Computers in Biology and Medicine 59 (2015) 106–115

Contents lists available at ScienceDirect

Computers in Biology and Medicine

journal homepage: www.elsevier.com/locate/cbm

No-reference hair occlusion assessment for dermoscopy images based on distribution feature

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ARTICLE INFO

Article history:
Received 8 September 2014
Accepted 30 January 2015

Keywords:
Dermoscopy image
Hair occlusion
Hair detection
Image quality
No-reference assessment

ABSTRACT

The presence of hair is a common quality problem for dermoscopy images, which may influence the accuracy of lesion analysis. In this paper, a novel no-reference hair occlusion assessment method is proposed according to the distribution feature of hairs in the dermoscopy image. Firstly, the image is adaptively enhanced by simple linear iterative clustering (SLIC) combined with isotropic nonlinear filtering (INF). Then, hairs are extracted from the image by an automatic threshold and meanwhile the postprocessing is used to refine the hair through re-extracting omissive hairs and filtering false hairs. Finally, the degree of hair occlusion is evaluated by an objective metric based on the hair distribution. A series of experiments was carried out on both simulated images and real images. The result shows that the proposed local adaptive hair detection method can work well on both sparse hair and dense hair, and the designed metric can effectively evaluate the degree of hair occlusion.

1. Introduction

Dermoscopy, as a non-invasive skin imaging technique which allows a better visualization of the skin surface and subsurface structures [1], is beneficial to diagnosing many skin diseases in clinical applications [2,3]. In the early diagnosis of malignant melanoma (MM), dermoscopy images play a significant role to increase the survival rate of patients. However, the automatic analysis of skin lesions is heavily impacted by hairs covering them. As shown in Fig. 1, hair pixels in dermoscopy images occlude some information of lesions such as border and texture, which will lead to imprecise segmentation and wrong classification. To overcome the hair occlusion problem [4], an effective hair detection and removal method is required.

In 1997, Lee et al. [5] proposed the DullRazor hair-removal algorithm which used morphological closing operation to identify the locations of dark hairs and replaced them by linear interpolation. Kiana et al. [6] improved the DullRazor method for detecting dark and light-color hairs. In [7], Xie et al. used morphological top-hat operator and statistic threshold to obtain the hair binary image. Then hairs were extracted according to the elongated state of connected region and removed from the image by the partial differential equations (PDE) inpainting algorithm. Abbas et al. [8] proposed the hair lines detection scheme based on the 2-D derivatives of Gaussian function in the CIE $L^*a^*b^*$ color space and then used the morphological operator to obtain smooth hair lines which were inpainted by the fast marching inpainting method. A similar approach was described in [9], which improved the canny method to roughly detect and remove hairs from dermoscopy images through a multi-resolution coherence transport inpainting method.

However, most of the algorithms above only deal with the case of mild hair occlusion. For dermoscopy images with dense hair like the rightmost one in Fig. 1, they perform badly due to (i) hardly extracting correct hair pixels and (ii) bad inpainting results in the crowded hair region. Hence, an effective assessment method for the degree of hair occlusion is necessary. If dermoscopy images with serious hair occlusion can be suggested to be abandoned or recaptured before they get into the automatic analysis system, the accuracy of automatic diagnosis for skin diseases will be effectively improved.

The presence of hair is a common quality problem for dermoscopy images. Although some hair detection and removal methods have been proposed, the hair occlusion assessment is still not addressed. Since there is no reference image for the dermoscopy image with hair, a no-reference assessment method is needed here. In the last few decades, lots of no-reference image quality assessment (IQA) methods have been developed for different purposes. In these IQA methods [10–12], the considered quality problems are mainly caused by distortions such as blur, noises, JPEG and JPEG2000 compression. As a real substance, the hair is not a distortion. Therefore, traditional IQA methods cannot be used for hair occlusion assessment.

In this paper, hairs in dermoscopy images are extracted by the local adaptive hair detection method firstly, and then the degree of

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http://dx.doi.org/10.1016/j.compbiomed.2015.01.023
0010-4825/

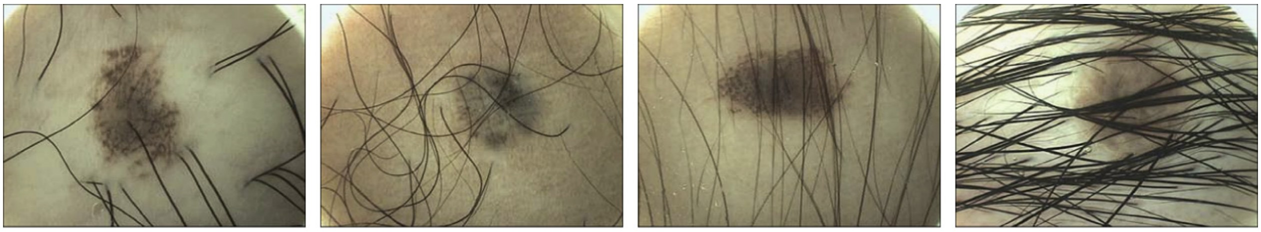

Fig. 1. A group of dermoscopy images with hair.

