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A SURVEY OF FACE RECOGNITION TECHNIQUES

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Abstract

Face recognition presents a challenging problem in the field of image analysis and computer vision, and as such has received a great deal of attention over the last few years because of its many applications in various domains such as information security, access management, biometrics, law enforcement etc.In this paper, an overview of some of the well-known methods developed for this purpose and attempts to give an idea of the state of the art of face recognition technology.

Keywords: Face Recognition, Person Identification, Biometrics

1. Introduction

Face recognition is used for two primary tasks: 1. Verification (one-to-one matching): When presented with a face image of an unknown individual along with a claim of identity, ascertaining whether the individual is who he/she claims to be.
2. Identification (one-to-many matching): Given an image of an unknown individual, determining that person's identity by comparing (possibly after encoding) that image with a database of (possibly encoded) images of known individuals.
Face verification is a 1:1 match that compares a face images against a template face images, whose identity being claimed .On the contrary, face identification is a 1: N problem that compares a query face image against all image templates in a face database. Face recognition techniques can be broadly divided into three categories based on the face data acquisition methodology: methods that operate on intensity images; those that deal with video sequences; and those that require other sensory data such as 3D information or infra-red imagery. Therefore a basic face recognition system contains the following sub-modules.

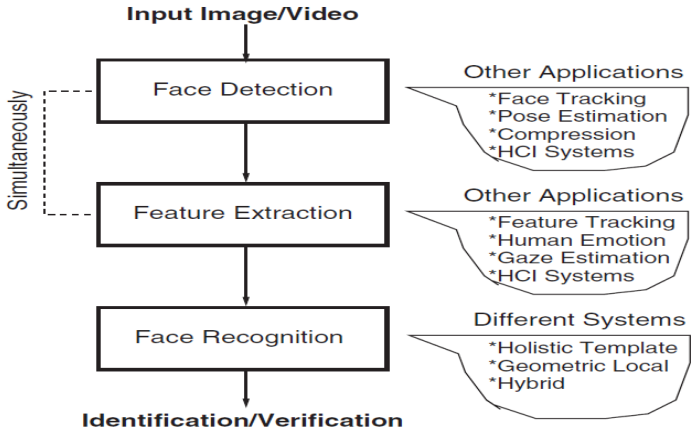

Figure 1: generic face-recognition system

There are numerous application areas in which face recognition can be exploited, a few of which are outlined below

Areas	Applications
Information Security	Access security (OS, data bases), Data privacy (e.g. medical records) ,User authentication (trading, on line banking)
Access management	Secure access authentication (restricted facilities) , Permission based systems Access log or audit trails
Biometrics	Person identification (national IDs, Passports, voter registrations, driver licenses), Automated identity verification (border controls)
Law Enforcement	Video surveillance, Suspect identification, Suspect tracking (investigation) Simulated aging, Forensic Reconstruction of faces from remains,
Personal security	Home video surveillance systems, Expression interpretation (driver monitoring system)

Table 1: Applications of face recognition

2. Technical Challenges

There are some key factors that can significantly affect system face recognition performances

A. Illumination: The variations due to skin reflectance properties and due to the internal camera control. Several 2D methods do well in recognition tasks only under moderate illumination

variation, while performances noticeably drop when both illumination and pose changes occur.

B. Pose: Changes affect the authentication process, because they introduce projective deformations and self-occlusion. Even if methods dealing with up to 32 Degree head rotation exist, they do not solve the problem considering that security cameras can create viewing angles that are outside of this range when positioned.

C. Expression: On the contrary, with exception of extreme expressions such as scream, the algorithms are relatively robust.

D. Time Delay: Because the face changes over time, in a nonlinear way over long periods. In general this problem is harder to solve with respect to the others and not much has been done especially for age variations.

E. Occlusions: At last, can dramatically affect face recognition performances, in particular if they located on the upper-side of the face, as documented in literature.

