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A Comprehensive Survey on Feature Extraction Techniques for Face Recognition and Component

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Abstract: This paper presents an overview of different feature extraction methods for face recognition. Selection of feature extraction method is probably the single most important factor in achieving high recognition performance in recognition system. Different feature extraction methods are designed for different representations of the facial representation. Recognition has been extensively studied in the last half century and progressed to a level, sufficient to produce technology driven applications. Rapidly growing computational power may enable the implementation of recognition methodologies. So here the feature extraction methods are discussed in terms of invariance properties reconstructability and variability of facial expression. This paper may solve the problem of choosing the feature extraction methods.

Keywords: *Feature Extraction, Feature Extraction Techniques, Machine Readable Travel Documents (MRTD).*

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I. INTRODUCTION

Face recognition is motivated not only by the fundamental challenges this recognition problem poses but also by numerous practical applications where human identification is needed. Face recognition has several advantages over other biometric technologies: It is natural, nonintrusive, and easy to use. Among the six biometric attributes considered by Hietmeyer [12], facial features scored the highest compatibility in a Machine Readable Travel Documents (MRTD) [18] system based on a number of evaluation factors, such as enrollment, renewal, machine requirements, and public perception. It can operate in either or both of two modes: (1) face verification (or authentication), and (2) face identification (or recognition).

This Paper gives the large number of feature extraction methods reported in the literature; a newcomer to the field is faced with some question like which feature extraction method is the best for a given application? This question led us to characterize the available feature extraction methods, so that the most promising methods could be sorted out. An experimental evaluation of these few promising methods most still be performed to select the best method for a specific application. In this process, one might find that a specific feature extraction method needs to be further developed.

II. FACE RECOGNITION PROCESSING

Face recognition is a visual pattern recognition problem. There, a face as a three-dimensional object subject to varying illumination, pose, expression and so on is to be identified based on its two-dimensional image (three-dimensional images e.g., obtained from laser may also be used). A face recognition system generally consists of four modules as depicted in Figure: detection, alignment, feature extraction, and matching, where localization and normalization (face detection and alignment) are processing steps before face recognition (facial feature extraction and matching) is performed.

Face detection segments the face areas from the background. In the case of video, the detected faces may need to be tracked using a face tracking component. Face alignment is aimed at achieving more accurate localization and at normalizing faces thereby whereas face detection provides coarse estimates of the location and scale of each detected face. After a face is normalized geometrically and photo metrically, feature extraction is performed to provide effective information that is useful for distinguishing between faces of different persons and stable with respect to the geometrical and photometrical variations. These problems may be analyzed from the viewpoint of face subspaces or manifolds, as follows.

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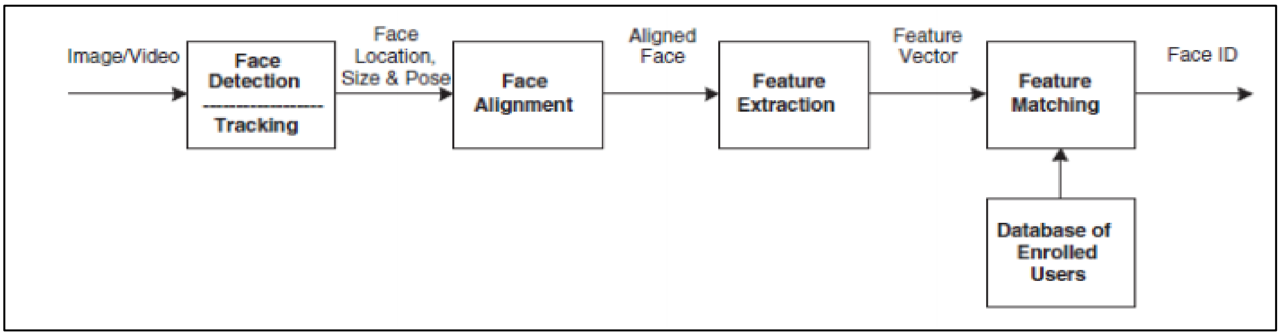

Fig 1 Face Recognition Processing Flow.

