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Face Detection and Recognition Techniques: A Survey

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Abstract: The biometric is a study of human behavior and features. Face recognition is a technique of biometric. Various approaches are used for it. Authentication & Identification has become major issue in today's digital world. Face recognition plays a significant role in authentication & identification. In this paper several existing face detection and recognition approaches are analyzed and discussed. Each approached is discussed briefly & compared with the other in terms of key evaluation parameters. As face detection is the elementary yet an important step towards automatic face recognition, main goal of this paper is to come up with an approach that is a good candidate for face detection and face recognition.

Keywords: Face Detection, Face Detection, Skin Color Modeling, Haar like Feature, Principle Component Analysi, Face Recognition, Haar Cascade, LBP, Eigenfaces, Fisherfaces.

I. INTRODUCTION

Facial recognition development has received many interests in recent years. It is a critical application in image analysis yet it is very challenging to create an automated system based on facial recognition. A system with ability to recognize human face accurately. One application of facial recognition is in the field of attendance management system. The manual attendance system is time-consuming, thus many research has been conducted with the automatic or smart attendance management system to resolve this issue. One solution is the application of biometric attendance management system. However, it is difficult to verify each student in the classroom as there are many students who attend the class, and if the system cannot detect or recognize one student, it will interrupt the learning process[2]. In addition, the biometric system needs much hardware that requires high cost and a lot of interaction with the students that makes it a time consuming system. The research on applying real-time facial recognition in attendance management system has been a real challenge. Automatic attendance marking can solve the main issues such as the error when inputting the data from the sheet to the manual attendance system, especially there is a concern that the data is not 100marking method considering the extremely large number of students in a university. The facial recognition process has many steps such as capture, extraction, comparison, and matching[2].

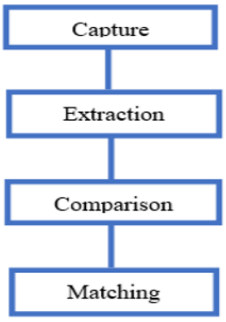

Fig 1. General face recognition process.

The operation in each process is: In step one the capture is the way to snap the picture during the enrollment of the system. Then in the Face Recognition step, extraction is used for finding or extract the specific feature from the face. The third step is comparison, where new input is used for comparison with the database (sample data). Finally, the last step is matching: the system will try to find the matching of the new face with the registered face based on extraction and comparison process. The sequence of the processes is illustrated in Fig. 1. There are several methods and algorithms that can be implemented in facial detection and recognition system. There are a lot of limiting on the research done in the past[2].

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II. LITERATURE SURVEY

Yang et al. [13] gives face detection approaches into four major categories: Knowledge-based, Feature invariant, Template matching and Appearance-based approaches. Knowledge-based approaches [14] [15] [16] depend on a set of rules, based on human knowledge, to detect faces. For example, a face often includes two eyes, a nose and a mouth within certain distances and positions relative to each other. Feature invariant approaches [17] [18] [19] locate faces by extracting structural features of the face. Generally, a statistical classifier is trained and, then, used to differentiate between facial and non-facial regions. Template matching approaches [20] [21] use predefined or parameterized face templates to locate and detect faces, by computing the correlation values between the template and the input image. Appearance-based approaches [22] [23] [24] depend on a set of delegate training face images to find out face models. Generally, appearance-based methods have shown superior performance compared to others [12]. Up till now, Viola-Jones face detector [24] has the most impact in face detection research during the past decade. It is broadly used in genuine applications such as digital cameras, and digital photo managing software.

Principle component analysis (PCA) is widely used for dimensionality reduction, Turk and Pentland introduce Eigenfaces in 1991 [26]. By this method, the dimensionality of a face model can be reduced from image pixel size to several principle basis, the basis may encode sufficient information about the face. However, it is designed in a way to best preserve data in the embedding space, and consequently cannot promise good discriminating capability.

Linear discriminant analysis (LDA) is also used for dimensionality reduction, and it provide a good discriminating capability. Fisherfaces [25] improve the face recognition system, but the drawback of this method is it cannot perform well in face verification.

LBP is a powerful method to solve face recognition problem, it is efficient and also easy to implement. The drawback is it is hard to determine a verification threshold, which mean the boundary between imposter and guest is hard to determine in chi square distance matrix space.

