

## **A Suggested System for Palmprint Recognition Using Curvelet Transform and Co-Occurrence Matrix**

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### **Abstract**

The main purpose of this paper is to create a palmprint recognition system (PPRS) that uses the curvelet transform and co-occurrence matrix to recognize a hand's palmprint. The suggested system is composed of several stages: in the first stage, the region of interest (ROI) was taken from a palmprint image, then in the second stage, the curvelet transform was applied to the (ROI) to get a blurred version of the image, and finally, unsharp masking process and sobel filtering were performed for edge detection. The third stage involves feature extraction using a co-occurrence matrix to obtain 16 features, while the fourth stage inclusion is the training and testing of the suggested approach. The algorithm ACO (ant colony optimization) has been adopted to evaluate the shortest path to the goal. CASIA PalmprintV dataset of 100 people (60 male and 40 female) was used in proposed work to rate the performance of the proposed system. ARR and EER metrics have been adopted to assess the performance of the proposed system. The experimental results showed a very high recognition rate (ARR) that reaches 100% for the right hand of a male and the left hand of a female. The overall accuracy rate (ARR) reaches 98.5% and EER equals 0.015.

**Keywords:** region of interest, unsharp masking, features extraction, ACO

### **نظام مقترح لتميز بصمة اليد باستخدام تحويل الكيرفلت ومصفوفة التواجد المشترك**

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### **الخلاصة**

الهدف الرئيسي للبحث هو تطوير نظام للتعرف على بصمة اليد (PPRS) باستخدام تحويل الكيرفلت ومصفوفة التواجد المشترك. النظام المقترح يتألف من عدة مراحل: في المرحلة الاولى تم استخلاص منطقة الاهتمام (ROI) من صورة بصمة اليد ، ثم في المرحلة الثانية ، تم تطبيق تحويل الكيرفلت على منطقة الاهتمام الناتجة للحصول على نسخة غير واضحة (بدون حواف) من صورة بصمة اليد ، ثم تم إجراء عملية حجب المناطق غير الحادة unsharp masking بالاعتماد على نسخة الصورة بدون حواف والناتجة

من تطبيق تحويل الكيرفلات ومن ثم تطبيق فلتر سوبل للكشف عن الحواف. تتضمن المرحلة الثالثة استخراج السمات باستخدام مصفوفة التواجد المشترك للحصول على 16 سمة ، بينما تتضمن المرحلة الرابعة التدريب واختبار النظام المقترح. تم استخدام خوارزمية تحسين مستعمرة النمل (ACO) لتقييم أقصر طريق للهدف. لتقييم أداء النظام المقترح استخدمت مجموعة بيانات CASIA PalmprintV المكونة من 100 شخص (60 ذكر و 40 أنثى) في هذه الورقة البحثية ، وتم اعتماد مقاييس ARR و EER لتقييم أداء النظام المقترح . أظهرت النتيجة التجريبية معدل تمييز مرتفع جدًا (ARR) يصل إلى 100% لليد اليمنى للذكور واليد اليسرى للإناث ، ومعدل الدقة الإجمالي ARR يصل إلى 98.5% و EER يصل إلى 0.015.

**الكلمات المفتاحية:** منطقة الاهتمام , حجب المناطق غير الحادة , استخلاص السمات , أمثلية مستعمرة النمل

## **1.Introduction:**

Biometrics is the study of determining an individual's identity using a vector of information obtained from a behavioral trait or a specific physical property. The way a person interacts and moves, including their manner of speaking, hand gestures, and signature, are all behavioral characteristics. Fingerprints, iris, eyes, face, veins, hand, shape, palmprint, and many other physical human features are included in the physiological type. The recognition process utilizing biometric technologies is aided by evaluating these qualities [1]. Biometric authentication systems are being increasingly used in a variety of applications, including physical access, security, and monitoring. For protection against theft and hackers, password-based security methods are extensively utilized. However, remembering long passwords is not a good idea all of the time. Individuals are recognized in biometrics using behavioral and physiological traits. It provides more security than security solutions that rely on passwords. Biometrics can be used to identify a person's palmprint, fingerprint, hand geometry, iris, face, vocal, signature, and other characteristics[2]. In the proposed method, the palm print will be recognized based on extracting features from the palmprint image after enhancing the edges in it by applying many of image processing techniques as well as using the ACO to assess the shortest path to the specific palmprint.

