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Survey & Review of Face Recognition Techniques Using MATLAB

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Abstract: ***As we all know that each human is having a face from which we identify that person. Similarly face recognition has become a most important biometric technology for recognizing human faces in today's world. The face recognition system uses multiple numbers of techniques to recognize the human faces. Thus we can say that the face recognition system is computer software which is developed for identifying and recognizing human faces in a computer programming language known as MATLAB. The main purpose of the human face recognition system is to first identify a human face then it recognizes that face by matching the input face image to its database stored face images. Finally if a best match is found then system prints a name and photo of that person who is recognized by it on the screen. Our face is not only our unique identity but also became our security system in today's world. Therefore the human face recognition system is a big mechanism used for security & surveillance. It detect criminals, terrorist and it even work well in banking access. Our approach will also be going to discuss all the face recognition techniques in 2 & 3 dimension used till now. Hybrid face recognition methods can be used for better results in future. Finally here our survey paper is providing a brief review of all the research papers as well as survey papers implemented till now.***

Keywords: Biometrics, Face recognition process and techniques, MATLAB

1. Introduction

Face recognition is one of the most important applications of biometrics based authentication system in the last few decades. Face recognition is kind of recognition task pattern, where a face is categorized as either known or unknown after comparing it with the images of a known person stored in the database.

Face features in face recognition for individual identification are considered a major method of the biometric area. Nowadays, the person appears in the video or digital image can automatically be identifying that person by Facial Recognition System (FRS) which is a significant technique to enhance security problems [77]. Recently, many researchers focused on the face recognition techniques. The human face in a person recognition application is a unique and valuable trait. In contrast, low resolution, light, person poses, and illumination variation are some of the drawbacks of faced person recognition. Therefore, face recognition system provides the researchers the opportunity to invent a new method to solve these drawbacks, which will enhance security and help in discovering new optimization techniques for face recognition [76]-[78]. The idea behind the face recognition system is to determine the known and unknown faces, so a face recognition system is basically, use pattern recognition. In this area of pattern recognition, artificial intelligence and computer vision our researchers had suggested many solutions to enhance the accuracy and robustness of recognition [79].

In recent years face recognition has received substantial attention from researchers in biometrics, pattern recognition, and computer vision communities. The machine learning and computer graphics communities are also increasingly involved in face recognition. Besides, there are a large number of commercial, securities, and forensic applications requiring the use of face recognition technologies. Face recognition has attracted much attention and its research has rapidly expanded by not only engineers but also neuroscientists, since it has many potential applications in computer vision communication and automatic access control system. Especially, face detection is an important part of face recognition as the first step of automatic face recognition[1]. However, face detection is not straightforward because it has lots of variations of image appearance, such as pose variation (front, nonfront), occlusion, image orientation, illuminating condition and facial expression. The aim of face detection is detect faces in any images or videos. In the last years many face-based algorithms have been developed and several studies regarding their performance exist [1]. Due to the increasing functionalities of mobile devices the implementation of these systems in cellphones is becoming a general demand.

In order to test and assess the developed systems, a large amount of face images databases have been created and made public for general use. In today's world security is most important therefore our face detection and recognition system not only prevent our cellphones from unauthorized access but it also provides security in many government offices and private working areas.

2. Problem Definition

The face recognition problem can be formulated as follows: Given an input face image and a database of face images of known individuals, how can we verify or determine the identity of the person in the input image?

3. History of Face Recognition

The subject of face recognition is as old as computer vision because of the practical importance of the topic and theoretical interest from cognitive scientists. Despite the fact that other methods of identification (such as fingerprints, or iris scans) can be more accurate, face recognition has always remains a major focus of research because of its non-

invasive nature and because it is people's primary method of person identification.
Perhaps the most famous early example of a face recognition system is due to Kohonen, who demonstrated that a simple neural net could perform face recognition for aligned and normalized face images. The type of network he employed computed a face description by approximating the eigenvectors of the face image's autocorrelation matrix; these eigenvectors are now known as 'Eigen faces.'

Kohonen's system was not a practical success, however, because of the need for precise alignment and normalization. In following years many researchers tried face recognition schemes based on edges, inter-feature distances, and other neural net approaches. While several were successful on small databases of aligned images, none successfully addressed the more realistic problem of large databases where the location and scale of the face is unknown.

Kirby and Sirovich (1989) later introduced an algebraic manipulation which made it easy to directly calculate the eigenfaces, and showed that fewer than 100 were required to accurately code carefully aligned and normalized face images. Turk and Pentland (1991) then demonstrated that the residual error when coding using the eigenfaces could be used both to detect faces in cluttered natural imagery, and to determine the precise location and scale of faces in an image. They then demonstrated that by coupling this method for detecting and localizing faces with the Eigen face recognition method, one could achieve reliable, real-time recognition of faces in a minimally constrained environment.

This demonstration that simple, real-time pattern recognition techniques could be combined to create a useful system sparked an explosion of interest in the topic of face recognition.

4. Related Work

Alaa Eleyan et al (2005) has analyzed that face recognition is one of the most important image processing research topics which is widely used in personal identification, verification and security applications. In this paper, a face recognition system, based on the principal component analysis (PCA) and the feed forward neural network is developed.

The system consists of two phases which are the PCA preprocessing phase, and the neural network classification phase. Jawad Nagi et al (2008) recognized that automatic recognition of people is a challenging problem which has received much attention during recent years due to its many applications in different fields. Face recognition is one of those challenging problems and up to date, there is no technique that provides a robust solution to all situations.

This research presents a new technique for human face recognition. Shamla Mantri et al (2011) proposed to label a Self-Organizing Map (SOM) to measure image similarity. To manage this goal, the author feed Facial images associated to the regions of interest into the neural network. At the end of the learning step, each neural unit is tuned to a particular Facial image prototype. Facial recognition is then performed by a probabilistic decision rule. This scheme offers very promising results for face identification dealing with illumination variation and facial poses and expressions.

Mohammod Abul Kashem et al (2011) investigated that face recognition has received substantial attention from researches in biometrics, pattern recognition field and computer vision communities. Face recognition can be applied in Security measure at Air ports, Passport verification, Criminals list verification in police department, Visa processing , Verification of Electoral identification and Card Security measure at ATM's. In this research, a face recognition system for personal identification and verification using Principal Component Analysis (PCA) with Back Propagation Neural Networks (BPNN) is proposed. Sasikumar Gurumurthy et al (2012) analyzed that human Face Recognition systems are an identification procedure in which a person is verified based on human traits. This research describes a fast face detection algorithm with accurate result. Lip Tracking is one of the biometric systems based on which a genuine system can be developed. Since the uttering characteristics of an individual are unique and difficult to imitate, lip tracking holds an advantage of making the system secure. The author use pre- recorded visual utterance of speakers has been generated and stored in the database for future verification. Nisha Soni et al (2013) introduced that face recognition (FR) is a challenging issue due to variations in pose, illumination, and expression.
The search results for most of the existing FR methods are satisfactory but still included irrelevant images for the target image. Navneet Jindal et al (2013) give an idea of face detection from a long database of face images with different backgrounds is not an easy task. In this work, the author demonstrated the face detection system of colored face images which is invariant to the background and acceptable illumination conditions. Cunjian Chen et al (2013) analyzed that the facial makeup has the ability to alter the appearance of a person. Such an alteration can degrade the accuracy of automated face recognition systems, as well as that of methods estimating age and beauty from faces.