III. PROPOSED MODEL

The general face recognition model is as shown in Figure 2. The general face recognition model contains two basic parts Enrollment and Recognition. The Enrollment part includes Registration phase in which first the image is captured, then the face detection algorithm for capturing the image is called. The captured image is then stored in database.
The second part that is the Face Recognition which takes place when teacher captures the image of the class. First image is captured then face detection of all students takes place, after detecting pre-processing is done on that images. Each students face features are extracted from the database and then the classification is done accordingly.

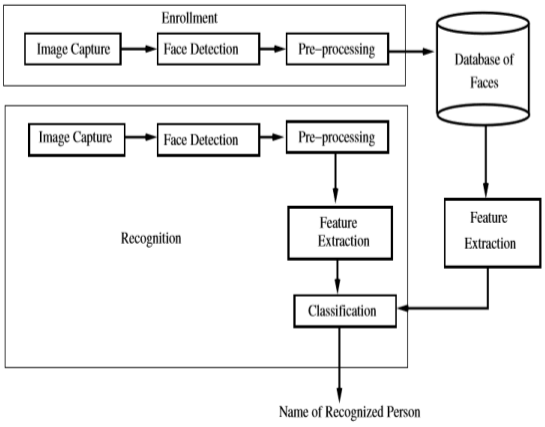

Fig 2. General face recognition model [3].

A. FACE DETECTION

a. High-Level Language based Face Detection
P Daesik Jang, Gregor Miller, Sid Fels, and Steve Oldridge et. al. give a new methods for a user oriented language model for face detection. Hear many open sources or commercial libraries to solve the trouble of face detection. There are still hard to use because they need explicit knowledge on details of algorithmic techniques.

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They projected a high-level language model for face detection with which users may develop systems easily. Important conditions are mainly considered to classify the big trouble of face detection. The conditions recognized here are then represented as expressions in terms of a language model so that developers may use them to express various problems. Once the conditions have developed by users, the proposed associated interpreter interprets the conditions to find and classify the best algorithms to solve the represented problem with corresponding conditions. The purpose of this technique is to come up with a high level language model for face detection with which users will expand systems easily and even without specific knowledge of face detection theories and algorithms. By doing this, the problem of selecting algorithms and deciding complicated parameters for algorithms are isolated from development of face-detection applications.

Developers just need to define the problem and express it with the language model suggested and an interpreter will select algorithms appropriate for the associated sub-space of the problem. They first consider the important conditions to classify the huge problem of face detection. The conditions identified here are then expressed in terms of a language model so that developers have been used them to express various requirements of a given problem. Once the conditions are expressed by developers, the interpreter plays an important role to interpret the conditions to find and organize the optimal algorithms to solve the represented problem.

The model is a part of the Open Vision Language (OpenVL), a vision language that allows programmers to describe their vision problem in terms of what it is they want to do, instead of how they want it done. A proof-of-concept is implemented and some example problems are tested and analyzed. They present two different detection problems to validate and demonstrate the ease of use of our proof-of concept language model proposed in this paper. Three different face detection algorithms have been implemented for the selection of proper algorithms in this paper: Ada Boost based algorithm, Neural Network based algorithm, and Color based algorithm.
The first case is to detect an upright, frontal and large face for face identification. Face detection is often used as a preprocessing for identifying persons by providing the exact future improvement, the technique need more face detection algorithms will be analyzed and added for more practical and better usability of the language model. Some intelligent approaches for selecting algorithms are necessary to be considered for more optimal selection process[9].

b. Feature Base Face Detection
Anima Majumder, L. Behera and Venkatesh K Subramanian et. al. presented different approach for fully automatic detection of facial features. The new techniques may use the basic concepts of facial geometry. They proposed to locate the mouth position, nose position and eyes position. The estimation of detection region for features like eye, nose and mouth enhanced the detection accuracy significantly. Hear we can use the H-plane of the HSV color space to propose for detecting eye pupil from the eye detected region.

