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A Comparison between Feature Extraction Techniques for Face Recognition

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Abstract— Generally speaking any face recognition system consists of mainly three stages: Face detection, Face representation and Face classification. In this paper we are focusing only on Face representation, which consist of feature extraction procedure. This paper reviews the Principal Component Analysis (PCA) algorithm and Linear Discriminant Analysis (LDA) algorithm which are popularly used for feature extraction in Face Recognition System. This paper demonstrates the comparison of PCA and LDA algorithm, and also it highlights a 3D Face Recognition algorithm as a improvement over other feature extraction algorithm.

Keywords— PCA, LDA, 3D Face Recognition

I. INTRODUCTION

The Face Recognition technology has found its application in various sectors of human life. As it found application in different field there was a need to improve the currently prevailing technology and methods. This led to invention and development of newer and better algorithms and techniques. Herein, we are trying to throw a light over some of the brilliant techniques developed so far. Principal Component Analysis (PCA) is one of the most popular appearance base methods used mainly for dimensionality reduction in compression and recognition problems [1].Another powerful dimensionality reduction technique is Linear Discriminant Analysis (LDA) which is also known as Fisher's Discriminant Analysis.LDA searches for a linear transformation such that the feature clusters are most separable after the transformation which can be achieved through scatter matrix analysis [1].A newly-emerging trend in facial recognition software uses a 3D model, which claims to provide more accuracy. Three-dimensional face recognition (3D face recognition) is a modality of facial recognition methods in which the three-dimensional geometry of the human face is used.

II. FEATURE EXTRACTION TECHNIQUES

Principle Component Analysis:

The origin of PCA is from Eigen Vectors. The Eigen vector that encompasses the major features of any input was considered as Principle Component.PCA belongs to linear transforms based on the statistical techniques. This method provides a powerful tool for data analysis and pattern recognition which is often used in signal and image processing as a technique for data dimension reduction or their de-correlation as well. It is a way of analysing, identifying patterns in data and express it in a way that highlights the similarities and differences .Its advantage is that it can be used as a compression method of data without any loss of information.

Principle Component Analysis (PCA) is a mathematical procedure that uses Linear Transformations to map data from high dimensional space to low dimensional space. By discarding minor components, the PCA effectively reduces the number of features and displays the data set in a low-dimensional subspace.[2]

Then after considering some distinctive factors some better version of the PCA were devised. They are as follow:

- **Kernel Principle Component Analysis (K-PCA) :**
  Kernel Principal Component analysis (kernel PCA) is an extension of kernel principal component analysis (kernel PCA) is an extension of PCA using techniques of kernel methods. (PCA) using techniques of kernel methods.
- **Multivariate Principle Component analysis M-PCA :**
  Multi-linear principal component analysis (MPCA) is a mathematical procedure that uses multiple orthogonal transformations to convert a set of multidimensional objects into another set of multidimensional objects of lower dimensions. There is one orthogonal (linear) transformation for each dimension (mode): hence multi-linear.

Linear Discriminant Analysis :

There are many possible techniques for classification of data. Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) are two commonly used techniques for data classification and dimensionality reduction. Linear Discriminant Analysis easily handles the case where the within-class frequencies are unequal and their performances has been examined on randomly generated test data. This method maximizes the ratio of between-class variance to the within-class variance in any particular data set thereby guaranteeing maximal separability. The use of Linear Discriminant Analysis for data classification is applied to classification problem in speech recognition [3].

Different approaches to LDA:
Data sets can be transformed and test vectors can be classified in the transformed space by two different approaches. Class-dependent transformation: This type of approach involves maximizing the ratio of between class variance to within class variance. The main objective is to maximize this ratio so that adequate class separability is obtained. The class-specific type approach involves using two optimizing criteria for transforming the data sets independently [3].

Class-independent transformation: This approach involves maximizing the ratio of overall variance to within class variance. This approach uses only one optimizing criterion to transform the data sets and hence all data points irrespective of their class identity are transformed using this transform. In this type of LDA, each class is considered as a separate class against all other classes [3].

