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A Survey: Face Recognition Techniques

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Abstract: In this paper we present a widespread and significant survey of face detection algorithms. Face detection is a necessary first-step in face recognition systems, with the idea of localizing and extracting the face region from the background. It also has numerous applications in areas such as passport-verification, video conferencing, crowd surveillance, detective agencies and military purposes. This paper compares existing face recognition techniques along with their advantages and disadvantages. Methods such as Eigen face (Eigen features), support vector machines, geometric based and correlation based approaches are discussed here.

Keywords: Face, recognition, support Vector Machines.

1. INTRODUCTION

The current evolution of computer technologies has envisaged an advanced machinery world, where human life is enhanced by artificial intelligence. However, this trend has already prompted an active development in machine intelligence. Computer vision, for example, aims to duplicate human vision. . Human beings have an inherit capability of easily identifying a person by the use of memory but computer systems lack memory issues.

It can be made to remember things via artificially inducing codes and features and through learning mechanisms named as supervised learning and unsupervised learning. But this learning can be successfully applied only if images of individuals are given in controlled conditions i.e., static background.

Lawrence et al., 1997) and several variations of them are used but each one has its boundaries. Even though successful in many applications, they do not show good performance when the face image is somewhat occluded. Since they are linear in nature they do not work well in non-linear cases.

This survey aims to provide insight into the contemporary research of face detection in a structural manner. Chellappa et al. have conducted a detailed survey on face recognition research. In their survey, several issues, including segmentation and feature extraction, related to face recognition have been reviewed. One of the conclusions from Chellappa et al. was that the face detection problem has been given only little attention. This has certainly changed over the past five years as we show in this survey.

2. OVERVIEW OF FACE RECOGNITION METHODS

In this section comparison is done among various face recognition methods including Eigen faces (Eigen features), Hidden Markov Model (HMM), geometric based and template matching algorithms. These algorithms are evaluated on the basis of their performance by comparing their results. After evaluating the family of face recognition techniques, the issues arising in recognition process are investigated.

2.1 Eigenfaces: In this approach face recognition problem is treated as an intrinsically two dimensional recognition problem. The system works by projecting face images which represents the significant variations among known faces. This significant feature is characterized as the Eigen faces. They are actually the eigenvectors. Their goal is to develop a computational model of face recognition that is fact, reasonably simple and accurate in constrained environment. Eigen face approach is motivated by the information theory. The Eigenfaces methods so called Eigenvector or Principal Component Analysis (PCA) methods are the general methods of face recognition.

While the classical eigenface method uses the KLT (Karhunen- Loeve Transform) coefficients of the template corresponding to the whole face image, the author Pentland et.al. introduce a face detection and recognition system that uses the KLT coefficients of the templates corresponding to the significant facial features like nose, mouth and eyes.

For each of the facial features, a feature space is built by selecting the most significant “eigenfeatures”, corresponding to the largest eigen values of the features correlation matrix. The major facial features were detected using the distance from the feature space and selecting the closest match. The scores of similarity between the templates of the test image and the templates of the images in the training set were integrated in a cumulative score that measures the distance between the test image and the training images. The method was followed by the detection of features under different viewing geometries by using either a view-based Eigen space or a parametric eigenspace..

Mathematically, Eigenfaces are the principal components that actually divide the face into feature vectors. The feature vector information is obtained from covariance matrix. These Eigenvectors are used to quantify the variation among multiple faces. The faces are characterized by the linear combination of highest Eigenvalues. The M Eigenfaces represent M dimensional face space.

Reference (Zhao and Yang, 1999) introduces a new technique to find out the covariance matrix by taking three images of different lighting conditions for Lambertian object. Pentland et al. (1994) used Eigenfeatures like eyes, nose, mouth, cheeks etc. instead of Eigenfaces. This method is less sensitive as compared to the Eigenface approach. In this case the system attains 95% recognition rate on 7562 FERET images of 3000 per person. In short, Eigenface approach is most reliable, fast and efficient that endows invariance information also in the presence of varying lighting and scaling conditions.

2.2 Neural networks: Templates have been also used as input to Neural Network (NN) based systems. Lawrence et.al proposed a hybrid neural network approach that combines local image sampling, A self organizing map (SOM) and a convolutional neural network. The SOP

provides a set of features that represents a more compact and robust representation of the image samples. These features are then fed into the convolutional neural network. This architecture provides partial invariance to translation, rotation, scale and face deformation. Along with this the author introduced an efficient probabilistic decision based neural network (PDBNN) for face detection and recognition. The feature vector used consists of intensity and edge values obtained from the facial region of the down sampled image in the training set. The facial region contains the eyes and nose, but excludes the hair and mouth. Two PDBNN were trained with these feature vectors and used one for the face detection and other for the face recognition.

