Rotation Invariant Face Recognition Using Radial Harmonic Fourier Moments

Ali Sami Azeez
IT Dept., Technical College of Management
Middle Technical University,

Abstract

Face recognition is one of the most important tasks in the biometric domain which still receive more concern due to its immense variety of applications. Face recognition has a lot of challenges, one of these challenges is the rotation variation which highly affects the accuracy of the face recognition task. In this paper, we have proposed rotational invariant face recognition technique based on radial harmonic Fourier moments which have the ability to provide global rotation invariant features. The proposed method's accuracy evaluated by carried out extensive experiments using two of the standard databases which are ORL and JAFFE. The results of these experiments indicated that the proposed method is rotation invariant and achieved high recognition rates in the presence of different variations.

Keywords**: **Rotation invariant, Face Recognition, Orthogonal Rotation Invariant Moments(ORIMs), Radial Harmonic Fourier Moments(RHFMs), Global features.

1. Introduction

Biometrics is an important domain that combines computer science and biological science [1]. Biometrics is using a measurable physiological, or behavioral characteristic, e.g., faces, palm veins, fingerprints, DNA, iris, keystroke dynamics, mouse dynamics, gait, voice recognition, etc. [2, 3]. Face Recognition is one of the extremely important, significant and famous biometric techniques, which had crucial effects in daily life. Face recognition is given more attention because it is employed in many important fields as in digital library, control access, human– intelligent computer interaction, buildings security, security missions (missing children, terrorist and criminal identification), real-time matching of surveillance video images, employee entries and authentication in secure systems like computers or bank ATM [4, 5] , as well as other purposes [6].

In the biometric domain, Face recognition field has a lot of advantages over other biometric fields because it doesn't need any special device

comparing by another biometric system like fingerprint and iris. Furthermore, it easy to use as well as it is less hassle than other biometric systems due they do not require contact either the awareness of the subject. It can deal with legacy photography databases, videotape, and other image sources [7]. However, Face recognition suffers from different challenges namely rotation, illumination, facial expression, wearing eyeglasses and pose variations, which affects the recognition accuracy [8-11]. The face recognition techniques can be divided based on feature extraction method type into 3 categories, which are local, global and combined local and global technique. In local, face recognition technique the face image features are extracted from facial regions by measuring the distance between eyes, mouth, side of the nose, corner points, goatee, etc. While the global technique is based on extracting the features from the entire face image. The combined local and global technique is based on extract both local and global features. In this paper, an accurate and rotation invariant face recognition method has proposed based on RHFMs as a feature extraction descriptor. The proposed method exploits the capabilities of RHFMs in terms of providing rotation invariant global features of the human face image. The distance between the training and testing face images has measured by utilizing the Euclidean distance measure.

The rest of the paper has ordered as follows: An overview of the related work has presented in Section 2. RHFMs discussed in Section 3. Section 4 describes the distance measure used in the proposed method. The utilized databases has described in Section 5. Section 6 describes the proposed system. Details of experimental results are given in Section 7, while Section 8 including the concluded of the paper.

2. An over view of related work

Face recognition is one of the most important fields in the biometric domain that received more interest in last dedicates. Therefore, many face recognition methods have been existed based on different feature extraction techniques [12-15]. Some of these techniques obtained high recognition rate. However, they aren't invariant to geometric transformation such translation, scaling, and rotation variations. In view of this, some of these methods are weak in the appearance of image noise; hence, they required additional efforts to remove the image noise. Orthogonal rotation invariant moments (ORIMs), are popularly used in digital image processing, there are several moments methods fall under ORIMs, which include Fourier-Mellin Moments (FMMs), Zernike Moments (ZMs), Pseudo Zernike Moments (PZMs) and RHFMs. The different and powerful characteristics of ORIMs prompted the researchers to use them in face recognition field.

