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An Efficient System for Face Recognition under Various Illumination Conditions

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Abstract

In computer vision, Face recognition has become a popular area of research. It is used for identification and security system. In Face recognition, more challenging thing is identifying various illumination conditions either varying lighting direction or varying lighting magnitude. To enhance recognition of this illumination of digital image using contrast stretching algorithm as a pre-processing step. Then the face region is detected using Adaptive Boosting (AdaBoost) algorithm. Its classifiers make their decisions based on the Haar features. And logarithmic nonsubsampled contourlet transform (LNSCT) is used to extract invariant feature of strong edges, weak edges, and noise from a face image. Artificial neural networks (ANN) have been used in the field of image processing and pattern recognitions. Person is recognized using ANN classifier.

Keywords: Adaboost, ANN, Face Recognition, LNSCT

I. INTRODUCTION

Face recognition has been growing rapidly in the past few years for various areas of Law Enforcement, Biometrics, Security, and other commercial uses. A biometric recognition system that identifies a person's identity using a person's physiological. A face recognition system, the variation in illumination is one of the main challenging problems. It has been proven that in face recognition, differences caused by illumination variations either varying lighting direction or varying lighting magnitude is more significant than differences between individuals. When the face image has irregularly lighted conditions, some places on the face image will remain too dark or too bright [05], [11].

To deal with the illumination variation issue of digital face images illumination normalization is done, which uses image processing techniques. For illumination normalization contrast stretching algorithm is used to normalize human face image in order to obtain face image's stability. Contrast stretching is a well-known technique for adjusting the contrast of the image due to illumination variations. In Contrast stretching normalization process the image data are normalized between maximum and minimum. After contrast stretching Gamma correction is applied on the face image it further enhances the local dynamic range of the image.

The face detection algorithm looks for specific Haar features of a human face. This algorithm allows the face candidate to pass to the next stage of detection, when one of these features is found. The sub-window is generated from the original image of face candidate as rectangular section. This sub-window is often scaled in order to obtain a variety of different size faces. The algorithm scans the entire image with this window and denotes each respective section a face candidate. The AdaBoost algorithm is a method for combining a set of weak classifiers to make a strong classifier. The weak classifiers make their decisions based on the Haar features. The results of all the classifiers are combined to make a strong decision based on which the face is detected.

Logarithmic nonsubsampled contourlet transform (LNSCT) algorithm is used to performs logarithm transform on digital image under various illumination conditions. In the logarithm domain the low-pass subband of face image and the low frequency part of strong edges can be regarded as the illumination component, while weak edges and the high frequency part of strong edges can be considered as the reflectance component. The Laplacian pyramids for multiscale decomposition, and directional filter banks (DFB) for directional decomposition in contourlet transform to achieve the shift-invariance. Non-sampling contourlet transform is used to decompose the logarithm transformed face image. It's extraction of illumination invariant facial features.

Artificial neural networks (ANN) were used in the fields of image processing (compression, recognition and encryption) and pattern recognition. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons.

The organization of the paper is as follows: In section 2, survey of various faces recognition techniques. In section 3, methodology of face recognition is described. In section 4 the experiment and result are tested and finally we have presented our work with the conclusion in section 5.

II. RELATED WORK

Human face detection and recognition techniques have attracted much attention over the years and many algorithms have been developed. Patrik Kamencay et.al., have proposed a method for face recognition using image segmentation based SPCA-KNN methods [01]. Here face region are segmented using graph based segmentation algorithm and extract feature from the segmented face region using Scale Invariant Feature Transform. The samples were classified using hybrid SPCA-KNN and the accuracy attained was 95.3%.

Mithila Sompura et.al., fast efficient algorithm is developed with the better recognition rate of face in different conditions

that is illumination, head pose, expressions etc. The proposed system extracts the global and local features using Principle Component Analysis and Local Binary Pattern respectively [2]. First apply the principle component analysis to extract the global features considering whole face and the local features by dividing the whole face in to sub-blocks using the Local Binary Pattern. This method achieves 93% accuracy.

Wonjun Hwang et.al presents a robust face recognition system for large-scale data sets taken under uncontrolled illumination variations [3]. The propose system consists of pre-processing method as normalizing and integrating the smoothed gradients of a facial image. The hybrid Fourier-based facial feature extraction are used to extracted from different Fourier domains in different frequency bandwidths, and then each feature is individually classified by linear discriminate analysis and a log likelihood ratio-based score fusion scheme for classifier. This proposed method shows an average of 81.49% verification rate on face images under various environmental variations such as illumination changes, expression changes, and time elapses.

