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Face recognition using Zernike moments and Radon transform

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Abstract--The global and local features play important and different roles in face recognition system. This paper proposes hybrid face recognition technique including radon transform and Zernike. Radon transform utilized to provide local features, while, Zernike moments utilized to capture global features. In this work the advantages of both Zernike moment and Radon transform are exploited. Extensive experiments are carried out using different standard face database such ORL, JAFEE and UMIST which are contain large variability in facial expression, pose and illumination. The experimental analysis refers that the proposed method outperform both Zernike moment and radon transform under different variations conditions such as pose, facial expression, and image noise.

Keyword--Face Recognition, Radon Transform, Zernike Moments, global features, local features.

I. INTRODUCTION

The importance of face recognition domain is increases by the time, because of its complexity and its numerous applications in various fields like digital library, control access, real time identification of face images in surveillance video, security in different building, criminal identification, and authentication in different organization and different economic and military fields. Face recognition problem suffer from many challenges which are illumination, facial expression, and pose variations. Face recognition system consist of three main stages which are face extraction, feature capturing, and classification. The stage of feature capturing is very important because it influence the performance of the whole face recognition system. The existing feature capturing techniques fall into two types which are local and global based techniques. The first one provides local features about sub regions of the face image such as shapes of eyes, nose, mouth and distance between these. The main advantage of these methods is not affected by irrelevant information in the face image such as background and hair, but is sensitive to facial expression variation which is the most challenge in face recognition problem. The second approach provides global features about the whole face image. However their performance is affected by irrelevant elements.

Among the global methods the use of orthogonal moments is gaining momentum. Since faces may undergo geometric transformations such as rotation, scaling, translation, the orthogonal radial moments provide the desired characteristics of being invariant to such changes. On the other side radon transform used effectively in face recognition problem as feature extraction method. In the proposed method we have combined the features extracted by both Zernike moments and Radon transform in the same feature vector to exploit their advantages.

The rest of this paper is organized as follows: the related work is discussed in Section 2. An overview of radon transform is presented in Section 3. Section 4 describes Zernike moments. Section

5 explains the proposed method. Section 6 describes the databases used for experiments. Section 7 contains detailed experiments. The conclusions are discussed in Section 8.

II. RELATED WORK

Zernike moments (ZMs) are capable to capture distinct features. This is due to the fact that ZMs have attractive traits such as minimum redundancy, rotation invariance, good image reconstruction capability. Therefore, many face recognition methods based Zernike moments are existed in literature. Lajevardi and Hussain [1] used ZMs in facial expressions recognition under the conditions of rotation and noise. Farajzadeh et al. [2] compared the accuracy of orthogonal Fourier-Mellin moments pseudo ZMs, ZMs and orthogonal Furrier- Mellin moments(OFMMs) in face recognition system. They indicated that the ZMs is outperform both pseudo ZMs and OFMMs. Zhi and Ruan [3] used ZMs, wavelet moments, Hus moments and Krawtchouk moments as feature extraction methods in facial expression recognition system. They compared performance and characteristics of the above methods and they indicated that wavelet moments are better than other moment invariant methods. Nor'aini et al. [4] investigated the performance of ZMs at different orders in face recognition system. They also in [5] compared the performance of different moment invariant methods in face recognition system. On the other hand combining the features captured by ZMs and other moment invariant methods in the same feature vectors leads to provide attractive features about the face image. Saradha and Annaduri [6] proposed hybrid feature extraction approach by combining the features of ZMs, Hu moments and Legendre in the same feature vector. They show that the hybrid feature extraction method outperform other moment methods in face recognition system. Most of the existed face recognition methods which used ZMs as feature extraction tool ignore the phase components, Li et al. [7] proved that the phase components provide significant features about the image. Singh et al. [8] investigated the performance of phase component of ZMs in face recognition system. They compare the performance of complex ZMs and ZMs. Their extensive experiments on different types of database indicated that complex ZMs achieve better recognition rate than that achieved using ZMs. Foon et al.[9] combined ZMs features with the coefficients of WT in the same feature vector. They show that higher order moments provide important features about face images. Bastani and Behbahani [10] used wavelet transform to reduce the computational time of the moment invariant methods.

