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A Review on Illumination Reduction Techniques for Human Face Recognition

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ABSTRACT

Human face recognition is one among the research areas within the current era of the research. It is one the widely used biometric technique for identification and verification of the face. There are many challenges to face recognition like illumination variation, aging, pose variation and facial expressions etc., which degrade the performance of the algorithm. The illumination variation problem is one among the well-known problems in face recognition in uncontrolled environment. In this paper we are presenting a detail survey on human face recognition under such uncontrolled conditions. Here we've explored different techniques proposed for illumination reduction used for face recognition generally. After illumination reduction any of the face recognition methods and any of the web available face database for recognition purpose. The objective of this review paper is to summarize and compare a number of the well-known methods for better understanding of reader.

KEYWORDS: *FR (Face Recognition), HE (Histogram Equalization), DCT (Discrete Cosine Transform), SIFT (Scale Invariant Feature Transform), GSIFT (Grid Scale Invariant Feature Transform*

I. INTRODUCTION

Face Recognition (FR) is a very simple term, may be a process of recognizing the face of an individual by a system. However, identifying faces through a digital eye isn't a simple task. Whenever face recognition is employed across the closed-circuit television it's often very difficult to accumulate the faces in controlled environment. So there has to be a system which is capable of recognizing the faces captured even in poor lightning conditions and variations in poses as against the faces taken in controlled environment. Although many approaches are proposed during last decade; however, real-world scenarios remain a challenge. Moreover, all the techniques are greatly suffering from variations and their performance get degraded when variations in illumination is present. The illumination problems arise when an equivalent face appears differently thanks to the change in lighting [1].

Face recognition has been a lively research area over the last many years.

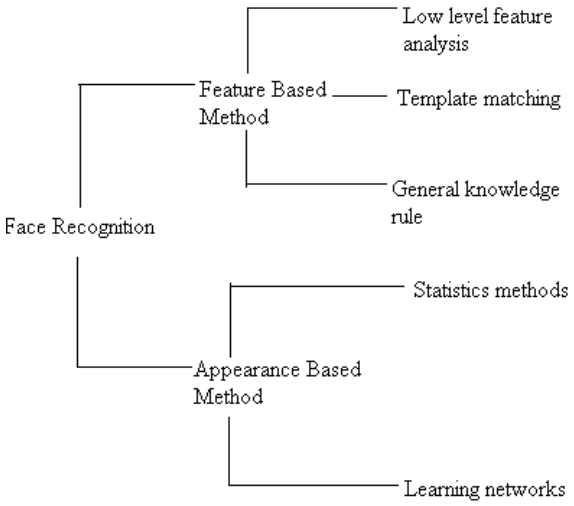

Figure 1: Face Recognition Methods

Many researchers have proposed various face recognition methods that are shown in figure 1.

Feature based methods finds the features of the face image like eyes, lips, nose, mouth etc. This method is also known as non-holistic approach. Appearance based method use entire face image for the popularity process. It is also known as holistic approach.

If all the methods categories listed above are taken into considered, many problems have been solved; but still so many of them remain in this field of research. In this paper, we provide an overview of all the leading illumination approaches which are widely used throughout the world for illumination problem. We explored the methods of implementation of each approach and on the basis of this exploration, we are presenting a survey paper that comprises as much literature study for the reader to know that what precisely the variations are which will be caused by variation in illumination, what approaches had been haunted till now to form continuous improvements in existing systems and their drawbacks etc.

The paper is organized as follows: in Section 2, the essential steps involved during a face recognition system, challenges in face recognition system, in section 3 discuss the illumination reduction techniques, and in section 4 finally, conclusion is given.

II. FACE RECOGNITION SYSTEM

Figure 2 shows the general block diagram for any face recognition system [2].

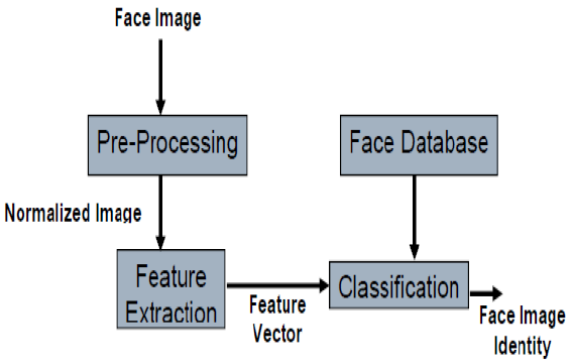

Figure 2 Face Recognition System [13]

General steps in any face recognition system as depicted in figure 2 are discussed below:

First a picture of the face is acquired as an input. This acquisition are often accomplished by digitally scanning an existing photograph or by using an electro-optical camera to accumulate a live picture of a topic. Second, using different methods we are extraction the features from the input image. The third step is to compare the features generated in step two with those in a database of known faces. The fourth step is the classification, for this step we can use any of the classifications methods. After classification it will identify the face.

