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A SURVEY ON FACE DETECTION METHODS AND FEATURE EXTRACTION TECHNIQUES OF FACE RECOGNITION

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Abstract: From the last two decades, face recognition is playing an important and vital role especially in the field of commercial, banking, social and law enforcement area. It is an interesting application of pattern recognition and hence received significant attention. The complete process of face recognition covers in three stages, face detection, feature extraction and recognition. Various techniques are then needed for these three stages. Also these techniques vary from various other surrounding factors such as face orientation, expression, lighting and background. This paper presents the complete study and review of various techniques used in face detection and feature extraction staged under different conditions.

Keywords: Face Recognition, Face Detection methods, Feature Extraction techniques.

1. INTRODUCTION

Face recognition is a challenging and interesting research topic in the field of pattern recognition which has been found a widely used in many applications such as verification of credit card, security access control, and human computer interface. Thus many face recognition algorithms have been proposed and survey in this area can be found in [2] [3] [4]. There are two central issues of an automatic face recognition system; they are (a) feature selection of representation of face. (b) Classification of new face image based on the chosen feature representation. Also in a face recognition environment, the result of feature selection may be affected by some variations in the face images, such as lighting, expression and pose.

(A) Why use face recognition?

The traditional authentication methods of person's identity include passwords, PINs, smart cards, plastic cards, token, keys and so forth. These could be hard to remember or retain and passwords can be stolen or guessed, tokens and keys can be misplaced and forgotten. However an individual's biological traits cannot be misplaced, forgotten, stolen or forged. Biometric-based technologies include identification based on physiological characteristics (such as face, fingerprints, finger geometry, hand geometry, hand veins, palm, iris, retina, ear and voice) and behavioural traits (such as gait, signature and keystroke dynamics) [1]. Face recognition appears to offer several advantages over other biometric methods. Face recognition can be done passively without any explicit action or participation on the part of the user since face images can be acquired from a distance by a camera. This is particularly beneficial for security and surveillance purposes. Furthermore, data acquisition in general is fraught with problems for other biometrics: techniques that rely on hands and fingers can be rendered useless if the epidermis tissue is damaged in some way (i.e., bruised or cracked). Iris and retina identification require expensive equipment and are much too sensitive to any body motion. Voice recognition is susceptible to background noises in public places and auditory fluctuations on a phone line or tape recording. Signatures can be modified or forged. However, facial images can be easily obtained with a couple of inexpensive fixed cameras. Face recognition is totally non-intrusive and does not carry any such health risks [5].

(B) Applications of face recognition

Face recognition is basically used for two primary authenticity modes:
Verification: Generally described as one to one matching system because the system tries to match the image presented the individual against a specific image already on file.
Identification: It checks the image presented against all others already in the database. Identification systems are described as a 1-to-n matching system, where n is the total number of images in the database.

There are numerous application areas in which face recognition can be exploited for these two purposes, a few of which are outlined below.
Security (access control to buildings, airports/seaports, ATM machines and border checkpoints [12, 13]; computer/ network security [14]; email authentication on multimedia workstations).

(i) Surveillance:
A large number of CCTVs can be monitored to look for known criminals, drug offenders, etc. and authorities can be notified when one is located.

(ii) General identity verification:
Electoral registration, banking, electronic commerce, identifying newborns, national IDs, passports, drivers licenses, employee IDs.

(iii) Criminal justice systems:
mug-shot/booking systems, post-event analysis, forensics

(iv) Image database investigations:
Searching image databases of licensed drivers, benefit recipients, missing children, immigrants and police bookings [5].

(v) "Smart Card" applications:
In lieu of maintaining a database of facial images, the face-print can be stored in a smart card, bar code or magnetic stripe, authentication of which is performed by matching the live image and the stored template [7].

(vi) Multi-media environments with adaptive human computer interfaces.

(vii) Video indexing (labelling faces in video) [10, 11]

(C) 3-stages of face recognition

Face recognition technology is a combination of various other technologies and their features and characteristics makes face recognition a better performer depending upon the application. Face recognition works under three phases- Detection, Extraction and Recognition. An explanation of each phase of face recognition is given in the next sections.

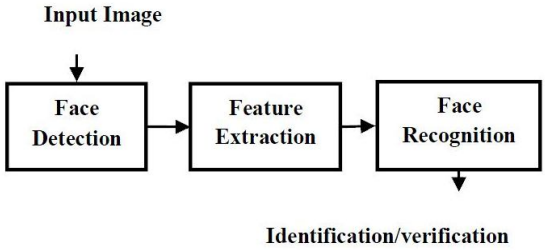

Figure 1: three main phases of face recognition problem

2. FACE DETECTION AND ITS VARIOUS METHODS

It is a fundamental part of the face recognition system because it has ability to focus computational resources on the part of an image containing face. Face detection involves the separation of image into two parts; one containing the face and the other containing the background. It is difficult because although commonalities exist between faces, they can vary considerably in terms of age, skin colour and facial expression [6]. Hjemal and Low [8] divides the face detection techniques into two categories named feature based techniques and image based techniques.