The proposed approach, at first, they detect the face using Viola and Jones' Boosting algorithm and a set of Haar-like cascade features. The eye look for area is minimized by assuming the eyes expected position to be at the upper part of the face. Haar-like features cascade is used for the eye detection. It locates the rectangular regions containing eyes. Given the eyes ROI, an algorithm is developed to locate the eye pupil by taking Hue information of the eye image. The hue image is threshold and contour is detected in the threshold image. Centroid of the contour is detected as the eye pupil. Next, the nose is detected using haar-like features. Having known the eyes center, and the position of the nose, an approach is proposed based on the facial geometry for mouth location estimation. An algorithm is developed to locate the lips corners points, which are considered as good features for tracking lips movement. Finally, nostrils are detected from the nose ROI by taking threshold of the gray nose image and obtaining the contours in the threshold image. The proposed a robust algorithm for automatic and accurate detection of different facial features. An improvement over detection of eyes, mouth and nose are done by estimating the probable region for each features. Geometrical interpretations of location of facial features, used in the algorithms are described with pictorial descriptions. It is observed that, with the use of facial geometry, the accuracy of features (eyes, nose and mouth) detection is greatly improved over that of using only the algorithm in whole face image. The proposed lip detection algorithm is found to be accurately detecting the lips corners for both neutral face images and smiling face images. The eye pupil detection method using H-plane of the HSV color planes image is found to be robustly detecting the pupil in spite of obstacles like wearing spectacles, bad illumination of eye area, variation is sizes of eyes. Algorithm developed using corner detection method, for detecting both inner and outer eye corners are found to be giving accurate results even in faces wearing spectacles. The proposed method for nostrils detection is also found to be accurately detecting in all kind of frontal images tested.

Future work can be done by extending the proposed approach in posed/tilted face images. The work can also be extended for expression recognition and automatic tracking of features in videos [10].

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c. Geometric Based Face Detection

Padma Polash Paul and Marina Gavrilova et. al. presented a PCA based modeling of geometric structure of the face for automatic face detection. The method improves the face detection rate and limits the search space. Skin Color Modeling (SCM) is one of the best face detection techniques for image and video. However, feature selection is very important for even better template matching performance in terms of detection rate and time.

This paper presents an efficient feature extraction and selection method based on geometric structure of the facial image boundary and interior. To model the geometric structure of face, Principle Component Analysis (PCA) and canny edge detection are used. Fusion of PCA based geometric modeling and SCM method provides higher face detection accuracy and improves time complexity. Both models provide filtering of image in term of pixel values to get the face location that are very fast and efficient for large image databases. Proposed system uses skin color model to reduce the search space. Orientation invariant threshold based on geometric model and improves system further. For reliable template matching, feature extraction and selection based on novel combination of geometric filter with SCM filter is introduced.

Proposed system is composed of two major components: first, skin regions are segmented using skin color model. In the second part, segmented regions are filtered using geometric model of face.

They can focus on four color spaces which are normally used in the image processing field:
RGB: Colors are precise in terms of the three main colors: red (R), green (G), and blue (B).
HSV: Colors can be represnted individually in the terms of hue (H), saturation (S), and intensity value (V). They are the three attributes that are apparent about color. The conversion between HSV and RGB is nonlinear.
The major goal in this segmentation process is to take away the background of the image from skin regions using formerly discussed skin color model. First, input image is changed into chromatic color space. A grayscale image of skin possibility is constructed using Gaussian model. Skin pixels have some set of stable values for each r, g and b component. A normalized image is consists of has three principles and they are normalized-red, normalized-green and normalized-blue. These normalized components are extracted by Segmentation process and later two images are constructed. Each of these images is changed into black and white image by applying dissimilar threshold for normalized input image.

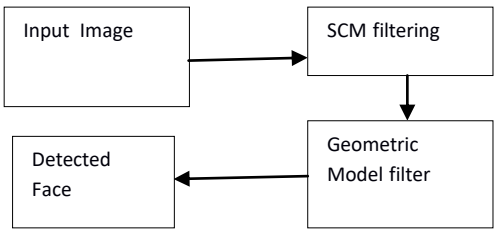

Fig 3 . Proposed Face Detection Block Diagram.

Their geometric modeling has three key steps. In the first step, detected skin regions are projecting using PCA. In the second step, projected skin regions are reconstructed using smaller number of Principal Components (PCs). Finally edges are detected from reconstructed skin regions. Since detected skin regions are in different size, each region is resized in to same resolution. A predefine mask is applied on each skink regions after resizing. Threshold value is rotation invariant because we are taking the cumulative sum of the projected geometric structure.

