PROPOSAL OF A HYBRID SYSTEM FOR POSE INDEPENDENT FACE RECOGNITION

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***Abstract*—Face recognition is an important field in image processing. However, most of the face recognition methods found today can recognize a face only if the face has frontal view. To overcome this flaw, the techniques of face recognition can be combined with the techniques of face frontalization, to recognize a face of any angle from the frontal view alone. This type of recognition has many real time applications like recognizing a person in a CCTV camera, auto tagging feature in Smartphone etc. Thus, this paper discusses about various face recognition and face frontalization techniques and our proposed two stage hybrid system. A brief description is provided about the methods. Then the results of these methods are evaluated and the methods are compared with each other and the methods to be incorporated into the system are selected.**

***Keywords*—Face Recognition; Image Processing; Computer Vision; Front Face Generation; Side Face; Face Angle.**

I. INTRODUCTION

Facial Recognition Systems, which has umpteen number of applications in the field of security and human computer interface, are basically built of few highly innerconnected methods and components. Nowadays, the computer vision capabilities have surpassed those of humans but even it faces problems when the inputs are from unconstrained and real-world scenario. To overcome these problems various improvisational methods of face frontalization and face recognitions are applied. Facial recognition (or face recognition) is a type of biometric software application that can identify a specific individual in a digital image by analyzing and comparing patterns. Frontalization can be defined as the process of synthesizing frontal facing views of faces appearing in an unconstrained photo and Recognition is the process of finally identifying the person or object in the photo[1].Face frontalization refers to the recovery of the frontal view of faces from single unconstrained images. Accurate face frontalization is a keystone for many face analysis problems. For example the recent success in face recognition in unconstrained conditions would not be possible without a meticulously designed face frontalization procedure [2].

These mentioned above are building blocks of a recognition system and there are various methods for the same. A detailed comparative study of three famous methods of face frontalization and three face recognition methods is made according to different factors such as accuracy, overhead and time.

II. FRONT FACE GENERATION

A. Effective face frontalization in Unconstrained Images

In the specified method [1], a simple approach is used, wherein a single unmodified 3D surface is used as an approximation of input faces. It is very efficient and forms aesthetic new frontal views and are used for face recognition and gender estimation. The face is detected with the help of an off-the-shelf face detection technique and then rescaled and cropped to a standard coordinate system. Facial feature points are localized and used to align the photo with a textured, 3D model of a generic, reference face. A rendered, frontal view of this face provides a reference coordinate system. An initial frontalized face is obtained by back-projecting the appearance (colors) of the query photo to the reference coordinate system using the 3D surface as a proxy. A final result is produced by borrowing appearances from corresponding symmetric sides of the face wherever facial features are poorly visible due to the query's pose. "Render" function- is used to render a ref. view and produce the 2D-3D correspondences, "calib" function- to estimate the projection matrix. 3D face geometry is taken from USF Human-ID database collection, face feature detection-using the SDM method. The total running time is approx 0.04 seconds.

B. Construction of Frontal Face using Face Mosaicing

In this method [3], frontal image is constructed from a person's available side-view images using face mosaicing. In the first step, an off-the-shelf eye-brow detection algorithm allows us to detect the eye-brow along with its position i.e. left or right. Now, by using this result it is possible to detect whether the given image is a left or right facing view of a face. In the next step, by using the length of the face and a face edge detection algorithm the facial areas are identified and extracted. Then, alignment mechanism using eye-brow leveling is used to mosaic them to construct the frontal face image. Finally, using geometrical transformation, the eyes are shifted to make it an almost perfect front facing view of the given face. Also an approximation of the frontal face from a single side-view image can be generated by cutting it according to the previous method and copying the same half into the second half. Experimental results show that frontal face images may be easily constructed and those images can be used further for face recognition. The process used for generating images is computationally fast.

C. Face frontalization for alignment and Recognition

Face Landmark Localization and Frontal Face Reconstruction [4] are combined together using a set of frontal images only. The paper proposes an appropriate model which can recover facial traits as well frontalized version of the face.

- A sparse error matrix is created that indicates the corrupted pixels of the pose invariant image.
- Now, one can find low-rank frontal image, linear combination coefficients and the error matrix.
- Then the image is normalized and Jacobian Matrix is created.
- The algorithm terminates when the change between two successive iterations is smaller than the threshold level.
- The Lagrange multipliers are then updated.
- The convergence conditions are then checked and the low rank images are produced.

Various experiments conducted on the FERET database show that the algorithm is better than LGBP, 3DPN, PIMRF, PAF, which are the most widely used methods in pose invariant face recognition. The paper even claims to be the first generic landmark localization method which achieves face frontalization, using a model of frontal images only.