Xiaoyang Tan et.al, [6] proposed a simple and efficient pre-processing approach that eliminates most of the effects of changing illumination keeping the essential appearance details that are needed for recognition unchanged. This paper depicted about Local ternary pattern (LTP) a generation of the local binary pattern (LBP) which is a local texture descriptor that is more discriminant and less sensitive to noise in region which is uniform and also details about to show that replacing comparisons based on local spatial histograms with a distance transform based similarity metric further improves this face recognition. Robustness is further improved by adding Kernel principal component analysis (PCA) feature extraction. Also set of experiments are performed to show that the proposed method outperforms several existing pre-processors for a range of feature sets, data sets and lighting conditions.

S. S. Shylaja et.al, [7] investigated the use of five novel approaches for learning low dimensional representation of a face image using the concept of transmutation and its variants. Comparisons among the proposed algorithms have been carried out and experiments taking. Two dataset Grimace and ORL are conducted. The results justified that transmutation method outperforms its variant. P.T. Chavda et.al, [8] discussed some normalized methods to solve some common problems in face images due to varying lightning conditions. Various pre-processing techniques suggested by different authors and their results are collected. The face recognition system using Principle Component Analysis (PCA) algorithm with Euclidean distance as a classifier is studied. This approach is experimented using Yale and ORL database.

Jia Mingxing, et.al, [10] proposed as combining SVM into the traditional face detection algorithm named AdaBoost. To training SVM classifier, extract several Haar-like features with the strongest classification ability. The classifier classify validation set of generalization capability and using the penalty factor setting with focus makes SVM classifier pay more attention to the face samples. AdaBoost has better higher detection rate and lower false detection rate, and decrease the training computation.

Jiapei Zhang et.al, [12] in this proposed methods for single image-based face recognition under varying lighting including an illumination pre-processing and an illumination-insensitive facial features extraction. It performs various type of feature extraction and it's concluded Gradient Face algorithm for controlled image and Gradieant Face and LTP for uncontrolled image. It's achieves 92.36% and 87.27% respectively.

III. METHODOLOGY

The proposed model working flow is shown in Figure 1. The complete model is divided into two phase i.e. training phase and testing phase. The architecture of proposed system consists of different steps like pre-processing, face detection, feature extraction and ANN classifier. In preprocessing stage the RGB input image is converted into gray scale image. ADaBoost algorithm is used to detect the face. Furthermore features are extracted by using LNSCT method. Finally classification process takes place by using ANN classifier. The following section represents the detailed explanation of each step.

3.1 Pre-Processing

In face recognition, the illumination problem as a challenging issue. The illumination issue is mainly referred to the variation caused by either varying lighting direction or varying lighting magnitude. The system comprises of two stages- training and testing.

In the training stage, normal images captured under perfect lighting conditions are considered. These images undergo RGB to gray scale conversion which is the pre-processing step. This conversion is carried out because color information in RGB image is of no use when it comes to identifying important edges, contours or other features. It is eliminating the hue and saturation information while retaining the luminance. Also gray scale simplifies the algorithm and reduces computational requirements.

In the testing stage, input image with some variation in the illumination is considered. This image undergoes pre-processing method which includes RGB to gray scale conversion and normalization. Normalization, a method that changes the range of pixel values, is carried out by employing contrast stretching algorithm. It is used to increase the dynamic range of the gray levels in the image.

The images can be enhanced by expanding the number of gray levels to a wider range, if the number of gray levels in the recorded image spread over a lesser range.

This contrast stretching algorithm enhances the image by stretching the intensity values range is shown in Figure 3. Normalisation, a method that changes the range of pixel values, is carried out by employing contrast stretching algorithm. It is used to increase the dynamic range of the gray levels in the image. The images can be enhanced by expanding the number of gray levels to a wider range, if the number of gray levels in the recorded image spread over a lesser range.