## **2.Related Work:**

In 2015, Jaswal et.al, present palmprint based biometrics using a mixture of 2D-DWT and Kernel PCA. For dimensionality reduction, palm print pictures were initially deconstructed using a 2-D DWT and a frequency range was established that was independent of a variety of image resolutions. Then, using kernel PCA, nonlinear mappings were used to discover the wavelet characteristics' primary constituents. The k-nearest neighbor classifier was used to match images. The algorithm was put to the test on a recognized standard database (CASIA), and the results demonstrate that it is effective in terms of Proper Classification Accuracy, Equal Error Rate, and Computation Time[3].

Also in 2015, Jaswal et.al. conducted a study providing a palm print recognition approach based on texture that uses a 2D Gabor filter for extracting texture features from the middle area of the hand and dimension reduction using subspace algorithms. The algorithm is put to the test on two norm datasets (CASIA and IIT Delhi), and the findings show that our strategy is efficient in tertiary education[4].

In 2016, Kaushik and Singh introduced a unique technique for facilitating a dynamic palm print pattern matching by hierarchically merging numerous palmprints' global and local aspects. Their palmprint matching technology works in two stages: user registration and user verification. In the initial phase of enrollment, a user obtains many palm print samples to keep as templates in the system. The samples are captured using a palm print scanner, after which they are preprocessed and feature extracted

to build templates. After that, the templates are recorded in a palm print collection. The palmprint scanner is utilized in the second and last phases to collect a new palm print sample[5].

In 2018, palmprint recognition, a subset of biometrics, was widely regarded as the most practical recognition method due to its advantages of low effort, convenience of usage, and high accuracy. The proposed method by Jyotismita Chakiis was unique in that it uses a revised two-stage ROI retrieval feature extracting method to retrieve the ROI's main lines by employing multi-resolution Frangi vessels improvement filtering, after which dividing the primary line image into similar and non-similar images using a new 2-component portion. The categorization of the palmprints image is based on the score of similarity and non-similarity. The goal of this method is to create a reliable palmprint recognition verification framework that uses textural features and has a lower complexity of computation, and then to improve the time needed for matching process and accuracy[6].

In 2019, Fei et al. offered a novel double-layer directional extracting approach for palmprint recognition. The process begins by extracting the apparent direction from a palmprint's surface layer. The implicit direction characteristics from of the energy map layer of the visible direction is then exploited further. Finally, the apparent and implicit direction features are combined using multiplying and adding techniques. The visible and implicit direction characteristics are combined as the histogram feature descriptor. The suggested technique achieves high performance on four different palmprint databases. It particularly shows promise for noisy palmprint image detection[7].

In 2021, in the field of biometrics Kadhm et al. suggest a system called Palmprint Recognition System which was precise and reliable .The system employed proposed feature selection and classification techniques that included direction, (LBP) features, C5.0, and (KNN). College of Engineering Pune (COEP) and Chinese Academy of Sciences (CASIA) palmprint image datasets were utilized in the system [8].

### **3.Unsharp Masking:**

Unsharp masking is one of sharpening techniques in spatial domain. It is a method of sharpening photos that has been used in the publishing industry for a long time. It involves deducting a blur copy of an image from the image itself. The term “unsharp masking” describes this procedure.

$$f_s(x, y) = f(x, y) - \bar{f}(x, y) \dots\dots(1)$$

Here  $f_s(x, y)$  is the sharp copy obtained via unsharp masking process and  $\bar{f}(x, y)$  signifies the blurred copy of  $f(x, y)$ .

Unsharp masking had its beginnings in darkroom photography, where it entailed attaching a blurred negative to a similar positive film, then developing the mixture to create a sharper image [9].