Radon transform has been successfully used in face recognition applications due to two reasons: The first one, radon transform has the ability to provide directional features [11, 12]. The second one radon transform are capable to extract the features from noisy face image [13]. Yuhua and Xin [14] used threshold to select significant radon transform coefficients. Dargham et al. [15] investigated the effect of chainging step size for the angle and vector of radon transform on the recognition rate. Many researchers combined radon transform with other feature extraction methods to increase the accuracy of face recognition system. Jadhav and Holambe [16] applied 3 levels discrete wavelet transform on the radon transform coefficients to derive multi-resolution facial features. They also in [13] combined radon transform with discrete cosine transform to enhance the low frequency components and to reduce the redundancy in data. Karsili and Acan [17] used principle component analysis to project the radon transform coefficients into lower dimensional space and also to improve the performance of principle component analysis in the directional change.

III. RADON TRANSFORM

The concept of the radon transform presented by J. Radon and used by many researcher in different applications such as geophysics, radar imaging, non destructive special testing, medical imaging, and face recognition. Radon transform converts the image components into peaks by compute the image projections at the different angles. Each projection derived by compute multiple line integrals of the intensities along a set of parallel beams. The general equation of the 2D Radon transform can be defined as: [12]

$$R(r,\theta)[f(x,y)] = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\,\delta(r - x\cos\theta - y\sin\theta)\,dx\,dy \tag{1}$$

Where $\delta\ (\cdot)$ is the *delta* function with value not equal zero only for argument equal 0, $\theta \in [0,\pi]$ is the angle of incidence of the beams. r is the perpendicular distance of the beam from the origin and can be compute as follows:

$r = x\cos\theta + y\sin\theta$, $r \in [-\infty,\infty]$.

The discrete approximation of 1 can be defined as:

$$R(r,\theta) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\,\delta(r - x\cos\theta - y\sin\theta) \tag{2}$$

IV. ZERNIKE MOMENTS

The function of ZMs is a set of orthogonal Zernike polynomials defined over the polar coordinate space in a unit circle. The ZMs of an image function $f(r, \theta)$ with order p and repetition q are given as: [8]

$$A_{pq} = \frac{p+1}{\pi}\iint_{x^2+y^2\le 1} f(x,y)V_{pq}^{*}(x,y)dxdy \tag{3}$$

where the image function $f(x,y)$ is defined over discrete square domain $N \times N$ and $V_{pq}^{*}(x,y)$ are the complex conjugate of the Zernike polynomials (ZPs), $V_{pq}(x,y)$ given by:

$$V_{pq}(x,y) = R_{pq}(r)e^{jq\theta} \tag{4}$$

Where p is a non-negative integer, $0 \le |q| \le p$, $j = \sqrt{-1}$, $p-|q| = even$, $\theta = \tan^{-1}(y/x)$, $\theta \in [0,2\pi]$ and $r = \sqrt{x^2+y^2}$.

The radial polynomials are expressed as:

$$R_{pq}(r) = \sum_{s=0}^{(p-|q|)/2} \frac{(-1)^s (p-s)!\,r^{p-2s}}{s!\left(\frac{p-|q|}{2}-s\right)!\left(\frac{p+|q|}{2}-s\right)!} \tag{5}$$

The discrete approximation of (3) is defined as:

$$A_{pq} = \frac{p+1}{\pi}\sum_{i=0}^{N-1}\sum_{k=0}^{N-1} f(x_i,y_k)\ V^{*}{}_{pq}(x_i,y_k) \tag{6}$$

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Where ($X_i = \frac{2i+1-N}{N\sqrt{2}}$, $y_k = \frac{2k+1-N}{N\sqrt{2}}$) for the Circle containing the whole image While ($X_i = \frac{2i+1-N}{N}$, $y_k = \frac{2k+1-N}{N}$) for inscribed circle within the image.

The inverse of Zernike moments function used to reconstruct the image as follows:

$$\hat{f}(x_i, y_j) = \sum_{p=0}^{p_{max}} \sum_{q=-p}^{p} A_{pq} V_{pq}(x_i, y_j) \tag{7}$$

Where p_{max} is the maximum order of moments.

V. PROPOSED METHOD

Zernike moments are powerful feature extraction technique, but are sensitive to noise. The effect of the noise on the performance of Zernike moments is increased whenever Zernike moments and other global moments are used to differentiate between very similar images [18]. The most important traits of radon transform that its capability to capture the lines from noisy image and also it capable to provide directional features. However, radon transform can not provide by itself sufficient information for recognition task[12]. Therefore, in our proposed method we have combined the features provided by Zernike moments and radon transform in the same feature vector to exploit their advantages in face recognition system.

