National Conference on Emerging Trends in Computer, Electrical & Electronics (ETCEE-2015)
International Journal of Advance Engineering and Research Development (IJAERD)
e-ISSN: 2348 - 4470 , print-ISSN:2348-6406,Impact Factor:3.134

Comparative Survey of Face Recognition Techniques

Dhavalsinh V. Solanki[#1], Dr. Ashish M. Kothari[*2]

[#1]*Post Graduate Fellow, ECD, AITS, Rajkot, Gujarat, India.*
[*2]*Assistant Professor, ECD, AITS, Rajkot, Gujarat, India*

***Abstract*— Face recognition has been a fast emergent and exciting area in real time applications. Automatic face recognition has shown great achievement for high-quality images under embarrassed conditions. In this paper techniques of Face detection along with Face Recognition are discussed. Human and object frames, background frames are separated by implementing a face detection algorithms like Viola-Jones & Skin Detection algorithms. In this paper we have discussed, analysed, & compare some popular face detection methods like PCA, LDA, PCA + LDA Hybridization and Gabor wavelet transformations and also tried to attempt a comparative study of these methods.**

***Keywords*— Principal Component Analysis (PCA), Viola- Jones, Gabor Filters, Fisher's Linear Discriminant Analysis (FLDA)**

I. INTRODUCTION

We are in the Era of Digital Multimedia. Here information contains in the form of: Audio, Images, Videos. Face is the most common biometric used by humans. A reliable automatic human face and facial feature detection is one of the most initial and important steps of face identification and face recognition systems for the purpose of locating and extracting the face region from the other objects and background [1]. How can machines detect multiple human faces present in an image or a video present with other objects? That is the problem. So in solution one needs processes like segmentation, extraction, and verification of faces.

First thing, Detection is not Recognition. The way to do recognition is by matching selected facial features from the image and a facial database. The basic flow of the face recognition system is shown in figure (1).

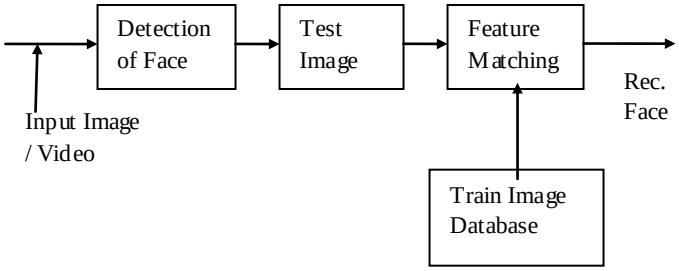

Fig 1. Block Diagram Of Face Recognition Process [2]

Moreover, there are several methods available for face recognition such as principal component analysis (PCA), linear discriminant analysis (LDA), PCA+LDA, Gabor wavelet for recognition and various hybrid combinations of these techniques. Here in this paper these techniques are discussed to get best required results.

II. FACE DETECTION

A. Viola-Jones object detection framework:

The Viola-Jones object detection framework proposed in 2001. It could detect the faces in high detection rate in real time applications.

There are three techniques present in Viola – Jones Frame Work:

1. Integral Image Representation for Feature Extraction
2. Adaptive Boosting for Face Detection
3. Cascade Classifier

Viola Jones method gives "Integral" image representation. A window of the target size is moved over the whole integral images. For each subset of the image the Haar-like feature is computed. This change is then compared to a known threshold that split up non-faces from faces. In viola Jones, mostly 3 kinds of features can be used, which named as two, three & four rectangular features. [3].

In two rectangular features the sum of the pixels within the white rectangles are subtracted from the sum of pixels in the dark rectangles. But the regions should be of the same size and shape and should be horizontally or vertically adjacent. (Figure 2, A & B).

In three rectangular features the sum within two outside rectangles (white rectangle) subtracted from the sum in a centre rectangle (Dark Rectangle). (Figure 2, C).

