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APPROACHES FOR HUMAN FACE RECOGNITION AND RETRIEVAL: A REVIEW

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Abstract

Human face recognition actually represents a challenging difficulty. Biometric based scheme is used to recognize or verify individual from a given digital image, in a procedure of face recognition. This process includes extraction of face features and afterwards recognizing it, nevertheless of expression, lighting, illumination, ageing, and pose, which is basically a difficult job. The techniques of human face recognition are divided into main three categories depending on data acquisition methods. These are the methods operating over intensity images, the methods dealing with the video sequences, the methods requiring some sensory data like infra-red imagery or 3D information. This paper represents summary of the famous face recognition methods in the above categories provided along with its benefits and the drawbacks.

Keywords*: Biometrics, face recognition, variation in pose, illumination, disguise, security, person information.*

1. INTRODUCTION

Biometrics is a part of Identification Science which measures behavioral and physical characteristics of human body, such as fingerprint, retina, iris, voice, face, gait and geometry of hand. It is based on what an individual inherently possess rather than what the individual carries (ID cards) or knows (passwords). This makes biometric authentication more robust to theft and forgery. Among all these biometric modalities, face has an inherent advantage to be non-invasive. Face recognition seems to be fully non-intrusive as well as it doesn't carry any health risks. All these modality technologies need some voluntary actions to be done by the user and have to stand in a fixed position ahead of a camera. But, face recognition are often done passively with none specific action or involvement on a part of an operator as face images are often acquired from certain distance by a camera. A recognition system operate in a verification (i.e. 1:1 matching) or an identification (i.e. 1:N matching) mode. Verification mode compares face images against master face images whose unique identity being claimed and identification mode compares a probe face image in contrast to all image templates in a face database.

H. Bhatt presented a focus on the different aspects. First, he presented various biometric modalities briefly (Fig.1).

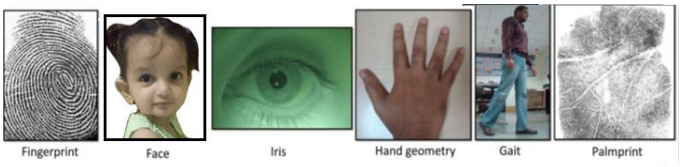

Fig.1 Biometric modalities

Second, he presented various covariates as existing and emerging covariates and a review for different techniques proposed to address the existing covariates along with limitations (Fig.2). Finally, he presented how the emerging covariates have evolved, what are its challenges, proposed techniques, and research directions in future for each of the covariates [1].

A typical block diagram for face recognition includes face detection, features extraction, classification. The key objective for detection process is to search if the given image contains faces or no faces are present in it. The method of face related feature extraction often used for identifying the presence along with location of some features, like eyes, eyebrow, nose, nostrils, mouth, lips, ears, etc. The classification includes comparison of input image i.e. probe and database i.e. gallery [4].

The problem to recognize a face can be given as follows:
For a given face image against stored face images in the known individuals database, how to verify or determine the face of the person given as input image?

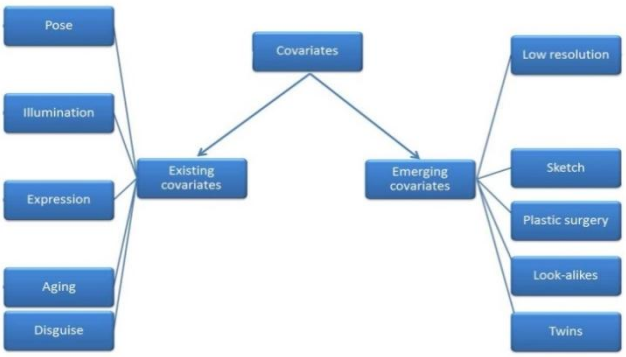

Fig.2 Different covariates

2. FACE RECOGNITION TECHNIQUES

A robust face recognition method should be capable of identifying a face captured in an uncontrolled environment. Face recognition techniques are broadly categorized into three classes depending on the information acquisition methodology of face:

1. Methods operating over intensity images.
2. Methods handling video sequences.
3. Methods requiring alternate sensory information such as 3D data or infra-red images.