5. Biometrics

Biometrics is used in the process of authentication of a person by verifying or identifying that a user requesting a network resource is who he, she, or it claims to be, and vice versa. It uses the property that a human trait associated with a person itself like structure of finger, face details etc. By comparing the existing data with the incoming data we can verify the identity of a particular person[1].

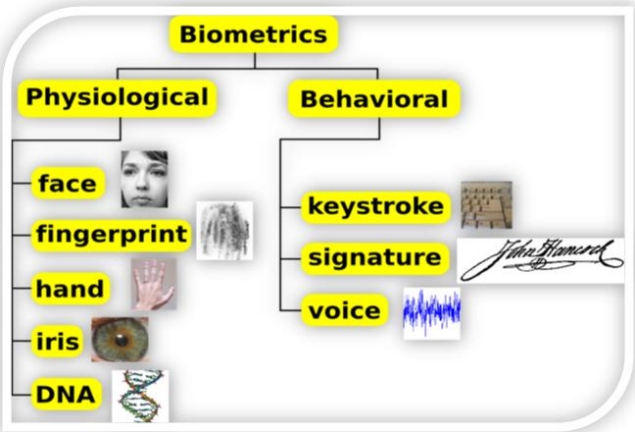

Figure 5: Types of Biometrics [68]

There are many types of biometric system like fingerprint recognition, face detection and recognition, iris recognition etc., these traits are used for human identification in surveillance system, criminal identification. Advantages of using these traits for identification are that they cannot be forgotten or lost. These are unique features of a human being which is being used widely [2].

6. Why Use the Face for Recognition

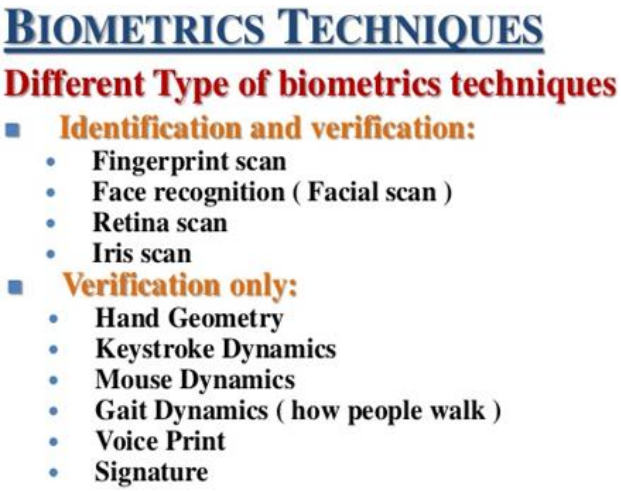

Figure 6: Illustrating the Biometric techniques & Face recognition importance [69]

Biometric-based techniques have emerged as the most promising option for recognizing individuals in recent years since, instead of authenticating people and granting them access to physical and virtual domains based on passwords, PINs, smart cards, plastic cards, tokens, keys and so forth, these methods examine an individual's physiological and/or behavioral characteristics in order to determine and/or ascertain his identity. Passwords and PINs are hard to remember and can be stolen or guessed; cards, tokens, keys and the like can be misplaced, forgotten, purloined or duplicated; magnetic cards can become corrupted and unreadable. However, an individual's biological traits cannot be misplaced, forgotten, stolen or forged. Biometric-based technologies include identification based on physiological characteristics (such as face, fingerprints, finger geometry, hand geometry, hand veins, palm, iris, retina, ear and voice) and behavioral traits (such as gait, signature and keystroke dynamics) [1].

Face recognition appears to offer several advantages over other biometric methods, a few of which are outlined here: Almost all these technologies require some voluntary action by the user, i.e., the user needs to place his hand on a hand-rest for fingerprinting or hand geometry detection and has to stand in a fixed position in front of a camera for iris or retina identification.

However, face recognition can be done passively without any explicit action or participation on the part of the user since face images can be acquired from a distance by a camera. This is particularly beneficial for security and surveillance purposes. Furthermore, data acquisition in general is fraught with problems for other biometrics: techniques that rely on hands and fingers can be rendered useless if the epidermis tissue is damaged in some way (i.e., bruised or cracked). Iris and retina identification require expensive equipment and are much too sensitive to any body motion. Voice recognition is susceptible to background noises in public places and auditory fluctuations on a phone line or tape recording. Signatures can be modified or forged.

However, facial images can be easily obtained with a couple of inexpensive fixed cameras. Good face recognition algorithms and appropriate preprocessing of the images can compensate for noise and slight variations in orientation, scale and illumination.

Finally, technologies that require multiple individuals to use the same equipment to capture their biological characteristics potentially expose the user to the transmission of germs and impurities from other users. However, face recognition is totally non-intrusive and does not carry any such health risks.

7. Face Recognition Process

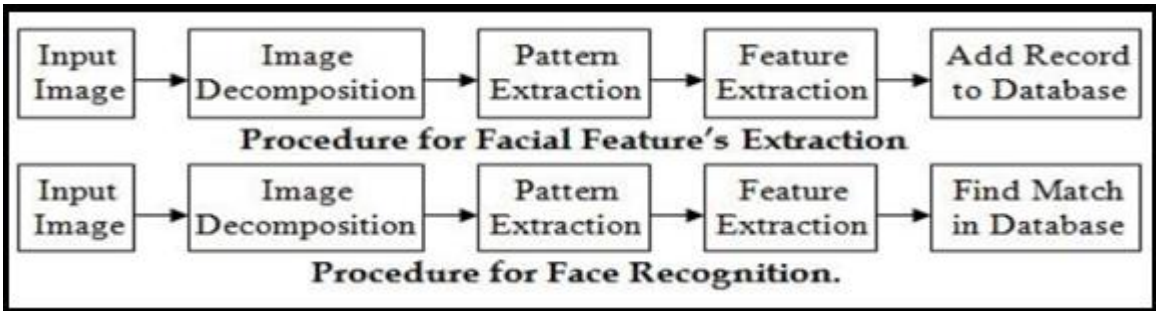

Figure 7.1: Procedure for face recognition [70]

Figure above shows the procedure of human face recognition process. From this block diagram we can just find out that this is a general procedure used for human face recognition.

In this figure the work of image decomposition is done by any method for example PCA, LDA, ICA, KPCA, SVM, AI, BPNN, etc. Now we will study all those methods in brief which were used till now. Below figure shows the above figure concept in more detail.