A. Challenges in Face Recognition System

The topic seems to be easy for a person's, where limited memory is often a main problem; whereas the issues in machine recognition are manifold. Some of possible problems for a machine face recognition system are mainly [2,3];

1) Face expression change: A smiling face, a crying face, a face with closed eyes, even a little nuance within the face expression can affect face recognition system significantly.

2) Illumination change: The direction where the individual within the image has been illuminated greatly effects face recognition success. A study on illumination effects on face recognition showed that lighting the face bottom up makes face recognition a tough task.

3) Aging: Images taken a while apart varying from 5 minutes to five years changes the system accuracy seriously.

4) Rotation: Rotation of the individual's head clockwise or counter clockwise (even if the image

stays frontal with reference to the camera) affects the performance of the system.

5) Size of the image: A test image of size 20x20 could also be hard to classify if original class of the image was 100x100.

6) Frontal vs. Profile: The angle during which the photo of the individual was crazy reference to the camera changes the system accuracy.

III. PRE-PROCESSING TECHNIQUES

Often images are not in the correct form to be plugged straight into recognition algorithm. The image may contain more information than one single face, and therefore the lighting conditions within the test image might not be an equivalent as within the sample data for training the algorithm. This can greatly affect the effectiveness or the popularity rate of the algorithm. Therefore, to get the simplest possible results, it's necessary to pre-process a picture to normalize lighting and take away noise before inserting it into a recognition algorithm.

A. *Histogram Equalization (HE)*

Histogram equalization (HE) is a classic method. It is commonly wont to make a picture with a consistent histogram, which is taken into account to supply an optimal global contrast within the image. However, HE may make an image under uneven illumination turn to be more uneven [4,13].

B. *Adaptive Histogram Equalization (AHE)*

It computes the histogram of an area image region centered at a given pixel to work out the mapped value for that pixel; this will achieve an area contrast enhancement. However, the enhancement often results in noise amplification in "flat" regions, and "ring" artifacts at strong edges. In addition, this technique is computationally intensive [5].

C. *LogAbout Method*

The LogAbout method which is an improved logarithmic transformation because the following equation:

$$g(x,y) = a + \frac{\ln(f(x,y)+1)}{blbc} \qquad (1)$$

Where g(x, y) is that the output image; f(x, y) is that the input image; a, b and c are parameters which control the situation and shape of the logarithmic distribution. Logarithmic transformations enhance low gray levels and compress the high ones. They are useful for non-uniform illumination distribution and shadowed images. However, they're not effective for top bright images [6]. An example of what the LogAbout algorithm does can be seen in figure 3.

Figure 3. LogAbout Illumination Normalization [6]

D. *Discrete Cosine Transform (DCT)*

In a face image, illumination usually changes slowly compared with the reflectance except some casting shadows and secularities on the face. As a result, illumination variations mainly dwell the low-frequency band. Therefore, we will remove the low frequency part to scale back illumination variation. The low frequency DCT coefficients are set to zero to eliminate illumination variations.

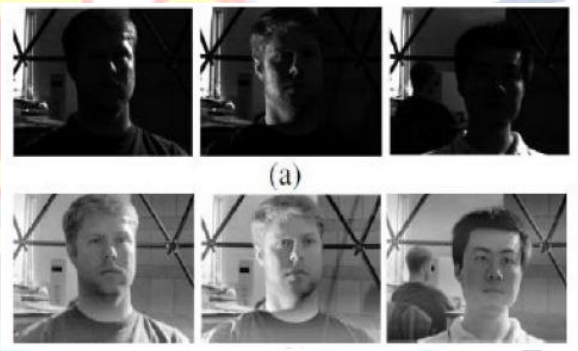

Figure 4. Original and DCT applied images [7]

Figure 4 shows the images with various illumination conditions and normalized images using DCT components [7].