2.1. Methods operating over intensity images

2.1.1 Feature-Based

Feature-based methods first process an input image for identifying it and then extract distinct facial features like the eyes, nose, mouth, etc. and then calculate the geometric interactions amongst the facial points. Thus reduces the input facial image to a vector of geometric features. Standard statistical techniques of pattern recognition are utilized for matching the faces using the obtained measurements. These methods show robustness to position variations observed in an input image. These methods stay invariant to size, orientation and lighting. The methods may be compactly represented and are able of matching to high speed. These methods show disadvantage of having difficulty in automatic feature detection.

2.1.2 Holistic

Holistic approaches make identification of faces using descriptions depending on the entire image instead of on local features of the face. These methods are subdivided into statistical and AI approaches. The image is characterized as a 2 dimensional array of the intensity values and face recognition is done by direct correlation comparisons between the input face and all faces in database. These methods are computationally very expensive. Statistical methods comprise PCA, LDA, ICA. [4].
AI approaches apply tools like neural networks and machine learning techniques to recognize faces like Support Vector Machine (SVM), Back propagation (BPNN), radial basis function (RBF) etc.

2.1.3 Hybrid Methods

These methods use a grouping of both holistic methods and feature extraction methods (fig.3). Normally 3D Images are used in hybrid methods [5].

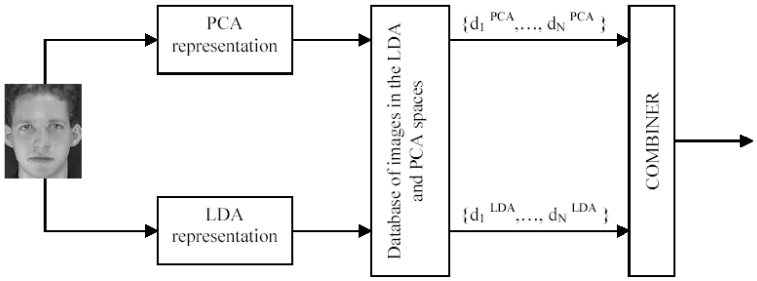

Fig.3 Hybrid Methodology

2.2 Methods That Deal With Video Sequences

Video-based method of face recognition comprises of 3 segments: one for detecting the face; second for extraction of features; and a third one for recognizing it.

2.3 Methods That Require Other Sensory Data

In modern years, attention is directed towards 3D model based and infra-red imagery methods.

2.3.1 3D Model Based

Techniques are currently being used to obtain 3D information are Scanning systems, Structured light systems, Stereo vision systems, Reverse rendering/shape from shading. The drawbacks of such approaches are their complexity and computational cost.

2.3.2 Infra-Red Imagery

Thermal IR imaging of faces is relatively insensitive to variations in lighting. Infra-red facial images expose the tissue and vein structure of human face which is unique for each individual. Still it possess some drawbacks as high cost thermal sensors, low resolution, high level of noise in the images, lack of generally accessible data sets of IR, the fact of IR radiation being opaque to glass making it possible to occlude and IR images are sensitive to changes in ambient temperature [2].

3. A REVIEW ON FACE RECOGNITION APPROACHES

In order to develop a useful and applicable system for face recognition several factors need to be taken in hand.

1. The speed of the overall system from detection to recognition should be acceptable.
2. The accuracy should be high
3. The system should be updated and enlarged easily, that is easy to increase the number of subjects that can be recognized [5].

The face recognition system must automatically recognize a face in given image irrespective of expression, lighting, illumination, pose, and ageing, which is a difficult task.

A hierarchical pose-dependent multi-state approach for detection of the facial feature and tracking with varied expression and varied face pose is proposed [6]. Hybrid representation integrates the Gabor wavelet and proposes a grey-level profile for effectively representing the feature points. It Characterize each, the global shape of the face of an individual and also the local structural details of every facial component. Experimental result proves that the recommended method significantly reduces the feature tracking error, compared to the classical feature tracking methods [6].

Multi-pose face detection and face expression recognition done with a hybrid-boost learning algorithm is proposed [7]. To accelerate the detection method, the system examines the whole frame for potential face sections by using skin color detection and segmentation. Then it applies the weak classifiers along with the strong classifier for face detection. The key contribution is towards proposing the weak hybrid classifiers selection depending on Harr-like (local) features and Gabor (global) features to provide the most discriminating data for the strong classifier in the final stage. The system is robust to size, poses, expressions, and defocus problems [7].

