Research Journal of Recent Sciences ISSN 2277-2502
Vol. **2(5),** 10-14, May **(2013)** *Res.J.Recent Sci.*

Sub-Holistic Hidden Markov Model for Face Recognition

Muhammad Sharif, Jamal Hussain Shah, Sajjad Mohsin, Mudassar Raza
Department of Computer Sciences, COMSATS Institute of Information Technology, Wah Cantt., 47040 PAKISTAN

Available online at: www.isca.in
Received 10th October 2012, revised 14th November 2012, accepted 2nd February 2013

Abstract

In this paper, a face recognition technique "Sub-Holistic Hidden Markov Model" has been proposed. The technique divides the face image into three logical portions. The proposed technique, which is based on Hidden Markov Model (HMM), is then applied to these portions. The recognition process involves three steps i.e. pre-processing, template extraction and recognition. The experiments were conducted on images with different resolutions of the two standard databases (YALE and ORL) and the results were analyzed on the basis of recognition time and accuracy. The accuracy of proposed technique is also compared with SHPCA algorithm, which shows better recognition rates.

Keywords: Face, recognition, 2D, image division, hidden Markov model, sub-holistic.

Introduction

Biometrics is usually used in pattern recognition system where a person is recognized by his/her unique identity. This unique identity may derive from physiological or behavioural traits of any individual. The collection of feature vector data of unique identity is stored in the database. At this step the feature are being extracted. Biometric significance increases because of its emerging applications in different fields of relevance. Face recognition is one of the many applications of Biometrics under image processing. But it is difficult to make a system that is comparable to human intelligence. Irregular lighting, density, depth of the image, unwanted objects and the angle at which the image is captured are some of the factors that make image processing difficult.

Many techniques have been developed in the past half century for image recognition. Every technique has its own pros and cons, as few are fast but less accurate, whereas the others are very accurate but time consuming.

Face recognition algorithms and techniques were initially developed in the early 1960s. The main emphasis of the image processing and recognition approaches of that time was the geometry of the facial parts i.e. eyes, nose, ears and mouth. The distance between each facial part, and the angle at which it has been captured, were also catered while processing an image. This kind of system proposed by Kanade[1] in 1973 was one of the first approaches towards automated face recognition. Another traditional technique in face recognition is Template Matching[2].

The modern techniques include 2-Dimentional (2D) and 3-Dimentional (3D) image processing and recognition. Most common used in 2D techniques are Principal Component Analysis (PCA)[3], Eigen face method[4], Linear Discriminant Analysis (LDA)[5], Hidden Markov Model (HMM)[6-12] and the Dynamic Link Architecture (DLA)[13], whereas the 3D techniques use the 3D Face Recognition and 3D Morphological Operations[14-15] etc. In real time applications a lot of challenges arises such as occlusion, illumination, expression in face recognition many authors developed their own algorithms to dealt with these challenges such as Hu J. et al[6], Gernoth T. et al[16], Vu N.S. et al.[17], Heo J.[18], Prabhu U.H. et al[19], Gross R. et al[20] and Sharif M. et al[21].

But face recognition is subjected to many great challenges when it comes to its use in real time applications.

The paper introduces a technique based on Hidden Markov Model and Named "Sub Holistic Hidden Markov Model (SHMM)". In this technique, the face image is divided into three portions and then recognized through Hidden Markov Model.

Methodology

Proposed Technique: The proposed system is divided into three major steps. Figure 1 shows the steps of proposed system.

Preprocessing Module: The image which is to be tested should be similar to the one stored in the database. It will make sure that all images that are used for face recognition are entered in the system in a uniform manner (normalization). It means that whenever a face image is to be matched with the database for recognition, it has to be preprocessed first. The most important property of preprocessing module is face detection, so that the resulting face image is in its proper form for the next module that is extracting templates. The reason is that the extraction of horizontal strips, containing left eye, right eye and lips can easily be determined. Accurate and consistent preprocessing is one of the most important steps in developing a good face recognition system.