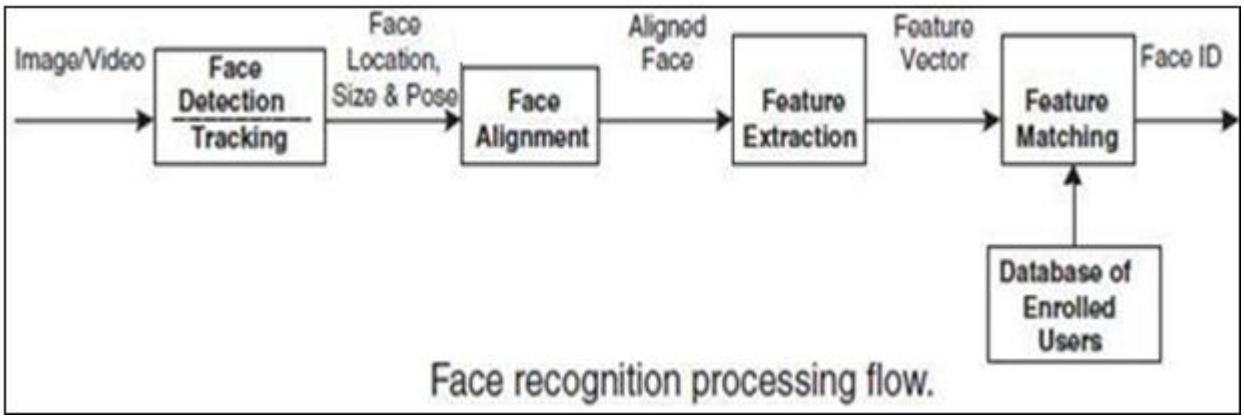

Figure 7.2: Showing the above face recognition process flow in the more detail [71]

8. Face Recognition Techniques

There are various number of techniques used till now in the process of human face detection and recognition. But from all these techniques here we are going to discuss the few of them which are popularly known in this field of image processing and pattern recognition. Face recognition is one of the most important applications of biometrics based authentication system in the last few decades. Face recognition is kind of recognition task pattern, where a face is categorized as either known or unknown after comparing it with the images of a known person stored in the database. Face recognition is a challenge, given the certain variability in information because of random variation across different people, including systematic variations from various factors such as lightening conditions and pose [1].

Face pose is a specifically difficult problem in this aspect simply because all faces seem similar; specifically, all faces consist of two eyes, mouth, nose, and other features that are in the same location [1] [2]. The human face is an extremely complex and dynamic structure with characteristics that can significantly and quickly change in time.

Face recognition involves a range of activities from various aspects of human life. Humans can recognize faces, but too many faces sometimes being hard to memorized, machine learning is now being improved to do this task.

Scientists attempt to understand the architecture of the human face when building or developing face recognition systems. Face recognition algorithms are using either geometrical techniques or feature-based approaches or holistic methods. All of them do not solve the aging problem. Almost all of them give an age tolerance as long as 20 years after the training. Faces between 1 year and 15 years cannot be recognized since face appearance changes fast. Face appearance becomes stable after teenage years. A recognition algorithm that can recognize faces for all ages does not exist.

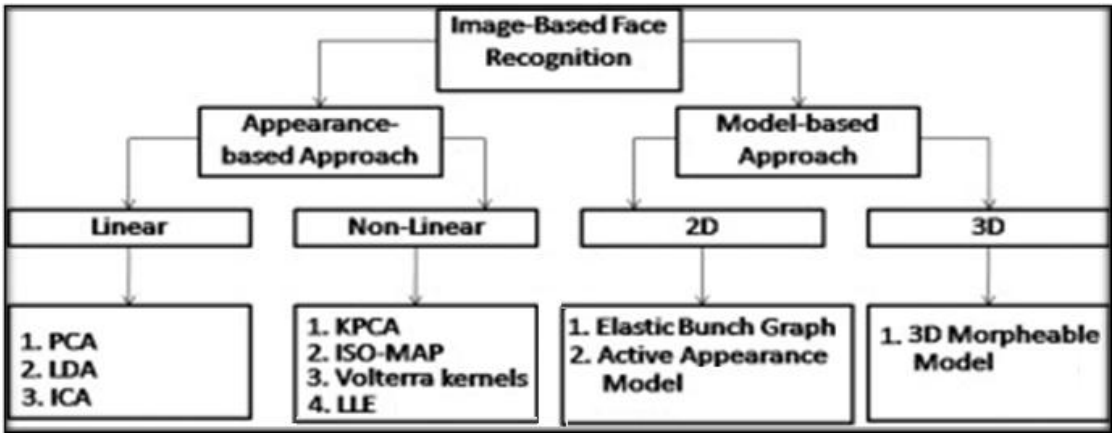

Figure 8: Showing face recognition techniques [72]

Now we are going to show another diagram of appearance based approach in the detail as follows and then we are going to discuss all these methods in detail:-

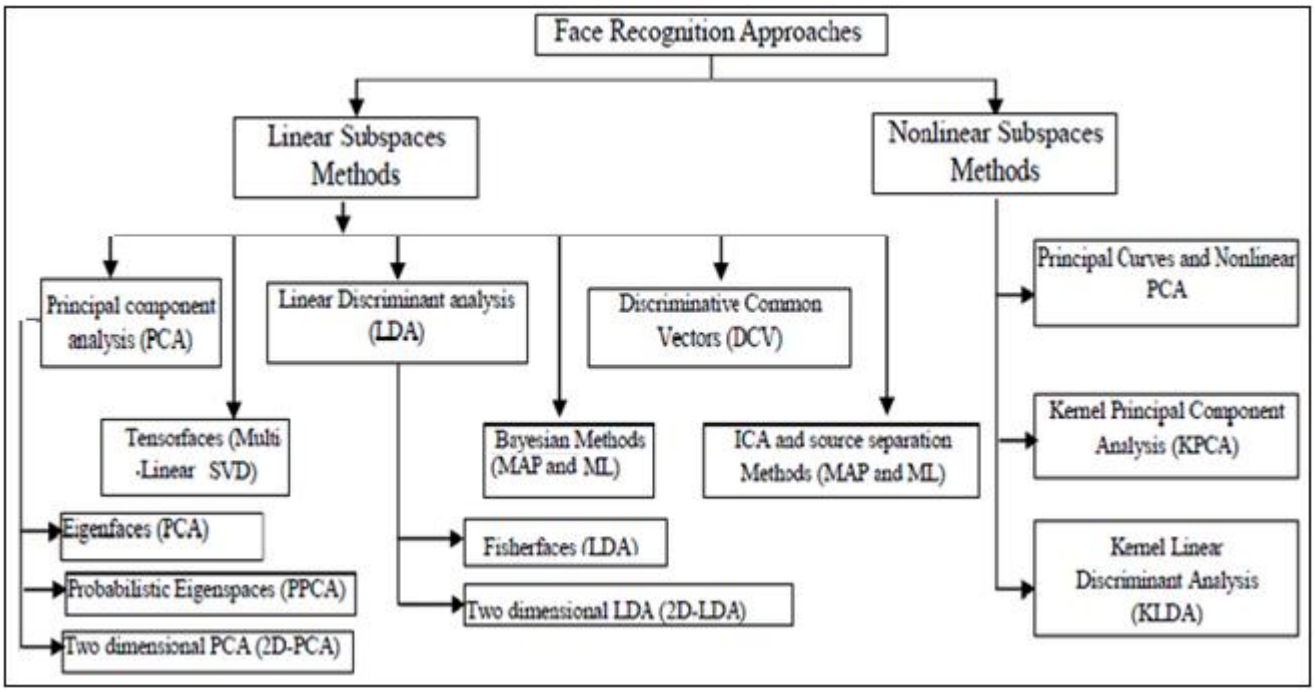

Figure 8.2: Face Recognition Approaches [73]

8.1 Principle Component Analysis (PCA)

This method is used for dimension reduction and feature extractions. Turk and Pentland were first used PCA for human face recognition [16], and the person faces reconstruction was done by Kirby and Sirovich [17]. This strategy helped to reduce the dimensionality of the original data by extracting the main components of multidimensional data [18]-[19]. The face recognition process is based on the new obtained data.