The proposed method works as follows:

a. Transform the face image to Radon space $R = (r, \theta)$
b. Compute the histogram of radon transform coefficients
c. Capture the global features of the face image by apply Zernike moments.
d. Combine the features provided by both Zernike moments and Radon transform in the same feature vector. The above steps applied on the training and test images
e. estimate the distance between training and test images. For this purpose we have used Euclidian distance. Figure 1 presented the proposed method's block diagram.

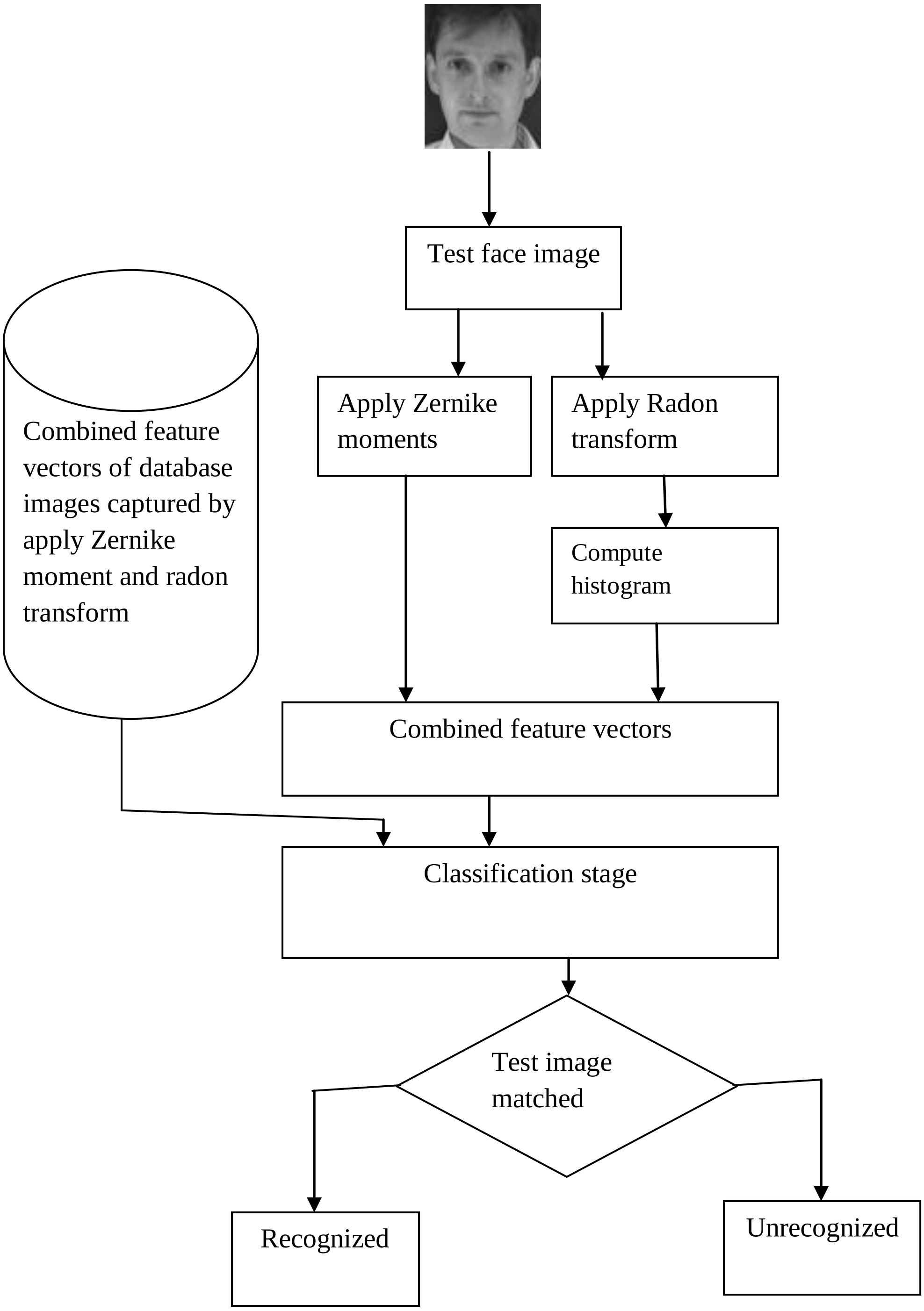

Fig.1. Proposed method's block diagram.

