PERFORMANCE EVALUATION OF ILLUMINATION INVARIANT FACE RECOGNITION ALGORTHIMS

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Abstract – *Evaluation methods are the paradigm to determine the accuracy and performance of the illumination invariant face recognition algorithms. Performance evaluation methods are used to differentiate, compare and elucidate various aspects of face recognition such as features of subjects, location and illumination. Changing illumination severely affects the recognition accuracy of various existing face recognition algorithms. To address the illumination problem various illumination insensitive face recognition methods are developed. This paper presents a hybrid approach of illumination invariant face recognition using Local Binary Pattern and Local Ternary Pattern fusion with illumination normalization and compares the performance of the proposed algorithm and traditional algorithms using the Receiver Operating characteristics(ROC).*

***Key Words*: Receiver Operating Characteristics, Illumination, Local Binary Patterns, Local Ternary Patterns, Gradient etc.**

1. INTRODUCTION

User authentication is an extremely important task for most of the security systems. The traditional methods of user authentication such as ID cards and passwords are recently being replaced by various forms of biometrics such as iris, fingerprint, voice, face etc. Face recognition is the best alternative among various forms of biometrics because the authentication can be carried out in a smooth manner without causing any disturbance to the user or stopping the user activities. Face recognition process is also economic due to the low cost of cameras and computers involved. The faces contained in the images and videos are automatically identified by the face recognition systems. Face recognition systems operate in two modes: (1) Face verification which is a one-to-one matching process compares the test image against a template image whose identity is being requested. (2) Face identification which is a one-to-many matching process compares the test image with all the template images present in the face database to find out the identity of the given test image [1].

Illumination variations are the major challenge for the various existing face recognition algorithms. The variations caused by changing lighting conditions for the same face image are often larger than the image variations caused by changing face identity of different face images [2]. The images of the same person with no change in poses, expressions or viewing angle appear to be dramatically different under varying lighting conditions. Various algorithms have developed such as Gradient faces, Weber face, Local binary pattern etc. to tackle the illumination problem and make the face recognition systems illumination insensitive.

Performance evaluation is a standard used to examine the efficiency of face recognition algorithms. This assessment is necessary to examine the quality of a particular technique, to refine its parameters and to select the best technique to address a particular problem. This paper presents a fusion of two local feature extraction techniques Local binary pattern and Local ternary pattern with gradient based illumination normalization in the pre-processing stage. Also the performance evaluation of the proposed system and existing techniques is carried out on the basis of Receiver Operating Characteristics (ROC).

2. EXISTING ILLUMINATION INVARIANT APPROACHES

Gradientfaces – Gradientfaces is a novel face recognition technique which is used to extract the features that are illumination invariant form the face images under variable lighting conditions. Gradient domain explicitly takes into consideration the relationships between neighboring pixel points which is the main motivation behind derivation of Gradient faces from the image gradient domain. Gradientfaces are capable of discovering the underlying inherent structures of the face images and their discriminating power is much larger in comparison to the illumination invariant measure extracted from the pixel domain. Gradientfaces outperform other methods such as SQI and LTV in terms of recognition accuracy and is more robust to noise and varying illumination including uncontrolled lighting conditions. The advantages of

Gradientfaces are (1) applied directly to single face image (2) no prior information is needed about 3Dface shape [4].

Weberface – Weberface is an illumination normalization technique based on the concept of Weber's law which states that the ratio of the minute perceptual change and the background is a constant. The stimuli are recognized in relative terms and not in absolute terms. The intensity of the current pixel and its relative difference in intensity with respect to its neighbors is computed for each pixel of the given face image. The ratio of these two terms is called Weberface and is capable of precisely extracting the local salient patterns of the input face image. Weberface is an illumination invariant representation of the face image according to the Lambertian Reflectance model. The method outperforms various state-of-art methods and is computationally more efficient [5].

Local Binary Pattern – Local Binary Pattern is a local feature extraction technique which is used to describe the shape and texture of the digital images. The features are extracted by dividing an image into several small sub-blocks. The features are basically the binary patterns which describe the local neighborhood of each pixel in a small local area. A single feature histogram is obtained by concatenating the features obtained from the various sub-blocks of the images, which represents the face image. For the comparison of images, the distance or similarity between their histograms is measured. The eight surrounding pixels of a particular pixel are transformed into a binary pattern by using the value of the center pixel as a threshold. The criteria used for thresholding is that if the neighboring pixel's value is greater than the center pixel, then it is assigned a value '1' otherwise a '0' is assigned. LBP is a very efficient method in terms of speed and discrimination performance [13].