III. FACE RECOGNITION

A recognition system is computer application that automatically identifying or verifying a person from a digital image. One of the ways to do this is by comparing selected facial features from the image and a facial database.

The variations of facial appearances caused by illumination, the appearances are classified into four main components: diffuse reflection, specular reflection, attached shadow and cast shadow [4].Variations among images of the same face due to illumination and viewing direction are almost always larger than image variations due to change in face identity.

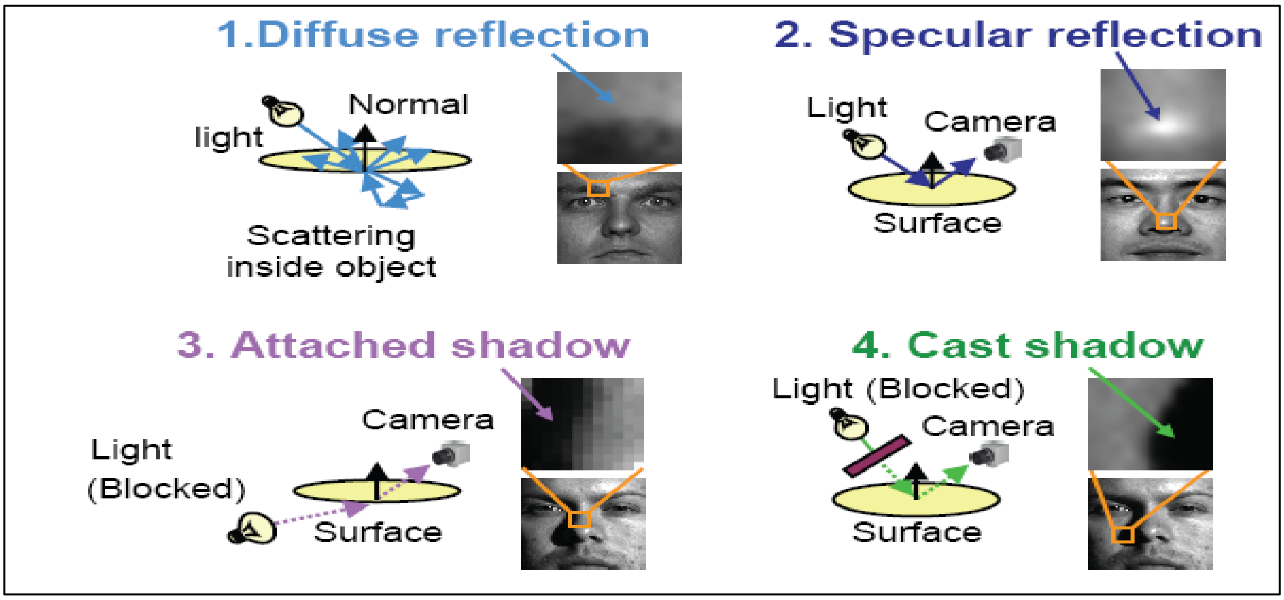

Fig 2 Face Recognition

For instance, illumination changes caused by light sources at arbitrary positions and intensities contribute to a significant amount of variability. The image often includes a human face together with a background. Some facial recognition algorithms identify facial features by extracting landmarks [9], or features, from an image of the subject's face. These features are then used to search for other images with matching features in this recognition system.

