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Video Based Face Recognition with Gabor Features and Locality Preserving Projections under Varying Partial Occlusion

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ABSTRACT: Face recognition is one of the most concentrated research topic as it is been used as an application in Smart cars, Air conditioners etc. The goal of the researchers is to develop a robust face recognition system with very high performance. To develop such a system is a critical issue in case of partial occlusion as it is difficult to extract the relevant facial features, thus decreasing the overall performance of the recognition system. Our approach develops robust face recognition system for video sequences whose performance is high even in case of partial occlusion. In our method we are using AdaBoost technique for detecting the human face. Relevant features are extracted using Gabor Wavelet; the extracted features are dimensionality reduced using Locality Preserving Project and Support vector machine is used as a classifier for detecting occluded and non-occluded pixels and finally K-Nearest Neighbor classifier is used for recognition by considering only the non-occluded pixels. Our Experiments are performed using own database and it is evaluated using two types of occlusions that is sunglasses and scarf.

KEYWORDS: Face detection, Occlusion, Sunglasses, Scarf, Face recognition, Video surveillance.

I. INTRODUCTION

Face recognition is a kind of biometric technique which does not require any human contact for authentication. It is very useful in many applications varying from commercial applications to law enforcement. Researchers are working very hard on face recognition systems to provide very high accuracy but the performance of the decreases in case of video surveillance especially when there is variation in occlusion. Considering the real world scenarios, from last few decades there is very less investigation related to occlusion even though occlusion is most common problem since people wear sunglasses and scarf regularly and there will be variation in pose and expressions.

The presence of occlusion may be intentional or non-intentional. Some people wear makeup, sunglasses, scarf in their daily life such type of occlusion are unintentional. But there are criminals or terrorists who purposely cover their face to avoid of being identified such type of occlusion are intentional fig1 shows various kind of occlusions which basically detoriates the performance of the system.

The main reason for the decrease in performance of the system during the presence of occlusion is that in case of partial occlusion it is difficult to extract the required facial features and hence recognition becomes difficult without those facial features.

Most of the previous works have concentrated mainly on finding corruption tolerant features that is those features which are free from occlusion or to find a classifier which decreases the effect due to the presence of partial occlusion on the recognition system. Researchers have also developed techniques where the system is given the

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knowledge of the presence of occlusion prior to recognition so that the system can avoid the extraction of those features which has the chances of being occluded. This technique of providing prior knowledge has greatly increased the rate of recognition.

In the proposed approach human faces are detected using AdaBoost method. Once the face is detected the facial features are extracted using Gabor wavelet, the extracted features are dimensionally reduced using Locality Preserving Projections (LPP) and Support Vector Machines (SVM) is used as a classifier to detect the non-occluded pixels which is then passed to K-Nearest neighbor classifier for recognition. Finally our approach is evaluated using our own dataset.

Fig 1: Different kinds of Occlusion which are unintentional and intentional

This paper is organized as follows. First we have discussed the various related works in section II. Then the proposed approach has been discussed in section III. In section IV simulation and results has been shown. Finally, in section V we have drawn the conclusion.

II. RELATED WORK

Previous research works have concentrated mainly on either finding corruption tolerant features or a classifier to obtain good recognition rate. They have even come up with a technique of first training the system about the presence of occlusion so that they have prior knowledge of the presence of occlusion and the system may not collect those features which are likely to be collected during the recognition stage.

Wenchao Zhang et.al [1] used Kullback-Leibler divergence between the local Gabor binary patter features of the local regions which are non-occluded local regions to get the probability of occlusion which was used for feature matching. One of the drawbacks of this method was that it had very high dimensionality

Hyun Jun Oh et.al [2] first divided the face image into a finite number of disjoint local patches. Then using principal component analysis (PCA) non-occluded patches were identified. Using 1-NN classifier for occlusion was detected finally they used local non-negative matrix factorization for recognition from non-occluded patches. Even though This method showed 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 [3] proposed a method where prior knowledge about occlusion was given in this each test image was described as a linear combination of training samples to obtain the smallest matching error for face recognition. The drawback of this method was that it requires both training and test set.

