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A Philosophical Review on Different Face Recognition Techniques

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Abstract— Owing to the past few decades, Face recognition came in to one of the most lively research areas in computer vision and pattern recognition. Human face recognition is indeed a challenging task, especially under the illumination and pose variations. It is challenging as well as attractive for its usefulness in the area of crime detection and identity verification. This paper compares the different face recognition techniques like feature extraction techniques like geometry-based feature extraction, appearance based techniques and template based feature extraction. With the increase in the number of proposed algorithms and techniques the survey and evaluation of these algorithms and techniques becomes more vital to provide a boost to the research activities. Henceforth, the primary aim of this paper is to provide a critical summary and working paradigm of the existing human face recognition techniques which in turn will be greatly useful for the researchers to compute the problems in hand.

Keywords— Face Recognition System, Face Detection, Holistic approach, Feature-based approach, Face Segmentation

I. INTRODUCTION

The human face is one of the most promising biometric modality due to the social acceptability and non-intrusiveness of its measurement through imaging. It requires minimal or no cooperation by the subject, which makes it ideal for surveillance. However, automatic face recognition is a very challenging task because the distinctiveness of facial biometrics is quite low compared to other biometrics. Moreover, changes caused by expressions, illumination, pose and facial makeup impose further challenges on accurate face recognition[1].

Face recognition is a process through which we can recognize the face by using facial characteristics. Face recognition process have commonly four steps i.e. Face Segmentation, Normalization, Feature extraction and classification. Face segmentation deals with the segmentation of individual faces. These faces are then normalized according to the geometrical properties. At the time of feature extraction, the feature is extracted from the normalized face. Then the face will be classified to the desired class. In face recognition, take a sample of the image; extract the feature from that image and save them in the image database. When new image is entered as input for recognition, features of that image is extracted and matched with the database, giving the output or recognized percentage with the database image[2].

Generally speaking, basic face recognition algorithms are categorized into holistic, feature-based and hybrid matching algorithms. Holistic recognition algorithms, such as Eigen faces basically extract global Features from the entire face. One limitation of holistic matching is that it requires accurate normalization of the faces according to pose, illumination and scale. Variations in these factors can affect the global features extracted from the faces leading to inaccuracies in the final recognition. Normalization is usually performed by manually identifying landmarks on the faces, which makes the whole process semi-automatic.

Feature-based matching algorithms extract local features or regions such as the eyes and nose and then perform matching operations using these features or their local statistics for recognition. One example of this category is the region-based three-dimensional (3-D) matching algorithm, which matches the 3-D point clouds of the eyes-forehead and the nose regions separately and fuses the results at the score-level. Another example is face recognition using local boosted features, which matches rectangular regions from facial images at different locations, scales and orientations. Feature based matching algorithms have an advantage over holistic matching algorithms because they are robust to variations in pose, illumination, scale, expressions and occlusions. Hybrid matching methods use a combination of global and local features for face recognition.

The rest of the paper is organized as follows. Section II discusses existing feature extraction techniques with Holistic

approaches like Eigenface approach, geometry based methods, appearance based techniques and template based methods with pros and cons of each. Finally, section III concludes the paper and points out the future research aspects.

II. DIVERSE FACE RECOGNITION TECHNIQUES

In this section, the description about the several previously emerged algorithm's working methodologies and features have been framed.

A. Eigenface Approach

The Eigenfaces methods so called Eigenvector or Principal Component Analysis (PCA) methods are the general methods of face recognition. Faces can be easily reconstructed by considering only a small amount of information obtained using Eigenfaces. [3] Eigenfaces are nothing but principal components mathematically that bifurcate the face into feature vectors in the form of covariance matrix. Then these vectors are used to calculate the variation among multiple faces. The faces are characterized by linear combination of highest Eigenvalues. The M Eigenfaces represent M dimensional face space. Here the researcher showed 96, 85 and 64% right categorization under varying lighting condition respectively, orientation and size by exploiting 2500 images of 16 each. The low face recognition rate is due to the silhouette background just at the back of the face [4].