(A) ***Feature based techniques:*** The feature based approaches use the facial features to their detection process. Hjemal and Low [8] further divide this technique into three categories: low level analysis, feature analysis and active shape model.

- ***Low level analysis:*** It deals with the segmentation of visual features by using the properties of pixels, gray scale level, and motion information. In [9], implemented an edge representation method for detecting the facial features in line drawings by detecting the changes in pixel properties. In [15], developed this further to detect human head outline. The edge based techniques rely upon the labeled edges which are matched to a face model for verification. Generally eyebrows, pupils and lips appear darker than surrounding regions, and thus extraction algorithms can search for local minima. In contrast, local maxima can be used to indicate the bright facial spots such as nose tips [6]. Detection is then performed using low-level gray-scale thresh-holding.
- ***Feature analysis:*** It uses additional knowledge about the face and removes the ambiguity produces by low level analysis. The first involves sequential feature searching strategies based on the relative positioning of individual facial features [6]. Initially prominent facial features are determined which allows less prominent features to be hypothesised.
- **Active shape models**: These are used to define the actual physical and higher-level appearance of features. These models are developed by Tim Cootes and Chris Taylor in 1995. These models are released near to a feature, such that they interact with the local image, deforming to take the shape of the feature [8]. ASM are models of the shapes of objects which iteratively deform to fit to an example of the object in a new image. It works in following two steps: Look in the image around each point for a better position for that point, update the model parameters to best match to these new found positions.

(B) ***Image based techniques:*** Face detection of facial features by explicit modelling is a very trivial approach because it may be troubled by the unpredictability of faces and environmental conditions. So there is a need for more robust techniques, capable of performing in unfriendly environments, such as detecting multiple faces with clutter-intensive backgrounds. Image based face detection has inspired a new research area and by virtue of this face detection is treated as a general pattern recognition problem. The image based approach contains the various approaches like neural networks, example based learning, support vector machine [6] [16].

3. FEATURE EXTRACTION AND ITS VARIOUS TECHNIQUES

Face recognition is an evolving area, changing and improving constantly. This section gives the overview of various approaches and techniques along with their advantages and disadvantages. Different approaches of face recognition can be categorized in three main groups such as holistic approach, feature-based approach, and hybrid approach [2].

- **Geometry Feature-based Approach**

The geometry feature-based approach methods analyze local features such as nose, eyes and
their geometric relationships. Sometimes this approach is known as only feature-based
approach [17].

- **Holistic Approach**

Many researchers followed this approach. In the holistic approach whole face region is taken into account as input data to the system. Various methods comes under this approach are eigenfaces, fisher faces, support vector machine, hidden markov model (HMM). They all are based on principal component analysis (PCA)[19].

- **Hybrid-Approach**

Under the hybrid approach the combination of local feature and whole feature is used. Modular eigenface, hybrid local feature methods are for hybrid approach. Human facial feature plays important in face recognition. Research and studies have determined that eyes, mouth and nose are amongst the most significant feature for recognition [18].

Some image processing techniques extract feature points such as eyes, nose, and mouth and then used as input data toward the application. Various approaches have been proposed to extract these facial points or features from the images. The basic approaches are as follows.

(A) Geometry –based Technique

In this technique feature are extracted using the size and the relative position of important components of images. In this technique under the first method firstly the direction and edges of important component is detected and then building feature vectors from these edges and direction. Canny filter and gradient analysis usually applied in this direction. Second, methods are based on the grayscales difference of unimportant components and important components, by using feature blocks, set of Haar-like feature block in Adaboost method [20] to change the grayscales distribution into the feature. In LBP [21] method, every face image divides into blocks and each block has its corresponding central pixel. Then this method examine its neighbor pixels, based on the grayscales value of central pixel it changes neighbor to 0 or 1. After that a histograms is build for every region and then these histograms are combined to a feature vector for the face image. Technique proposed by Kanade [22], also comes under this[28].

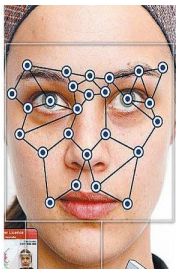

Figure 2: geometric representation of a person

(B) Template Based Technique:

This technique extracts facial feature using appropriate energy function. Methods have been proposed by Yuille et al. [23], detecting and describing features of faces using deformable templates. In deformable templates the feature of interest, an eye for example, is described by a Parameterized template. These parameterized templates enable a priori knowledge about the expected shape of the features to guide the detection process [23]. An energy function is defined to links peaks, edges, and valleys in the image intensity with corresponding properties of the template. After that the template matching is done with the image, thereby deforming itself to find the best fit. For the descriptor purpose final parameter value is used. In the Template based first an eye template is used to detect the eye from image. Then a correlation is found out between the eye templates with various overlapping regions of the face image. Eye region have a maximum correlation with the template[28].