### **4.Co-occurrence Matrix**

Among the most popular statistical methods used to extract texture characteristics is the co-occurrence matrix and obtaining a number of traits based on mathematical equations in which the intensity distribution and relative placements of nearby pixels in an image are described [10],[11].

In this paper, four traits will be used as in the following equations:

$$\text{Energy: } \sum_t \sum_w x^2(t, w) \dots\dots(2)$$

$$\text{Entropy: } \sum_t \sum_w x(t, w) \log x(t, w) \dots\dots(3)$$

$$\text{Contrast: } \sum_t (t - w)^2 x(t, w) \dots\dots(4)$$

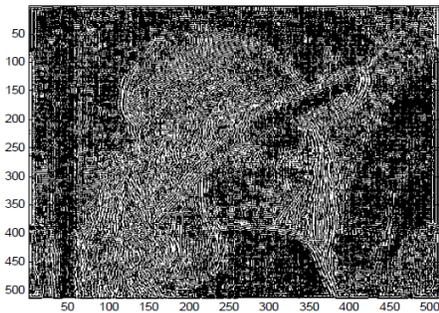
$$\text{Homogeneity: } \sum_t \sum_w \frac{x(t,w)}{1 + |t-w|} \dots\dots(5)$$

where  $x$  is an image Matrix and  $t,w$  are matrix indices

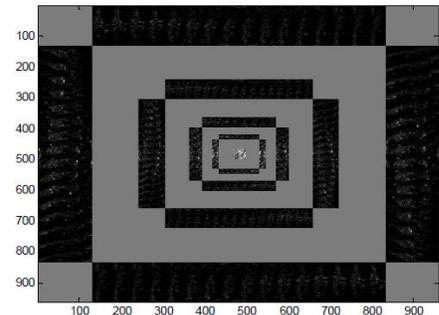
**5. Curvelet Transformation:**

The wavelet transform is a multi-scale transformation of frame elements indexed by location and scale. The curvelet transform is a hierarchical transformation similar to the wavelet transform. The curvelet pyramid, unlike the wavelet transform, has a high degree of directivity and anisotropy, and can reflect singularities with a limited number of parameters. The curvelet transform is intended to address the following significant limiting phenomena in two-dimensional images, along the jagged edges [12].

The original images which the curvelet transform run on can get the coefficients  $C\{i\}\{j\}(k1,k2)$  where  $i,j, (k1,k2)$  reflect size, direction, and the matrix coordinate of the  $j^{\text{th}}$  direction on scale level  $i$ , respectively. The innermost layer is called the first scale layer or course scale layer. It is a matrix whose elements are composed of low frequency coefficients, and occupies most of the energy of the coefficients, and contains the overview of the image; for example, a  $512 \times 512$  image using Curvelet transform can be partitioned into six scale layers; the innermost layer is called the first scale layer or course scale layer, it is a matrix whose elements are composed of low frequency coefficients, and occupies most of the energy of the the  $6^{\text{th}}$  layer, also known as the fine layer, which is a matrix whose components are made up of high frequency coefficients and represents the image's edges and information. Every layer coefficient is split into four large directions, each of which is further divided into eight, eight, sixteen, sixteen little directions., and each small direction is a matrix whose elements are composed of the medium and coefficients of high frequency as demonstrated in Figures 1 and 2. [13].



**Fig.1 Image of the top five level coefficient matrix of Lena based on Curvelet transform**



**Fig.2 Image of sixth level coefficient matrix of Lena based on Curvelet transform**

**6. Ant Colony Optimization (ACO):**

ACO is a simple a generic research strategy that employs artificial intelligence to emulate the behavior of ants when gathering food to discover novel answers to complicated issues[14]. Ants are naturally adept at determining the shortest route from a food source to their nest. Ants leave a fragrant material “pheromone” on the ground to mark the route that the rest of the colony must take between the food source and their colony. This scent fades with time, but it persists for the short distances the ant travels to and from the colony. Follow shorter roads with more pheromone; this natural phenomenon served as the foundation for the development of ACO algorithms.

