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FACE RECOGNITION UNDER OCCLUSION BY FACIAL ACCESSORIES: A REVIEW

Thazheena T, Aswathy Devi T

Abstract— **Face recognition technique plays an important role in security applications for automatically identifying and verifying a person from an image or from a video sequence in the surveillance area. Although significant progress has been made in face recognition technology, it is still suffering when facing uncontrolled environments such as occlusions, drastic illumination changes, facial pose variations etc. Occlusion detection in face recognition system is an essential problem nowadays. The facial landmark hidden by some object is termed as facial occlusion. Facial occlusions are mainly caused due to the presence of sunglasses, cap, scarf, mask etc which degrades the performance of a face recognition system. Face is one of the most important human's biometrics used in every day human communication which plays a major role in conveying identity. Face recognition is the process of identifying one or more people in images or videos by analyzing its. The goal of face recognition system is to recognize faces in still image and image sequence from video, robustly as possible to the image variations such as illumination, pose, occlusion, expression, etc. The goal of this paper is to discuss various literature works which are used for the purpose of recognition of face under partial occlusion. In this paper, we first present an overview of face recognition and thereafter we represent various face recognition techniques.**

***Index Terms*— Face recognition, PCA, LBP, NN, MBWM, EMP**

I. INTRODUCTION

Face is one of the most important human's biometrics which is used in every day human communication and due to some of its unique characteristics plays a major role in conveying identity.

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***Thazheena T,** PG Scholar, Dept. of ECE, LBS Institute of Technology for Women, Kerala, India*
***Aswathy Devi T,** Assistant Professor, Dept. of ECE, LBS Institute of Technology for Women, Kerala, India*

Face recognition is the process of identifying one or more people in images or videos by analyzing it, which is an important part of many biometric, security, and surveillance systems. There are several problems that make face recognition a very difficult task. Face recognition technology is a well advanced one that can be applied for many commercial applications such as personal identification, security system, image-film processing, computer interaction, entertainment system, smart card, surveillance and so on which is tabulated here in Table.1.

SL. NO	AREAS	SPECIFIC APPLICATIONS
1	Information Security	Database Security, Desktop Logon, Intranet Security, Medical Records, Internet Access, Network Security
2	Biometrics	Voters Registration, National ID Cards, Drivers License, Passports, Entitlement Programs
3	Law Enforcement And Surveillance	CCTV Control, Advanced Video Surveillance, Suspect Tracking And Investigation, Portal Control
4	Access Control	Facility Access, Vehicular Access
5	Entertainment	Video Game, Virtual Reality, Human-Robot-Interaction, Human-Computer-Interaction
6	Identity Verification	Banking Field, Electronic Commerce

Table 1: Typical Applications of Face Recognition

Face recognition technology is still suffering when facing uncontrolled environments such as occlusions, drastic illumination changes, facial pose variations etc. The goal of face detection system is to

detect a face robustly as possible to the image variations such as illumination, pose, occlusion, expression, etc. Partial occlusion has been found in many areas of image processing. Occlusion can be of two types, i.e. natural occlusion and synthetic occlusion. Natural occlusion refers to obstruction of views between the two objects in an image without any intension while synthetic occlusion refers to artificial blockade of intentionally covering the image's view. Facial occlusions can thus degrade the performance of face detection systems. Therefore, robustness to partial occlusions is thus crucial in nowadays. To develop an efficient face recognition system several factors must be considered such as the speed of the system from face detection to face recognition, the accuracy of recognition and finally the system should be easily upgradable based on the progression in technology.

II. BASIC FACIAL RECOGNITION SYSTEM

Face recognition system can be performed with both the still images and image sequence from a video. The two basic applications of a face recognition system are identification and verification process. In the identification problem, the face to be recognized is unknown and matched against face of a database containing known individuals. In the verification problem the system confirms or rejects the claimed identify of the input face. Basic face recognition system which consists of four steps such as face detection, face alignment, feature extraction and face matching is shown below in Fig 1.