F. Image Orientation: Face images directly vary for different rotations about the camera's optical axis.

G. Imaging Conditions: When the image is formed, factors such as lighting (spectra, source distribution and intensity) and camera characteristics (sensor response, lenses) affect the appearance of a face.

H. Presence or Absence of structural components: Facial features such as beards, mustaches, and glasses may or may not be present and there is a great deal of variability among these components including shape, color, and size.

3. Literature Survey

Face recognition is one of the most relevant applications of image analysis. It's a true challenge to build an automated system which equals human ability to recognize faces. Although humans are quite good identifying known faces, we are not very skilled when we must deal with a large amount of unknown faces. The computers, with an almost limitless memory and computational speed, should overcome human's limitations. Face recognition remains as an unsolved problem and a demanded technology.

3.1. Historical Perspective

In fact, the earliest works on this subject were made in the 1950's in psychology. They came attached to other issues like face expression, interpretation of emotion or perception of gestures. Engineering started to show interest in face recognition in the 1960's. Historical perspective of this work started from Pioneers Automated Facial Recognition include: W. Bledsoe, H. C. Wolf, and C. Bisson. During 1964 and 1965, Bledsoe, along with Chan and Bisson, worked on using the computer to recognize human faces [1, 11, 12]. He was proud of this work, but because the funding was provided by an unnamed intelligence agency that did not allow much publicity, so little of the work was published. He continued later his researches at Stanford Research Institute.

Bledsoe designed and implemented a semi-automatic system. Some face coordinates were selected by a human operator, and then computers used this information for recognition. He described most of the problems that even 50 years later Face Recognition still suffers - variations in illumination, head rotation, facial expression, and aging. Researches on this matter still continue, trying to measure subjective face features as ear size or between-eye distance. For instance, this approach was used in Bell Laboratories by A. Jay Goldstein, Leon D. Harmon and Ann B. Lesk. They described a vector, containing 21 subjective features like ear protrusion, eyebrow weight or nose length, as the basis to recognize faces using pattern classification techniques.

Lin (2000) in his survey paper said that face recognition is attracting much attention in the society of network multimedia information access. Areas such as network security, content indexing and retrieval, and video compression benefits from face recognition technology because "people" are the center of attention in a lot of video. Network access control via face recognition not only makes hackers virtually impossible to steal one's "password", but also increases the user-friendliness in human-computer interaction. Indexing and/or retrieving video data based on the appearances of particular persons will be useful for users such as news reporters, political scientists, and moviegoers. For the applications of videophone and teleconferencing, the assistance of face recognition also provides a more efficient coding scheme. In this paper, we give an introductory course of this new information processing technology. Also the paper shows the readers the generic framework for the face recognition system, and the variants that are frequently encountered by the face recognizer. Several famous face recognition algorithms, such as eigenfaces and neural networks.

Heisele et al (2001) presented a paper a component-based method and two global methods for face recognition and evaluate them with respect to robustness against pose changes. In the component system we first locate facial components, extract them and combine them into a single feature vector which is classified by a Support Vector Machine (SVM). The two global systems recognize faces by classifying a single feature vector consisting of the gray values of the whole face image. In the first global system we trained a single SVM classifier for each person in the database. The second system consists of sets of viewpoint-specific SVM classifiers and involves clustering during training. We performed extensive tests on a database which included faces rotated up to about 40^0 in depth. Their experiment shows that using facial components instead of the whole face pattern as input features significantly simplifies the task of face recognition.

Lu et al(2002) presented new method utilizes a new variant of D-LDA to safely remove the null space of the between-class scatter matrix and applies a fractional step LDA scheme to enhance the discriminatory power of the obtained D-LDA feature space based on linear discriminant analysis. And it can be considered as a generalization of a number of techniques which are commonly in use. The DF-LDA method presented here is a linear pattern recognition method. Compared with nonlinear models, a linear model is rather robust against noises and most likely did not over fit. Although it had been shown that distribution of face patterns is highly non convex and complex in most cases, linear methods are still able to provide cost effective solutions to the FR tasks through integration with other strategies, such as the principle of "divide and conquer" in which a large and nonlinear problem is divided into a few smaller and local linear sub-problems. But the development of mixtures of localized DF-LDA to be used in the problem of large size face recognition as well as the development of a non-linear DF-LDA through the utilization of kernel machine techniques are research topics under current investigation.

