DESIGN OF
FACE RECOGNITION
SYSTEM

Submitted in the partial fulfillment of the Degree of Bachelors of Technology

Submitted By

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CERTIFICATE

This is to certify that project report entitled " DESIGN OF FACE RECOGNITION SYSTEM", submitted by **Anubhav Srivastava (111475)** in partial fulfillment for the award of degree of Bachelor Of Technology in Information Technology to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other.

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ACKNOWLEDGEMENT

“EXPRESSION OF FEELINGS BY WORDS MAKES THEM LESS SIGNIFICANT WHEN IT COMES TO STATEMENT OF GRATITUDE”

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ABSTRACT

Automatic Face recognition of people has received much attention during the recent years due to its many applications in different fields such as law enforcement, security applications or video indexing. Up to date, there is no technique that provides a robust solution to all situations and different applications that face recognition may encounter. In general, we can make sure that performance of a face recognition system is determined by how to extract feature vector exactly and to classify them into a group accurately. It, therefore, is necessary for us to closely look at the feature extractor and classifier. The system utilizes a combination of techniques in two topics; face detection and recognition. The face detection is performed on live acquired images without any application field in mind. Processes utilized in the system are white balance correction, skin like region segmentation, facial feature extraction and face image extraction on a face candidate. In this project, PCA is used for detecting the face. Then from the human face structure, the four relevant regions such as right eye, left eye, nose, and mouth areas are cropped in a face image. Variations in lighting conditions, pose and expression make face recognition an even more challenging and difficult task.

Keywords: Support Vector Machine (SVM), Principal Component Analysis (PCA), Graphical user Interface (GUI), Region of Interest (ROI), Discrete Cosine Transform (DCT).

CHAPTER 1

Face Biometric: An Overview

1.1 INTRODUCTION

Face recognition systems are part of facial image processing applications and their significance as a research area is increasing recently. They use biometric information of the humans and are applicable easily instead of fingerprint, iris, signature etc., because these types of biometrics are not much suitable for non-collaborative people. Face recognition systems are usually applied and preferred for people and security cameras in metropolitan life. These systems can be used for crime prevention, video surveillance, person verification, and similar security activities. Face recognition system is a complex image-processing problem in real world applications with complex effects of illumination, occlusion, and imaging condition on the live images. It is a combination of face detection and recognition techniques in image analyzes. Detection application is used to find position of the faces in a given image. Recognition algorithm is used to classify given images with known structured properties, which are used commonly in most of the computer vision applications. These images have some known properties like; same resolution, including same facial feature components, and similar eye alignment. Recognition applications uses standard images, and detection algorithms detect the faces and extract face images which include eyes, eyebrows, nose, and mouth. That makes the algorithm more complicated than single detection or recognition algorithm. The first step for face recognition system is to acquire an image from a camera. Second step is face detection from the acquired image. As a third step, face recognition that takes the face images from output of detection part. Final step is person identity as a result of recognition part. Acquiring images to computer from camera and computational medium (environment) via frame grabber is the first step in face recognition system applications. The input image, in the form of digital data, is sent to face detection algorithm part of a software for extracting each face in the image.

Comparing face images is one of the many biometric ways of recognizing an individual. It has many uses starting with searching for an individual in a database, retrieving personal information about the individual, gaining access to data based on one’s unique facial identity etc. It has many applications in forensics, tracking and monitoring, counter terrorism, prevention of identity theft, IT industries, and financial services. Face images and the expressions are also used for evaluating a person's mood and determining the behavior of the individual. For example in casinos, an individual's face is monitored to determine cheating and fraud. One particularity about face recognition is that it is nonintrusive unlike retinal scan, finger print scan and other biometric methods. Face comparison is based on image comparison. Different regions and aspects of one's face, like eyes, ears, nose etc, can be used as vital parameters in distinguishing one individual from another. Many techniques can be used to process the data provided by the image of a face. Once processed, this data can be compared with existing data in a database of other images, and determine whether the face in question matches that of an individual in the database or if the image is of a person in the database but taken ten years earlier.

In brief, face recognition is a case of pattern recognition and involves any one of the following:

a. Authentication in which the individual's identity is confirmed by comparing with a uniquely stored identity for example the ATM machine or your home pc login. This is a one – to – one match.
b. Recognition in which a subject is compared to a database of multiple subjects for identification purposes. For example comparing a mug shot in a forensic database. This is a one – to – many comparisons.
c. Surveillance in which a subject from a video frame is compared to a small group of individuals. For example cameras at an airport terminal scanning for possible known terrorists. This is a case of comparison of one – to – a – list of selected few.

1.2 MOTIVATION:

Among the various biometric ID methods, the physiological methods (fingerprint, face, DNA) are more stable than methods in behavioural category (keystroke, voice print). The reason is that physiological features are often non-alterable except by severe injury. The behavioural patterns, on the other hand, may fluctuate due to stress, fatigue, or illness. However, behavioural IDs have the advantage of being non intrusiveness. People are more comfortable signing their names or speaking to a microphone than placing their eyes before a scanner or giving a drop of blood for DNA sequencing. Face recognition is one of the few biometric methods that possess the merits of both high accuracy and low intrusiveness. It has the accuracy of a physiological approach without being intrusive. For this reason, since the early 70's, face recognition has drawn the attention of researchers in fields:

- Security
- Psychology
- Image processing
- Computer vision

This project is a step towards developing a face recognition system which can recognize dynamic images. In that case the dynamic images received from the camera can first be converted in to the static one's and then the same procedure can be applied on them. One key advantage is that it does not require the cooperation of the test subject to work. Properly designed systems installed in airports, multiplexes, and other public places can identify individuals among the crowd, without passers-by even being aware of the system. Other biometrics like fingerprints, iris scans, and speech recognition cannot perform this kind of mass identification.

1.3 OBJECTIVE:

1. **Implementation of pre-processing technique:** In real-world applications where uncontrolled and uncooperative behaviour of subjects is highly expected, pre-processing step is crucial to enhance the recognition rate and ensure the robustness and reliability of such systems. The pre-processing techniques used are:

- Image negative transformation.
- Logarithmic transformation.
- Power-law transformation
- Histogram Equalisation

2. **Image Compression using Discrete Cosine transforms:** The objective is to reduce irrelevance and redundancy of the image data in order to be able to store or transmit data in an efficient form.

3. **Face detection:** Face detection is the first step of face recognition system. Output of the detection can be location of face region as a whole, and location of face region with facial features (i.e. eyes, mouth, nose etc.).

4. **Features extraction:** Face features like nose, eyes, lips, mouth are extracted from the face of the person whose identity is to be verified.

5. **To create a database of various faces with different attributes:** Database is created which contains the images of the people whose identity is to be verified by the face recognition system.
6. **Identification of the input face from database:** Identity of the input face is verified from database by comparing the extracted features of the input image with the stored image of the input face.

1.4 BACKGROUND AND LITERATURE REVIEW:

The earliest work to partially automate face recognition was done by Bledsoe (1966a, b). It was a hybrid human – computer system that classified faces based on fiducially marks entered on photographs manually. Distance between points such as the corners of the mouth, eyes, tips of the nose and chin were normalized and their ratios were used as parameters for classification. Since then there has been significant advancement in the field of face recognition. There are many approaches to frontal face recognition. Among these, some of the most successful ones are Eigen faces[1], neural network [2], Dynamic link architecture [3], Hidden Markov model[4], Geometrical feature matching[5], and template matching[6]. Factors such as misalignment, pose variation, and occlusion make robust face recognition a difficult problem [7]. It is known that statistical features such as local binary pattern are effective for local feature extraction, whereas the recently proposed sparse or collaborative representation-based classification has shown interesting results in robust face recognition, robust kernel representation model with statistical local features (SLF) for robust face recognition.

Initially, multi-partition max pooling is used to enhance their variance of SLF to image registration error. Then, a kernel based representation model[8] is proposed to fully exploit the discrimination information embedded in the SLF, and robust regression is adopted to effectively handle the occlusion in face images. In recent years, local pattern based features have attracted increasing interest in object detection and recognition systems. Local Binary Pattern (LBP)[9] feature is widely used in texture classification and face detection. But the original definition of LBP is not suitable for human detection. Experiments are performed on INRIA dataset, which shows the proposal GLBP feature is more discriminative than histogram of orientated gradient (HOG)[10], histogram of template (HOT) and Semantic Local Binary Patterns (S-LBP), under the same training method and the computation of GLBP feature is parallel, which make it easy for hardware acceleration. These factors make GLBP feature possible for real-time human detection. Face recognition is a complicated object recognition problem due to abundance of various face expressions, face position and lighting changes. Different methods for solving the problem can be classified into: Neural Networks, Template Matching, PCA, geometric feature based matching and algebraic moments. Also, hybrid systems constructed of two or more of the previous methods are made. Facial feature extraction methods could be divided in two categories: texture-based and shape-based methods. Texture-based methods take local texture e.g. pixel values around a given specific feature point instead of concerning all facial feature points as a shape (shape-based methods). Some texture-based facial feature extraction algorithms are: facial point detection using log Gabor wavelet networks[11] by employing geometry cross-ratios relationships, neural-network-based eye-feature detector by locating micro-features instead of entire eyes. Some shape-based facial feature extraction algorithms including AAM, based on face detectors are: view-based active wavelet network, view-based direct appearance models. The combination of texture and shape-based algorithms are: elastic bunch graph matching, adaBoost[12] with Shape Constraints, 3D Shape Constraint using Probabilistic-like Output. Cristinacce and Cootes used the Haar features based adaBoost classifier combined with the statistical shape model. Most of the above mentioned algorithms are not entirely reliable due to variation in pose, illumination, facial expression, and lighting condition and high computational complexity. So, it is indispensable to develop robust, automatic, and accurate facial feature point localization algorithms, which are capable in coping different imaging conditions.

In real-world applications where uncontrolled and uncooperative behavior of subjects is highly expected, pre-processing steps[13] is crucial to enhance the recognition rate and ensure the robustness and reliability of face recognition systems. Various pre-processing techniques such as logarithmic transformation, Gabor wavelet transformation [14] and histogram equalization [10] are used to enhance the quality of the input image. Gabor wavelet transformation[14] involves convolving a face image with a series of Gabor wavelets at different scales, locations, and orientations and extracting features from Gabor filtered images. Various face recognition algorithms such as Principle Component Analysis (PCA) [15] and Support Vector Machine (SVM*)* [15]. Principle Component Analysis (PCA) method is based on algebraic statistics to extract the essential characteristics of face images. Support vector machine (SVM) is used to detect the face as it contains almost all the problems of machine learning: Pattern Recognition, Regression Estimation and Probability Density Estimation.Currently, Active Shape Model (ASM) [16] and Active Appearance Model (AAM) are extensively used for face alignment and tracking The ASM models shape variation across the training set with a statistical shape model and an individual model for each local feature. At run-time each local model updates its estimate of the best local match and the shape model is fitted to the full set of point estimates to eliminate false positive matches. Active shape models are a method of modeling shape variation across a training set of labeled examples. The shape model can be fitted to a set of feature detections to remove outliers.

1.5 BIOMETERIC AUTHENTICATION TECHNOLOGY:

Biometrics [17] is automated method of identifying a person or verifying the identity of a person based on a physiological or behavioural characteristic. Examples of physiological characteristics include hand or finger images, facial characteristics. Biometric authentication requires comparing a registered or enrolled biometric sample (biometric template or identifier) against a newly captured biometric sample (for example, captured image during a login). During enrolment, as shown in the picture below, a sample of the biometric trait is captured, processed by a computer, and stored for later comparison. Biometric recognition can be used in identification mode, where the biometric system identifies a person from the entire enrolled population by searching a database for a match based solely on the biometric. Sometime identification is called "one-to-many" matching. A system can also be used in verification mode, where the biometric system authenticates a person’s claimed identity from their previously enrolled pattern. This is also called “one-to-one” matching.

