ISSN:0975-9646

Face Recognition under Pose Variations

Jagdish P. Sarode and Alwin D. Anuse

Dept. of E & TC Engineering,
Maharashtra Institute of Technology,
Pune, India

Abstract -A Face Recognition system is computer application for automatically identifying or verifying a person from a digital image or a video frame. Due to the change of lighting condition, expression, occlusion, rotation, etc. the human face appearance could change considerably. In this project a model based approach is used. In this approach the Moment based feature extraction techniques (Hu's Moments and Zernike Moments) are implemented on two different face databases containing different poses of the face. Extracted feature are classified by kNN classifier and Correct Recognition Rate is calculated.

Keywords: Face recognition, Pose Variation, Model Based Approach,Feature Extraction, Hu's Moments, Zernike Moments, kNN classifier.

INTRODUCTION

A computer application used for automatically identifying and /or verifying a person from a digital image or a video is called a Face Recognition. In personal security and access control applications use of biometrics is the need of hour. Commonly used biometric methods are Voice, Iris, Face, and Fingerprint recognition. Among these methods, Face Recognition provides a more direct, friendly and convenient identification method and it is more acceptable to users as compared to other biometric methods. Because of variation in face pose angle, illumination, expression and occlusion there are many challenges in face recognition. Face appearance changes drastically with change in facial pose because of misalignment as well as hiding of many facial features and hence recognition of faces under pose variations has proved to be a difficult problem. Face recognition under pose variations refers to recognizing face images of different poses. Face recognition rates are very poor when one tries to match images of different poses of same person using any well known recognition technique. A pose tolerance technique is needed because most of the time, for matching purpose of each test face under recognition, there exists only a one corresponding image of frontal face in data base. Hence, generation of either the frontal face image or the frontal face features from the non-frontal face image is necessary. With the help of day to day experience, human beings learns some kind of transformation between different posed face images because of this learning ability of human it is very easy for them to recognize faces in varying poses. To generate front face features there is a need to obtain such a transform through learning and finally transformation is used. This paper deals with the generation of features of a frontal face from the features of a different pose image. Then the generated frontal features are matched with the database image's features. Feature vector of two different posed images are related by a linear transformations using the assumptions of the Linear Object Class [1]. For feature extraction, moment based techniques are used. Moments finds simple properties of image such as image's area, centroid and information about its orientation. Feature vectors are obtained for the images in frontal and a non-frontal poses [11].

A regression technique can be used because of linear transformation between the features which is used to obtain frontal face features of non-frontal probe images for matching [1]. In the field of face recognition past studies show that the biggest challenge is to reliably recognize people in the presence of image/object variations that occur naturally in our daily life. In practical applications head pose variations is extremely important. Rotation, scaling and lighting variations are major challenges in face recognition.For tackling the pose variation problem various algorithms are developed from last 30 years.J. Kumar, Aditya Nigam, Surya Prakash and Phalguni GuptaClassifies the face recognition approach by three general approaches (i) Model based approach (ii) Appearance based approach and (iii) 3D based approach [1].Shan Du, Rabab Ward classifies the algorithm to tackle the pose variations in following categories (i) The invariant feature extraction based approach (ii) The multiview based approach and (iii) 3D range image based approach.[4].R. Rajlakshmi, M. K. Jeyakumar review/ discuss the face recognition by using different classifiers and the feature extraction methods as a) Face recognition using ICA b) Face recognition using Pose estimation and shadow compensation c) Face Recognition based on Hybridization process d) Face Recognition across pose illumination and e) Face Recognition by Histogram fitting and AAM (Active Appearance Method) [3]. H. Zhou, A. H. Sadkahas combined Gabor features within the scope of diffusion-distance calculation. This strategy starts from the Gabor filtering that consists of three scales and six orientations. It is followed by the calculation of diffusion distance based on a Bayesian model. The recognition rate of the proposed algorithm reduces while handling the occlusions due to dramatical pose changes [5].Z. Liu, J Yang, C. Liu use fusion of color, local spatial and global frequency information for face recognition. In this method the multiple features of input image are obtained by hybrid color space, the Gabor image representation, the local binary patterns (LBP) and the discrete cosine transform (DCT) [6].

Model based approach extracts geometrical parameters, also called as moments of the image. It is used for dimensionality reduction of the feature vector. Generally, different geometrical parameters (Moments) of the image's are image area, centroid and information about its

orientation. The different models used in this approach are Active Appearance Model (AAM), active Shape Model (ASM) and Elastic Bunch Graph Model (EBGM). These models create and deform the generic face model to match with the input image; feature vectors obtained from the face model are used for classification.

