Rotation Invariant Palmprint Recognition Using Radial Harmonic Fourier Moments

Ali Mohammed Sahan, * Ph.D(Lecturer)

Abstract

The accuracy of a Palmprint recognition system is highly depending on the extracted features from Palmprint image. The radial harmonic Fourier moments have attractive characteristics such as rotation invariant, high resistance against image noise, and less redundancy, therefore, they have the capability to provide distinct features about Palmprint image. In this work a Palmprint recognition method was proposed based on radial harmonic Fourier moments as a feature extraction descriptor to provide distinct and rotation invariant features about Palmprint images. The analysis of the results of the extensive experiments conducted over two standard Palmprint databases refers that the proposed method is rotation invariant and achieves high recognition rate even in presence of image noise. Furthermore, the proposed method outperforms other Palmprint recognition methods which utilized other orthogonal rotation invariant moments such as pseudo Zernike moments and Zernike moments.

Keywords: Palmprint Recognition, Radial Harmonic Fourier Moments, Zernike Moments, Pseudo Zernike Moments.

* Technical College of Management, Baghdad

1. Introduction

The recent medicine studies indicated that the details of the Palmprint convey important information about the human such as health, heredity, nationality, intelligence, temperament, and geological distribution. Palmprint recognition is a biometric process considers the unique features like wrinkles, ridges on the surface of the palm, and principal lines to differentiate between the Palmprint of the humans. Palmprint recognition domain has received more attention due to its different applications [1] such as personal identification, diagnostics of diseases, blood relation identification, selection of athletes, criminal detection [2], and access control[3] …etc. In the proposed method Radial Harmonic Fourier Moments (RHFMs) are considered as a global descriptor to extract rotation invariant features of the Palmprint images. Extensive experiments have been conducted to assess the accuracy of the proposed approach over two standard Palmprint databases which are IIT Delhi Palmprint database and CASIA Palmprint database. Also the accuracy of the proposed approach over rotation variation using different rotation angles is evaluated. Furthermore, the impact of image noise on the recognition accuracy is examined. The Canberra distance mesure is used in the proposed work to compute the distance between the tests and the database Palmprint images.

The rest of this paper is organized as follows: Section 2 presented the related work. The RHFMs are explained in Section 3. The utilized similarity measure is cleared in Section 4. Section 5 contains the details of Region Of Interest (ROI) localization. The proposed method is explained in Section 6. Section 7 presented details of experimental analysis. And Section 8 contains conclusions.

2. Related work

There are many Palmprint recognition methods have been existed based on different techniques [4-11]. Some of these methods achieved high recognition rate. However, they are not invariant to geometric transformation such rotation, translation, and scaling variations. On the other hand some of these methods are ineffective in presence of image noise, therefore, they required additional efforts to remove the image noise. The Orthogonal Rotation Invariant Moments (ORIMs) have distinct traits which are robustness to image noise, rotation invariant, and minimum redundancy. There are many moments methods fall under ORIMs which are RHFMs, Orthogonal Fourier-Mellin Moments (OFMMs), Pseudo Zernike Moments (PZMs), and Zernike Moments (ZMs). The distinct characteristics of ORMs motivated the researchers to use them in Palmprint recognition, therefore, many Palmprint recognition based ZMs and PZMs methods have been presented. R. Gayathri and P. Ramamoorthy proposed automatic Palmprint identification methods [12], used ZMs to capture the features of Palmprint. The analysis of the results indicated that using high order of ZMs improve the accuracy of Palmprint recognition system. However, high order ZMs leads to increase the computation complexity. The Palmprint Verification method in [13] presented by P. Ying-Han et al. utilized three type of moments to capture the features of Palmprint, which are PZMs, ZMs, and Legendre Moments (LMs).They show that the recognition rate gained using PZMs is better than those achieved using ZMs and LMs. S. Gnanou et al. presented hand recognition method [14], uses combined Palmprint recognition method consist of ZMs and log Gabor filter. The Palmprint recognition method [15] proposed by S. Karar and R. Parekh uses ZMs to extract Palmprint features. In this method the distance between test and database palm images is computed by subtracting the test Palmprint image from the mean of the database Palmprint images. S. Ashok et al. used ZMs in Palmprint identification method [16]. The hybrid Palmprint authentication system [17] proposed by Y. Pang et al. consist of Wavelet Transform (WT) and PZMs. The experimental analysis of this method indicated that the high order of PSZMs provide distinct features about the Palmprint images. However, the above mentioned methods did not conducted experiments for rotation variation.

