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Face Recognition Techniques: A Survey

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Abstract- Face Recognition technique is generally used for real time application. Reliability is the more important thing for security. Facial Recognition is rapidly becoming area of interest. Face biometrics is useful for authentication that recognizes face. In this paper survey of face recognition methods exhibit and discuss their pros and cons. The objective of this paper is to provide a survey of face recognition methods that appeared in the previous literature over the past decade and also differentiate them into meaningful approaches.

Keywords- Face Recognition, Knowledge-based, Feature-invariant, Template matching, Appearance-based, PCA, LDA

I. INTRODUCTION

A system requires authenticity to recognition the identification of an individual entity. The reason is to ensure that the services are accessed only by an authorized user and not else others. In Biometric, face recognition is depend on their behavioral characteristics of individuals. A biometric recognition system consists following four main Steps: [26]

1. Capture a Image : Image capture of a biometric trait
2. Feature Extraction: Module extracts the certain features from the biometric data
3. System Database: It stores the features extracted from biometric data.
4. Matching: module that matches the features extracted from the biometric imputed data with the features stored in the system database.

II. FACE RECOGNITION PROBLEM

However, the major Limitations of any facial Recognition algorithms are [10][37]

A. Facial Aging

In the human body, many changes occur with respect to the time and it can also be noticed on the face of the person due to hormonal and biological changes.

B. Accessoriness Used during input images

In a few cases, Peoples uses many accessories on their faces like goggles, specs, some type of nose ring, boys can have beard etc. these factors can effect on the result.

C. Pose Invariant

Face recognition with different facial poses that is known as pose problem. If face rotation made very big changes in face appearance it reduce recognition rate. If person try to match same image with different facial pose, it show the different result. [8] [52]

D. Lighting Conditions

The lightening conditions like background light, brightness, contrast, shadow etc. are not always same for the input. So the system must be smart enough to adjust these changes accordingly.

E. Plastic Surgery

In some special cases, due to some accidental reasons or so, many peoples have gone through the plastic or cosmetic surgery as a result of which the inputs of their faces can be unknown for the system.

F. Accidental Face Detection

Due to some emergency conditions or some accidents, the face of the victim damaged enough to lose his identity.

III. REVIEW OF FACE RECOGNITION METHODS

Face recognition methods divided into following four categories [5][14][29]

- Knowledge-based methods
- Feature-invariant methods
- Template matching methods
- Appearance-based methods

A. Knowledge Based Method

These are rule-based methods. They try to capture our knowledge of faces and translate them into a set of rules. It is simple to guess some easy rules. For example, a face usually has two symmetric eyes, and the eye area is darker than the cheeks. Facial features could be the distance between eyes or the color intensity difference between the eye area and the lower zone. The big problem with these methods is the difficulty in building an appropriate set of rules. If the rules are general then they are false positive. Furthermore, if the rules were too detailed then there false negatives. The solution is to make hierarchical knowledge-based methods to overcome these problems. These methods show themselves efficient with simple inputs. After all this method is very limited. It's unable to find many faces in a complex image. But, what happens if a person is wearing glasses? There are other features that can deal with that problem. For example, there are algorithms that detect face-like textures or the color of human skin. [7][29] It is very important to select the best color model to detect faces. A Few recent researchers use more than one color model. For example, RGB and HSV are used together successfully.[47]

B. Feature Invariant Method

Feature-invariant methods that try to find invariant features of a face despite its angle or position. This method Aim to find structural features of a face that exists even when the viewpoint, pose, or lighting conditions change. Facial recognition utilizes different features of the face – like: Mouth, Cheekbones, Nose, Eye, Chin, Lips, Forehead, Ears, Upper outlines of the eye sockets, the areas surrounding the cheekbones, the sides of the mouth, and the location of the nose and eyes. The distance between the eyes, the length of the nose and the angle of the jaw. [29] In this method we firstly, try to find eye-analogue pixels, so it removes undesirable pixels from the image. After performing the segmentation process, they consider each eye-analogue segment as a candidate

of one of the eyes. Then, a set of rule is executed to determinate the potential pair of eyes. When eyes are selected, the algorithm calculates the face area as a rectangle. The four vertexes of the face are determined by a set of method. So, the potential faces are normalized to a fixed size and orientation. Then, the face regions are verified using a back propagation neural network.