Appearance based approach uses pixel intensity or intensity derived parameters for face recognition. To cope with the problem of dimensionality reduction two classical approaches are used one is Principle Component Analysis (PCA) and other is Multiple Decrement Analysis (MDA). Gabor filters are also use for feature extraction. Transfer feature vector of posed image to frontal face image are stored in the data base.For classification matching techniqueslike Euclidian distance etc. are used [1].

The above approaches are having some drawbacks. In model based approach manual intervention is required for deciding landmarks on the image. It is also computationally intensive approach. In appearance based approaches, calculation of accurate transformation is critical. Because of multicollinearity and hetroscedasticity least Square technique does not perform well. Multicollinearity arises because of highly correlated predictor variables in a regression model. 3D models require more images of subject in different pose and it is computationally intensive and time consuming [1].

FACE RECOGNITION SYSTEM FLOW CHART

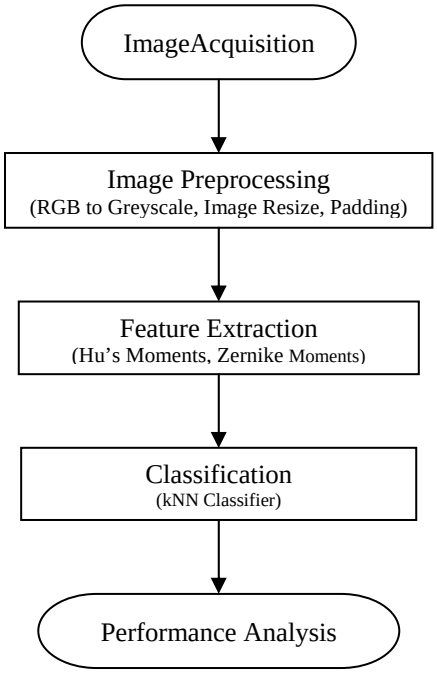

Fig.1Face recognition System flow chart

Flow chart of face recognition system is given in figure 1. In the preprocessing stage RGB to greyscale conversion, image resizing and padding operations are done. For feature extraction Hu moments and 4^{th} and 8^{th} order Zernike moments are used respectively. Hu moments feature vector contents seven moments and 4^{th} order Zernike moments gives feature vector of nine moments where as 8^{th} order Zernike moments gives a vector of twenty five moments. kNN classifier with k = 1 is used to classify the face images. For AT&T database out of the ten orientations eight are used for training purpose and two are used for testing purpose. For Indian Face Databaseout of the eleven orientations, eight are used for training purpose and three are used for testing purpose.

FACES DATABASES

AT&T Database of Faces

AT&T Database of Faces [9], (It was also called as 'The ORL Database of Faces'), contain a set of face images taken at AT&T laboratory. This database contains forty distinct individual and for each individual there are ten different images. For some individual, these images were captured at different times, with different light conditions and also for different facial expressions like open/closed eyes, different smiles and with glasses or no glasses. All the images were captured on dark background with the subjects in an upright, frontal position. The files are in PGM format. The each image is of 256 grey levels per pixel [9].

Fig. 2 Subject of AT&T Face database [9]

Fig. 3 Different orientations of a particular Subject [9]

Indian Face Database

(Indian Institute of Technology Kanpur)

This database is created in campus of Indian Institute of Technology Kanpur. This database contains images of 40 distinct subjects having eleven different poses for each person. Imagescaptured on bright homogeneous background and the subjects are in an upright, frontal position. For each individual, following looking poses are

captured: front, left, right, up, up towards left, up towards right, down, laughter,neutral, sad/disgust,smile. The files are in JPEG format [10].

Fig. 4 Subject of Indian Face Database (Females) [10]

Fig. 5 Different orientations of a particular Subject [10]

Fig. 6 Subject of Indian Face Database (Males) [10]

Fig. 7 Different orientations of a particular Subject [10]

Table 1 Summary of Database used for Testing

	AT&T Database	Indian Face Database (IIT Kanpur)
Total Persons	40	56 (22 Female + 34 Male)
Poses / Person	10	11
Poses used for Training	8	8
Poses used for Testing	2	3

Summary of database used for testing is shown in table 1.

FEATURE EXTRACTION

It is a dimensionality reduction technique. In this project Hu's Moments and Zernike Moments are used for feature extraction.