3. *Radial Harmonic Fourier Moments (***RHFMs***)*

The orthogonal rotation invariant moments (ORIMs) possess distinct traits of being rotation invariant, robust against noise, and less redundancy. Among of ORIMs methods such as PZMs, and ZMs, RHFMs possess to be less complexity [18], therefore, RHFMs are used in different image processing applications such as character reconstruction [19], cell image recognition [20], image description[21], image reconstruction [22], image recognition [23], tumor cell recognition [24].

The set of RHFMs of order p and repetition q over a unit disk can be defined as follows [19]:

$$A_{pq} = \frac{1}{2\pi} \int_0^{2\pi} \int_0^1 f(r,\theta)\, W^*_{pq}(r,\theta)\, r dr d\theta \qquad \text{…. (1)}$$

where $W^*_{pq}(r,\theta)$ is the complex conjugate of $W(r,\theta)$ of order p and repetition q, and $W_{pq}(r,\theta) = R_p(r)\, e^{jq\theta}$ .The order p and repetition q are defined as: $p \geq 0$ and $|q| \geq 0$.

The radial kernel functions are defined by :-

$$R_p(r) = \begin{cases} \dfrac{1}{\sqrt{r}}, & p = 0 \\ \sqrt{\dfrac{2}{r}}\cos(\pi p r), & p\ even \\ \sqrt{\dfrac{2}{r}}\sin(\pi(p+1)r), & p\, odd \end{cases} \qquad \text{…. (2)}$$

4. Distance Mesure

In order to estimate the similarity between the database and test Palmprint images, Canberra distance measure can be used. This distance evaluates the sum of series of fraction differences between coordinates of the objects. The values of these differences are between 0 and 1. Canberra distance measure can be defined as follows [26]:

$$d(D,Q) = \sum_{i=0}^{F-1} \frac{|M_i(D) - M_i(Q)|}{|M_i(D)| + |M_i(Q)|} \qquad \text{…. (3)}$$

where D and Q represent the database and query Palmprint images respectively, M_i is the extracted moment, while F represent the total moments i.e. the length of feature vector of both database and query Palmprint images.

5. Region Of Interest Localization

The ROI of Palmprint contains most important information about the Palmprint, therefore, localizing this area leads to increase the accuracy of Palmprint recognition system. In this paper the method of extract ROI [25] has been adopted. In this method the y-axis of ROI area is created by determining the gabs between fingers. Then the x-axis is determined by making perpendicular line on y-axis. In the proposed method the resulting ROI form is corrupted into 64* 64 pixel image. Figure (1) shows the extracted ROI of the Palmprint using the above mentioned method.

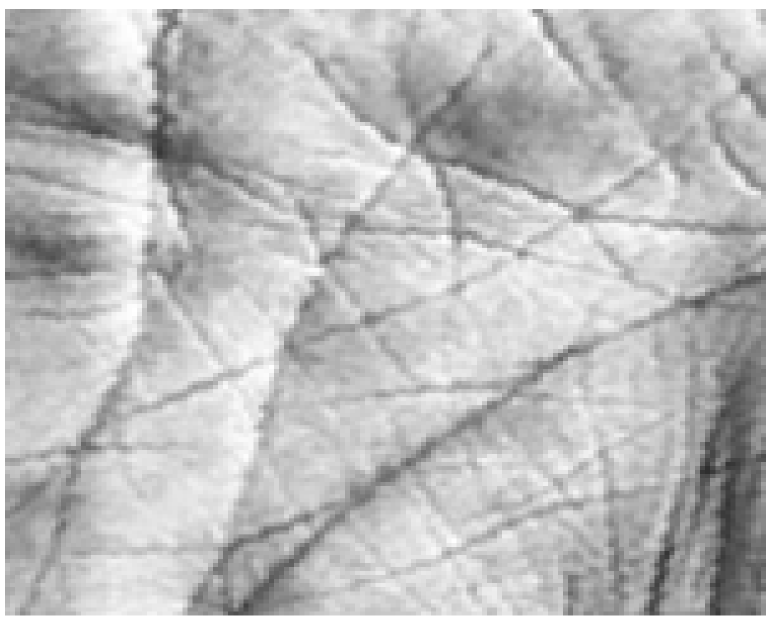


Figure (1) the extracted ROI of the Palmprint.