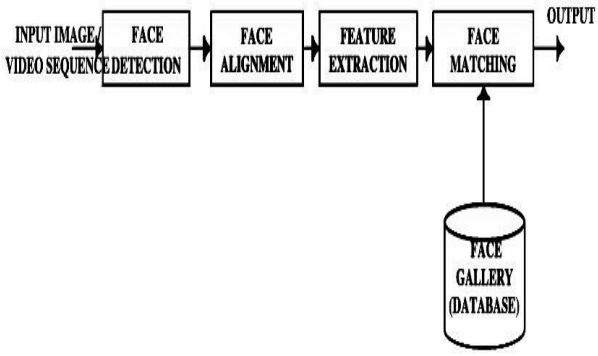

Fig 1: Face Recognition System

However, before face recognition is performed, the system should determine whether there is a face in a given still image or image sequence of video or not. So, the first step in face recognition system is to detect the face in an image which is termed as face detection process. If the face is present, then it returns the location of the image. Pre-processing steps are done for removing the noise. Pose variations, Facial expression; Occlusion, etc are various factors which makes the face detection a challenging task. The second step is the face alignment process where the facial image obtained from the detection step is aligned for achieving accurate normalization and localization. Next comes the feature extraction process where it detect the presence and location of facial features such as nose, eyebrow, eyes, lips, nostrils, mouth, ears, etc. The last step is the face matching process where the extracted features are compared with the features stored in the gallery of images and then the corresponding output is obtained. The input image is also called as probe image and the database is called as face gallery. When considering the case of face recognition under partial occlusion condition, the probe image with occluded face is detected first and all the remaining steps are done in the detected image.

The face recognition methods can be classified into following category:

- ❖ Structural / Feature base approach
- ❖ Holistic approach
- ❖ Hybrid approach

A. Structural / Feature base approach:

In feature based approach, the local features like nose and eyes are extracted and it can be used as input data for structural classifier for making the task of face recognition easier. Feature base approach can be further classified into generic, template based and structural matching method. Hidden Markov model and dynamic link architecture methods belong to this category.

B. Holistic approach:

In holistic approach, the entire face is taken as the input for face detection system to perform face recognition. Examples of holistic methods are eigenfaces, fisherfaces, support vector machines and independent-component analysis approaches. They all are based on principal component-analysis (PCA) techniques which can be used to simplify a dataset into lower dimension by retaining the characteristics of dataset.

C. Hybrid approach:

Hybrid approach is combination of feature based and holistic approach. In this approach both local and entire faces is used as the input to face detection system and are generally used for 3D face recognition.

III. TECHNIQUES USED FOR FACIAL RECOGNITION UNDER OCCLUSION

In [1], Zhaohua Chen, Tingrong Xu, and Zhiyuan Han have solved the problem of face recognition under occlusion due to sun glasses or scarves. They propose a new approach which first detects the presence of sunglasses or scarves and only the non- occluded region was processed here. Occlusion detection can be obtained by selecting non occluded patches from the faces by using Principal Component Analysis (PCA) and Support Vector Machines (SVM) while the recognition of the non-occluded portion is done with the help of block-based weighted Local Binary Patterns (LBP). For detecting the occluded region in the face, the image is sub-divided in to finite number of patches and each patch was examined separately. They have divided faces in to 6 symmetrical patches since the configuration and size of the patches are important in the performance of occlusion detection. Occlusion detection is done for each local patch independently with the help of an effective classifier. Since each local patch is still a high dimensional vector which makes computation infeasible, they deal with each patch image in a low dimensional subspace after the dimension reduction using PCA. Thus six PCA subspaces are obtained correspondingly to the 6 local patches of non-occluded faces. After the dimension reduction operation they estimate the six patches of the face image whether it is an occlusion patch. Support Vector Machine (SVM) classifier which is based on the principle of structured risk minimization is used for classification purpose in this approach since SVM finds an optimal hyper plane to separate data into two classes. For the recognition process, the basic LBP operator assigns a particular value for each and every pixel of an image by thresholding its P neighborhoods on a circle of radius R centered on the pixel with its intensity. As a result of this thresholding, each pixel has P-bit binary code. The histogram of this P-bits binary code can be used as face descriptor and for an efficient representation; LBP histograms are extracted from the non-occluded patches respectively, and concatenated to build a global description of the face. For obtaining the performance of the rest of the regions, they performed a set of experiments on different parts of the face which indicates that the accuracy of the facial recognition in different places is different.