The suggested ACO in [15] has been adopted in this paper, there are four steps describing these algorithm:

**I.Set up the parameters:**( $N$ )denotes the total number of ants.

- ( $x_{ij}$ )The amount of tracks leading back to the nest., where  $x_{ij} i=1,2,3 \dots n$  and  $j=1,2,3 \dots p$

- ( $T_{ij}$ ) The amount of substance with a strong scent is the sum of all pathways in the starting state as  $T_{ij}=1$  .
- Setting  $L=1$ .  $L$  is the coefficient of frequency.

**II. Calculating the probability ( $p_{ij}$ ) of each route “search path”.**

$$p_{ij} = \frac{T_{ij}}{\sum_{i,j=1}^p T_{ij}} \dots\dots(6)$$

**III. Finding the best and the worst track from the tracks that ants chosen depending on the following criteria:**

- A set of random numbers is generated ( $r_1, r_2, r_n$ ), the correct number is found within the period (0, 1).
- applying the target function  $f=f(x_{ij})$  on all routs, then calculate the worth of each track that has been chosen
- The objective function differs from one question to the next and is determined by the nature of the situation. As a result, from the tracks chosen by the user, the most beneficial track( $f_{best}$ ) representing the shortest distance is chosen AC.

$$f_{best} = \min f(x) \dots\dots(7)$$

$$f(x) = \sum_{i=1}^{d-1} [ [100] (x_{i+1} - x^2)^2 + (x_i - 1)^2 ] \dots\dots(8)$$

**IV. Stop Condition:**

If all of the ants pick the correct path, the algorithm will come to a halt; otherwise, all of the ants will go back to the colony and the process will begin again.

The pheromone substance is modified in this situation according to the following regulation and the  $L = L+1$  algorithm's second frequency begins, with  $L$  denoting the number of iterations.

$$T_{ij}^{(L)} = T_{ij}^{(old)} + \sum_k T^{(k)} \dots\dots(9)$$

Where  $T_{ij}^{(old)}$  is the proportion of pheromone substance from the last iteration, given in equation (9) :

$$T_{ij}^{(old)} = (1 - p)T_{ij}^{(L-1)} \dots\dots(10)$$

**7. Palmprint Features:**

A palmprint image has various distinguishing characteristics that are utilized for identifying individuals. Palmprint depiction benefits from extracting features like minutia, ridges, and single points, high-resolution images are required. On the other hand, a low-resolution image can be utilized to extract features such as main lines and wrinkles [16].

**8. Suggested Algorithm (PPRS):**

Figure 3 demonstrates the suggested system schematic diagram, which consists of two phases: Training phase and testing phase. Both phases convolve the following steps:

**1. Preprocessing:**

This first stage of proposed system consists of three main steps:

A) Reading image: Read the image from the database.

B)Smoothing: Apply smoothing for noise reduction.

C)Binarization: Convert the gray image into a binary image based on a threshold value. Figure 4 shows the implementation of this step.