6. The Proposed Palmprint Recognition Method

The proposed Palmprint recognition system includes three main stages. The first stage is extracting Palmprint ROI. The second stage is feature extraction, which play dominant role in the comparison between Palmprint images. In this paper RHFMs is considered to extract rotation invariant features of database and test Palmprint images. The third stage is the classification stage. In this stage the similarity between the feature vectors of the query and database Palmprint images is estimated, in order to make final recognition decision. Canberra distance measure is used to estimate the distance between test and database images.

The proposed method can be explained as follows:-

1-Extract the ROI of the test Palmprint image and corrupted it to 64 x 64 pixel image.

2-Compute RHFMs of the extracted ROI of the test Palmprint image, and construct its feature vector.

3- Use Canberra distance measure to estimate the distance between the feature vectors of the test and database of ROI images. The feature vectors of the database Palmprint images are constructed offline by computing RHFMs of their extracted ROI image.

4-Find minimum distance between the database and test images, if the test image belong to the same class of database image which has minimum distance, then the decision is "Match" otherwise is "Not Match". Figure (2) shows block diagram of the proposed work.

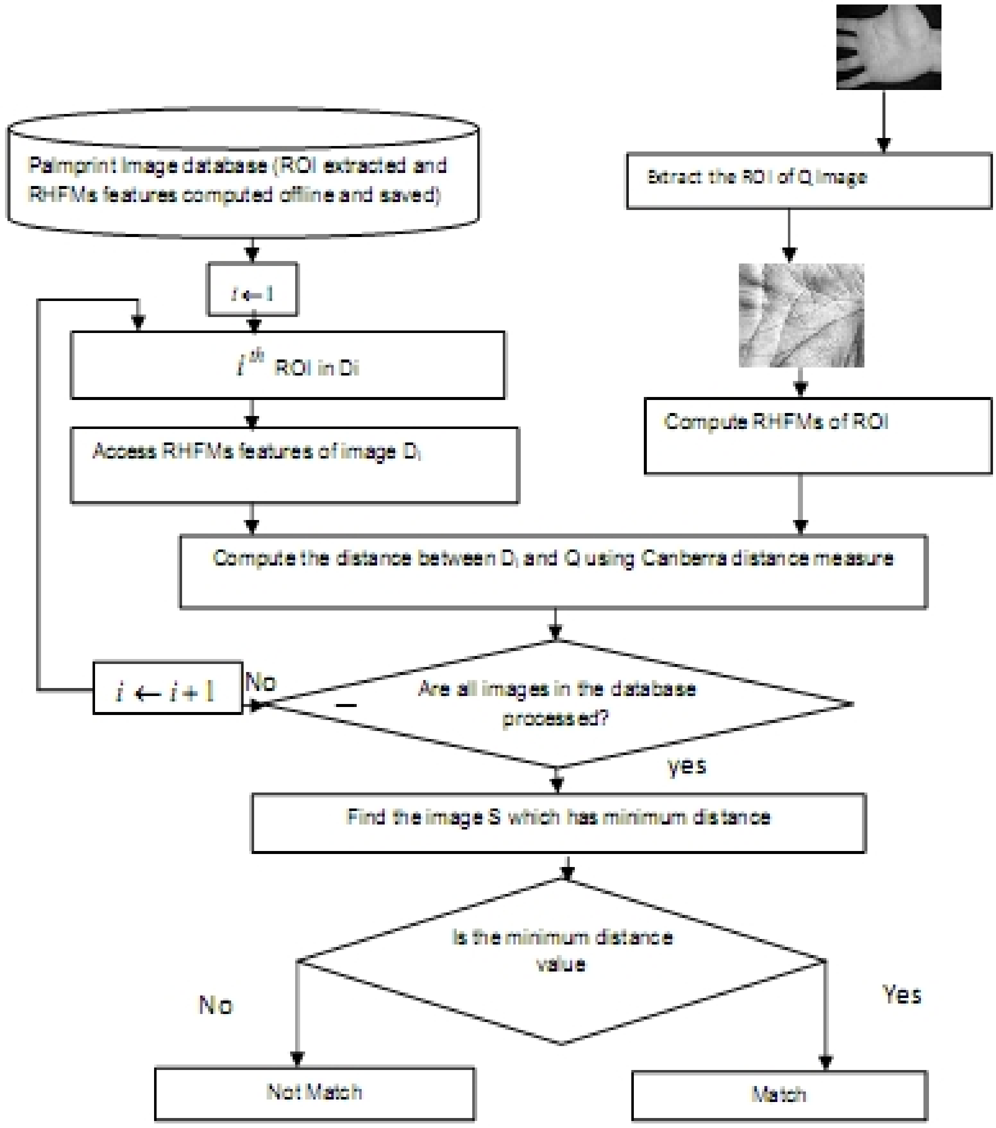
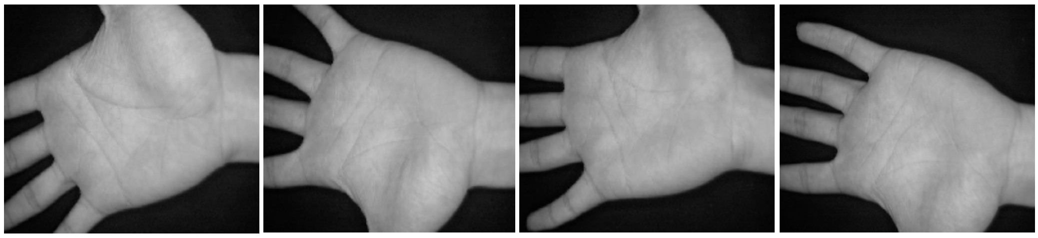