Juwei Lu et al (2003) propose a kernel machine-based discriminant analysis method, which deals with the nonlinearity of the face patterns' distribution. It is well known the techniques that can introduce low-dimensional feature representation with enhanced discriminatory power is of paramount importance in face recognition (FR) systems and the distribution of face images, under a perceivable variation in viewpoint, illumination or facial expression, is highly nonlinear and complex. It is, therefore, not surprising that linear techniques such as those based on principle component analysis (PCA) or linear discriminant analysis (LDA), cannot provide reliable and robust solutions to those FR problems with complex face variations. The proposed method also effectively solves the so-called "small sample size" (SSS) problem which exists in

most FR tasks.

Zhao et al (2004) proposed a novel face recognition method based on multi-features using a neural networks committee (NNC) machine. The committee consists of several independent neural networks trained by different image blocks of the original images in different feature domains. In this paper four different feature domains have been used for extracting features from input images, including the interest operator (IO), the principal component analysis (PCA), the Fisher's linear discriminant (FLD) and the Kernel Fisher linear discriminant (KFLD).In addition radial basis function neural networks (RBFNN) are adopted to implement the committee members. The final classification results represent a combined response of the individual networks. Then, we use the designed neural networks committee to perform human face data recognition. The experimental results show that the classification accuracy of our proposed NNC is much higher than that of single feature domain.

Guo et al (2005) proposed a example-based learning for computer vision can be difficult when a large number of examples to represent each pattern or object class is not available. In such situations, learning from a small number of samples is of practical value. Hence several classification methods have been compared in the case of a small number of training examples per class. Probability distribution based learning methods such as the simplified Bayes classifier and AdaBoost cannot solve this problem. Margin-based methods such as FSLP and SVMs can accurately solve the recognition problem in the small sample case. Furthermore, FSLP can also address the feature selection problem, avoiding the *curse of dimensionality*. Their major contributions to this work are : 1) systematic evaluation of several popular methods in machine learning for a vision problem in the small sample case; 2) introduction of a novel algorithm called FSLP, and an analysis of how it can do feature selection together with classifier training while also circumventing the *curse of dimensionality* problem; and 3) analysis of the expected relative performance of these algorithms for learning in the small sample case, regardless of the classification task.

Kong et al (2005) in their paper provided an up-to-date review of research efforts in face recognition techniques based on two-dimensional (2D) images in the visual and infrared (IR) spectra such as PCA,ICA,LFA,LEM,EGM,HMM, local feature based etc. Face recognition systems based on visual images have reached a significant level of maturity with some practical success. However, the performance of visual face recognition may degrade under poor illumination conditions or for subjects of various skins colors.IR imagery represents a viable alternative to visible imaging in the search for a robust and practical identification system. While visual face recognition systems perform relatively reliably under controlled illumination conditions, thermal IR face recognition systems are advantageous when there is no control over illumination or for detecting disguised faces. Face recognition using 3D images is another active area of face recognition, which provides robust face recognition with changes in pose. Recent research has also demonstrated that the fusion of different imaging modalities and spectral components can improve the overall performance of face recognition.

Eleyan et al (2006) developed and compared two face recognition systems, one based on the PCA followed by a feed forward neural network (FFNN) called PCA-NN, and the other based on LDA followed by a FFNN called LDA-NN, are developed. The two systems consist of two phases which are the PCA or LDA preprocessing phase, and the neural network classification phase. This proposed systems show improvement on the recognition rates over the conventional LDA and PCA face recognition systems that use Euclidean Distance based classifier. Additionally, the recognition performance of LDANN is higher than the PCA-NN among the proposed systems.