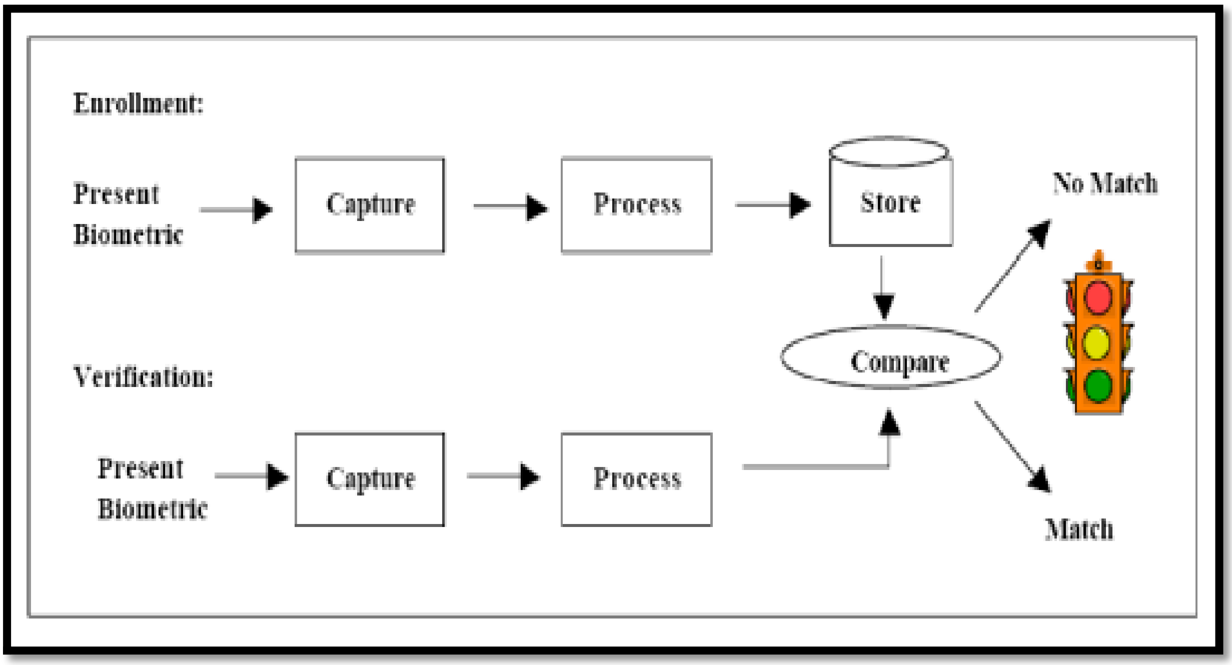


Fig. 1.1: A simple process of biometric authentication technique

Biometric Characteristics

Universality: Every individual accessing the application should possess the trait.

Uniqueness: The given trait should be sufficiently different across individuals comprising the population.

Permanence: The biometric trait of an individual should not change with time.

Measurability: It should be possible to acquire and digitize the biometric trait so that it can be measured.

Performance: The recognition accuracy and the resources required to achieve that accuracy should meet the constraints imposed by the application.

Acceptability: It indicates to what extent people are willing to accept the biometric system.

Biometrics	Universality	Uniqueness	Permanence	Collectability	Performance	Acceptability
Face	High	Low	Medium	High	Low	High
Fingerprint	Medium	High	High	Medium	High	Medium
Hand Geometry	Medium	Medium	Medium	High	Medium	Medium
Keystrokes	Low	Low	Low	Medium	Low	Medium
Hand Vein	Medium	Medium	Medium	Medium	Medium	Medium
Iris	High	High	High	Medium	High	Low
Retinal Scan	High	High	Medium	Low	High	Low
Signature	Low	Low	Low	High	Low	High
Voice Print	Medium	Low	Low	Medium	Low	High
F. Thermograms	High	High	Low	High	Medium	high
Odor	High	High	High	Low	Low	Medium
DNA	High	High	High	Low	High	Low
Gait	Medium	Low	Low	High	Low	High
Ear	Medium	medium	High	medium	Medium	High

1.5.1 Face recognition:

The identification of a person by their facial image can be done in a number of different ways such as by capturing an image of the face in the visible spectrum using an inexpensive camera or by using the infrared patterns of facial heat emission. Facial recognition in visible light typically model key features from the central portion of a facial image. Using a wide assortment of cameras, the visible light systems extract features from the captured images that do not change over time while avoiding superficial features such as facial expressions or hair. Several approaches to model facial images in the visible spectrum Principal Component Analysis [15] , Local Feature Analysis, neural networks, elastic graph theory, and multi-resolution analysis. Some of the challenges of facial recognition in the visual spectrum include reducing the impact of variable lighting and detecting a mask or photograph. Some facial recognition systems may require a stationary or posed user in order to capture the image, though many systems use a real-time process to detect a person's head and locate the face automatically. Major benefits of facial recognition are that it is non-intrusive, hands-free, and continuous and accepted by most users.

Fig. 1.2: Identification of faces by face recognition system

The various biometric traits are as follow:

1.5.2 Fingerprints recognition:

Fingerprints [18] are unique for each finger of a person including identical twins. One of the most commercially available biometric technologies, fingerprint recognition devices for desktop and laptop access are now widely available from many different vendors at a low cost. With these devices, users no longer need to type passwords – instead, only a touch provides instant access. Fingerprint systems can also be used in identification mode. Several states check fingerprints for new applicants to social services benefits to ensure recipients do not fraudulently obtain benefits under fake names. Fingerprint identification, known as dactyloscopy, or hand print identification, is the process of comparing two instances of friction ridge skin impressions (see Minutiae), from human fingers or toes, or even the palm of the hand or sole of the foot, to determine whether these impressions could have come from the same individual. The flexibility of friction ridge skin means that no two finger or palm prints are ever exactly alike in every detail; even two impressions recorded immediately after each other from the same hand may be slightly different. Fingerprint identification, also referred to as individualization, involves an expert, or an expert computer system operating under threshold scoring rules, determining whether two friction ridge impressions are likely to have originated from the same finger or palm (or toe or sole). An intentional recording of friction ridges is usually made with black printer's ink rolled across a contrasting white background, typically a white card. Friction ridges can also be recorded digitally, usually on a glass plate, using a technique called Live Scan.

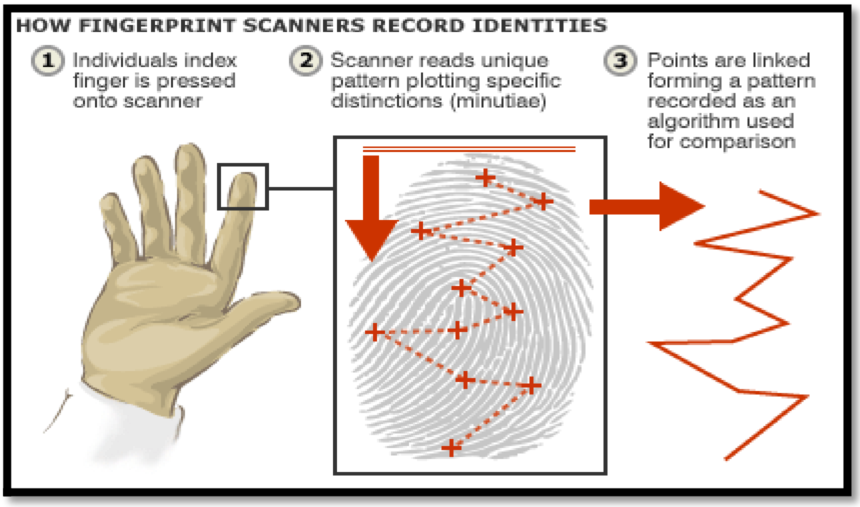


Fig. 1.3: Working of Finger Print Scanner

1.5.3 Iris recognition:

This recognition method uses the iris of the eye, which is the coloured area that surrounds the pupil. Iris patterns [19] are thought unique. The iris patterns are obtained through a video-based image acquisition system. Iris scanning devices have been used in personal authentication applications for several years. Systems based on iris recognition have substantially decreased in price and this trend is expected to continue. The technology works well in both verification and identification modes (in systems performing one-to-many searches in a database). Current systems can be used even in the presence of eyeglasses and contact lenses. The technology is not intrusive. It does not require physical contact with a scanner. Iris recognition has been demonstrated to work with individuals from different ethnic groups and nationalities. Iris recognition is an automated method of biometric identification that uses mathematical pattern-recognition techniques on video images of the iris of an individual's eyes, whose complex random patterns are unique and can be seen from some distance. Not to be confused with other, less prevalent, ocular-based technologies, retina scanning and eye printing, iris recognition uses camera technology with subtle infrared illumination to acquire images of the detail-rich, intricate structures of the iris externally visible at the front of the eye. Digital templates encoded from these patterns by mathematical and statistical algorithms allow the identification of an individual or someone pretending to be that individual. Databases of enrolled templates are searched by matcher engines at speeds measured in the millions of templates per second per (single-core) CPU, and with remarkably low false match rates.

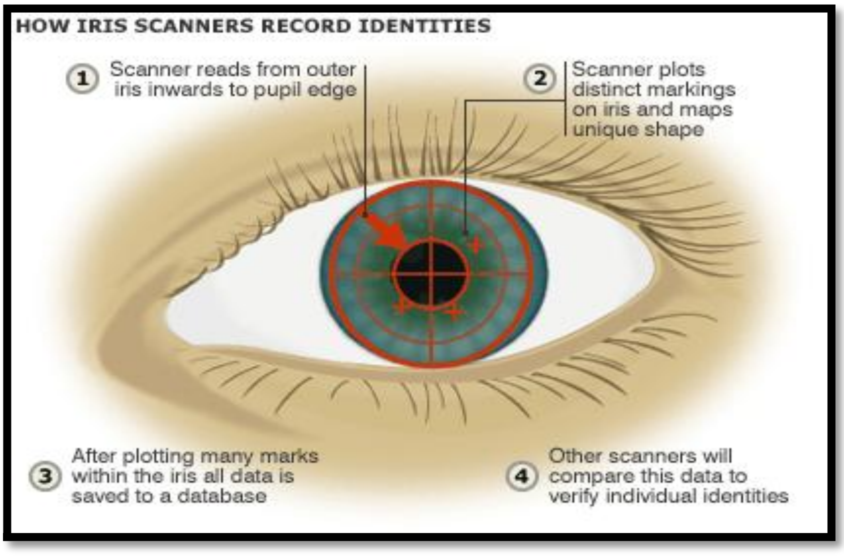


Fig. 1.4: Working of Iris Recognition

1.5.4 Signature verification:

This technology uses the dynamic analysis of a signature to authenticate a person. The technology is based on measuring speed, pressure and angle used by the person when a signature is produced. One focus for this technology has been e-business applications and other applications where signature is an accepted method of personal authentication. Digital signatures [19] employ a type of asymmetric cryptography. For messages sent through a non-secure channel, a properly implemented digital signature gives the receiver reason to believe the message was sent by the claimed sender. Digital signatures are equivalent to traditional handwritten signatures in many respects, but properly implemented digital signatures are more difficult to forge than the handwritten type. Digital signature schemes, in the sense used here, are cryptographically based, and must be implemented properly to be effective. Digital signatures can also provide non-repudiation, meaning that the signer cannot successfully claim they did not sign a message, while also claiming their private key remains secret; further, some non-repudiation schemes offer a time stamp for the digital signature, so that even if the private key is exposed, the signature is valid. Digitally signed messages may be anything represent able as a bit string: examples include electronic mail, contracts, or a message sent via some other cryptographic protocol.

