

摘 要

人脸识别是图像分析和理解领域中最成功的应用之一，近年来得到了迅速的发展，但是阻碍人脸识别技术应用到实际中的瓶颈之一——光照问题，一直没能得到很好的解决。目前，解决光照问题的预处理方法主要有两大类：基于模型的方法和基于图像处理技术的方法。其中，前者往往从成像模型出发，试图估计光照或对图像进行重新打光，因此在理论上更加完善，但往往因为约束条件过强而不能很好的使用；而后者尽管仅仅从图像灰度变换的角度处理，但却以其简单有效性在实用中得到了更多的重视。从实用的角度出发，本文重点研究了基于图像处理技术的光照预处理方法，取得了以下研究结果：

1. 提出了一种对数边缘图的光照预处理方法，在CMU-PIE光照人脸图像数据库上取得了良好的效果；
2. 分析了现有文献中验证光照预处理方法性能的方案，发现现有的多数方案具有严重的缺陷，难以真正验证不同预处理方法的有效性，本文以CMU-PIE、FERET、CAS-PEAL等多个人脸库为基础，提出了一种更为完备的验证方案；
3. 基于上述验证方案，本文研究并对比分析了直方图均衡化、直方图规定化、Gamma灰度校正、自商图像、相位图、相对梯度、对数边缘图等预处理方法。

基于本文提出的验证方案，对上述光照预处理方法进行对比实验分析，我们得出了三个重要结论：

1. 某些光照预处理方法的通用性能很差，因此，需要选择多种光照图像库来验证预处理算法在处理光照问题方面的通用能力；
2. 尽管多数光照预处理方法对包含光照变化的图像数据库有良好的效果，但部分光照预处理方法对没有光照变化的人脸图像的认识反而有负面影响，因此，在考察光照预处理方法处理光照变化图像的性能的同时，还要考察其对没有光照变化的图像的处理效果；
3. 某些光照预处理方法与不同的识别算法结合呈现出很大的性能差异，因此对比光照预处理技术时，还需验证它们对不同识别算法的适应能力。

上述结论不仅对研究光照预处理方法具有重要的参考价值，还对设计光照预处理算法，用于实际的人脸识别应用系统具有重要的参考价值。

关键词： 人脸识别，光照预处理，自商图像，相对梯度，对数边缘图

Research on Illumination Preprocessing Approaches in Face Recognition

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Face recognition is one of the most successful applications in image analysis and understanding. It has received rapid development recently. However illumination variation is still one bottleneck preventing face recognition technique from being used into practice. The preprocessing approaches coping with illumination variation can be classified into two categories: the model-based approaches and the image-based approaches. Although the model-based approaches seem more perfect in theory, they commonly introduce more constraints, which make them not practical enough for applications. However, the image-based approaches commonly exploit simple and efficient image processing techniques and they are often used in practical systems. From applications, we studied the image-based approaches and achieved the following results:

1. Proposed a preprocessing method based on logarithmic edges and got good results on CMU-PIE face database.
2. Analyzed the current schemes validating illumination preprocessing approaches and found they have limitations and cannot validate these preprocessing approaches effectively. Based on CMU-PIE, FERET, CAS-PEAL face databases, we proposed a more general scheme to validate illumination preprocessing approaches.
3. Based on the scheme proposed above, we studied and compared histogram equalization, histogram specification, Gamma intensity correction, self-quotient image, phase image, relative gradients and logarithmic edges.

Based on the experimental results we got the following three conclusions:

1. Some preprocessing approaches have weak generalization. Therefore, different illumination images databases should be considered in order to validate their generalization in coping with illumination variation.
2. Although most preprocessing approaches can cope with illumination variation well, some may bring negative influence on images without illumination variation, so we should consider the images both with illumination variation and without illumination variation.
3. When combined with different recognition algorithms, some preprocessing approaches show great difference on performance. Therefore when validating these approaches, their flexibility to different recognition algorithms should be considered.

Key words: face recognition, illumination preprocessing, self-quotient image, relative gradient, logarithmic edges