STUDY OF COMPUTER AIDED FACE RECOGNITION METHODS IN CONSTRAINED AND UNCONSTRAINED ENVIRONMENT

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Abstract

Tools of face recognition methods have its own advantages and disadvantages making face recognition a challenging task for image analysis. Under constrained environment the analysis becomes easy. Whereas under the unconstrained environment the tasks become more challenging due to various factors like illumination, facial expressions and poses, changes in the face contour because of age and many other factors. These factors hinder the extraction of features of facial expression making it much harder to recognize. This paper has compared the different classification methods for both constrained and unconstrained face recognition which enable the researchers to opt for suitable methods according to their needs.

Keywords: Face recognition, constrained, unconstrained, FRT, PCA, LDA, Face recognition Methods.

1. BACKGROUND

Digital facial image is used to recognizing an individual in face recognition. Recognition of face done in our day to day activity by humans is not a challenging task, as humans can correlate the known vs. unknown easily. But the challenge in face recognition through machine is facial geometry recognition. The number of work done by National Institute of Standards and Technology (NIST)¹ for the past 20 years which has been set as benchmark for face recognition techniques. The technique named Face recognition techniques (FRT) has been able to recognize 92% of the unknown faces have been successfully recognized. This accuracy is under the constraint environment where the factors like illumination are controlled. Therefore
the images collected with careful cooperation, FRT has been more accurate. To identify any individual in an unconstrained environment is still a challenge for facial recognition reliability. When variations are found in facial pose, illumination, and expression, FRT performance deteriorates significantly. Factors like compression of images, obstruction, shadows, blurring etc lead to fall in accuracy of the face recognition.

2. AUTOMATED FACIAL RECOGNITION

Automated face recognition is considered as a pattern matching problem where the position of eye, ear, nose, facial outline are compared and matched. This comparison is done between the probe and gallery facial images probing the similarity and thus finding the true match. Non linearity is a major challenge in this pattern matching. Non linearity is something called as variation like variation in the lighting condition or variation in illumination. Different images are captured in different variation of light. In Ref Figure- 1, the process of Automatic Face recognition System has been explained. Here in above figure any object or person image is an input which is input to any face detector. Face detector will detect the face from the image then particular detector will check that is face aligned? If face is not aligned as per the requirement then face of that particular image will aligned as per requirement of the author. As the face is aligned then feature will extract from that particular image by applying different algorithm. Features like eyes, nose, and ears. After the feature extraction feature matching is done, is there any matched feature or In other words desired output is achieved or not from the process.

Face recognition systems through face detectors are capable of achieving satisfactory results in constrained environments however when it is applied in unconstrained environment the detection rate gets reduced to about 50-70%. In addition to this approximately 3% faces are detected false positive. Due to fact there should be some novel methods that can improve upon the performance of Face Recognition systems in unconstrained environments.
The face recognition done by we humans in our daily life also work on the same technique where we see the face of any object and try and extract the features like height, color, eyes, hair, position of the nose etc and try to match these features with the features of the persons stored in our memory. Once we find a match, we can recognize the person or the object we are looking at. The same technique is applied in automated face recognition.

Face recognition is based on two essentials factor that is individuality and matching in order to differentiate between two faces. Individuality may be described as the possibility of bio-metric patterns within a group may be identical. In other words the individuality is a measure of the possibility that how a given pattern is identical against the target population. However, while measuring the individuality of sample by facial geometry, the major problem faced is the insufficient availability of statistical analysis.

3. TOOL USED

- Matlab
- OpenCV
- Theano
- Tensorflow
- Caffe
- OpenFace
- DeepFace
- NVidia Tesla K40
- Amazon Mechanical Turk

FACE RECOGNITION TECHNIQUES

The face recognition techniques can be put under two different heads namely

i) Appearance based method

ii) Model based methods

The following figure shows the classification of face recognition technique (Figure- 2)

3.1 Appearance-based Face Recognition Methods:

3.1.1 Linear Appearance-based Face Recognition Methods

1. Principal component analysis (PCA): PCA is defined as Principal component analysis. It is well liked method in the field of extracting the feature and representing the data which helps in reducing the dimension of the image and retains
the variation of the images, which results in compressed demonstration of face image. The solution plan of the PCA method is to renovate the face images into a tiny set of character feature images, known as Eigen faces which are the foremost mechanisms of the preliminary training set of the face images. PCA yields projection directions that make the most of the total scatter across all face images.

2. Linear discriminant analysis (LDA)\textsuperscript{8,9}: Drawbacks of Principal component analysis technique is overcome by LDA using linear discriminant criterion. LDA is an influential face recognition technique used for face recognition. The linear discriminant criterion make best use of the ratio of the determinant of the class scatter matrix of the expected population to the determinant of the within class scatter matrix of the expected population. Different face classes can be discriminated by this technique.