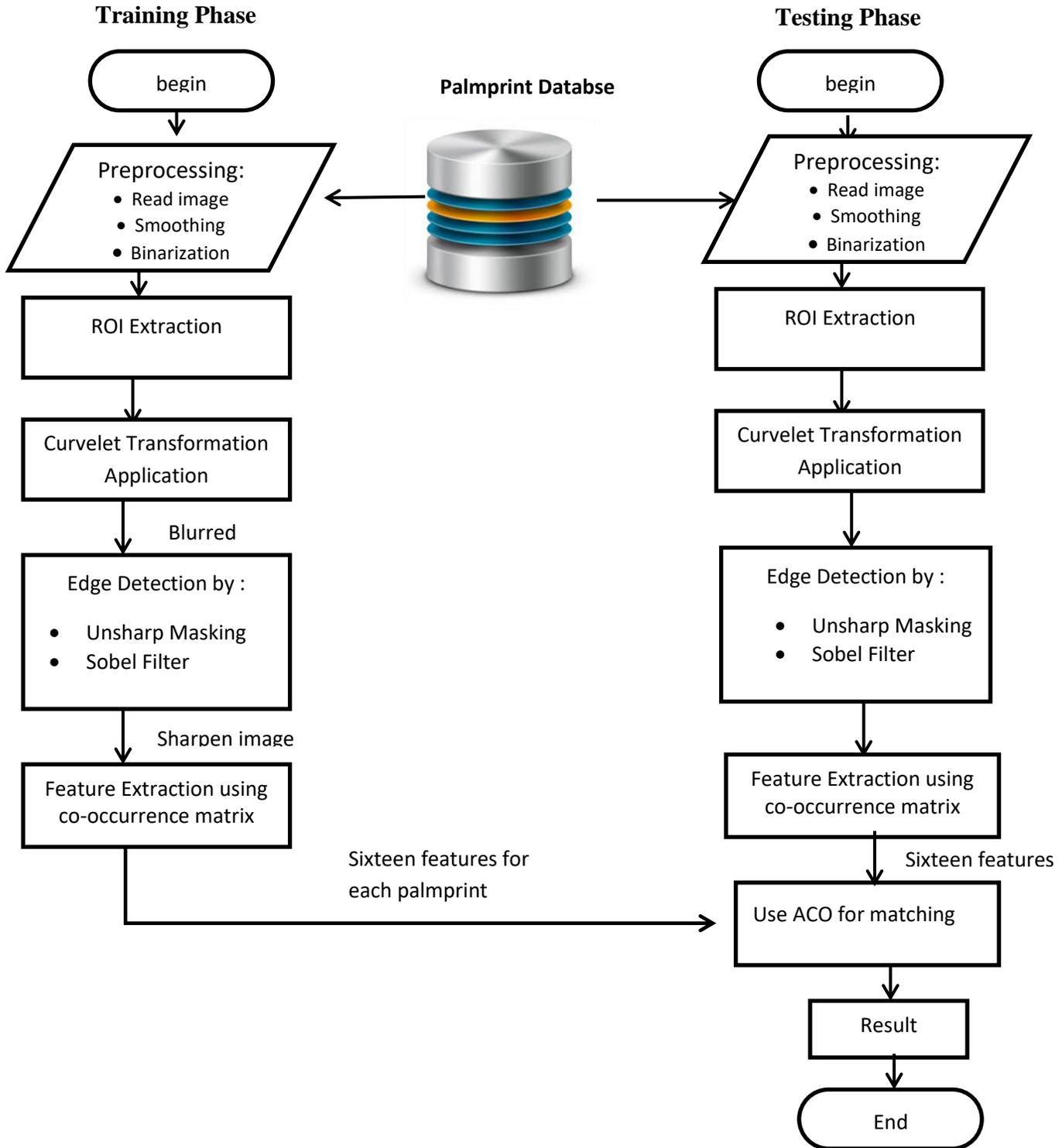
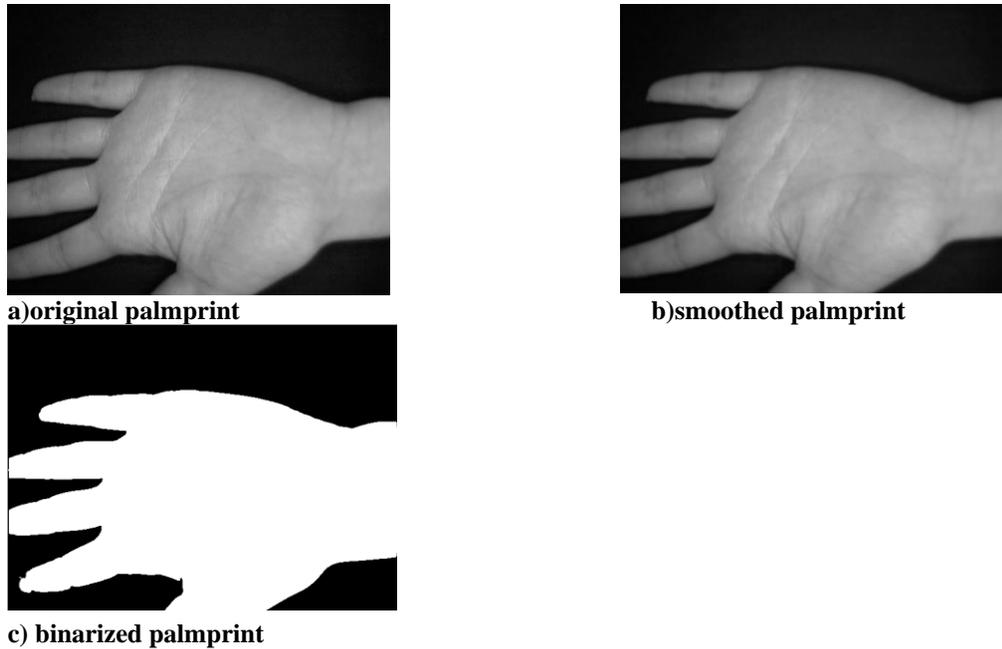


