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Face and Facial Expression Detection Using Viola-Jones and PCA Algorithm

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Abstract

Facial expression is a prominent posture beneath the skin of the face. They are the way of communication in humans which convey many things non- verbally. During the past years face recognition has received significant attention as one of the most important applications of image understanding and analysis. Many algorithms have been implemented on different static and non-static conditions .Static conditions include static and uniform background, identical poses, similar illumination, neutral frontal face .Non static conditions include position, partial occlusion orientation; varying lightening conditions and facial hair which make recognition process a complex problem. All these factors influence face recognition process. The main stages for face recognition include face detection, feature representation and classifications. Researchers have described distinct approaches for face recognition. In this work we present a glimpse of face detection techniques, methods used their performance & their limitations and proposed a new technique for Face Detection based on Viola and Jones algorithm and principal component analysis. At the end we have shown simulation results for the proposed technique and establishedthat proposed technique is performing better than the existing one. The proposed system is implemented in MATLAB version 7.1.4.0.739 (R2012a).

INTRODUCTION

Object detection is detecting a specified object class such as cars, faces, number plate ext. in a given image or a video sequence. Object detection has many applications in computer based vision such as object tracking, object recognition, and scene surveillance.

Face detection has been regarded as the most complex and challenging problem in the field of computer vision, due to the large intra-class variations caused by the changes in facial appearance, lighting, and expression. Such variations result in the face distribution to be highly nonlinear and complex in any space which is linear to the original image space. Moreover, in the applications of real life surveillance and biometric, the camera limitations and pose variations make the distribution of human faces in feature space more dispersed and complicated than that of frontal faces. It further complicates the problem of robust face detection.

Face detection techniques have been researched for years and much progress has been proposed in literature. Most of the face detection methods focus on detecting frontal faces with good lighting conditions. According to Yang's survey, these methods can be categorized into four types: knowledge-based, feature invariant, template matching and appearance-based.

In recent decade, facial expression recognition has become a progressive area of research. There are many applications and algorithms that use facial expressions to evaluate human nature, feelings, judgment, opinion .These expressions are produced as a result of distortions of facial features due to the contraction of facial muscles. Facial expression recognition is not an easy task because of circumstances like illumination, facial occlusions, face color, face shape etc..

Face detection systems have many problems pertaining to pose, light, facial expression and quality of picture. It can be solved by applying some sort of image

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preprocessing before they are applied for further analysis purpose.

The facial expression detection system is divided into fourmajor steps:

1. Face detection
2. Normalization
3. Feature extraction
4. Classification

Face detection & normalization phase detects the face and lighting effects are reduced to some extent. The next step is feature extraction which extracts the features & irrelevant features are eliminated in feature selection process. Final step is classification where the facial expressions are classified in to four basic emotions shown in Fig. 1. Generally, there are two techniques in the facial expression recognition process the first technique is based on facial feature & the other considers the holistic view of the recognition problem.

A.Feature based approach:

In this approach the local features (like nose, eyes) of the face are found. Then these features are segmented & then they are used as the input data for structural classifier. The techniques like dynamic link architecture, pure geometry & hidden Markov model (HMM) are classified under this category.

Images with different expressions

Fig.1. Examples of four basic emotions (neutral, happiness, sadness and surprise) uses includes tracking facial features, detection of activation of facial muscles (Facial Action Units).

B. Holistic approach:

In this approach the statistical methods are used to extracts the statistical characterization from the entire training sample images. There are techniques like eigen faces, probabilistic eigen faces, fisher face, support vector machines(SVM), nearest feature lines (NFL) and independent-component analysis which use holistic approach for facial expression detection.

C. Hybrid approach:

Hybrid approach is a combination of above two mentioned approaches. The idea of this method comes from how human vision system perceives both local features and whole face. The methods like modular eigenface, hybrid local feature, shape normalized, and component based methods are used in hybrid approach.

PRE-PROCESSING TECHNIQUES:

Image pre-processing techniques takes the form of signal conditioning (such as noise removal, variation of pixel position) together with segmentation, location and is used for detection and tracking of a face or its parts. Steps involved in pre- processing of an image are as briefed in this section.

VIOLAJONES ALGORITHM:

STEPS:

A.Read Image:

In this phase a method that can extract the shape of the eyes, nose, mouth and chin, is used and it helps to distinguish the face by distance and scale of those organs.

