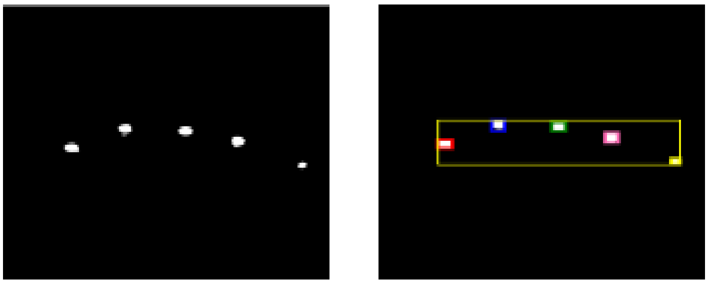


(a) (b)

Figure 7. conversion to the binary; (a) determine check point, (b) convert to binary

Table 1. Illustrate some of the value for X, Y

	Pixel ocation (x)	Pixel location (y)
1	168	608
2	168	609
3	168	610
4	168	611
5	168	612
6	168	613
7	168	614
8	168	606
9	169	607
10	169	608



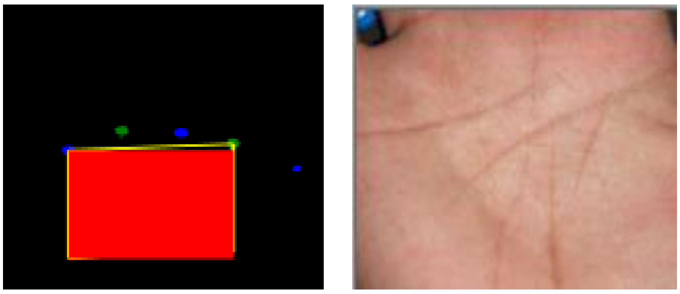
(a) (b)

Figure 8. the rectangle of the important object; (a) convert to binary, (b) rectangle object

Table 2. Illustrate distance between checkpoint

	Des	Min(x)	Min(y)	Max(x)	Max(y)	MidP(x)	MidP(y)
1	Box	168	511	831	703		
2	Blue	168	595	208	633	188	614
3	Green	316	511	352	558	334	534
4	Blue	479	521	518	559	498	540
5	Yellow	626	565	662	609	644	587
6	Blue	807	677	831	702	819	690

b. Region of interest (ROI) Sub-phase: In this sub-phase, there are many steps, summarized below:
1) ROI: in these steps, the important region for palmprint image is determined through placing the rectangle and removing the unimportant region. Figure 9 shows the important region for the palmprint image.



(a) (b)

Figure 9. the important region for the palmprint image; (a) rectangle of the important region, (b) the important region

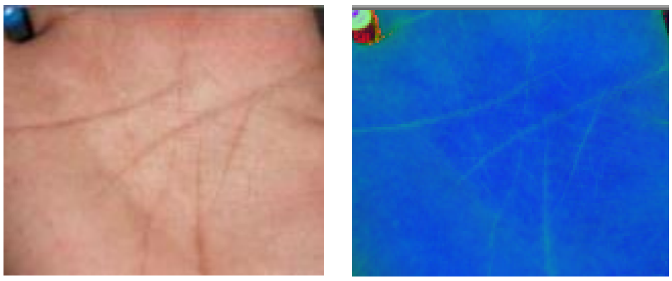
2) Skin area (conversion to the HSV): in these steps, color palm print image has been converted to the HSV. Figure 10 shows the conversion to the HSV. The (5), (6), and (7) apply the transmutation rules to get the (H, S, V) values from RGB color space [22], [23].

$$H=\begin{cases}(\frac{G-B}{Max-Min})/\ 6 & if\ R=Max\\ (2+\frac{B-R}{Max-Min})/\ 6 & if\ G=Max\\ (4+\frac{B-R}{Max-Min})/\ 6 & if\ B=Max\end{cases} \quad (5)$$

$$S=(\frac{Max-Min}{Max}) \quad (6)$$

$$V= \text{Max} \quad (7)$$

3) Clip Region: in these steps, the region of the palm print is cut off. Figure 11 show clip palm print.



(a) (b)

Figure 10. the conversion to the HSV; (a) region important, (b) onvert HSV

Figure 11. Clip palm print

c. Edge detector (ED) Sub-phase: In this sub-phase, kirsch filter edge detection has been utilized. Every pixel of the images utilizes these eight masks for making convolution, every masking has a large response to particular edge orientation, the maximum value related to every 8 orientations was series to output value regarding such point. In addition, the masking concatenation number of greater responses comprises the code of edge orientation [24], [25]. Figure 12 apply kirsch filter for palmprint image.