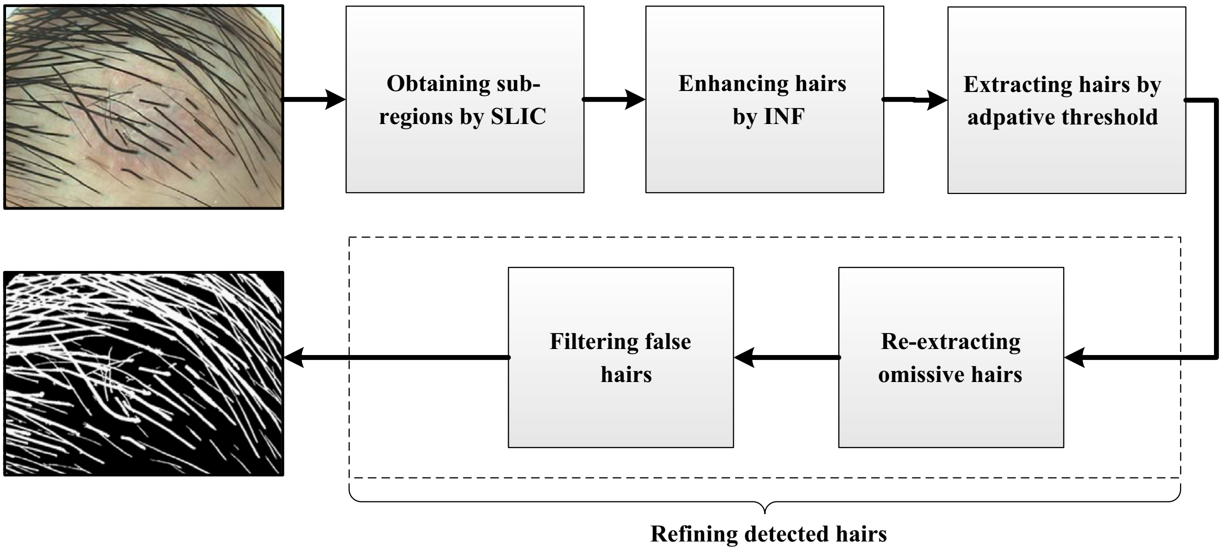

Fig. 2. Flow chart of proposed hair detection algorithm.

hair occlusion is evaluated according to the hair distribution features. The remainder of this paper is organized as follows. In Section 2, the local adaptive hair detection approach is described in detail. In Section 3, we introduce the assessment method for the degree of hair occlusion. Experimental results and analysis are presented in Section 4. Finally, Section 5 gives the conclusions.

2. Hair detection

Generally, hair detection contains two steps: hair enhancement and threshold segmentation. In most of state-of-the-art hair detection methods, the enhancement and the thresholding are usually global, for example the methods described in [7,8]. However, there are disparities in the color and texture between the healthy skin region and the lesion region. Similarly, relative to regions of the same background, the region with dense hair tends to have a different contrast from the region with sparse hair. Therefore the global hair detection method cannot adapt to the local variety of color and texture in dermoscopy images. In this paper, a local adaptive hair detection method is proposed for dermoscopy images, as shown in Fig. 2. The image is clustered into sub-regions using a simple linear iterative clustering (SLIC) algorithm [13] firstly, then hairs in each sub-region are enhanced through isotropic nonlinear filtering (INF) [14] and extracted by the proposed adaptive threshold.

2.1. Obtaining sub-regions by SLIC

Superpixel algorithms are very useful as a preprocessing step for computer vision applications like object class recognition and medical image segmentation [13,15]. As a superpixel method, the SLIC algorithm [13] is simple to implement and outputs better quality superpixels that are compact and roughly equally sized. Let $[l_i, a_i, b_i, x_i, y_i]^T$ be the 5-dimensional space, where $[l_i, a_i, b_i]^T$ represents CIE $L^*a^*b^*$ color space and $[x_i, y_i]^T$ is the pixel position. According to [13], a distance measure D_S is defined to enforce color similarity as well as pixel proximity in this 5-D space as follows:

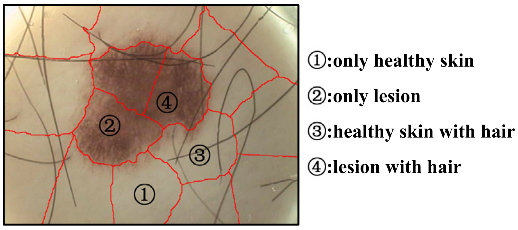

Fig. 3. Sub-regions obtained by SLIC.

$$D_S = d_{lab} + \frac{h}{S} d_{xy} \tag{1}$$

where the *lab* distance d_{lab} equals $\sqrt{(l_i - l_k)^2 + (a_i - a_k)^2 + (b_i - b_k)^2}$, the *xy* distance d_{xy} equals $\sqrt{(x_i - x_k)^2 + (y_i - y_k)^2}$, $[l_k, a_k, b_k, x_k, y_k]^T$ is the 5-D feature of the *k*th cluster center, S is the grid interval which decides the number of clusters and h is the compactness parameter. The greater the value of h is, the more spatial proximity is emphasized and the more compact the cluster is. The algorithm obtains the clustering result by iteratively repeating the process of associating pixels with the nearest cluster center and recomputing the cluster center.

In this paper, the value of S is a quarter of the width of the image and h is set to 80. Fig. 3 shows an example of clustering result for a dermoscopy image using the SLIC method. The dermoscopy image with hair is clustered into several uniform sub-regions, which can be approximately classified into 4 types: only healthy skin,