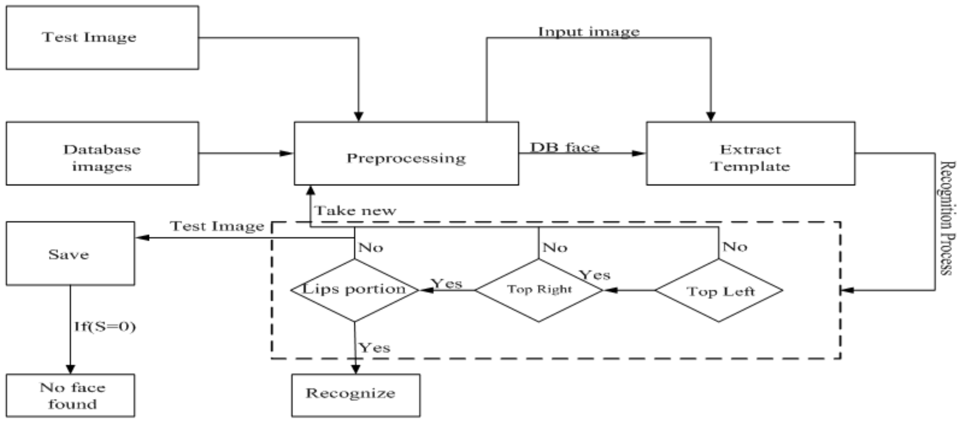

Figure-1
Flow Diagram of Proposed System

Taking pixel value as observation vectors could be a bit risky because of its sensitivity against image noise, image rotation and large dimension of observation vector, which results in a high computational complexity[7]. In preprocessing, the most important feature is training the database. The trained database is divided in such a way that all the top left quadrants of the image are kept in one database, top right quadrant and lips portion are in the other databases.

The quadrant of the same images stored in the trained database contains same index number. This feature has been shown in figure 2:

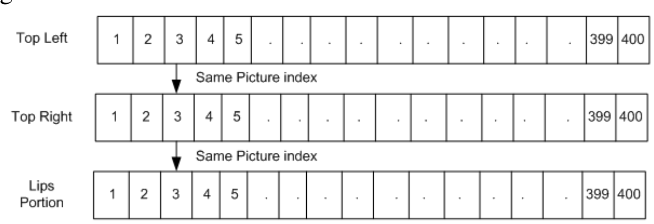

Figure-2
The extracted features are saved with same index number

The training process of top left, top right and lips portion is depicted in figure 3.

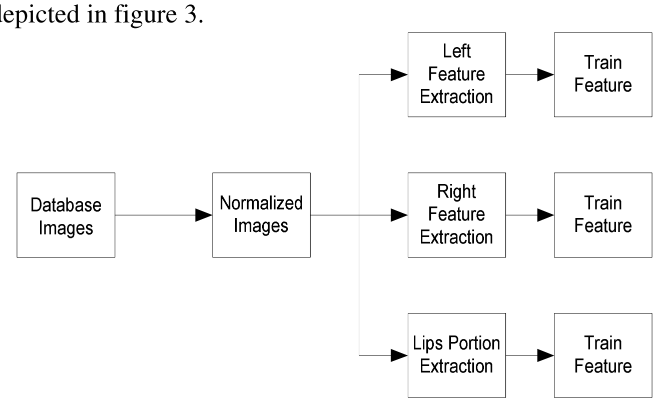

Figure-3
Training process of Database images

Extracting the Template Module: This module receives a normalized image from the preprocessed module. This module splits the input face into three portions (Top Left, Top Right and Lips portion). We have not used other sub-sets of the face which include unnecessary portions like background, nose etc as shown in figure 4.

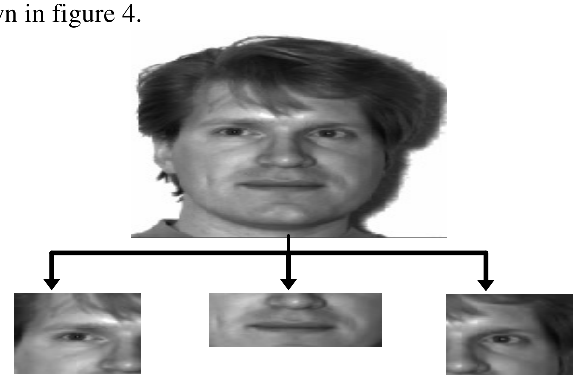

Figure-4
Extracted Template of Image

The main idea of face division comes from Hidden Markov Model (HMM) where HMM training scheme is used as an iterative process for clustering data. Initial parameters are obtained by using training data and prototype model. Main goal is to obtain the observation probability, for this, data is segmented uniformly and is matched with each model to extract the initial model parameter. Then by using Viterbi Algorithm, training observation cycles are segmented into states. This procedure is used by Takahashi Y. et al[10] for face recognition.