Fig.2. Image to be read

B.Detect Image:

The main concern of face detection is to identify all image regions which contain a face regardless of its

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direction, background & lighting conditions. Such task is tricky since faces can have a vast assortment in terms of shape, color, size or texture. Image detection phase does this.

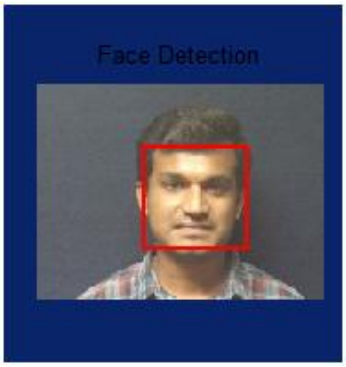

Fig.3.1. Face Detection

Fig.3.2. Eyes detection

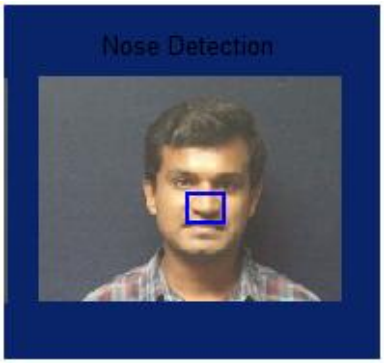

Fig.3.3.Nose detection

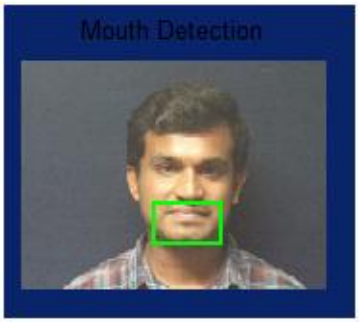

Fig.3.4 Mouth detection

C.Identify Facial Feature Points:

Feature points of an image like eyes, chin, eyebrows, lips, nose, etc. are identified and marked during this phase.

D.Color Space Transformation and Lighting Compensation:

In this phase skin-color detection is used as an intermediate step of face detection.

E.High Frequency Noisy Removing:

Noise from the image is removed in this stage using noise removal algorithms

Fig.. Noise Removal from the Image

F.Edge Detection and Size Reduction:

Image edges are detected and marked in this stage. End points of features, chooses the dimensionality reducing linear projection that maximize the scatter of all projected samples.

Fig.. Edge Detection and Size Reduction

PCA (PRINCIPAL COMPONENT ANALYSIS): FACE RECOGNITION:

Principal Components Analysis (PCA) is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analyzing data. If there are a lot of images that are close to each other in the PCA space, it means that the images quite resemble but differ

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slightly from each other. The directions of these variations is important because it „says" something about in what the images differ. A „cloud" of these images could therefore be spanned by the directions of the variations, which are called the Principal Components. To characterize the trends exhibited by this data, PCA extracts directions where the cloud is more extended. For instance, if the cloud is shaped like a football, the main direction of the data would be a midline or axis along the length of the football. This is called the first component, or the principal component.

PCA will then look for the next direction, orthogonal to the first one, reducing the multidimensional cloud into a two-dimensional space. Using PCA we find a subset of principal directions (principal components) in a set of training faces. Then we project faces into this principal components space and get feature vectors. Comparison is performed by calculating the distance between these vectors. Usually comparison of face images is performed by calculating the Euclidean distance between these feature vectors. Sometimes the angle-based distance is used. The steps involved in performing PCA on a set of data are:-

1. Get some data
2. Subtract the mean
3. Calculating the covariance matrix
4. Calculate the eigenvectors and Eigen values of the covariance matrix Choosing components and formatting a feature vector
5. Deriving the new data set
6. Getting the old data back

PCA is a technique based on the concept of Eigen faces and was first introduced by Kirby and Sirivich in 1988. PCA also known as KarhunenLoeve projection). It is one of the more successful techniques of face recognition and easy to understand and describe using mathematics. This method involves using Eigen faces. Eigen faces have been used to track human faces. They use a principal component analysis approach to store a set of known patterns in a compact subspace representation of the image space, where the Eigen vectors of the training image set span the subspace. In this method, the input image and images of the eigen face gallery should be the same size and we have to normalize the input image so that the eyes, nose and mouth are properly lined up i.e. we only consider the face region and that should be a frontal face. In case of a non-frontal face it may result poor performance.

