Improving the Efficiency of Face Recognition System for Images with Different Illumination Conditions

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Abstract **- This paper proposes a novel technique that improves the face recognition rate for multispectral face images by selecting the narrowband for the given illumination. The existing methods have demonstrated good recognition performance with frontal, centered and expressionless views of faces acquired under controlled lighting conditions. One of the main challenges to face recognition system is the degradation caused by varying illumination. In this paper, a technique that improves the recognition rate, optimal spectral range is specified automatically based on the given lighting condition of the images. This technique consists of three main sequential processes - Image acquisition, Spectral band selection and Image fusion. The given input image is compared with the gallery images, and similarity score is generated. Then quantified measure is calculated to separate the genuine and imposter similarity scores. From the previous values, optimal narrow bands are selected and images of those bands are fused together, which gives more information about the image. This fused image is fed into the classifier to calculate the recognition rate. The results produced by this method outperform all the other conventional methods used for broad-band images under varying lighting conditions.**

Keywords **- Face Recognition, Illumination, Band Fusion, Narrowband, Similarity Score, Divergence.**

1. INTRODUCTION

Face recognition is one of the interesting research areas in an improvised computer world. It attracts many researchers to work in the new research area like invariant feature recognition systems; facial expression recognition and for identifying the faces which has been changed because of operations like plastic surgery, images which are taken in different lightening and etc. Face recognition plays an important role in image processing applications by means of commercial and security purposes. When face recognition is considered, illumination and changes in poses takes place a vital role. Because of this reason many of the face recognition systems cannot produce the accurate results. The image of a same person can look totally different when the photo is taken from in different lightening. This is shown in the Fig1. So the presence of bad illumination conditions may lead the face recognition system to make incorrect decision in recognizing a face.

However, due to difficulty in controlling the lighting conditions in practical applications, variable illumination is one of the most challenging problems with face recognition. The possibilities of wrong recognition of same images in different illuminations have been proved through many research works. In existing face recognition system, they were trained only for images which are taken in controlled lightings. After that some systems came which considered the illumination as the major role for wrong identification. But the results were not satisfying one. Because all that systems have three main phases, to process the image under different lightening conditions. They are i) Preprocessing and Normalization ii) Feature Extraction iii) Face Modeling. But each of these algorithms has some disadvantages which may lead to wrong results for images under varying illuminations.

Fig 1. Images taken in different Illumination

Some of the face recognition algorithms used preprocessing steps that are easy to use but restricted to produce the detailed informations. In other steps, algorithms are sensitive to illumination invariant features. So these techniques are not sufficient for images with various illuminations. In [13] prototype image from a given image is used for the recognition with the help of varying albedo illumination model which is simple which lead to 60% recognition rate. Then a technique is introduced which uses visible image with an images captured near infrared bandwidth, in a spectrum level 700-1000nm. Even though it produced the accepting level of results, it is successful since it needs a complex registration procedure.

This paper deals with multispectral images. Multispectral imaging is a technique that provides images of a scene at multiple wavelengths and can generate precise optical spectra at every pixel. Fig 2 shows the sensor response for monochrome and multispectral imaging system. These multispectral images are used for two main reasons, i) the illumination can be separated from the color of the object ii) the narrowband which has the face information can be extracted and it can be processed. Aim of the technique used in this paper is spectral range extension for specified illumination for improvised face recognition. In [16], many of the illumination based works used eigen light fields and Bayesian face sub regions methods. Consider that there are total numbers of multispectral bands for the given image is NB and λ_k denote the central wavelength of the k^{th} band. The complete set of multispectral bands is B= $\{\lambda_k | k=1...N_B\}$. The method proposed in this paper finds the spectral sub band which produces the fused image to outperform the conventional broadband images.