Figure 12. Show Kirsch filter

4.3. Feature extraction phrase (FEP)

In this phase, only the important information is an extractor of the palm print image after the preprocessing phase. The extractor information shows the required features to differentiate amongst the persons. The suggested scheme utilizes the HAS and storing features for all classes for all samples of the color palm print images for a person in training database features (TRDBF). There are parameters for HAS. Tables 3 and 4 are showing the results for a sample of palm print images [26], [27].

Harmony Search Algorithm
Input: palm print image.
Output: features palm print image.
Step1: read palm print image after kirsch filter.
Step2: Locate objective function f(x), x = (x1, x2… xd) T.
Step3: Locate harmony memory agreeing rate (raccept).
Step4: Locate pitch regulating rate (rpa) and another parameter.
Step5: t < max number of cycles).

```
    while (i < number of variables)
       if (rand<raccept) choose a value for var i
       if (rand<rpa) adjust the value
     end if
       else
choose a random value
    end if
end while
accept the new memory if better
end while
step6: pick the better solution
End
```

Also, in this phase generated regions for features through utilizing the harmony search. Table 5 shows the region for palmprint image features. This Table 6 shows the result features for the class of palmprint images. Table 6 shows the features for the region of the palm print image. After that, the distance is computed among the region features, Table 7 shows the distance amongst the features for the palmprint images.

Table 3. Parameters for HAS

Parameters (HAS)	Value
Number of variables (NVAR)	128
Number of ineguality constraints (NG)	6
Number of eguality constraints (EG)	0
Maximum number of iterations (Maxitr)	100
Harmony memory size (HMS)	128
Harmony Consideration Rate 0<HMCR<1	0.9
Minimum pitch adjusting rate (PARmin)	0.1
Maximum pitch adjusting rate (PARmax)	0.99
Minimum bandwidth (bwmin)	0.0001
Maximum bandwidth (bwmax)	1.0

Table 4. Range of variables (PVB)

No	PVB (1.1)	PVB (1.2)
1	0.0156823992729187	0.4311443567276
2	0.401982605457306	0.275295495986938
3	0.985373914241791	0.802587389945984
4	0.696100771427155	0.417599201202393
5	0.734488189220428	0.277168393135071
6	0.356586277484894	0.433457136154175
7	0.944971024990082	0.121549963951111
8	0.645951330661774	0.347832679748535
9	0.104432284832001	0.185402512550354
10	0.0776847004890442	0.432759523391724

Table 5. Region for palmprint image

# Region	Min x	Min y	Max x	Max y	Count Point	Cumulative	Prop
1	0	0	114	114	32	1968.61393535137	61.5191854797304
2	114	0	228	114	4	573.901878356933	143.475469589233
3	0	114	114	228	4	524.313468933105	131.078367233276
4	114	114	228	228	0	0	0
5	228		228	228	0	0	0
6	0	228	288	456	0	0	0
7	228	288	456	456	0	0	0

Table 6. Show features for palmprint image

	Region (3)	Region (7)	Region (7)	Region (7)	Region (25)	Region (25)	Region (25)
Class1	58.1889391022345	134.900260925293	142.195129394531	177.496475219727	0	0	0
	79.1983976308693	119.079803466797	136.850280761719	0	0	0	0
	82.9219209243502	140.011088053386	124.940908432007	0	0	0	0
	90.5385870859027	118.827606201172	138.595091247558	0	0	0	0
	65.6999092522791	138.616140365601	138.87163289388	171.898223876953	0	0	0
	83.467136846648	130.195753479004	0	0	0	0	0
	61.5191854797304	143.475469589233	131.078367233276	0	0	0	0
	88.0046582221984	138.601744431715	126.804272969564	166.662434895833	0	0	0
	61.5191854797304	143.475469589233	131.078367233276	0	0	0	0
	61.5191854797304	143.475469589233	131.078367233276	0	0	0	0

Table 7. Show distance

No.	Distance
0	121.655250549316
1	46.0108680725098
2	71.0070419311523
3	68.0073547363281
4	90.3382568359375
5	91.0054931640625
6	78.0064086914063
7	45.0111083984375
8	67.0074615478516
9	38.0131568908691
10	49.0306015014648

4.4. Recognition phase

In this phase, Gaussian distribution has been utilized for computing the distance amongst the features for the recognition of the palm print owner and make decision of the class to which it belongs. Table 8 shows the distance which is utilized by Gaussian distribution.