Figure (2) Block Diagram of the proposed Palmprint recognition method



(a)

(b)

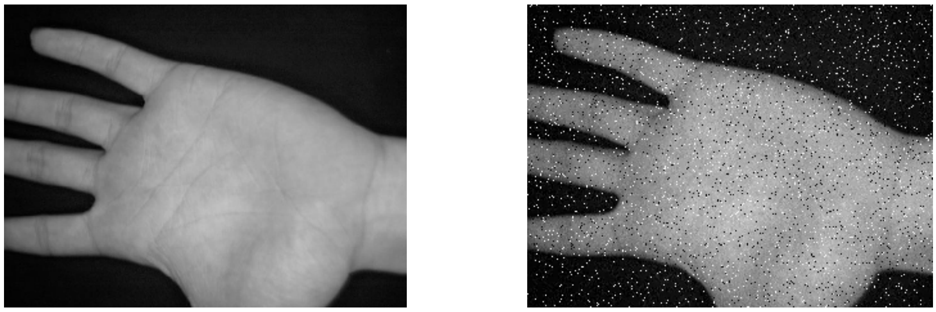
Figure (3) parts of used databases: a-few images of CASIA database, b- few and images of IIT Delhi touchless database

7. Experimental Analysis

The proposed method is implemented in Microsoft V C++ 6.0 using a PC (I5) and RAM (4GB). In order to achieve fair and accurate evaluation of the proposed Palmprint recognition method, two standard Palmprint databases are used, sample of them are shown in figure (3), which are:-

1- CASIA Palmprint database [27]: Includes 5,502 8 bit gray-level JPEG image files. The images of this database are related to 312 subjects. For each subject there are several images for both right and left Palmprint.
2- IIT Delhi Palmprint Database [28]: Contains 1300 bitmap Palmprint images for 230 subjects. At least 5 images are taken in both right and left for each subject. The ages of the subjects are in the age of 14-56.

Moreover, additional experiments are carried out to assess the performance of the proposed method under rotation and noise variations. The additive noise is salt-and-paper noise which causes bright points in dark areas, and dark points in bright areas of the image. Figure (4) shows a Palmprint image before and after noise addition.



(a) (b)

Figure (4) a-Palmprint image before noise addition, b-Palmprint image after salt-and-pepper noise addition

7.1. Performance Analysis Under Different Moment Orders

Two experiments to assess the accuracy of the proposed approach under different RHFMs moment orders (p) and repetitions (q) are carried. The first experiment is performed on CASIA Palmprint database, in this experiment 50 subjects with 10 samples for each one are randomly selected. The first 5 images are utilized for training, while, the remains 5 images are used for testing, therefore, the total images used for training and testing is 500 images. The results of this experiment are presented in table (1). The second experiment is carried out on IIT Delhi Palmprint Database. In this experiment 50 subjects with 8 samples are randomly selected. The first 4 images are used for training, while, the remains 4 images are utilized for testing, therefore, the total number of testing and training images is 400 images. Table (2) presented the results of this experiment. From table (1) it can be seen that the maximum recognition rates at gained using proposed method are %96.5 and %96.6 at order and repetition 10, and order and repetition 16 respectively. Also the results in table (2) reflect the same trend at order and repetation10 and repetition 16 with maximum recognition %97.3 and %97.0 respectively. However, the computation complexity at order and repetition 10 is less than of that at order and repetition 16. This is due to the fact that the number of RHFMs at order and repetition 10 is less than the number of RHFMs at order and repetition 16.