As far as speed of the system is concerned, the feature extraction time is approximately 0.5 sec while it takes 4 h for training data set. Lin et al. (1997) innate the modular geometry based PDBNN (Kung and Taur, 1995). The PDBNN is basically used three fold i.e., for face detection, eyes detection and face recognition. It actually categorizes the network into K subnets used to identify a single person in a database. The face subnet calculates the probability with Guassian model. Comparatively, Guassian materials endow changeable and complicated model for probability calculation.

The learning strategy of PDNN performs in two step process. In the first step, all the subnets are trained from their own images while in the second step, the subnets are trained on decision basis with different samples. For second step, the limited training samples of misclassified patterns are used. Neural Networks and statistical methods are optional approaches for PDBNN while distributed computed principle is practical approach for parallel computers. In Lin et al. (1997) it is observed that the recognition rate for PDBNN is 96% in real time for limited persons. Nevertheless, the recognition rate goes down for large data set due to the increased computational cost.

2.3 Spatial Matching Detector Method: This approach embraces the Support Vector Machines, various template matching methods, other discriminable Kernel Cost Function methods, and so on. Terrillon, J.-C.—Shirazi, M. N.—Sadek, M offered a novel detection method, which worked well even in the case of a complicated image collection of detected images which was called a multi-template. Only images which passed the threshold test imposed by the first detector were examined by the second detector, etc. The algorithm's performance compared favorably to the well-known eigenface and support vector machine based algorithms, but was substantially faster.

2.4 Correlation Based Methods: Correlation based methods for face detection are based on the computation of the normalized cross correlation coefficient Cn [4, 5]. The first step in these methods is to determine the location of the significant facial features such as eyes, nose or mouth. The importance of robust facial feature detection for both detection and recognition has resulted in the development of a variety of different facial feature detection algorithms. The facial feature detection method proposed by Brunelli and Poggio uses a set of templates to detect the position of the eyes in an image, by looking for the maximum absolute values of the normalized correlation coefficient of these templates at each point in test image [6, 2]. To cope with scale variations, a set of templates at different scales was used.

The problems associated with the scale variations can be significantly reduced by using hierarchical correlation. For face recognition, the templates corresponding to the significant facial feature of the test images are compared in turn with the corresponding templates of all of the images in the database, returning a vector of matching scores computed through normalized cross correlation. The similarity scores of different features are integrated to obtain a global score that is used for recognition. Other similar method that use correlation or higher order statistics revealed the accuracy of these methods but also their complexity. Beymer extended the correlation based on the approach to a view based approach for recognizing faces under varying orientation, including rotations with respect to the axis perpendicular to the image plane(rotations in image depth) [7]. To handle rotations out of the image plane, templates from different views were used. After the pose is determined ,the task of recognition is reduced to the classical correlation method in which the facial feature templates are matched to the corresponding templates of the appropriate view based models using the cross correlation coefficient. However this approach is highly computational expensive, and it is sensitive to lighting conditions.

2.5 Hidden Markov Models (HMMs) : Inactive Stochastic modeling that depends on HMM is an ideal approach for speech applications.(Samaria and Fallside (1993) uses the same approach to identify the human face while categorizing the intuitive face into number of features like eyes, nose, mouth, etc. Given that, HMMs need a series of experimental 1D and 2D images; images should be transformed to either a chronological sequence of 1D or 1D spatial.

In Samaria and Harter (1994) a series of interpretation was obtained from a group of facial image pixels using spatial sampling technique. All facial image pixels are constituted by 1D vector series. Each examined vector is represented in the form of block containing L Lines which is comprised of M lines. An examined sequence of an unidentified test image is sampled for the first time. Then it matches with the gallery images stored in the database. Probably the best match is considered to be high and the model exposes the identity of test face. Castellani et al. (2008) introduced a new method that works on 3D meshes and operates only to the discriminant features of face using dynamic HMM. At the end, the author exposes from the recognition rate that the system works well under varying facial expressions and also good for real time environment.

