ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

Volume 3, Special Issue 3, March 2014

2014 International Conference on Innovations in Engineering and Technology (ICIET'14)

On 21st & 22nd March Organized by

K.L.N. College of Engineering, Madurai, Tamil Nadu, India

Face Detection on Real Life Images and Video Frames Based On Linear Discriminant Analysis

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ABSTRACT- Face detection system has already become an important issue and several techniques have been developed. It remains as one of the challenging problem in the field of image analysis and computer vision. It also presents a detailed idea about the face detection techniques which improves the rate of detection. Initially the image extracted from video frames, still images and database is to be preprocessed for the normalization of contrast and brightness by using Histogram equalization. Then extract the facial features like eyes, nose and mouth from the facial image using the Linear Discriminant Analysis. Based on the facial feature extracted, the face is detected from the image. Linear Discriminant Analysis mainly performs dimensionality reduction. It also provides us with a small set of features that carry the most relevant information for classification purposes. Linear Discriminant groups the images of the same class and separate images of different classes. LDA performs even well for low resolution images and also some images containing illumination variation and out of plane rotation of faces. Its application is mainly for face recognition and gender classification.

KEY WORDS- *P*reprocessing, feature extraction, Linear Discriminant Analysis, face detection, gender classification

I. INTRODUCTION

In the recent years, Face detection has become a popular area of research in computer vision and one of the most successful applications of image analysis. Face detection is concerned with finding whether or not there are any faces in a given image and, if present, return the image location and content of each face. The main motivation behind this approach is to come out with the best face detection approach that satisfies the need for real-time hardware implementation and also for gender classification. The face detection problem is challenging as it needs to account for all possible appearance variation caused by change in illumination, facial features, occlusions, etc. In addition, it has to detect faces that appear at different scale, with in-plane rotation and also for out of plane rotation. In spite of all these difficulties, tremendous progress has been made in the last decade and many systems have shown impressive real-time performance. As face detection is the first step of any face processing system, it finds numerous applications in face recognition, face tracking, facial expression recognition, facial feature extraction, gender classification, clustering, attentive user interfaces, digital cosmetics, biometric systems, Human Computer Interaction system, demographic classification and surveillance system.

Linear Discriminant analysis explicitly attempts to model the difference between the classes of data. LDA is a powerful face recognition technique that overcomes the limitation of Principle component analysis technique by applying the Linear Discriminant criterion. This criterion tries to maximize the ratio of the determinant of the between-class scatter matrix of the projected samples to the determinant of the within class scatter matrix of the projected samples. Linear Discriminant group images of the same class and separates images of different classes of the images. The LDA encodes discriminatory information in a linear separable space of which bases are not necessarily orthogonal.

This paper is organized as follows. In Section 2, related work is presented. In Section 3, the proposed system that models the steps which was involved in face detection is described. In Section 4, the experimental results and its analysis is presented. In Section 5, conclusions are drawn.

II. RELATED WORK

There are several algorithms used to detect the facial images from still images, databases and video frames. Some of the related works used for feature extraction are Principle Component Analysis, Multi-linear Principle Component Analysis, Independent Component Analysis, Neural Networks, Dynamic Link Architecture or Graph Matching and Viola Jones Method. A number of recent works studied for face detection and feature extraction based on appearance based approaches.

Juan Bekios-Calfa, Jose´ M. Buenaposada, and Luis Baumela.[1] proposed, using PCA and LDA for feature extraction. The algorithm is mainly for dimensionality reduction. Yan-Wen Wu, Xue- Yi Ai.[2] proposed a face detection technique in color images using adaboost algorithm. M.A. Vicente, P.O. Hoyer, and A. Hyva¨rinen,[4] used the appearance based linear feature extraction techniques. J. Yang and J.-y. Yang,[12] suggested that LDA is better than PCA for dimensionality reduction.

Yunfei Jiang and Ping Guo,[5] compared the various feature extraction techniques for face detection as well as feature extraction. M. Zhu and A.M. Martı´nez,[6] used the Principal Component Analysis for selecting the most discriminative principal component which is used for dimensionality reduction in LDA. P. Zhang, J. Peng, and N. Riedel,[7] briefly proposed the Discriminant analysis to overcome the small sample size problem.

A general statement of problem can be formulated as that given still or video image, identify one or more persons in the scene using stored database of faces and display their information. Some of the difficulties are faced during face detection. They are recognition of faces from an uncontrolled environment, lightning condition may vary tremendously, facial expressions also vary from time to time appear at different orientations, face can be partially occluded and also some aging effects

III. PROPOSED SYSTEM

The proposed method presents a Linear Discriminant Analysis. This method can be used for face detection and also for facial recognition. It is based on appearance based approach or holistic based approach. It works on the whole face region as the raw input to the recognition system. It doesn't consider individual features like eye, nose, mouth etc but works on the whole face for comparing similarity.

