A Review of Existing Hair Removal Methods in Dermoscopic Images

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ABSTRACT : *Malignant melanoma cases are increasing day by day. The early detection of the type of skin lesion can be beneficial for increasing the survival rate. The obtained dermoscopic images of skin contain hair. These have to be removed for proper detection and improvisation in successive image processing modules. This paper puts a light on the different hair removal methods in dermoscopic images.*
Keywords: *Dermoscopy, Hair Removal, Melanoma, Morphological closing, Skin Lesion*

I. INTRODUCTION

Malignant melanoma is increasing among the whole population in the world. While the overall age-standardized mortality rate of cancer is decreasing in the world, the mortality rate of melanoma continues to increase in the world from around thirty years. As shown in figure.1 hair pixels, usually present in dermoscopic images, occlude some of the information of the lesion such as its boundary and texture. Therefore, in melanoma recognition and classification tasks these hair artifacts must be removed. In a realtime CAD tool, an automatic hair removal method that preserves all the lesion features while keeping its computational cost low enough to be used is needed. However, hair problem has not been fully addressed in the literature. Ineffective hair removal algorithms lead toward over segmentation and poor pattern analysis, disturbing the tumor's patterns. In fact, to perform effective pattern analysis, an effective hair-repairing algorithm is required. Some of the hair removal methods are addressed in this work.
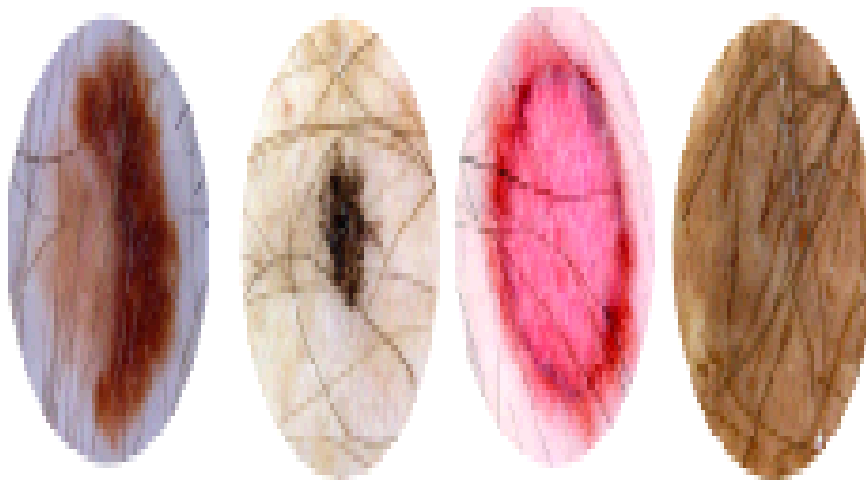

Figure.1 difficulties to do melanoma classification in case of four skin tumors occluded with hair pixels for digital dermoscopy.

II. LITERATURE SURVEY

Lee et al. [2] used the bilinear interpolation method for hair removal. Schmid [3] used a median filter to reduce the influence of small structures, such as hair, on the segmentation result. Similarly the work of Saugeona et al. and Fleming et al [3] detect and remove hair using morphological operations and thresholding. Xie et al. [4] proposed novel automated hair removal algorithm based on partial differential equation (PDE).
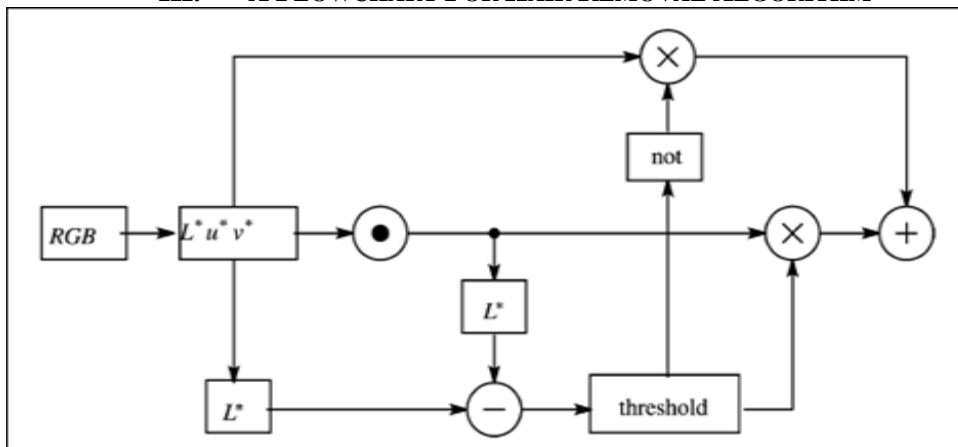
III. A FLOWCHART FOR HAIR REMOVAL ALGORITHM

Figure.2 a hair removal algorithm flowchart.

