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Modern Face Recognition Algorithm and Techniques: A Survey

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Abstract: Face recognition techniques has evolved as importance and interest research area. Face recognition is a specific pattern recognition technique in digital image analysis with the pattern of localizing face region from background. Face recognition has many applications in various fields such as intelligent human computer interfaces, video surveillance and so on. Several techniques have been proposed for face recognition with their advantage and limitations. This paper presents a survey of various modern face detection methods. Finally, in this survey, a novel method and technique are envisioned to overcome the limitations of previous face recognition techniques.

Keywords: Face Recognition, Pattern Recognition, Eigenfaces, Biometric Identification.

1 Introduction

Face recognition [1] system is basically a computer application which is developed for identification and verification of a person from database of computerized video source. The faces identified with the help of face features in a face recognition system. Face recognition with machine learning methods becomes a new research are because there is a need to develop such system which should be user friendly as well as capable to secure our possession and also give privacy without compromising the identity. The general face recognition working process is presented in Figure 1.

In order to develop a system which is able to control both the necessity face recognition play a great role, means it should establish system which is user friendly with providing great security. With the support of machine learning technique faces are recognized where the image size is very low resolution or it is not able to identify the person. There are several applications of face recognition system in various fields like in image processing and it also has application in the gaming. This technology also launched a game which uses face recognition method to recognize that it is a human face or vampires. Many recent games are in market based on this method with affordable cost. Many other applications of face recognition is creating mental notes with the help of smart phones and this facilitate in organizing face images as a reminder [2]. There are various application in distinguishing TV shows that recognize the TV shows we are watching. It also discover application in image search, solving sudoku puzzles, augmented reality, in security and also in protecting more about ourself in public [3][4].

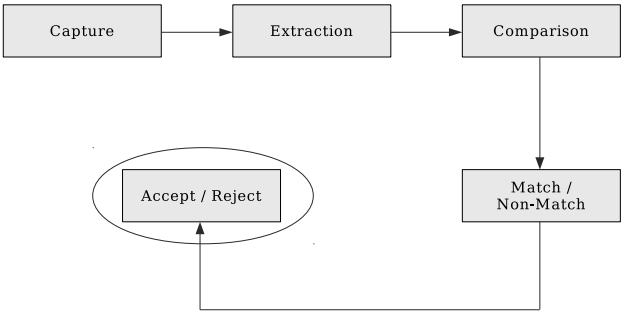

Figure 1: Face Recognition Working Steps

Generally there are two types of features which are used in face recognition system.

- **Global Feature:** The global feature identifies the whole image. This feature is usually not identically robust as a alteration in the image component may create it to break down as it will misrepresent the resulting form.
- **Local Feature:** The local feature identifies a patch within the image. Multiple local signifier and descriptor are employed to manage a image and this is more effective as not everything of the signifier and descriptors require to coordinate for the correlation to successful making. This develops it more robust.

There are two main reasons for the interest of research in face recognition.

1. It provides best scope in the application designing of video surveillance and security. Many of the fields in facial expression change with time, poses may be different, partial front position and low-resolution, now it is also embedded into an application on low determination images which can be developed by the natural settings and configuration. Still, face recognition based on low resolution image is still an critical subject in the research area.

2. Face recognition is also applied for application to prevent fake identification cards, voter fraud and biometric usages also find application in phones.

2 Face Recognition Tasks

Usually it involves three major problems in automatic face recognition task. Three key task of face recognition are:

1. Face detection with the rough normalization on face image.

2. Feature extraction with normalization.

3. Identification or verification the face.

It Sometimes becomes challenging task to categorize each subtask. For example, many features are common in face detection and recognition. The facial and some common features are structures like nose, eyes, mouth and extraction of all features can be possible simultaneously [5]. Other difficulties in face recognition or detection are the different size of database, noise, background effect and distinct speed of the model [6].

The steps in face recognition are:

1. Firstly detect the face.

2. After feature extraction, it is required to save into a classification model.

Features for face recognition can be global or local and this feature type depends on the model. Mainly two statistics are considered in detection problem: true positives (detection rate) and false positives (detections in non face regions). The true positive rate should be maximum for an ideal system and false positive rates should be minimum. Face recognition play a major role and it is a day-to-day procedure for humans, in building a computer system, it has great demand and a large future scope [7]. Face recognition may encounter many heavy challenges in terms of identical face expressions, factional occlusion, pose variations and even at low resolution, basically depend on environment condition and the biometric devices which is kept at a far distance. However low resolution face recognition has great research scope. Complexity increases when image size is small with low quality, which degrades the performance of face recognition [8].

