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ROTATION INVARIANT FACE RECOGNITION USING JACOBI –FOURIER MOMENTS

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ABSTRACT

The face image comprises different global and local details related to the whole and different local areas of the face image, therefore extract global features from the local areas leads to provide distinct distinguishing of the face images. In this, work a face recognition approach based on Jacobi-Fourier moments has been presented. Jacobi-Fourier moments used to provide global and distinct features about local areas in the face image. These features are used to construct histogram bins. Extensive experiments are carried out using different standard face database such as ORL, JAFEE and UMIST which are contain large variability in facial expression, pose and illumination. The experimental analysis refers that the proposed approach outperforms the traditional method under pose, facial expression, and different variations as well as it rotation invariant.

Keywords: *Rotation Invariant, Face Recognition, Jacobi-Fourier Moments, Global Features, Local Features.*

1. INTRODUCTION

The human face image has different components occupied different positions. These positions comprise important details about the face image which are the local features. Furthermore, all these positions participate each to other to form global features about the whole face image. On the other hand, the face image affected by many variations such as poses, illumination, facial expression, and rotation. Therefore, face recognition can be considered as an important field in the biometric domain which has numerous applications in various fields [1,2] like electronic library, security in different building, control access, on line face image identification in surveillance video, criminal identification, and authentication in different organization and different economic and military field. The above-mentioned issues lead to increase the attention in scientific research of face recognition field. Therefore, many face recognition techniques have been proposed. These techniques consider different feature extraction methods which can classify into local, global, and mixed local and global features. The local feature extraction method captures local features about the face image these methods are robust against irrelevant information like hair and background. However, they are affected by environmental conditions [3]. The global feature capturing methods provide global details about the whole image of the human face. However, these methods are affected by face facial expressions variation. The hybrid local and global methods decrypting both local and global features that leads to providing robust recognition of the face images. Most of the face recognition methods are suffer from geometric problems because their recognition accuracy affected by rotation, scaling, and shifting variations. The rotation invariant moments techniques provides solutions for these geometric problems, therefore, a lots of face recognition techniques have been presented [4-11].

The proposed face recognition method presented feature extraction technique based on Jacobi-Fourier moments (JFMs). In this technique, the face image divided into different local equal areas and then JFMs used to extract global features from these areas which comprise local details. In order to reduce the dimensionality of the resulted feature, the histogram bins have been computed to feed into the classification stage. The importance of our presented work is lies in evaluating the performance of rotation invariant hybrid global and local feature in face recognition system.

The rest of this paper is organized as follows: the related work is discussed in Section 2. An overview of JFMs presented in Section 3. Section 4 describes the proposed technique. Section 5 presented the used distance measure. Section 6 describes the utilized standard face databases. Section 7 presented the details of the experimental part. Section 8 discussed the conclusions existed in this work.

2. RELATED WORK

The JFMs can be considered as a strong feature descriptor due to its attractive characteristics like rotation invariance, good image reconstruction and representation capability and minimum redundancy. Therefore, many face recognition methods based on JFMs have been existed in literature. C. Camacho-Bello et.al.[12] Proposed a fast and accurate algorithm for JFMs computation. The proposed algorithm is utilized in image description and compared with other related methods. C. Toxqui-Quitl et. al. [13] presented a motion descriptor based on JFMs used to classify the objects from motion blurred images. N. V. S. Sree Rathna Lakshmi and C. Manoharan [14] utilized JFMs as a feature extraction descriptor for detecting micro-calcifications in mammograms. K. Sankar and K. Nirmala [15] also used JFMs as a feature extraction descriptor to classify mammogram images into abnormal and normal. Rahul Upneja and Chandan Singh [16] proposed a fast computation algorithm of JFMs. The proposed algorithm used in invariant image recognition. Francisco Solís et.al. [17] presented static sign recognition system for Mexican language base JFMs. They represent each sign image by 64 JFMs in order to reduce the computational dimensionality. The system achieves %95 recognition accuracy using the artificial neural network in the classification stage. Cesar Camacho-Bello et.al. [18] used JFMs for color image description. Guleng Amu [19] presented an algorithm to compute Pseudo JFMs in Cartesian coordinate instead of the polar coordinate in order to reduce the computation dimensionality. The evaluation of the presented algorithm under image reconstruction referred that the computation of JFMs in Cartesian coordinate gains advantages against of its computation in polar coordinate. The JFMs didn't utilize yet in face recognition problem, therefore, contribution of the proposed technique is analyzing the performance of these invariant moments as a rotation invariant hybrid global and local feature descriptor in face recognition system.

