Robust Face Recognition Technique under Varying Illumination

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ABSTRACT
Face recognition is one of a complex biometrics in the field of pattern recognition due to the constraints imposed by variation in the appearance of facial images. These changes in appearance are affected by variation in illumination, expression or occlusions etc. Illumination can be considered a complex problem in both indoor and outdoor pattern matching. Literature studies have revealed that two problems of textural based illumination handling in face recognition seem to be very common. Firstly, textural values are changed during illumination normalization due to increase in the contrast that changes the original pixels of face. Secondly, it minimizes the distance between inter-classes which increases the false acceptance rates. This paper addresses these issues and proposes a robust algorithm that overcomes these limitations. The limitations are resolved through transforming pixels from non-illumination side to illuminated side. It has been revealed that proposed algorithm produced better results as compared to existing related algorithms.

Keywords: Face; Illumination; Pixels; recognition; Textural Features.

1. Introduction

Face recognition is a very challenging research area because even the images of same person seem different due to occlusion, illumination, expression and pose variation [1; 2; 3; 4; 5]. Advanced research in the field of face recognition shows that varying illumination conditions influence the performance of different face recognition algorithms [6; 7]. On the other hand, training or testing is also sensitive under varying illumination conditions. These are the factors that make face recognition difficult and have gained much attention for the last so many decades. A large number of algorithms have been proposed in order to handle illumination variation. Categorically these algorithms are divided into three main distinctions.
The first approach deals with image processing modelling techniques that are helpful to normalize faces having different lighting effects. For that purpose histogram equalization (HE) [8; 9], Gamma intensity correlation [9] or logarithm transforms [10] work well in different situations. Various proposed models are widely used to remove lighting effects from faces. In [11] authors eliminate this dilemma by calculating similarity measure between the two variable illuminated images and then computing its complexity.

Similarly in [12] authors try to remove illumination by exploiting low curvature image simplifier (LCIS) with anisotropic diffusion. But the drawback of this approach is that it requires manual selection with less than 8 multiple parameters due to which its complexity is increased. Secondly, uneven illumination variation is too tricky even by using these global processing techniques. To handle uneven illumination, region based histogram equalization (RHE) [9] and block based histogram equalization (BHE) [13] are used. Moreover, their recognition rates are much better than the results obtained from HE. In [9] the author suggested a method called quotient illumination relighting in order to normalize the images.

Another approach which handles face illumination is 3D face model. In [14; 15] researcher suggested that frontal face with different face illumination produces a cone on the subspace called illumination cone. It is easily estimated on low dimensional subspace by using generative model applied on training data. Subsequently, it requires large number of illuminated images for training purpose. Different generative models like spherical harmonic model [16; 17] are used to characterize low dimensional subspace of varying lighting conditions. Another segmented linear subspace model is used in [18] for the same incentive of simplifying the complexity of illuminated subspace. For this purpose the image is divided into parts from the region where similar surface appears. Nevertheless, 3D model based approaches require large ingredients of training samples or need to specify the light source which is not an ideal method for real time environment.

In the third approach, features are extracted from the face parts where illumination occurs and then forward them for recognition. In general, a face image I (x,y) is regarded as a product $I(x,y) = R(x,y) * L(x,y)$, where $R(x,y)$ is the reflectance and $L(x,y)$ is the illuminance at each point (x,y) [19]. Nonetheless, it is much complicated to extract features from natural images. The authors in [20] proposed to extract face features by applying high-pass filtering on the logarithm of image. On the other hand, the researcher in [21] introduces Retinex model for removing illumination problem. This Retinex model is further enhanced to multi scale Retinex model (MSR) in [22]. One more advancement of this approach is extended in [23] which introduces illumination invariant Quotient image (QI) and removes illumination variation for face recognition. Similarly in [24; 25] QI theory is enhanced to self-quotient image (SQI) using the same idea of Brajovic [26]. Another way to obtain invariant illumination is to divide the same image from its smoothed version. However, this system is complicated due to the appearance of sharp edges in low dimension feature subspace by using weighted Gaussian filter. The same problem is solved in [27] that uses logarithm total variation model (LTV) to obtain illumination invariant through image factorization. Likewise, the author in [28] reveals that there is no illumination invariant; however it is obtained from aforementioned approaches.

According to [29], the illumination variant algorithms are categorized into two main classes. The first class of algorithms deals with those facial features which are insensitive to lighting conditions and are obtained using algorithms like edge maps [30], image intensity derivatives [31] and Gabor like filters [32] etc. For this type of class bootstrap database is mandatory while it increases error rate when gallery set and probe set are comparatively misaligned.

The second class believes that illumination is usually occurring due to 3D shape model under different poses. One of the limitations of model based approach is that it requires large training set of different 3D illuminated images. Due to this drawback its scope is limited in practical face recognition systems.

2. Materials and methods

Large number of techniques has been proposed for illumination invariant face recognition where each method reveals good result in specific conditions and environment. After eliminating lighting condition from the face, it can be easily visualized by human beings. The limitation across geometric based face recognition is that it only works on limited frontal face databases. These methods are traditional but nowadays variety of subspace methods are used like Principal Component Analysis (PCA), Independent Component Analysis (ICA), Support Vector Machine (SVM) and Linear Discriminant Analysis (LDA) etc. These are the subspace methods that depend on pixel level information because this pixel level information is used to convert high dimensional input data into low dimensional feature subspace. Low dimensional data are arranged according to inter class and intra class mean. Histogram equalization is the most popular and powerful approach to remove illumination from images. The main drawback of this approach is that though it is a reliable method to eradicate lighting from images but it can destroy the actual density value of the face. The actual pixel values are changed in a sense that during inter and intra class mean estimation of histogram equalization, some noise is added that changes the pixel value. In this paper, a technique is proposed which handles produced noise with highest recognition rate. More discussion is provided in later section.

2.1 Histogram Equalization

A brief description of histogram equalization is provided in this part. The superior property of histogram is that it provides general formula for contrast enhancement so that the information which is hidden due to illumination factor becomes visible. Let us consider that G is the grey level image while ni shows grey pixels appearance in the image ith times.