Another advantage of the proposed method it is very fast in computation because of the filtering. If the filter values of Input Image SCM filtering Detected Face Geometric Model filter Mayank Chauhan et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (2) , 2014, 1615-1618 www.ijcsit.com 1616 skin segments are within the range of a face or non face system can take decision so time complexity to identify the face become O(1). Fusion of PCA based geometric modeling and SCM method provides higher face detection accuracy and improves time complexity. Convincing experimental results confirm that the proposed method improves the face detection rate and limits the search space, thus making it very fast and efficient for large image databases[11].

d. Haar Like Feature Based Face Detection

OpenCV is the leading open source library for computer vision, image processing and machine learning, and now features GPU acceleration for real-time operation. OpenCV is released under a BSD license and hence it's free for both academic and commercial use. It has C++, C, Python and Java interfaces and supports Windows, Linux, Mac OS, iOS and Android. OpenCV was designed for computational efficiency and with a strong focus on real-time applications[5].
OpenCV has many features some are mentioned as follows:

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• Image/video I/O, processing, display (core, imgproc, highgui]
• Object/feature detection (objdetect, features2d, nonfree)
• Geometry-based monocular or stereo computer vision (calib3d, stitching, videostab)
• Computational photography (photo, video, superres)
• Machine learning clustering (ml, flann)
• CUDA acceleration (gpu)

Haar Cascade:
The Haar Classifier is a machine learning based approach, an algorithm created by Paul Viola and Michael Jones; which are trained from many many positive images (with faces) and negatives images (without faces). Object Detection using Haar feature-based cascade classifiers is an effective object detection method proposed by Paul Viola and Michael Jones in their paper, ”Rapid Object Detection using a Boosted Cascade of Simple Features” in 2001. It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. It is then used to detect objects in other images[5].

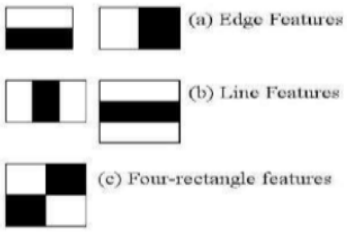

Fig 4.Haar Cascade features[5].

Initially, the algorithm needs a lot of positive images (images of faces) and negative images (images without faces) to train the classifier. Then we need to extract features from it. For this, Haar features shown in the below image are used. They are just like our convolutional kernel. Each feature is a single value obtained by subtracting sum of pixels under the white rectangle from sum of pixels under the black rectangle[5].

There are many techniques available for face detection other than OpenCV like Cam Shift Algorithm, for finding via motion. Initially Haar Cascade was time consuming but after the modified version it is not time consuming. It is very efficient in performance and is popularly used for face detection. Cam Shift algorithm is not very time consuming but is very expensive to buy and is not that effective in performance. Finding via motion is also one of the technique for face detection but is very time consuming and performance wise it is not so reliable as compared to any other algorithm[5].

B. FACE RECOGNITION
In the introduction, an overview of facial recognition in attendance marking system is discussed. Then, in this section, we explain the various approaches to facial recognition such as: Facial recognition is a category of biometric software that maps an individual’s facial features mathematically and stores the data as a face print. The software uses deep learning algorithms to compare a live capture or digital image to the stored faceprint in order to verify an individual’s identity[8].

In this system the face recognition is done by using following techniques:
A. Eigenfaces
The motivation of developing eigenfaces came from the work done by Sirovich and Kirby. They efficiently represent face images using principal component analysis for the first time. They calculated a coordinate system which was profoundly describing the actual face image. They named it as 'eigenpicture'. They proposed that any collection of images can be reconstructed to a low dimensional value by storing a weight of each images. The weight can be found by projecting the image in the eigenpicture[6].
Face recognition using eigenfaces have some initialization stages:

- Prepare a training set. These images will be used for training the system. As in our project we have 165 face images in total for 15 persons. We took our data for several times using different size of training set[6].
- Calculate eigenfaces from the training set of images. We have to keep M images which correspond to the highest eigenvalues. M images create the face space. If new face images are appeared then they will be automatically added and updated[6].
- Calculate the M dimensional weight space for each image by projecting the face image onto face space[6].