3. JACOBI-FOURIER MOMENTS

The image function under polar coordinates can be defined using JFMs of repetition m and order n as [16,20,21]

$$H_{nm} = \int_0^{2\pi}\int_0^1 f(r,\theta)V_{nm}^*(p,q,r,\theta)rdrd\theta \qquad (1)$$

where p and q represented the real parameters, n refer to nonnegative integer, while m refer to an integer and $V_{nm}^*(p,q,r,\theta)$ is the complex conjugate of JFMs kernel function $V_{nm}(p,q,r,\theta)$

$$V_{nm}(p,q,r,\theta) = R_n(p,q,r)w_m(\theta) \qquad (2)$$

The function is a polynomial of JFMs and can be defined as follows:

$$R_n(p,q,r) = b_n(p,q,r)J_n(p,q,r) \qquad (3)$$

Where $J_n(p,q,r)$ are represented the shifted Jacobi polynomials and $b_n(p,q,r)$ are weight function

$$J_n(p,q,r) = \frac{n!(q-1)!}{(p+n-1)!}\sum_{k=0}^{n}\frac{(-1)^k(n+k+p-1)!r^k}{k!(q+k-1)!(n-k)!} \qquad (4)$$

$$b_n(p,q,r) = \left[\frac{(q+n-1)!(p+n-1)!(p+2n)}{n![(q-1)!]^2(p-q+n)!}(1-r)^{p-q}r^{q-2}\right]^{1/2} \qquad (5)$$

$$w_m(\theta) = \frac{1}{\sqrt{2\pi}}e^{jm\theta} \qquad (6)$$

The simplest computation for $R_n(p,q,r)$ are:

$$R_n(p,q,r) = \left[(p+2n)(1-r)^{p-q}r^{q-2}\right]^{1/2}A_n(p,q)P_n(p,q,r) \qquad (7)$$

Where

$$P_n(p,q,r) = \sum_{k=0}^{n}\frac{(-1)^k(n+k+p-1)!r^k}{k!(q+k-1)!(n-k)!} \qquad (8)$$

And

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$$A_n(p,q)=\left[\frac{n!(q+n-1)!}{(p+n-1)!(p-q+n)!}\right]^{1/2} \quad (9)$$

4. PROPOSED TECHNIQUE

The proposed method utilized Jacobi moments as a feature extraction technique in order to provide distinct and rotation invariant features about the face image. These moments are applied on the local area of the face image; therefore, the resulting features represent global features of local areas in the face image which leads to provides an accurate description of the face image. The resulted features are used to construction histogram bins which feed to the classification stage.

The proposed face recognition technique can be described as follows:

1. Divide the face image into equal local areas.
2. Apply Jacobi moments on each divided local area in order to extract global rotation invariant features.
3. Generate the histogram bins of the resulted features.
4. Compute the distance between training and test images. For this purpose, we have used Cosine distance similarity measure.

Figure 1 illustrates the proposed technique's block diagram.

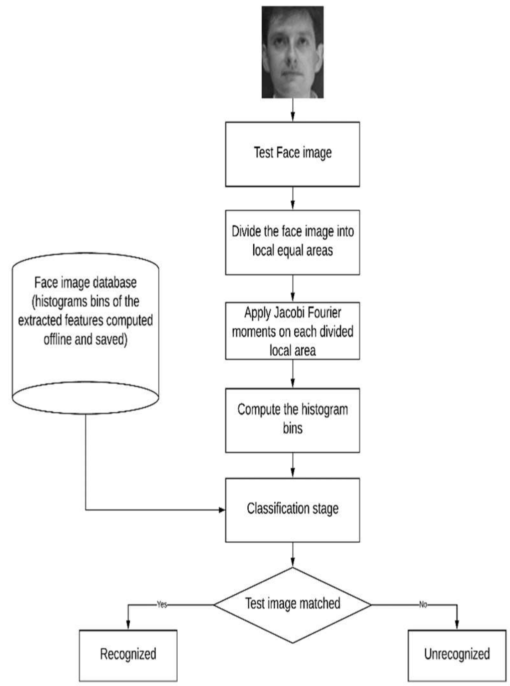

Fig. 1. the block diagram of the proposed technique.

