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Video Based Face Recognition Using Gabor Features and LBP under Varying Illumination or Pose

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ABSTRACT: Face recognition has become one of the intense and interesting research topic in the recent years. The goal is to design a robust face recognition system for flawless recognition of face image under unconditional environment like illumination and pose variations, which are the two major critical challenges in the face recognition. Illumination and pose may hinder the appearance of the face image and also may hinder the faultless recognition. Goal of the proposed approach is to build an robust high performance face recognition system for video surveillance, as less amount of research work is done and the researchers are trying to improve the accuracy under video surveillance. In the proposed approach, the face image is detected using the skin color tone based method, the features of the detected face is extracted using the Gabor wavelet transform, local binary pattern and tensor locality preserving projections is used to dimensionality reduce the features extracted and classification is performed using the support vector machine. This approach is tested on standard YouTube celebrity database under different environmental conditions.

KEYWORDS: Face Recognition, Illumination, pose, video Surveillance, Gabor Wavelet transform (GWT), Local binary pattern (LBP), Tensor locality preserving projections (TLPP).

I. INTRODUCTION

Face recognition is a one of the important biometric application for analysis and understanding of image and it has gained the attention in the recent years. Even though the other biometric techniques like finger print, palm print and iris recognition has highest degree of recognition, the subject requires compliance during the recognition process. Face recognition can be performed with lesser degree of compliance.

Even the face recognition provides high degree of the recognition accuracy the accuracy decreases under the video surveillance when there is immense crowd and when there is variations in the illumination and pose. The face recognition is an challenging under uncontrolled environment like illumination, pose and occlusions. Illumination and pose may change the occurrence of face image and also hinder the correct recognition.

Many of the holistic approaches for face recognition are based on the gray scale images, these are not robust enough to cope up with variations that occurs during the data capturing stage and also the converting the color image into gray scale image may lead to loss of some information of the image, As the color image is increasingly being used since they contain additional biometric information, so we propose a face recognition system based on color images.

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The proposed approach skin color likelihood is used for detecting the face as the color processing is faster than any other facial features, the features of detected face is extracted using gabor wavelet transform and local binary pattern, Tensor locality preserving projection is used for dimensionality reduction, and nonlinear support vector machines is used for classification.

II. RELATED WORK

Over the past half century face recognition has been one of interesting research topics. Face recognition methods are based on extracting some of the unique features from the face image. This approaches can be classified as holistic approach, feature based approach and hybrid approach. The holistic approaches of face recognition will encode the entire face image. Many of these holistic methods such as ICA, PCA, and LDA were introduced [1-5]. Most of these methods are based on the gray scale images, for face recognition color images are being used because it contains additional biometric information [6-8]. The feature based approach relies on detecting the individual facial characteristics and their geometric relationships [9-11]. Apart from this different local regions of face image can be used to perform face recognition [12-14]. The face recognition is challenging under varying illumination and pose, so Gabor wavelet transform [15] and Local binary patterns [16] methods are using for feature extraction which will extract the local regions of the face that are robust to illumination, the tensor locality preserving pattern [17] is used for dimensionality reduction which uses the matrix representation of image and the support vector machine [18] is used for face recognition.

III. PROPOSED APPROACH

3.1 *Overview:*

Fig 1 shows the block diagram of proposed approach. In the face detection phase the skin regions are detected using the skin color toned based approach in YCbCr color space, then the face region is segmented from the other skin regions using the REGIONPROPS method. The local features of the detected face region is obtained using Gabor wavelet transform by convoluting the Gabor wavelets with the face image and local binary pattern by dividing the face image into small rectangle regions and histogram is generated for each region and then the global histogram is obtained and the feature vector of both methods are concatenated, Tensor locality preserving projections [TLPP] is applied for reducing the dimensions obtained by Gabor wavelet transform and LBP. Non liner Support vector machine classifier is used for classification.