Local Directional Pattern based approaches – The approaches based on LDP [7] such as LDP, EnLDP, LDN are functional in gradient domain to obtain the illumination insensitive representations. Directional information is utilized to obtain edge responses that are invariant to changing lighting conditions. The different kinds of textures in facial images are distinguished by accurately encoding the different edge responses around each pixel due to the fact that edge magnitudes are invariant to illumination variations. In the 8-bit binary LDP code, the three bits corresponding to the three most prominent numbers are assigned value '1' and a '0' is assigned to the other 5 bits. For each pixel position, the edge response values in all the eight directions are computed using Kirsch Compass Masks to obtain the LDP feature and then a code is generated from the relative strength magnitude. The LDP codes are robust against changing illumination conditions and represent the face efficiently even in the presence of random noise. The LDP histograms extracted from the small divided sub-regions of the face image are concatenated into a single feature vector which efficiently represents the face image.

EnLDP [8] is an enhanced version of Local Directional Patterns which uses a 6-bit binary code where the first three bits correspond to the top positive directional number and the successive three bits correspond to the second top positive directional number. LDN [9] stands for Local Directional Number which is also a 6-bit coding scheme where the first three bits correspond to the top positive directional number and the successive three bits correspond to the top negative directional number. The corresponding LDP, EnLDP and LDN faces are obtained by converting the generated codes into their decimal values.

Eight Local Directional Patterns – The edge responses are computed using Kirsch compass masks which give the eight directional edge images. The edge significance in their respective directions is represented by these eight edge images. The edge responses are highly significant but each of them has a different level of importance. So the information in all the eight directional numbers for each pixel is used to obtain the associated 8-bit binary code. If an image is having positive directional number, then the value of the respective bit is set to '1' otherwise the value is set to '0'. Then the final ELDP value is obtained by computing the decimal value of the 8-bit binary code. All the eight directional numbers are used by ELDP and more valuable structural information is represented by ELDP [10]. However the images need to be smoothened first using a Gaussian filter before carrying out the ELDP process.

AH-ELDP [11] stands for Adaptive Homomorphic Eight Local Directional Patterns. In this method, the low frequency illumination components are suppressed while the high frequency components such as texture information are strengthened by employing adaptive Homomorphic filter in the frequency domain. The Homomorphic filter is adjusted for each face image by an adaptive constant c on the basis of slope of variations in the low frequency components of the image and thus the illumination influence is reduced. The contrast of the filtered image is stretched by using interval type-2 fuzzy sets for applying an interpolative enhancement function on the image. Finally AH-ELDP image is obtained by using kirsch compass masks to produce edge responses and by considering the relationship among eight directional numbers.

The CELDP [6] method operates by using logarithmic fractal dimension based complete eight local directional patterns. The low frequency components of the image are attenuated to reduce the illumination effect by using adaptive Homomorphic filter. The facial features such as eyes, nose, eyebrows etc. are enhanced while noise is suppressed by using logarithmic fractal dimension as edge enhancer technique. Finally the CELDP is used to overcome the illumination effect and noise since it not only considers the relations among the magnitudes and directions of all the eight directional patterns but also provides more effective information about the neighborhood.

3. PROPOSED METHOD

The proposed method is based on local gradient based illumination normalization along with the fusion of the two local texture descriptors at the feature level. To obtain the illumination invariant face representation, a ratio of the gradient amplitude to the original image intensity is computed which is insensitive to changing lighting conditions [3].

Local binary pattern is a very efficient local feature extraction technique which demonstrates the texture and shape information of the face image and is invariant to monotonic variations in grayscale images. Local ternary pattern [12] is an extended form of LBP which uses a threshold constant to change the neighborhood pixels into a binary pattern. LTP is a noise resistant version of LBP.
Combining information from two different feature extraction techniques provides more discriminative information about the image features. Therefore, a feature level fusion of two techniques is carried out and Artificial Neural Network is used in the classification stage due to its iterative learning process and efficient performance.

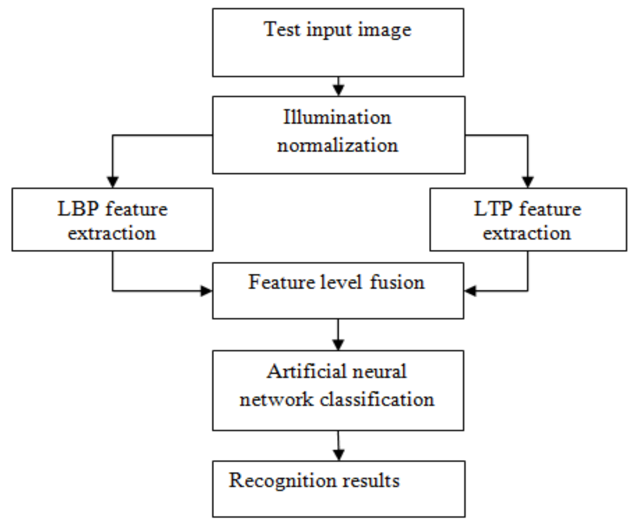

Figure 1 Block diagram of the proposed method

4. EXPERIMENTAL RESULTS

The ROC [6] curves are used to embellish the ability of a binary classifier to verify and discriminate the various samples. The true positive rate (TPR) is plotted against false positive rate (FPR) of the classifier. A method having a higher value of TPR and lower value of FPR is said to have good verification and discrimination capability.