Hu's Moments:

Hu, in 1962 introduced 'Hu moments' which are invariant to translation, scale as well as rotation. Hu moments are a set of seven moments which are nonlinear combinations of normalized central moments up to order three Authors and Affiliations

Algorithm for Feature Extraction by using Hu's Moments:

1. Start
2. Acquire the image
3. Convert colored image to grayscale image
4. Calculate Geometrical Central Moments

$$\boldsymbol{m_{pq}} = \sum_{x=1}^{M} \sum_{y=1}^{N} \boldsymbol{x^p\ y^q\ f(x,y)} \qquad (1)$$

Where $\boldsymbol{m_{pq}}$ is the moment of order *(P+Q)*, *p,q* = 0,1,2,… and *M*x*N* is size of image

5. Calculate Normalized Central Moments

$$\boldsymbol{m_{pq}} = \sum_{x=1}^{M} \sum_{y=1}^{N} (\boldsymbol{x} - \overline{\boldsymbol{x}})^{\boldsymbol{p}}\ (\boldsymbol{y} - \overline{\boldsymbol{y}})^{\boldsymbol{q}} \boldsymbol{f(x,y)} \qquad (2)$$

Here $\overline{\boldsymbol{x}}$ and $\overline{\boldsymbol{y}}$ are the centroids of the image and are defined by:

$$\overline{\boldsymbol{x}} = \frac{\boldsymbol{m_{1,0}}}{\boldsymbol{m_{0,0}}} \quad \text{and} \quad \overline{\boldsymbol{y}} = \frac{\boldsymbol{m_{0,1}}}{\boldsymbol{m_{0,0}}} \qquad (3)$$

Above central moments are origin independent and hence they are translation invariants. For scale invariance divide corresponding central moment by 00^{th} moment i.e. scaled energy of the original moment as given in equation (4)

$$\boldsymbol{\eta_{ij}} = \frac{\boldsymbol{\mu_{ij}}}{\boldsymbol{\mu_{00}}^{\left(1+\frac{i+j}{2}\right)}} \qquad (4)$$

6. Calculate Seven Moments Invariants using Normalized Central Moments given by equation (4).

$M_1 = \eta_{20} + \eta_{02}$

$M_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2$

$$M_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2$$
$$M_4 = (\eta_{30} - \eta_{12})^2 + (\eta_{21} - \eta_{03})^2$$
$$M_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$

$$M_6 = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})$$

$$M_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] - (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \quad (5)$$

7. Combine these Seven Invariants to form the feature vector of the image
8. Stop
9.

Zernike Moments (ZM):

Zernike in 1934 introduced a set of complex polynomials called the Zernike polynomials. These polynomials form a complete orthogonal basis set defined on the interior of the unit disc, i.e., $x^2 + y^2 = 1$.ZM is geometrical orthogonal moments. Orthogonal moments are rotation as well as scale invariants and very robust in the presence of noise.

Algorithm for Feature Extraction by using Zernike Moments:

1. Start
2. Define the order and repetition of the moment
3. Acquire the image
4. Convert colored image to grayscale image
5. Resize image to 120 x 120 pixels
6. Converts the intensity image I to double precision
7. Calculate the Radial Polynomial using

$$V_{nm}(x, y) = \sum_{s=0}^{(n-|m|)/2} \frac{(-1^s)\left((x^2+y^2)^{\frac{n-2s}{2}}(n-s)!\right)}{s!\left(\left(n+\frac{|m|}{2}\right)-s\right)!\left(\left(n+\frac{|m|}{2}\right)-s\right)!} \quad (6)$$

8. Calculate Zernike Moments using

$$Z_{nm} = \frac{n+1}{\Pi}\sum_{x=-1}^{1}\sum_{y=-1}^{1} f(x, y)V^*_{nm}(x, y) \quad (7)$$

9. Combine these invariants to form feature vector of the image.
10. Stop.

RESULTS

Table 2 shows the result of Face Recognition System by using Hu's Moments

Table 2: Correct Recognition Rate by Hu's Moments

Method	Data Base	Correct Recognition Rate	Average Correct Recognition Rate
Hu's Moments	ORL	32.50%	31.03 %
	IIT K (Male)	33.33%	
	IIT K (Female)	27.27%	

Table 3 shows the result of Face Recognition System by using Zernike Moments

Table 3: Correct Recognition Rate by Zernike Moments

Method	Database	Correct Recognition Rate	Avg. Correct Recognition Rate
4th Order Zernike Moments	ORL	72.50 %	78.44 %
	IIT K (Male)	76.47 %	
	IIT K (Female)	86.36 %	
8th Order Zernike Moments	ORL	77.50 %	78.09 %
	IIT K (Male)	76.47 %	
	IIT K (Female)	80.30 %	