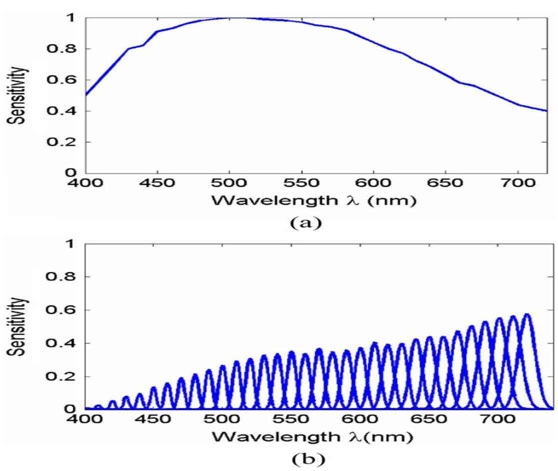


Fig.2. Spectral Response for a) Monochromatic b) Multispectral Image System

In section 2, the importance of illumination in face recognition and the physical characteristics of that factor are discussed. Section 3 discusses the proposed algorithm that calculates the similarity scores. In section 4 the experimental results of the works has been discussed. Section 5 provides conclusion of the work and also the possibilities to extend the work in future.

2. ILLUMINATION FACTOR

Multispectral images have been used federally designated tasks which may design push-broom and Charge Coupled Device (CCD) with narrow or broadband filters. These kinds of images will not have any changes in it and should be processed as it is for an efficient result. Here, to capture the images in various wavelengths and to produce the stack of images in different wavelength tunable filters can be used. In [14] various illuminations characteristics has been discussed and experimentally explained. Here conical coordinate systems used for spectral color space systems. Intensity values of a multispectral image can be affected by four factors. They are a) spectral reflectance of a subject R(λ), spectral distribution of the illumination ; L(λ) spectral response of the camera ; S(λ) the transmittance of the liquid-crystal- tuneable filter (LCTF) ; T(λ) So camera response 'p' in a wavelength λk , can be calculated as, $p_{\lambda k} = R_{\lambda k} L_{\lambda k} S_{\lambda k} T_{\lambda k}$

Fig.3. Same Image in Different Illumination conditions

Deciding minimum and maximum level of wavelengths for the selected multispectral image will help us to find the λ. For each selection of λ except the illumination factor, other three factors will be constant which depends upon the factors like skin reflectance and sensor response. Each band will have the different illumination level. Fig.3 shows the same image in different illumination and also different region of people will be having different skin colours. So their reflectance level will be also changing. This leads to the change in the illumination level too. But other three factors will not have any change. Illumination in one band can be changed to another illumination present in another band by changing or giving some weights to the present illumination. So finally intensity of a fused image can be obtained with some improvements..

3. ALGORITHM METHODOLOGY

3.1 Similarity Score

The database will have all the images, which has to be trained properly. This will be used as a gallery which will have some N images, and it can be denoted as $\{g_1 \ldots g_N\}$.The input image will be considered as a probe. This probe will be compared with all gallery images and produces some similarity scores (S_{ij}) for each band. This similarity score can be any one of these two types i) Genuine or ii) Imposter. Genuine: similarity score between probe and gallery for same subjects. G_k : $\{\mathbf{S}^{\mathbf{k}}_{\mathbf{ij}}$, i=j} and Imposter: similarity score between probe and gallery for different subjects. I_k :{ $\mathbf{S}^{\mathbf{k}}_{\mathbf{ij}}$, i ≠j}. Fig. 3 shows the similarity scores for Genuine and Imposter set*s*. S^k_{ij} is the similarity score between the probe image of the i^{th} subject collected at the k^{th} band and the gallery image of the j^{th} subject. Here finding the similarity score plays a vital role. In existing systems this score has been found by using some existing face recognition system. Varying similarity scores may give various results. So in this proposed work, the mathematical formula will be used which will increase the probability of getting more efficient system.