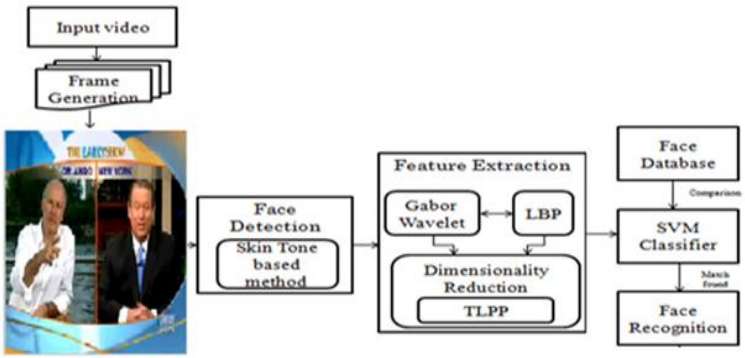

Fig 1: Block diagram of proposed method

3.2 *Face detection using skin likelihood:*

Face detection is one of the important step in face recognition. Skin color based approach is used for face detection. Efficient face detection is process of tracking the face without any prior knowledge of the previous frames.

Skin is a widely used feature in the image processing for face detection. Skin color is the unique feature, skin color pixels can be easily detected using color histogram. Color processing is faster than processing any other facial feature and

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color is orientation invariant. Many methods has been proposed for using skin color for face detection [20]. Skin color is used for region segmentation.

Skin color is modeled in YCbCr color space in which luminance component(y) is separated from chrominance components (Cb, Cr), in these pixels are classified into skin and non-skin. Skin color can be identified by the presence of the chrominance components. The color histogram is generated for the given image, Cb and Cr are uniformly and consistently distributed in YCbCr color space. Any skin pixel that satisfies the below equation in the YCbCr color space indicates the skin pixels.

$$95 < Cb < 120$$
$$155 < Cr < 225$$

Once the skin regions are detected, it is converted into binary image in which 1's represent skin pixels and 0's represent the non-skin pixels, then the REGIONPROPS (BW, ALL) method will determine the properties of the connected components in the binary image. Based on the size of the bounding box the face region pixel is set to 1 and rest skin region is set to 0. Then the original image convoluted with above obtained unsigned 8-bit integer binary image representation to obtain the face region as show in the Fig 2.

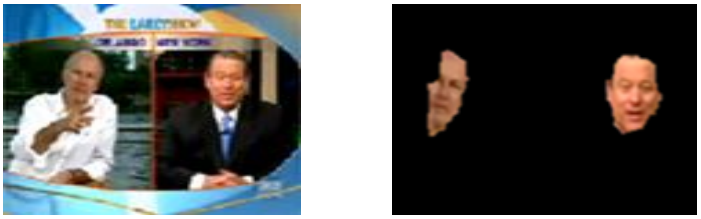

Fig 2: Input frame and Output of face detection

3.3 *Face Recognition:*

3.3.1 *Feature Extraction using Gabor Wavelet Transform (GWT) and Local Binary Pattern (LBP):*

a) Gabor wavelet filter [22] is used to extract the local facial features. Wavelet transformation results in the strong representations which are robust to varying lighting conditions and are capable of capturing the substantial facial features. A wavelet transform is created by passing the image through the series of filter bank stages. In horizontal direction the filtered output is down sampled by the factor of 2 and in vertical direction each signals are filtered by identical filter pair.

The Gabor representation of the face image is obtained by convolving the face image with the Gabor filters. Let f(x,y) be the face image, its convolution with the Gabor filter $\psi_{\mu,\nu}(z)$, and is defined as

$$G_{wf}(x, y, \mu, \nu) = f(x, y) * \psi_{\mu,\nu}(z)$$

Where

$*$ - denotes convolution operator

2 scales and 2 orientations Gabor filters are used. Convolving the image with each of the 4 Gabor filter can generate the Gabor features.

b) LBP [23] is used for extracting the facial features as the LBP is an simple and efficient texture operator which will label each pixel by thresholding the neighborhood of each pixel. the Fig 3 shows the operation of LBP operator. The face is divided into the small non-overlapping rectangular regions of specific size, and the histogram is independently computed for each region, then the histograms are concatenated to form an final histogram sequence as the model of the given face image.

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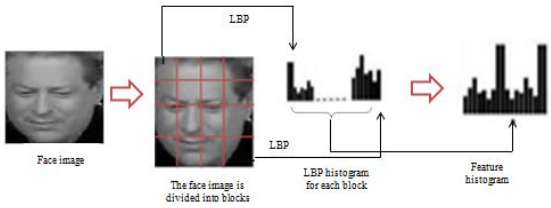

Fig 3: Face description using LBP operator

3.3.2 *Dimensionality Reduction using Tensor Locality Preserving Projections (TLPP):*

TLPP [24] is used for reducing the dimensions of features that are extracted using GWT and LBP. Dimensionality reduction is the process of reducing the number of features that are considered for face recognition. TLPP is the multi-linear case of the LPP. It is useful when the data samples are to be represented as matrices or higher-order tensors. Tensor is multi-linear mappings over a set of vector spaces. Tensor is the higher order generalization of vector (first order tensor) and a matrix (second order tensor).