C. Template Matching Method

This algorithm compares input images with stored template of faces or features. Template matching methods try to define a face as a function. One can slap to search a standard pattern of all the faces. Each features can be defined independently.

For example, a face can be divided into eyes, face contour, nose and mouth. Also a face model can be built by edges.

But this method is limited to faces that are anterior. A face can also be represented in the shape pattern. Other templates use the relation between darkness and face regions in terms of brightness. These standard templates are compared to the input images to detect faces. This method is easy to implement, but it is incomplete for face detection. It will not give good results for variations in scale, shape and pose. However, deformable templates have been proposed to deal with these problems. [29]

D. Appearance-Based Methods

The models are learned from a set of training images that capture the representative variability of faces. The templates in appearance-based methods are learned from the examples in the images. In general, appearance-based methods rely on techniques from machine learning and statistical analysis to search the relevant features of face images. These techniques are also used in feature extraction for face recognition.

a) Eigenface based Methods - PCA Algorithm

In this method, the original scheme for determination of the eigenfaces using PCA will be representing. A detailed (and more theoretical) description of PCA can be found in [1] [11][16][18][43].

Step 1: Prepare the data

The faces constituting the training set (Γ_i) should be prepared for processing.

Step 2: Subtract the mean

Average matrix Ψ has to be calculated, then subtracted from the original faces (Γ_i) and the result stored in the variableϕ_i:

$$\Psi = \frac{1}{M} \sum_{n-1}^{M} \Gamma_n \qquad (i)$$

$$\phi_i = \Gamma i - \Psi \qquad (ii)$$

Step 3: Calculate the covariance matrix

In step three, the covariance matrix C is calculated according to

$$C = \frac{1}{M} \sum_{n-1}^{M} \Phi_n \Phi_n^T \qquad \text{(iii)}$$

Step 4: Calculate the eigenvectors and eigenvalues of the co-variance matrix

The eigenvectors (eigenfaces) $\mathcal{U}_i$ and the corresponding eigenvalues λ_i should be calculated. The eigenfaces must be normalized so that they are unit vectors, i.e. length 1. The description of the exact algorithm for determination of eigenvalues and eigenvectors is eliminating, as it belongs to the standard arsenal of most math programming libraries.

Step 5: Select the principal components

From M eigenvectors (eigenfaces) $\mathcal{U}_i$, only M^0 should be chosen, which have the highest eigenvalues. The higher the eigenvalue, the more characteristic features of a face does the particular eigenvector describe. Eigenfaces with low eigenvalues can be omit-ted, as they explain only a small part of characteristic features of the faces.

After M^0 eigenfaces $\mathcal{U}_i$ are determined, the" training" phase of the algorithm is finished

b) Distribution based Methods – LDA Algorithm [23]

LDA also called as Fisher's Discriminant Analysis. This is another dimensionality reduction technique. It is an example of a class specific method i.e. LDA maximizes the between – class scattering matrix measure while minimizes the within – class scatter matrix measure, which make it more steady for classification.[23]. Lih-Heng Chan [38] proposed a framework of facial biometric was designed based on two subspace methods i.e., Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). First, PCA is used for dimension reduction, where original face images are projected into lower-dimensional face representations. Second, LDA was proposed to provide a solution of better discriminant. Both PCA and LDA features were presented to Euclidean distance measurement which is conveniently used as a benchmark. LDA-based methods outperform PCA for both face identification and verification. Fisher faces are one the most successfully widely used method for face recognition. It is based on appearance method. In 1930 Fisher developed linear/fisher discriminant analysis for face recognition which shows successful result in face recognition process [52]. The limitation of LDA is that within the class scatter matrix is always single, after all the number of pixels in images is larger than the number of images so it can boost detection of error rate if there is a variation in pose and lighting condition within same images. So to overcome this problem many algorithms has been proposed. Because the fisher faces technique uses the advantage of within-class information so it minimizes the variation within class, so the problem with variations in the same images such as lighting variations can be overcome [39].