Meng Yang et.al [4] proposed sparse representation based classification (SRC) for face recognition. First they constructed Gabor occlusion dictionary using Gabor features which was compressed hence reducing the computational cost of SRC. But this method works well with pose up to 15 degree.

Rui Min et.al [5] proposed a occlusion detection method from the face image using Gabor wavelets, PCA and support vector machine (SVM) after which the recognition of non-occluded facial part was done by using block-based local

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binary pattern. This method worked well for occlusion in case of sunglasses and scarf and was not suitable for automatic face detection under video surveillance.

Shengcai Liao et.al [6] applied a alignment-free face representation method using multi-key point descriptors(MKD) . Gabor ternary pattern was used for discriminative face recognition .The drawback of this method was that it did not give guarantee of detecting partial face and it required manually cropping of face image in such cases.

Shih-Ming et.al[7] 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. But this method had a decrease in accuracy under partial occlusions.

Xingjie Wei et.al [8] applied structural sparsity to deal with illumination and occlusion. The face image was represented as a structured union of subspaces in a feature space of high dimension, using this cluster occlusion dictionary was created and then WLD was used for handling varying occlusion and illumination. But this method works well for occlusion with scarf when compared to sunglasses.

Tomoki Hosoi et.al [9] they developed fast weighted PCA which computed PCA only on effective pixels of the image. First they calculated the Eigen space for training image and then the occluded regions of the input image which was reconstructed for recognition. This method provided an advantage of reconstructing the occluded regions, but the reconstruction accuracy need to be improved.

Rui Min et.al[10] where they considered an input image from which occlusion detection was performed using a canonical face set after which occlusion inpainting on the image was performed based on fields-of-experts model and then face recognition was performed. This method performed well in case of complex sparse occlusion, but not in case of other type of occlusions.

As we have seen the various works for face recognition we have come across a number of drawbacks. Some of the previous work have very high dimensions, few work well for only a particular type of occlusion and some techniques require prior knowledge about occlusion is not given hence decreasing the recognition rate and most importantly all these techniques works on face image as input and not on video. So we have proposed an efficient technique which works for video surveillance. We are first training our system so that it has the prior knowledge about the presence of occlusion. The face is detected using AdaBoost technique. Occlusion detection is performed using Gabor wavelet, Locality preserving projections (LPP) and SVM. By using LPP this technique provides very low dimension. The non-occluded pixels are used for recognition with the help of K-NN classifier.

III. PROPOSED APPROACH

Here is the brief overview of our proposed approach. Fig 2 shows the complete system flow of our proposed approach. As shown in the figure below given a video the face is first detected using AdaBoost technique. The occlusion detection is performed using the features which are extracted using Gabor wavelet. The extracted features are dimensionally reduced using locality preserving projections. Then the presence of occlusion is detected using support vector machine. Then the non-occluded pixels are passed to K-NN classifier for recognition. Here the system is trained in advance so that occlusion detection can perform easily.

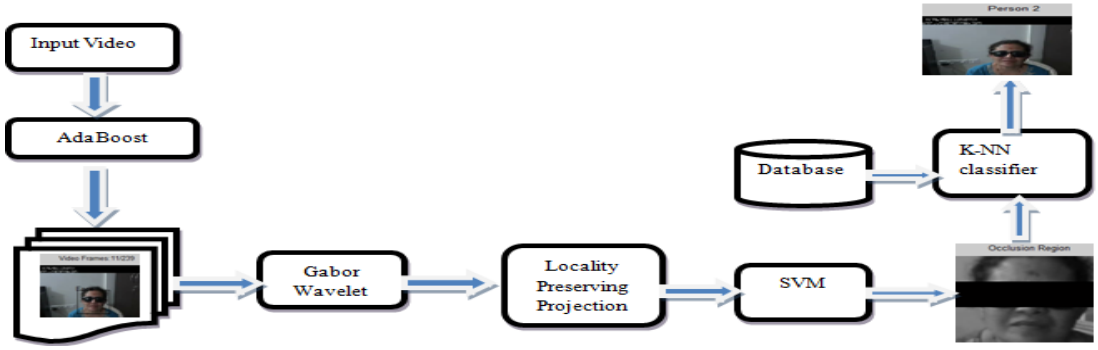

Fig 2: Proposed approach for detection and recognition of face under occlusion

3.1. Face Detection using AdaBoost technique: In our approach AdaBoost technique is used for detecting human face in video using the Haar features of the face [11]. It is based on viola- Jones algorithm. It is a boosting