In four rectangular features, it will calculate the difference between diagonal pairs of rectangles. (Figure 2, D).

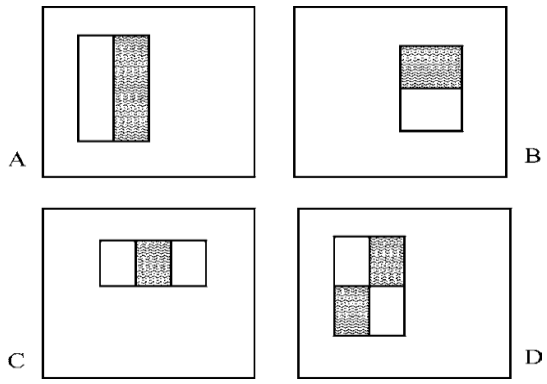

Fig 2. Different Type of Features Window [3]

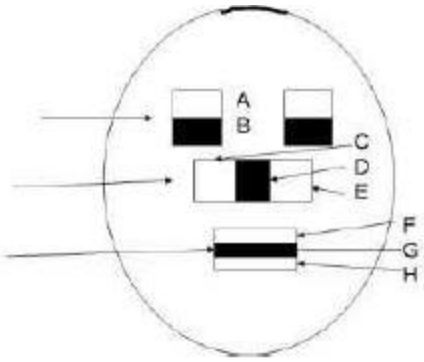

Fig 3. Example of Face Features
Two eyes= (Area_A - Area_B)
Nose = (Area_C+ Area_E- Area_D)
Mouth = (Area_F+ Area_H -Area_G)

The eye-area or shaded area is dark and the nose-area or white area is bright. So f is large, hence it is face. This logic works same as on nose & mouth.

Ada boosting or Adaptive boosting is a machine learning algorithm is used to increase the performance level of a simple learning algorithm. This is use for classification purpose [4]. It adds many weak classifiers to become a strong classifier.

Calculation of Haar-Like Features: It is decision-tree classifiers with at least 2 leaves [5].

value of rectangle feature

$$h_t(x) = \begin{cases} 1 & \text{if } p_t f_t(x) < p_t \theta_t \\ 0 & \text{otherwise} \end{cases}$$

$h_t(x)$: window; θ_t: threshold; P_t= polarity{+1,-1}

Where, x = 24*24 pixels sub-window
f = Applied feature
p = the polarity
θ = threshold decides whether x should be classified as a positive (a face) or a negative (a non-face).

In order to improve calculation efficiency, speed accuracy and reduces the false positive rates, Viola Jones uses cascaded classifiers. It's used to reject negative sub-windows while sensing mostly all positive cases. The detection process consists of a degenerate decision tree, what we call a "cascade". A positive result from the first classifier prompts the assessment of a second classifier which has also been adjusted to reach very high detection rates. A positive result from the second classifier prompts a third classifier, and so on. If one get the negative result at any point it will results in the immediate rejection of the given sub-window.

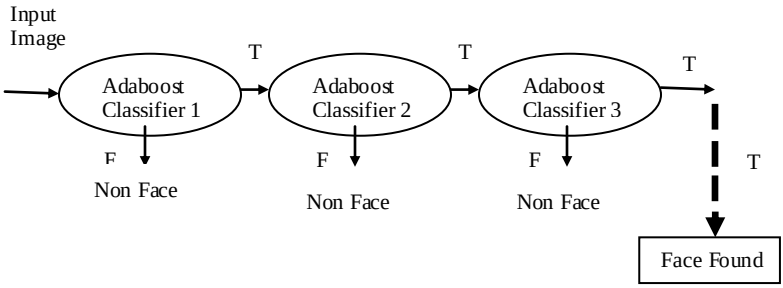

Fig 4. The cascade classifier

Viola Jones method gives high detection rate and low false positive rate than any other methods. It also can be used for high Speed detection [1].