The illumination normalization is very much necessary for Eigenfaces. Instead of Eigenfaces, Eigen features like eye, nose, mouth, cheeks, and so forth is used. Calculating the subspace of the low dimensional representation is used for data compression [16], [20]-[23]. The work [24] done by (Abdullah et al., 2012) presented three experiments to enhance PCA efficiency by reducing the computational time while keeping the performance same.

The results showed that the accuracy is same with the second experiment with less computational time. According to this approach, the computation time reduced by 35% compared with the original PCA method especially with a large database. While, (Mohit P. Gawande et al., 2014) [25] has proposed a new face recognition system for personal identification and verification using different distance classifiers with PCA. This technique is applied on ORL database.

8.2 Euclidean distance

The Euclidean distance between two points in either the plane or 3-dimensional space measures the length of a segment connecting the two points. It is the most obvious way of representing distance between two points. The Pythagorean Theorem can be used to calculate the distance between two points, as shown in the figure below. If the points (x1, y1) and (x2, y2) are in 2 dimensional space then the Euclidean distance between them is given by equation:-

$$\sqrt{(X2 - X1)^2} + \sqrt{(Y2 - Y1)^2}$$

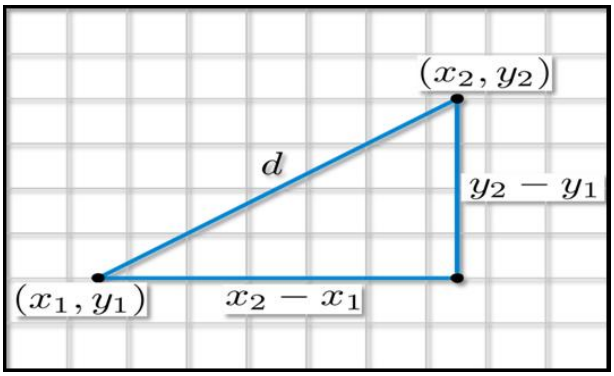

Figure 8.1.2: Concept of Euclidean Distance [74]

The experiment results show that PCA provided improved results using Euclidian distance classifier and the squared Euclidian distance classifier than the City Block distance classifier, which gives better results than the squared Chebyshev distance classifier. While, using the Euclidian and the Squared Euclidian distance classifier, the recognition rate is the same. In addition, (Poon et al., 2016) [26] presented several techniques for illumination invariant were examined and determine powerful one for face recognition that works better with PCA. The selected technique is named Gradient faces and at the pre-processing stage the experimental results showed that improves the recognition rate. Whereas, (Barnouti, N.H., 2016) [27] Illustrate a system using PCA-BPNN with DCT. In this method, PCA is combined with BPNN, and from face recognition view, the technique 4th International Engineering Conference on Developments in Civil & Computer Engineering Applications 2018 (ISSN 2409-6997) will distinguish human faces easily. Also, the face databases are compressed using DCT. The recognition rate of this method is more than 90% that carried out on Face94 and Grimace face databases.

In contrast, (Fares Jalled 2017) [28] Proposed "Normalized Principal Component Analysis (NPCA) for face recognition". The experiment result of face recognition performance rate is carried out on the ORL and Indian Face Database.

8.3 Independent Component Analysis (ICA)

This algorithm is a linear combination of statistically independent data points. The main goal of this technique in contrast of PCA which supply an independent image representation instated of uncorrelated one of PCA [29]. ICA minimizes the input of both second-order and higher-order dependencies. It follows the Blind Source Separation (BSS) problem; it aims to decompose an observed signal into a linear combination of unknown independent signals [30]-[31]. The research [32] (Sharma and Dubey, 2014) provided face recognition system using PCA–ICA, and training using neural networks as a Hybrid feature extraction.

This technique extracts the invariant facial features by implementing PCA/ICA-based facial recognition system to build a refined and reliable face recognition system. Also, in [33] (Kailash J. et al., 2016) it has been illustrated that the cost function is reduced to maximizing the independence of extracted features as well as the sum of the mutual information between extracted features and a target variable. The global feature extraction based on edge information, and the local features based on modular ICA which is used in this research. As a summary, the new technique of feature extraction work will give future direction for the research in biometrics field. In recent years so many techniques are emerged for face recognition but still all are not 100% satisfactory, all the techniques have some advantages as well as some disadvantages.

8.4 Linear Discriminant Analysis (LDA)

Linear Discriminant Analysis- This technique is extensively explored the illumination change and synthesis for facial analysis using appearance-based approaches to achieve an illumination-invariant but not works properly under variations in pose and different lighting conditions. LDA is used for feature extraction and dimension reduction, its widely used to search for linear groups of features while maintaining the separate of classes and also known as Fisherface. LDA is a supervised learning method that uses more than one training image for each class [38].

The original work of the Fisherface projection method is to solve the illumination problem by maximizing the ratio of between-class scatter to within-class scatter. Fisherface is less sensitive to pose, lighting, and expression variations. LDA optimizes the low dimensional representation of the objects [27] [38]. Singularity problem is the limitation of the classic LDA. Face recognition is challenged by the small sample size (SSS) problem through LDA when the total number of training images is less than the feature space dimension. Another LDA problem is the high computational cost in cases of huge data [14].

8.4 Kernel Linear Discriminant Analysis (KLDA)

The input space is mapped onto the feature space through non-linear mapping, and then the PCs in the feature space are determined. They can compute the dot products of two feature vectors even without knowing what the vectors are. The kernel method enables the construction of non-linear versions of any method that can be expressed solely in term of dot products. Given the increase in dimensionality, the mapping is made implicit and economical by using kernel functions that satisfy Mercer's theorem.

(Kamerikar and Chavan, 2014) [30] done a comparison between kernel LDA (KLDA) and LDA methods. This comparison show that LDA works better when a lesser number of training images are chosen per person. For any face database, whether colored or gray scale, LDA performs better than KLDA for a smaller number of training images per person. The projection of training images for the KLDA scatter within classes is closer than in LDA, but the scatter between classes are farther than in LDA. The average recognition rate of the KLDA performance is better than that of LDA.

8.5 Support Vector Machine (SVM)

In SVM based classification systems, the classification performed by constructing a new hyper plane that provides maximum separation among the data items. The margin of the hyper plane should be at the maximum. The vectors that found near the hyper plane are called support vectors. Every point in the input space is non-linearly mapped into a high-dimensional feature space. This mapping is done using kernel functions.