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algorithm and it does not require any prior knowledge about the structure of the face. To perform detection it takes only two inputs one is the training se and other is the feature set. The algorithm works by constructing a weak classifier which is combination of number of classifiers. It reduces the error caused due to training and generalization. Here a classifier is trained for each training sample and then the best classifier with the lowest error rate is selected for detection. This algorithm generates 15 frames per second for a conventional 700MHz Intel Pentium III. and we have restricted the frame generation to about 100 frames.

3.2.

3.2. Occlusion detection: We are first detecting the presence of occlusion so that we can obtain only the non-occluded pixels. Here to perform occlusion detection the required features are extracted using Gabor wavelet. Since the obtained features have very high dimension it is dimensionally reduced using LLP and then SVM classifier is used for detecting non-occluded pixels. Fig 3 shows the occlusion detection using a mask.

Fig 3: Occlusion detection

3.2.1. Feature Extraction Using Gabor Wavelet: For extracting facial features Gabor Wavelet is being used [12]. The purpose of selecting Gabor Wavelet is that it has enhanced discriminative power, its computational properties and its biological relevance. The Gabor Wavelet is developed using a Gaussian envelope and complex sinusoidal carrier. Here in our approach nearly four Gabor Wavelets are developed. Once the wavelets are generated features are extracted using convolution between the wavelets and the face image.

$$C_{\mu,\nu}(x,y) = I(x,y) * \psi_{\mu,\nu}(z)$$

The features extracted from the above convolution are called Gabor magnitude pictures and they are in vector form hence they are also called as feature vectors.

3.2.2. Dimensionality Reduction using Locality Preserving Projections: LPP is used to reduce the dimensions of the extracted features [13]. It is a linear dimensionality reduction problem. In this technique the maps are designed to minimize a different objective criterion of the classical linear technique. Its preserving quality makes it suitable for information retrieval applications. In this technique the raw data which is the feature vector are taken and they are mapped to m points. Once the mapping is done the graph is constructed using these m points using K-nearest neighbor. After the construction of the graph weights are assigned using Heat kernel or simple-minded technique using the formula

$$W_{ij} = e^{-\frac{\|\mathbf{x}_i - \mathbf{x}_j\|^2}{t}}$$

and then the Eigen maps are generated using the graph as given by $XLX^T\mathbf{a} = \lambda XDX^T\mathbf{a}$. LPP has very low error rate when compared to LDA and PCA.

3.2.3. Occlusion detection using SVM: SVM classifier is used for occlusion detection [14]. Detection of occlusion is a two class classification problem and non-linear SVM has proven to be the best classifier for a two class classification. SVM also provides extra information for classification. It can also be used even in case of high dimensional data. Since SVM is used for occlusion detection the occluded pixels are marked with 1 and the non-occluded pixels are marked with -1. During the classification pixels marked with 1 are placed above the hyper plane and pixels marked with -1 are placed below. The following quadratic equation we can obtain the support vector

$$f(x) = \text{sign}\left(\sum_{j=1}^{N} \alpha_j y_j K(x_j, x) + b\right).$$

Here Radial Basis Function kernel is used to fit the maximum – margin hyper plane.

3.3. Face recognition using K-nearest neighbor classifier: In our approach K-NN classifier is used for face recognition [15]. After occlusion detection the non occluded pixels are passed to K-NN classifier for recognition. The K-NN

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classifier works by finding the closest labeled example for an unlabeled example. The closest class is determined by using a distance metric. The distance metric used by K-NN classifier to find the closet classes for an unlabeled example is the Euclidean distance. The distance measure done by Euclidean distance is as given below.

$$d_w(x_u, x) = \sqrt{\sum_{k=1}^{D} (w[k] \cdot (x_u[k] - x[k]))^2}$$

The K-NN classifier selects the classes whose Euclidean distance is closest to the threshold used.