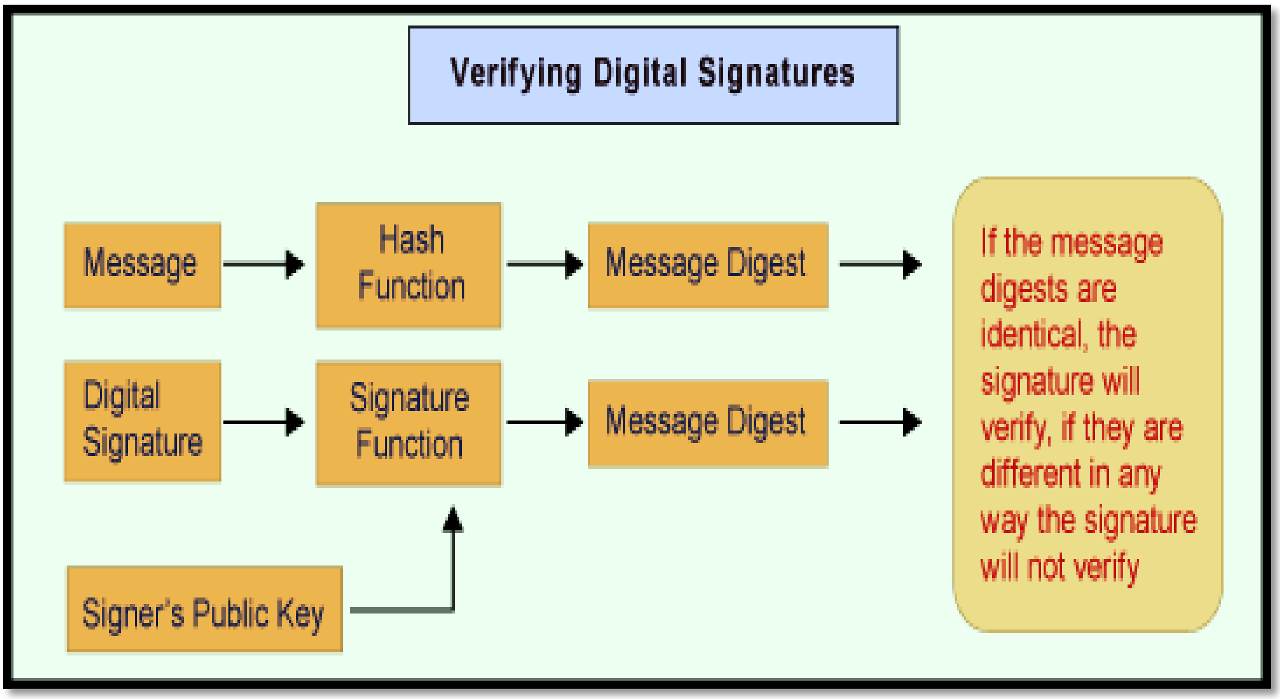


Fig. 1.5: Working of Signature Verification

1.5.5 Speech recognition:

Speech recognition [21] has a history dating back some four decades, where the outputs of several analog filters were averaged over time for matching. Speaker recognition uses the acoustic features of speech that have been found to differ between individuals. These acoustic patterns reflect both anatomy (e.g., size and shape of the throat and mouth) and learned behavioural patterns (e.g., voice pitch, speaking style). This incorporation of learned patterns into the voice templates (the latter called "voiceprints") has earned speaker recognition its classification as a "behavioural biometric." Speaker recognition systems employ three styles of spoken input: text-dependent, text-prompted and text independent. Most speaker verification applications use text-dependent input, which involves selection and enrolment of one or more voice passwords. Many companies market speaker recognition engines, often as part of large voice processing, control and switching systems. Capture of the biometric is seen as non-invasive.

The performance of speech recognition systems is usually evaluated in terms of accuracy and speed. Accuracy is usually rated with word error rate (WER), whereas speed is measured with the real time factor. Other measures of accuracy include Single Word Error Rate (SWER) and Command Success Rate (CSR).However, speech recognition (by a machine) is a very complex problem. Vocalizations vary in terms of accent, pronunciation, articulation, roughness, nasality, pitch, volume, and speed. Speech is distorted by a background noise and echoes, electrical characteristics. Accuracy of speech recognition varies with the following:

- Vocabulary size and confusability
- Speaker dependence vs. independence
- Isolated, discontinuous, or continuous speech
- Task and language constraints
- Read vs. spontaneous speech
- Adverse conditions

CHAPTER 2

FACE RECOGNITION TECHNIQUES

2.1 SOME BASIC EXISTING TECHNIQUES:

Some facial recognition algorithms identify facial features by extracting landmarks, or features, from an image of the subject's face. For example, an algorithm may analyze the relative position, size, and/or shape of the eyes, nose, cheekbones, and jaw. These features are then used to search for other images with matching features. Other algorithms normalize a gallery of face images and then compress the face data, only saving the data in the image that is useful for face recognition. A probe image is then compared with the face data. One of the earliest successful systems is based on template matching techniques applied to a set of salient facial features, providing a sort of compressed face representation.

Recognition algorithms can be divided into two main approaches, geometric, which look at distinguishing features, or photometric, which is a statistical approach that distills an image into values and compares the values with templates to eliminate variances.

Popular Face Recognition Algorithm includes:

a) Principal Component Analysis.

b) Support Vector Machine.

c) Linear Discriminate Analysis

d) The Hidden Markov Model

e) The Neuronal Motivated Dynamic Linking Model

2.2 EMERGING TRENDS:

2.2.1 3-Dimensional recognition:

A newly emerging trend, claimed to achieve improved accuracies, is three-dimensional face recognition. This technique uses 3D sensors to capture information about the shape of a face. This information is then used to identify distinctive features on the surface of a face, such as the contour of the eye sockets, nose, and chin. One advantage of 3D facial recognition is that it is not affected by changes in lighting like other techniques. It can also identify a face from a range of viewing angles, including a profile view. Three-dimensional data points from a face vastly improve the precision of facial recognition. 3D research is enhanced by the development of sophisticated sensors that do a better job of capturing 3D face imagery. The sensors work by projecting structured light onto the face. Up to a dozen or more of these image sensors can be placed on the same CMOS chip—each sensor captures a different part of the spectrum.

2.2.2 Skin texture analysis:

Another emerging trend uses the visual details of the skin, as captured in standard digital or scanned images. This technique, called skin texture analysis, turns the unique lines, patterns, and spots apparent in a person's skin into a mathematical space. The skin texture is the appearance of the skin smooth surface. To the features of this texture, many factors are occurring, for instance diet and hydration, amount of collagen and hormones, and, of course, skin care. A gradual decline in skin is moreover superimposed by age. As skin ages, it becomes thinner and more easily damaged, with the appearance of wrinkles. The deterioration is also accompanied by a darkening of skin colour for an over-absorption of the natural colouring pigment, melanin, by the top most cell layer in skin. The skin texture also depends on its body location. In the case of image processing, we have to consider the fact that texture appearance is changing with image recording parameters, that are camera, illumination and direction of view, a problem common to any real surface. The task to have a quantitative evaluation of the skin features is quite complex, as in all the cases where image analysis must be applied to surfaces with irregular non-periodic patterns. In the digital image processing, several methods have been developed to classify images and define statistical distances among them, with the aim to decide whether, in a set of many images, there exist some which are close to any arbitrary image previously encountered. The texture discrimination can be obtained by choosing a set of attributes, the texture features, which account for the spatial organisation of the image.

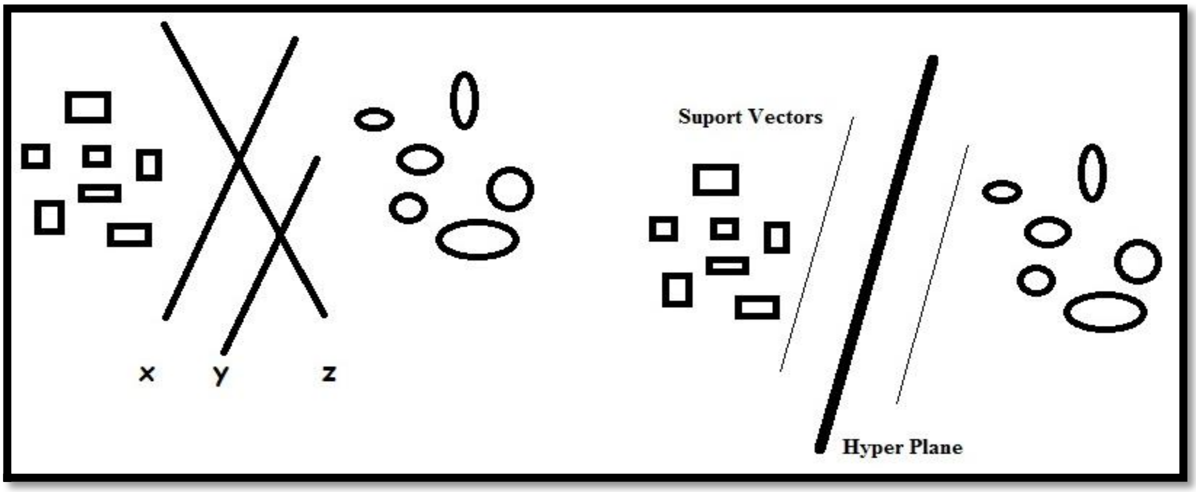
2.3 FACE RECOGNITION ALGORITHMS:

2.3.1 Support vector machine:

SVM [15] takes a set of input data and predicts, for each given input, which of two possible classes forms the output, making it a non-probabilistic binary linear classifier. Given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall on.

In machine learning, support vector machines (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. Given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other, making it a non-probabilistic binary linear classifier. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall on. a support vector machine constructs a hyper plane or set of hyper planes in a high- or infinite-dimensional space, which can be used for classification, regression, or other tasks. Intuitively, a good separation is achieved by the hyper plane that has the largest distance to the nearest training data point of any class, since in general the larger the margin the lower the generalization error of the classifier.

Whereas the original problem may be stated in a finite dimensional space, it often happens that the sets to discriminate are not linearly separable in that space. For this reason, it was proposed that the original finite-dimensional space be mapped into a much higher-dimensional space, presumably making the separation easier in that space. To keep the computational load reasonable, the mappings used by SVM schemes are designed to ensure that dot products may be computed easily in terms of the variables in the original space, by defining them in terms of a kernel function selected to suit the problem. The hyper planes in the higher-dimensional space are defined as the set of points whose dot product with a vector in that space is constant. The vectors defining the hyper planes can be chosen to be linear combinations with parameters of images of feature vectors that occur in the data base. With this choice of a hyper plane, the points in the feature space that are mapped into the hyper plane. Note that if kernal function becomes small as y grows further away from x, each term in the sum measures the degree of closeness of the test point x to the corresponding data base point x_i. In this way, the sum of kernels above can be used to measure the relative nearness of each test point to the data points originating in one or the other of the sets to be discriminated. Note the fact that the set of points x mapped into any hyper plane can be quite convoluted as a result, allowing much more complex discrimination between sets which are not convex at all in the original space.