Therefore, many face recognition based FMMs, ZMs and PZMs methods have presented. Yee Ming Chen and Jen-Hong Chiang [16], Offered a mixed various features extraction method for face recognition module by using FMMs method, The Fourier-AFMT achievement extract frequency a constant features and OFMM method extracted moment constant features are employed individually, CCM(correlation coefficient method) is classifying and combining certain both kind of features. The test results reveal the average rate of accuracy recognition proposed techniques is far good. Same Authors have been proposed a face recognition based on FMMs by Fusing multiple features [17], a Taylor-AFMT, and Fourier-AFMT are distinguished for face recognition by a comparative study. Then they presented a hybrid face recognition framework based on Fourier-AFMT to extract the presented feature. The First step, extract the intensity facial and edges of the directionality features while the second step is using CCM to combine and classify two characters of features. Sajad Farokhi et al. [18], introduced a new face recognition approach based on Hermite kernels (HKs) and ZMs for coping with alteration expression of the face image, differences pose and scale of the head, the influences of time-lapse and using eyeglasses. The infrared images have employed to process the force of illumination changes on recognition of face image, and the infrared images have employed to process the force of illumination changes on face recognition. In addition, both local and global features combined together and used in the determination fusion step. ZMs have used to provide a global feature as a feature extractor, while the images of the face are divided into various spots and filtered spot-wise with HKs in The local part. The review of the main part which is followed by a linear that differentiate analysis is applied to data vectors to produce outstanding features.The fusion decision is applied to vector feature properly and the combination of both global and local features. The preliminary results achieved showed that the proposed ZMHK method improved the face recognition accuracy. Furthermore, it outperformed some other existing face recognition methods. Tolga Alasag and Muhittin Gokmen [19], Formulated a method that uses Local Zernike Moments (LZM) and Gauss scale space for face recognition in low-resolution face images. The face recognition framework has designed according to the test outcome. The outcome shows that the suggested framework is promising for real-world applications. Also, Evangelos Sarıyanidi et al. [20], proposed a new representation of local LZM for face recognition by measuring ZMs at each pixel of a face image using the local neighborhood of each pixel. Madeena Sultana et al. [21], introduced a technique to solve diverse illumination, pose, and expression

condition which is one of biggest challenges in face recognition systems, by employed lower order PZM based method which can efficiently recognize faces regardless of illumination, pose, and expression change. Due to optimal choice of the features, they introduced a technique obtains much better recognition rate; Extensive experimentation proves the high recognition rate and robustness of the recommended technique under varying conditions.

The RHFMs have attractive characteristics such as rotation invariant, less redundancy, and high resistance against image noise. Thus, they have the capability to provide distinct and rotation features. Therefore, they have used in different applications as will discuss in section 3. Recently RHFMs has implemented in successfully in the biometric field due to their attractive characteristics. Ali Mohammed Sahan [22], has utilized the RHFMs as a feature extraction descriptor in the Palmprint Recognition system. The mentioned attractive features of RHFMs motivate us to employ it in our proposed face recognition system spatially it is not used in face recognition. So our contribution to this work, which we have examined the capabilities of RHFMs in face recognition system.

3. Radial Harmonic Fourier Moments (RHFMs)

In 2003, H Ren et al. have been proposed the RHFMs [23], RHFMs is one of The orthogonal rotation invariant moments (ORIMs) which have distinct characteristics such as less redundancy, rotation invariant, and robust against noise. As to other ORIMs methods, RHFMs have used to improve the image reconstruction, decrease both computational complexity and noise sensitivity, and magnitude invariance. therefore, RHFMs have used in different image processing applications such as image recognition [23], tumor cell recognition [24], cell image recognition[25], image reconstruction [26], Character reconstruction [27], Geometrically invariant image watermarking [28], Chinese Chess Character [29] and also in biometric palm print recognition [22]…etc. The definition of RHFMs is as following:[27]

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

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

$p \geq 0\ and\ |q| \geq 0.$

The kernel of radial functions have been defining as follow:

$$R_P(r) = \begin{cases} \sqrt{\frac{2}{r}} sin(\pi(p+1)r), & p\ odd \\ \frac{1}{\sqrt{r}}, & p = 0 \\ \sqrt{\frac{2}{r}} cos(\pi pr), & p\ even \end{cases} \quad (2)$$

4. Distance measure

In this work, the classification stage has been used the Euclidean distance measure into distinguishing between the face images. The Euclidean distance measure between training and test features vectors can be defined as:[30]