Recognition Module: The third and last module of the proposed technique is recognition process. In this, searching process starts by taking the top left quadrant of test image and match with the templates of corresponding quadrant in the trained images. If the match does not give satisfactory results, it would be considered as an error. If the match gives satisfactory results then it will move to next quadrant of the same image and hence the third quadrant will be matched in the same manner.

Results and Discussion

Standard databases (ORL and YALE) were used to obtain the Face Recognition Rate (FRR) against varying image resolution. Table 1 shows both databases resolutions that were used to obtain the results:

Table-1
Images Resolution of ORL and YALE Database

S.No.	Image Resolution	
	ORL	YALE
1	112 X 92	163 X 240
2	56 X 46	128 X 192
3	37 X 23	100 X 100
4	22 X 18	56 X 46
5	18 X 15	30 X 30

Experiment and Results based on Timing: The analysis was taken on the bases of recognition time per image (in seconds) as depicted in figure 5. As the resolution per image decreases, the recognition time varies accordingly, table 2 shows the varying image resolution of ORL and YALE database:

Table-2
Recognition Time Per image (seconds) against varying resolution (from table I)

Resolution	Recognition Time Per image(seconds)	
	ORL	YALE
1	0.124	0.172
2	0.11	0.144
3	0.093	0.11
4	0.089	0.109
5	0.07	0.091

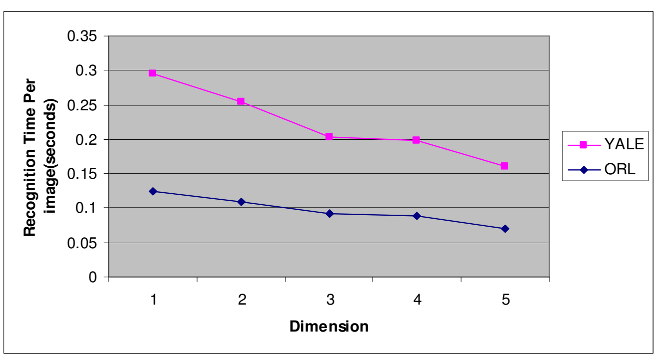

Figure-5
ORL and YALE Recognition Time Per image (seconds) against varying resolution. (from table I)

In order to calculate the recognition time, 24 images of various resolutions, as mentioned above in table 1 were taken from ORL database and 10 images were taken from YALE database. The resolution used is also mentioned in table 1 under the heading of image resolution. The combined results obtained from both the databases for recognition time are shown in table 3 and figure 6.

Table-3
Recognition Time (seconds) against varying resolution. (from table I)

Resolution	Recognition Time in Seconds	
	ORL Database	YALE Database
1	29.616	15.654
2	27.354	11.048
3	20.059	8.362
4	19.73	5.452
5	19.395	5.304

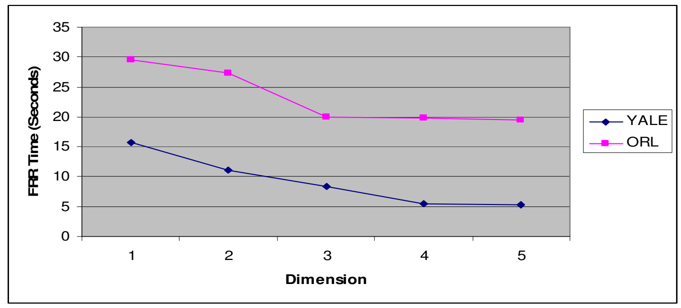

Figure-6
ORL and YALE Recognition Time (seconds) against varying resolution

Experiment and Results based on Recognition Rate: In order to calculate the recognition rate images were categorized under different resolutions, 112 X 92, 56 X 46, 37 X 23, 22 X 18 and 18 X 15 for ORL database. Each resolution consists of 8 sets of 400 images, each set is divided in such a way that first set contains first 50 images, second set contains 100, and third set contains 150 and so on up till 400 images. The combined Percentage recognition rate of each resolution is shown in table 4 and its respective figure 7.