When face recognition experimentations are isolated into two sections, the 1st part gives the execution of face acknowledgment calculations evaluated on a heterogeneous face database that contains variations due to pose, expression and illumination. The 2nd experiment is executed to calculate effect of disguises on face recognizing algorithm [8]. Here, the images are subdivided into two sets: (1) The training dataset to prepare individual face recognizing algorithms and (2) The gallery-probe dataset (test set) to find performance of the

recognition algorithms. The performance of each appearance based, feature based, texture based algorithms when compared using the heterogeneous and the disguise face database, it shows that the texture based algorithms yield better accuracy and better verification compared to appearance based and the feature based algorithms.

A detailed survey on 2 dimensional face recognition, in uncontrolled conditions explore with different techniques proposed for illumination and the pose problem in addition with the classifiers that are successfully used for recognition of the face normally. It gives a complete review of classifiers that are utilized as a part of the given recognition system [9].

3 dimensional faces modeling is of great importance in face analysis, and recognition. The direct methodology to get 3D face images is using 3D sensors. But, 3D sensing seems relatively quite expensive and the acquisition time can be slow. To solve this conflict of unavailability of 3 dimensional face data for improving recognition performance in unconstrained environments, two different strategies are proposed: (i) the normalization of 2 dimensional face images, and (ii) 3 dimensional image modeling from 2 dimensional images [10].

Latest advances in automatic recognition of face, that effect the forensic face recognition group is presented by A. K. Jain [11]. It highlights some of the problems and challenges in a field of forensic face recognition. It increases the attention and comprehension of important difficulties in forensic face recognition.
The problem for forensic face recognizing is that, a query picture (or a probe image) having low-quality is available, which is of an unidentified subject obtained from a source. In criminological face recognition, preprocessing methods receive face image as an input, and output an enhanced-quality face image. These methods are isolated into 2 main categories [12]. The first category uses preprocessing methods for enhancing the quality of a face image. The 2nd category designs special purpose face-recognition systems for a specific matching problem.

An algorithm which uses low resolution 3 dimensional sensor for robust faces recognition is presented in [13] under challenging conditions. A face recognizing algorithm designed for 3D sensors having low resolution consists of preprocessing stages for estimating canonical frontal view from non-frontal views. It requires only nose tip position. The proposed framework is evaluated on a publicly available dataset which results into recognition of faces under different expressions, poses, illumination and disguise using a single algorithm.

When a combination of Image Sharpening (IS), Active Illumination Equalization (AIE), Mirror Image Superposition (MIS), Standard Deviation Filtering (SDF) and Binary Particle Swarm Optimization (BPSO) is used, it increases the performance of FRS. An ideal recognition rate is obtained but still it has limitation for real time application [14].

For upgrading the FR system performance, a unique grouping of Contourlet Transform (CT), Discrete Cosine Transform (DCT) and Binary Particle Swarm Optimization (BPSO) is used with an effective technique of illumination normalization called selective truncation in DCT domain (ST-DCT) [15]. Results show the increased recognition rate.
The algorithm depend on Eigen face approach that represents PCA method is developed by A. A. Shinde, in which a small set of significant features are used to describe the variation between face images. It also cleared that recognition rate increases with increase in number of the training pictures per person. If the least distance between test imagery and other images seems to be zero, the test image entirely matches the image in the training base [16].

A comparative learning of face recognition system is presented [17] based on face restoration. It's performed in 2 successive steps, within the 1st step; two techniques for restoration of an image are used called Centralized sparse representation (CSR) and Adaptive Sparse Domain Selection with Adaptive Regularization (ASDS-AR). In the 2nd step, the set of techniques that have used are PCA, LDA, KPCA and KFA for recognizing a face. Results recommend that GLDA ensures most reliable verification rates for both techniques CSR and ASDS-AR.

Investigations of Content Based Image Retrieval (CBIR) of given face image is performed in transform domain. Features of the face image are extracted in the spectrum domain of particular transforms out of DCT, DWT, CT, and WHT. 4 face images databases used for the performance analyses of features selection methods. The retrieval rate is database dependent. DWT is the best according to retrieval rate while WHT is the best according to the speed of retrieval [18].

Active shape models (ASMs) are the statistical models that iteratively deformed to get fit to new image can be used in uncontrolled pose images. The Point Distribution Model (PDM) which is statistical shapes model, have constrained shapes to vary in only training group of labeled examples. Then weighted matching is applied between input image and database images. A noise reduction filter is also used in the image, which is used to eliminate single black pixel on white background. It's reliable for uncontrolled pose pictures [19].

