Palm print recognition based on harmony search algorithm

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Article Info

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%.

Keywords:
Edge detector
Harmony search algorithm
Palm print
Region of interest
Segmentation

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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

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extraction of the direction information from the images. In addition, PCA was used for selecting the uncorrelated 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 preferable 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 as 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):

\[ \text{PAR}(g_n) = \text{PAR}_{\text{min}} + \left( \frac{\text{PAR}_{\text{max}} - \text{PAR}_{\text{min}}}{N_I} \right) \times (N_I - g_n) \]  

\[ \text{HMCR}(g_n) = \text{HMCR}_{\text{min}} + \left( \frac{\text{HMCR}_{\text{max}} - \text{HMCR}_{\text{min}}}{N_I} \right) \times g_n \]  

Exponential in (3) and (4):

\[ \text{PAR}(g_n) = \text{PAR}_{\text{max}} \times e^{\left( \frac{N_I - g_n}{\text{PAR}_{\text{max}}/N_I} \right)} \]
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.

\[
HMCR(gn) = HMCR_{min} \cdot e\left(-\frac{\text{ln}[\frac{HMCR_{min}}{HMCR_{max}}]}{g}\right)
\]  

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.
4.2. Preprocessing phase

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

a. Segmentation Sub-phase: In this sub-phase, there are many steps including:

1) Rotate image: rotates the palm print image 90 degrees. Figure 4 illustrates palm print 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 palm print image.
3) Determination of the checkpoint: used to determine the distance among the fingers by utilizing the checkpoint. Figure 6 illustrates determining checkpoint of palm print image.
4) Convert to binary: In this step, it 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 palm print image. Figure 8 shows the rectangle of the important object. Table 2 shows the values of the distance between the checkpoints.

| No Pixels | Row/Column \((x,y)\) | \(Z\) (Preprocessing on x and y) | Value | HSV | SkinHS \(V\) | Contrast |
|----------|-----------------|---------------------------------|-------|-----|-------------|----------|
| 1        | 1.1             |                                 | Red   | Green | Blue | H | S | V |             |
|          | 1.2             |                                 |       |       |      |   |   |   |             |
|          | ...             |                                 |       |       |      |   |   |   |             |
| 2        | 2.1             |                                 |       |       |      |   |   |   |             |
|          | 2.2             |                                 |       |       |      |   |   |   |             |
|          | ...             |                                 |       |       |      |   |   |   |             |

Figure 3. Example of 3D array contents

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

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

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

![Figure 7. conversion to the binary; (a) determine check point, (b) convert to binary](image)
Table 1. Illustrate some of the value for X, Y pixel location (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 |

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) |
|------|--------|--------|--------|--------|---------|---------|
| Box  | 168    | 511    | 831    | 703    |         |         |
| Blue | 168    | 595    | 208    | 633    | 188     | 614     |
| Green| 316    | 511    | 352    | 558    | 334     | 534     |
| Blue | 479    | 521    | 518    | 459    | 498     | 540     |
| Yellow| 626    | 565    | 662    | 609    | 644     | 587     |
| 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.

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

![Figure 11. Clip palm print](image)

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].

![Figure 12. Show Kirsch filter](image)
Harmony Search Algorithm
Input: palm print image.
Output: features palm print image.
Step 1: Locate objective function $f(x)$, $x = (x_1, x_2… x_d)$ T.
Step 2: Locate objective function $f(x)$, $x = (x_1, x_2… x_d)$ T.
Step 3: Locate harmony memory agreeing rate ($r_{accept}$).
Step 4: Locate pitch regulating rate ($r_{pa}$) and another parameter.
Step 5: $t < \text{max number of cycles}$.
\[
\text{while (i < number of variables)} \\
\quad \text{if (rand < } r_{accept} \text{) choose a value for var i} \\
\quad \text{if (rand < } r_{pa} \text{) adjust the value} \\
\quad \text{end if} \\
\quad \text{else} \\
\quad \text{choose a random value} \\
\quad \text{end if} \\
\text{end while} \\
\text{accept the new memory if better} \\
\text{end while} \\
\text{step 6: pick the better solution} \\
\text{End}
\]

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 inequality constraints (NG) | 6 |
| Number of equality 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 | 0.0156823927923987 | 0.4311445667276 |
| 2 | 0.4019826054576036 | 0.27529549586938 |
| 3 | 0.985373914241791 | 0.80258738945984 |
| 4 | 0.6961007714271555 | 0.41759963951111 |
| 5 | 0.734488189220428 | 0.277168393135071 |
| 6 | 0.35658277484894 | 0.433457136154175 |
| 7 | 0.944971024990082 | 0.121549963951111 |
| 8 | 0.645951330661774 | 0.347832679748535 |
| 9 | 0.104432284832001 | 0.185402512550354 |
| 10 | 0.0776847004890442 | 0.43275952391724 |

| 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           | 573.901873856933 | 143.4375496598233 |
| 3       | 0     | 114   | 114   | 228   | 4           | 524.3134683933105 | 131.078367233276 |
| 4       | 114   | 114   | 228   | 228   | 0           | 0           | 0   |
| 5       | 228   | 228   | 0     | 0     | 0           | 0           | 0   |
| 6       | 0     | 228   | 288   | 456   | 0           | 0           | 0   |
| 7       | 228   | 288   | 456   | 456   | 0           | 0           | 0   |
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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 | Mean | Variance |
|--------|-------|------|----------|
| Region (3) | Man | 73.2577105503673 | 160.732157314637 |
| Region (7) | Man | 135.065880569067 | 89.4119006790942 |
| Region (7) | Man | 120.149241739909 | 1813.01670162773 |
| Region (7) | Man | 51.605713992513 | 6910.98541538104 |
| Region (25) | Man | 0 | 0 |
| Region (25) | Man | 0 | 0 |
| Region (25) | Man | 73.2577105503673 | 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.

\[
\text{FAR} = \frac{\text{Number of false recognition attempts}}{\text{Total number of attempts}} \times 100
\]  

(8)

\[
\text{RR} = \frac{\text{Number of correct attempts}}{\text{Total number of attempts}} \times 100
\]  

(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

| 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            | Median Filter Matrix + Normalization + Enhancement                                            | 78.12% for geometrical features, 92.30% in texture feature | Zernike moments                      |
| [8]  | COEP Palm Print  | Binary hand + Extracted Palm print + print Image in Gray scale Intensity + Gray level co-occurrence matrix (GLCM) | 99.95%                  | Support vector machine (SVM)         |
| [9]  | Hand Image       | generalized Hough transform (GHT), convolutional neural network (CNN)                        | very high, EER = 0.04%  | minutia-cylinder code (MCC)          |
| [10] | THUPALMLAB       | Region of interest (ROI detection) + PCA                                                    | ED(CASIA) 6.41          | Probabilistic Rough set (PRST), Euclidean distance |
| [11] | CASIA, IIT Delhi | Region of interest (ROI area), convolutional neural network (CNN)                           | ED (IIT Delhi Touchless) 7.14 |                                            |
| [12] | THUPALMLAB       | Region of interest (ROI area), convolutional neural network (CNN)                           | ED (COEP) 4.25          |                                            |
| [13] | POLYU Spectral, PolyU                           | Invariant Moments, ROI, Palmprint principal lines data extraction and Hough transform       | 99.99%                  | PRLU activation Function              |

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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