Let x; y be two M by N images,

x = (x^1, x^2, x^3, x^{MN}), y = (y^1, y^2, y^3, y^{MN}), where

$d_E^2(x,y) = \sum_{k=1}^{MN}(x^k - y^k)^2$ (3)

5. The used standard face database

a. ORL (Olivetti Research Laboratory) datasets, it's composed of four hundred images of furry human subjects, and each subject has ten diverse facial view representations. The size of each image is 92x112 pixels with 256 gray levels. The image of each case varies in facial expression, illumination, position, pose, scale, and detail.

b. JAFFE (Japanese Female Facial Expression) datasets, it's composed of 213 images of seven various varieties of human feeling and facial expressions like disgust, fear, neutral, anger, sadness, happiness, and surprise, for ten female models from Japan. There are two to four samples for each facial expression per lady. The size 256 x 256 pixels is the dimension of each image. Fig1 shows few samples of the utilized databases. The images in the earlier dataset are of various sizes. In this work, we have converted the dimension of the database face images into 64 x 64 pixels in order to facilitate the experimentation part.

(a)

(b)

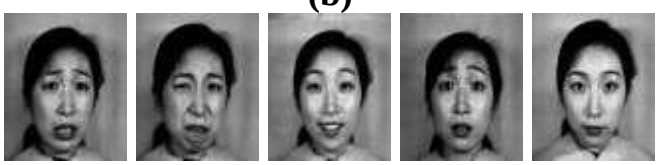


Fig 1: few samples of (a) ORL database and (b) JAFFE database

6. Proposed method

The proposed paradigm goes through three steps; the first step is inserting the image, second step feature extraction, which plays a dominant role in the comparison between the face images. For this purpose, we have considered the RHFMs as a global feature extraction descriptor to extract rotation invariant features from the images. The third step is the classification stage. The Euclidean distance measure has utilized to compute the distance between the training facial images and query.

The suggested paradigm can explain as follows:

1. Insert the image.
2. Test the inserted image.
3. Capture the global features of the face image using Radial Harmonic Fourier Moments.
4. Database images have been undergone feature extraction using RHFMs
5. Compute the distance between training and test images. For this purpose, we have used Euclidean distance.
6. Find minimum distance within the database and test images, if the test image relates to the same class of database image which has a minimum distance, then the decision is "Recognized" except is "Unrecognized." the block diagram of the proposed work has been shown in the Fig. 2.