For the given data points A1,....,An from an unknown manifold **M** embedded in a tensor space $R^{I_1 \times I_2 \times \cdots \times I_k}$, first we construct a neighborhood graph **G** to represent the local geometric of **M.** The corresponding affinity matrix S= [Sij]nxn is defined based on the heat kernel as:

$$S_{ij} = \begin{cases} exp(-\|A_i - A_j\|_f^2 / t), if \;\; A_j \in 0(k, A_i) \; or \; A_j \in 0(k, A_j) \\ 0, \qquad\qquad\qquad\qquad Otherwise \end{cases}$$

Where O (K, Ai) denotes the K nearest points of Ai and t is positive constant.

3.3.3 *Classification using Support Vector Machine (SVM) Classifier*

SVM [25] is used for classifying the feature vectors extracted. The classification task involves separating the data into training set and the testing sets. Support vector machines searches for the closest points, which are represented as the vector of real numbers which is called as support vectors. The objective of SVM is to produce a model based on training data which predicts target values of the test data given only the test attributes.

Consider the training set consists of N pairs $\{x_i, y_i\}_{i=1}^{N}$ where xi is feature vector of face and yi $\in$ {-1,+1} is the label which indicates if the sample xi is matched or not. The training vectors xi are mapped on to higher dimensional.SVM finds an optimal separating hyper plane $\{\alpha_i, i \in [1, N]\}$ and predicts the label of an unknown face x by

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

Where $\{x_j, j \in [1, N]\}$ are support vectors. The non linear SVM applies the kernels K (xi, xj) to fit the maximum margin hyper plane in the transformed feature vector. We have used the Radial basis function (RBF) kernel, RBF kernel nonlinearly maps the data samples into higher dimensional space, so it can handle when the relation between the class labels and attributes are nonlinear. RBF has less numerical difficulties.

Fig 4: Output of face recognition

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IV. SIMULATION RESULTS

For our experimental analysis we have considered standard you tube celebrity video data set. It contains the video data with different illumination conditions and poses. The original images in the database are normalized, resized and down-sampled and these images are used to train the system. The Table 1 shows the detection and recognition rate of each video and the Fig5, Fig 6, Fig 7, Fig 8, Fig 9, Fig 10, Fig 11, Fig 12, Fig 13 shows the outcome of the each video under varying illumination and pose. We have considered 1 or 2 person for each video.

# of videos	# of persons/frame	Detection Rate	Recognition Rate
1	1	98	98
2	2	98	83
3	1	97	95
4	2	98	85
5	1	97	87
6	1	98	96
7	1	98	97
8	1	98	97
9	1	98	96

Table 1: Experimental results

The Fig 5 output of the face recognition with frontal view and dark illumination which has one person.

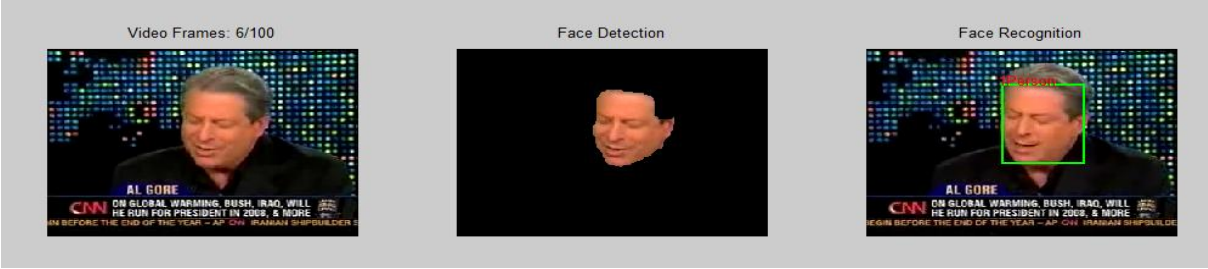

Fig 5: Video 1

The Fig 6 output of the face recognition with bright illumination and pose variations which has two persons.