VI. DATABASES USED FOR EXPERIMENTS

In our experiments we have used different types of face database we can explain them as follows:

a) ORL: contains 40 subjects. Each subject includes 10 different variations like pose, scales, illumination, facial expression, and little bit of rotation. Therefore it consist of 400 images.

b) JAFFE: consist of 10 Japanese female subjects with total of 213 face images. Each subject has 2-4 examples of seven facial expressions like disgust, surprise, angry, fear, happy, and natural. The total

c) UMIST: contains 564 frontal to profile images distributed on 20 subjects. each subject has different pose view from profile to frontal with pose angles between -90 to 0. To reduce the dimensionally we normalized the size of the above database to 64x64 pixels. Figure2 shows parts of the above databases.

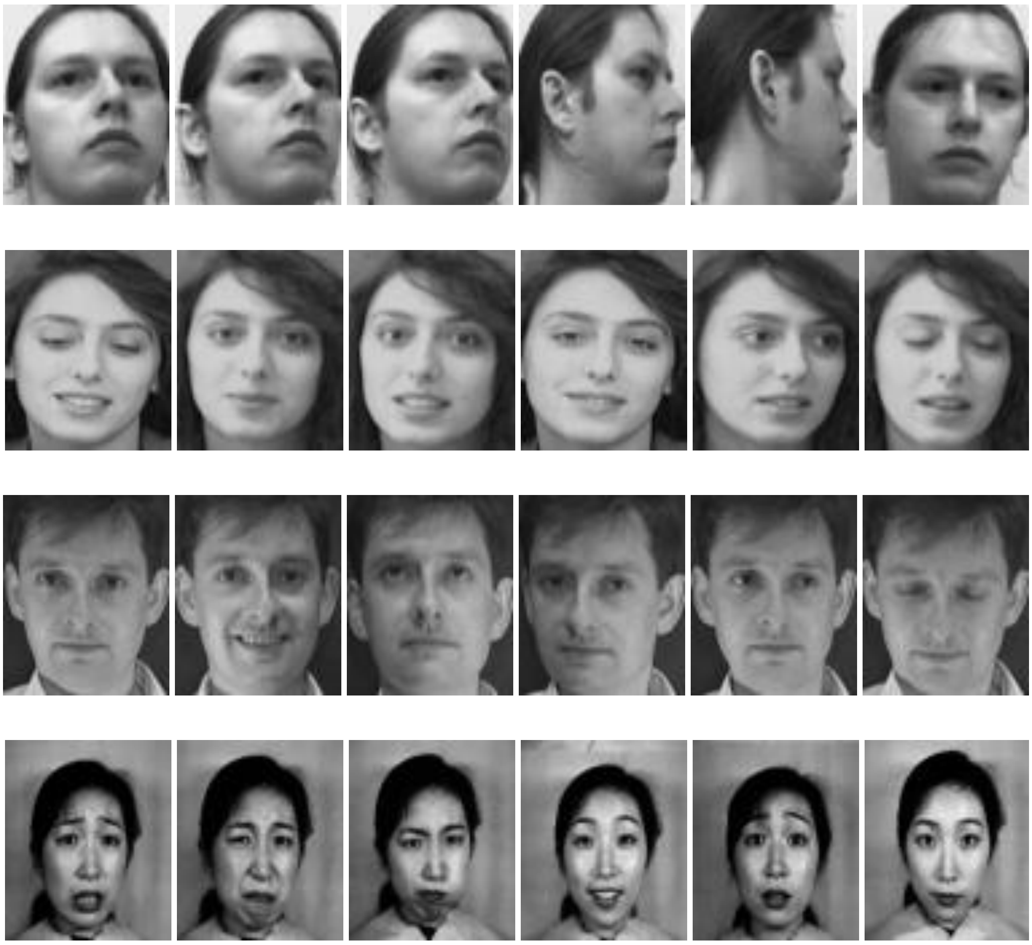

Fig.2. Parts of the JAFFE, ORL and UMIST databases.

VII. EXPERIMENTS RESULTS

We conduct extensive experiments on the above mentioned databases to assess the accuracy of the proposed approach for facial and pose variations in face recognition system. Furthermore, we investigate the impact of the noise on the accuracy of the proposed approach. We also compared the accuracy of the proposed approach with the accuracy of both Zernike moments and radon transform. The proposed method is implemented in Microsoft V C++ 6.0 using a I5-PC and 4GB RAM.

7.1. PROPOSED METHOD EVALUATION UNDER POSE VARIATION

In this section we investigate the robustness of the proposed approach against pose variation. 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 fro testing. Figure3 display the training and testing images. The results of this experiment are showed in Table1. The analysis of these results indicated that the proposed approach is better than both Zernike moments and radon transform under the condition of pose variation

Figure3. (a) Training image, (b) Testing image.