IV. FACIAL EMOTION RECOGNITION SYSTEM

It is a computer system that attempt to automatically analyze and recognize facial emotions. For example, although facial expressions can convey emotions, they can also express intention, cognitive processes, physical effort, or other intra or interpersonal meanings [5]. Some examples of feelings that can be expressed are:

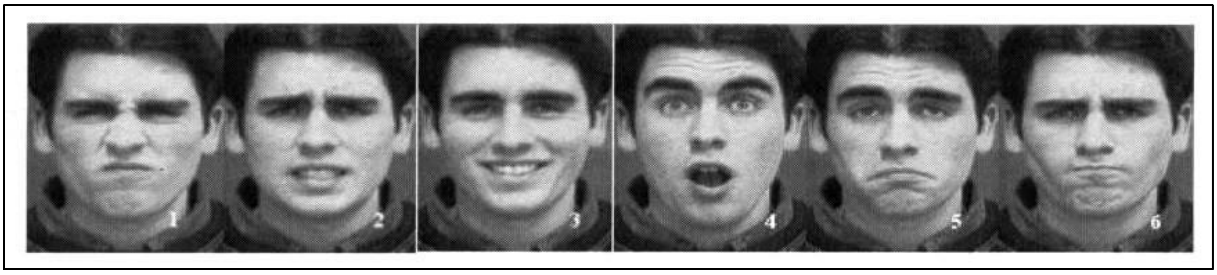

Fig 3 Facial Emotion

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V. IMAGE PREPROCESSING

Data in a paper document are usually captured by optical scanning and stored in a file of picture elements, called pixels. These pixels may have values: OFF (0) or ON (1) for binary images. This collected raw data must be further analyzed to get useful information. Such processing includes the following:

- *Thresholding:*

A grayscale or color image is reduced to a binary image.

- *Noise reduction:*

The noise, introduced by the optical scanning device or the writing instrument, causes disconnected line segments, bumps and gaps in lines, filled loops etc.

- *Size Normalization:*

Each segmented character is normalized to fit within suitable matrix like 32x32 or 64x64 so that all characters have same data size.

- *Skew Detection and Correction:*

Handwritten document may originally be skewed or skewness may introduce in document scanning process. This effect is unintentional in many real cases.

- *Thinning:*

The boundary detection of image is done to enable easier subsequent detection of pertinent features and objects of interest.

VI. FEATURE EXTRACTION

Feature extraction and selection can be defined as extracting the most representative information from the raw data, which minimizes the within class pattern variability while enhancing the between class pattern variability. For this purpose, a set of features are extracted for each class that helps distinguish it from other classes, while remaining invariant to characteristic differences within the class .

Devijver and kittler define feature extraction as the problem of "extracting from the raw data the information which is most relevant for classification purposes, in the sense of minimizing the within class variability." After surveying various paper or author we would conclude that feature extraction methods are classified in three major groups:

- *Global Transformation*
- *Statistical Features*
- *Geometrical and Topological Features*

- *Global Transformation*

A continuous signal generally contains more information than needs to be represented for the purpose of classification. Deformations like translation and rotation are invariant under global transformation and series expansion. Common transform and series expansion methods used in the recognition field are:

- *Fourier Transforms:*

The general procedure is to choose magnitude spectrum of the measurement vector as the features in an n-dimensional Euclidean space. One of the most attractive properties of the Fourier Transform is the ability to recognize the position-shifted characters, when it observes the magnitude spectrum and ignores the phase. Fourier Transforms has been applied to face recognition in many ways.

- *Gabor Transform:*

It is a variation of the windowed Fourier Transform. In this case, the window used is not a discrete size, but is defined by a Gaussian function.

- *Wavelets:*

Wavelet transformation is a series expansion technique that allows us to represent the signal at different levels of resolution.

- *Moments:*

Moments, such as central moments, Legendre moments, Zernike moments, form a compact representation of the original document image that make the process of recognizing an object scale, translation, and rotation invariant.

- *Karhunen-Loeve Expansion:*

It is an eigen-vector analysis, which attempts to reduce the dimension of the feature set by creating new features that are linear combinations of the original ones Karhunen-Loeve expansion is used in several pattern recognition problems such as face recognition.

- *Statistical Features:*

Representation of a document image by statistical distribution of points takes care of style variations to some extent. Although this type of representation does not allow the reconstruction of the original image, it is used for reducing the dimension of the feature set providing high speed and low complexity. The major statistical features mentioned below are used for character representation:

- *Zoning:*

The frame containing the character is divided into several overlapping or non-overlapping zones. The densities of the points or some features in different regions are analyzed.