A brief analysis is conducted by Sun et al. (2010) on different facial patterns via adaptive 3D face model series. The role of tracking model based method is usually used to accommodate the lack of feature vector. Similarly, spatial temporal face model descriptor is used in order to evaluate the system. One of the major drawbacks of HMM is that it is sensitive to geometrical shape. In order to cope with such problem, a confirmation based Hidden Markov Model is appreciated while the experimental results reveal that the

proposed model is highly preferable as compared to traditional HMMs and various standards based HMM models.

2.6 Geometrical feature matching: The geometric feature based approaches are the earliest approaches to face recognition and detection [1]. In these systems, the significant facial features are detected and the distances among them as well as other geometric characteristic are combined in a feature vector that is used to represent the face. To recognize a face, first the feature vector of the test image and of the image in the database is obtained. Second, a similarity measure between these vectors, most often a minimum distance criterion, is used to determine the identity of the face. As pointed out by Brunelli and Poggio, the template based approaches will outperform the early geometric feature based approaches [2]. Geometric feature matching technique is based on the computation of a group of photos from the face geometry [43].

2.7 Template matching: In template matching, we can exploit other face templates from different prospects in order to characterize single face. Primarily, grey levels that match the face image can also be processed in proper format (Bichsel, 1991). In Bruneli and Poggio (1993) the Pop and Bruneli is available for all aspects of developing automatic four template features i.e., eyes, nose, mouth, face and selecting the entire set. The system is evaluated by comparing results from geometrical based algorithms on 188 images of 47 subjects. The pattern matching algorithm is a very practical approach, very simple to use and approximately achieves 100% recognition rate. The Principal Component Analysis using Eigenface provides the linear arrangement of templates. The main advantage of this approach is that it is easy to implement and is less expensive than any other feature classifier. Comparatively, template based algorithms are more expensive and cannot be easily processed. However, the recognition process is easily handled between the given template and input image. The complexity arises only during the extraction of template.

Generally template based techniques outperform as compared to feature based methods. In short, every algorithm has some disadvantages as well.

2.8 3D-morphable model:

Construction, shape and texture ofany example of a convex combination of vector describe a real face (Vetter and Poggio, 1997). Accessories of 3D image deformation model can be identified in two ways in different screening environment. Model 1: A Model accessory confirms that the model can be based on the coefficient representing the shape and texture inherent in the face and independent of imaging conditions (Georghiades et al., 2001; Zhao and Chellappa, 2000). Currently, (Zhao and Chellappa, 2000) amalgamates 3D Morphable model with computer aided system. As a single image, the algorithm repeatedly calculates three- dimensional shape, texture and all relevant consideration of three-dimensional scene. Lambertian reflection is limited to lighting, specular reflections and shadows having a significant impact on the appearance of human skin that should not be considered I nto account[43]. This method is based on three-dimensional facial deformation model to confine the exact properties of faces that can be routinely learned from the data set. Deformable model actually constitutes geometry and texture of the face and includes probability density function as face space.

In this paper, the author focuses on 3D Morphable model for head and ear. In (Shu-Fan and Shang-Hong, 2011) facial expressions are handled using the same approach of Morphable model in order to produce and synthesize animation. For this the author introduced a model of Weighted Feature Map. The experimental result reveals high performance and robustness of the system against existing methods. In Unsang et al. (2010) the 3D aging model is presented to overcome facial aging problem. Experimental results reveal improved performance for face recognition systems with tackling facial aging problem. Similarly in Utsav et al. (2011), presented a face recognition system based on 3D generic elastic model for tackling the problem of pose variation during recognition of face. The presented 3D model comprises a database of 2D pose views which are further adjusted for matching process. Experimental results reveal high recognition accuracy under controlled as well as uncontrolled real-world scenarios.

2.9 Support Vector Machine Approach: Face recognition is a K class problem, where K is the number of known individuals; and support vector machines (SVMs) are a binary classification method [18]. By reformulating the face recognition problem and reinterpreting the output of the SVM classifier, they developed a SVM-based face recognition algorithm. The face recognition problem is formulated as a problem in difference space, which models dissimilarities between two facial images. In difference space we formulate face recognition as a two class problem[44]. The classes are: dissimilarities between faces of the same person, and dissimilarities between faces of different people. By modifying the interpretation of the decision surface generated by SVM, we generated a similarity metric between faces that are learned from examples of differences between faces. The SVM-based algorithm is compared with a principal component analysis (PCA) based algorithm on a difficult set of images from the FERET database. Performance was measured for both verification and identification scenarios. The identification performance for SVM is 77-78% versus 54% for PCA. For verification, the equal error rate is 7% for SVM and 13% for PCA.

