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Literature Survey on Face Recognition In Case Of Partial Occlusion and Its Applications

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Abstract: **Face recognition is an important security application for automatically identifying and verifying a person from image or video source. Face recognition under partial occlusion is a challenge in the field of image analysis and biometrics. Although face recognition has been encouraging, the task turned out to be difficult when illumination, expression, occlusion vary considerably. Occlusion is mainly caused due to sunglasses, cap, scarf, beard, make up etc which deteriorates the performance of the face recognition system. Face recognition is mainly used in the field of security where the system automatically detects and recognizes the presence on human in the surveillance area. While there are numerous amount of research in the field of face recognition under occlusion in an uncontrolled environment, the goal of this paper is to discuss various literature works which are used for face recognition under partial occlusion. In this paper we are also going to discuss some of the important applications of face recognition.**

Keywords: **Face recognition, Occlusion, Face detection, Holistic method, Structural method, hybrid method.**

I. INTRODUCTION

Face recognition is one of the most used biometric techniques from many years. It is one of the most important research areas in biometric and pattern recognition due to its numerous applications in the area of security access control, law enforcement, surveillance application etc. Biometric is a kind of technique which utilizes the biological features of an individual for identifying a person. There are various biometric techniques such as facial recognition, Iris recognition, finger print, finger vein, lips and voice recognition. To develop an efficient face recognition system several factors must be considered, first the speed of the system from face detection to face recognition should be acceptable, second the accuracy of recognition should be high as possible, and third the system should be easily upgradable based on the progression in technology.

The below Fig 1 shows the face recognition system which consists of four steps face detection, face alignment, feature extraction and face matching.

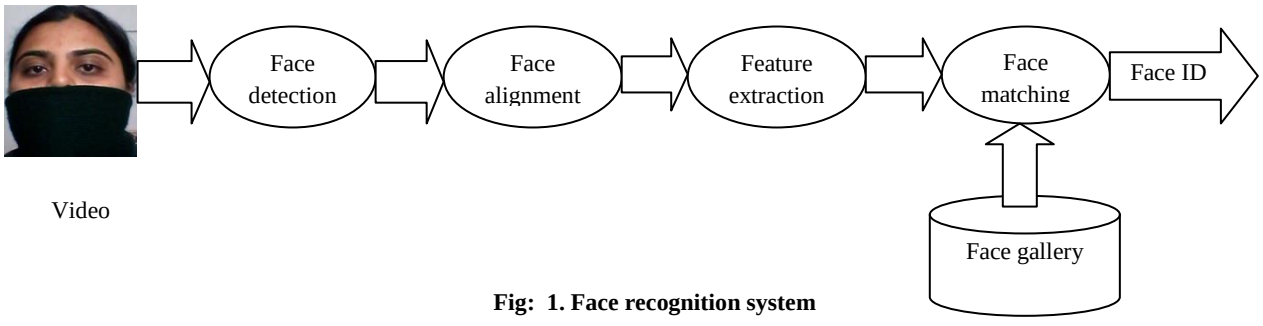

Fig: 1. Face recognition system

The first step in face recognition system is face detection which identifies the face area which consists of face size and occlusion. The second step is the face alignment where the obtained face image from the detection step is aligned for achieving accurate normalization and localization. The third step is the feature extraction where the facial features such as

iris, lips, skin color etc is extracted. The last step is the face matching where the extracted features are compared against the features stored in the gallery of images and then the respective output is obtained.

Some of the advantages of face recognition system are that:

- It does require any co-operation of subject to do its work.
- It can easily identify individuals from massive crowed.
- The system is very easy to use and does not require the contact of a person for authentication.

The face recognition methods are classified into the following category:

- Holistic method
- Structural method
- Hybrid method

In holistic method the entire face is considered as input that is the entire face features are considered for recognition. One of the best examples of this type of method is eigenfaces and principal component analysis. In structural method selected local features such as eyes, nose and mouth are extracted for their location and local statistics are fed into the classifier. The structural method is further classified into generic, template based and structural matching method. Hybrid methods are the combination of holistic and structural methods and are generally used for 3D face recognition.

In this paper, in the second section various literature works, the technique used, the dataset used and the accuracy rate obtained has been explained and in the third section some of the important applications of face recognition system has been discussed.

II. LITERATURE WORKS

Bo Gun Park et.al[1] proposed a attribute relational graph matching (ARG) algorithm in which the line edges were considered which had all the geometric quantities and relational information which were encoded in the graph structure. The matching is then performed based on relational vector space which consists of feature correspondence and structure similarity. They used AR face and Hong-IK face database and obtained an accuracy of about 97.73%. This method was robust in extreme cases such as screaming and occlusion, but its performance decreased during the presence of shading due to illumination changes.

Jongsun Kim et.al [2] proposed a part-based local representation called locally salient ICA (LS-ICA) for face recognition under partial occlusion. Here part-based local basis of image were created using kurtosis maximization and then LS-ICA was used for basis image selection which contained only discriminate localized features for face recognition. They used FERET, AR face and AT&T database and obtained an accuracy of about 75-80%. The performance of this method was robust to partial occlusion and local distortion regardless to the distance measure used. This method was proved to provide better recognition rate for the faces in FERET database when compared to AR face database.