(Zagouras et al., 2007) [31] used Kernel functions for the experiments include linear, polynomial, and radial basis function kernels. The experiments are conducted using the ORL face database comprising 400 images of 40 individuals. A total of 200 randomly selected samples serve as the training set. This sample set is used to construct the Eigenfaces and to train the SVM. Changing the feature vector size alters the input vector size of the classifier because the output is given directly to the classifier after the PCA transformation.

8.6 Hidden Markov Model (HMM)

The stochastic modeling of a non-stationary vector time series based on the Hidden Markov Model (HMM) is very successful for speech applications. Applying this method on human face recognition initially divides the faces into different regions, such as the eyes, nose, and mouth, which can be associated with the states of an HMM. The images need to be converted into either a 1D temporal sequence or a 1D spatial sequence because HMMs require a 1D observation sequence and 2D images.

(Sun et al., 2010) [33] briefly analyzed different facial patterns via an adaptive 3D face model series. The role of the tracking-model-based method is usually to accommodate the lack of a feature vector. Similarly, a spatial temporal face model descriptor is used to evaluate the system. One of the

major drawbacks of HMM is its sensitivity to geometrical shapes. To cope with such a problem, a confirmation-based HMM is appreciated, where the experimental results reveal that the proposed model is highly preferable than traditional HMMs and various standard-based HMM models.

8.7 Elastic Bunch Graph Matching (EBGM)

EBGM method identifies a person in a new face image by comparing the new face image to other faces stored in a database. The method extracts feature vectors called Gabor Jets from interest point on the face, and then those features are matched to corresponding features from the other faces in the database [8].

Change in one feature does not disable this method to recognize the person anymore. This method is relatively insensitive to variations in facial positions. EBGM is very sensitive to light and takes too much matching time; thus, it is inappropriate for actual environments.

The graphs that are placed on the face should be compared to obtain better performance, but these graphs require a huge storage of convolution images [8].

EBGM method operates in three phases. First, important landmarks on the face located by comparing the Gabor Jets extracted from the new image to those taken from the training images. Second, each face image is processed into a smaller description of that face called a Face Graph. In the last phase, the similarities among many Face Graphs are compared by calculating the similarities of the Gabor Jets features. The Face Graph with the highest similarity has the highest possibility of belonging to the same person. Although, all of these phases affect the method performance.

8.8 Kernel Principal Component Analysis (KPCA)

Non-linear PCA is also derived from different methods, different kernel methods are generalized to form one of the major types of non-linear PCA called Kernel PCA (KPCA). Primarily, KPCA calculates PCA by mapping the original input into a high dimensional feature space using different kernel methods. (Liang et al., 2009) [28] used KPCA for face hallucination. The main concept of using KPCA is that this method can classify both linear and nonlinear data. Different resolution images have also been observed to contain similar features in the kernel subspace.

(Wang and Zhang, 2010) [29] outlined another approach for handling facial expressions and extracting suitable features. In this regard, the polynomial kernel is effectively employed to deal with nonlinear structures resulting from expression changes. In addition, the nearest neighbor and Euclidean distance are used for a compact representation. The experiment results are outstanding compared with those of traditional PCA-based approaches.

(Vinay et al., 2015) done comparison between GABOR-PCA and GABOR KPCA variants in order to ascertain the performance variation. ORL database is used to test the system performance. The results demonstrated that the GABOR-PCA method outperformed GABOR-KPCA by 6.67% (Euclidean), 0.83% (Cosine), 12.00% (City Block) and 4.17% (MAHCOS). This upsurge is contrary to the general assumption that KPCA is by default a better choice.

8.9 AI Approach

AI basically stands for “Artificial Intelligence”. This concept works on artificial brain which works like just very few portions of brain but not complete.AI approaches utilize tools such as neural networks and machine learning techniques to recognize faces.

8.10 Local Feature-Based Methods

Most of earlier face recognition methods belong to this category. In these methods, usually only a single image per person is used to extract geometrical measures such as the width of the head, the distances between the eyes, and so on. The extracted features are then stored in the database as templates for later matching usage. In early 1990s, Brunelli and Poggio described a face recognition system, which can automatically extract 35 geometrical features to form a 35-dimensional vector for face representation, and the similarity matching is performed with a Bayes classifier.

8.11 Back Propagation Neural Network

BPNN is an Artificial Neural Network (ANN) based powerful technique which is used for detection of the intrusion activity. Basic component of the BPNN is a neuron, which stores and processes the information. BPNN which is used for linear as well as non linear classification is a supervised learning algorithm in which error difference between the desired output and calculated output is back propagated.

The procedure is repeated during learning to minimize the error by adjusting the weights thought the back propagation of error. As a result of weight adjustments, hidden units set their weights to represent important features of the task domain. BPNN consists of three layers: 1) Input Layer 2) Hidden Layer and 3) Output Layer. Number of the hidden layers, and number of hidden units in each hidden layers depend upon the complexity of the problem. Learning in BPNN is a two step processes [2].

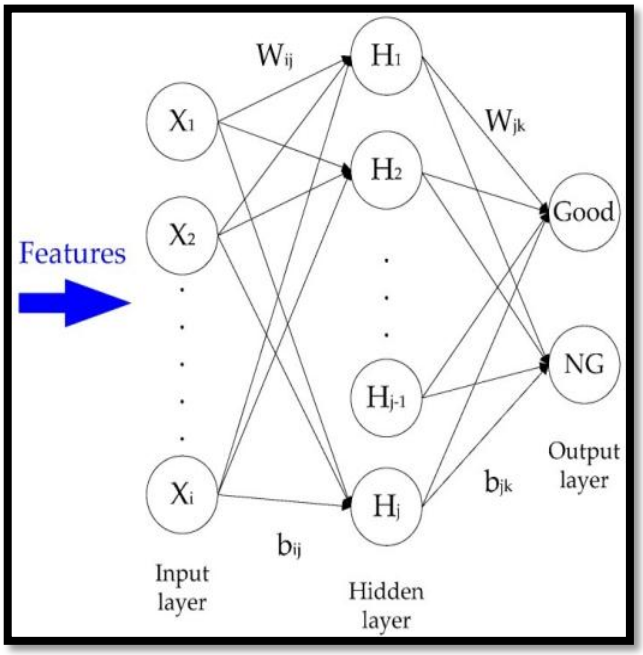

Figure 8.11: Multilayered Neural Network [75]

The back propagation algorithm is a multi-layer network using a weight adjustment based on the sigmoid function, like the delta rule. According to the back-propagation Network (BPN) algorithm, is a fully feed forward network connection. The activation travels in a direction from input layer to the output layer and the units in one layer are all connected to every unit in the next layer.

Basically, back-propagation algorithm consists of two sweeps of the network which are the forward sweep and the backward sweeps. Forward sweep defines the network from the input layer to the output layer, in which it propagates the input vectors through the network to provide outputs at the output layer in the end. During the forward sweep, the weights of the networks are all fixed.