B. Skin Color Detection:

In an organized background, skin detection can be appropriate to locate faces in images. Skin detection typically used in color images and videos, which is a very effectual technique to detect skin-colored pixels. Skin color is a unique feature of human faces. Processing of Color feature is much quicker than processing other facial features so that it can be used as an initial process for other face detection techniques.

Skin detection has also been used to trace body limbs, such as hands [6]. Though, many objects in the real world have skin colors, such as leather, wood, etc., which can be falsely detected by a skin detector. Skin detection is very suitable in finding human faces as well as hands in well-ordered situations where the background is definite which does not contains color pixels matched with skin color pixels. As it is working on color pixels this method can't use on gray-scale, infrared, or other types of images that do not contain color information. A skin detector typically converts a given pixel

into a suitable color space and then uses a skin classifier to tag the pixel whether it is a skin or a non-skin pixel.

The hybridization of Viola Jones and Skin Colour detection can give better detection rate than a single method [1].

III. FACE RECOGNITION

A. *Principal Component Analysis (PCA):*

Principal component analysis (PCA) is a dimensionality reduction technique [7] which is used for face recognition problems. It is also known as eigen space projection or karhunen - loeve transformation. To calculate the Eigen vectors of the covariance matrix is the first step of PCA, and second step is to project the original data onto a lower dimensional feature space, it known as eigen vectors with large eigen values. One can say that there is heavy noise present in any input signal. However, if the input signal is in the form of images, they are not completely random and instead of the differences, there are patterns. These patterns, which can be observed in all images, could be - in the domain of face recognitionn - the presence of objects like eyes, nose, mouth, Smile in any face as well as their relative distances between these objects. These characteristic features are known as eigenfaces in the facial recognition area. Or most generally in Principle Component Analysis method. They can be extracted out of original image data by means of the mathematical tool called Principal Component Analysis (PCA) [8].

Steps for recognition using PCA: [8]

STEP 1: Prepare the Data

Here the number of faces is M, and the whole set i.e. S. In the set S every image is transformed into vector size N.

$$S = \zeta 1, \zeta 2, \ldots\ldots \zeta M$$

STEP 2: Obtain The Mean

$$\psi = {}^{1}/_{M} \sum_{n=1}^{M} \zeta n$$

STEP 3: Subtract mean from original Image:

$$\phi i = \zeta i - \psi$$

STEP: 4 Co variance Matrix Calculations:

$$C = {}^{1}/_{M} \sum_{n-1}^{M} \phi n \, \phi n^{T}$$

$$C = A * A^{T}$$

STEP: 5 Calculate Eigen Values & Eigen Vectors of the Co variance matrix.

STEP: 6 Now, Eigenvectors are found as per the previous step, the next step is to order these eigenvectors as per highest to lowest values of them. So, it will be in order of significance.

Eigenvector with the highest eigen value is known as the principle component of the data set. Choose the highest eigen value and forming a feature vector.

STEP: 7 towards Recognitions:

The new face is transformed into its eigenface components and the resulting weights form the weight vectors.

$$\omega k = \mu_{k}{}^{T}(1 - \psi)$$

Where ω = weight, μ = eigenvector, Γ = new input image, Ψ = mean face

The weight vector $\Omega^{\mathbf{T}}$ is given by,

$$\Omega^{T} = (\omega 1, \omega 2, \ldots\ldots \omega M)$$

Poor discriminating power within the class and large computation are common problems in PCA method. This limitation can overcome by Linear Discriminant Analysis (LDA) [9].

The Dis advantages of this technique is that the scatter which is being maximized is not depending upon only the between-class scatter which is useful for classification, but PCA also depends on the within-class scatter, which carries undesirable information for classification. In videos most of the variation from one image to another depends on lighting changes. Thus if PCA is presented with images of faces under varying illumination, Ω^{T}, the projection matrix will have Eigenfaces (i.e. Principal components) which keep the variation due lighting in the projected feature space. This drawback can overcome by various Linear Discriminant techniques.