Arbitrary hyper-plane(x, y, z) Optimal hyper-plane

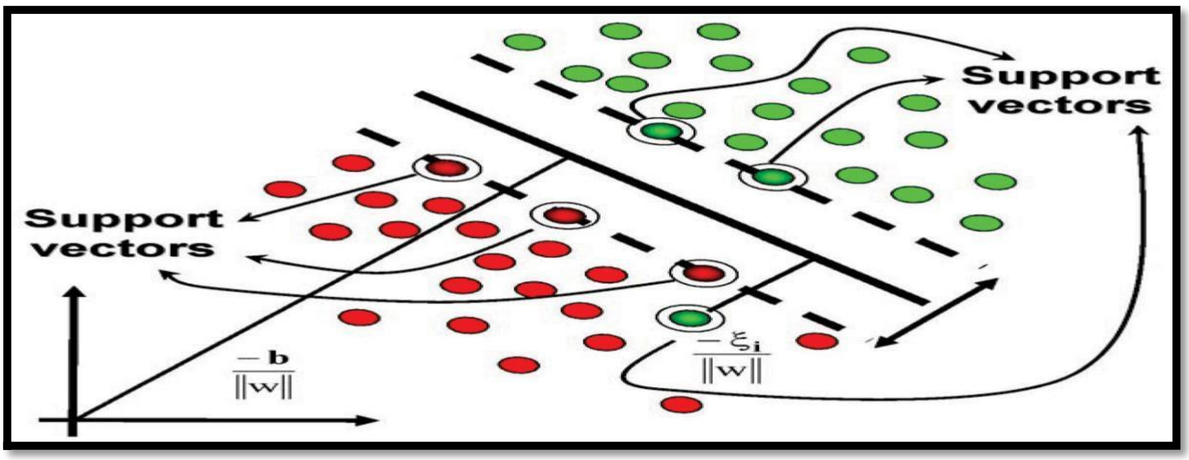


Fig. 2.1: Support Vector Plane

2.3.2 Principal component analysis:

Principal Component Analysis [15] is a statistical procedure that uses orthogonal transformation to convert a set of observations of correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. This transformation is defined in such a way that the first principal component has the largest possible variance and each succeeding component in turn has the highest variance possible under the constraint that it be orthogonal to (i.e., uncorrelated with) the preceding components. Principal components are guaranteed to be independent if the data set is jointly normally distributed. PCA is sensitive to the relative scaling of the original variables. Principal component analysis (PCA) has been called one of the most valuable results from applied linear algebra. PCA is used abundantly in all forms of analysis from neuroscience to computer graphics - because it is a simple, non-parametric method of extracting relevant information from confusing data sets. With minimal effort PCA provides a roadmap for how to reduce a complex data set to a lower dimension to reveal the sometimes hidden, simplified structure that often under lies it. The goal of principal component analysis is to compute the most meaningful basis to re-express a noisy data set.

PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate such that the greatest variance by some projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on.

Consider a data matrix, X, with zero empirical means (the empirical (sample) mean of the distribution has been subtracted from the data set), where each of the n rows represents a different repetition of the experiment, and each of the p columns gives a particular kind of datum (say, the results from a particular sensor).

Mathematically, the transformation is defined by a set of p-dimensional vectors of weights or loadings $\mathbf{w}_{(k)} = (w_1, \dots, w_p)_{(k)}$ that map each row vector $\mathbf{x}_{(i)}$ of X to a new vector of principal component scores $\mathbf{t}_{(i)} = (t_1, \dots, t_p)_{(i)}$, given by

$$t_{k(i)} = \mathbf{x}_{(i)} \cdot \mathbf{w}_{(k)}$$

in such a way that the individual variables of t considered over the data set successively inherit the maximum possible variance from x, with each loading vector w constrained to be a unit vector.

First component

The first loading vector $w_{(1)}$ thus has to satisfy

$$\mathbf{w}_{(1)} = \underset{\Vert \mathbf{w} \Vert = 1}{\arg\max} \left\{ \sum_i (t_1)^2_{(i)} \right\} = \underset{\Vert \mathbf{w} \Vert = 1}{\arg\max} \sum_i \left(\mathbf{x}_{(i)} \cdot \mathbf{w} \right)^2$$

Equivalently, writing this in matrix form gives

$$\mathbf{w}_{(1)} = \underset{\Vert \mathbf{w} \Vert = 1}{\arg\max} \left\{ \Vert \mathbf{X}\mathbf{w} \Vert^2 \right\} = \underset{\Vert \mathbf{w} \Vert = 1}{\arg\max} \left\{ \mathbf{w}^T \mathbf{X}^T \mathbf{X} \mathbf{w} \right\}$$

Since $w_{(1)}$ has been defined to be a unit vector, it equivalently also satisfies

$$\mathbf{w}_{(1)} = \arg\max \left\{ \frac{\mathbf{w}^T \mathbf{X}^T \mathbf{X} \mathbf{w}}{\mathbf{w}^T \mathbf{w}} \right\}$$

The quantity to be maximised can be recognised as a Rayleigh quotient. A standard result for a symmetric matrix such as X^TX is that the quotient's maximum possible value is the largest eigenvalue of the matrix, which occurs when *w* is the corresponding eigenvector.

With $w_{(1)}$ found, the first component of a data vector $x_{(i)}$ can then be given as a score $t_{1(i)} = x_{(i)} \cdot w_{(1)}$ in the transformed co-ordinates, or as the corresponding vector in the original variables, $x_{(i)} \cdot w_{(1)}\, w_{(1)}$.

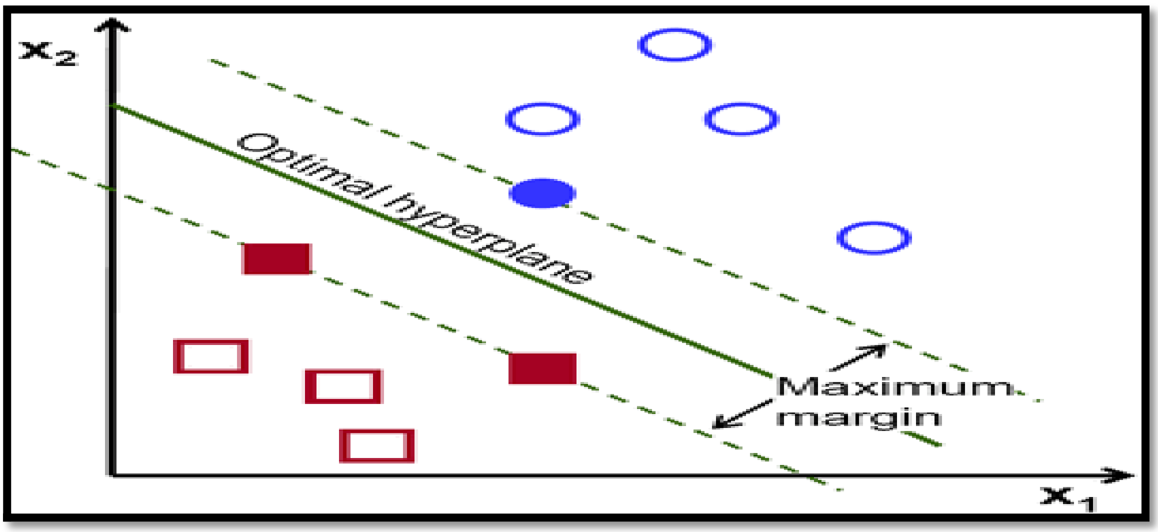


Fig. 2.2: Principal component analysis hyperplane

2.3.3 Linear discriminant analysis:

Linear discriminant analysis (LDA) [18] and the related Fisher's linear discriminant are methods used in statistics, pattern recognition and machine learning to find a linear combination of features which characterizes or separates two or more classes of objects or events. The resulting combination may be used as a linear classifier or, more commonly, for dimensionality reduction before later classification.

LDA is closely related to ANOVA (analysis of variance) and regression analysis, which also attempt to express one dependent variable as a linear combination of other features or measurements. However, ANOVA uses categorical independent variables and a continuous dependent variable, whereas discriminant analysis has continuous independent variables and a categorical dependent variable (*i.e.* the class label), regression and probit regression are more similar to LDA, as they also explain a categorical variable by the values of continuous independent variables. These other methods are preferable in applications where it is not reasonable to assume that the independent variables are normally distributed, which is a fundamental assumption of the LDA method.

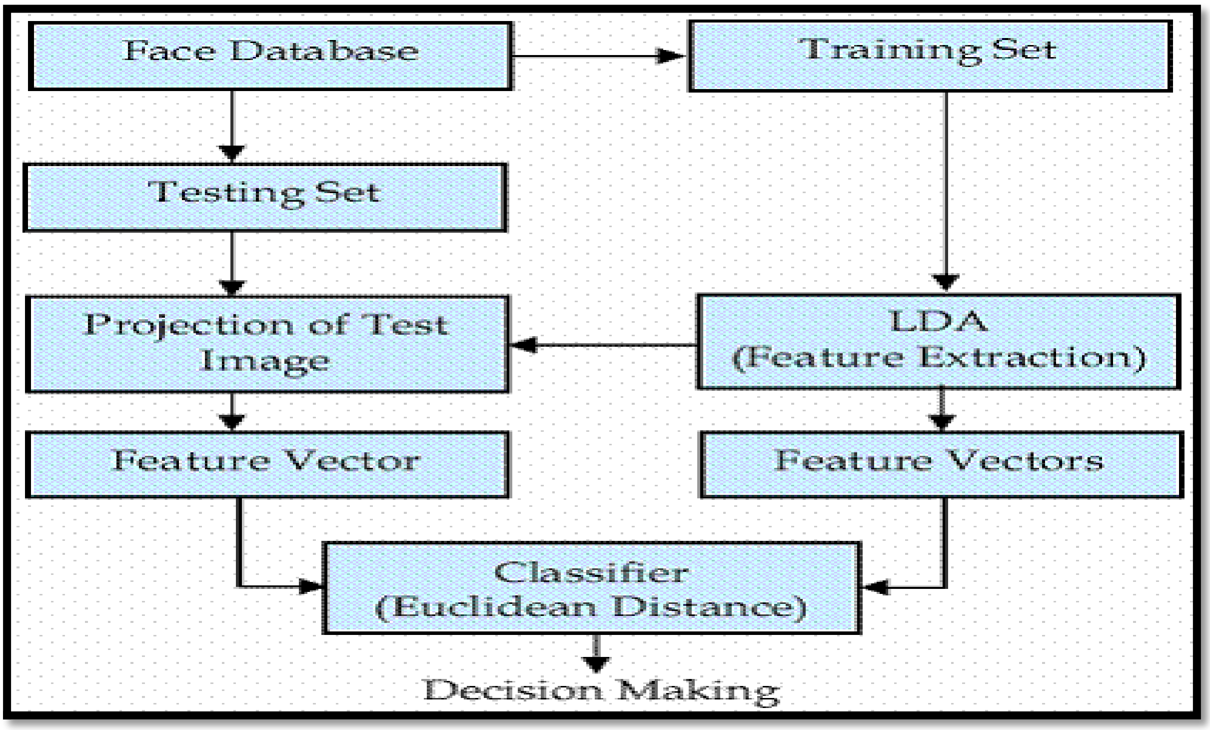


Fig. 2.3: Block diagram of linear discriminant analysis

LDA is also closely related to principal component analysis (PCA) and factor analysis in that they both look for linear combinations of variables which best explain the data.LDA explicitly attempts to model the difference between the classes of data. PCA on the other hand does not take into account any difference in class, and factor analysis builds the feature combinations based on differences rather than similarities. Discriminant analysis is also different from factor analysis in that it is not an interdependence technique: a distinction between independent variables and dependent variables (also called criterion variables) must be made.