Table (1): Performance of the proposed method over CASIA Palmprint database (first experiment)

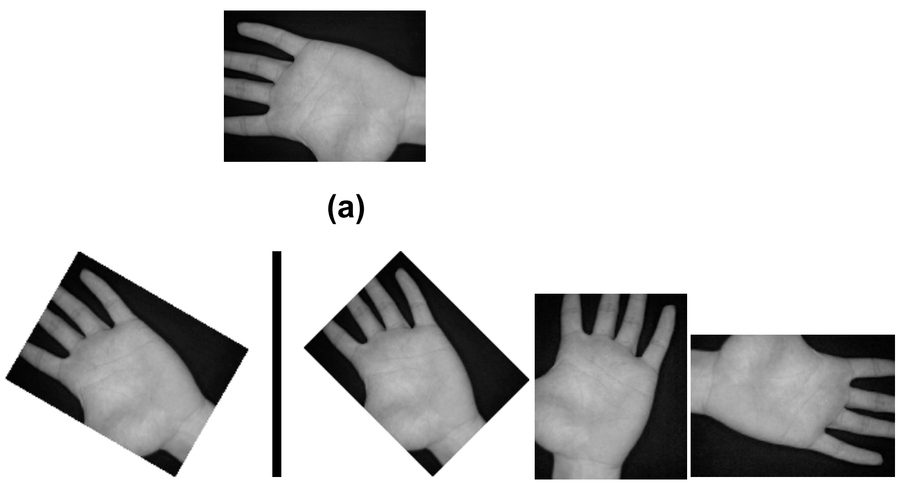
RHFMs orders and repetitions	Recognition rate (%)
6	90
8	95.7
10	96.5
12	94,8
14	93.5
16	96.6

Table (2): Performance of the proposed method over Delhi Palmprint database (second experiment)

RHFMs orders and repetitions	Recognition rate (%)
6	92.3
8	96
10	97.3
12	95
14	94.7
16	97.0

7.2. Performance Analysis Over Rotation Variations

In this section the accuracy of the proposed approach is evaluated under rotation variation, using two experiments with the two datasets described in Section 7.1. In these experiments, the ROI of test images are rotated by 30°, 45°, 90°, and 180°, while, the ROI of database images are taken without rotation. Figure (5), shows one ROI image and its rotated version. Table (3) presented the results of the above mentioned experiments. It is observed that the largest effect is noticed at 45° where the recognition accuracy have dropped from 96.5% to 95.6%. for CASIA Palmprint image database and from 97.3% to 96.5% for IIT Delhi Palmprint Database . Therefore, the proposed technique is accurate even under image rotation variation, this is due to the fact that RHFMs have the ability to provide rotation invariant features about the Palmprint images.



(a)

(b) (c) (d) (e)

Figure(5) a- Palmprint image without rotation, b- Palmprint image with 30° rotation angle, c- Palmprint image with 45° rotation angle, d- Palmprint image with 90° rotation angle, e- Palmprint image with 180° rotation angle.

Table (3): proposed method's recognition rates over rotation variation

Method	Recognition rate (%) over rotation variation				
	unrotated image	30° rotation	45° rotation	90° rotation	180° rotation
CASIA Palmprint image database (first experiment)	96.5	96.0	95.6	96.2	96.5
IIT Delhi Palmprint Database (second experiment)	97.3	96.7	96.5	97.1	97.3

7.3 Performance Evaluation Under Noise Variation

The impact of image noise on the accuracy of the proposed method is examined in this section by carrying out two experiments over the same dataset described in Section 7.1. In both experiments the salt-and-pepper noise is added to the ROI Palmprint test images, while, the ROI Palmprint database images are taken without noise. In these experiments the recognition rates are computed at order and repetition 10. The results of these experiments are presented in table (4) which showed that the recognition rates achieved using proposed method are slightly affected by image noise. This means that the proposed method is more resistant to image noise, because of the robust of RHFMs against the image noise.