3. Independent component analysis (ICA)\textsuperscript{10,11}: One of the familiar method for generating space localized features is to apply independent component analysis to generate origin vectors that are statistically autonomous and linearly co-related with PCA\textsuperscript{12}. Independent Component Analysis is used to minimize second-order and higher order dependencies in the input image to find the basis along which the data are statistically independent. Blind source separation (BSS) problem is closely related to ICA, where the objective is to decay an experimental signal to a linear arrangement of not known self-sufficient signals.

3.1.2 Non-Linear Appearance-based Face Recognition Methods

1. Kernel Principal Component analysis (KPCA)\textsuperscript{13}: Kernel PCA allows us to take a broad view usual PCA to nonlinear dimensionality reduction. Through non linear mapping idea the input space is transforms into a feature space and then calculates the major components in that feature space. KPCA is a development of the PCA method.

2. ISOMAP: ISOMAP is developed based on minimizing the
reconstruction error with multi-dimensional scaling; it may not be optimal from classification viewpoint.

3. Locally Linear Embedding (LLE): For learning and classification, LLE uses a distinct procedure to the problem by applying dimensionality-reduction to the data. The main goal behind this procedure is to identify a locally-linear fit by which each data point can be illustrated by a linear combination of its closest neighbors.

3.2 Model-based Face Recognition Methods
3.2.1 2D – Model Based Face Recognition Methods
1. Elastic Bunch Graph Matching (EBGM): Firstly define the structure of the graph for desired pose. First image is taken and by hand defining the node locations on the face that are easy to focus, like corners of the eyes or mouth, the center of the eyes, the tip of the noise, distance between two eyes. This face graph is made for one instance or the data is recorded for one face. If the same is matched with the second image may be both the faces will different so accuracy degrades. So for that reason number of instances are created and bunch graph is created. As it become rich by the time that new image is created using the bunch graph this is called Elastic bunch graph matching.

2. Active Appearance Model (AAM): When the term accurate locating objects comes in existence the Active Appearance Model (AAM) is used by the researchers. In this model large amount of face images with various shapes are collected for the training of the machine. Different set of point is used to explain the face shape so that objects can be located accurately.

3.2.2 3D – Model Based Face Recognition Methods
Face analysis is done using 3D Morphable Models. Single facial image as input is passes to 3D Morphable Models because the intrinsic properties of 3D faces provide a representation that is immune to intra-personal variations such as pose and illumination. When a facial input image is provided to 3DMM, it can recover shape and texture of 3D face along with its properties.
such as illumination and pose through a fitting process.

4. CHALLENGES

The major challenges in the area of face recognition which lead to the fall in accuracy or higher error rates are the following:

1. Illumination: Factor of light on the probe image hinders in the feature extraction of the face. This occurs when the light in the image is less than the required. Research work for this challenge has been done by Adini Y., et.al, Gross R., et.al and Zou X., et.al.\(^{18,19,20}\).
2. Occlusion: Obstruction that hinders the appearance of the face may be deliberate or natural. These could be because of the probe image wearing sun glasses, scarfs, cap etc when the image was being clicked. These obstructions do not allow the feature extraction properly thus leading to higher false positives. The work to overcome this challenge has been done by Wright J., et.al. Kim J., et.al.\(^{21,22,23}\).
3. Expression: When the face expression of any person changes accordingly facial geometry of that person also changes which further influence the face recognition accuracy. Technique used for this is Local region-based or patch-based. Research to overcome this challenge has been done by Li et al.\(^{24}\) who proposed an expression invariant face recognition method.
4. Age: With the change of age the facial texture shape also change by changing the geometry of the face from infant to teen age to adulthood and so on. Age invariant feature descriptors named as Gradient Orientation Pyramid (GOP) has been proposed by Ling, H., et al and Ramanathan, N., et al.\(^{25,26}\).
5. Pose: Out of plane rotation of the image like the object not directly looking at the camera is a major a challenge found in face recognition systems. Zhang W., et.al and Ahonen T., et.\(^{27,28}\). EBGM and LBP are the local region based approaches which is proposed by the author. (Table-1)

CONCLUSION:
The face recognition is a challenging area where in the hindrance is posed by
illumination, Occlusion, expression, age and poses. The tools available are under the constant challenge of these factors as the face recognition area requires feature extraction and feature selection which provides the efficiency and accuracy of face recognition problem.

REFERENCES:
1. www.nist.gov
10. B. Draper, K. Baek, M.S. Bartlett, and J.R. Beveridge, Recognizing faces with PCA and ICA, Comput Vis Image Understand (Special Issue on Face Recognition) 91 (2003), 115–137


17. J. Huang, B. Heisele, V. Blanz, Component-based Face Recognition with 3D Morphable Models, Proc. of the 4th International Conference on Audio- and Video-Based Biometric Person Authentication, AVBPA 2003, 09-11 June 2003, Guildford, UK, pp. 27-34


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Figure- 2. Face recognition techniques\(^4\): Classification

![Face Recognition Diagram]

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