To separate, the above two imposter and genuine groups should not be overlapped so that appropriate threshold can be found which will lead to 100% accurate results. But in real world it is not possible. So separating these two similarity scores leads to the better performance of the system by selecting the narrow band. This paper increases the accuracy of the recognition system. To find out this similarity score, the variables are standardized by using, mean absolute deviation. Then the similarity score is calculated using Euclidean distance method. Each band of the multispectral image will produce different similarity scores which may lead to different recognition rate for each band. Distributing these similarity values and their probability range will give the information that which band range produces the more accurate result. Selecting the band range plays vital role in this. Many similarity score calculations has been proposed by researchers earlier. For example in [15], feature learning method is used to produce the similarity score matrix and in clustering based approach. But basically clustering graph method is a complicated process. In this work the spectrum level is considered between 480nm to 720nm.This spectrum level can be extended to get good results.

3.2. Description

The proper face recognition system starts with pre-processing and normalizing of probe and gallery images. This gives the equal weight to all the pixels in the image. This pre-processing involves steps like segmentation, histogram equalization and then normalization of the resultant images. After pre-processing, feature extraction of an image should be done. In feature extraction, there are two main types like Global and Local feature extraction. In case of local feature extraction, eye points, mouth points or nose tips can be detected and those will be used in a comparison. But in the case of global feature extraction, values like mean, standard deviation of an image will be calculated and that will be used for comparison. This global method used to calculate the minute values of an image. In this paper, global feature extraction method is taken.

Principle Component Analysis is a one of the best Global methods which will produce the eigenfaces for the given input image. This method is an example for the dimensionality reduction process. By using this PCA features can be extracted for both probe and gallery images. This will be used to calculate the similarity scores. When the probe is compared with the entire gallery samples, these PCA features will be compared and returns the result as Genuine or Imposter similarity score by using efficient mathematical formulas. To calculate the similarity score, in this paper a complex wavelet structural similarity (CWSSIM) is used. This method has been proved as one of the best methods in [4]. CWSSIM method is insensitive to illumination variation. The formula for CWSSIM is given as:

$$CWSSIM(C_x C_y) = \frac{2\left|\sum_{i=1}^{N} C_{x,i} C_{y,i}^{*}\right| + K}{\sum_{i=1}^{N} |C_{x,i}|^2 + \sum_{i=1}^{N} |C_{y,i}|^2 + K}$$

Here C_x and C_y are the components of x and y which are the given images to be compared. The value of K is a small positive constant value set as 0.03. In Fig 5 The similarity score calculation for the images are shown.

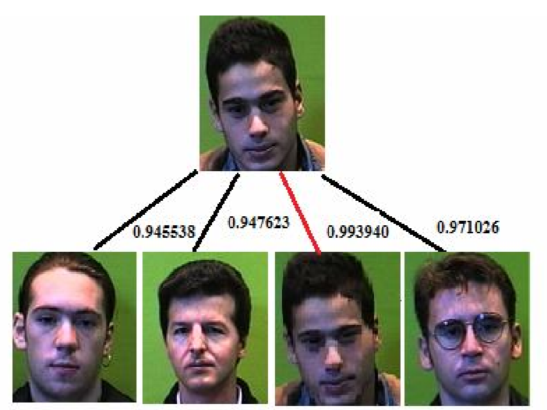


Fig.4. Genuine and Imposter Similarity Score Calculations

After calculating the S_{ij}, band selection should be done. This can be done by distributing the imposter (I_K) and genuine (*G_K*) similarity score by using Kernel Density Function. It is noted that there should be one margin between these two sets to avoid the overlapping of them. This can be done by calculating the distance between these two genuine and imposter sets by using the Bhattacharyya distance.