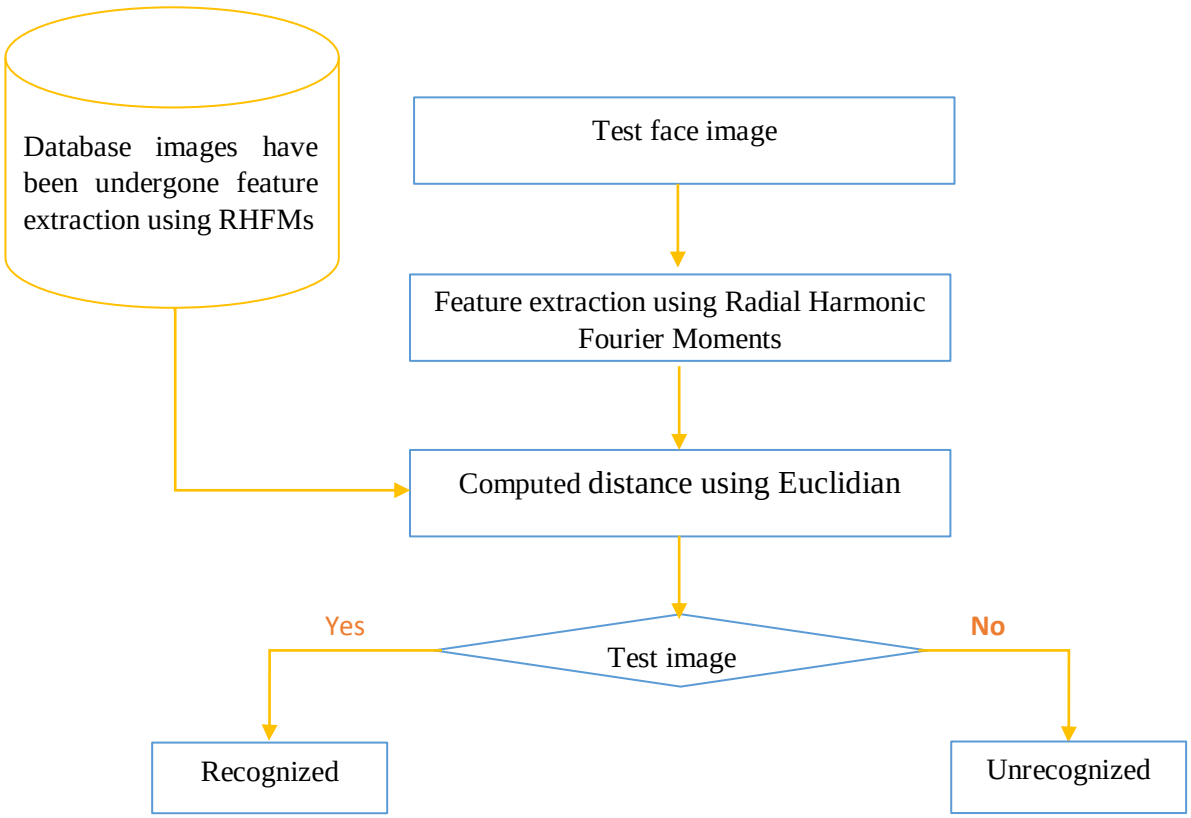


Fig.2. The fellow chart of proposed work

7. Experimental analysis

In this part, the accuracy of the suggested method has been evaluated by carried out extensive experiments on two standard face image databases, which are ORL and JAFFE. We conduct detailed experiments on the above face databases to analyze the recognition performance of our suggested method. The performance has been compared with the similar methods published in the literature. For this purpose, we implement the recommended method and a few existing methods in Microsoft Visual C++ under Windows OS on a personal computer with 6 GB RAM and corei7 CPU.

7.1. Assessment the recognition accuracy over different variations

In this experiment, we have examined the accuracy of the proposed method in the presence of different variations such like position, pose, facial expression, illumination, detail, and scale.

For this purpose we have constructed dataset from ORL database by randomly selecting five images from each class for training and the remains five images used for testing, Fig 3 shows few face images of the dataset mentioned above. Table1 presented the recognition rates achieved using different orders and repetitions of RHFMs. It observed that the highest recognition rate is %95.5 at order and repetition 8 which provides 81 rotation invariant features about the image of the face.

(a)

(b)

Fig 3: (a) samples of training face image, (b) samples of testing face image

Table 1: Recognition rates achieved using different RHFMs orders and repetitions under different variations

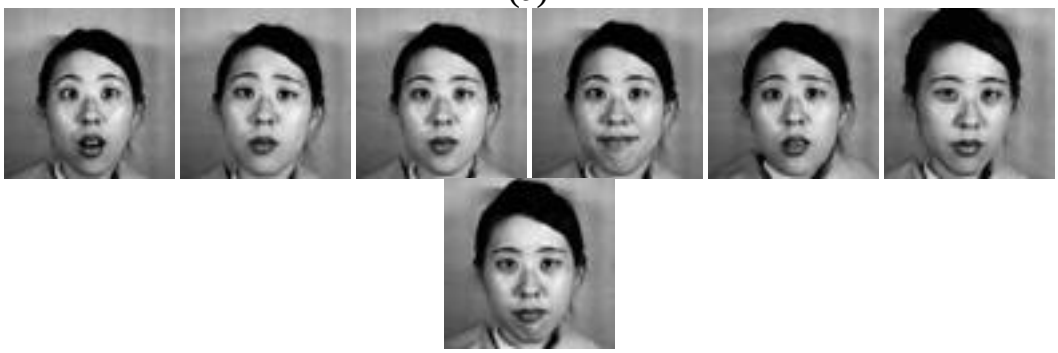
Order and repetition	Number of the features	Recognition rate %
1	4	71
2	9	89.5
4	25	92.5
6	49	94.8
8	81	95.5