IV. COMPARATIVE STUDY OF DIFFERENT FACE RECOGNITION METHODS

Table 1. Comparative Study of Different Face Recognition Methods

Face Recognition Methods	**Knowledge-Based Methods**	**Feature-Invariant Methods**	**Template Matching Methods**	**Appearance-Based Methods**	
				Eigenface-Based Methods	**Distribution Based Methods**
Overview of the Methods	1. Encode human knowledge of what constitutes a typical face (usually, the relationship between facial features) 2.Capture our knowledge of faces, and translate them into a set of rules 3.Ruled-based methods	1. Aim to find structural features of a face that exist even when the pose, viewpoint, or lighting conditions vary 2. Distinctive features of the face like Mouth, Nose, Eye, Cheekbones, Chin, Lips, Forehead, Ears	1. Several standard patterns stored to describe the face as a whole or the facial features separately 2. Compare input images with stored patterns of faces or features 3. Different features can be defined independently for example; a face can be divided into eyes, face contour, nose and mouth. Also a face model can be built by edges	1. Based on Principal Component Analysis (PCA reduces the dimension of the data) 2. Create an image subspace (face space) which best discriminates between faces like faces occupy near points in face space. It Compare two faces by projecting the images into faces speed and measuring the distance between them.	1. Based on Fisher's Linear Discriminant Analysis (LDA maximizes the between-class scatter LDA minimizes the within-class scatter) 2. Fisher faces Uses „within-class" information to maximize class separation.
Benefits of the Methods	1. Easy to come up with simple rules 2.Based on the coded rules, facial features in an input image are extracted first, and face candidates are identified 3.Work well for face localization in uncluttered background	1. Features are invariant to pose and orientation change 2. find invariant features of a face anyway of it's angle or position.	1. simple to implement	1. Relatively simple 2. Fast 3. Robust 4. Work well with high dimension	1. Faster than eigenfaces, in some cases 2. Has lower error rates 3. Works well even if different illumination 4. Works well even if different facial express

Limitation of the Methods	1. Difficulty in building an appropriate set of rules 2. Difficult to translate human knowledge into rules precisely: detailed rules fail to detect faces and general rules may find many false positives 3. Difficult to extend this approach to detect faces in different poses: implausible to enumerate all the possible cases.	1. Facial expression 2.Difficult to locate facial features due to several corruption (illumination, noise, occlusion) 3. Difficult to detect features in complex background	1. Limited to faces that are frontal. 2. A face can also be represented as a shape. 3. Templates needs to be initialized near the face images 4.Difficult to enumerate templates for different poses (similar to knowledge-based methods) 5. It cannot achieve good results with variations in pose, scale and shape	1. Different head pose 2. Different alignment 3. Different facial expression	1. Small databases 2. The face to classify must be in the DB 3. Can't work well with high dimension

V. BENEFITS OF BIOMETRIC FACIAL METHODS [7][8]

A. No More Time Fraud

Due to face biometric systems in your Industry or organization is that you won't have to worry about time fraud. A person can be identified or rejected in a matter of seconds. It will be impossible for buddy punching to occur, since everyone has to have their face scanned to clock in.

B. Better Security

You'll also enjoy better security with a facial biometrics system. Not only can you track employees, but any visitors can be added to the system and tracked throughout the area too. Anyone that is not in the system will not be given access.

C. Automated System

Many companies like the fact that biometric imaging systems are automated. You won't have to worry about having someone there to monitor the system.

D. Easy Integration

Biometric facial systems are also easy to integrate into your company. Usually they will work with existing software that you have in place.

E. High Success Rate

Facial biometrics technology today has a high success rate, especially with the emergence of 3d face recognition. It is extremely difficult to fool the system, so you can feel secure knowing that your system will be successful at tracking time and attendance while providing better security.

F. User Friendly Systems

Biometrics Systems is easy to install and after that, we can do job quickly, reliably and uniformly. We need only a minimum amount of training to get the system operational and there is no need for expensive password administrators.

G. Convenience

It's considered to be a convenient security solution because you don't have to remember passwords, or carry extra badges, documents, or ID cards. People forget passwords and ID cards are lost, which can be a huge headache with traditional security methods.

VI. CONCLUSION

This paper has tryout to survey a significant number of papers to cover the recent development in face recognition field. Present study exposes that face recognition algorithm can be enhanced using hybrid methods for better performance. The list of references to provide more detailed understanding of the approaches described is enlisted. We apologize to researchers whose important contributions may have been overlooked.

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