Fig.3 The suggested system schematic diagram



**Fig.4 preprocessing step**

2. **ROI Extraction:** region of interest in palmprints has been extracted in a proposed system based on an algorithm in [16], [17]. Figure 5 shows the extracted ROI from a palmprint.



**Fig.5 Extracted ROI**

3. **Curvelet Transformation Application:** Curvelet transformation is applied to ROI resulting from the previous step to obtain a blurred version of ROI (the innermost layer) as illustrated in Figure 6 which consists of low frequency coefficients.



**Fig.6 Blurred version of a palmprint**

**4. Edge Detection: this step involves two phases** as in Figure 7:

- Unsharp masking to enhance the edges represented by principal lines and wrinkles in ROI.
- Using sobel mask filter on sharp copy of ROI after applying the unsharp masking process in order to detect edges of principal lines and wrinkles as high frequency coefficients of ROI thus producing a sharpened palmprint image.



**Fig.7 Edge detection a) sharp copy of a palmprint**

**b) edges in a palmprint**

...rast, and homogeneity can be extracted by compute co-occurrence matrix from a sharpened palmprint image, finding sixteen (16) values (4 values for each feature). In the training phase, ACO is used for the matching process to find the identified palmprint in the database.

**9. Results and Discussions:**

The proposed method has been performed using matlab 2020. The dataset samples (100 people: 60 male and 40 female, for each there are (8) right hand palmprint & (8) left hand palmprint (1600 images)) which have been used to test the proposed system are from standard Palmprint images (CASIA) which were created by the "Chinese Academy of Sciences Institute of Automation".

A variety of measures are utilized to evaluate the suggested palmprint image recognition system's performance, such as Equal Error Rate (EER), and Accuracy of Recognition Rate (ARR) [8].

$$ARR = \frac{\text{number of correctly classified samples}}{\text{total number of samples}} \dots (11)$$

$$EER = 1 - GAR \dots (12)$$

The experiment shows that the overall ARR of the proposed system is 98.5 percent, with an EER of 0.015, and the ARR computed separately for female and male. Results for the left and right hand are presented in Table1.

**Table (1) Accuracy of recognition rate ARR**

	All samples	Right hand samples	Left hand samples
male	98.333%	100%	96.6667%
female	98.7500%	97.5%	100%

Besides ARR and EER, there are other metrics that have been used to assess the proposed system. These metrics are :” True positive (TP) “,” False positive (FP)”, “True negative (TN) “,” False negative (FN)”, “accuracy “,”sensitivity” and “specificity”. They were derived from confusion matrix. the following paragraph defines and explains how to calculate these metrics.

To clarify further, we will use Person1 as an example and explain what these metrics mean for Person1[18]:

**Person1:** “positive for first person”

**another:** “negative for first person “

The fourth measurements for first person defined as:

True positive (TP) = “No. of persons accurately recognized as person1”.

False positive (FP) = “No. of persons mistakenly identified as person1”.

True negative (TN) =”No. of persons accurately recognized as another”.

False negative (FN) = “No. of persons mistakenly identified as another”.