Xiao yang Tan et.al[3] proposed a method where they used self-organizing map(SOM) to represent each individual face image, then they used two strategies for learning the SOM topological map where a single SOM map was trained for all samples and then a separate SOM map was used for each class. They then used soft K-nearest neighbor classifier for recognition from SOM topological map. They used AR face database and obtained an accuracy of about 85-90%. This method is robust to expression variance and partial occlusion; it is also very intuitive due to visualization capabilities, but this method requires pre-training of samples before face recognition.

Wenchao Zhang et.al [4] proposed a method where they represented the face using local Gabor binary pattern histogram sequence. In this a Gabor magnitude picture of the face image was created using Gabor filter then it was converted to LGBP maps using LBP and then a histogram sequence was developed for all the local regions of the face. This histogram was then concatenated to obtain the final histogram which contained details of all the common features. Then the final histogram was used for face recognition by assigning various weights. They used AR face and FERET database and obtained an accuracy of about 80-98%. This method has achieved the best result for FERET face database when

compared to AR face database, but this method is not suitable for matching two histograms especially when there is variation in pose and occlusion.

Wenchao Zhang et.al[5] proposed a method where they used kullback-leiber divergence between the local Gabor binary patter features of the local regions of the face and that of the non-occluded local regions to get the probability of occlusion later they used this probability for feature matching. They used AR face database and obtained an accuracy of about 84%. This method was developed to overcome the problem of LGBPHS method, but this method has very high dimensionality.

Hyun Jun Oh et.al [6] proposed a method where they first divided the face image into a finite number of disjoint local patches. Then principal component analysis (PCA) was used to identify the non-occluded patches from the above obtained patches. Then they used 1-NN classifier for occlusion detection finally they used local non-negative matrix factorization for face recognition from non-occluded patches. They used AR face database and obtained an accuracy of about 84-87%. This method shows very good recognition rate in case of sunglasses, scarf, smile and right-light, but the recognition rate is low in case of scream.

Hongjun Jia et.al [7] proposed a method where each test image was described as a linear combination of training samples using the concept of linear combination best reconstruction to obtain the smallest matching error for face recognition. They used AR face database and obtained an accuracy of about 90-96%. This method was used to provide the best reconstruction for class labels, but this method requires both training and test set.

Meng Yang et.al [8] proposed a method to improve the sparse representation based classification (SRC) for face recognition. Here they considered the image Gabor-features and compressed it using Gabor kernels to form a Gabor occlusion dictionary. This reduction in Gabor-features greatly reduced the computational cost of SRC which was used for face recognition. They obtained an accuracy of about 99%. This method has compact occlusion dictionary hence it has reduced computational cost, but this method is efficient for pose variation only up to 15 degree.

Rui Min et.al [9] proposed a method where occlusion detection from the face image was done using Gabor wavelets, PCA and support vector machine (SVM). Then the recognition of non-occluded facial part was done by using block-based local binary pattern. They used AR face database and obtained an accuracy of about 81.25%. This method provides robustness against occlusion, non- occluded faces and illumination change, but This method works only for occlusion in case of sunglasses and scarf and it is not suitable for automatic face detection under video surveillance.

Shengcai Liao et.al [10] proposed a method where they developed a alignment-free face representation method using multi-key point descriptors(MKD) whose size was determined by the actual image content. The key point descriptor called Gabor ternary pattern was developed for discriminative face recognition and then SRC was used for recognition. They used FRGC, AR face, Pub Fig face database and obtained an accuracy of about 80-90%. This method works well for synthesized partial faces and holistic faces, but this method does not give guarantee of detecting partial face and it requires manually cropped face image in such cases.

Shih-Ming et.al[11] proposed a method where the input image was processed by linear binary pattern then the image was slided in a block manner using 2D-DCT to obtain the DCT coefficients then the coefficient was applied to embedded HMM classifier for face recognition. They used AR face database and obtained an accuracy of about 81-86%. This method achieved high accuracy rate under neutral face, expression and illumination variations, but there is decrease in accuracy under partial occlusions.

Xingjie Wei et.al [12] proposed a method where they considered structural sparsity to deal with illumination and occlusion. The face image was represented as a structured union of subspaces in a high dimensional feature space, using this cluster occlusion dictionary was created and then WLD was used for handling varying occlusion and illumination. Then these features were used for face recognition. They used Extended Yale B and AR face database and obtained an accuracy of about 87.5-92%. This method outperforms incase of illumination and occlusion changes, but this method works well for occlusion with scarf when compared to sunglasses.

Tomoki Hosoi et.al [13] proposed a method where they developed fast weighted PCA which computed PCA only on effective pixels of the image. The main aim of this method was to first calculate the Eigen space for training image and then the occluded regions of the input image was reconstructed for recognition. They used FRGC, MBGC, FERET and multi-PIE database and obtained an speed of about 60msec-150sec faster. This method provides an advantage of reconstructing the occluded regions, but the reconstruction accuracy need to be improved.