LDA is face recognition method proposed by Etemad and Chellapa. Fisherfaces are generated by Linear Discriminant Analysis which attempts to maximize the scatter of the training images in face space. It attempts to maximize the between-class scatter, while minimizing the within-class scatter. In other-words, moves images of the same face closer together, while moving images of different faces further apart. LDA is widely used to find linear combinations of features while preserving class separability. Since it achieves higher accuracies and also reduces the error rate.

Some of the goals of Linear Discriminant Analysis are given here. It performs dimensionality reduction while preserving as much of the class discriminatory information as possible. It seeks to find directions along which the classes are best separated. It takes into consideration the scatter within-classes but also the scatter between-classes.

A. Proposed system architecture

The various steps involved in face detection is depicted in fig 1. This algorithm can detect faces in uncontrolled environment like illumination, pose variation, different orientation, occlusion and also some ageing effects. Initially the image from database, video frames or still images is to be pre-processed for contrast and normalization. After pre-processing, the feature vectors are extracted from facial images using Linear Discriminant Analysis. These features are used to detect faces from the given images. The feature extraction technique is broadly classified into 2 types.

They are appearance based and geometry based technique. Here LDA comes under appearance based technique. They extract the whole face image. The features may be eyes, nose, and mouth and so on. They project original face space to fisherfaces and generate a feature vector. These feature vectors provides a projection matrix and reduces the redundant information. From the extracted feature vector, the face region can be detected.

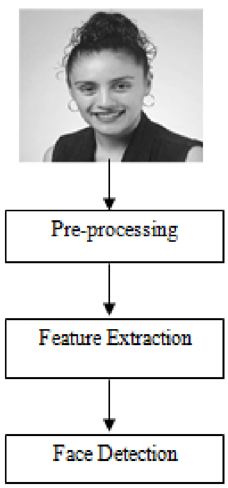

Fig 1. Steps involved in face detection

B. Pre-processing

Preprocessing the images commonly involves removes the low frequency background noise, normalizing the intensity of individual particle images, removing reflections and masking portions of images. Here for pre-processing the image, the histogram equalization technique is chosen.

Histogram equalization tries to equal brightness levels over the whole brightness scale. For an N x M image with G gray-levels, create an array H with a length G initialized with zeroes. Then calculate the histogram of gray levels for the image. Take each pixel and increment the element of H that corresponds to intensity level of the pixel. If the intensity level is found, then form the cumulative level histogram. The cumulative histogram tells you how many pixels have the gray-levels less than or equal to the p_{th} graylevel.

C. Feature Extraction

In order to perceive and detect human faces, we must extract the prominent features on the faces. Usually those features like eyes, nose and mouth together with their geometry distribution and shape of face is applied. Human face is made up of eyes, nose, mouth and chin etc. They are differences in shape, size and structure of those organs. We can describe them with the shape and structure of the organs so as to recognize them.

One common method is to extract the shape of the eyes, nose, mouth and chin. Here appearance based approach uses whole face image for face detection. We should pick up the feature points which represent the most important characteristics on the face. The number of the feature points should take enough information and not be too many. This process can be done by dimensionality reduction which reduces the redundant and irrelevant information in facial parts.

This section briefly reviews the theory underlying the dominant appearance based feature extraction techniques, namely, linear Discriminant analysis. Linear Discriminant Analysis (LDA) is the powerful tool used for data reduction and feature extraction in the appearance based approaches.

D.Linear Discriminant Analysis

When using appearance-based methods, we usually represent an image with $n\times m$ pixels by a vector in a $n\times m$ dimensional space. In practice, this $n\times m$ dimensional space, however, is too large to allow robust and fast object detection and recognition algorithms. A common way to solve this problem is to use dimensionality reduction techniques. One of the most well known techniques is Linear Discriminant Analysis (LDA). It is also known as Fisher Discriminant Analysis (FDA). It is used to find projections that maximize the ratio of the between-class scatter against the within-class scatter.

It is a "classical" technique in pattern recognition, where it is used to find a linear combination of features which characterize or separate two or more classes of objects or events. LDA is used to determine the low-dimensional features from a high-dimensional space that helps to group images of the same class and separate images of different classes. This method selects features that maximize the ratio of the between-class scatter to the within-class scatter.