LDA works when the measurements made on independent variables for each observation are continuous quantities. When dealing with categorical independent variables, the equivalent technique is discriminant correspondence analysis.

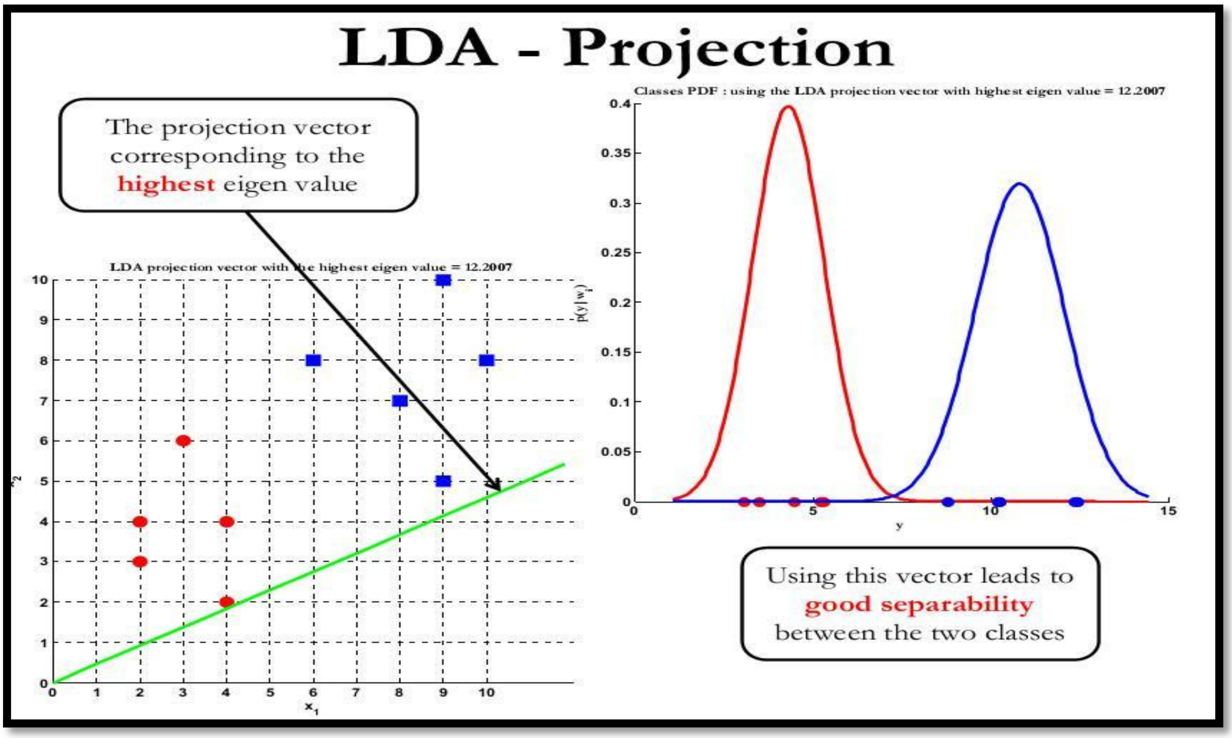


Fig. 2.4: Projection of linear discriminant analysis

2.3.4 Hidden markov model:

A hidden Markov model (HMM) [4] is a statistical Markov model in which the system being modelled is assumed to be a Markov process with unobserved (hidden) states. A HMM can be considered the simplest dynamic Bayesian network. The mathematics behind the HMM was developed by L. E. Baum and co-workers. It is closely related to an earlier work on optimal nonlinear filtering problem (stochastic processes) by Ruslan L. Stratonovich, who was the first to describe the forward-backward procedure.

In simpler Markov models (like a Markov chain), the state is directly visible to the observer, and therefore the state transition probabilities are the only parameters. In a hidden Markov model, the state is not directly visible, but output, dependent on the state, is visible. Each state has a probability distribution over the possible output tokens. Therefore the sequence of tokens generated by an HMM gives some information about the sequence of states. Note that the adjective 'hidden' refers to the state sequence through which the model passes, not to the parameters of the model; the model is still referred to as a 'hidden' Markov model even if these parameters are known exactly.

Hidden Markov models are especially known for their application in temporal pattern recognition such as speech, handwriting, gesture recognition, part-of-speech tagging, musical score following, partial discharges and bioinformatics.

A hidden Markov model can be considered a generalization of a mixture model where the hidden variables (or latent), which control the mixture component to be selected for each observation, are related through a Markov process rather than independent of each other. Recently, hidden Markov models have been generalized to pair wise Markov models and triplet Markov models which allow to consider more complex data structures and to model no stationary data.

2.3.5 The neuronal motivated dynamic linking model:

In this approach, the system is inherently invariant with respect to shift, and is robust against many other variations, most notably rotation in depth and deformation. The system is based on Dynamic Link Matching. It consists of an image domain and a model domain, which we tentatively identify with primary visual cortex and Infero-temp oral cortex. Both domains have the form of neural sheets of hyper columns, which are composed of simple feature detectors (mo deled as Gab or-based wavelets). Each object is represented in memory by a separate model sheet, that is, a two-dimensional array of features. The match of the image to the models is performed by network self-organization, in which rapid reversible synaptic plasticity of the connections (\dynamic links") between the two domains is controlled by signal correlations, which are shaped by fixed inter-columnar connections and by the dynamic links themselves. The system requires very little genetic or learned structure, relying essentially on the rules of rapid synaptic plasticity and the a priori constraint of preservation of topography to end matches. This constraint is encoded within the neural sheets with the help of lateral connections, which are excitatory over short range and inhibitory over long range.

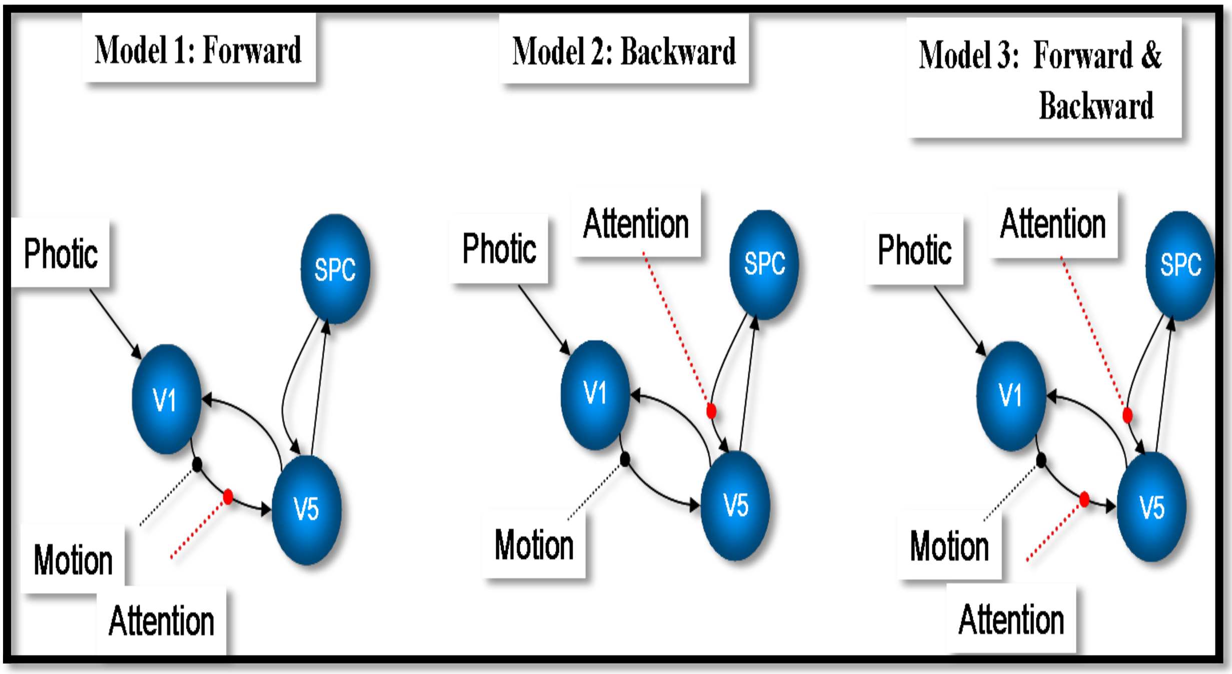
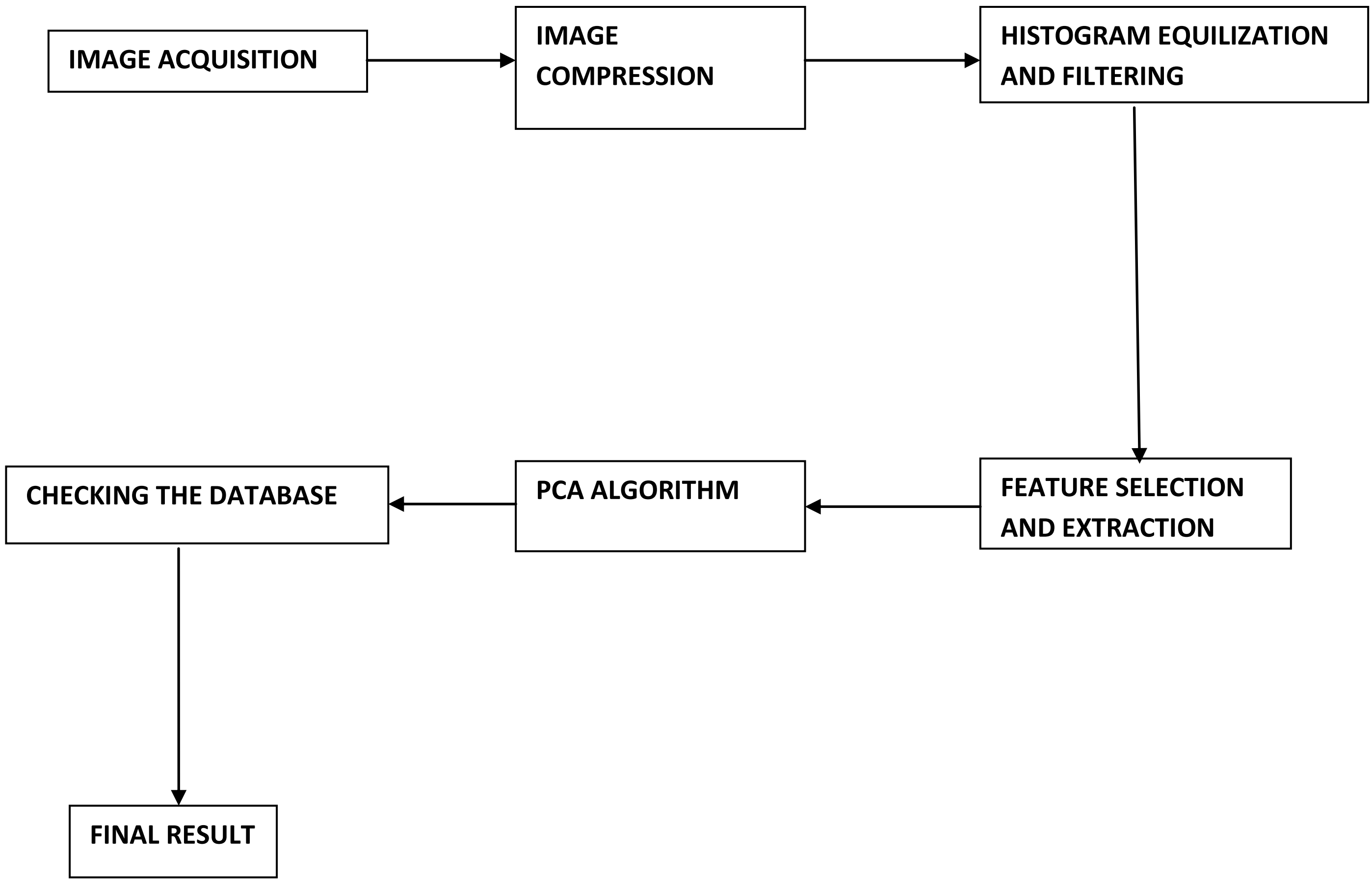


Fig. 2.5: The neuronal motivated dynamic linking model

CHAPTER 3

PROPOSED ARCHITECTURE



3.1 IMAGE ACQUISITION:

The first stage of any vision system is the image acquisition stage. After the image has been obtained, various methods of processing can be applied to the image to perform the many different vision tasks required today. However, if the image has not been acquired satisfactorily then the intended tasks may not be achievable, even with the aid of some form of image enhancement. Image acquisition can be broadly divided into two categories namely, static and dynamic image acquisition.

