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Research Article

Face Detection Techniques- A Review

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Abstract

This paper gives the idea about challenging problem in the field of image analysis and as such it has achieve a great attention over the last few years because of its many applications in various domains. Face detection techniques can be mainly divided into three categories based on the face data acquisition methodology ie. the methods that operate on intensity of images. In this paper, an overview of some of the well-known methods in each of these categories is provided and some of the benefits and drawbacks of the techniques are included. Furthermore, a discussion outlining the incentive for using face detection and attempt to give an idea of the state of the art of face detection technology.

Keywords*: Person Identification, Biometrics, PCA, SPCA, Eigen face.*

1. Introduction

Over a last decade face detection has become increasingly important in the direction of content based video processing, pattern recognition, surveillance, computer vision, fraud detection, psychology, neural network etc.

In recent years, face detection has achieved substantial attention from both research areas and the market but still remained very challenging in real time applications. A lot of face detection algorithms along with their modifications have been developed during the past decades. A number of typical algorithms are presented being categorized into appearance based and model-based schemes etc.

On the other hand, with exception of extreme expressions such as scream, the algorithms are relatively robust to facial expression. Another important factor is the time delay, because the face changes over time in a nonlinear way over long periods.

2. Background Concepts

2.1 *Why Use the Face For Detection?*

Biometric-based techniques have emerged as the most promising option for recognizing individuals in recent years since, instead of authenticating people and granting them access to physical and virtual domains based on passwords, PINs, smart cards, plastic cards, tokens, keys and therefore these methods examine an individual's physiological and behavioral characteristics in order to determine and ascertain his identity.

Passwords and PINs are hard to remember and can be stolen or guessed. Cards, tokens, keys and the like can be misplaced, forgotten, purloined or duplicated. Magnetic cards can become corrupted and unreadable.

However, an individual's biological traits cannot be misplaced, forgotten, stolen or forged. Biometric-based technologies include identification based on physiological characteristics (such as face, finger prints, finger geometry, hand geometry, hand veins, palm, iris, retina, ear and voice) and behavioral traits (such as gait, signature and keystroke dynamics). Face detection appears to offer several advantages over other biometric methods, a few of which are outlined here.

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

Signatures can be modified or forged. However, facial images can be easily obtained with a couple of inexpensive fixed cameras. Good face recognition algorithms and appropriate preprocessing of the images

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can compensate for noise and slight variations in orientation, scale and illumination. Finally, technologies that require multiple individuals to use the same equipment to capture their biological characteristics potentially expose the user to the transmission of germs and impurities from other users.

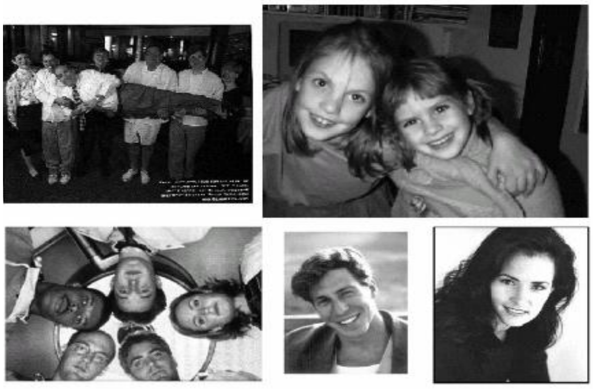

Fig 1: Detection of no. of faces in different orientation.

2.2 *Importance of Face Detection*

A step towards automatic target recognition.
First step in many surveillance systems.
First step for any fully automatic face recognition system.
Face is a highly non rigid object and has lots of applications.

2.3 *Why Face Detection is Difficult?*

Pose (Out-Of Plane Rotation):
Frontal, 45 degree, profile, upside down
Presence or Absence of Structural Components:
Beards, mustaches and glasses.
Facial Expression:
Face appearance is directly affected by a person's facial expression
Occlusion of Faces:
Faces may be partially occluded by other objects.

Fig 2: Recognition of no. of faces in various angles

Fig 3: Detection of faces in different ways

3. Methodology

3.1 *Methods to Detect Faces*
Template Matching Methods
Several standard patterns stored to describe the face as a whole or the facial features separately.
Appearance Based Method
The models (or templates) are learned from a set of training image.
Imaging Conditions
Lighting (spectra, source distribution and intensity) and camera characteristics (sensor response, gain control)
Knowledge Based Methods
Encode human knowledge of what constitutes a typical face.
Feature Invariant Approaches
Aim to find structural features of a face that exist even when aim the pose, viewpoint or lighting condition.
Orientation (In Plane Rotation)
Face appearance directly vary for different rotations about the camera's optical axis.