Given a set of N images $\{x_1,x_2,.,x_N\}$ with each image belonging to one of c classes $\{X_1,X_2,.,X_C\}$, LDA finds a linear transformation matrix W in such a way that the ratio of the between-class scatter and the within-class scatter is maximized. The between-class and within-class scatter matrices given in (1) and (2) and are defined by,

$$S_B = \sum_{i=1}^{c} N_i(\mu_i - \mu)(\mu_i - \mu)^T \quad (1)$$

and

$$S_W = \sum_{i=1}^{c} \sum_{x_k \in x_i} (x_k - \mu_i)(x_k - \mu_i)^T \quad (2)$$

respectively, where μ_i denotes the mean image of class X_i, μ is a global mean, and N_i denotes the number of images in class X_i. If the within-class scatter matrix S_W is not singular, LDA finds an orthonormal matrix W_{opt} maximizing the ratio of the determinant of the between-class scatter matrix to the determinant of the within-class scatter matrix as

$$W_{opt} = \arg\max \frac{|W^T S_B W|}{|W^T S_W W|} = [W_1\, W_2 \ldots\ldots W_m] \quad (3)$$

The set of bases of the solution $\{w_i|\ i=1,2,\ldots m\}$ is constituted by generalized eigenvectors of S_B and S_w corresponding to the m largest eigenvalues i.e. $S_B w_i = \lambda_i S_w W_i$, $i=1,2,\ldots m$. The features of an image *x* is then computed by projecting it onto the space spanned by the eigenvectors.

The Methodology in LDA is as follows

- Taking samples for class1 and class2
- Calculate the mean of class1 and class2
- Determine covariance matrix of the class1 and class2
- Calculate within-class scatter matrix using the equation (1)
- Calculate the between-class scatter matrix using the equation (2)
- Calculate the mean of all the classes
- Now compute the LDA projection i.e. $invS_W*S_B$
- The LDA projection is then obtained as the solution of generalized eigen value problem $W=eig(S_W^{-1} S_B)$

  Where W is the projection vector

A classical statistical approach for feature extraction and dimension reduction is easy to predict. The optimal transformation can be readily computed by applying an eigen-decomposition on the scatter matrices of the given training data set. However classical LDA requires the total scatter matrix to be nonsingular. In many applications such as information retrieval, face recognition, and microarray data analysis, all scatter matrices in question can be singular since the data points are from a very high-dimensional space and in general the sample size does not exceed this dimension.

D. Gender Classification

Human can easily differentiate between male and female, fast and accurate. But it is a challenging task for computer vision to determine the gender of a subject from facial images. Classification is the last step of gender classification in which the face is successfully classified as that of a male or female. For this purpose different types of classifiers are used. e.g., LDA, KNN, NN and SVM.

Face is a prominent feature for gender classification. To make the processing faster they have reduced the dimensions by detecting the face from image. LDA is used to reduce dimension and convert the face image into eigenvector. It contains different information about gender face. LDA acts as a classifier also.

IV. EXPERIMENTAL RESULTS

A. Database for face detection

The Database contains a 100 images of faces with variations in background (indoors, outdoors, complex, simple) facial structural components (beards, moustaches, and glasses), poses (frontal, near-frontal, profile), orientation (upright and upside down), facial expressions, imaging conditions (poor quality, good quality) occluded areas, age, gender, race and size. Experiments were carried out with varying size of the training dataset, intensity normalization, histogram equalization, scaling training and testing dataset.

The test was performed using 7 training images. The results are as followed in Table.1

Table 1.Face Detection Results using 7 training images

	numFace	Numhit	numRep	numFal	Run time(sec)
1.jpg	7	5	0	0	57
2.jpg	5	4	0	1	46
3.jpg	9	7	0	2	43
4.jpg	10	9	0	1	55
5.jpg	15	13	0	2	61
6.jpg	8	8	0	1	53
7.jpg	12	12	0	0	51

- numFace : total number of faces in the picture
- numHit : number of faces successfully detected
- numRep : number of faces repeatedly detected
- numFal : number of case where a non-face is reported
- run time : run time of the face detection routine

In the pre-processing step, image intensities are normalized. Histogram equalization is then performed on these images. The experimental result shows that the face detection on various real life images, still images, video frames and also database.

Further, these images may have quality variations and contain multiple faces with variations in color, position, scale, rotation, pose, and facial expression. They are used as sample face images which contain single and multiple face images. Some of the sample images in Rowley et al.'s are given below. Most images contain more than one face and the face size varies significantly.

These experiments are carried out to illustrate the face detection under non-uniform background. In order to obtain a fair empirical evaluation of face detection methods, it is important to use a standard and representative test set for experiments. Thus training set will provide the specific feature set during dimensionality reduction. This feature vector will play a major role in face detection. Some of the test images for face detection and the detected faces are shown in fig 2 and fig 3.