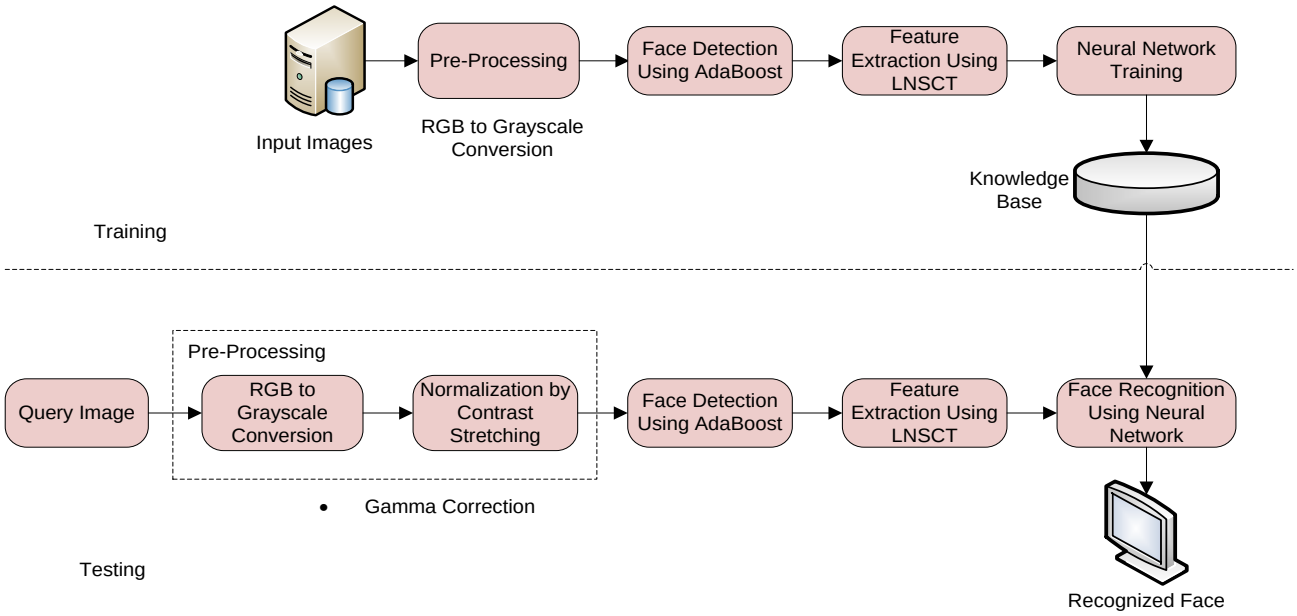


Figure 1: Block Diagram of the Illumination Invariant Face Recognition System

Gamma correction: it is the non linear gray level transformation that changes gray level I with I^{γ} for $(\gamma > 0)$ or $\log(I)$ for $(\gamma = 0)$, where $\gamma \in [0, 1]$ is a user defined parameter. This improves local dynamic range of image in shadowed or dark area whereas compressing it in bright areas and at highlights. Light intensity reflected from an object is the product of incoming illumination L and local surface reflectance R. Here they want to recover object level information independent of illumination and taking logs makes the task simpler by changing product into a sum: for steady local illumination, the specified reflectance step generates a specified step in $\log(I)$ irrespective of real intensity of illumination.

(a) (b) (c)

Figure 2: Shows the various illumination of testing input image. (a) Normal image; (b) Low contrast image; (c) High contrast image.

(a) (b) (c)

Figure 3: Applying contrasts stretching and gamma correction algorithm to various illumination images.

(a) Normal image; (b) low contrast image; (c) high contrast image.

3.2 Face Detection using AdaBoost

Then the face is detected using Adaptive Boosting (AdaBoost) algorithm. The AdaBoost algorithm is a method for combining a set of weak classifiers to make a strong classifier. The weak classifiers make their decisions based on the Haar-wavelet like features. Haar-like features impulses a real-time performance with fairly high detection and low false positive rates. It's performance of boosted cascade classifier. Despite training time of such a system is rather lengthy. So that AdaBoost algorithm is used to select a specified number of weak classifiers with lowest error rates for each cascade and the process is repeated until a set of optimization is satisfied. It picks out several features with the strongest classification ability as weak classifiers, after that make these weak classifiers become a strong classification.

The results of all the classifiers are combined to make a strong decision based on which the face is detected under various illumination conditions. The black colour rectangle box indicates the face detected area of various illumination conditions. The Figure 4 shows the detected face images in normal, low and high contrast using AdaBoost algorithm.

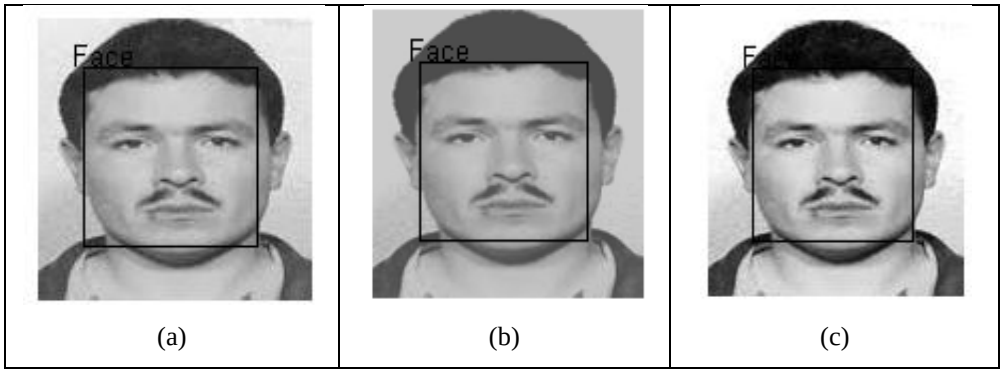


Figure 4: Face detection using AdaBoost algorithm. (a) Face detected in normal image (b) Face detected in low contrast image (c) Face detected in high contrast image