Distribution of Genuine set by using KDF is,

$$\hat{p}_{G,k}(x) = \frac{1}{Nh_{G,k}} \sum_{i=1}^{N} K\left(\frac{x - S_{ii}^{k}}{h_{G,k}}\right)$$

and

$$\hat{p}_{G,k}(x) = \frac{1}{N(N-1)h_{I,k}} \sum_{i=1}^{N} \sum_{j=1, j\neq 1}^{N} K\left(\frac{x - S_{ij}^{k}}{h_{I,k}}\right)$$

Here k (.) and $h_{G,K}$ / $h_{I,k}$ denotes kernel function and width of the band respectively. By using the above equations probability distribution is found for genuine and imposter sets. Then the divergence method is used to separate these probabilities. Normally KL (Kulback-Leibler) method is used for this calculation. Here in previous the work, Jefferey divergence method is said to be best for Face-It similarity Score method. But in this work, these scores has been calculated by using mathematical formula which is expected to be better than the existing method. For this Bhattacharyya Distance method is used to improve the recognition rate. The formula shown in the next page explains working way of preferred distance calculation method:

$$J_B(p1, p2) = -\log\{\int [p1(x)p2(x)]^{1/2} dx\}$$

After finding out the distance between the probabilities, the number of highest values will be selected as per the number of bands N_B. These bands will be fused by using the Harr wavelet-based fusion. Fusion technology is used because it can reduce the error rate and reliability can be increased. Many fusion technologies are available which are discussed in [17]. The fig 5 elaborates working of the algorithm proposed in this paper which gives the better face recognition rate.

Algorithm:

1. Image pre-processing method like segmentation, normalization and histogram equalization are performed.
2. Features are extracted by using the global method - Principle Component Analysis for face detection.
3. Similarity Score, $S_{i,j}$ is calculated by comparing the probe and gallery image using CWSSIM.
4. Probability Density Function is found for both similarity scores for each band by using Kernel Density Function to distribute the Sij.
5. The difference between the above two KDF's is found by using Bhattacharyya distance which gives the largest separation measure by ordering all the divergence values in descending order. Wavelet based fusion is used to get the fused images.

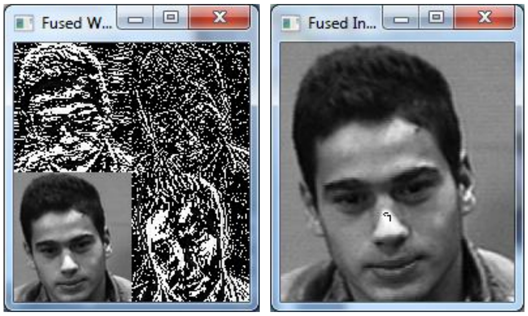
Fig .5. Algorithm Methodology

4. EXPERIMENTAL RESULT

In this section, the experimental results given. The Gallery is maintained with some images. The probe image has been collected with different illumination conditions for the above gallery images. One of the probe images with different illumination is given as input and is compared with all the images in gallery. This produces the similarity score as genuine and imposter sets.

This similarity scores are distributed by using Kernel Density Estimation. These sets are diverged by means of Bhattacharyya distance. By means of the above distances the highest two bands are selected and fused for the improved face recognition rate. The Fig. 6 shows the output images obtained using this method. The ideal software meant for digital image processing namely IDL is used to obtain the results.

Original Input and Wavelet Transformed Image



Fused Wavelet Transformed and Inversed Image

Fig.6. Formation of Fused Images by using Harr Wavelet Transform

5. CONCLUSION AND FUTURE WORK

From the study and analysis of face recognition concepts and methodologies, it has been proved that illumination or changes in the lighting conditions degrades the efficiency of the face recognition system. Many research works have contributed to overcome the issues regarding this illumination like Infra Red methodology. But the results are not satisfying one. In this method the images from different illumination can be handled by using the good similarity score calculations which are used to find out the imposter and genuine probability sets and divergence method to find out the narrow-bands. These narrow-bands will lead to the improved face recognition rate. From the existing systems it is proved that this narrowband selection leads to the better recognition rate through Face-It, rather than other methods. But adopting to different computational method for similarity score and divergence leads to the improved recognition rate.

In future, totally different illumination level and climate can be considered for recognition. The improvement of the hardware setup also can be done in recognition system. For multispectral image systems this lens clarity and hardware setup plays important role.

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