B. *Linear Discriminant Analysis (L.D.A) :*

Mostly peoples attracted towards the use of LDA (instead of PCA) due to lack of efficiency of PCA in the Facial

Recognition domain. Also in PCA creation of the face subspace does not capture discrimination between humans.

The linear discriminant analysis (LDA) is one of the most effective strategies in face distinguishment area. It yields a viable representation that sprightly changes the original information space into a low-dimensional feature space where the information is decently divided.

The purpose of discriminant analysis is to classify objects. If one can see that groups on the image can be separated by line or plane (linearly separable), one can use LDA for it. If only two features, the separators between objects group will become lines.

As next, if the features are three, plane can be used for separation. If these features are more than three, separator will be hyper-plane. Generally linear discriminant analysis (LDA) procedure is utilized for information arrangement and dimensionality decrease. In LDA the principle point is to boost the between-class scatter matrix measure while minimizing the within (intra) class disperse grid measure [10].

Steps for recognition using LDA:

- Let's consider a set of N sample images:

  {x1, x2, … Xn}.

- Assume that each image belongs to one of c classes:

  {x1, x2, …. xc}.

- Calculate within-class scatter matrix as:

$$S_W = \sum_{i=1}^{c} \sum_{x_k \in X_i} (x_k - \mu_i)(x_k - \mu_i)^T$$

- Calculate Between-class scatter matrix as:

$$S_B = \sum_{i=1}^{c} N_i (\mu_i - \mu)(\mu_i - \mu)^T$$

- Calculate the eigenvectors of the projection matrix:

$$W = S_W^{-1} S_B$$

Where, X_k = K_{th} Sample of Class i
C= Number of Classes
μ_i = mean of class i
N_i = is the number of samples in class X_i
μ = mean of all classes

Compare the test image's projection matrix with the projection matrix of each training image by similarity measure. The result is the training image which is the closest to the test image [11].

As discussed earlier, illumination & brightness is the major problem in video based recognitions. Illumination adaptive linear discriminant analysis (IALDA) is there to solve illumination variation problems in face recognition [12].

The recognition accuracy of the suggested method (IALDA) is far higher than that of PCA method and LDA method. At the same time, this also indicates that the proposed IALDA method is robust for illumination variations.

Fisher faces linear Discriminant algorithm can give about 80% accurate results. The whole result purely depends upon how efficiently you create the database [2].

C. PCA + LDA Hybridization:

LDA is one of the most used algorithms for feature selection in appearance based methods [13]. Numerous LDA based face distinguishment framework likewise utilize PCA as first step, the reason for it is to reduce dimensions & after it they use LDA to maximize the discriminating power of feature selection. Because in LDA there is a problem of small sample size, and we know that data sets should have larger samples per class for good feature extractions.

Thus if one going to use LDA directly than it's a problem of feature extraction.

For a one type of solution one can use [14] Gabor filter for front face images & PCA is there to reduce dimension of filtered feature vectors & than after one can use LDA to extract required features. A recursive algorithm for calculating the discriminant features of PCA-LDA procedure is introduced in. Here, in this method we come to think about difficult issue of discriminating vectors from an incrementally arriving high dimensional data stream without processing the relating covariance matrix.

The Daniel L. Swets and Juyang Weng [13] discussed two stage hybridization of PCA-LDA method. In this proposed method the function of PCA is to project images from the original image space to the low-dimensional space and make the within-class scatter Non-degenerate. Despite the fact that in first step they have utilized PCA for dimension reduction which can likewise uproot the discriminant data that is valuable for classification.

For memory usage and in the calculation of first basis vectors, PCA-LDA hybrid algorithm seems very efficient.This algorithm can give comparatively very good face recognition success than both individual techniques LDA & PCA.