3. MODERN TECHNIQUES

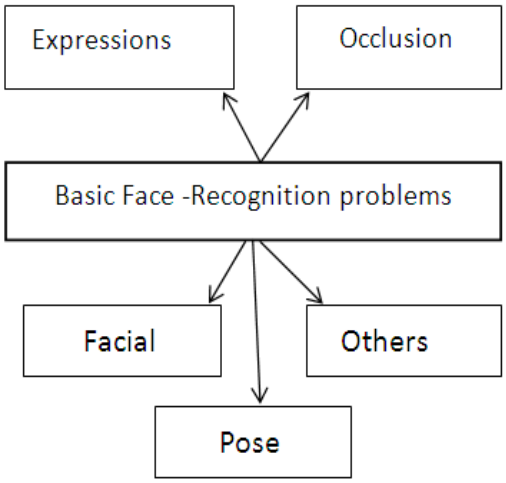
To make a grip on lighting factors appeared on the images, edge detection is a good approach to shape the facial features that can be hidden due to unusual lighting conditions. The Line Edge Map algorithms are not used for pattern recognition but widely used to handle the lighting factors. The edge images are mostly used during object recognition and confer equivalent results as obtained after preprocessing the image. Takács (1998) finds out similarity measures using edge maps and attains 92% accuracy. Some authors' used line edges to extract the shape of facial features. This approach can be used with template matching and geometrical algorithms [43].

It actually works in such a way that jumbles the sequence of pixels in one line and constitutes geometrical information (purdue Univ. Face Database, 2002). It is a pattern recognition learning technique used for face recognition. It endows additional accuracy although it does not require some extra information. It can classify same features in one class and different in another class by calculating the hyper plane on the vector space. The SVM approach is good to classify medium size facial features (Manikandan and Venkataramani, 2011). Guo et al. (2000) exposes binary tree recognition policy to handle face recognition problem and adopts SVM classifier for feature extraction. Deniz et al. (2003) mingles Principal Component Analysis (PCA) with Independent Component Analysis (ICA) using similar properties. In order to catch accurate and perfect results, MCSs group together multiple outputs obtained from different classifiers. Usually, this approach is used in pattern recognition in such a way that it chooses the mature output from multiple classifiers and is used for face recognition. Handling the problem of pose variation, in Antitza and Dugelay (2011) presented an approach for face recognition in video. The approach is based on multimodal soft biometric traits specifically those taken from patches of hair, skin and clothes. Another technique for real-time face recognition using skin is presented in Muhammad et al. (2011a); the proposed method made use of skin detection (in RGB color space) and block approach.

4. FACTORS AFFECTING FACE RECOGNITION

Though fore-mentioned techniques solve the face recognition problem but there are some other issues that actually degrade the performance of face recognition. These issues actually rise in real life because in real situation the person's face is not always neutral (not expressionless).

Other face recognition issues occur due to varied pose, expression, lighting conditions on the image and occluded objects etc. as shown in the following Fig. 2.



Factors Affecting Face Recognition

4.1 Facial expression: Facial expression poses a nonlinear structure in face recognition tasks. By nature every person has expressions on his/her face used for non verbal communication. Facial expression can result in a change in both transient and intransient facial features which is a form of local and global features of the face (Ghanem et al., 2010; Zhengya et al., 2011). Categorically these transient and intransient facial features are divided into number of algorithms to handle this issue. These algorithms are model based, motion based and muscles based approaches while the others are the combination of these three.

Motion based approaches are pixel estimation algorithms in order to calculate the intensity across pixels. Numerous algorithms are used to calculate the pixel variation like face plane algorithm with displacement vector, geometric deformation of facial features etc.

4.2 Facial aging: Facial aging cause texture and shape changes which ultimately effect the performance of face recognition systems (Unsang et al., 2010). Physically facial aging creates wrinkles which can also effect 3D model of the face for face recognition. To overcome facial aging problem, Unsang Prang et al. (2010) presented a technique in there study (Unsang et al., 2010) which is based on 3D aging model to improve the performance factor of face recognition system.

5. CONCLUSION

In this survey, various face recognition techniques are used for detecting faces in various applications. Also factors affecting face recognition system in different aspects as accuracy, performance etc are also been discussed here. It is also been observed that to tackle different factors such as pose variation, occlusions, facial aging etc. different techniques are used separately. Likewise some incorporated approaches are used to tackle multiple face recognition factors in a single face recognition system. So in order to develop a universally accepted face recognition system which can handle all face recognition factors, an integrated choice can be deployed in future.

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