Rui Min, Abdenour Hadid and Jean-Luc Dugelay proposed a robust face recognition approach under occlusions in [2] which first detects the presence of scarf/sunglasses in the image and then process the non-occluded facial regions. Occlusion detection is done by using Gabor wavelets, PCA and Support Vector Machines (SVM), while the recognition of the non-occluded facial part is performed using block-based Local Binary Patterns (LBP). During the training phase, local binary patterns (LBP) were used to represent the gallery images (face templates), thus obtaining an LBP feature space. For occlusion detection, they divide the probe image into number of facial components and each of the components is individually analyzed by an occlusion detection module. The number and the shape of the components are determined by the nature of the occlusions. Since this approach focus on detection of scarf and sunglasses, they divide the entire image into two equal parts. Once the face is sub divided into two facial components, Gabor wavelet features are extracted from each component. Then this feature vector is subjected to dimensionality reduction by using PCA. The result obtained is then fed into an SVM classifier for determining whether an occlusion is present or not in each facial component. Occlusion detection using this method is more robust against texture variations and also tolerates better image degradation. The LBP features from non- occluded parts are selected and used for recognition. The recognition is performed by comparing the selected LBP features from the probe image with that of selected LBP features from non-occluded component in template image. LBP features are extracted from the non-occluded components and concatenated to build enhanced feature histogram that provides the face descriptor. The nearest neighbor (NN) classifier and Chi-square distance are used for the recognition of face. This approach may not be optimal for other types of occlusions because here they are dividing face region into upper and lower part. Thus more accurate segmentation of the occluded regions may then be needed.

P. Karthigayani and S. Sridhar in [4], proposed a work in which the initial stage is to extract features using canny edge detection technique and classify the occluded and non occluded region using Decision Tree

Based Occlusion Detection (DTOD) classifier for occlusion recognition. During second stage, Elastic Matching Pattern (EMP) is carried out for face verification and the recognition is achieved by using Maximum Likelihood Classifier (MLC). Back Propagation Neural Network (BPNN) method is used to estimate the age of the human in the third stage. The proposed work deals with various conditions like illumination, variability in facial expressions, presence of occlusions. The decision tree C5.0 algorithm is used for occlusion detection in facial image. Training vectors are used for calculating the gain ratio for the entire feature. Entropy of the image can be obtained from the information gain in the decision tree.

G Nirmala Priya and R S D Wahida Banu proposed a method in [5], where they developed a two phase algorithm for occlusion invariant face recognition. A feature based approach is used here for detecting partial occlusions for a given input face image. In the first phase, occlusion detection was performed by dividing the face image into finite number of disjointed local patches and features are extracted for each patch. Features thus obtained from the corresponding occlusion-free patches of training images are further used for face image recognition. Then the SVM classifier was used occlusion detection for each patch separately. In second phase, recognition was performed using Mean Based Weight Matrix (MBWM) on the occlusion free image patches based on the technique Euclidean nearest neighbor. They used GTAV face databases which include many occluded face images by sunglasses and hand. This method perfectly works for local patch-based occlusion, but the accuracy is low for other type of occlusions.

IV. CONCLUSION

Face recognition is basically a pattern recognition task performed specifically on faces which becomes an exciting technology for past years. So many research works has been carried out in the field face recognition under partial occlusion due to its specialty. Also it can be described as classifying a face into either “known” or unknown, after comparing with stored known images. Computational models of face recognition must address several difficult problems. The difficulty in computation of face recognition arises when the faces obtained possess partial occlusion, illumination condition, pose variation etc. In this paper, we have discussed the various works on face recognition under partial occlusion. Face recognition under partial or full occlusion still proves to be an interesting research area especially in an uncontrolled environment.

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