10	121	95

7.2. Assessment the recognition accuracy over facial expressions variation

In order to evaluate the accuracy of the proposed method under facial expression, we have conduct experiment on JAFFE database. In this experiment, the training dataset is constructed by randomly selecting one face image from each of the seven different expression groups which are (surprise, sadness, anger, neutral, fear, happiness, and disgust) for every class, while, the remaining face images used for constructing the testing dataset. Therefore, the total number of the testing dataset is 143 while it is 70 for training datasets. Fig 4 shows some samples of the datasets used in this experiment. The results presented in Table 2 of the above-mentioned experiment refer that the highest recognition rate is %98.6 obtained at the order and repetition 10 which provides 121 features while the orders and repetitions 6 and 8 are achieved %97.9.

(a)



(b)

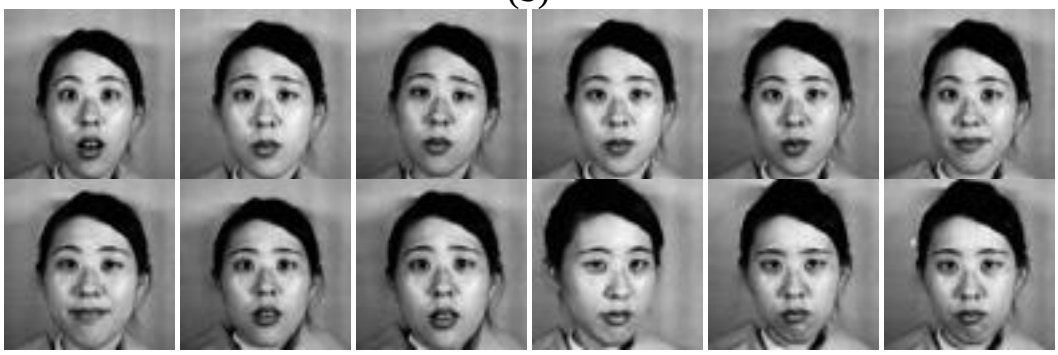


Fig 4: (a) samples of training dataset, (b) samples of testing dataset

Table 2: Recognition rates achieved using different RHFMs orders and repetitions under facial expressions variation

Order and repetition of RHFMs	Number of the features	Recognition rate %
1	4	70.6
2	9	95.9
4	25	97
6	49	97.9
8	81	97.9
10	121	98.6

7.3. Assessment the recognition accuracy over rotation variation

The rotation variation is an important and big challenge in face recognition. Therefore, we have conduct experiments to assess the accuracy of the suggested method over different rotation angles. In these experiments, we have utilized the same training dataset in Section 7.1, while the testing dataset is constructed by rotating the testing dataset in Section 7.1 by three rotation angles which are 30°, 45°, and 90°. Fig 5 shows one face image and its rotated version at 30°, 45°, and 90°. In these experiments, we have considered the order and repetition 8. The results of these experiments, which are presented in table3, indicated that the recognition rates after rotation (%95.3, %95.1, and %95.2) are close to the recognition rate before a rotating basis (%95.5) which means that the offered system is rotation invariant.

Fig 5: (a)

a b c d

original face image, (b) original face image rotated by 30°
(c) Original face image rotated by 45°**, (c) original face image rotated by** 90°

Table 3: Recognition rates achieved using different RHFMs orders and repetitions over different rotation angles

Rotation angles	Recognition rates %
30°	**95.3**
45°	**95.1**
90°	**95.2**

8. Conclusions

In This work, we propose an accurate and rotational invariant face method has been introduced by utilizing the RHFMs as feature descriptor. The experimental part of this work refers that the RHFMs can extract distinct global features, which have the ability to distinguish between different face images. Furthermore, these features are slightly affected by different rotation angles, which mean they are rotation invariant. The highest recognition rate obtained over different variations is %95.5 at the order and repetition 8, while its %98.6 at the order and repetition 10 over facial expression variation. The analysis of the outcome shows that the suggested method is robust against image noise. The comparison between the suggested method and other face recognition methods based on other ORIMs techniques indicates that the proposed method outperforms other face recognition methods that utilized other ORMs techniques such as ZMs and PSZMs.