The backward sweep hence defines network from the output layer to the input layer, where it is similar to forward sweep except that the error values are propagated back through the network. This is done in order to determine how the weights are to be changed during the training, in which the weights are all adjusted in accordance of an error correction rule where the actual response of the network is subtracted from the target response to produce an error signal [10].

In fig.8.11, the hidden units send activation to each output units and thus during backward sweep, this hidden unit will received an error signals from the output units. Basically, the number of processing elements in each layer will vary according to the applications verified.

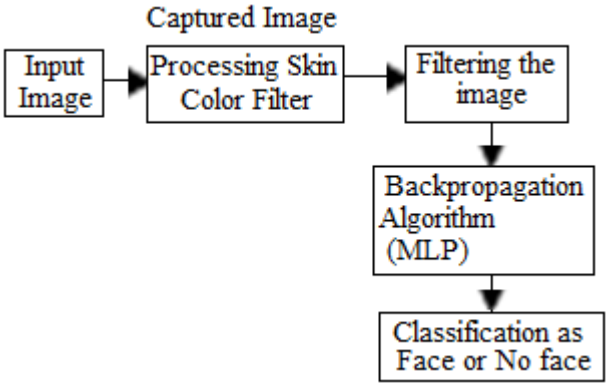

Figure 8.11.2: Block diagram of Back propagation multilayer Perceptron (MLP)

8.12 Three-D Model Based

The 3D face recognition methods have become more popular; these methods use 3D sensors to capture information about face shape. They can be divided into two main categories (3D face reconstruction and 3D pose estimation) [24]. The human face is a surface that lies in a 3D space intrinsically. Therefore, 3D model can better represent faces, particularly in handling facial variations such as pose and lighting.

There is a growing demand for better facial recognition systems, those which have lesser or no problems with lightning, different angles and expressions. 3D facial recognition is an upcoming market, the techniques are getting better, the research completer and the hardware less expensive. Figure below illustrates how 3-dimension face detection & recognition system works.

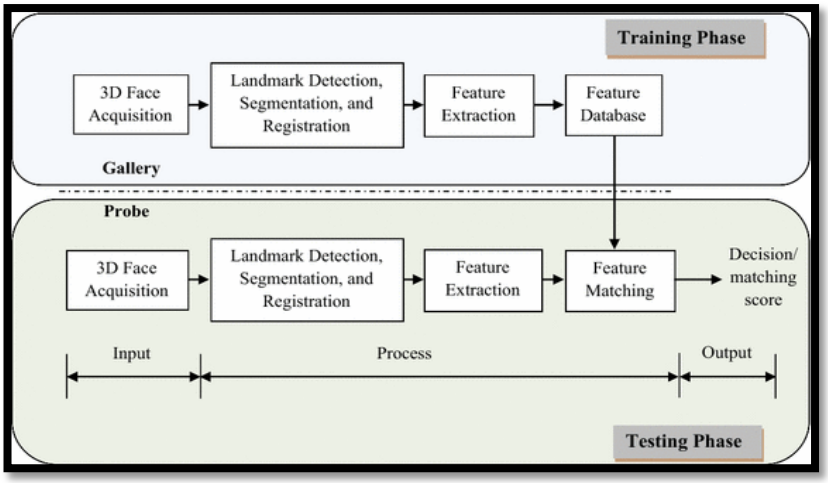

Figure 8.12: 3-D face detection and recognition system [76].

Now we will discuss the techniques which are falls under 3-D model:-

- **Knowledge-based methods** -This model based on human knowledge of the typical human face geometry and facial features arrangement A hierarchical approach may be used, which examines the face at different resolution levels[4].
- **Feature invariant method** -This aim to find structural features that exist even when the viewpoint or lighting conditions vary and then use these to locate faces. Different structural features are being used: facial local features, texture, and shape and skin color [4].
- **Template Matching Approaches**-To detect a face in a new image, first the head outline, which is fairly consistently roughly elliptical, is detected using filters, edge detectors, or silhouettes. Then the contours of local facial features are extracted in the same way, exploiting knowledge of face and feature geometry.
- **Appearance-based methods** -While template matching methods rely on a predefined template or model, appearance-based methods use large numbers of examples (images of faces and \ or facial features)depicting different variations (face shape, skin color, eye color, open\closed mouth, etc). Face detection can be viewed as a pattern classification problem with two classes: ―face and non-face. The non face class contains images that may depict anything that is not a face, while the face class contains all face images [4].

9. Face Recognition from Video Sequences

Since one of the major applications of face recognition is surveillance for security purposes, which involves real time recognition of faces from an image sequence captured by a video camera, a significant amount of research has been directed towards this area in recent years. A video-based face recognition system typically consists of three modules: one for detecting the face; a second one for tracking it; and a third one for recognizing it [56]. Most of these systems choose a few good frames and then apply one of the recognition techniques for intensity images to those frames in order to identify the individual [57]. A few of these approaches are briefly described below.

Howell and Buxton [58] employed a two-layer RBF network [59, 60] for learning/training and used Difference of Gaussian (DOG) filtering and Gabor wavelet analysis for the feature representation, while the scheme from [61] was utilized for face detection and tracking. Training and testing were done using two types of image sequences: 8 primary sequences taken in a relatively constrained environment, and a secondary sequence recorded in a much more unconstrained atmosphere (Figs. 16, 17). The image sequences consisted of 62 to 94 frames. The use of Gabor wavelet analysis for feature representation, as opposed to DoG filtering, seemed to yield better recognition results. The recognition accuracies reported varied quite a bit, ranging from 99%, using 278 images for training and 276 for testing, to 67%, using 16 training and 538 testing images.

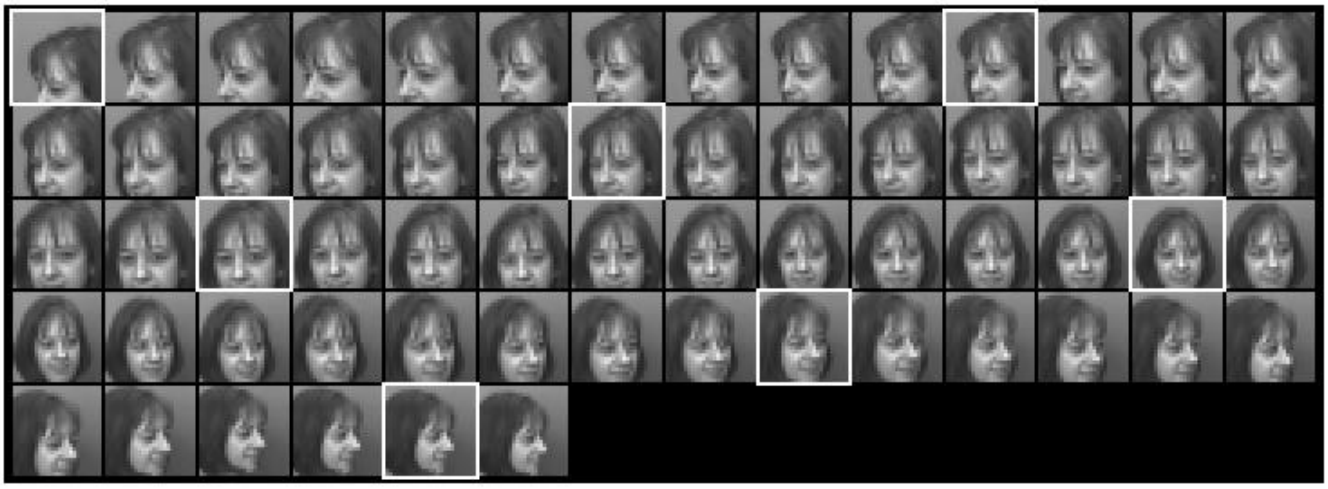

Figure 9.1: A complete Primary sequence for the class Carla, after segmentation but before preprocessing [58]