Factor	**A**	**B**	**C**
Database used	AR and LFW databases	The Indian database	FERRET, MultiPIE and AFW databases
Accuracy	0.92	Unspecified	0.98
Method used	3D face shape estimation	Face Edge detection and mosaicing	Face landmark localization and frontal face reconstruction
Limitation	No specific disadvantage	High degree of rotation and distorted eyebrows	Angle of faces between -30 degrees and +30 degrees

Table 1. Comparison of Front Face generation techniques

III. FACE RECOGNITION

A. Face Recognition with Deep Learning

[5] Deep learning in particular Convolutional Neural Network is used for face recognition. Public database of LFW is used to train these CNN's and then the paper compares the working of different CNN architectures. Convolutional neural network (CNN) rebranded as 'deep learning' has achieved very impressive results on face recognition in unrestrained environment. CNN's are trained using LFW public database and to improve the discrimination between them, metric method is used. Three architectures of CNN's are compared, according to the size of their database, namely, CNN-small CNN-medium and CNN-large. The activation function used is Rectification Linear Unit. During training, the learning rate is set to0.001 for three networks, and the batch size is fixed to 100.Metric Learning is used and implemented through the Joint Bayesian Model.
For evaluation, LFW contains 5,749 subjects and 13,233 images. LFW is divided into 10 predefined splits for 10-fold cross-validation. Each time nine of them are used for model training and the other one (600 image pairs) for testing. The required images used are aligned by deep funneling and cropped to 58X58 based on the coordinates of two eye centers.

The face recognition rate is evaluated by mean classification accuracy and standard error of the mean.

B. Face Recognition using PCA method

This paper [6] aims to recognize faces using PCA based face recognition technique. PCA uses the concept of eigenvectors and eigenvalues. If there are N sample images, then N-1 eigenvectors and eigenvalues are used to represent the face. Low order eigenvectors have higher variation while high order eigenvectors have lower variance. Thus high order eigenvectors are discarded assuming it to be noise. Eigenface components are used to represent pictures. Eigenfaces are nothing but eigenvectors of the covariance matrix of a set of images. Linear combinations of Eigenfaces are used to represent each individual face. The number of principle components (k) to be used is given by:

$$\frac{\sum_{i=1}^{k}\lambda_i}{\sum_{i=1}^{M}\lambda_i} > Threshold$$

Various steps now need to be performed to recognize the image. A vector is obtained by projecting test image onto a face space. Calculate distance between vector and face class denoted by € .A distance threshold (ɵ) is calculated which is defined as half the distance between original image and reconstructed image. If € > ɵ, then images don't match. If € < ɵ then image matches. This is how face recognition using PCA method works.

C. Adaptively Weighted Sub pattern PCA

The method [7] is based on Sub pattern Principal Component Analysis. The main idea behind the method is that, different parts of human face have different discrimination capabilities when considering facial variations. Adaptively weighted sub-pattern PCA attempts to overcome face illumination condition and facial expression variations. It first divides the face image into sub faces and carries out PCA computation on each sub area independently. After this step, the contribution factor of each local area is adaptively computed. This contribution factor is later incorporated into final classification decision. The mean face of training input was the base used for finding this contribution factor. For the classification stage, input image is also partitioned into sub-patterns and each sub-pattern is classified individually. Finally, the expected contribution of classification result of all sub-patterns is incorporated to generate the classification result. Experimental results in [7] show that AW-Sp PCA is highly effective for recognition, it also outperformed traditional PCA, Modular PCA and Sub pattern PCA. A system to successfully recognize faces can be developed with the help of Aw Sp PCA and a Hebbian learning model.

Factor	**Deep learning**	**Aw – Sp PCA**	**PCA**
Method	Metric Learning using CNNs.	Sub pattern PCA with Hebbian Learning	Principal Component Analysis using Eigen values
Accuracy	0.8669 to0.8829	0.8788 to 0.9675	0.8410 to0.9545
Face illumination and face expressions	Does not overcome	Overcomes this crucial problem	Can be overcome using LDA
Database used	LFW database	Yale, AR and ORL database	University of Essex and Indian Face database

Table 2. Comparison of Face Recognition methods

IV. OUR PROPOSED METHOD

Our proposed method includes a combination of Face Recognition and Face Frontalization.

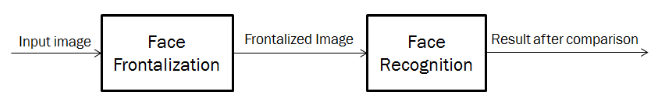

Fig 1. Proposed Hybrid Model

As described in the diagram, the input image will be first frontalized. This frontalized image will then be passed on to face recognition module. This module then, compares the frontalized image to the images stored in the database and displays the result accordingly. For face frontalization we use the method of 3D Face Estimation [1]. Here, the input image is mapped onto a 3D reference model. This reference model is then projected as 2D face using transformation techniques of rotation and translation. Then the 2D face is generated. This image is then sent to face recognition module. We are using adaptively weighted Sub-pattern PCA. [7] Here, the image is subdivided into number of regions. Then based on the importance of each region in face recognition, the regions are assigned weights. Then, depending on which region of the input image matches the corresponding region of test image, the input is classified. Here, we use Aw sp-PCA because when we create the frontalized, there is a possibility that some parts of the image which are generated might be distorted. To reduce the effect of distortion, the weights prove to be very useful. Overall, we believe by using this method, we can overcome various problems like uneven illumination, expression variation, pose and angle variations that exist in current methods.

V. CONCLUSION

The field of image processing is expanding its horizons for the domains of human computer interaction, robotics and biometrics. Pose invariant face recognition provides applications in all these fields. It becomes possible to generate a front facing image of each person and then follow a competent face recognition algorithm to compare it with images in a database. This system would mark the threshold of contemporary modules which would overcome the problems associated with the traditional face recognition system. Our future work will focus on implementing the proposal to achieve competent accuracy against the contemporary systems.

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