D. Gabor Wavelet Transformations:

Face recognition is one of the most important applications of Gabor wavelets. The Gabor wavelets are usually known as Gabor filters in this scope of applications. In recent years, Gabor wavelets have been widely used for face representation by face recognition researchers [15]. In recent research, Gabor filters recognised as most efficient representation in face recognition domain. Also using the Gabor filter as a first step of (at front end) of face recognition system could be highly successful.

Graph matching of coefficient is also a successful face recognition method. At the same time this technique conveys a few disadvantages as well, in the same way as, their matching complexity in nature, manual limitation of training graphs, and overall execution time. And so forth.

The elastic graph matching framework is one of the analytic face recognition approaches, and this framework is used mainly for feature points detection and face modelling. Besides the analytic approaches, Gabor wavelets can be used for holistic approaches, too. A face image is first convolved with a set of Gabor wavelets and the resulting images can be further combined with PCA or LDA to reduce the feature dimension and generate the salient representation.

A technique is presented in [16] feature vectors extracted from the Gabor wavelet transformation of frontal face images combined together with ICA for enhanced face recognition. Among the new techniques used for feature extraction, it is proved that Gabor filters can extract the maximum information from local image regions [17] and it is invariant against, translation, rotation, variations due to illumination and scale.

In [18] they Hicham Mokhtari, Idir Belaidi and Said Alem discussed comparative techniques & analysis about face recognition algorithms using gabor transforms also, They have used ORL databases. They have done these things in three stages first, they used directly the following face recognition methods (LDA, KFA, and PCA) and in the second, they associated it with the Gabor wavelet and in the third, they related it with the Phase Congruency. & Results shows that Gabor wavelet gives better results than Phase Congruency. Among the methods tested, GLDA was judged the best achieving the lowest error rate compared to other methods.

Gabor wavelets are biologically motivated. It appears to be quite perspective, insensitive to small changes in head poise and homogenous illumination changes, robust against facial hair, glasses and also generally very robust compared to other methods. However it was found to be sensitive to large facial expression variations. Also, it was found that placement of wavelets should be consistent for efficient recognition. face tracking and face position estimation.

Gabor features are also used for gait recognition and gender recognition recently [19] [20].

IV. APPLICATIONS

It can be used in various activities like human robot interaction, video games, human computer interaction.

It can also use in authentication process like immigration, passports, welfare fraud, national ID, drivers' licenses, entitlement programs, voter registration.

It can also use for security purposes like desktop logon, application security, TV parental control, personal device logon, file encryption, database security, medical records, intranet security, internet access, secure trading terminals.

If it is video based face recognition system than Video Summarization (It's not like trailer of the movie but its collection or extraction of required information from the whole video) & Video Retrieval are the two main applications of this approach. It is also used for Video Surveillance, CCTV control and surveillance [21], suspect tracking and investigations.

V. CONCLUSIONS

Here, in this paper we have tried to cover recent development in the field of the face recognition. In first step of it (Detection) Viola Jones & Hybridization of Viola Jones methods gives proficient results. And Present study concludes that for enhanced face recognition new algorithm has to evolve using hybrid methods such as PCA+LDA, Gabor filter (Feature Extractor) may yields better performance in terms of face detection rate and accuracy. From discussion we can conclude that GLDA is the efficient achieving & lowest error rate method. Fisher's face discriminant method can also provide good accuracy & efficiency in video based face detection algorithms. The references are here to provide more detailed understanding of the approaches described is enlisted.

REFERENCES

[1] Amr El Maghraby Mahmoud Abdalla Othman Enany Mohamed Y. El Nahas "Hybrid Face Detection System using Combination of Viola - Jones Method and Skin Detection", *International Journal of Computer Applications (0975 – 8887), Volume 71– No.6, May 2013*.

[2] N. J. Chhasatia, K. A. Shah, C. U. Trivedi, V. J. Chauhan, ""Who are there in the movie??" – The improved approach for person recognition from the movie." *IEEE, ICCIC*, December 2013.

[3] Viola, P. and M. J. Jones (2004). "Robust Real-Time Face Detection." *International Journal of Computer Vision*, 57(2): 137-154.