3.3 Feature Extraction using LNSCT

Next step is to extract features of the detected face. In order to recognise face under varying lighting conditions like dark lighting. It extracts illumination invariant facial features using logarithmic non-subsampled contourlet transforms (LNSCT). LNSCT utilizes nonsubsampled contourlet transform (NSCL), which is fully shift-invariant, multi-scale, multi-directivity geometrical structure transform. Contourlet transform provides better approximation coefficients than normal wavelet transform. Reflectance component and illumination effect can be analyzed using NSCT in logarithmic domain. Linear matrix decomposition of the image into different frequency sub-bands using logarithmic domain has the advantage of extracting intrinsic illumination invariant features very well compared with decomposition performed in image domain. In illumination component, low-pass sub-band of face image and low frequency part of strong edges can be regarded. While weak edges and the high frequency part of strong edges can be considered as the reflectance component in the logarithm domain. The system presented here makes use of these features in order to make it robust against varying lighting conditions.

3.4 ANN Classifier

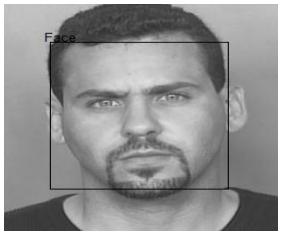
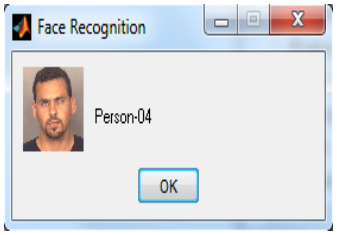
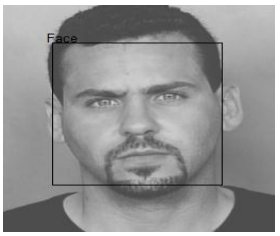
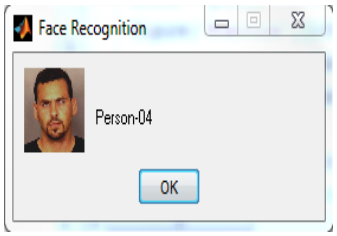
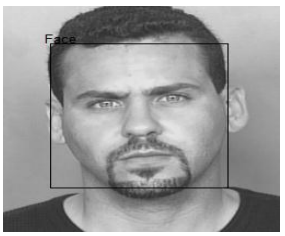
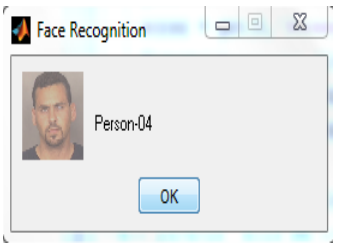
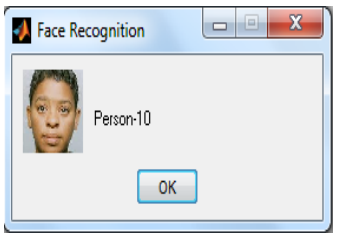
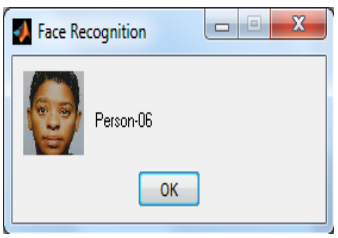
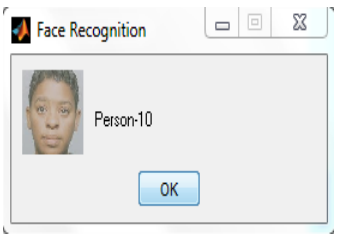
By implementing artificial neural networks (ANNs), Classification and recognition of images using facial features is achieved. Artificial neural network with feed-forward topology is called feed-forward artificial neural network. It has only one condition, feature must flow from input to output direction, and this is no back-loops. It has on limitations on layers, type of transfer function in individual artificial neuron. The feed-forward artificial neural network is a single perception that is capable of learning linear separable problems.