IV. ILLUMINATION INVARIANT FEATURE EXTRACTION TECHNIQUES

Illumination problem arises due to uneven lightning on faces as illustrated in figure 5. This uneven lightning brings variations in illumination which affects the classification greatly since the countenance that are getting used for classification gets affected thanks to this variation.

Figure 5: The illumination problem [2]

A. SIFT Method

The Scale Invariant Feature Transform (SIFT) algorithm [8] locates scale and shift invariant points in an image. The located point is represented by an orientation invariant feature vector. The SIFT features extracted from an image are characterized by two parts: the first part is a 4 dimension vector consisting of location in terms of horizontal and vertical co-ordinates, the size of the purpose and it's orientation, the second part may be a 128 dimension vector that's orientation invariant.

The first attempts to use SIFT features for face recognition was borrowed directly from the object recognition literature [9]. The step by step procedure is as follows:

1. Match each feature within the test image to each feature in each training image. Matching is done using a distance based criterion. A feature (say x) from the test image is said to match a feature (y) from the training image, if the least distance between the 2 features is the least, and is less than a pre-defined threshold.

2. Find the training image that has the very best number of matches with the test image. Assign the test image to the category of this training image.

In [9], it's shown that this easy approach yields better results than those obtained from standard face recognition methods like PCA (Principle Component Analysis) and Fisherfaces. The problem with this method is that it is very time consuming. Matching between two images has requires of n2 computations, where n is the average number of SIFT features in each image.

SIFT features, although very fashionable within the visual perception community have hardly been used for face recognition. SIFT features have the following advantages [10]:

1. They are invariant to scale.
2. They are invariant to 2D transformations like transformations and translation and rotation.
3. Lowe [11], showed that practically these features are invariant to a limited amount of 3D projection transformations.
4. SIFT features are invariant to changes in illumination.

SIFT has its own problems. First, the number of SIFT features that are generated from an image cannot be controlled. Two face images generally have different number of SIFT features. Owing to this problem, SIFT features cannot be used with standard machine learning tools like Support Vector Machine or Neural Network. The second problem is computational as SIFT features are of high dimension. Matching an outsized number of high dimensional features among all images during a database is time consuming.

B. GSIFT Method

The GSIFT (Grid SIFT) uses SIFT features for face recognition defines the Minimum pair Distance (MPD) between two images. MPD between two images is that the minimum distance between two given SIFT features, where one feature belongs to at least one image and therefore the other belongs to the opposite image.

A grid based approach step by step procedure is carried out in the following manners:

1. Divide the face image into s=16 i.e. 4X4 uniform grids.
2. Find the SIFT features for the test and the training images.
3. For each grid find the MPD between the features of test image and those of every training image.
4. Find the sum of MPDs over all its grids for each training image.
5. Repeat steps 3 and 4 for all the training images.
6. Assign the test image to the training image that has the minimum total MPD.

The advantages gained by this approach [12] are illustrated in Figure 4. The two images on the highest depict keypoint locations gained by original keypoint detector under different illumination conditions. The number of

detected keypoints in the top right image is smaller than in the left image, moreover many of the keypoints are detected in different locations than in the left image, consequently reduction of keypoint matches is expected. In case SIFT descriptors are computed at predefined fixed locations, as presented in bottom images of Figure 6, greater robustness to variable illumination can be achieved.

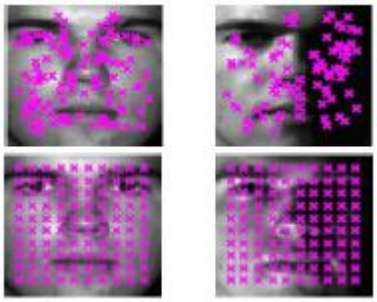

Figure 6 Keypoints detected under different illumination conditions by SIFT method [12]

V. Conclusion

As we have gone through the literature and reviewed most of the recent developments in face recognition none of the techniques is able to provide best performances under all uncontrolled circumstances. Although, face recognition has been claimed to be an almost solved problem, however recognition under uncontrolled conditions remained a field of research. This review paper mainly focuses on the research efforts for illumination problems. Most of the strategies that have been analyzed claim satisfactory recognition rates only when tested on standard databases or some part of them. The recognition rate claimed by each of researcher depends on the database used and the number of subjects on which recognition task has been performed.

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