References

1 Xiong, J.: 'Essential Bioinformatics ' (Cambridge University Press, 2006. 2006)
2 Marcel, S., Nixon, M.S., and Li, S.Z.: 'Handbook of Biometric Anti-Spoofing' (Springer, 2014. 2014)
3 Revett, K.: 'Behavioral biometrics: a remote access approach' (John Wiley & Sons, 2008. 2008)
4 Sahan, A.M.: 'Face recognition using effective and fast approach', International Journal of Modern Trends in Engineering & Research, 2016, 3, (11), pp. 43-60
5 Fontaine, X., Achanta, R., and Süsstrunk, S.: 'Face Recognition in Real-world Images', in Editor (Ed.)^(Eds.): 'Book Face Recognition in Real-world Images' (2017, edn.), pp.
6 Gumus, E., Kilic, N., Sertbas, A., and Ucan, O.N.: 'Evaluation of face recognition techniques using PCA, wavelets and SVM', Expert Systems with Applications, 2010, 37, (9), pp. 6404-6408
7 Majekodunmi, T.O., and Idachaba, F.E.: 'A Review of the Fingerprint, Speaker Recognition, Face Recognition and Iris Recognition Based Biometric Identification Technologies', 2011
8 Roy, S., and Podder, S.: 'Face detection and its applications', International Journal of Research in Engineering & Advanced Technology, 2013, 1, (2), pp. 1-10

9 Riyazoddin, S., and Reddy, M.J.: 'A Robust Online Method for Face Recognition Under Illumination Invariant Conditions', Global Journal of Computer Science and Technology, 2012

10 Abdullah, M.F.A., Sayeed, M.S., Muthu, K.S., Bashier, H.K., Azman, A., and Ibrahim, S.Z.: 'Face recognition with symmetric local graph structure (slgs)', Expert Systems with Applications, 2014, 41, (14), pp. 6131-6137

11 Xu, Y., Zhu, X., Li, Z., Liu, G., Lu, Y., and Liu, H.: 'Using the original and 'symmetrical face'training samples to perform representation based two-step face recognition', Pattern Recognition, 2013, 46, (4), pp. 1151-1158

12 Sahan, A.M., Kadhim, Z.O., and Majed, A.: 'Face recognition using zernike moments and radon transform', IJMTER, 2015, 02, (11), pp. 299-307

13 Wang, J., Zheng, J., Zhang, S., He, J., Liang, X., and Feng, S.: 'A Face Recognition System Based on Local Binary Patterns and Support Vector Machine for Home Security Service Robot', in Editor (Ed.)^(Eds.): 'Book A Face Recognition System Based on Local Binary Patterns and Support Vector Machine for Home Security Service Robot' (IEEE, 2016, edn.), pp. 303-307

14 Yi, D., Lei, Z., and Li, S.Z.: 'Towards pose robust face recognition', in Editor (Ed.)^(Eds.): 'Book Towards pose robust face recognition' (2013, edn.), pp. 3539-3545

15 Klare, B.F., and Jain, A.K.: 'Heterogeneous face recognition using kernel prototype similarities', IEEE Transactions on Pattern Analysis and Machine Intelligence, 2013, 35, (6), pp. 1410-1422

16 Chen, Y.M., and Chiang, J.-H.: 'Face recognition using combined multiple feature extraction based on Fourier-Mellin approach for single example image per person', Pattern Recognition Letters, 2010, 31, (13), pp. 1833-1841

17 Chen, Y.M., and Chiang, J.-H.: 'Fusing multiple features for Fourier Mellin-based face recognition with single example image per person', Neurocomputing, 2010, 73, (16), pp. 3089-3096

18 Farokhi, S., Sheikh, U.U., Flusser, J., and Yang, B.: 'Near infrared face recognition using Zernike moments and Hermite kernels', Information Sciences, 2015, 316, pp. 234-245

19 Alasag, T., and Gokmen, M.: 'Face recognition in low resolution images by using local Zernike moments', in Editor (Ed.)^(Eds.): 'Book Face recognition in low resolution images by using local Zernike moments' (2014, edn.), pp. 1-7