Table1: Recognition rates of proposed approach and ZMs and radon transform over pose variation

Method	Recognition rate
Proposed method	92.5%
Radon transform	90%
ZMs	87.5%

7.2 PROPOSED METHOD EVALUATION 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. It is noticed that the proposed approach achieve better recognition rates than that achieved using Zernike moments and radon transform. On the other hand the recognition rates achieved using radon transform is better than that achieved using Zernike moments. This is due to the fact that the process of computing the projections in radon transforms leads to preserve the variations in the intensity values. This trait improves the accuracy of the proposed method in recognize face image under the condition of facial expression variations as mention by the results in Table2

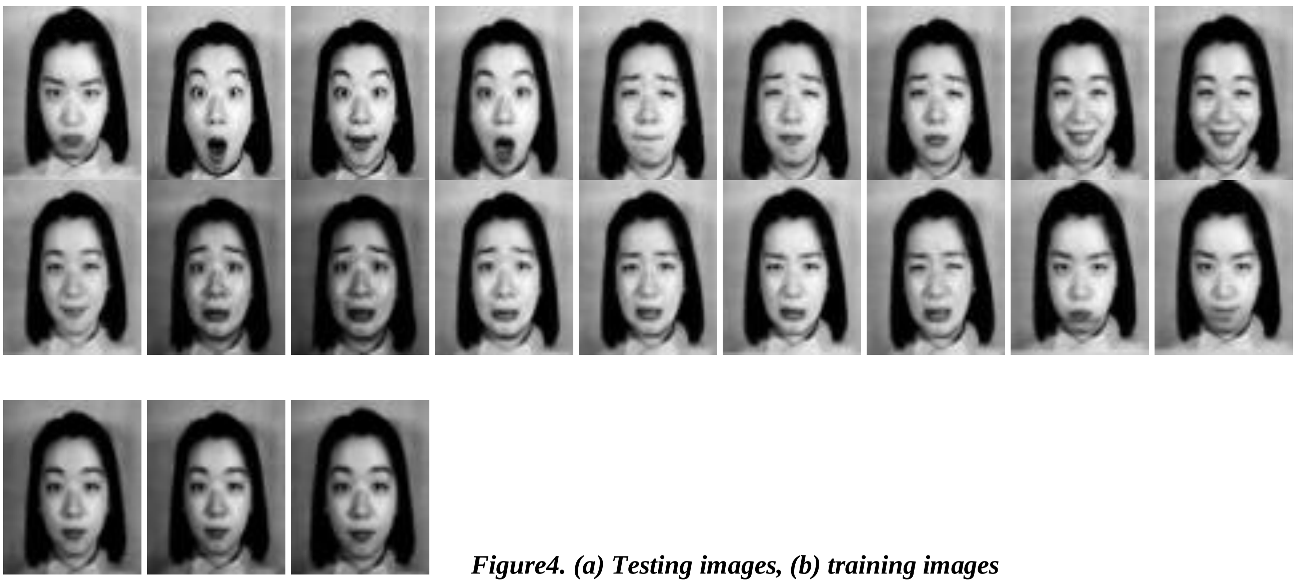

Figure4. (a) Testing images, (b) training images

Table2: Recognition rate achieved using proposed method and Zernike moment and radon transform under the condition of facial expression variation

Method	Recognition rate
Proposed method	97.6%
Radon transform	95.3%
Zernike moments	94%

7.3 PROPOSED METHOD EVALUATION UNDER NOISE VARIATION

The impact of image noise on the proposed method is evaluated in this section by conducting experiments on ORL database. In these experiments we randomly selected five images for the training and remain five images for the test. We add white mean zero noise to the test images. Figure.5 shows the face image before and after adding noise. Table 3 presented the results of these experiments. It is noticed that radon transform and the proposed method are less sensitive to image noise than ZMs because they are able to capture distinct features from the noisy image.