IV. SIMULATION AND RESULTS

The proposed approach is applied on own data set. For this purpose we are using 8 videos, in each video there are persons either with sunglasses or scarf. For this we have constructed our own dataset. The videos are first resized and down sampled. The frame height is set to 320X240 the number of bits per second is set to 328 Kbits/sec. Before testing, the system is first trained using image of size 128X128 pixels.

During the testing phase the face is image is cropped to 256X256 to obtain the exact face region and it is then converted to a gray scale image. The occlusion detection is performed and it is shown in the form of a black band. The Table 1 shows the experimental results which gives the detailed description of the detection and recognition rate of each video. Fig 4, Fig 6, Fig 7 and Fig 10shows the outcome when occlusion is of type scarf, Fig 5, Fig 9 shows the outcome when occlusion is of type sunglasses and Fig 8 and Fig 11 shows the outcome when there is no occlusion. Each video is tested using our method under different occlusion condition and with one person per frame.

Input Video Sequence	Type of Occlusion	No. of persons/frame	Face detection rate %	Face recognition rate %
Test video 1	Scarf	1	98	98
Test video 2	Sunglasses	1	98	98
Test video 3	Scarf	1	98	98
Test video 4	Scarf	1	98	98
Test video 5	Without occlusion	1	98	98
Test video 6	Sunglasses	1	98	98
Test video 7	Scarf	1	98	98
Test video 8	Without occlusion	1	98	93

Table 1: Experiment Results

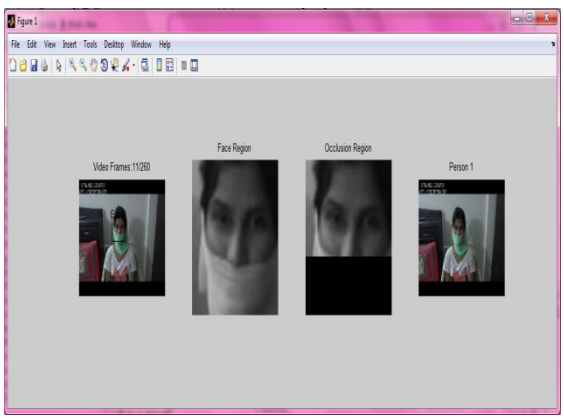

Fig 4: Video1

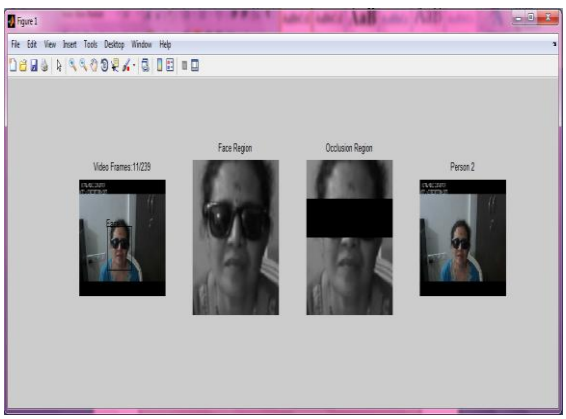

Fig 5: Video2

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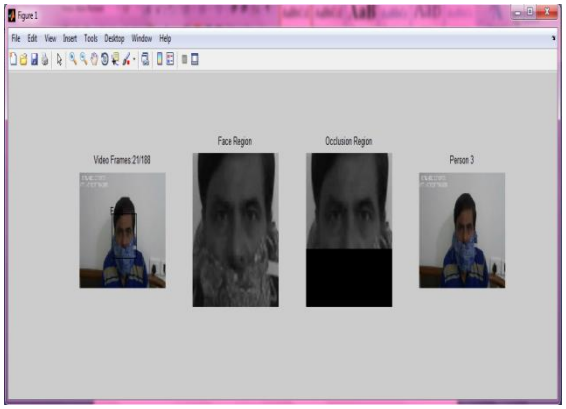