5. COSINE DISTANCE SIMILARITY MEASURE

The cosine distance similarity measure evaluates the similarity between two feature vectors in the angular direction [22]. It estimates the angle between feature vectors. The lower the angular separation refers to little similarity. The cosine distance similarity measure can be defined as:

$$d=\frac{\sum_{i=0}^{N-1}(F_i(T)\times F_i(D))}{\sqrt{\sum_{i=0}^{N-1}(F_i(T)^2}\sqrt{\sum_{i=0}^{N-1}(F_i(D)^2}} \quad (10)$$

where $F_i(T), F_i(D)$ represent the features of test and database video frames, N is the total features number.

5.1 The Database Used In The Experimental Part

In the experimental part of this work we have used different types of face database we can explain to them as follows:

1. JAFFE: consist of 10 Japanese female subjects with a total of 213 face images. Each subject has 2-4 examples of seven

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facial expressions like disgust, surprise, angry, fear, happy, and natural. [23]

6. UMIST: contains 564 frontals to profile images distributed on 20 subjects. each subject has different pose view from profile to frontal with pose angles between -90 to 0 [23].
7. ORL: contains 40 subjects. Each subject includes 10 different variations like the pose, scales, illumination, facial expression, and a little bit of rotation. Therefore, it consists of 400 images [23]. Appendix A: shows parts of the used databases.

6. EXPERIMENTAL ANALYSIS

We carried out extensive experiments on the above-mentioned face databases in order to evaluate the accuracy of both traditional and proposed method under different face image variation such as pose, facial expression, and rotation variation as well as different variation in the same time. We reduce the dimensionality of the images of the used databases by cropped these images into 64 x 4 pixels. The Matlab has been used to prepare the database while all utilized algorithms have implemented using VC++ 6.0 and PC has 5.0-GHZ-CPU and 4GB-RAM.

6.1. Evaluate The Proposed Method Under Pose Variation.

The robustness of the proposed approach against pose variation has been investigated. For this purpose, we conduct experiment over UMIST database. In this experiment we select 8 images with different angles of pose for the training and two profile images for testing. Figure.2. display the training and testing images. The results of this experiment are shown in Figure.3. indicated that the highest recognition rates gained using the traditional and proposed methods at the order and reputation 12 are %93 and %96.5 respectively. Which means that the proposed approach is better than the traditional use of Jacobi-Fourier moments under the condition of pose variation.

(a)

(b)

Fig.2. (a) Training image, (b) Testing image.

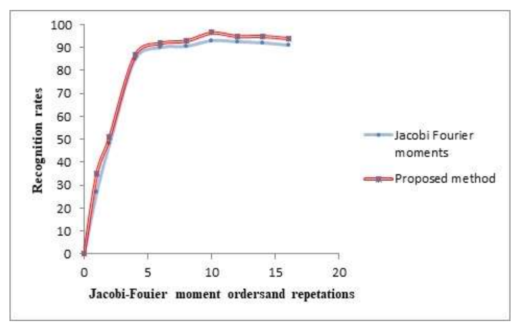

Fig.3. Recognition rates of proposed the approach over pose variation.

6.2. Evaluate The Proposed Method Under Facial Expression Variation.

We conduct an experiment over JAFFE database to evaluate the accuracy of the proposed approach under facial expression variations. In this experiment we select 3 normal faces are used for the training, and the remains faces are used as a test. Figure. 4 displays the test and training images utilized in this experiment. The analysis of the result recognition rates which illustrated by Figure.5. indicates that the accuracy of the proposed approach is better than that the traditional method and achieved improvement in recognition rate approximately %3.5 under facial expression variation.

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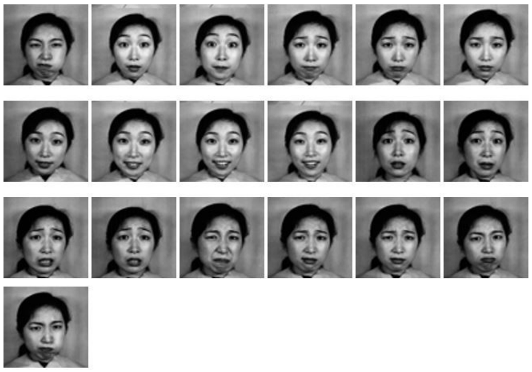
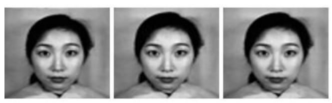