Static image acquisition is the most common form. Almost all microscopes can be easily adapted to accept a digital camera via. The sample is prepared on a microscope slide which is placed on the microscope stage. Once the sample has been focused on, then an image can be acquired in digital format, and image processing algorithms can be used to isolate particles in the field of view and measure them.

3.2 PRE-PROCESSING TECHNIQUES:

The first step is image acquisition in which live captured images are converted to digital data for performing image-processing computations. These captured images are sent for pre-processing to enhance the quality of the input image. The pre-processing technique is applied to enhance the quality of the input image. The most widely used pre-processing techniques are image negative transformation, power law transformation, logarithmic transformation and histogram equalization. Histogram Equalization method is used to re-map the gray levels of an image.

3.3 Histogram Equalisation:

Histogram equalization is a common technique for enhancing the appearance of images. Suppose we have an image which is predominantly dark. Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed into the dark end of the histogram. If we could `stretch out' the grey levels at the dark end to produce a more uniformly distributed histogram then the image would become much clearer. Histogram equalization involves finding a grey scale transformation function that creates an output image with a uniform histogram (or nearly so).

Assume our grey levels are continuous and have been normalized to lie between 0 and 1.

We must find a transformation T that maps grey values r in the input image F to grey values s = T(r) in the transformed image.

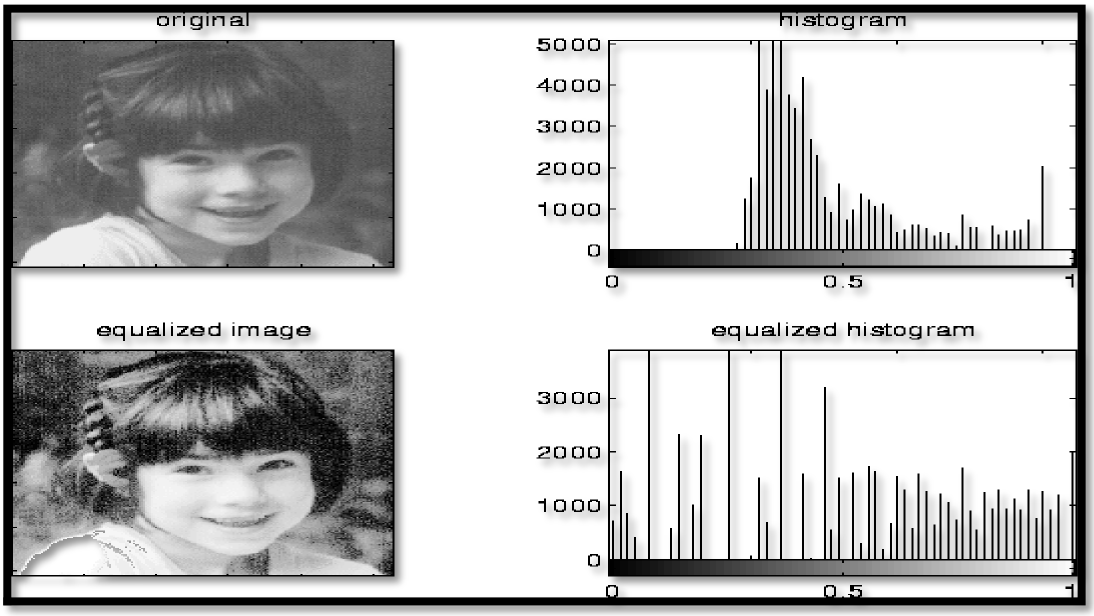


Fig 3.6: Histogram Equalisation applied on the input image

3.4 IMAGE COMPRESSION USING DCT:

After the successful application of above mentioned technique, the input image is compressed using Discrete Cosine Transformation (DCT) algorithm [9] to reduce the size of the input image. A discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important in numerous applications in science and engineering, from lossy compression of audio and images (where small high-frequency components can be discarded) to spectral methods for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient, whereas for differential equations the cosines express a particular choice of boundary conditions of the series undertaken.

$$F(u,v) = \frac{C_u}{2}\frac{C_v}{2}\sum_{y=0}^{7}\sum_{x=0}^{7} f(x,y)\cos\left[\frac{(2x+1)u\pi}{16}\right]\cos\left[\frac{(2y+1)v\pi}{16}\right]$$

with:

$$C_u = \begin{cases} \frac{1}{\sqrt{2}} & \text{if u} = 0, \\ 1 & \text{if u} > 0 \end{cases} ; C_v = \begin{cases} \frac{1}{\sqrt{2}} & \text{if v} = 0, \\ 1 & \text{if v} > 0 \end{cases}$$

DCT expression for a window size of 8

3.5 Feature selection and extraction:

We have used robust adaptive algorithm that extracts the facial feature points fast as well as accurate way under varying illuminations, expressions and lighting conditions. We have defined four regions of interest as depicted in Fig 4 chosen from the intense literature review [10] which are right-eye, left-eye, nose and mouth regions. The regions of interest are from the face whose detailed dimensions are shown in the Fig. 5. The input image size is W×H where W=image width, H=image height. The size of the right-eye is given by the dimensions 0.375W×0.25H and for the left-eye is 0.375W×0.25H (Fig. 5). The mouth area is given by the dimensions 0.50W×0.16H.The dimensions of regions. of interest were also checked for accuracy by calculating these values for ten different faces. After the extraction of features from the input image, the average of pixel values of the region of interests are stored in the database. The stored average of pixel values of the regions of interest will be used for comparison, whenever the image will be given as input for face recognition. After the comparison of facial features from the database, the system displays the result, whether the face is of the given person or not.

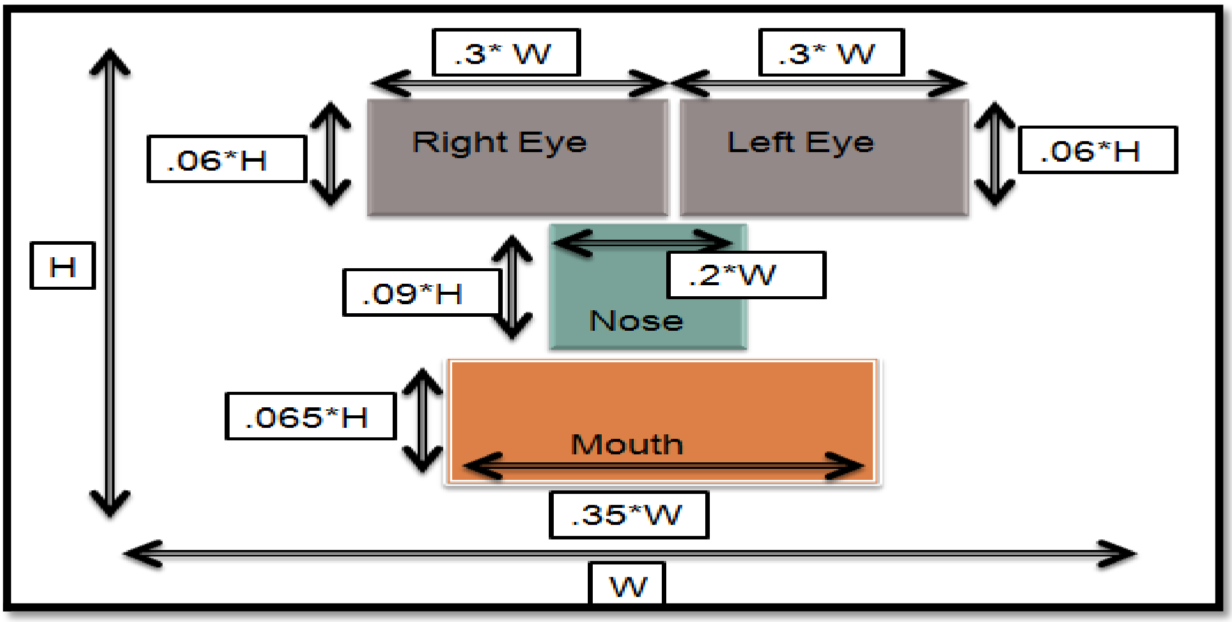


Fig. 3.10: Location and size of four ROIs of a face image such as (a.) Right Eye (Size:0.3W×0..06H), (b.) Left Eye (Size:0.3W×0.06H), (c.) Nose (Size: 0.20W×0.09H), (d.) Mouth (Size: 0.35W×0.065H) where, W=Image Width and H=Image Height.

3.6 PCA ALGORITHM

PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate such that the greatest variance by some projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on.

- Calculate within-class scatter matrix , S_w

  $$S_w = \sum\sum(x_i^j - \mu_j)(x_i^j - \mu_j)^T$$

  where

  x_i^j : i^{th} sample of class j

  C : Number of classes

  N_j : Number of samples in class j

- Calculate between class scatter matrix , S_b

  $$S_b = \sum (\mu_j - \mu)(\mu_j - \mu)^T$$

where μ represents the mean of all classes.

- Calculate the eigenvectors of the projection matrix

  $$W = eig(S_w^{-1} S_b)$$

- Compare projection matrices of test image and training images and the result is the training image closest to test image.

The advantages of PCA over other algorithms are:

1) Lack of redundancy of data given the orthogonal components .
2) Reduced complexity in images' grouping with the use of PCA
3) Smaller database representation since only the trainee images are stored in the form of their projections on a reduced basis.
4) Reduction of noise since the maximum variation basis is chosen so the small variations in the background are ignored automatically

3.7 GRAPHICAL USER INTERFACE:

A graphical user interface (GUI) is a human-computer interface i.e., a way for humans to interact with computers that uses windows, icons and menus and which can be manipulated by a mouse and often to a limited extent by a keyboard as well. A window is a rectangular portion of the monitor screen that can display its contents e.g., a program, icons, a text file or an image seemingly independently of the rest of the display screen. A major feature is the ability for multiple windows to be open simultaneously. Each window can display a different application, or each can display different files e.g., text, image or spreadsheet files that have been opened or created with a single application. An icon is a small picture or symbol in a GUI that represents a program, a file, a directory or a device such as a hard disk or floppy. Icons are used both on the desktop and within application programs. Examples include small rectangles to represent files, file folders to represent directories and buttons on web browsers for navigating to previous pages, for reloading the current page, etc. A GUI is useful for visualize your program and GUI is useful for presenting final software. It also makes it easier to adjust parameters and visualize your programs.