Ahonen et al (2006) proposed a novel and efficient facial representation based on dividing a facial image into small regions and computing a description of each region using local binary patterns. These descriptors are then combined into a spatially enhanced histogram or feature vector. The texture description of a single region describes the appearance of the region and the combination of all region descriptions encodes the global geometry of the face. The LBP operator has been widely used in different applications such as texture classification, image retrieval, etc. The results of this experiment clearly show that facial images can be seen as a composition of micro patterns such as flat areas, spots, lines, and edges which can be well described by LBP.

Gandhe et al (2007) discuss and an implemented different method of face recognition such as Principal Component Analysis, Discrete Wavelet Transform Cascaded with Principal Component Analysis, Contour Matching and Isodensity Line Maps Cascaded with Hopfield Neural Network. All these algorithms are tested on ORL Database and BioID Database. The feasibility of these algorithms for human face identification is presented through experimental investigation. The face similarity meter was found to perform satisfactorily in constrained conditions of exposure, illumination and contrast variations. In contour matching though recognition rate is very high but recognition time per image is very high. In Isodensity Line Maps+ Hopfield Neural Network Method no of spurious states equal to 0.15N, where N is the no. of neurons in the Hopfield neural network. But still method has scope to

1. To rescale the energy function in Hopfield network to avoid the spurious states and to improve the recognition rate.
2. Use neurofuzzy approach to improve recognition rate.

Wright et al (2008) proposed a method for automatically recognizing human faces from frontal views with varying expression and illumination, as well as occlusion and disguise. They consider the recognition problem as one of classifying among multiple linear regression models, and argue that new theory from sparse signal representation offers the key to addressing this problem. Based on a sparse representation computed by ℓ-minimization, This new framework provides new insights into two crucial issues in face recognition: feature extraction and robustness to occlusion. For feature extraction they show that if sparsity in the recognition problem is properly harnessed, the choice of features is no longer critical as number of features is sufficiently large and the sparse representation is correctly computed. Unconventional features such as down-sampled images and random projections perform just as well as conventional features such as Eigenfaces and Laplacianfaces, as long as the dimension of the feature space surpasses certain threshold, predicted by the theory of sparse representation. This framework can handle errors due to occlusion and corruption uniformly by exploiting the fact that these errors are often sparse w.r.t. to the standard (pixel) basis. The theory of sparse representation helps predict how much occlusion the recognition algorithm can handle and how to choose the training images to maximize robustness to occlusion.

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whether the number of features is sufficiently large and whether the sparse representation is correctly computed. Unconventional features such as down-sampled images and random projections perform just as well as conventional features such as Eigenfaces and Laplacianfaces, as long as the dimension of the feature space surpasses certain threshold, predicted by the theory of sparse representation. This framework can handle errors due to occlusion and corruption uniformly by exploiting the fact that these errors are often sparse with respect to the standard (pixel) basis.

Agarwal et al (2010) presented a methodology for face recognition based on information theory approach of coding and decoding the face image. Proposed methodology is connection of two stages – Feature extraction using principle component analysis and recognition using the feed forward back propagation Neural Network. This scheme is independent of excessive geometry and computation. Recognition system is implemented based on eigenface, PCA and ANN. Principal Component analysis for face recognition is based on the information theory approach in which the relevant information in a face image is extracted as efficiently as possible. Further Artificial Neural Network was used for classification because of its ability to learn ' from observed data.

Gumus et al (2010) proposed present an evaluation of using various methods for face recognition. As feature extracting techniques they used wavelet decomposition and Eigenfaces method which is based on Principal Component Analysis (PCA). After generating feature vectors, distance classifier and Support Vector Machines (SVMs) are used for classification step. They examined the classification accuracy according to increasing dimension of training set, chosen feature extractor–classifier pairs and chosen kernel function for SVM classifier. For classification step using the extracted features they used both SVM with both RBF and Polynomial Kernels with optimum parameters for high classification rates and nearest distance classification approaches and created six training sets to compare classification accuracies of these approaches with various pose counts per individual. Considering weighted means of recognition rates, Wavelet based recognition gave better results than PCA based approach.

