摘 要

自动人脸识别技术经过几十年的发展，在可控条件下已经可以达到比较理想的性能。然而，在环境变化剧烈的情况下，人脸识别的性能会急剧下降。现有的人脸识别方法通常是基于较低分辨率的人脸图像来提取全局外观特征或局部区域特征进行识别，但分辨率的限制往往使得识别算法无法关注人脸的细节特征。而实际上，高分辨率图像所包含的更多信息，如皮肤细节特征（斑痣特征等），对提高人脸识别性能有着重要意义。随着高清相机的普及和高性能计算机的发展，高分辨率人脸分析逐渐成为一个新的研究课题。

本文即针对高分辨率人脸分析问题展开研究。首先调研和分析了已有的高分辨率人脸识别研究方法；进而针对高分辨率图像丰富的皮肤细节特征，提出了面部奇异区域的概念并研究了面部奇异区域自动检测算法；最后对基于面部奇异区域的人脸识别算法进行了深入探索。本文的主要研究成果概括如下：

1. 提出面部奇异区域自动检测算法框架。该算法主要分为两个阶段：1）获取候选奇异区域：利用 MSER 等方法检测到大量显著性区域，作为候选的奇异区域 2）过滤奇异区域：根据面部特征点定位结果，得到特定人的面部掩膜，从而分割出面部皮肤，以去除五官上的候选区域。进而根据基于中央周边差的显著性度量方法，为每个区域计算显著性值，去除显著性较小的候选区域。
2. 提出基于局部颜色分析的区域检测算法。其主要思想为：将人脸图像进行划分，在每一个小块区域内部，利用灰度信息统计的方法来进行显著性区域的检测。具体来讲，对每一个小块中所有像素点的灰度值分布进行统计，用一个单高斯对此分布进行拟合，灰度值偏离该单高斯分布的像素点即为局部特异点，它们构成的足够大的连通区域即为关注的局部显著性区域。
3. 基于面部奇异区域的人脸识别算法。首先提出基于面部奇异区域位置的弹性匹配算法，其性能高于经典的 Eigenfaces 算法。进而提出基于几何对齐的 SIFT 匹配人脸识别算法，该方法可获得与基于 LBP 的人脸识别方法可比的性能。与传统人脸识别算法融合后，识别性能得到进一步提高。

上述研究成果表明，面部奇异区域有很强的判别力，面部细节信息的融合有助于进一步改善人脸识别性能。

关键词：人脸识别；高分辨率图像；面部奇异区域；区域检测算法；显著性度量

Facial Marks Extraction for High Resolution Face Recognition

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After decades of development, automatic face recognition technology achieves a satisfied performance under controlled conditions. However, face recognition performance would decrease dramatically when confronted a remarkable environmental change. Existing face recognition methods are usually based on the low resolution face image and extract the global or local appearance features for the classification. Limited by the low resolution, these methods cannot obtain the features like the face skin details. But in fact, face skin details (such as moles and freckles) contained in the high resolution face image play an important role in improving the face recognition performance. With the popularity of high-definition cameras and high-performance computers, high resolution face analysis becomes a new research topic.

Our research work focuses on the problem of high resolution face analysis. Firstly, this dissertation reviews and analyses the previous works in this field. Then, in terms of the rich face skin details in the high resolution image, a concept of facial marks is proposed. Accordingly, a novel automatic facial marks detection framework is built. Finally, a face recognition algorithm based on the facial marks that detected previously is explored. To summarize, the contributions of this dissertation are summarized as follows:

1. Propose a novel frame to detect the facial marks automatically. The detection process contains two main stages: 1) getting the candidate irregular regions: using the blob detection methods such as MSER to get a lot of candidate regions. 2) Filter the irregular regions: a skin segmentation scheme based on the ASM method is adopted to filter the detected irregular regions in the facial organ areas. Then, a novel local saliency measure is designed to evaluate a region’s uniqueness and used to filter the less salient regions.
2. Propose a local color analysis-based region detector. The main idea is: partition the human face image into many overlapping patches firstly. Then the salient regions are detected by gray values distribution in each patch. Concretely speaking, the distribution of the gray values for all pixels in a patch is modeled by a Gaussian distribution. Then the pixel in this block

with its gray value deviate from the Gaussian distribution is determined as a local outlier. The connected regions that composed by the local outliers are the final irregular region detection results.

3. Propose facial marks based face recognition methods. Firstly, this dissertation proposes a face recognition method of elastic matching based on the positions of the facial marks, which outperforms Eigenfaces, a classical face recognition method. Then, another face recognition framework is explored, which extracts the SIFT descriptor for each facial mark and uses SIFT matching followed by geometric verification for the recognition process. This method achieves a comparable performance with LBP-based face recognition method.

The above-mentioned research results show that facial marks have strong discriminating ability. The fusion of the face skin details can further improve the face recognition performance.

Keywords: face recognition; high resolution; facial mark; saliency; region detector