3.2 *Direct Correlation Method*

The direct correlation method of face recognition matching by Brunelli and Poggio consists of the direct comparison of pixel intensity values taken from facial images. Now, we convert bitmap images of 65 by 82 pixels into a vector of 5330 elements and describing a point within a 5330 dimensional image space.

Again, by measuring the distance between these points, we got the indication of image resemblances. Similar images are placed close together within the image space while dissimilar images are placed at a long distance. Extending this idea to faces, calculating the Euclidean distance *d* between two facial image vectors (often referred to as the query image *q*, and gallery image *g*) we get an indication of similarity. A threshold is then applied to make the final verification decision.

3.3 Vector Representation of Images

Image data can be represented as vectors i.e. as points in a high dimensional vector space. For example: a p * q 2D image can be mapped to a vector by lexicographic ordering of the pixel elements (such as by concatenating each row or column of the image). Instead of this high-dimensional embedding, the natural constraints of the imaging process dictate that the data will in fact lie in a lower-dimensional (though possibly disjoint) manifold. The primary goal of the subspace analysis is to identify, represent, and parameterize this manifold in accordance with some optimality criteria.

Let, $X = (x_1, x_2 \ldots\ldots x_N)$ represent the $n{*}N$ data matrix, where each xi is a face vector of dimension n, concatenated from a $p * q$ face image, where $n = p * q$.

Here, n represents the total number of pixels in the face image and N is the number of different face images in training set. The mean vector of the training images $\mu = \sum_{i=1}^{N} x_i$ is subtracted from each image vector.

3.4 The Eigen Face Method

While analyzing the terms of mathematics, eigen faces are the principal components of the distribution of faces, or the eigenvectors of the covariance matrix of the set of face images. PCA finds the eigen-vectors, called Eigen Faces of the covariance matrix corresponding to the generic training images.

The eigen vectors are ordered to represent different amounts of the variation respectively, among the faces. Each face can be represented exactly by a linear combination of the eigen faces. It can also be approximated using only the best eigenvectors with the largest eigen values. The best M eigen faces construct an M dimensional space called face space. L. Sirovich and M. Kirby used principal component analysis to efficiently represent pictures of faces. They argued that any face images could be approximately reconstructed by a small collection of weights for each face and a standard face picture (eigen picture)

Distribution-Based Method [Sung & Poggio 94]
Masking

Reduce the unwanted background noise in a face pattern

Illumination Gradient Correction

To find the best fit brightness plane and then subtracted from it to reduce heavy shadows caused by extreme lighting angles. Histogram equalization: compensates the imaging effects due to changes in illumination and different camera input gains.

3.5 PCA

PCA has been widely used in face detection and is considered as one of the most successful algorithm. It reduces the dimension effectively without losing the primary information. In the traditional PCA the differences between individuals. This paper employed a new feature projection approach based on Advanced PCA method, doing the optimum transformation for the differences between the classes. The occluded part of the face and detects the occluded regions in the input image by means of an auto-associative neural network. At first the network is trained on the non-occluded images in normal conditions while during the testing the original face can be reconstructed by replacing occluded regions with the recalled pixels. The training data set consisted of ninety three 18 × 25, 8-bits images while the trained network has been tested using three types of test data: pixel-wise, rectangular, and sunglass. In the results the authors claim that the classification performance is not decreased even if 20– 30% of the face images is occluded.

On the other hand, this method suffers from two of the main problems of the NN based approaches: the system retraining in case of new enrolments and the little availability of training samples. Moreover, a method which is able to deal with both occlusions and illumination changes. They presented a complete scheme for face recognition based on salient feature extraction.

3.6 SPCA

In the Advance PCA method, detection has been done by comparing the testing image with the reconstructed images with the projection of the test image in the feature spaces of all persons. It is time consuming to reconstruct the images with projection of testing image in the feature space.

In SPCA, this reconstruction has been eliminated and detection is done by finding the distance measure with the weights obtained by the projection of testing image and the training images. First seven steps are same as per APCA. Next step is to calculate the Euclidean distance between the weights of test image and the weights of each training image. Find the smallest distance and the corresponding class of weight. It will be the recognized class of the image.