GRAPHICAL REPRESENTATION OF RESULTS

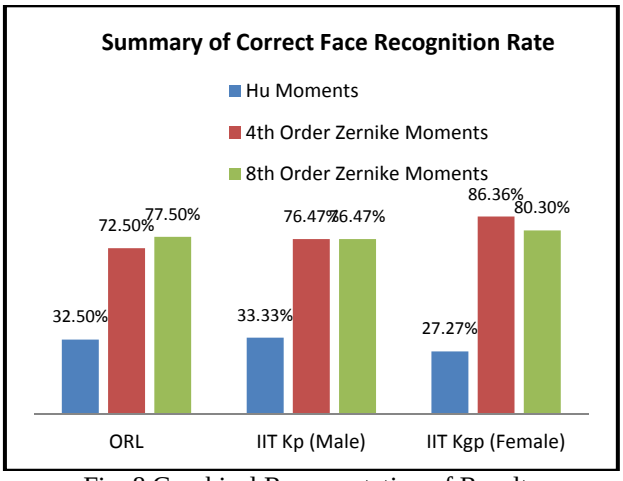

Fig. 8 Graphical Representation of Results

Table 4: Summary of the face recognition experiment

Method	Data base	No. of Persons	Poses/ Persons	No. of Training Images	No. of Moments / Pose	Recog-nition Rate (%)
Hu's Mom-ents	ORL	40	10	8	7	32.50
	IIT Kp. (Male)	34	11	8	7	33.33
	IIT Kp. (Female)	22	11	8	7	27.27
4th Order Zernike Mom-ents	ORL	40	10	8	9	72.50
	IIT Kp. (Male)	34	11	8	9	76.47
	IIT Kp. (Female)	22	11	8	9	86.36
8th Order Zernike Mom-ents	ORL	40	10	8	25	77.50
	IIT Kp. (Male)	34	11	8	25	76.47
	IIT Kp. (Female)	22	11	8	25	80.30

CONCLUSION

In this paper face recognition using moments has been presented. Three experiments were conducted using Hu moments, 4^{th} order Zernike moments and 8^{th} order Zernike moments. Features were extracted using these methods. kNN classifier is used for classification. From the experimental results it was observed that face recognition rate using Hu moments is 31.03%, using 4^{th} order Zernike moments is 78.44% and using 8^{th} order Zernike moments is 78.09%. The performance of Hu's moments are not satisfactory and can't be used for face recognition. Result of Zernike moments are good and can be used for face recognition.

REFERENCES

[1] Jeet Kumar, Aditya Nigam, Surya Prakash, Phalguni Gupta, "**An Efficient Pose Invariant Face Recognition System**", International Conference on Soft Computing for Problem Solving (SocProS 2011) December 20-22, 2011. Vol. -2, pp 145-152, Online ISBN 978-81-322-0491-6.

[2] Rajiv Kapoor, PallaviMathur, "**Face Recognition using Moments and Wavelets**", International Journal of Engineering and Applications (IJERA) Vol. 3, Issue 4, Jul – Aug 2013, pp. 82 – 95 (ISSN:2248 – 9622)

[3] R. Rajalakshmi, M. K. Jeyakumar, "**A Review on Classification used in Face Recognition Methods under Pose and Illumination Variation**", International Journal of Computer Science Issues (IJCSI), Vol 9, Issue 6, No 2, November 2012, (ISSN:1694-0814)

[4] Shan Du, Rabab ward, "**Face Recognition under pose variations**", ScienceDirect, Journal of the Franklin Institute 343 (2006) 596 – 613

[5] H. Zhou, A. H. Sadka, "Combining perceptual features with diffusion distance for face recognition", IEEE Transactions on systems, man and cybernetics part C: applications and reviews, 41(5), 2011, 577-588.

[6] Z. Liu, J. Yang, C. Liu, "Extracting Multiple Features in the Cid color space for face recognition", IEEE Transactions on image Processing, 19(9), 2010, 2502-2509.

[7] http://omega.albany.edu:8008/

[8] http://crsouza.blogspoy.in/2010/03/kernel-function-for-machine-learning.html

[9] www.cl.cam.ac.uk/research/dtg/attarchive/facedatabase.html

[10] Vidit Jain, Amitabha Mukherjee. **The Indian Face Database**.http://vis-www.cs.umass.edu/~vidit/IndianFaceDatabase

[11] Simon Xinmeng Liao, "Image analysis by moments", the department of electrical and computer engineering, the University of Manitoba Winnipeg, Manitoba, Canada, 1993.