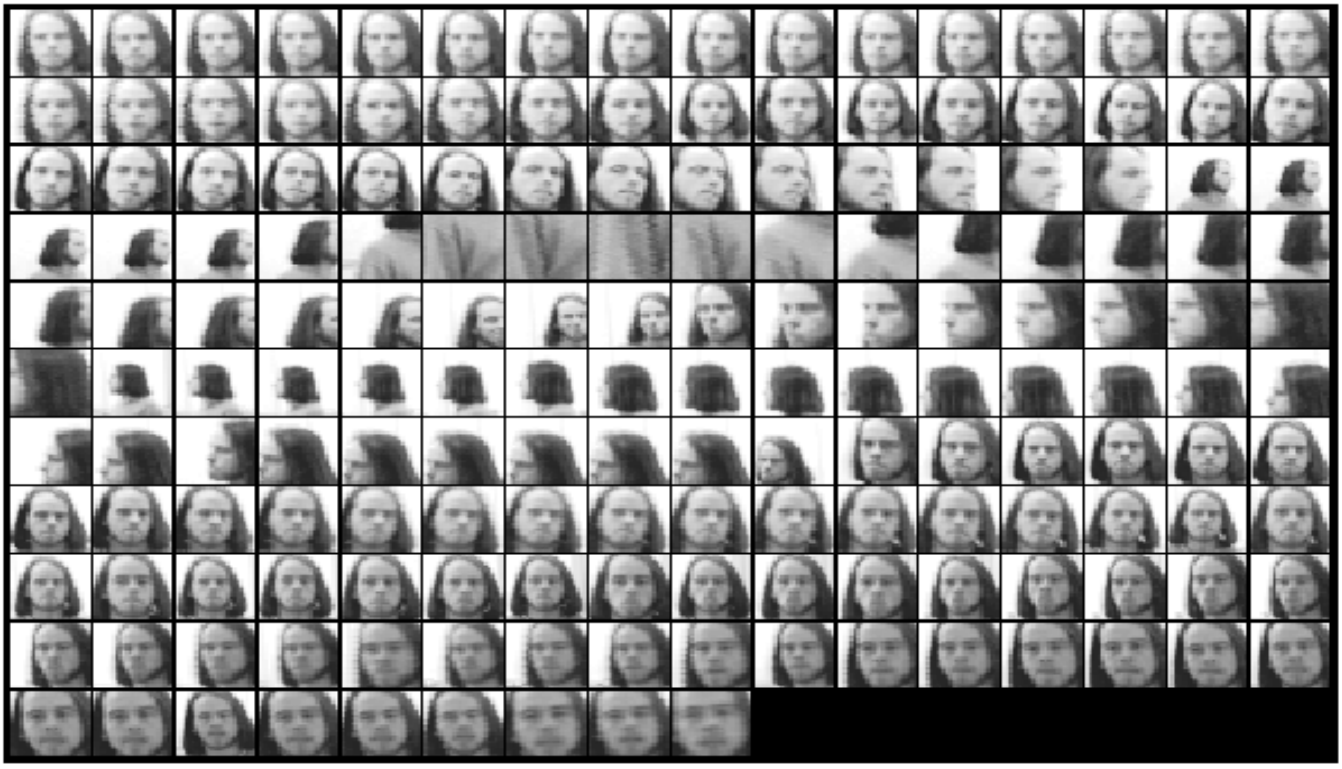

Figure 9.2: A complete Secondary sequence for the class Steve, after segmentation but before preprocessing [58]

De Campos et al. [62] propose a recognition system which uses skin color modeling [63] to detect the face, then utilizes GWN [64] to detect prominent facial landmarks (i.e., the eyes, nose, and mouth) and to track those features. For each individual frame, eigen features [55] are then extracted and a feature selection algorithm [65] is applied over the combination of all the eigen features, and the best ones are selected to form the feature space.

A couple of classifiers described in [66] are then applied to identify the individual in the frame and, finally, a super classifier based on a voting scheme [67] performs the final classification for the entire video sequence (Figs. 9.3, 9.4).

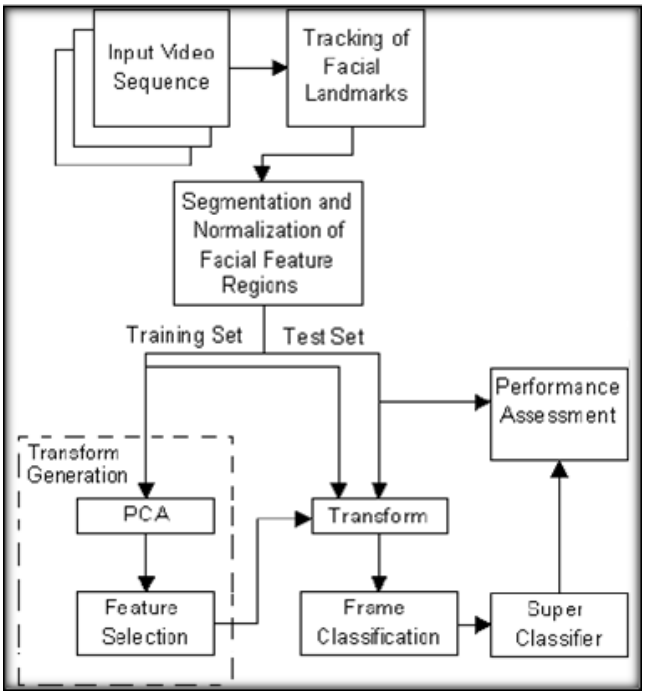

Figure 9.3: Overview of the project [62].
(Courtesy of T. E.de Campos, R. S. Feris and R. M. Cesar Jr.)

Good recognition results (97.7% accuracy) have been reported using 174 images of the eyes of 29 people (6 images per person).