- *Crossings and Distances:*

A popular statistical feature is the number of crossing of a contour by a line segment in a specified direction. The character frame is partitioned into a set of regions in various directions and then features of each region are extracted.

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- *Projections:*

Pixels can be represented by projecting, the pixel gray values onto lines in various directions. This representation creates one-dimensional signal from a two dimensional image, which can be used to represent the image.

- *Geometrical and Topological Features*

Various global and local properties of face can be represented by geometrical and topological features with high tolerance to distortions and style variations. Various topological and geometrical representations can be grouped in four categories:

- *Extracting and Counting Topological Structures:*

In this category, lines, curves, splines, extreme points, maxima and minima, cups above and below a threshold, openings, to the right, left, up and down, cross (X) points, branch (T) points, line ends (J), loops (O), direction of a stroke from a special point, inflection between two points, isolated dots, a bend between two points, horizontal curves at top or bottom, straight strokes between two points, ascending, descending and middle strokes and relations among the stroke that make up a face are considered as feature[24].

- *Measuring and Approximating the Geometrical Properties:*

In this category, the image are represented by the measurement of the geometrical quantities such as, the ratio between width and height of the bounding box of a image, the relative distance between the last point and the last y-min, the relative horizontal and vertical distances between first and last points, distance between two points, comparative lengths between two strokes, width of a stroke, upper and lower masses of words, word length curvature or change in the curvature[26].

- *Coding:*

One of the most popular coding schemes is Freeman's chain code. This coding is essentially obtained by mapping the strokes of a character into a 2-dimensional parameter space, which is made up of codes. There are many versions of chain coding.

- *Graphs and Trees:*

Image are first partitioned into a set of topological primitives, such as strokes, holes, cross points etc. Then, these primitives are represented using attributed or relational graph[27].

VII. SOME OTHER FEATURE EXTRACTION TECHNIQUES

There are some other techniques which are classified as follows-:

- *Template Matching*

This is the simplest way of image recognition, based on matching the stored prototypes. The matching operation determines the degree of similarity between two vectors (group of pixels, shapes, curvature etc.) A gray-level or binary input image is compared to a standard set of stored prototypes. According to a similarity measure (e.g.: Euclidean, Mahalanobis, Jaccard or Yule similarity measures etc).

- *Statistical Techniques:*

Statistical decision theory is concerned with statistical decision functions and a set of optimality criteria, which maximizes the probability of the observed pattern given the model of a certain class[23]. Statistical techniques are based on following assumptions:

- Distribution of the feature set is Gaussian or in the worst case uniform,
- There are sufficient statistics available for each class.
- Given collection of images is able to extract a set of features which represents each distinct class of patterns.

VIII. COMPONENT USED IN FACE RECOGNITION SYSTEM

- *PCA Based Face Recognition System*

A 2-D facial image can be represented as 1-D vector by concatenating each row (or column)into a long thin vector. Let's suppose we have M vectors of size N (= rows of image × columns of image) representing a set of sampled images. pj 's represent the pixel values.

$$xi = [p1 \, . \, . \, . \, pN]^T, \; i = 1, \, . \, . \, . \, , M \ldots (1)$$

The images are mean centered by subtracting the mean image from each image vector. Let m represent the mean image.

$$m = \frac{1}{M} \sum_{i=1}^{M} x_i$$

And let wi be defined as mean centered image

$$wi = x_i - m$$

Principal Component Analysis commonly uses the eigen faces [13,15] in which the probe and gallery images must be the same size as well as normalized to line up the eyes and mouth of the subjects whining the images[25]. Approach is then used to reduce the dimension of data by the means of image compression basics [17] and provides most effective low dimensional structure of facial pattern.