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- By the algorithm developed by Turk and Pentland, these steps will be performed every time when there will be free computational capacity[6].
- After the initialization, they have followed these steps to recognize a new face image.
- Calculate weights for the new input image and the M dimensional eigenfaces by projecting the input image onto the face space.
- Check if the input image is close enough to the 'face space'. If it is close enough then it is a human face image otherwise it doesn't.
- If it is a human face, then try to find closest weight pattern to find the identified person.
- We can include this image and update eigenfaces or the weight patterns if we like.
- If we can find the same unknown face several times then we can calculate its weight pattern and include this one into our known database face images. This is an optional step[6].

Last two steps are optional. If we do not include them into algorithm this is not going to affect the base algorithm. Eigenfaces method is mainly a dimensionality reduction method or it is also known as Principle Component Analysis or Karhunen-Loevemethod for face recognition. This method reduces dimensionality which maximizes the scattering of all the images[6].

Given, training set of N images, Γi (i= 1,2 ... N). The size of every image is m x n. We can convert the set into a matrix.
A = [Φ1,Φ2,..,Φn]
Where Φi is a column matrix which represents an image [6].
• Φi = Φi-μ
• Φi = reshape (Γ_i , $[mn, 1]$)
• μ = $mean_i$(Φi)
The scatter matrix will be like,

$$S_T = AA^T$$

A linear transformation W mapping is an image mapping on a p-dimensional feature space. The condition is like p < = N <<mn . PCA selects the W_{opt} to maximize the determinant of the previously calculated scatter matrix of the image,

$$W_{opt} = argmax_w |W^T S_T W| = [w1w2 \dots \wp]$$

Where Wi's are eigenvectors of ST matrix for p largest eigenvalues. They represent different eigenfaces. The feature face dimension is automatically reduced to p. Then we can calculate the weight and Euclidean distance of training images and test images. To determine whether it is a face or not we have a threshold. If the value of Euclidean distance is below than that threshold, then we can say it's a human face. To recognize that image properly, we have to find out the closest distance and this distance must be below than a certain value[6].

B. Fisherfaces

Fisherfaces method is another popular method for face recognition. It is developed by Belhumeur. It uses both Principle Component Analysis (PCA) and Linear Discriminant Analysis (LDA) to produce the projection matrix. It is similar to the eigenfaces method. The fisherfaces method has an advantage of using within class information. It minimizes variation within class besides maximizing class separation[6].

To prove this we assume we have more than one face image of a subject in the training set. The images will be different like different illumination condition, orientation or facial expressions. Then the training set will be like[6],
Training Set = {Γ1,Γ2,Γ3,Γ4,…..,Γm}
Where Γi is an image matrix which represents training images. It's a set of images. It is divided into C number of class which represents number of person. Each class contains images of only one person. This is like[6],
X={Γ1,Γ2,Γ3,Γ4}
X={Γ5,Γ6,Γ7,Γ8}
…
X={ Γm-3,Γm-2,Γm-1,Γm}
We will compute three scatter matrix for within class (Sw), between class (Sb) and total distribution (St) of the training set[6].
St= $\sum_{n=1}^{m}(\Gamma n - \psi)(\Gamma n - \psi)^T$
St= $\sum_{i=1}^{C} X \vee (\Gamma n - \psi)(\Gamma n - \psi)^T$
St=$\sum_{i=1}^{C}\sum_{\Gamma k \epsilon Xi}(\Gamma n - \psi)(\Gamma n - \psi)^T$

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Where $\psi = \frac{1}{m}\sum_{n=1}^{m} \Gamma n$ the average image of the training is set and $\psi i = \frac{Xi \vee \sum_{\Gamma i \in Xi} \Gamma i}{1}$ is the average of each class. Using Principle Component Analysis (PCA) on the scatter matrix ST and using dominant M-C components, we create the projection matrix Upca We use Upca for dimensionality reduction within class. The c-l eigenvectors of the scatter matrices, Ufld is shown below

$$fldargmax\left(\frac{U^T U_{pca}^T S_b U_{pca} U}{U^T U_{pca}^T S_w U_{pca} U}\right)$$

And after that finally U_{ff} is calculated. The equation is stated below. This will project an image on a image space with c-l dimension, where between scatter is maximize while the within scatter is minimized for each class[6].

$$U_{ff} = U_{fld} U_{pca}$$

Once U_{ff} is generated, it is used as the same way of projection matrix in eigenfaces .

