Regression-Based Automated Facial Image Quality Model

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ABSTRACT

Nowadays, biometric technologies became reliable and widespread means of unobtrusive user authentication in a variety of real-world applications. The performance of an automated face recognition system has a strong relationship with the quality of the biometric samples. The facial samples can be affected by various quality factors, such as uneven illumination, low or high contrast, excessive brightness, blurriness, etc. In this article, the authors propose a quality estimation method based on linear regression analysis to characterize the relationship between different quality factors and the performance of a face recognition system. The regression model can predict the overall quality of a facial sample which reflects the effects of various quality factors on that sample. The weights assigned to the different quality factors by the linear regression model reflect the impact of those quality factors on the performance of the recognition system. Therefore, the prediction scores generated from the model is a strong indicator of the overall quality of the facial images. The authors evaluated the quality estimation model on the Extended Yale Database B. They also performed a study to understand which quality factors affect the face recognition the most.

KEYWORDS

Facial Image Quality, Intelligent Adaptive System, Linear Regression Model, Quality Index, Recognition Accuracy

INTRODUCTION

Despite the widespread use of automatic facial recognition systems, their consistent performance is affected when presented with uncooperative users and uncontrolled environments. Image quality has a very strong connection with the recognition performance and identification errors of a biometric system (Grother & Tabassi, 2007; Alonso-Fernandez et al., 2012; Bharadwaj et al., 2014). The quality of facial images during enrollment and verification stages significantly affects the performance of an automated face recognition system. Poor quality of data, due to changes in lighting conditions, facial expressions, pose, occlusion, and poor sensor quality, may cause efficiency loss. Recent studies show that variations in lighting conditions, resolution, camera movement, occlusion, expressions and other quality factors have a major impact on the recognition rate of a face biometric system (Sellahewa &

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Jassim, 2010; Abaza et al., 2012; Abaza et al., 2014; Punnappurath et al., 2015). Researchers have attempted to categorize the face-based quality factors based on digital formatting of facial images, scenes and photographic. Several techniques have been proposed in the literature to effectively compute different quality factors (Wang & Bovik, 2002; Abaza et al. 2012; Abaza et al., 2014; Sang et al. 2009). However, few attempts have been made to jointly consider various quality factors under one framework (Abaza et al., 2012; Abaza et al., 2014). Though researchers have considered a partial subset of these quality factors, there is yet no effective analysis of the impact of different quality factors on the performance of a face recognition system. Therefore, an effective quality estimation model is needed, which can characterize the quality of the facial image by integrating different quality measures into a single quality score which is an indicator of the overall quality of the facial image. The model should also reflect the impact of different quality factors on the face recognition performance.

The overall quality score can be used to save preprocessing time and improve face recognition accuracy. It will also reduce the number of poor quality facial images acquired during the enrollment process thereby improving matching performance. Selecting high quality facial images for recognition can improve the system robustness and reduce the false positive rate and false negative rate. This unified score can be used to assign weights in case of feature-level or score-level fusion of different modalities (Paul & Gavrilova, 2015). Therefore, we propose a novel method that will consolidate different quality scores into a single evaluation score to indicate the overall quality of the facial image. The proposed model considers different quality factors, such as illumination, contrast, brightness and focus of the facial images, and generates a unified evaluation score. We use a linear regression based approach to capture the relationship between various quality scores and corresponding matching score of a facial image. The preliminary quality estimation model was proposed in the ICCI*CC 2017 Conference (Zohra et al., 2017). In the previous approach, we trained the model using the relationship between quality scores and recognition performance considering that a large group of facial samples have the same recognition performance. This relationship reflects the quality of a large group of data rather than individual quality. On the other hand, the matching score of a sample is a strong indicator of the usability of that sample as a biometric trait. Therefore, in this paper, we design a quality estimation model using linear regression analysis which considers the relationship between various quality scores and the matching scores of the facial image. Discrete wavelet transform (DWT)-based feature extraction technique is applied to extract the facial features from the images. A distance score is calculated by comparing the probe and template images which is also known as matching score. The linear regression model is trained using these matching scores and various quality scores for predicting the overall quality of the facial image. This article is the extended version of the ICCI*CC 2017 Conference paper (Zohra et al., 2017). The quality estimation model is evaluated on the Extended Yale database B (Georghiades et al., 2001; Lee et al., 2005) with 38 users. The database has considered various illumination conditions, and we have synthetically generated about 800 samples with other quality factors, such as contrast, brightness and focus for validating the proposed quality estimation model.

The organization of the rest of the paper begins with the review of the existing quality assessment methods in the literature, and presents a comprehensive study of the methods investigated in the Literature Review section. The Quality Assessment Model section presents the detailed description of the proposed model for overall quality assessment of the facial image. The database and experimental setup are described in the next section. Discussions and analysis of the experimental results are presented in the Experimental Results and Discussions section. Finally, the Conclusion section summarizes the discussion with some future directions.
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