[4] K. T. Talele, S. Kadam, A. Tikare, "Efficient Face Detection using Adaboost", IJCA Proc on "*International Conference in Computational Intelligence"*,2012.

[5] Phillip I.W.,Dr. John F. "Facial feature detection using haar classifiers", *JCSC 21*, 4 (April 2006).

[6] Imagawa, K., Lu, S., Igi, S.: "Color-based hands tracking system for sign language recognition in: FG '98:" *Proceedings of the 3rd. International Conference on Face & Gesture Recognition, Washington, DC, USA, IEEE Computer Society* (1998) 462

[7] Y. Cheng, C.L. Wang, Z.Y. Li, Y.K. Hou and C.X. Zhao, "Multiscale principal contour direction for varying lighting face recognition", *Proceedings of IEEE 2010*.

[8] S. syed navaz, T. dhevi sri & Pratap mazumder, "Face recognition using principal component analysis and neural networks", *IJCNWMC, vol. 3, issue 1*, mar 2013, 245-256.

[9] Mohemmed Javed, Bhaskar Gupta, "Performance Comparison of Various Face Detection Techniques", *IJSRET, Vol 2, Issue 1*, PP 0019-0027, April 2013.

[10] Martinez A.M. and Kak A.C., "PCA versus LDA", *IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 23*, No.2, pp. 228-233, 2001.

[11] Önsen TOYGAR1 Adnan ACAN2 "Face recognition using PCA, LDA and ICA approaches on colored images", *Journal of electrical & electronics engineering year 2003 volume 3* (735-743).

[12] Zhonghua Liu , Jingbo Zhou,Zhong Jin, "Face recognition based on illumination adaptive LDA", *International Conference on Pattern Recognition*,2010.

[13] D. L. Swets and J. J. Weng, "Using discriminant eigenfeatures for image retrieval", *IEEE Trans. PAMI.*,vol. 18, No. 8, 831-836, 1996.

[14] C.Magesh Kumar, R.Thiyagarajan , S.P.Natarajan, S.Arulselvi,G.Sainarayanan, "Gabor features and LDA based Face Recognition with ANN classifier", *Proceedings Of ICETECT 2011*.

[15] Tao D, Li X, Wu X, Maybank SJ, "General tensor discriminant analysis and Gabor features for gait recognition". *IEEE Trans PAMI* 29(10):1700–1715,2007.

[16] Arindam Kar, Debotosh Bhattacharjee, Dipak Kumar Basu, Mita Nasipuri, Mahantapas Kundu, "High Performance Human Face ecognition using Independent High Intensity Gabor Wavelet Responses: A Statistical Approach", *International Journal of Computer Science & Emerging Technologies (E-ISSN: 2044-6004*) 178 Volume 2, Issue 1, February 2011.

[17] H. Deng, L. Jin, L. Zhen, and J. Huang. "A new facial expression recognition method based on local gabor filter bank and pca plus lda". *International Journalof Information Technology*, vol.11, pp.86-96, 2005.

[18] Hicham Mokhtari, Idir Belaidi and Said Alem, "Performance Comparison of Face Recognition Algorithms based on face image Retrieval", *Research Journal of Recent Sciences*, Vol. 2(12), 65-73, December (2013).

[19] Li X, Maybank SJ, Yan S, Tao D, Xu D, "Gait components and their application to gender recognition". *IEEE Trans* SMC-C 38(2):145–155,2008.

[20] Zhang W, Shan S, Gao W, Chen X, Zhang H, "Local Gabor binary pattern histogram sequence (LGBPHS): a novel non-statistical model for face representation and recognition". *In Proceedings of the10th IEEE international*.

[21] S. Sangeetha, S. Deepa, "A Survey on Video Summarization using Face Recognition Methods" *International Journal of Advance Research in Computer Science and Management Studies Special Issue*, December 2013.