Accuracy: A test's accuracy for each person refers to its capacity to correctly distinguish between the corresponding person and another person. We must determine the fraction of TP and TN in all analyzed cases to assess a test's accuracy. This can be expressed mathematically as:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \dots (13)$$

Sensitivity: A test's sensitivity refers to its capacity to appropriately identify first person cases. Calculate the fraction of true positives in first person instances to estimate it. This can be expressed mathematically as:

$$Sensitivity = \frac{TP}{TP + FN} \dots (14)$$

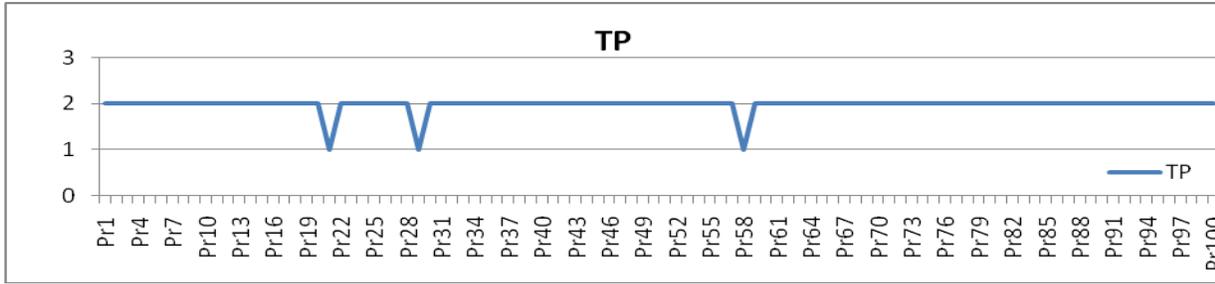
Specificity: A test's specificity refers to its capacity to appropriately identify other cases. Calculate the fraction of true negatives in another instances to estimate it. This can be expressed mathematically as:

$$Specificity = \frac{TN}{TN + FP} \dots (15)$$

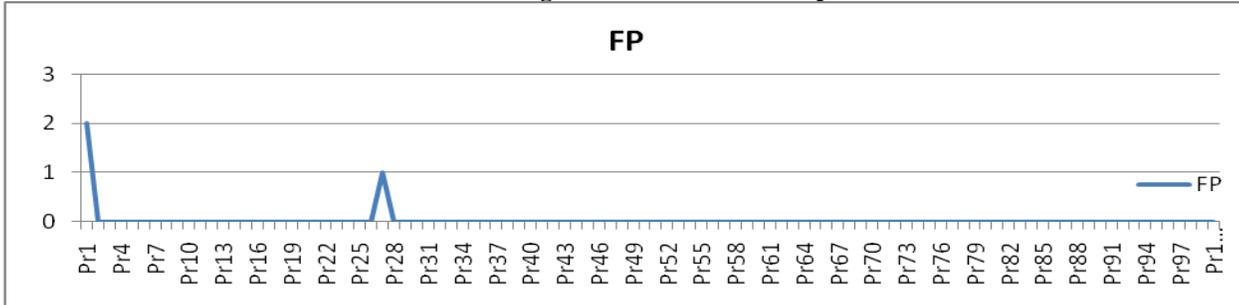
The metrics mentioned above were calculated from the confusion matrix, and I noticed these metrics for all persons are similar to the second person except for persons (1, 21, 29 and 58). Table 2 shows the values of these metrics for persons(1,2,21,22,27,29,58,59,100), Since the rest of the 100 people have the same metrics values of second person (P2), it not mentioned in table 2 because of the large number of persons. rather figures (Fig.8, Fig.9, Fig.10, Fig.11) illustrate the values for each metric for all 100 persons.