- *Linear Discriminant Analysis (LDA) Based Face Recognition System*

As highly structured two-dimensional patterns, human face images can be analyzed in the spatial and the frequency domains. The results of this analysis can be supported by subjective psycho visual finding[18]. To analyze any representation V, where V can be the original image[28], its spatial segments, or transformed images, we provide the following framework. we compute the within- and between-class scatter matrices as follows:

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$$S_w^{(V)} = \sum_{i=1}^{L} \Pr(C_i)\Sigma_i ,$$

$$S_b^{(V)} = \sum_{i=1}^{L} \Pr(C_i)(\mu - \mu_i)(\mu - \mu_i)^T .$$

IX. FUTURE RESEARCH

The approach described in this paper is initially successful and encouraging in face recognition of some faces but more research is to be done in the following domain:

- Size of database is to be increased with illumination variation, pose variation, distance variation, date-variation, expression variation and occlusion variation conditions must be considered while capturing the dummy face of the subject[19].
- Our current study reports observed changes due to covariates; however the analysis does not attempt to explain the cause of the effect in detail[20]. Answering the underline cause of the affects will assist in designing more robust face recognition algorithms and then based on their values the most effective algorithm would perform the matching. Alternatively the weighting of an algorithm response would change based on estimated covariates.
- In this respect the evaluation of other types of algorithms are to be done[21].
- Design and development of new algorithms to distinguish between some samples of faces[22]

X. CONCLUSION

There are so many challenges to develop a comprehensive face recognition database and one of the most fundamental problem in data acquisition is the ability to take consistent, high-quality, repeatable images. In order to compare the performance of some face recognition algorithms on faces we have prepared as well as presented a database and tested the matching accuracy of PCA, LDA, etc face recognition algorithms. Selection of feature extraction methods is probably the single most important factor in achieving high recognition performance[25]. Methods for treating the problem of recognition have developed remarkably in the last two decades. Still a lot of research is needed to tackle the challenges in face recognition so that commercially viable software solutions can be made available. It is hoped that this comprehensive discussion will provide insight into various concepts involved, and boost further advances in the area. The difficulty of performing accurate recognition is determined by the nature of the material to be clear and by its quality. Generally, misrecognition rates for unconstrained material increase progressively from source to destination image. Methods of increasing sophistication are being pursued.

REFERENCES

[1]. Lucas D.Introna, H.Nissenbaum.: “Facial Recognition Technology, A survey of policy and implementation Issues”, CCPR.

[2]. W. Zhao, R.Chellpa, A.Rosenfield, P.J.Phillips, : “Face Recognition A Literature Survey”.

[3]. P.J. Bert, E.H.Adelson(1983): “The Laplacian Pyramid as Compact Image Code”, IEEE Transaction on Communication, Vol. COM-31, No.4.,

[4]. R.C.Gonzalez, R.E.Woods(2009): “Digital Image Processing”, Pearson Education.

[5]. G. Givens, J.R. Beveridge, B.A. Draper, P. Grother, and P.J. Phillips(2004): “How Features of the Human Face Affect Recognition: A Statistical Comparison of Three Face Recognition Algorithms”, Proc. IEEE Int’l Conf. Computer Vision and Pattern Recognition, vol. 2.

[6]. P.J. Phillips, P.J. Flynn, T. Scruggs, K.W. Bowyer, J. Chang, K. Hoffman, J.Marques, J. Min, and W. Worek(2005): “Overview of the Face Recognition Grand Challenge”, Proc. IEEE Int’l Conf. on Computer Vision and Pattern Recognition, 947-954. The International Journal of Multimedia & Its Applications (IJMA) Vol.4, No.4, August 2012

[7]. P.J. Phillips, H. Moon, S.A. Rizvi, and P.J. Rauss(2000): “The FERET Evaluation Methodology for Face-Recognition Algorithms”, IEEE Transaction on PAMI , vol. 22, no. 10, 1090-1104.

[8]. P.Wang, J.Qiang, J.L.Wayman(2004): “Modeling and Pridicting face recognition system Performance Based on analysis of similarity score”, IEEE Transaction on PAMI, Vol. 29, No.