Table (4): proposed method's recognition rates achieved using over noise variation

Database type	Recognition rate before noise addition	Recognition rate after addition of salt-paper noise
CASIA Palmprint image database (first experiment)	96.5	96.1
IIT Delhi Palmprint Database (second experiment)	97.3	97.0

7.4. Comparison With Other ORMs Methods

A comparison between the accuracy of the proposed method and the accuracy of other methods which utilized other ORMs techniques such as ZMs in Palmprint recognition [15], high order ZMs in automatic Palmprint identification [12], and PZMs in Palmprint authentication [17] has been achieved in this section. In this comparison the same dataset that used by compared methods are considered. Table (5) presented the results of this comparison. It noticed that the accuracy of the proposed method is better of the accuracy of the method in [17], while, it slightly better than the accuracy of the methods in [12, 15]. Whoever, the proposed method utilises RHFMs which are better than ZMs and PZMs in terms of computational cost and numerical stability at high orders.

Table (5): The results of the comparison between proposed method and the methods in [12, 15, and 17]

Compared method	Recognition rates % achieved using compared method	Recognition rates % achieved using proposed method	description of Palmprint dataset used in the comparison
ZMs in Palmprint recognition [15]	98.0	99.0	4 subjects each subject has 20 Palmprint images, 10 images used for test and remains 10 images used for training
High order ZMs in automatic Palmprint identification [12]	98.0	99.0	125 subjects each one has 5 Palmprint images, 1 image used for test and remains 4 images used for training
PZMs in Palmprint authentication [17]	95.7	99.2	50 subjects, each one has 5 Palmprint images. The test image are in the sequence of 1, 3, and 5, while, the remains images in the sequence of 2 and 4 used for training

8. Conclusions

This work proposes rotation invariant Palmprint recognition method based on RHFMs. The RHFMs provide distinct rotation invariant global features about Palmprint images. The extensive experiments indicate that the proposed method achieves high recognition rate over two standard Palmprint databases. Moreover, the results of the experiments conducted using different rotation angles for the Palmprint test images refers that the proposed method is rotation invariant. The analysis of the results shows that the proposed method is robust against image noise. The comparison between the proposed method and other Palmprint recognition methods based on other ORIMs techniques indicates that the proposed method outperforms other Palmprint recognition methods which utilized other ORMs techniques such as ZMs and PSZMs. The comparison results of the proposed method at different RHFMs orders (p) and repetitions (q) indicated that the accuracy of the proposed method at order (p) and repetition (q) equal to10 is close to its accuracy at order (p) and repetition (q) equal to 16. Using Canberra distance measure leads to exhibit the robustness of the proposed method at different variations.

9. References

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تمييز راحة اليد المضاد للتدوير بأستخدام عزوم فوريير توافقية نصف القطر

م. د. علي محمد صحن*

المستخلص

ان دقة نظام تمييز راحة اليد تعتمد كثيرا على الصفات المستخلصة من راحة اليد. عزوم فوريير توافقية نصف القطر لها خصائص جذابة مثل عدم التأثر بالدوران، مقاومة عالية ضد تشويش الصورة، وكثافة بيانات اقل، لذالك لها القابلية على استخلاص صفات مميزة عن راحة اليد. في هذا العمل اقترحت طريقة لتمييز راحة اليد اعتمادا على عزوم فوريير توافقية نصف القطر كمستخلص صفات للتزويد بصفات مميزة ومضادة للتدوير. ان تحليل نتائج التجارب المكثفة التي اجريت على اثنين من قواعد بيانات راحة اليد القياسية تشير الى ان الطريقة المقترحة مضادة للتدوير وتحقق معدل تمييز عالي حتى مع وجود تشويش الصورة. علاوة على ذالك فأن الطريقة المقترحة تتفوق على طرق تمييز راحة اليد الاخرى التي تستخدم طرق العزوم المضادة للتدوير المتعامدة الاخرى مثل عزوم زرنايك الزائفة وعزوم زرنايك.

الكلمات المفتاحية: تمييز راحة اليد ، عزوم فوريير توافقية نصف القطر ، عزوم زرنايك ، عزوم زرنايك الزائفة

* الكلية التقنية الادارية - بغداد