Fig.2 shows a flowchart for hair removal algorithm. A morphological closing operator • is applied to the three components of the L* u* v* uniform color space. A spherical structuring element is used. The L* u* v* color space is chosen because the luminance component is best suited to differentiate hair from dark pigment, unlike most of the linear color space transformations that provide a so-called intensity component. A hard threshold is then applied to the difference between the luminance between and after the morphological closing. Hair is a light-absorbent body and a constant threshold is adequate to produce satisfactory results. The selected pixels are replaced by their value after morphological closing while other pixels are left unchanged. It may happen that dark pigmented structures are masked out as well, usually inside the lesion. The luminance component L* made the difference between hair and pigmented structures.

IV. HAIR REMOVAL TECHNIQUES
IV.1. Hair Removal by Linear Interpolation Method-Dullrazor Software

The Dullrazor software is introduced to digitally remove hairs from dermoscopic images. The objective behind developing Dullrazor was to remove the dark thick hairs. As such, it cannot remove the light colored or thin hairs. It used the bilinear interpolation method to remove hair pixels. It consisted of three steps (1) Identifying dark hair locations morphological closing operation. (2) Replacing hair pixels by bilinear interpolation. (3) Smoothing the final result by adaptive median filter. Fig.3 shows the outcomes of the above steps in the Dullrazor and its effect on segmentation of a lesion. Dullrazor has some disadvantages (a) It often leads to undesirable blurring and color bleeding. (b) Morphological masks applied are limited to number of discrete orientations and thus sensitive to orientation of linear elements. (c) Incapability to distinguish between hairs and line segments of the tumor patterns.
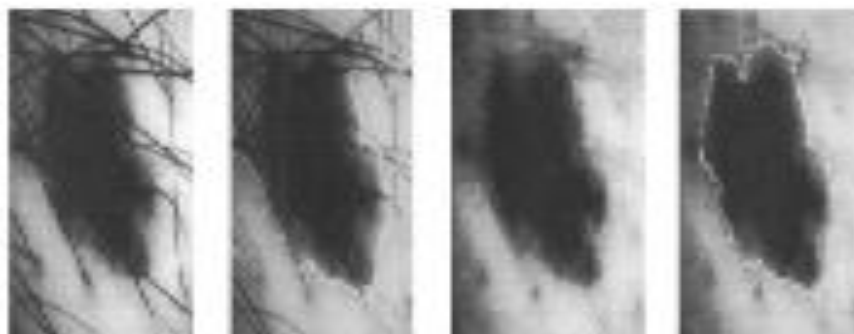

Figure.3 hair removal and segmentation using dullrazor

IV.2. Hair Disocclusion Using Inpainting Based on PDE

Inpaiting is a technique which was originally used to restore film and photographs, is used to disocclude hair from dermoscopic images of skin lesions. The influence of hair to diagnosis anal yis can be eliminated through

excluding the hair regions from further analysis. But for the image segmentation, it can improve the veracity of segmentation to repair the melanoma texture occluded by hairs. Inpainting is the art of rebuilding the basics of visual art and consists of filling-in unknown data in a known region of an image, with the principal objective of restoring harmony to the given damaged picture with parts worn by time, overexposed objects or objects we want to remove from the image. Currently most of the image inpainting models are based on PDE (partial differential equation) or TV (total variational equation). The PDE based inpainting methods, which realize information diffusion through the difference between pixels, have advanced property in preserving the linear geometry feature of image and are suitable for restoration of small scale target region. Hair object, the thin curve, can be regarded as a small object in every small section and is just consistent with the algorithm property of PDE. Therefore the PDE based inpainting method is selected to repair the hair-occluded information.
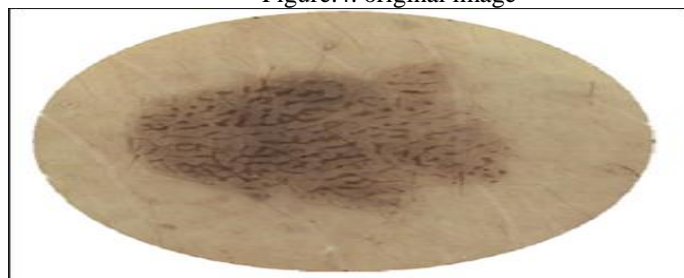