Fig.5 (a) face image before adding noise (b) Noisy image with SNR 15dB (c) Noisy image with SNR 12dB (d) noisy image with SNR 7dB

Table3: The recognition rate versus the noise

Method	No noise	Image SNR 15dB	Image SNR 12dB	Image SNR 7dB
Proposed method	96.5%	96.5	96.5	96
Radon transform	90%	90%	90%	89.7%
ZMs	94%	93.5%	92.5%	91.3%

VIII. CONCLUSIONS

The proposed approach combined the characteristics of both ZMs and radon transform. ZMs as feature extraction method provides strong global features about the face image but are not capable to provide accurate local features and also are sensitive to the noise. Radon transform capable to extract accurate features from noisy image and provides local directional features, and also capable to preserve the variation in the intensity values during the computation of the projections .The proposed method exploit the above advantages for both radon transform and ZMs. The experiments indicated that combining the features of both ZMs and radon transform in the same feature vector leads to reduce their disadvantages and provides good features have the ability to recognize the face image under the conditions of facial expression and pose variations, and also efficient to recognize noisy image.

REFERENCES

[1] S. M. Lajevardi and Z. M. Hussain, “higher order orthogonal moments for invariant facial expression recognition”, Digital Signal Processing, vol.20, pp.1771-1779, 2010.

[2] N. Farajzadeh, K. Faez and G. Pan, “Study on the performance of moments as invariant descriptors for practical face recognition systems”,IET, vol.4, pp.272-285, 2010.

[3] R. Zhi and Q. Ruan, “A Comparative Study on Region-based Moments for Facial Expression Recognition”, Image and Signal Processing, vol.2, pp.27-30, 2008.

[4] A.J. Nor’aini, P. Raveendran and N. Selvanathan, “Human Face Recognition using Zernike moments and Nearest Neighbor classifier”, Conference on Research and Development , Shah Alam, Selangor, MALAYSIA, 27-28 June, 2006.

[5] A.J. Nor’aini, P. Raveendran, N. Selvanathan “A Comparative Analysis of Zernike moments and Principal Component Analysis as Feature extractors for Face Recognition”, Biomed 06, IFMBE Proceedings 15, pp. 37-41, 2007

[6] A. Saradha and S. Annaduri, “A Hybrid Feature Extraction Approach for Face Recognition Systems”, ICGST’s GVIP Journal, vol.5, issue. 5, pp. 23-30, 2005.

[7] S. Li, M. Lee and C. Pun, “Complex Zernike Moments Features for Shape-Based Image Retrieval”, IEEE, vol.39, no.1, pp.227-237, 2009.

[8] C. Singh, N. Mittal and E. Walia, “Face recognition using Zernike and complex Zernike moment features”, Pattern recognition and image analysis, vol.21, pp.71-81, 2011.

[9] N. Foon, Y. Pang, A. Jin and D. Ling “An Efficient Method for Human Face Recognition Using Wavelet Transform and Zernike Moments “, Proceedings of the International Conference on Computer Graphics, Imaging and Visualization (CGIV’04), pp.65-69,204

[10] A. Bastani and E. F. Behbahani, “An Efficient Feature Extraction with Orthogonal Moments and Wavelet Transform for Human Face Recognition System”, European Journal of Scientific Research, vol.52, pp.313-320, 2011.

[11] G.Y. Chen, T.D. Krzyzak “Invariant pattern recognition using radon, dual-tree complex wavelet and Fourier transforms”, Pattern Recognition, vol. 42, pp.2013-2019, 2009.

[12] E. Magli, G. Olmo and L. Lo Presti, “Pattern recognition by means of the Radon transform and the continuous wavelet transform” , Signal Processing, vol.73, pp. 277-289, 1999.

[13] Dattatray V. Jadhav _, Raghunath S. Holambe, “Radon and discrete cosine transforms based feature extraction and dimensionality reduction approach for face recognition”, Signal Processing, vol.88, pp. 2604– 2609, 2008.

[14] Z. Yuhua and W. Xin “Study of Finite Radon Transform in Face Recognition”, Second International Conference on Computer Modeling and Simulation. pp. 29-32, 2010

[15] J. Dargham, A Chekima and E. Moung Sigeru Omatu “Radon transform for face recognition” Artif Life Robotics 15:359–362, 2010.

[16] Dattatray V. Jadhav and Raghunath S. Holambe , “Feature extraction using Radon and wavelet transforms with application to face recognition”, Neurocomputing, vol.72 pp.1951–1959, 2009

[17] L. Karsili and A. Acan, “A Radon Transform and PCA Hybrid for High Performance Face Recognition “,2007 IEEE International Symposium on Signal Processing and Information Technology, pp.246-251.

[18] D. Shen and H. H.S. IP, “Discriminative wavelet shape descriptors for recognition of 2-D patterns, Pattern Recognition,” vol.32, pp.151-165, 1999.