3 Literature Survey

In this paper we surveyed and analyzed adaptive modern face recognition techniques.

3.1 Geometrical Feature Matching

Geometrical features matching method is based on the set of geometrical features mathematical computation of the face image [9]. The face recognition is possible even at low resolution as 8×6 pixels when an individual facial feature is hardly revealed in detail implies that the overall geometrical configuration of the facial features is sufficient for recognition. The overall shape configuration of the image can be identified by a vector position and size of the main facial features, such as nose, eyes and eyebrows, angle of jaw, mouth and face outline shape [10].

3.2 Support Vector Machine (SVM)

Many support vector machine (SVM) [11] based computer vision problem has been proposed. An SVM for face detection is required where the discrimination lies between two categories: face and non-face.

Support vector machine (SVM) is a learning technique which can be applied for general purpose pattern recognition because it has high generalization performance without other knowledge [12][13]. Initially, given a set of points belonging to two classes, a support vector machine (SVM) finds a hyper plane which divides the largest possible fraction of points at the same class on the same side, with increasing distance between class and its hyperplane. This hyperplane is known as Optimal Separating Hyperplane (OSH) [14] which reduces the risk of misclassifying not only examples in the database of training set but also the unobserved example of the test set.

3.3 Hidden Markov Models (HMMs)

The hidden markov model [15] is a probability and statistical based model which can be used in pattern recogni-

tion techniques. The stochastic modeling of non-stationary vector time series based on hidden markov model (HMM) has been very successful for speech recognition applications. Faces were intuitively divided into regions such as the eyes, nose, mouth, jaw etc., which can be associated with the states of a hidden Markov model. Since HMMs need a one-dimensional observation sequence and images are two-dimensional, so the images should be converted into either 1D temporal sequences or 1D spatial sequences [16][17].

3.4 Appearance-Based Face Recognition

Appearance-based face recognitions are classical pattern matching techniques and it can be categorized into linear analysis methods like Principal Component Analysis (PCA) [18], Linear Discriminant Analysis (LDA) [19], Independent Component Analysis (ICA) and nonlinear analysis methods, like Kernel Principal Component Analysis (KPCA). Traditional linear appearance-based methods are PCA, ICA and LDA, these methods have their own basis vector components of higher dimensional face image coordinates. With the help of these linear analysis techniques the face vectors are projected to the basis coordinates.

By projection of higher dimensional input image space into a lower dimensional space vector, the dimensions of the original input image space vectors can be minimized. The score of matching pattern lies between the test face image and training images which are estimated by computing the differences between their space vector projections. There are more similarity between those two face images if the score is higher.

3.4.1 Principal Component Analysis

Principal component analysis (PCA) [20] is for computing the vector spaces that generally describe their minimized area of image space. This is basically eigenvector and also called Karhunen-Love expansion [21], eigenpicture and principal component. The principle behind the principal component analysis is to compute the vectors that best describe the distribution of face images in the database of complete image space. This principle is represented by Figure 2.

Computation of PCA is usually accomplished by projecting new image into the vector subspace (face space) paired by eigen faces and classifying the face by comparing its coordinate location in face space with the positions of known individuals. The function of PCA is to compute a subspace where the deviation is maximized.

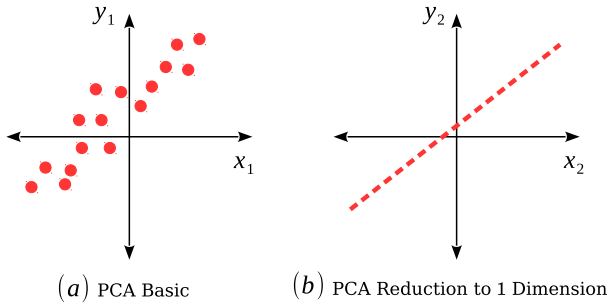

Figure 2: The Concept of PCA

3.4.2 Independent Component Analysis

For improving the performance of PCA, an additional discriminant analysis is needed because it extracts only the principal features which is not related to the adaptive face recognition. So,independent component analysis (ICA) [22] describes more effective data representation as compared to PCA as its target is to give an independent representation instead of non-correlated structure and image decomposition. ICA is basically a generalization form of PCA [23].