C. Local Binary Pattern-

The main purpose of Local Binary Pattern was designed for texture classification. The successful of LBP in robustness under illumination variations, discriminative power and computational simplicity have make it more useful in computer vision study in term of detection. After a lot of study and research that has been widely through by the researchers, it also can be applied in object detection based on other terms and does not only focusing in texture classification. During the accurate target object detection step, LBP feature are generally used.

Local Binary Pattern was introduced by Timoojala. The standard version of the LBP of a pixel is formed by thresholding the 3*3 neighborhood of each pixel value with the center pixel value let gc be the center pixel gray level and gi (i=0,1...7) be the gray level of each surrounding pixel .Fig.1 illustrate the basic LBP operation. If gi is smaller than gc, the binary result of the pixel is set to 0 otherwise set to 1.All the results are combined to get 8 bit value. The decimal value of the binary is the LBP feature[8].

The local Binary Pattern is a technique of face detection and recognition using both shape and texture information of a image it is very effective for image textures. The human face area is segmented into small regions to measure local binary pattern histogram which is used to recognize image. The local binary patterns are used to select the target region of the image and form a matrix for feature selection[7].

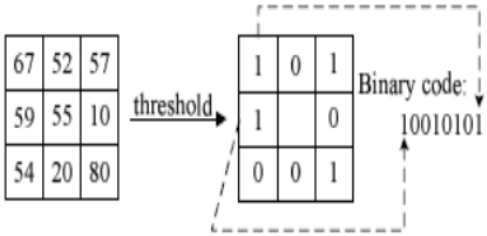

Fig 5. Illustration of Basic LBP operator[8].

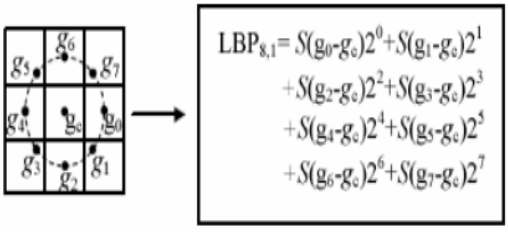

Fig 6. The LBP operator of a pixel's circular neighborhood with r=1, p=8[8].

Bilinear interpolation method is used for a sampling point does not fall in the cener of pixel .Let LBPp,r denote the LBP feature of a pixel circularly neighborhoods,where r is the radius and p is the number of neighborhood points on the circle .from fig.4 we can write ,

$$LBP_{p,r} = \sum_{p=0}^{p-1} s(g1 - gc)\, 2^i, S(x) = \begin{cases} 1 if x \geq 0 \\ 0 otherwise \end{cases}$$

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The concept of uniform patterns is introduced to reduce the number of possible bins. Any LBP pattern is called as uniform if the binary pattern consists of at most two bitwise transitions from 0 to 1 or vice versa. For example if the bit pattern 11111111(no transition) or 00110000 (two transitions) are uniform where as 10101011 (six transition) are not uniform. The uniform pattern constraint reduces the number of LBP pattern from 256 to 58 and it is very useful for face detection[8].

TABLE 1.
THEORITICAL COMPARISON OF SEVERAL EXISTING METHODS IN TERMS OF KEY PARAMETERS WITH FEATURE BASE FACE DETECTION

Approach /Parameter	Haar like Feature base Face Detection	Geometric Base Face Detection
Precision	High	Low
Execution Time	Low	High
Learning Time	High	High
Ratio between detection rate & false alarm	High	Low

TABLE 2.
PROS & CONS OF SEVERAL EXISTING FACE DETECTION METHODS

Technique	Merits	Demerits
Feature base Face Detection	More accurate and Low execution time	High learning time
Geometric Base Face Detection	Effective approach and Easy to implementation	Low accuracy and More false alarm
Haar Like Feature Base Face Detection	Improved feature extraction part and Less false alarm	High execution time and Complex to implement

TABLE 3
Accuracy of four methods tested without imposter

Methods	Neutral	Illumination	Expression	Pose
PCA	0.80	0.81	0.8455	0.77
LDA	0.91	0.92	0.89	0.83
LBP	0.94	0.97	0.91	0.92

IV. CONCLUSION

Authentication & Identification has become major issue in today's digital world. Face detection and recognition plays a significant role in authentication & identification. There are several existing approaches available to do so. In this paper several methods are explained, analysed & compared. From theoritical analysis & comparison and focusing on the key parameters, haar like feature extraction face detection approach is found as a very good candidate for face detection.

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