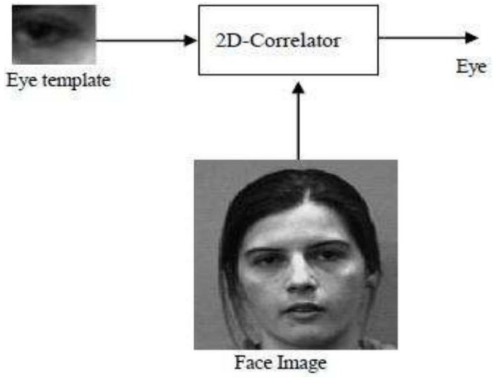

Figure 3: An example of Template based face recognition

(C) Appearance Based Approach:

This approach process the image as two dimensional patterns. The concept of "feature" in this approach is different from simple facial features such as eyes and mouth. Any extracted characteristic from the image is referred to a feature. This method group found best performer in facial feature extraction because it keep the important information of image and reject the redundant information. Method such as principal component analysis (PCA) and independent component analysis are used to extract the feature vector. The main purpose of PCA is to reduce the large dimensionality of observed variable to the smaller intrinsic dimensionality of independent variable without losing much information [25]. It has been observed that many natural signals, including speech, natural images, are better described as linear combinations of sources with super-Gaussian distributions. In that case, ICA method better than PCA method because: I) ICA provides a better probabilistic model of the data. II) It uniquely identifies the mixing matrix. III) It finds an unnecessary orthogonal basic which may reconstruct the data better than PCA in the presence of noise such as variations lighting and expressions of face. IV) It is sensitive to high order

statistics in the data, not just the covariance matrix [26] [28].

(D) Color Based Method:

With the help of different color models like RGB skin region is detected [29] [30]. The image obtained after applying skin color statistics is subjected to binarization. Firstly it is transformed to gray-scale image and then to a binary image by applying suitable threshold. All this is done to eliminate the color and saturation values and consider only the luminance part. After this luminance part is transformed to binary image with some threshold because the features for face are darker than the background colors. After thresholding noise is removed by applying some opening and closing operation. Then eyes, ears, nose facial features can be extracted from the binary image by considering the threshold for areas which are darker in the mouth than a given threshold. After getting the triangle, it is easy to get the coordinates of the four corner points that form the potential facial region[27][28].

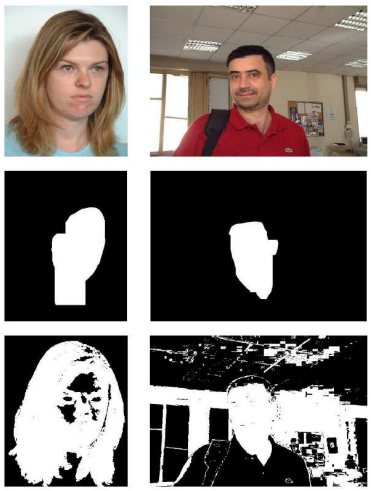

Figure 4: original image with different skin maps

After studying all the techniques of feature extractions, we can now conclude the features, characterstics, advantages and disadvantages of the above described techniques. And their comparison can be concluded as:

Table 1: comparison between various feature extraction techniques

Author	Technique	Methods	No. of feature	Advantages	Disadvantages
T.Kanade, 1997	Geometry-based	Gabor wavelet method	Eyes, mouth and nose	Small data base, recognition rate 95%	Large no. of features are used
A Yuille, D. Cohen, and P. Halllim an, 1989	Template based	Deformable template	Eyes, mouth, nose and eyebrow	Recognition rate 100%, simple manner	complexity description b/w template and images has long time
C Chang, T.S. Huang and C. Novak, 1994	Color-based	Color based feature extraction	Eyes and mouth	Small database with simple manner	Performance is limited due to diversity of backgrounds.
Y. Tian, T. Kanade, and J.F. Cohn, 2002	Appearance based approaches	PCA, ICA, LDA	Eyes and mouth	Small no. of features recognition rate 98%	-need good quality image -large database require

4. CONCLUSION

This paper discussed various face detection and feature extraction techniques in face recognition. Both are the integral and important part of face recognition because face classification is totally dependent on these two. Template based methods are easy to implement but not represent global face structure. While color segmentation based methods used color model for skin detection with morphology operation to detect features. So different color model and illumination variation these factors can affect performance. Appearance based methods represent optimal feature points which can represent global face structure. Geometry based methods such as Gabor wavelet transform face feature extraction provide stable and scale invariant features.

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