Applications:

- In addition to the examples given below, LDA is applied in positioning and product management.
- Bankruptcy prediction: In bankruptcy prediction based on accounting ratios and other financial variables, linear discriminant analysis was the first statistical method applied to systematically explain which firms entered bankruptcy.
- Face recognition
  In computerized face recognition, each face is represented by a large number of pixel values. Linear discriminant analysis is primarily used here to reduce the number of features to a more manageable number before classification. Each of the new dimensions is a linear combination of pixel values, which form a template. The linear combinations obtained using Fisher's linear discriminant are called Fisher faces, while those obtained using the related principal component analysis are called Eigen faces

3-D face recognition:

A newly-emerging trend in facial recognition software uses a 3D model, which claims to provide more accuracy. Three-dimensional face recognition (3D face recognition) is a modality of facial recognition methods in which the three-dimensional geometry of the human face is used. Capturing a real-time 3D image of a person's facial surface, 3D facial recognition uses distinctive features of the face -- where rigid tissue and bone is most apparent, such as the curves of the eye socket, nose and chin -- to identify the subject. These areas are all unique and don't change over time. One of the ways to do this is by comparing selected facial features from the image and a facial database. It has been shown that 3D face recognition methods can achieve significantly higher accuracy than their 2D counterparts.

Working of 3-D face recognition :

Detection:
Acquiring an image can be accomplished by digitally scanning an existing photograph (2D) or by using a video image to acquire a live picture of a subject (3D).

Alignment:
Once it detects a face, the system determines the head's position, size and pose. The subject has the potential to be recognized up to 90 degrees, while with 2D, the head must be turned at least 35 degrees toward the camera.

Measurement:
The system then measures the curves of the face on a sub-millimeter (or microwave) scale and creates a template.

Representation:
The system translates the template into a unique code. This coding gives each template a set of numbers to represent the features on a subject's face.

Matching :
If the image is 3D and the database contains 3D images, then matching will take place without any changes being made to the image. However, there is a challenge currently facing databases that are still in 2D images. 3D provides a live, moving variable subject being compared to a flat, stable image.

Verification or Identification:
In verification, an image is matched to only one image in the database (1:1). For example, an image taken of a subject may be matched to an image in the Department of Motor Vehicles database to verify the subject is who he says he is. If

identification is the goal, then the image is compared to all images in the database resulting in a score for each potential match (1:N). In this instance, you may take an image and compare it to a database of mug shots to identify who the subject is.

Drawbacks in 3-D face recognition :
The main drawback of the majority of 3D face recognition approaches is that they need all the elements of the system to be well calibrated and synchronized to acquire accurate 3D data (texture and depth maps). Moreover, most of them also require the cooperation or collaboration of the subject making them not useful for uncontrolled or semi controlled[5].Also the absence of a consistent parameterization among face meshes or point clouds makes it impossible to directly obtain registered features with a uniform sampling pattern; this prevents appearance-based methods[4].

In the worst case, the enrolled individual (probe) claims identity of a person whose template is stored in the database (gallery). We refer to the data used for a specific recognition task as a template. The face recognition algorithm needs to compare a given face with a given template and verify their equivalence [6][7].When a 3D image is taken, different points (usually three) are identified. For example, the outside of the eye, the inside of the eye and the tip of the n 6ose will be pulled out and measured. Once those measurements are in place, an algorithm (a step-by-step procedure) will be applied to the image to convert it to a 2D image.

Combination steps of PCA and ICP for 3-D Face recognition :
In order to provide an accurate 3D face alignment method, especially one that is able to align the faces of the same subject into a consistent form, an integrated improved ICP-based face alignment approach to correct 3D face images. The whole face alignment procedure has four phase as following:

1. Crop the main face area by using a sphere with its center at the nose tip which is detected as in the previous chapter.[8]
2. Align all cropped faces according to its PCA coordinates.[8]
3. Make use of the symmetric character of the face to implement the alignment especially along y and z-axis.[8]
4. Align faces to a standard face template by using ICP algorithm to optimize the alignment along x-axis.[8]

III. Comparison of PCA and LDA

TABLE I: Comparison of PCA and LDA

Principal Components Analysis	Linear Discriminant Analysis
The prime difference between LDA and PCA is that PCA does more of feature classification.	The prime difference between LDA and PCA is that LDA does data classification.
The shape and location of the original data sets changes when transformed to a different space.	LDA doesn't change the location but only tries to provide more class separability and draw a decision region between the given classes.
PCA calculates best discriminating components without knowledge about groups	LDA calculates the best discriminating components about groups which are defined by the client (user).

IV. Conclusions

3D face recognition algorithm had been developed taking into consideration the merits of PCA and LDA combined. This resulted in an better accuracy in recognition and detection. This improvised method proved to be useful in field very security and accuracy is of utmost importance. 3D face data are less sensitive to lighting variation and pose change, which have been adopted either as an addition or a substitution to face images in recognition tasks. Thus for a proper detection and recognition the feature of any particular image must be accurately extracted. There after depending upon these features an image can be recognized. PCA, LDA and 3d face algorithm can be used.

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