Paisitkriangkrai et al (2011) proposed effective and efficient framework for learning an adaptive online greedy sparse linear discriminant analysis model for face recognition. In this The key contributions of this work are

1) They propose an efficient incremental greedy sparse LDA classifier for training an object detector in an incremental fashion. The online algorithm integrates the GSLDA based feature selection with our adaptation schemes for updating weights of linear discriminant functions and the linear classifier threshold. Our updating algorithm is very efficient.Here they neither replaced weak learners nor throw away any weak learners during updating phase.

2) The online GSLDA serves as a better (in terms of performance) alternative to the standard online boosting for training detectors. This is the first time to apply the online sparse linear discriminant analysis algorithm to object detection.

3) This algorithm can efficiently update the classifier when new instances are inserted while achieving comparable classification accuracy to the batch algorithm.2 Our findings indicate that online learning plays a crucial role in object detection, especially when the initial number of training samples is small. By applying this online technique the classification performance can be further improved at the cost of minor increases in training time.

Jain et al (2012) presented a new way to recognize the face using facial recognition software and using neural network methods. That makes a facial recognition system to protect frauds and terrorists. The steps followed for the implementation of this method are

1) Detection: Acquiring an image can be accomplished by digitally scanning an existing

photograph (2D) or by using a video image to acquire a live picture of a subject.
2) Alignment: Once it detects a face, the system determines the head's position, size and pose. As stated earlier, the subject has the potential to be recognized up to 90 degrees, while with 2D, the head must be turned at least 35 degrees toward the camera.
3) Measurement: The system then measures the curves of the face on a sub-millimeter (or microwave) scale and creates a template.
4) Representation: The system translates the template into a unique code. This coding gives each template a set of numbers to represent the features on a subject's face.
5) Matching: If the image is 3D and the database contains 3D images, then matching will take place without any changes being made to the image. However, there is a challenge currently facing databases that are still in 2D images.

Ahmad et al (2012) proposed a method for automatic face recognition system where usually we have surveillance cameras at public places for video capture and these cameras have their significant value for security purpose. It is widely acknowledged that the face recognition have played an important role in surveillance system as it doesn't need the object's cooperation. The actual advantages of face based identification over other biometrics are uniqueness and acceptance. In this paper they tested the PCA, LDA, LBP and Gabor with following five type of dataset and tired to get the accuracy. The five set of data sets are

1. Face collection with plain green background; no head scale and light variation but having minor changes in head turn, tilt, slant position of face and considerable change in expressions.
2. Face collection with red curtain background, variation is caused by shadows as subject moves forward having minor changes in head turn, tilt and slant; large head scale variation; some expression variation, translation in position of face and image lighting variation as subject moves forward, significant lighting changes occur on faces moment due to the artificial lighting arrangement.
3. Face collection with complex background; large head scale variation; minor variations in head turn, tilt, slant and expression; some translation in face position and significant light variation because of object moment in artificial light.
4. Face collection with plain background small head scale variation; considerable variation in head turn, tilt, slant and major variation in expression; minor translation in face position and light variation.
5. Face collection with constant background having minor head scale variation and light variation; huge variation in turn, tilt, slant, expression and face position.

4. Conclusion

Face recognition is taking place in many sectors nowadays because it works well under constrained conditions. But there can be many advances in this direction because there are vast scopes of improvement and development. As considered above, all current face recognition the algorithms fail under the vastly varying condition under which humans need to and able to identify other people. So, future work can be done in the direction that people can recognize the images in 'Real-Time' in less constrained condition. Almost all traditional and recent methods of face recognition are facing the problems such as change in illumination, pose variation, and change in expressions, aging factors and alignment. So, one of the promising future in face recognition approach is 'Enhancement' so as it will be applicable to even low resolution conditions.

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