P= total no. of correct samples
N= total no. of incorrect samples

- True Positive (TP) – If a prediction has a positive value for the outcome as well as actual value, then it is called true positive (TP).
- True Negative (TN) – If the actual value as well as outcome of a prediction is negative, it is called true negative (TN).
- False Positive (FP) – If the outcome of a prediction is positive while the actual value is negative, it is called false positive(FP)
- False Negative (FN) – If the outcome for a prediction is negative while the actual value is positive, it is called false negative (FN).
- True Positive Rate (TPR) – The probability with which a template is correctly matched with an existing pattern in the database. It is almost same as ‘hit rate’ or ‘recall’.
- False Positive Rate (FPR) – The probability with which a template is falsely matched with an existing pattern in the database. It is also called ‘false alarm’ or ‘fallout’ [14].

The ROC curves are plotted for two popular face databases AR and Extended Yale B database. The AR face database has a total of 3536 facial images consisting of 136 individuals out of which 76 are men and 60 are women. The images are frontal view face images with different illumination conditions, facial expressions and occlusions. The face images of 9 persons under 12 different illumination conditions are used in this paper for plotting the ROC curves for the proposed algorithm and the previous techniques. The Yale B database consists of 5760 images having size 192 ×168 pixels for 10 persons with 9 different poses and 64 illumination conditions for one pose. The Extended Yale B database is an extended form of Yale B database with 10 to 38 subjects having 21 888 single light images with the same viewing conditions as in Yale B. The frontal pose images of 20 persons with 26 different illumination conditions per person are used in this work to plot the ROC curves for the proposed and the previous techniques.

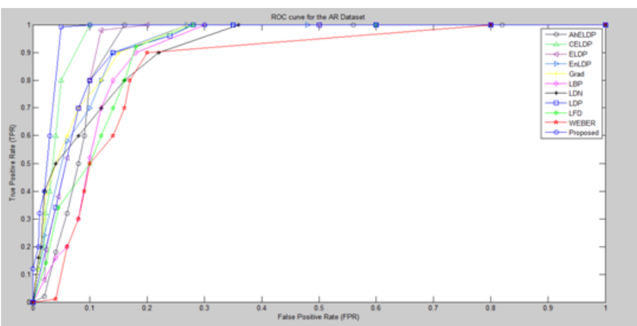

Figure 2 ROC curves for the AR database

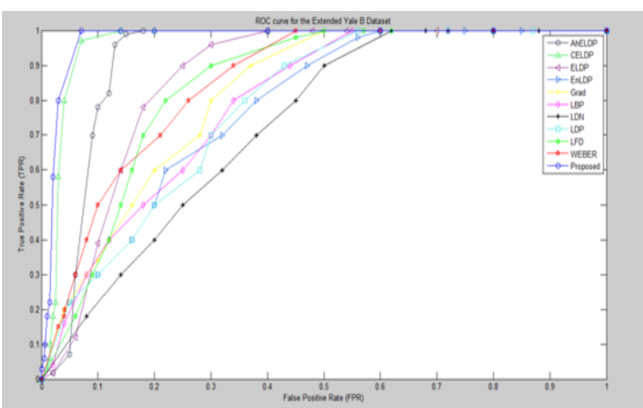

Figure 3 ROC curves for the Extended Yale B database

As it is clear from the ROC curves on the two popular face databases AR and Extended Yale B that the proposed method based on hybrid feature extraction technique LBP-LTP is having the outstanding verification and discrimination capability in comparison to the other state-of-art techniques of illumination invariant face recognition since the proposed method is having the largest area under the ROC curve.

5. CONCLUSION

The major goal of this paper is to evaluate and compare the performance of the proposed method and the various state-of-art methods on the basis of their Receiver Operating Characteristics (ROC). The proposed method uses the concept of hybrid feature extraction technique and gradient based illumination normalization. It is inferred from the study of current literature that combining information from the two different feature extraction techniques can result in better performance. The proposed method outperforms the various existing techniques due to its largest area under the ROC curve and higher TPR but lower FPR values.

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