**Table (2) shows various metrics for assess the proposed system**

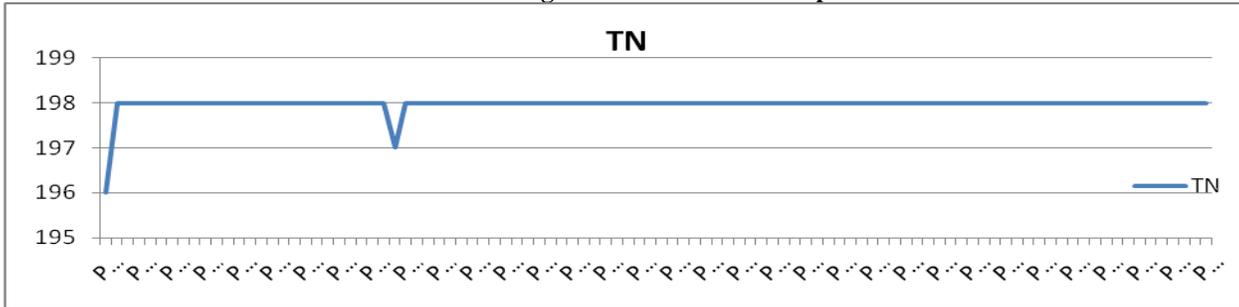
	P1	P2	-	P21	P 22	-	P27	-	P29	-	P58	P59	-	P100
TP	2	2	-	1	2	-	2	-	1	-	1	2	-	2
FP	2	0	-	0	0	-	1	-	0	-	0	0	-	0
TN	196	198	-	198	198	-	197	-	198	-	198	198	-	198
FN	0	0	-	1	0	-	0	-	1	-	1	0	-	0
Accuracy %	99	100	-	99.5	100	-	99.5	-	99.5	-	99.5	100	-	100
Sensitivity%	100	100	-	50	100	-	100	-	50	-	50	100	-	100
Specificity%	98.98	100	-	100	100	-	99.49	-	100	-	100	100	-	100



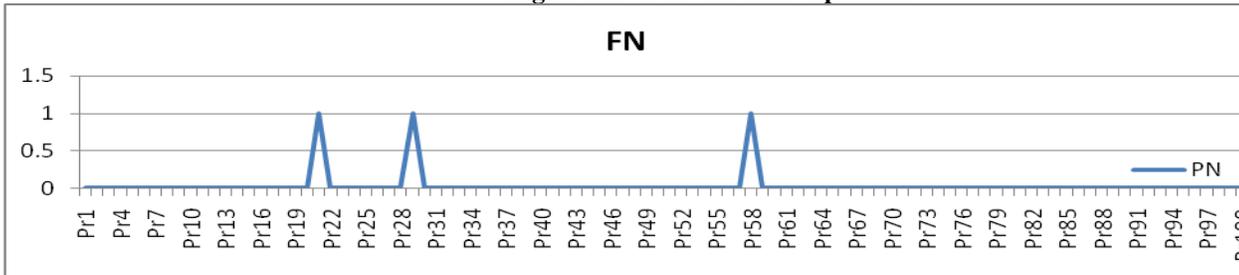
**Fig.8 shows TP for all 100 persons**



**Fig.9 shows FP for all 100 persons**



**Fig.10 shows TN for all 100 persons**



**Fig.11 shows FN for all 100 persons**

Table (3) ARR obtained by proposed system compared with some existing methods:

**Table .3 comparison between proposed system and another algorithms**

Method	Accuracy
2D-DWT and Kernel PCA [3]	94%
Two dimensional Gabor Filter and Sub Space Approaches [4]	91%
2D-LPF +Gabor filter+ PCA[5]	98%
Frangi-filter and 2-component partition method [6]	90.25%
<b>Proposed System</b>	<b>98.5%</b>

## **10. Conclusion:**

In this work, a system was presented to recognize the palmprint. The proposed system reached a very high accuracy recognition rate, which reached to 98.5%.

Co-occurrence matrix was an efficient method to extract features and ACO was reliable artificial intelligent algorithm to find shortest path to the identified person. The accuracy rates have been computed individually for each person, they reached 99% as a lowest value and the highest value was 100%. As well as for the sensitivity, it was 100% for all tested palmprint images except palmprints images for three persons, also the specificity value reached 100% for all tested palmprint images except for two persons. The proposed system showed higher accuracy compared to some existing methods.

## **11. Acknowledgement:**

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