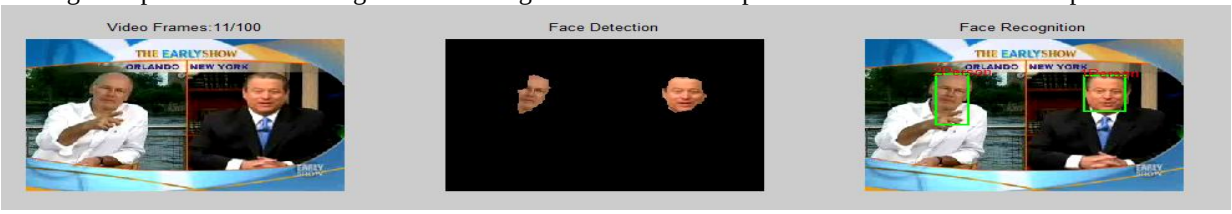

Fig 6: Video 2

The Fig 7 shows the output of the face recognition with dark illumination and pose variations which has one person.

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Fig 7: Video 3

The Fig 8 shows the output of the face recognition with dark background illumination which has two persons.

Fig. 8.Video 4

The Fig 9 shows the output of the face recognition with dark background illumination and 45 degree pose which has one person

Fig 9: Video 5

The Fig 10 shows the output of the face recognition with dark illumination, pose and partial occlusion which has one person

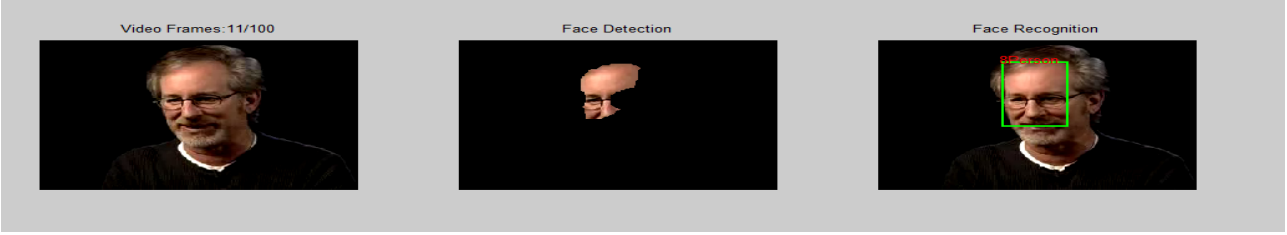

Fig 10: Video 6

The Fig 11 shows the output of the face recognition with dark illumination, frontal view and partial occlusion which has one person

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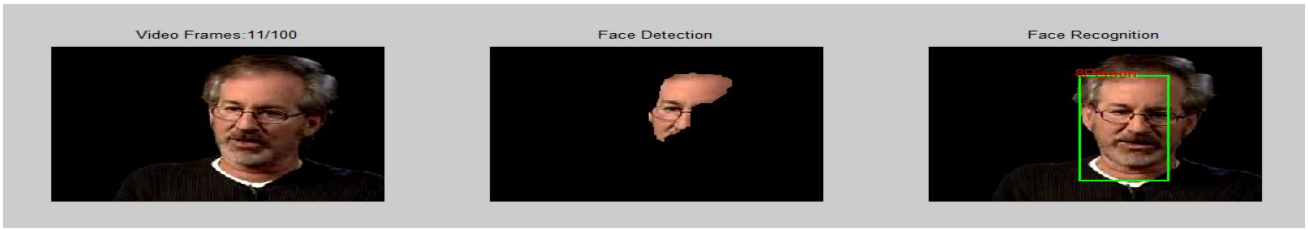

Fig 11: Video 7

The Fig 12 shows the output of the face recognition with bright illumination and frontal view which has one person

Fig 12: Video 8

The Fig 13 shows the output of the face recognition with bright illumination and pose variations which has one person

Fig 13: Video 9

V. CONCLUSION

An high performance illumination and pose invariant robust face recognition system is proposed to overcome the drawback of sub-space learning methods. In the proposed approach, the face is detected and recognized in the video streams using skin color based method for face detection as the skin color is the most important feature than any other facial features. For face recognition, facial features are extracted using the Gabor wavelet transform and local binary patterns and the extracted feature vectors are dimensionally reduced using the computationally simple tensor locality preserving projections and the support vector machine classifier is used for classification. The proposed approach is tested on standard YouTube celebrity database and obtained the recognition rate which is comparatively efficient than the sub-space learning methods such as PCA, LDA.

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