Table-4
FRR (Percentage) of ORL at different resolution

Resolution	ORL FRR (Percentage)	
	No. of Failure	FRR (Percentage)
112 X 92	2	99.5%
56 X 46	3	99.25%
37 X 23	10	98.75%
22 X 18	15	97.5%
18 X 15	19	95.25%

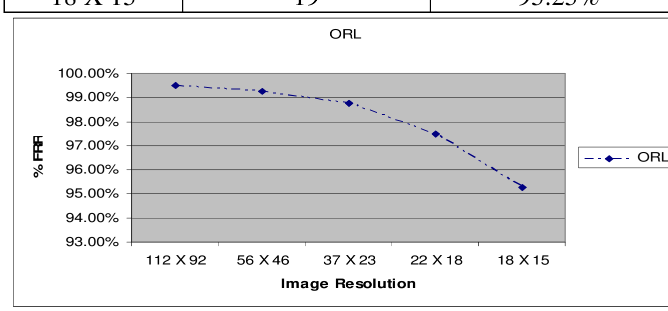

Figure-7
FRR (Percentage) of ORL at different resolution graph

Table 5 shows the dataset of YALE database of varying resolution listed ahead 163 X 240, 128 X 192, 100 X 100, 56 X 46 and 30 X 30. In this case 3 sets of images are formed, each sets is divided in such a way that first set contains first 5 images, second set contains 110, and third set contains 165. The combined Percentage recognition rate of each resolution is shown in figure 8.

Table-5
FRR (Percentage) of YALE at different resolution

Resolution	YALE FRR (Percentage)	
	No. of Failure	FRR (Percentage)
163 X 240	1	99.39%
128 X 192	1	99.39%
100 X 100	2	98.78%
56 X 46	6	96.36%
30 X 30	9	94.54%

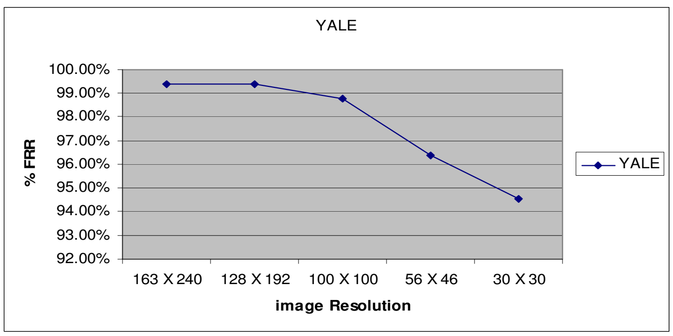

Figure-8
FRR (Percentage) of YALE at different resolution graph

Comparison of Proposed Technique with SHPCA: The proposed face recognition technique was tested and compared with Sub-holistic PCA (SHPCA)[16] under the condition of FRR (Percentage) and with timing. Five different resolutions of same database (ORL) were used for the comparison of proposed technique with the SHPCA. The results indicate that the proposed technique provides recognition rates of 99.5% at image resolution of 112 X 92 whereas SHPCA[7] achieved results of 94.5% at same resolution, remaining results are shown in table 6.

Table-6
FRR (Percentage) of SHHMM and SHPCA at different resolution of ORL Database

Resolution	ORL Database with SHHMM		ORL Database with SHPCA	
	No. of Failure	FRR (Percentage)	No. of Failure	FRR (Percentage)
112 X 92	2	99.5%	22	94.5%
56 X 46	3	99.25%	14	96.5%
37 X 23	10	98.75%	17	95.75%
22 X 18	15	97.5%	21	94.75%
18 X 15	19	95.25%	23	94.25%

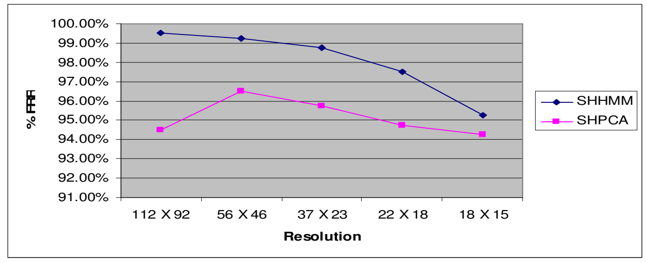

Figure-9
FRR (Percentage) of SHHMM and SHPCA at different resolution of ORL Database

Conclusion

The results were taken by using the proposed technique on different resolutions of ORL and YALE database. The process consists of dividing the face image into three quadrants namely top left, top right and lip portion. This division is beneficial to reduce the recognition time. Through analysis, it is concluded that when the resolution is reduce, the face has been losing its original data which is difficult to recognize and hence it generates much error rate in face recognition. The proposed technique handled these issues to some extent and produces the better results.