Figure.4. original image

Figure.5. image after inpainting using PDE

IV.3. Hair Removal by Fast Marching Scheme
This method does not interfere with the tumor's texture. Moreover, this hair repairing algorithm is easily combined in melanoma CAD tool. This method is divided into three steps (a) hair detection with the use of a derivative of Gaussian (DOG) (b) refinement by morphological techniques (c) hair repair by fast marching image inpainting.
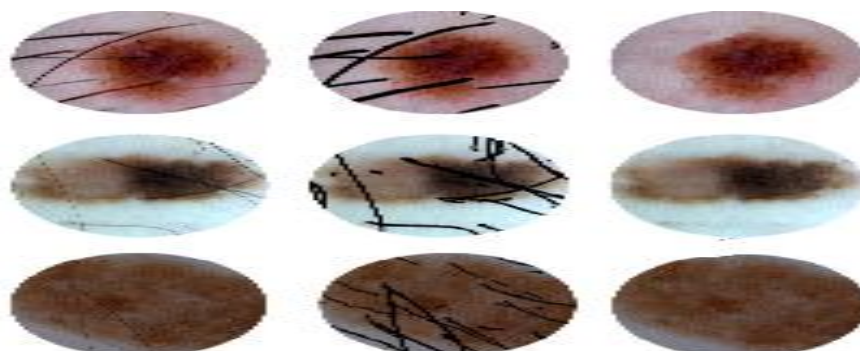

Figure.6. a result of the hair occluded repairing method by fast marching scheme.

Fig.6 shows the result obtained by using fast marching scheme. To repair hair-occluded information from dermoscopy images, the fast inpainting method is utilized and improved by introducing a perceptually uniform color space. The inpainting technique utilize a fast marching method to traverse the inpainting domain while, transporting the image values in a coherence direction by means of a structure tensor. Through the measure of the strength of the coherence, this inpainting technique switches between diffusion and directional transport. By

adding this robust coherence strength, the fast marching inpainting method is more effective than other inpainting methods such as exemplar based one. This method is approximately 37% more effective for region filling than the exemplar based inpainting technique, removing the noise without damaging the patterns and texture part of the lesion.

V. COMPARISONS

The Dullrazor method is used to remove thin and thick dark hair. However, hair pixels with a color slightly different to the tumour color are not detected. Also, it uses a 2 pixel neighbourhood to inpaint. Therefore the detected area provide diffused patterns. Partial differentiation based methods pay much attention to hair lines detection. The PDE based techniques are time-consuming and moreover the inpaint of the detected area produces some negative effects on the patterns. The fast marching scheme method repairs the occluded information in a manner that is closer to human vision without disturbing the tumor's patterns. By computing strength of the coherence, this inpainting method switches between diffusion and directional transport. It does not disturb tumor's patterns.

TABLE 1

Method	Remarks
Linear interpolation	Efficient in removing thin and thick dark hair, often leads to undesirable blurring and color bleeding, sensitive to orientation of linear elements, incapable to distinguish between hair and line segments. If boosted so that it does not disturb texture, then can be used for dermoscopic image analysis.
Inpainting based on PDE	More attention is given to hair lines detection, time consuming, produces negative effect on patterns, not so suitable for dermoscopic image analysis. If it is used non-iteratively then its efficiency for dermoscopic image analysis can be increased.
Fast marching	It does not disturb tumor patterns, it repairs information in such a manner that it is close to human vision. Uses non-iterative PDE's, so can be efficiently used in dermoscopic image analysis.

VI. FINDINGS

In this paper, a comparative study of different methods used for automatic detection of hair and restoration of the texture-part of tumors from occluded information is presented. This comparative study is essential to reduce undesired segmentation and classification results of melanoma and other pigmented lesions, affected by the hairs covering it.

Three hair repairing techniques are discussed here, linear interpolation, inpainting by using PDE and the fast marching scheme algorithm. The advantages of using fast marching method is that it uses non-iterative PDE's and it utilizes structure tensor to robustly determine coherence direction that switches between diffusion and directional transport. If the computational complexity and the tumor disturbance pattern of the linear interpolation and inpainting methods are improved then they can be used for hair removal. In case of PDE, if instead of iterative, non iterative PDE is used then it can be benefited for hair removal purposes.

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