2D-3D method of face-matching based on PCA algorithm with Canonical Correlation Analysis (CCA) is developed [20] to learn mapping in 2D face picture and the 3D face data. It used 2D face picture as a probe and the 3D face information as a gallery. CCA deal with 2 sets of information or data simultaneously, as compared with PCA and LDA. The classification and recognition results of modified CCA-PCA method are better to those of the CCA method.

A face recognition methodology based on a bag having geometrical features is proposed with Support Vector Machines (SVM), Genetic Algorithm (GA) and Minimum Redundancy Maximum Relevance (mRmR) with Mutual Information Difference (MID) and Mutual Information Quotient (MIQ). Experimental results indicated that these approaches tested with a linear SVM classification can be compared with holistic approaches recently developed [21].

To enhance the overall performance of FR systems 3 novel methods, viz., Face Detection based on 8-Connectivity-of-Skin-Region (FDCSR), Standard Deviation based Pose Detection (SDPD) and Gamma Ray Burst Rhombus Star (GRBRS) feature mask are proposed. FDCSR and SDPD are used as preprocessing steps. GRBRS is used to extract the salient features of the face on the Fast Fourier Transform (FFT). It is successful in handling pose variations [22].

A novel methodology, that simulates fixations and saccades mechanism in human perception visually, is proposed to deal especially with the face recognition in single image for each person problem [23]. This method outperforms significantly a state-of-art approach for the problems related to occlusion, which do not receive enough attentions compared with other challenging variations. In some extreme cases where the uncontrolled variations cause large deformations of the face, it achieves comparable performance with a much lower computational cost.

When PCA is analyzed and when its performance applied to the face recognition, it forms a subspace (face space) wherever the faces in a database are represented using a minimized number of the features called feature vectors [24]. PCA reduces large dimensionality data space into the smaller dimensionality feature space. It is fast, reliable but works much well in constrained environment. Result shows that PCA based methods provide higher representations and attain lower error rate for face recognition along with simple calculations and quick speed.

Studies show that fusion of numerous face modalities enhances performance as compared with single modal face recognition. IR (Infrared) face recognition can be promising, because it is closely invariant towards the illumination changes including the total darkness. But it could not provide the expected results. The performance using multiple modalities for face recognition is better than using a single one [25].

The current video databases of faces contain one subject in a video sequence. But, video sequences in real world are much challenging and generally contain more than one individual in a video which are used in actual applications such as face tagging, mobile phone, and time-attendance. In latest years, researches are going on designing video-based face recognition algorithms [26] in which three evaluation settings are used, Frame-to-Frame, Video-to-Frame and Video-to-Video Matching.

The face recognition applications can be combined with the fingerprint, finger-vein, iris or other biometric systems to increase their level of security. The research done by R. Singh and K. Gupta [27] has following objectives: to develop a hybrid algorithm for face recognition using skin color model with a fuzzy neural network, to implement and evaluate the model in MATLAB simulation environment.

An ideal normalizing method should be automatic, database independent and high-fidelity, where the face appearance must be preserved with little artifact and information loss presented for automatic detection, recognition of players. A learning-free High-Fidelity Pose and Expression Normalization (HPEN) algorithm is developed [28] which could recover canonical-view, expression-free images of good quality. The progressive performance is achieved in a constrained and an unconstrained environment.

The sparse representation based classification (SRC) improves the rate of face recognition. Smoothed l_0 algorithm has faster calculation speed with requirement of less measured values than other methods. The sparse representation and the smoothed l_0 algorithm are used for recognition to improve performance [29]. The result demonstrates that SRC $+l_0$ algorithm gives lower recognition rate than Gabor feature SRC, but is faster than GSRC.

A large scale, more difficult and large variability surveillance camera face database cater the need of tackling the problems related to face recognition and verification [30]. The images are captured and recorded with a controlled and an uncontrolled condition, with various imaging conditions. The database displays the operational variability in face pictures such as expressions, pose, occlusion.

A face recognition method is proposed to reconstruct a frontal face from the non-frontal face which when given a test image, automatically detects the face and facial features [31]. The mirroring operation is applied for frontal face reconstruction. It has an advantage that, it does not need training process, head pose estimation, 3D model generation, landmark point fitting, manual selection of landmark points.