Table 8. Compute Gaussian distribution

#Region		Class
Region (3)	Man	73.2577105503673
	Variance	160.732157314637
Region (7)	Man	135.065880569067
	Variance	89.4119000790942
Region (7)	Man	120.149241739909
	Variance	1813.01670162773
Region (7)	Man	51.6057133992513
	Variance	6910.98541538104
Region (25)	Man	0
	Variance	0
Region (25)	Man	0
	Variance	0
Region (25)	Man	73.2577105503673
	Variance	160.732157314637

5. RESULT ANALYSIS

The evaluation results of palmprint recognition scheme have been evaluated through the use of two measurements that were known as false alarm rate (FAR) and recognition rate (RR). The (8) and (9) have been utilized for calculating these measures [28]-[31]. Table 9 shows the best-attained recognition rate.

$$\mathrm{FAR} = \frac{\text{Number of false recognition attempts}}{\text{Total number of attempts}} * 100 \tag{8}$$

$$\mathrm{RR} = \frac{\text{Number of correct attempts}}{\text{Total number of attempts}} * 100 \tag{9}$$

In the 3-fold cross validation the dataset is divided to 3 equal parts, where 2 of them are utilized for the training and the 3rd is utilized for testing. By comparison to another study that has used the same dataset

COEP palm print, but used a different approach for the recognition using texture and geometrical characteristics. It should be noted that, in this study, the best results were achieved by using harmony search algorithm (HS) in a sensible computational time quantity, some parameters like the robustness, tuning, scalability, and adaptability have been observed in critical characteristics. Moreover, in this study, the method that is performed through placing the rectangle and removing the unimportant region is the best method of finding the region of interest (ROI).

Table 9. The attained recognition rate for the training and testing for all classes

	Recognition Rate Evaluation Criteria	
	FAR	RR
Training	0.0	100%
Testing	13.3%	92.60%

Table 10 shows the dataset, preprocessing, features, methods and recognition rate (RR) that have been used in the previous works. In terms of comparison, the performance analysis is noticed of the recognition palm print more effective because of using a set of the algorithms for preprocessing (segmentation, a region of interest (ROI image) and edge detector (Kirsch filter)) and also because of several advantages for harmony search algorithm (HS) the optimum resolution and a good adequate resolution has been obtained in a sensible quantity of the computational time, a few parameters such as robustness, tuning, scalability, and adaptability are observed in the critical characteristics. In addition, this work uses the dataset of the COEP, and has given good result with the harmony search algorithm (HS).

Table 10. Shows a comparison of previous schemes

Ref.	Dataset	Preprocessing and Features	Recognition rate (RR) %	Method used
[6]	Hong Kong PolyU	Gabor Filter+2L wavelet transform + PCA	99.67%	Euclidean distance
[7]	PolyU	segmented ROI	91.25%	Zernike moments
[8]	COEP Palm Print	Median Filter Matrix + Normalization + Enhancement	78.12% for geometrical features, 92.30% in texture feature	essential lines as texture feature (TF) and finger length (FL) as geometrical feature
[9]	Hand Image	Binary hand + Extracted Palm print + print Image in Gray scale Intensity + Gray level co-occurrence matrix (GLCM)	99.95%	Support vector machine (SVM)
[10]	THUPALMLAB	generalized Hough transform (GHT), convolutional neural network (CNN)	very high, EER = 0:04%	minutia-cylinder code (MCC)
[11]	CASIA, IIT Delhi Touchless, COEP	Region of interest (ROI detection) + PCA	ED(CASIA) 6.41 ED (IIT Delhi Touchless) 7.14 ED (COEP) 4.25 PRST(CASIA) 3.52 PRST (IIT Delhi Touchless) 3.83 PRST (COEP) 2.38	Probabilistic Rough set (PRST), Euclidean distance
[12]	PolyU Multi-Spectral, PolyU 2D+3D Palmprint	Region of interest (ROI area), convolutional neural network (CNN)	99.99%	PRLU activation Function
[13]	CASIA	Invariant Moments, ROI, Palmprint principal lines data extraction and Hough transform	99.99%	machine learning technicality

6. CONCLUSION

In the presented study, a new palm print recognition on the basis of the harmony search algorithm has been proposed. In this work, efficient performance has been obtained because of the use of the dataset college of engineering pune (COEP), in addition, many steps have been used for the preprocessing and palm print extraction, which include segmentation, a region of interest (ROI Image), and edge detector. After that, an important algorithm has been used, which is the harmony search for the extraction of the features for the palmprint images, after that, the distance between features has been computed for the region of the palm print images through the use of the Gaussian distribution for the purpose of recognizing the palm print images. Where harmony search in previous papers has been used with the hand but in this research paper it has been used with the palm print images, for this reason, good results have been obtained in the recognition of the palm print. According to these results, the proposed scheme offers highly efficient recognition scheme for the palm prints. It should be noticed, that the limitation of the proposed scheme is the fact that the harmony search algorithm (HSA) is discrete, single-objective, and multi-objective problems. Also, further enhancement could be done, which includes combining the HSA with other algorithms, which is strongly satisfying and the identification can be used for the palmprint recognition.

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