20 Sarıyanidi, E., Dağlı, V., Tek, S.C., Tunc, B., and Gökmen, M.: 'Local Zernike Moments: A new representation for face recognition', in Editor (Ed.)^(Eds.): 'Book Local Zernike Moments: A new representation for face recognition' (IEEE, 2012, edn.), pp. 585-588

21 Sultana, M., Gavrilova, M., and Yanushkevich, S.: 'Expression, pose, and illumination invariant face recognition using lower order pseudo Zernike moments', in Editor (Ed.)^(Eds.): 'Book Expression, pose, and illumination invariant face recognition using lower order pseudo Zernike moments' (IEEE, 2014, edn.), pp. 216-221

22 Sahan, A.M.: 'Rotation Invariant Palmprint Recognition Using Radial Harmonic Fourier Moments', Al-Mansour Journal, 2016, (25), pp. 67-84

23 Ren, H., Ping, Z., Bo, W., Wu, W., and Sheng, Y.: 'Multidistortion-invariant image recognition with radial harmonic Fourier moments', JOSA A, 2003, 20, (4), pp. 631-637

24 Ren, H., Liu, A., Ping, Z., and Bai, D.: 'Study on a novel tumor cell recognition system based on orthogonal image moments', in Editor (Ed.)^(Eds.): 'Book Study on a novel tumor cell recognition system based on orthogonal image moments' (Springer, 2008, edn.), pp. 290-292

25 Hai-Ping, R., Zi-Liang, P., Wu-Ri-Gen, B., Yun-Long, S., Sheng-Zu, C., and Wen-Kai, W.: 'Cell image recognition with radial harmonic Fourier moments', Chinese Physics, 2003, 12, (6), pp. 610

26 Singh, C., Pooja, S., and Upneja, R.: 'On image reconstruction, numerical stability, and invariance of orthogonal radial moments and radial harmonic transforms', Pattern recognition and image analysis, 2011, 21, (4), pp. 663-676

27 Ren, H., Liu, A., Zou, J., Bai, D., and Ping, Z.: 'Character reconstruction with radial-harmonic-Fourier moments', in Editor (Ed.)^(Eds.): 'Book Character reconstruction with radial-harmonic-Fourier moments' (IEEE, 2007, edn.), pp. 307-310

28 Chun-peng, W., Xing-yuan, W., and Zhi-qiu, X.: 'Geometrically invariant image watermarking based on fast Radial Harmonic Fourier Moments', Signal Processing: Image Communication, 2016, 45, pp. 10-23

29 Kejia, W., Honggang, Z., and Ziliang, P.: 'Chinese chess character recognition with radial harmonic fourier moments', in Editor (Ed.)^(Eds.): 'Book Chinese chess character recognition with radial harmonic fourier moments' (IEEE, 2011, edn.), pp. 1369-1373

30 Michel Marie Deza, E.D.: 'Encyclopedia of Distances' (Springer-Verlag Berlin Heidelberg, 2016, 4 edn. 2016)

تمييز الوجوه المضادة للتدوير باستخدام عزوم فوريير التوافقية النصف قطرية

المستخلص

ان تمييز الوجوه هو أحد اهم مهمات المقاييس الحيوية البايومترية والتي لاتزال تستقبل مزيد من الاهتمام بها بسبب كثرة تطبيقاتها. ان أنظمة تمييز الوجوه تواجه تحديات كثيرة، ومن هذه التحديات هي تمييز صورة الوجه تحت تأثير التدوير والذي يؤثر كثيرا على دقة التمييز. في هذا البحث تم اقتراح تقنية لتمييز الوجوه مضادة للتدوير باستخدام عزوم فوريير التوافقية النصف قطرية التي بأماكنها توفير صفات عامة مضادة للتدوير عن صورة الوجه. تم تقييم دقة الطريقة المقترحة من خلال التجارب المكثفة التي اجريت على اثنين من قواعد البيانات القياسية للوجوه (***ORL and JAFFE***) وان تحليل النتائج لهذه التجارب بين ان الطريقة المقترحة هي مقاومة للتدوير وتحقق معدلات عالية من التمييز.

الكلمات المفتاحية: تمييز الوجوه, الصفات العامة, ثابت الدوران, عزوم فوريير التوافقية النصف قطرية