(a)



(b)

Fig. 4. (a) Testing images, (b) training images

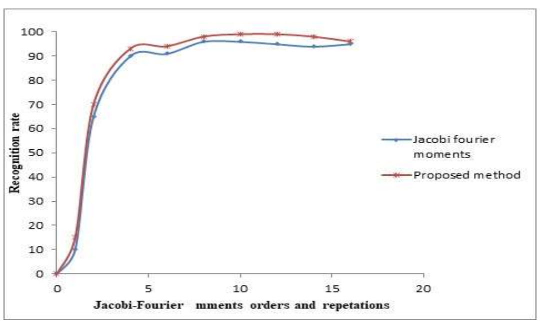


Fig. 5. Recognition rates of the proposed approach over facial expression variation.

6.3. Evaluate The Proposed Method Under Different Variations

In order to assess the effect of different variations on the accuracy of the proposed method, we carried out excrements using ORL database which contains different variations.

These experiments are utilized five random images for the training and remain five images for the test. Figure.6 shows part of the utilized face database setup, while Figure.7 presented the results of these experiments. The analysis of these experiments indicated that the recognition accuracy achieved using proposed technique is approximately %3 higher than the recognition rate achieved using the traditional method under different variations.

(a)

(b)

Fig. 6. (a) Testing images, (b) training images

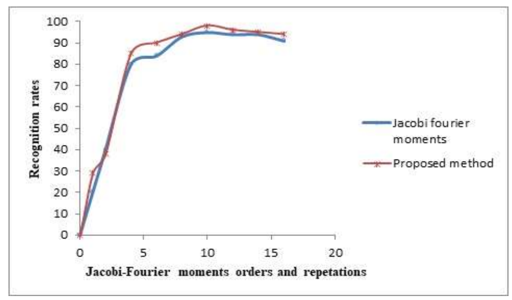


Fig. 7. Recognition rates of the proposed approach over different variation

6.4. Evaluate The Proposed Method Under Rotation Variation

In this section accuracy of the proposed technique has been analyzed under rotation variation using ORL database, we conduct experiments on ORL database. In these experiments, the same database setup used in the experiment of evaluation of different variations is considered. The test images are rotated by 30˚, 90˚, and 180˚while the training images without rotation angle. Figure.8 presented part of the training and test face images. The results of these experiments which presented in table1 revere that the recognition rates after rotation are very close to those achieved before rotation, which means that the proposed method is rotation invariant.

Some of the other previous face recognition methods achieved high recognition rates. However, the performance of these methods is very weak under rotation variation which leads to produce low recognition accuracy, while our proposed technique is robust against rotation variation as well as it achieved high recognition rate.

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(a)

(b)

Fig. 8. (a) training face images, (b) test face images rotated at 30˚

Table 1. Evaluate the proposed technique against rotation variation on ORL database.

Recognition rate before rotation	Recognition rate after rotation at 30˚	Recognition rate after rotation at 90˚	Recognition rate after rotation at 180˚
98.2%	98%	98%	98%

7. CONCLUSIONS

In this work, we presented a face recognition technique based on Jacobi-Fourier moments. In this technique, the Jacobi-Fourier moments used to extract rotation and global features from local areas in the face image, and then the histogram has been constructed based on these features. The experimental analysis of the experiments carried out on standard face databases under facial expression, pose, and different versions indicated that the proposed technique improves the accuracy of the recognition rates achieved using the traditional method which utilized Jacobi-Fourier moments for the whole face image. This leads to conclude that extracting global features from local face image areas leads to increase the discrimination of these features. Furthermore, experiments are implemented to assess the impact of rotation variation on the proposed technique revered that the proposed technique is rotation invariant.

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Appendix A: Databases used

Fig. A.1: parts of ORL database

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Fig. A.2: parts of JAFFE database

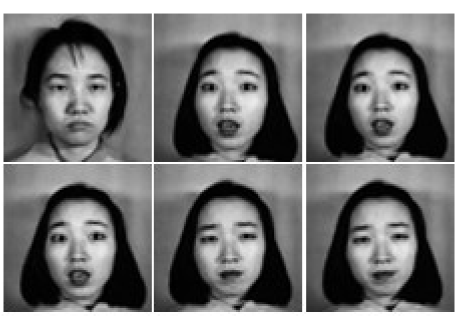

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Fig. A.3: parts of UMIST database

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