ANNs are used to estimate or approximate functions that are dependent on inputs. To evaluate output coefficients, the input coefficients of ANNs utilizes hidden layer. The output coefficients of training phase obtained from ANNs are stored in the knowledge base to recognize faces. These features are sent to the neural network. The neural network recognises the person by comparing the features extracted with the trained coefficients stored in the knowledge base.

IV. EXPERIMENTAL AND RESULTS

The proposed approach is implemented on various illumination conditions. Table 1 show the input image of each person with various illuminations. An input image of normal image is a1, b1 as low contrast image and c1 as high contrast image. In table 1, a2, b2 and c2 show the contrast stretching images. Face is detected using AdaBoost algorithm that shows in a3, b3 and c4. And the person is recognized using ANN classifier that shows in a4, b4 and c4. It has miss classification that show in person 10 as person 06 for low contrast image. This classification has some problem for classifying low and high contrast image.

Table 1: Shows the various illumination of the test image with their result.

PERSON	INPUT IMAGE	PRE-PROCESSED IMAGE	FACE DETECTED IMAGE	RECOGNIZED PERSON
Person 04	 (a1)	 (a2)	 (a3)	 (a4)
	 (b1)	 (b2)	 **(b3)**	 (b4)
	 (c1)	 (c2)	 (c3)	 (c4)
Person 10	 (a1)	 (a2)	 (a3)	 (a4)
	 (b1)	 (b2)	 (b3)	 (b4)
	 (c1)	 (c2)	 (c3)	 (c4)

Person 19

(a1) (a2) (a3) (a4)

(b1) (b2) (b3) (b4)

(c1) (c2) (c3) (c4)

The proposed face detection system uses "IIIT-Delhi" database. Here total 60 images are used for testing process and 20 images for training process. The overall accuracy of the proposed system is 96.66%. The calculation metrics of accuracy is taken in terms of T_p T_n F_p F_n. Where T_p = True positive, T_n is True negative, $F_p$is False positive and $F_n$is False negative. The accuracy of the proposed system is calculated by using the below equation (01). The Table 2 shows the confusion matrix of the proposed system. The Table 3 shows the comparison table of the existing and the proposed system.

The Figure 5 shows the accuracy graph of the existing and the proposed system, from the graph we can say that the proposed ANN classifier will give the better accuracy as compared to the other existing systems.

$$Accuracy = \frac{T_p + T_n}{T_p + T_n + F_p + F_n} \quad (01)$$

Table 2: Confusion Matrix for the Proposed System

Total No=60	Predicted No	Predicted Yes
Actual No	1 (TN)	1 (FP)
Actual Yes	1 (FN)	57 (TP)

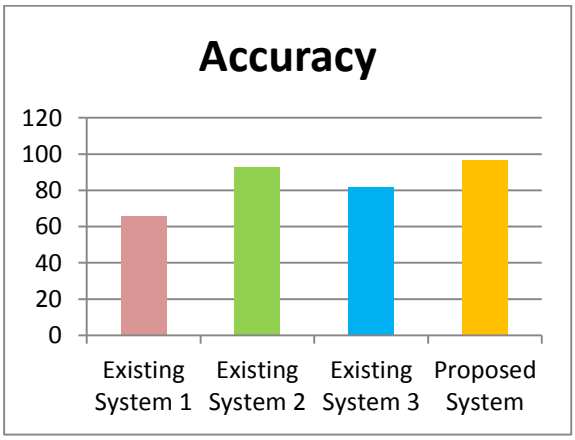


Figure 5: Comparison Graph for Accuracy

Table 3: Comparison Table of the Existing and Proposed System

Method	Accuracy
SPCA-KNN	85.9%
BPMLP (Back Propagation Multilayer Perceptron)	93%
Global Features	81..49%
Proposed method ANN(Artificial Neural Network)	96.66%

V. CONCLUSION

Face recognition under various illuminations is more challenging one. In this paper we proposed the pre-processing feature extraction and classifier. First, we proposed a pre-processing method based on intensity adjustment and contrast enhancement to get the enhanced image. We also proposed the AdaBoost algorithm based on the Haar features to detect the human face. And Logarithmic nonsubsampled contourlet transform (LNSCT) is used to extract invariant feature of strong edges, weak edges, and noise from a face image. LNSCT utilizes nonsubsampled contourlet transform (NSCL), which is fully shift-invariant, multi-scale, multi-directivity geometrical structure transform. Contourlet transform and provides the better approximation coefficients than normal wavelet transform. Reflectance component and illumination effect can be analyzed using NSCT in logarithmic domain. Using ANN classifier, it used to recognize the person with more accuracy.

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