CHAPTER 4

RESULTS

4.1 HISTOGRAM EQUALISATION:

Histogram Equalization method is used to re-map the gray levels of an image.

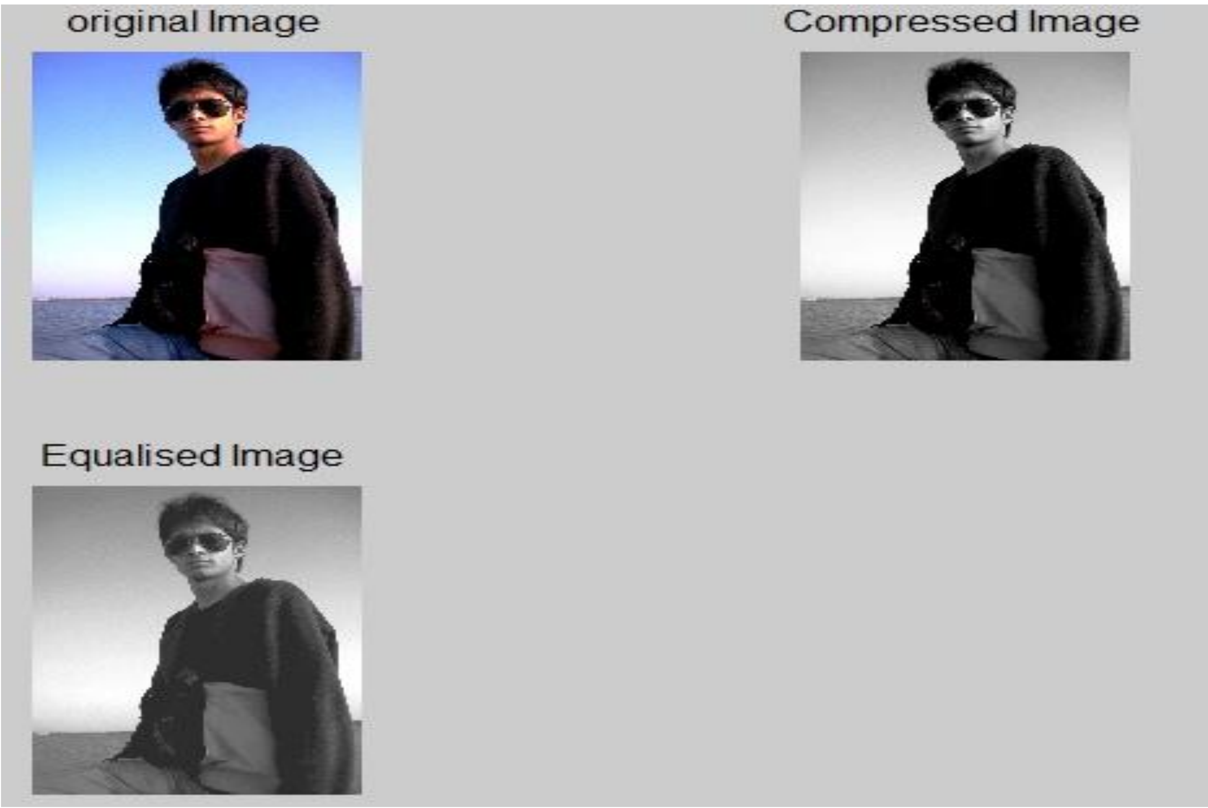


Fig. 4.2: Histogram Equalisation

In the given figure, the pixels values of the input image are uniform and the brightness of the image has increased after applying histogram equalisation.

4.2 IMAGE COMPRESSION:

The input image is compressed using Discrete Cosine Transformation (DCT) algorithm [9] to reduce the size of the input image. A discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies.

- **Size of original image-65Kb**
- **Size of output image-46Kb**

Fig. 4.3: Compression of image using DCT

By applying the discrete cosine transform the size of the input image has reduced significantly. The main purpose of image compression is to reduce the computational time of the algorithm. As we can see earlier the size of image was 65Kb which then reduced to 46Kb after applying DCT.

4.3 FEATURE EXTRACTION:

The regions of interest from the input image namely right eye, left eye, nose and mouth are extracted .

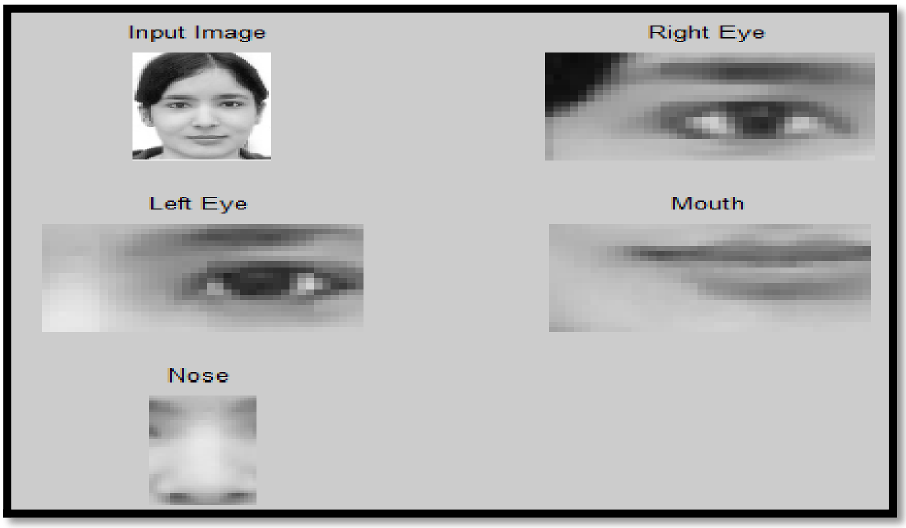


Fig. 4.7(a): Face feature extraction.

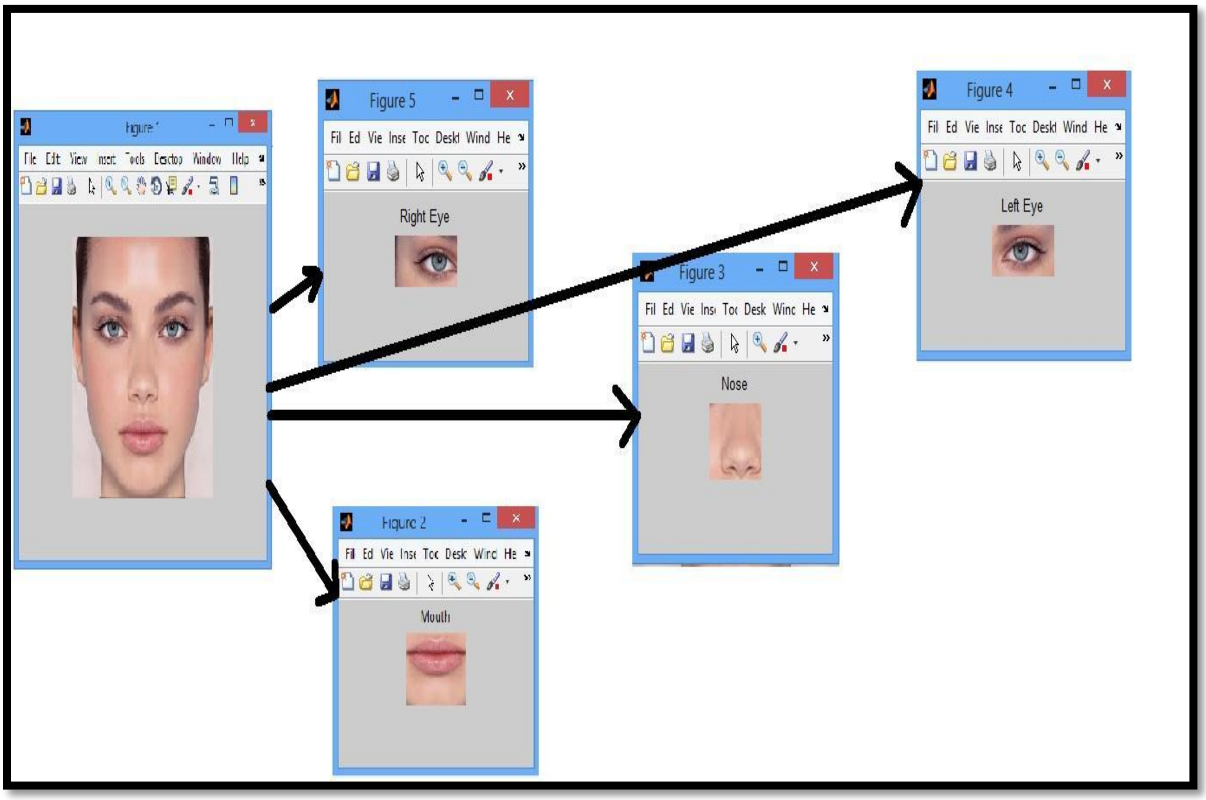


Fig. 4.7(b): Face feature extraction.

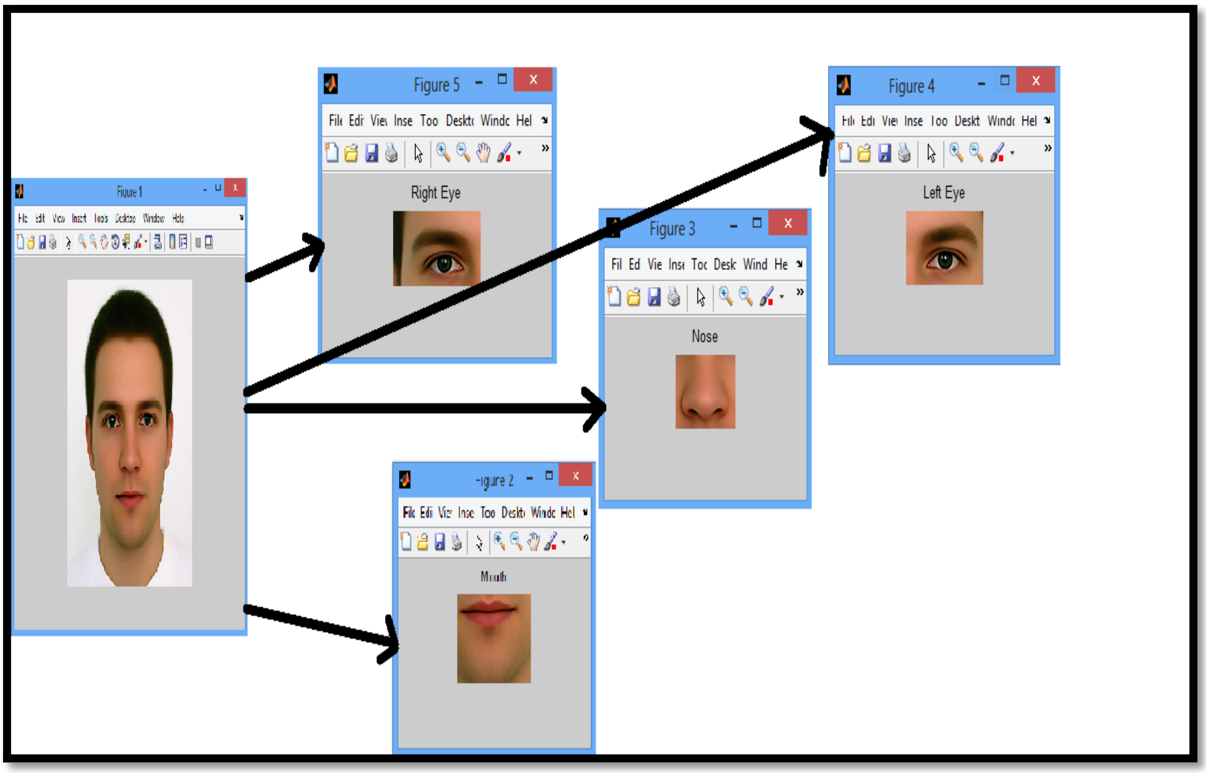


Fig. 4.7(c): Face feature extraction.