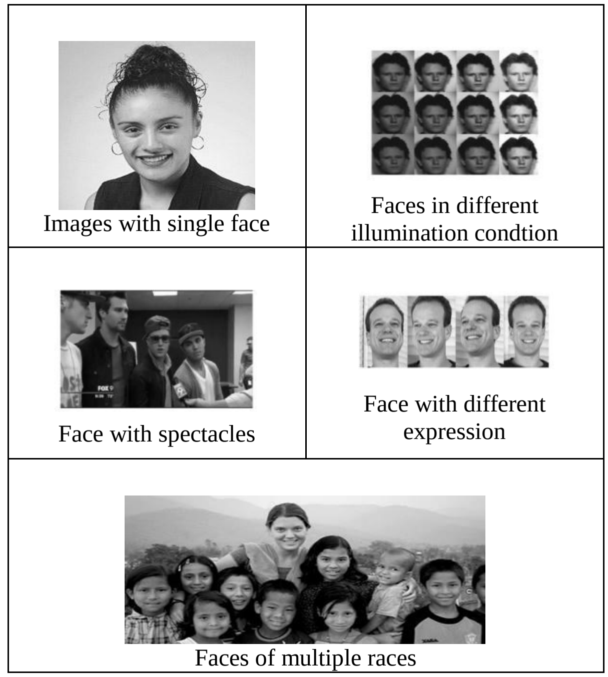

Fig 2. Test image for face detection

The Linear discriminant algorithm can detect up to 95% of faces from the set of databases, still images and video frames with an acceptable number of false positives. But 100 % face detection in image with single face is detected.

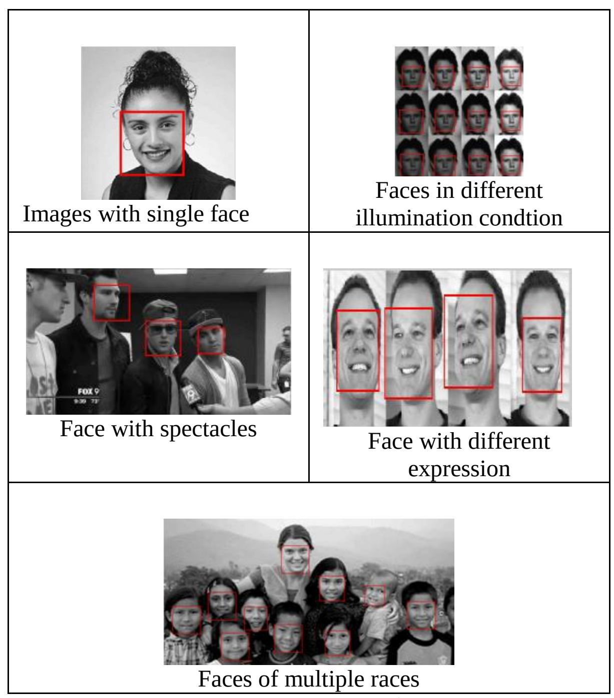

Fig 3. Test image with detected faces

The scope of the considered techniques in evaluation is also important. In this survey, we discuss at least four different forms of the face detection problem:

- Localization in which there is a single face and the goal is to provide a suitable estimate of position; scale to be used as input for face recognition.
- In a cluttered monochrome scene, detect all faces.
- In color images, detect (localize) all faces.
- In a video sequence, detect and localize all faces.

LDA performs well even for low resolution images and also some images containing illumination variation and out of plane rotation of faces. Nonlinearity and distortions introduced by image capture device can drastically reduce the accuracy of feature based techniques. Such errors have virtually no impact on the performance of holistic techniques (LDA). Hence, appropriate preprocessing should be performed. The system's accuracy can be improved by more sophisticated image processing and normalization techniques.

V. CONCLUSION

In this paper, the approach of face detection using face images extracted from still images, database and video frames to improve the classification rate with image processing and pattern recognition techniques. However, it can also be seen as a one of the few attempts at solving one of the grand challenges of computer vision, the recognition of object classes. The class of faces admits a great deal of shape, color, and variability due to differences in individuals, non-rigidity, facial hair, glasses, and makeup.

Images are formed under variable lighting and 3D pose and may have cluttered backgrounds. Hence, face detection research confronts the full range of challenges found in general purpose, object class recognition. However, the class of faces also has very apparent regularities that are exploited by many heuristic or model based methods or are readily "learned" in data driven methods. One expects some regularity when defining classes in general, but they may not be so apparent. Finally, though faces have tremendous within-class variability, face detection remains a two class recognition problem (face versus non-face).

Processing various real time images clearly prove that Linear Discriminant Analysis is faster but have low accuracy when comes from images in uncontrolled environment like occlusion. The future plan is to apply this technique for Gender Classification and also to improve the detection rate and robustness in images of uncontrolled environment.

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