Fig 6: Video3

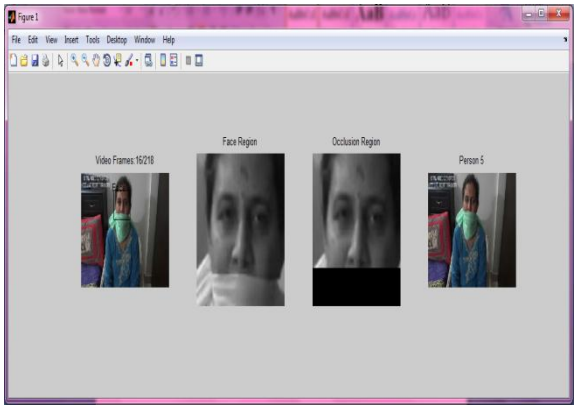

Fig 7: Video4

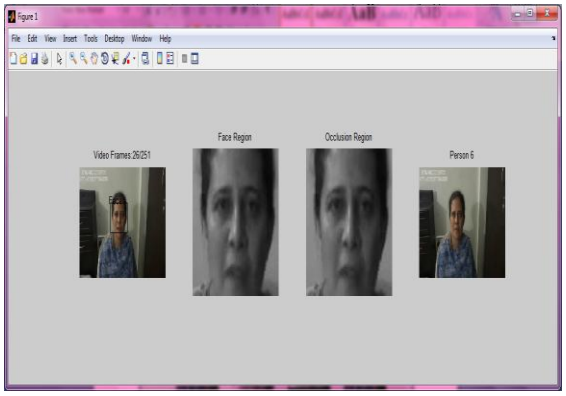

Fig 8: Video5

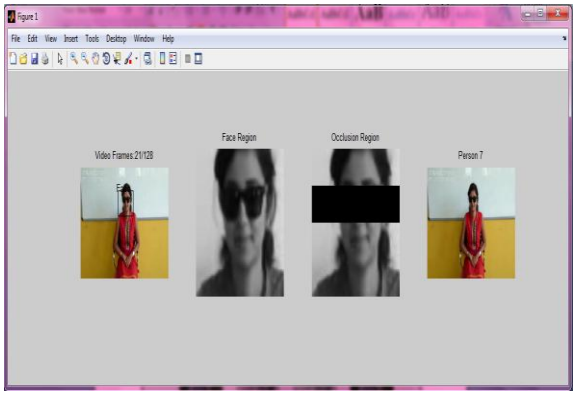

Fig 9: Video6

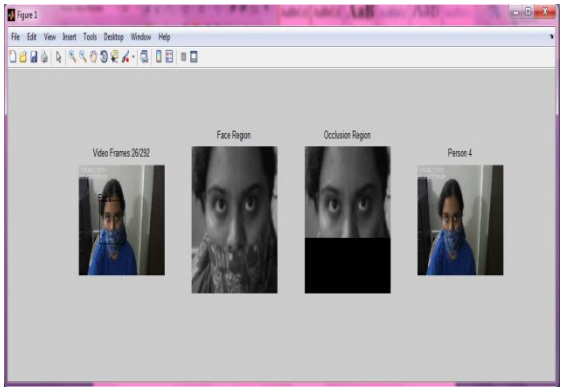

Fig 10: Video7

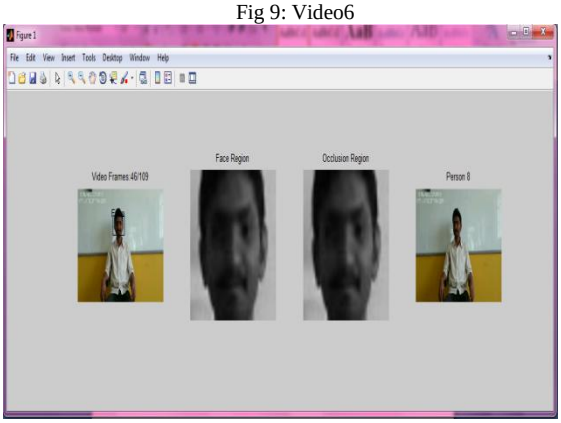

Fig 11: Video 8

V. CONCLUSION

Our approach was evaluated using own database. Our approach has overcome the drawbacks of various subspace learning methods. In our method we have used AdaBoost technique for detecting human face and hybrid combination of Gabor Wavelet, Locality Preserving Projections and SVM classifier is used to obtain the occluded and non-occluded

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pixels. Using non-occluded pixels recognition is performed using K-NN classifier, thus increasing the recognition rate which is more when compared to other subspace learning methods.

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