3.4.3 Linear Discriminant Analysis

Linear discriminant analysis (LDA) is process applied in machine learning and pattern recognition for computing a linear combination of features which classifies two or more classes of objects. Image similarities and projections are related together, various image projections place far away PCA is used, however, the projection of different class images are mixed together. LDA [19] is capable to enhance the ratio of between-class distribution to its within-class distribution [24]. LDA is also known as Fisher Discriminant Analysis (FDA).

3.4.4 Non-Linear Analysis

LDA techniques are not dedicated for the relationship among pixel vectors of the images. Various nonlinear relationship exist within a face image, particularly under the complex deviation in viewpoint, dissimilar illuminations and different face expressions those are mathematically nonlinear. Linear analysis models are enhanced into nonlinear analysis to extract non-linear features of images, such as Kernel PCA, Kernel ICA [25] and Kernel FLD. By using nonlinear analysis techniques the actual input images are projected nonlinearly into the higher dimensional feature image vector space. The distribution of image vector spaces in this higher dimensional vector space, can be modified into linear pattern.

3.5 Eigenfaces Method

Eigenfaces [26] was the name acknowledged to the set of eigenvectors as it is used in human face recognition. Eigenfaces method generally use dimensionality reduction technique. The correlation techniques are computationally costly and the huge amount of storage space is needed, so dimensionality reduction technique such as eigenfaces is needed. In this method, the eigen vector as a reduced dimension is extracted from the higher dimensional images vectors. In this method, the principal components are evaluated more easily [27].

Let T is a matrix of preprocessed training image sets, its each column of the image vector have one mean-subtracted image. A covariance vector is calculated as

$$S = TT^T \tag{1}$$

An eigenvector decomposition of S is given by

$$Sv_i = TT^T v_i = \lambda_i v_i \tag{2}$$

However TT^T is a huge vector, so the eigenvalue decomposition are taken of this equation:

$$T^T T u_i = \lambda_i u_i \tag{3}$$

By multiplying with T on both sides of the equation it becomes:

$$TT^T T u_i = \lambda_i T u_i \tag{4}$$

It demonstrates that, if u_i is an eigenvector of $T^T T$, then $v_i = Tu_i$ is an eigenvector of vector S. If a training image set of 500 images of 100×100 pixels, then the vector $T^T T$ is a 500×500 vector, those are manageable than the 10000×10000 covariance vector. The eigenfaces technique has advantage over traditional techniques, such as the processing speed and system efficiency. The system can represent several subjects points with a comparatively small set of data of images because eigenface is primarily a dimension reduction technique. As an adaptive face recognition method eigenface is invariant to the large reductions in image dimensions.

4 Problem Formulation

The pattern matching and face recognition techniques discussed in literature survey have some limitations. Several face recognition methods succeed and failed also at broadly various viewing points and illumination conditions. Generally one method which is extremely appropriate for some type of images but cannot be applied under other circumstance.

In another point of view, the face recognition methods required in adaptive and useful day-to-day recognition system which cannot be applied to one specific applicable recognition technique. It appears that various individual face recognition on different applications creates a problem due to this limitation. The overall limitations can be considered in different face recognition techniques as image quality, image size, angles of face structure, processing speed and time complexity of the algorithms. These limitations can not be totally removed, but can be reduced.

5 Proposed Methodology

Among various face recognition methods, there are some basic, fundamental and efficient face recognition methods which use similar concepts, basic dimensionality reduction method and mathematical calculations. The analysis introduces that various conditions of face recognition methods can be effectively combined to enhance the identification performance that can be achieved with a given image gallery. The analysis shows that for the given images the combination of three face classifiers is superior to two classifiers. Further researches, however, have to investigate whether this is a general behavior, and how much influence the quality of the images and the choice of the face classifiers have.

However, among fundamental methods and algorithms, some methods have advantages over other methods for face recognition, and by applying the soft computing techniques the recognition rate can be effectively improved. So the best solution approach for biometric pattern matching algorithms and face recognition methods will be the hybrid method of best combinations of soft computing techniques. The combination of best features of different methods or hybrid methods will represent improved face recognition.

6 Conclusion and Future Work

In this paper, we presented a comprehensive survey and theoretical analysis of various face recognition methods. This survey presents a general adaptive face recognition methods along with conditions affecting recognition system in various aspects as accuracy and performance. It is analyzed that to capture conditions such as pose variation, facial aging illumination conditions etc. different methods are used independently. Similarly, some integrated approaches are used to solve multiple face recognition factors in a single face recognition system. So for developing a universal facial recognition system which

can handle all face recognition factors, the hybrid approach will be the improved method.

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