In the above mentioned results, the features of the input image is extracted according to the dimensions mentioned in the figure After the extraction of features, the mean value of pixels of the features extracted is stored in the database.

4.4 FINAL RESULT:

The final result shows the extraction of features after the application of pre –processing techniques such as histogram equalisation and box filter on the input image.

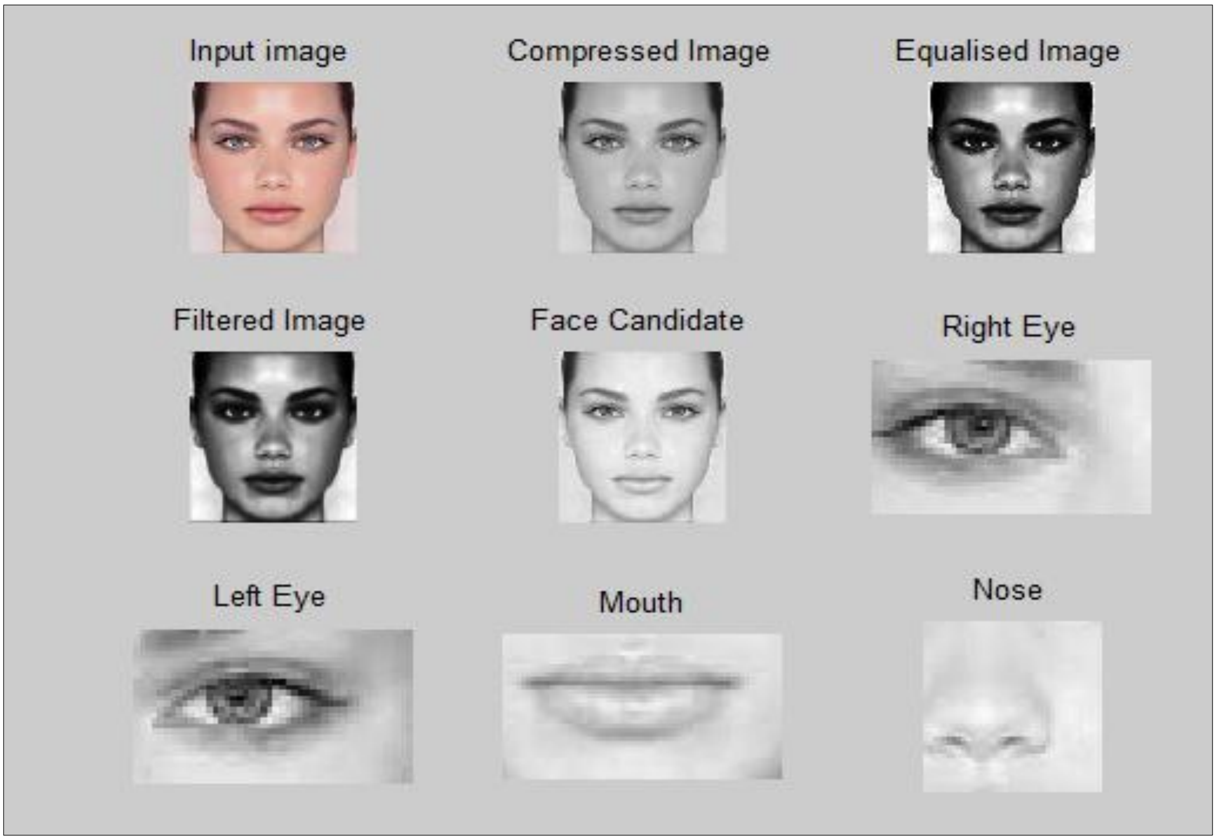


Fig 4.8: Final result: Depicts the result input image, compressed, equalized and filtered image along with the features extracted from the face.

CHAPTER 5

5.1 APPLICATION AREAS:

Access Control- Face verification, matching a face against a single enrolled exemplar, is well within the capabilities of current Personal Computer hard-ware. Since PC cameras have become widespread, their use for face-based PC logon has become feasible, though take-up seems to be very limited. Increased ease-of-use over password protection is hard to argue with today's somewhat unreliable and unpredictable systems, and for few domains is their motivation to progress beyond the combinations of password and physical security that protect most enterprise computers. As biometric systems tend to be third party, software add-ons the systems do not yet have full access to the greater hardware security guarantees afforded by boot-time and hard disk passwords. Vision face-based screen lock is one example, bundled with PC cameras. Naturally such PC-based verification systems can be extended to control authorization Achievements and Challenges in Fingerprint Recognition 109for single-sign-on to multiple networked services, for access to encrypted documents and transaction authorization, though again uptake of the technology has been slow.

Face verification is being used in kiosk applications, notably in Mr. Payroll's (now innovatory) cheque-cashing kiosk with no human supervision. Innovatory claims to have one million enrolled customers. Automated Teller Machines, already often equipped with a camera, have also been an obvious candidate for face recognition systems (e.g. Visage's Face PIN), but development seems not to have got beyond pilot schemes. Banks have been very conservative in deploying biometrics as they risk losing far more through customers disaffected by being falsely rejected than they might gain in fraud prevention. Customers themselves are reluctant to incur burdensome additional security measures when their personal liability is already limited by law. For better acceptance, robust passive acquisition systems with very low false rejection probabilities are necessary. Physical access control is another domain where face recognition is attractive (e.g. Cognitec's FaceVACS, Miros' True Face) and here it can even be used in combination with other biometrics. Biometric Identification is a system which combines face recognition with speaker identification and lip motion.

Identification Systems - Two US States are testing face recognition for the policing of Welfare benefits. This is an identification task, where any new applicant being enrolled must be compared against the entire database of previously enrolled claimants, to ensure that they are not claiming under more than one identity. Unfortunately face recognition is not currently able to reliably identify one person among the millions enrolled in a single state's database, so demographics (zip code, age, name etc.) are used to narrow the search (thus limiting its effectiveness), and human intervention is required to review the false alarms that such a system will produce. Here a more accurate system such as finger print or iris-based person recognition is more technologically appropriate, but face recognition is chosen because it is more acceptable and less intrusive. In Connecticut, face recognition is the secondary biometric added to an existing finger print identification system. Several US States, including Illinois, have also instituted face recognition for ensuring that people do not obtain multiple driving licenses.

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 required identification, face recognition is the best biometric for video data. Though gait or lip motion recognition have some potential. Face recognition can be applied without the subject's knowledge. Automated face recognition can be applied 'live' to search for a watch-list of 'interesting' people, or after the fact using surveillance footage of a crime to search through a database of suspects. The deployment of face-recognition surveillance systems has already begun though the technology is not accurate enough yet. The US government is investing in improving this technology and while useful levels of recognition accuracy may take some time to achieve, technologies such as multiple steerable zoom cameras, non-visible wavelengths and advanced signal processing are likely to bring about super-human perception in the data-gathering side of surveillance systems.

Pervasive Computing - Another domain where face recognition is expected to become very important, although it is not yet commercially feasible, is in the area of pervasive or ubiquitous computing. Many people are envisaging the pervasive deployment of information devices. Computing devices, many already equipped with sensors, are already found throughout our cars and in many appliances in our homes, though they will become ever more widespread. All of these devices are just now beginning to be networked together. We can envisage a future where many everyday objects have some computational power, allowing them to adapt their behaviour — to time, user, user control and a host of other factors. The communications infrastructures permitting such devices to communicate to one another are being defined and developed (e.g. Bluetooth, IEEE 802.11). So while it is easy to see that the devices will be able to have a well-understood picture of the virtual world with information being shared among many devices, it is less clear what kind of information these devices will have about the real physical world. Most devices today have a simple user interface with inputs controlled only by active commands on the part of the user. Some simple devices can sense the environment, but it will be increasingly important for such pervasive, networked computing devices to know about the physical world and the people within their region of interest. Only by making the pervasive infrastructure ‘human aware’ can we really reap the benefits of productivity, control and ease-of-use that pervasive computing promises. One of the most important parts of human-awareness is to know the identity of the users close to a device, and while there are other biometrics that can contribute to such knowledge, face recognition is the most appropriate because of its passive nature.

There are many examples of pervasive face recognition tasks: Some devices such as Personal Digital Assistants (PDAs) may already contain cameras for other purposes, and in good illumination conditions will be able to identify their users. A domestic message centre may have user personalization that depends on identification driven by a built-in camera. Some pervasive computing achievements and challenges in Fingerprint Recognition may need to know about users when not directly interacting with advice, and may be made ‘human aware’ by a network of cameras able to track the people in the space and identify each person, as well as have some under-standing of the person’s activities. Thus a video conference room could steer the camera and generate a labelled transcript of the conference; an automatic lobby might inform workers of specific visitors; and mobile workers could be located and kept in touch by a system that could identify them and redirect phone calls.

5.2 CHALLENGES:

- Methods for face detection and recognition systems can be affected by -

a) Pose.

b) Presence or absence of structural components, facial expression, occlusion, image.

c) Orientation, imaging conditions, and time delay (for recognition).

- The other major limitation in biometric based system is the bad image which could be due to many reasons, one of which could be intensity of light.

- Different types of light conditions hinder the use of biometric systems at a level like when user is logging onto a system or a number of users are operating a single system.

5.3 FUTURE SCOPE:

- Face recognition systems used today work very well under constrained conditions, although all systems work much better with frontal mug-shot images and constant lighting.
- All current face recognition algorithms fail under the vastly varying conditions under which humans need to and are able to identify other people.
- Next generation person recognition systems will need to recognize people in real-time and in much less constrained situations.
- Technology used in smart environments has to be unobtrusive and allow users to act freely.
- Wearable systems in particular require their sensing technology to be small, low powered and easily integrable with the user's clothing.
- Considering all the requirements, identification systems that use face recognition and speaker identification seem to us to have the most potential for wide-spread application.
- Cameras and microphones today are very small, light-weight and have been successfully integrated with wearable systems. Audio and video based recognition systems have the critical advantage that they use the modalities humans use for recognition.
- Finally, researchers are beginning to demonstrate that unobtrusive audio-and-video based person identification systems can achieve high recognition rates without requiring the user to be in highly controlled environments.

5.4 CONCLUSION:

Face recognition is one of the several biometric identification techniques used for recognising people. There are several methods that can be used to achieve this purpose. Some of the most common algorithms are using PCA or Eigen faces. The extraction of facial features such as left eye, right eye, nose and mouth by incorporating Support Vector Machine technique for identifying person has been a novel approach and has given us successful results.

Face recognition technology has come a long way in the last twenty years. Today, machines are able to automatically verify the identity information for secure transactions, for surveillance and security tasks, and for access control to buildings. These applications usually work in controlled environments and recognition algorithms that can take advantage of the environmental constraints to obtain high recognition accuracy. However, next generation face recognition systems are going to have widespread application in smart environments, where computers and machines are more like helpful assistants.

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