The correlation of entire face does not show reasonable results. The illumination normalization is very much necessary for Eigenfaces. Eigen features like eye, nose, mouth, cheeks, etc can be used instead of Eigenfaces. This approach is less sensitive as compared to the Eigenface method. In this case the system attains 95% recognition rate on 7562 FERED 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. In recent developments, a face recognition technique which is based on Multi linear principal component analysis and locality preserving projection to improve the performance of face recognition system which uses MPCA for facial image preprocessing and LPP for extraction of facial features. Experimental results reveal good facial recognition accuracy. Eigenface algorithm using principal component analysis (PCA) for reduce dimension to find vectors have best value to distribute face image in input face space. This vector define subspace named face space, training set projected into face space to find set of weight that describe contribution of each vector in face space.

B. Geometry based Techniques

In this method the features are extracted by using relative positions and sizes of the important components of face. This group method concentrates in two directions. First, detecting edges, directions of important components or region images contain important components, then building feature vectors from these edges and directions. Using filters such as Canny filter to detect eyes or mouth region of face image, or the gradient analysis method which is usually applied in this direction. Second, methods are based on the grayscales difference of important components and unimportant components, by using feature blocks, set of Ha ar-like feature block in Adaboost method[5] to change the grayscales distribution into the feature. In LBP[6] method, it divides up the face image to regions (blocks) and each region corresponds with each central pixel. Then it examines its pixel neighbors, based on the grayscales value of central pixel to change its neighbor to 0 or 1. Therefore, every pixel will be represented in a binary string. Since then, we build histograms for every region. Then these histograms are combined to a feature vector for the face image. One of the methods is Gabor wavelets transform feature extraction.

C. Appearance based Techniques

In these methods is using linear transformation and statistical methods to find the basic vectors to represent the face. In the literature for this aim such as PCA and ICA in detail, goal of PCA method is to reduce the number of dimensions of feature space, but still to keep principle features to minimize loss of information. PCA method uses second-order statistic in the data. However, PCA method has still disadvantages. High order dependencies still exist in PCA analysis, for example, in tasks as face recognition, much of the important information may be contained in the high-order relationships among the image pixels, not only second-order. While other method ICA uses technique independent component analysis. It is an analysis technique not only use second-order statistic but also use high order statistic. PCA can be derived as a special case of ICA which uses Gaussian source models. PCA is not the good method in cases non Gaussian source models. It has been observed that many natural signals, including speech, natural images, are better described as linear combinations of sources with super-Gaussian distributions. In that case, ICA method is better than PCA method because of the following factors.

- ICA provides a better probabilistic model of the data.
- It uniquely identifies the mixing matrix.
- It finds an unnecessary orthogonal basic which may reconstruct the data better than PCA in the presence of noise such as variations lighting and expressions of face.
- It is sensitive to high-order statistics in the data, not just the covariance matrix.

The Appearance based method group found the best performer in facial feature extraction because it keeps the important information of face image, rejects redundant information and reflect face global structure. It requires that the image matrices must be first transformed into vectors, which are usually of very high dimensionality. This causes expensive computational cost and sometimes the singularity problem.

D. Template based Techniques

This method group will extract feature of face such as eyes, mouth, nose, etc. based on template function and appropriate energy function. An image region is the best appropriateness with template for eye, mouth or nose, which will minimize the energy. The methods have been proposed such as deformable template and genetic algorithms. In the deformable template method, the feature of interest, an eye, is described by a parameterized template. An energy function is defined to links edges, peaks, and valleys in the image intensity with corresponding properties of the template. Then the template matching is done with the image, by altering its parameter values to minimize the energy function, thereby deforming itself to find the best fit. The final parameter values can be used as descriptors for the features.

E. Template based Eye and Mouth Detection

In this method, the correlation of eye template with various overlapping regions of the face image is found out. An eye template is used to detect the eye from face image. The region with maximum correlation with the template refers to eye region. The method of template matching is given as an algorithm, which is so simple and easy to implement. The algorithm steps are as follows.

- Step 1: An eye template of size m × n is taken.
- Step 2: The normalized 2-D auto-correlation of eye template is found out.
- Step 3: the normalized 2-D cross-correlation of eye template with various overlapping regions of the face image is calculated.
- Step 4: The mean squared error (MSE) of auto correlation and cross-correlation of different regions are found out. The minimum MSE is found out and stored.
- Step 5: The region of the face corresponding to minimum MSE represents eye region.
- Step 6: From eye region eyes points extracted.
- Step 7: From eye points mouth point can be detected.

This technique is easily implemented with key face features but it does not represent global face structure. The method does not require any complex mathematical calculation and prior knowledge about the features geometry.