References

1. Kanade T., Picture processing by computer complex and recognition of human faces, doctoral dissertation, Kyoto University, **(1973)**
2. Levada A.L.M. Correa D.C., Salvadeo D., Saito J.H., Mascarenhas N., Novel approaches for face recognition: Template-matching using Dynamic Time Warping and LSTM neural network supervised classification, 15th International Conference on Systems, Signals and Image Processing, 241-244 **(2008)**
3. Turk M. and Pentland A., Face recognition using eigenfaces Proc. IEEE Conf. Comput. Vis. Pattern Recogn, 586-591 **(1991)**
4. Matthew A. Turk and Alex P. Pentland, Face recognition using eigenfaces. Proc. CVPR, 586-591 IEEE, June **(1991)**
5. Daniel L. Swets John Weng, Using Discriminant Eigenfeatures for Image Retrieval, IEEE Transactions on Pattern Analysis and Machine Intelligence Volume 18, Issue 8 **(1996)**
6. Hu J., Deng W. and Guo J., 2D projective transformation based active shape model for facial feature location, IEEE Conference Proceedings, 2442-2446 **(2011)**
7. Ara V., Nefian and Monson H., Hayes III, Hidden Markov Models for face recognition, IEEE International Conference on Acoustic Speech and Signal Processing **(1998)**

8. Wang H. and Cao Y., An HMM-Based Face Recognition Model under Variable Pose in Videos, Chinese Conference on Pattern Recognition (CCPR), 1-7 **(2010)**

9. Hu Y. and Liu B., Face Recognition Based on PLS and HMM, Chinese Conference on Pattern Recognition CCPR, 1-4 **(2009)**

10. Takahashi Y., Tamamori A., Nankaku Y. and Tokuda K., Face recognition based on separable lattice 2-D HMM with state duration modeling, IEEE International Conference on Acoustics Speech and Signal Processing (ICASSP), **(2010)**

11. Chien J. and Liao C., Maximum Confidence Hidden Markov Modeling for Face Recognition, IEEE Transactions on Pattern Analysis and Machine Intelligence, 606-616 **(2008)**

12. Kotropoulos C.L. Tefas A. and Pitas I., Frontal face authentication using discriminating grids with morphological feature vectors, IEEE Transactions on Multimedia, **2**, 14-26 **(2000)**

13. Berretti S., Del Bimbo A. and Pala P., 3D Face Recognition Using Isogeodesic Stripes, IEEE Transactions on Pattern Analysis and Machine Intelligence, **32**, 2162-2177 **(2010)**

14. Zaeri N., Feature extraction for 3D face recognition system, International Conference on Multimedia Computing and Systems (ICMCS), 1-4 **(2011)**

15. Muhammad Almas Anjum, An Improved Face recognition using Image Resolution Reduction and Optimization of Feature vector PhD Thesis, College of E and ME Nust RawalPindi-Pakistan **(2008)**

16. Gernoth T., Gooßen A. and Grigat R.R., Face recognition under pose variations using shape-adapted texture features, IEEE Conference Proceedings, 4525-4528 **(2010)**

17. Vu N.S. and Caplier A., Efficient statistical face recognition across pose using local binary patterns and gabor wavelets, IEEE Conference Proceedings, 1-5 **(2009)**

18. Heo J., Generic elastic models for 2d pose synthesis and face recognition, Ph. D. dissertation, CMU, **(2009)**

19. Prabhu U.H. and Savvides J.M., Unconstrained Pose Invariant Face Recognition Using 3D Generic Elastic Models, IEEE Transactions on Pattern Analysis and Machine Intelligence, 1-1 **(2011)**

20. Gross R., Matthews I. and Baker S., Appearance-based face recognition and light-fields, IEEE Transactions on Pattern Analysis and Machine Intelligence, **26**, 449-465 **(2004)**

21. Sharif M., Mohsin S. and Javed M.Y., A Survey: Face Recognition Techniques, *Research Journal of Applied Sciences, Engineering and Technology*, **4**, 4979-4990 **(2012)**