[9]. P.J.Phillips, H.Moon, S.A.Rizvi, P.J.Rauss(1999): “Face Evaluation Methodology for Face Recognition Algorithms”, Technical report NISTIR 6264.

[10]. Intelligent multimedia Lab: “Asian Face Image Database PF01”, Technical Report, San 31, HyojaDong, Nam-Gu, Pohang, 790-784, Korea.

[11]. P. J. Phillips, H. Moon, P. J. Rauss, and S. Rizvi(2000): “The FERET evaluation methodology for face recognition algorithms”, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol.22, No. 10.

[12]. Anil K.Jain, L.Hong, S.Pankanti(2000): “Biometric Identification”, Communication of the ACM, Vol. 43, No.2.

[13]. P. Belhumeur, J. Hespanha, D. Kriegman(1997): Eigenfaces vs. Fisherfaces: “Class specific linear projection”, IEEE Transactions on PAMI, 19(7), 711-720.

[14]. A.M. Martinez, A. C. Kak(2001): “PCA versus LDA”, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol 23. No. 2.

[15]. M. Turk and A. Pentland(1991): “Eigenfaces for Recognition”, J. Cognitive Neuroscience, 3(1).

[16]. F. Samaria, A. Harter(1994): “Parameterisation of a Stochastic Model for Human Face Identification”, Proceedings of 2nd IEEE Workshop on Applications of Computer Vision, Sarasota FL.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul430

[17]. L.Sirvoich and M.Kirby(1987): A low dimensional Procedure for Characterization of Human Faces, J.Optical SOC. Am. A, Vol. 4, No. 3, 519-524.
[18]. J.F. Cardoso(1997): “Infomax and Maximum Likelihood for Source Separation”, IEEE Letters on Signal Processing, vol. 4, 112-114.
[19]. Matthew Turk and Alex Pentland, "Eigenfaces for Recognition," Journal of Cognitive Neuroscience, vol. 3, no. 1, pp. 71–86, 1991.
[20]. Peter N. Belhumeur, João P. Hespanha, and David J. Kriegman, "Eigenfaces vs. Fisherfaces: Recognition Using Class Specific Linear Projection," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 19, no. 7, pp. 711–720, 1997.
[21]. Timo Ahonen, Abdenour Hadid, and Matti Pietikäinen, "Face Recognition with Local Binary Patterns," European Conference on Computer Vision, 2006.
[22]. David G. Lowe, "Distinctive Image Features from Scale-Invariant Keypoints," International Journal of Computer Vision, vol. 60, no. 2, pp. 91–110, 2004.
[23]. Navneet Dalal and Bill Triggs, "Histograms of Oriented Gradients for Human Detection," IEEE Conference on Computer Vision and Pattern Recognition, 2005.
[24]. Yaniv Taigman, et al., "DeepFace: Closing the Gap to Human-Level Performance in Face Verification," IEEE Conference on Computer Vision and Pattern Recognition, 2014.
[25]. Florian Schroff, Dmitry Kalenichenko, and James Philbin, "FaceNet: A Unified Embedding for Face Recognition and Clustering," IEEE Conference on Computer Vision and Pattern Recognition, 2015.
[26]. Jiankang Deng, et al., "ArcFace: Additive Angular Margin Loss for Deep Face Recognition," IEEE/CVF Conference on Computer Vision and Pattern Recognition, 2019.
[27]. Wenyi Zhao, Rama Chellappa, P. Jonathon Phillips, and Azriel Rosenfeld, "Face Recognition: A Literature Survey," ACM Computing Surveys, vol. 35, no. 4, pp. 399–458, 2003.
[28]. Omkar M. Parkhi, Andrea Vedaldi, and Andrew Zisserman, "Deep Face Recognition," British Machine Vision Conference, 2015.
[29]. Mei Wang and Weihong Deng, "Deep Face Recognition: A Survey," Neurocomputing, vol. 429, pp. 215–244, 2021.