Rui Min et.al[14] proposed a method where they considered an input image, then by using a canonical face set occlusion detection was performed after which occlusion inpainting was performed on the image based on fields-of-experts model. Using the inpainted face image face recognition was performed. They used AR Face database and obtained an accuracy of about 97.14%. This method outperforms in case of complex sparse occlusion, but this method may not work well in case of other type of occlusions.

Xingjie Wei et.al [15] proposed a method where they considered a face image and then random sampling was performed taking into account the local deformation caused due to occlusion and expression. Then using large number of random samples face recognition was performed with the help of NN classifier using the concept of DICW distance. They used FRGC and AR face database and obtained an accuracy of about 93.7-94.9%. This method is robust for local deformation of the face image, but this method works well for illumination and pose when compared to occlusion.

G Nirmala Priya et.al [16] proposed a method where they developed a two phase algorithm for face recognition. In the first phase occlusion detection was performed by dividing the face image into local patches and then SVM classifier was used. In the second phase recognition was performed using mean based weight matrix (MBWM) on the occlusion free patches based on the technique Euclidean nearest neighbor. They used GTAV face database and obtained an accuracy of about 96.50%. This method works well for local patch-based occlusion, but the accuracy is low for other type of occlusions.

TABLE I: COMPARISON OF VARIOUS LITERATURE WORKS ON OCCLUDED FACE RECOGNITION

Sl.NO	Methods	Year of Publishing	Author	Database	Accuracy Rate
1	ARG + Relational vector space[1]	2005	Bo Gun Park et.al	AR face &Hong-IK	97.73%
2	Kurtosis maximization + LS-ICA[2]	2005	Jongsun Kim et.al	FERET, AR face & AT&T	75-80%
3	SOM + Soft k-NN[3]	2005	Xiao yang Tan et.al	AR face	85-90%
4	Gabor filter + LBP + LGBPHS[4]	2005	Wenchao Zhang et.al	AR face & FERET	80-98%
5	LGBP + Kullback-Leibler divergence LGBPHS[5]	2007	Wenchao Zhang et.al	AR face	84%
6	PCA + 1-NN + LNMF[6]	2008	Hyun Jun Oh et.al	AR face	84-87%
7	Linear combination reconstruction[7]	2008	Hongjun Jia et.al	AR face	90-96%
8	Gabor kernel + Gabor occlusion dictionary-SRC[8]	2010	Meng Yang et.al	Gabor occlusion dictionary	99%
9	Gabor wavelet + PCA + SVM + OA-LBP[9]	2011	Rui Min et.al	AR face	81.25%
10	MKD + SRC[10]	2011	Shengcai Liao et.al	FRGC, AR face, LFW & Pub Fig	80-90%
11	LBP + 2D-DCT +HMM classifier[11]	2011	Shih-Ming et.al	AR face	81-86%
12	Structured Sparsity + WLD[12]	2012	Xingjie Wei et.al	Extended Yale B & AR face	87.5-92%
13	Eigen space + FW-PCA[13]	2012	Tomoki Hosoi et.al	FRGC, FERET, MBGC & Multi-PIE	60msec-150msec faster

14	Conical face set + Inpainting sparse occlusion[14]	2012	Rui Min et.al	AR face	97.14%
15	Fixation & saccade + NN-classifier[15]	2013	Xingjie Wei et.al	FRGC & AR face	93.7-94.9%
16	SVM + MBWM[16]	2014	G Nirmala Priya et.al	GTAV face	96.50%

III. IMPORTANT FACE RECOGNITION APPLICATIONS

- **Person Identification:** Face recognition system is used to identify people to provide authorization similar to secret identification key or password. This is mainly used to remove duplications in voter registration system, adhaar etc thus providing security to the nation.
- **Access Control:** Face recognition system is mainly used in organizations to control the computer login and to protect the office access, thus providing security to organizations information.
- **Security:** Face recognition system is mainly used in public areas such as bus station, railway station , airport etc to identify terrorist, criminals etc.
- **Database investigation:** Face recognition system is mainly used for searching licensed drivers, missing child and police booking.
- **Video Surveillance:** Face recognition system is mainly used in large organizations and malls to provide protection against terrorist attacks and robbery. The protection is provided with the help of CCTV cameras which is examined in the control rooms.

IV. CONCLUSION

Face recognition is an exciting technology from many years. Much research works has been carried out in the field face recognition under partial occlusion. Many researchers have carried out their work in a controlled environment. In this paper we have discussed the various literature works on face recognition under partial occlusion. We have also discussed the most important application of face recognition as the biometric technique. This paper can provide the readers good information regarding the various literature works, the method used and the accuracy rate obtained. Each literature work has its own pro's and con. Researchers are still working to improve the face recognition system both in 2D & 3D for large applications such as e-commerce, national ID etc. They are also still working on to overcome the cons of previous methods especially in uncontrolled environment. Face recognition under partial or full occlusion still proves to be an interesting research area among many researchers especially in an uncontrolled environment.

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