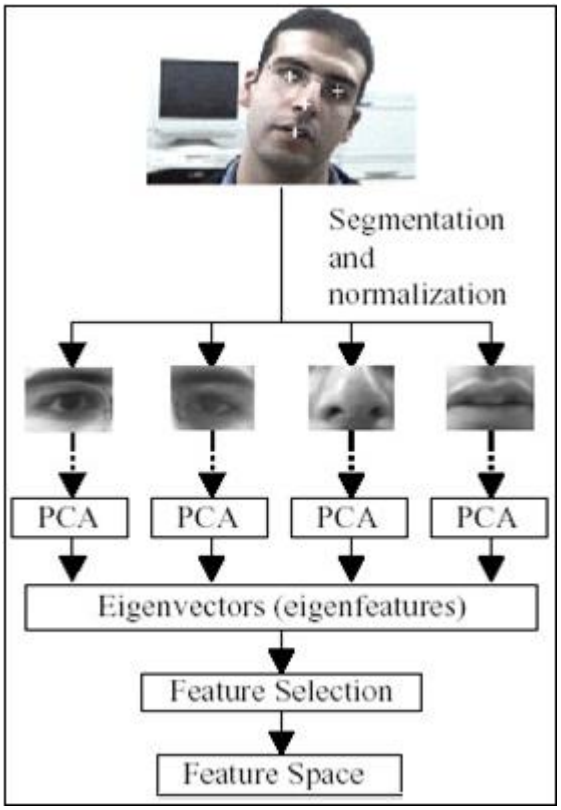

Figure 9.4: Feature space generation [62].
(Courtesy of T. E.de Campos, R. S. Feris and R. M. Cesar Jr.)

10. Face Recognition Database

Several face databases are available to face recognition researchers. Some of the familiar databases are shown in Table 10.1 & 10.2. The database varies in size, scope, and purpose. The photographs in many of these databases are acquired by small research teams specifically to study face recognition [38] [39].

Name	Individuals	Image Resolution
AT&T (ORL)	40	92 x 112 Gray Scale
FERET	1199	256 x 384 Gray Scale/ RGB
AR Face Database	126 70 Male 56 Female	576 x 768 RGB
PIE Database, CMU	68	640 x 486 RGB

Table 10.1: Face recognition database

Name	Individuals	Image Resolution
Bio ID Face Database	23	382 x 288 Gray Scale
The Yale Face Database	15 14 Male 1 Female	320 x 243 Gray Scale
The Yale Face Database B	10	640 x 480 Gray Scale
UMIST Face Database	20	92 x 112 Gray Scale
The MUCT Landmarked	276	480 x 640 RGB
Face 94	153	180 x 200 RGB
Indian Database	40	640 x 480 RGB
Grimace Database	20	180 x 200 RGB

Table 10.2: More face recognition databases

11. Challenges in Face Recognition

There are some challenges in our face recognition system they are as follows:-

- Pose of the face.
- Illumination or lighting condition of the image taken.
- Size of the face in the image.
- Expressions of the face in the image.

As shown above we have 4 points in our above section and now I am going to discuss them in detail. As I talk about the pose of the face then here that should be in front position. This is necessary because our system recognizes front view of the faces of given persons. Similarly illumination or lighting conditions should be good because the image taken in that circumstances should be clearly visible for recognization of that person by the system. Face size also matters in the image. This is because If the face size is large so background area reduces and if the face size is small then background area increases in the image respectively. That's why here I have taken our image database photographs from close-up view to capture the face or head area only of the persons. All these precautions points described above will help us for a better recognization process.

12. Classification of Face Recognition

Face recognition scenarios can be classified into two types Fig. 3, Face verification (or authentication) and Face identification (or recognition).

1) **Face verification:** It is a one-to-one match that compares a query face image against a template face image whose identity is being claimed. To evaluate the verification performance, the verification rate (the rate, at which legitimate users are granted access) vs. false accepts rate (the rate at which imposters are granted access) is plotted, called ROC curve. A good verification system should balance these two rates based on operational needs.
2) **Face identification:** It is a one-to-many matching process that compares a query face image against all the template images in a face database to determine the identity of the query face. The identification of the test image is done by locating the image in the database that has the highest similarity with the test image [4]. The identification process is a "closed" test, which means the sensor takes an observation of an individual that is known to be in the database.

13. MATLAB

MATLAB stands for Matrix Laboratory is a computer programming language. Researchers and programmers create software of face recognition & detection system using this language of MATLAB. It is an easy and compatible language used for this purpose. The MATLAB has readymade built in function of mathematics in it. We can make software of pattern and image processing in 2 and 3 dimensions using any suitable algorithm with the help of MATLAB.

14. Applications of Face Recognition

There is various numbers of applications working in the world today but here I am going to discuss some important parts of it as below:-

- **Security**-: access control to buildings, airports/seaports, ATM machines and border checkpoints; computer/ network security; email authentication on multimedia workstations.
- **Criminal justice systems**-: Mug-shot/booking systems, post-event analysis, forensics.
- **Image database investigations**-: Searching image databases of licensed drivers benefit recipients, missing children, immigrants and police bookings.
- **Smart Card applications**-: In lieu of maintaining a database of facial images, the face-print can be stored in a smart card, bar code or magnetic stripe, authentication of which is performed by matching the live image and the stored template.
- **Access Control**- Face verification, matching a face against a single enrolled exemplar, is well within the capabilities of current Personal Computer hardware. Since PC cameras have become widespread, their use for face-based PC logon has become feasible, though take-up seems to be very limited [1].
- **Surveillance**- The application domain where most interest in face recognition is being shown is probably surveillance. Video is the medium of choice for surveillance because of the richness and type of information that it contains and naturally, for applications that require identification, face recognition is the best biometric for video data.
- **Border Control** -Biometrics technology is used to provide effective identification processes, and definitely a relevant security solution for Border Control/ Airports. Iris recognition, fingerprinting, document verification and vascular verification are all burgeoning Biometric technologies [1].
- **Smart Mirror**-Today's world new technology is the smart mirror. The smart mirror provides beauty tips to its users. It also control our home appliances and it provides warning to us if we are missing something on its screen.

Video Indexing	Labeling faces in video
Civilian Applications	e-booking and ecommerce
Human Computer Interactions	Interactive gaming and proactive computing.
Multimedia Environment with Adaptive Human Computer Interface	Part of context aware or ubiquitous systems, recognizing a customer and assessing the customer needs.

Table 14: Showing applications of face recognition system

15. Drawbacks of Face Recognition

There are some drawbacks of face detection and recognition system which are as follows:-

- Face recognition system can't tell the difference between the identical twins.
- It is less effective in low light conditions and angle of the face not properly inclined towards the camera.
- Face recognition can't recognize the faces which were changed after their plastic surgery.

Please note that for side view recognization of the faces the training database must also contain the photos of the side view faces with the front views faces photographs otherwise the system will only recognize the faces from the front view only.

16. Conclusion

After completing this survey and review paper I have concluded that the human face detection and recognition has many applications in our daily life. In this paper I have discussed mostly all the techniques and algorithm used in 2D as well as 3D for face recognition system. I have also discuss about recognization of faces in videos. I have also discussed the introductory part of MATLAB. In my survey I realize that face recognition is nearly a current topic and there are so many places in the world where its applications can be used. The main aim of my survey paper is to aware people of the latest techniques and methods used in this procedure of face recognition.

17. Future Work

As we all know that research has its no end. Thus researchers will keep doing research on new technologies forever. In future I would like to give my appreciation for hybrid techniques. Hybrid techniques are the combination of two or more techniques. For new and better results our researchers can use hybrid techniques in future for human face detection and recognition system.

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