F. Neural Network based Face Detection

For face detection process training a neural network is a very difficult task as the problem arises in characterizing prototypical non-facial images. In the case of face recognition the sets are to be made are of different faces where as the two sets in face detection are facial images and non-facial images. It is easy to get a representative sample of images which contain faces, but it is much harder to get a representative sample of those which do not. The number of subjects in the second set can grow very quickly. This problem can be avoided using a big set of non facial images in the training process. This approach has been used with tremendous success as far as frontal face detection is concerned. The retinally connected neural network examines small windows of a facial image and decides whether each window has a face.

The system uses multiple networks to improve performance. [7] In the new neural network model proposed, the Constrained Generative Model performed an accurate estimation of the face set, using a small set of counter-examples. It uses of three layers of weights allows to evaluate the distance between an input image and the set of face image. An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurones) working in unison to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process.

G. Fuzzy Theory based Approach

Learning in biological systems involves adjustments to the synaptic connections that exist between the neurones. This is true of ANNs as well. This approach uses fuzzy theory to representing diverse, non-exact, uncertain, and inaccurate knowledge or information. And information carried in individual fuzzy set is combined to make a decision. A new method to detect faces in colour images based on the fuzzy theory is proposed where two fuzzy models are used to describe the skin colour and hair colour respectively, where a uniform colour space is used to describe the colour information to increase the accuracy and stableness. Here two different models have been used to take out the skin colour portions and the hair colour portions. Then a comparison is made between them with some pre-built templates with the help of fuzzy theory based methods for pattern matching that identifies human faces. Processes of composition and de-fuzzification form the basis of fuzzy reasoning. Fuzzy reasoning is performed to recognize face in the context of a fuzzy system model that consists of control, solution, and working data variables; fuzzy sets; hedges; fuzzy; and a control mechanism.

H. Holistic Approach

The holistic approaches to face detection embody global information of faces; the disadvantage of this approach is the variances captured may not be relevant features of the face. Face recognition is indeed a difficult problem as faces can vary a great deal in their orientation, facial expression and lighting conditions. The goal was to provide a survey of recent holistic approaches to face detection that complement previous surveys. We summarized holistic approaches like Eigen face based method, spatial matching detector method, neural networks method and fuzzy theory based method. The holistic approaches have the main advantage of distinctly capturing the most prominent features within the given facial images, so as to uniquely identify individuals amongst the given set; also automatically finding features. However, disadvantages are that face recognition performance could be drastically be affected by lighting, orientation and scale; or, features found from faces may not form part of the face but may be some other feature has been captured. For (example), features from the background of a facial image. So in order to develop a universal face recognition system which can handle all face recognition factors, the integrated approach could be a choice.

III. CONCLUSION and FUTURE SCOPE

Beside the above-mentioned approach to face recognition, some researchers also used other methods to perform the studies on face recognition, i.e., the rules of the shape and albedo of a face under all possible illumination conditions, Bayesian decision, etc. In order to develop a universal face recognition system which can handle all face recognition factors, the integrated approach could be a choice. A method that integrates the above different methods and applies different techniques would be the answer to all the drawbacks.

The best features for face recognition cannot be simply determined without evaluation of the face recognition algorithms. That is why the best feature sets for face recognition are still not sufficient. Extensive evaluation can help to achieve a more reliable set of face features and help to increase the performance of the overall system. The thermal face recognition achieved higher performance ranks and average confidence rates than visual face recognition under different lighting conditions and expressions in cases where no eyeglasses were worn.

The face feature extraction is important application for various other applications with different techniques considering different parameters. Every method has pros and cons such as template based methods are easy to implement but not represent global face structure. While color segmentation based methods used color model for skin detection with morphology operation to detect features. Different color models and illumination variation factors can affect performance. Appearance based methods represent optimal feature points which can represent global face structure but disadvantage is high computational cost.

The PCA technique performs satisfactory when test image to be recognized. The Eigen face approach does provide a practical solution that is well fitted to the problem of face recognition. It is fast, relatively simple. This method was found to be robust enough. Geometry based methods such as Gabor wavelet transform face feature extraction provide stable and scale invariant features. Wavelets enable localization in both spatial and frequency domains with high frequency salient feature detection. And such set of continuous 2D Gabor wavelets will provide a complete representation of any image.

Hopefully, the comparisons in this paper do provide a step toward impacting on increasing the performance of feature extraction techniques for face recognition systems.

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