3.7 *Advance PCA*

The traditional PCA method doesn’t consider the difference between the classes and in the training process of computing the eigen space in which all training images are involved. If the training image number is very high or the dimension of the images is high then the intermediate process of computing eigenvector is very complex. In traditional PCA if we want to add new training image, the whole eigen space, eigen values, the feature vectors of the all the images must be calculated again & it is time consuming work.

In an Advanced PCA, the new training and projection method has been employed to reduce the training time. In Advanced PCA, all the training images has been classified to different person classes, then train the images of each person individually and calculated the eigen subspace, feature parameters respectively. Finally, project the testing image to the eigen subspace of each person and choose the most similar person as the result of recognition.

3.8 The Occlusion

One of the main drawbacks of the appearance based paradigm (e.g. PCA) is its failure to robustly recognize partially occluded objects. One way to deal with partially occluded objects such as faces) is by using local approaches. In general, these techniques divide the face into different parts and then use a voting space to find the best match. However, a voting technique can easily misclassify a test image because it does not take into account how good a local match is. In order to cope with this problem each face image is divided into k different local parts. Each of these k local parts is modeled by using a Gaussian distribution (or equivalently, with a mixture of Gaussians) which accounts for the localization error problem.

3.9 Changes in Illumination

Lot of changes greatly within and between days and among indoor and outdoor environments. Due to the 3D structure of the face, a direct lighting source can cast strong shadows that vanish certain facial features. It has been shown experimentally and theoretically for systems based on Principal Component Analysis that differences in appearance induced by illumination are larger than differences between individuals. Now, dealing with illumination variation is central topics in compute vision numerous approaches for Illumination invariant face detection have been proposed.

The way in which changes in illumination can affect performances of some face detection methods. They define three different classes in order to grade the methods: the shape from shading approaches which formation of the face, from one or more of its views, their presentation based methods which try to get a characterization of the face invariant to illumination changes and the generative methods, which produce a wide set of synthetic images containing as variations as possible.

Positive Examples:

Get as much variation as possible.

Manually crop and normalize each face image into a standard size (e.g.19×19 pixels).

Creating virtual examples

Negative Examples:

Any images that do not contain faces.

A large image subspace.

Boot strapping.

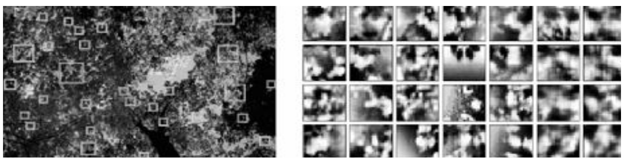

Fig 4: Positive and negative examples

4. Results

It can have multiple detections of a faces.

At different scale.

At a slightly displaced window location.

Able to detect upright frontal faces.

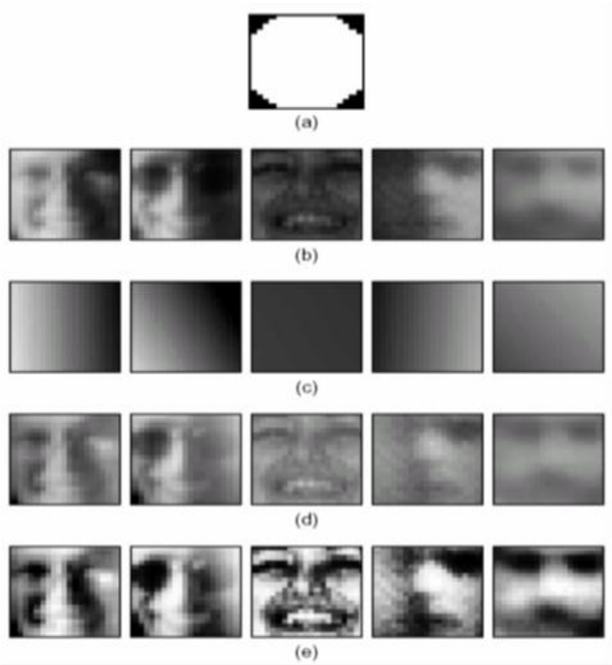

Fig 5: Analysis of different faces

Fig 6: Experimental results of different faces

Conclusion

Face detection is a challenging problem in the field of image processing and computer vision that has received a great deal of attention over the last few years because of its many applications in various domains. Research has been conducted vigorously in this area for the past four decades or so, and though huge progress has been made us encouraging results have been obtained and current face detection systems have reached a certain degree of maturity when operating under constrained conditions.

However, they are far from achieving the ideal of being able to perform adequately in all the various situations that are commonly encountered by applications utilizing these techniques in practical life.

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