Eigen faces:

In information theory concept, if we want to extract some information from a face image, we first encode it and then compare it with some other encoded face image on a database. A simple way to extract the information from a face image is to capture the variation in a collection of face images and use this information to encode and compare individual face images. Mathematically, we wish to find the principal components of distribution of faces or the eigenvectors of the covariance matrix of a set of face images. These eigenvectors are a set of features, which together characterize the variation between face images. Each image location contributes more or less to each eigenvectors, so that we can display the eigenvectors as a sort of ghostly face, which we call an eigenfeces. In the training set, each face image is represented by a linear combination of the eigenfaces. Hence the number of possible Eigen faces is same as the number of face images.

A facial recognition system is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. One of the ways to do this is by comparing selected facial features from the image and a facial database. It is typically used in security systems and can be compared to other biometrics such as fingerprint or eye iris recognition systems. Among the different biometric techniques, facial recognition may not be the most reliable and efficient. However, one key advantage is that it does not require aid (or consent) from the test subject. Properly designed systems installed in airports, multiplexes, and other public places can identify individuals among the crowd.

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EXPRESSION ANALYSIS:

Expression categorization is performed by a classifier, which often consists of models of pattern distribution, coupled to a decision procedure. A wide range of classifiers, covering parametric as well as nonparametric techniques, has been applied to the automatic expression recognition problem. The two main types of classes used in facial expression recognition are action units (AUs), and the prototypic facial expressions defined by Ekman.

PROPOSED ALGORITHM:

In this work, face expression method proposed uses Viola and Jones algorithm and principal component analysis that tries to match an image with respect to expression of the face. Proposed method considers an image to be resized to N x N (Original image I having N value of pixel). The image considered is then changed into grayscale with two dimensions for 2-D image. Steps taken in extracting the image expressions are as briefed in the section below.

1. Detect feature points of face with the help of equation 1.

$$I(x) = \sum_{i=0}^{i \le x} \sum_{j=0}^{j \le y} I(x, y) \quad (1)$$

2. Find edges of image using equation 2:

$$V + F - E = 2 \quad (2)$$

Where V denote the number of vertices, F denote the number of faces and E denote the number of edges 3. Mapping of image from the values in I to new value in J is done using equation 3. The value s are mapped in to values between low_in and high_in map to value between low out and high_out for lighting compensation.

J=imadjust(I,[low_in;high_in],[low_out; high_out]) (3)

4. After the the Skin segmentation (using the RGBYCbCr model) of the image is done.

5. After this Principal Component Analysis of the image is performed using equation 4:

$$[C, S, L] = \text{princomp}(I) \quad (4)$$

Where C is p-by-p matrix, each column containing coefficients for one principal component S is Representation of X is principal comp. Space rows of score correspond to observation, columns to components L is Eigen values of the covariance matrix of I. It is the variance of Score

6. Then eigen values and eigen vectors of image are found using this equation 5:

$$(A - \lambda I)Kv = 0 \quad (5)$$

7. Mean values of the imaged used for training is calculated.

8. Euclidean Distance from neutral in an image is measured using equation 6:

$$Euclidean\ Distance(x, y) = \sqrt{(x1 - y1)^2 + (x2 - y2)^2 + \cdots .. (xn - yn)^2} \quad (6)$$

9. Calculation of accuracy rate id then done on the basis of Euclidean distance and mean error using equation 7:

$$acc = \left((Dist_{frm_{Neutral}} - error) * Dist_{frm_{Neutral}} \right) * 100 \quad (7)$$

10. Emotions of the test images are then detected and the results are stored in Results.text file.

RESULTS:

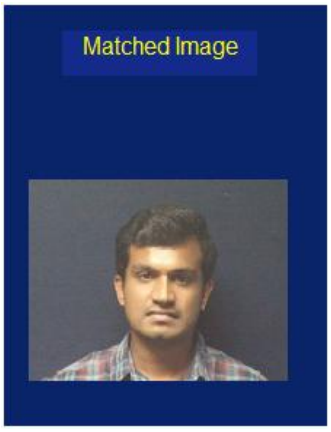

Fig: Detected Image

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CONCLUSION:

In this paper we discussed Face Detection Technique based on Viola and Jones algorithm and principal component analysis with the help of this technique, we can recognize an accurate and high speed emotion detection system.

The techniques used in this work detect human facial expressions and recognize them on the basis of accuracy and computational time. Some of them contain drawbacks in term of detection rate, accuracy or timings. The most optimum detection rate can be obtained through combination of given techniques, extract the features from the images as per ones need and final comparison can be done to find out the results. The success of implementation depends on pre-processing stage on the images because of illumination and feature extraction.

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