The IJB-A protocol evaluates template pairs instead of evaluating image pairs, where a template is a set of one or more images which is more realistic use-case with multiple pictures of a single subject. Pose variability is handled by learning Pose-Aware Models (PAMs) for frontal, half-profile and full-profile poses. It applies the idea of multi-alignment to adjust the pose and remove pose variations [32].

3D Dense Face Alignment (3DDFA) framework proposed a solution for the problems of face alignment through large poses within which a dense 3D face model is fitted to the image via convolutional neutral network (CNN) [33]. 3DDFA skips the 2D landmark detection and starts from 3DMM fitting with cascaded CNN to handle the self-occlusion problem.

A method which reproduces individual 3D shapes from numerous single images of one person, judges their quality and then combines the best of all results is proposed [34]. The main aim of the work is a quality measure which judges a reconstruction with no information about the true shape. This method selects the most plausible reconstructions, operates on different region of the face separately, and merges them into a one 3D face.

The effect of changing illumination and the pose conditions within face recognition is addressed in [35]. The face regarding same person seems to be differing, under varying pose and illumination conditions. Actual details of image may vary tremendously, a 3D object when projected over a 2D surface. Principal Component Analysis is recommended as a tool for model based methods while 3 dimensional linear subspaces are used under class based approaches.

Optimized algorithmic chains are processed offering optimum classification accuracy while lower execution time [36]. Results show increased classification rates using algorithmic fusion. The face recognition algorithm for 2 dimensional and 3 dimensional face images using LBP operator and PCA algorithm with SVM classifier provided very good results, in terms of the recognition rates. Increased accuracy is detected for the 3 dimensional face recognition methods. Images with varying background cannot be used for this method.

A novel methodology for absolutely automatic expression recognition is presented in facial image sequences [37]. A prototypical sequence of expression is formed for every facial expression class by taking the median of the landmark tracking results from the training facial expression sequences. The AdaBoost learning algorithm is always used for boosting classification performance of simple learning algorithm.

An augmented reality application for sports broadcasting during play is developed and along with the personal information of players is displayed [38]. It used Adaboost algorithm with haar like features for the features selection and then for classification. Face recognition is performed using Adaboost with the LDA as weak learner and NNC. The performance of traditional LDA-based approach is improved by incorporating it in the boosting framework.

Suppose we've given a set of images, where every image contains many faces and is associated with a few names in the equivalent caption, the goal of face naming is to infer the proper name for every face [39]. It developed another distance metric learning technique named ambiguously supervised structural metric learning (ASML).

Traditional FR methods based on Visible Spectrum (VS) face some challenges like object illumination, pose variation, expression changes, and facial disguises which decrease the performance of object identification along with its verification. The Infrared Spectrum (IRS) is also used for human FR, in order to overcome every limitation [40]. But there are few limitations of IR face recognition such as eye glass problem, physiological problem etc.

4. APPLICATIONS

Here are plentiful application areas where face recognition methodologies are used.

- Security
- Surveillance
- General identity verification
- Criminal justice organizations
- Image database investigations
- “Smart Card” applications
- Video indexing
- Witness face reconstruction

5. CONCLUSION

The face recognition techniques have some limitations which are listed in the given table according to the factors like robustness to variations, processing speed, face recognition accuracy, and the cost for the overall system.

Table 1. Comparison of face recognition techniques

Methods / Factors	Feature-Based	Holistic	Hybrid	3D Model Based	Infra-Red Imagery
Robustness to variations	Pose, Size of Image, Lighting	Pose, Expression, Lighting	Pose, Expression, Lighting, Occlusion	Pose, Lighting	Sensitive to lighting
Speed	Moderate	High	High	Moderate	Slow
Accuracy	High	Moderate	High	High	Moderate
Cost	Low	Low	Moderate	High	High

Prevalent FR systems, which achieve good recognition rates for a wide range of variations, are computationally complex and use a lot of processing power and precious training and testing times. Also, they are limited to a certain domain of challenges and do not provide good recognition when faced with a wide range of challenges. Our main aim is to use an efficient face recognition method with the fusion (Holistic, Feature based) methodology of various algorithms like PCA, LDA, etc. along with neural network which achieves better face recognition results despite variations in pose, illumination, expression and disguise.

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