

Software tool for contrast enhancement and segmentation of melanoma images based on human perception

Irene Fondón¹, Qaisar Abbas^{2,3}, M. Emre Celebi⁴, Waqar Ahmad^{2,3} and Qaisar Mushtaq^{2,3}

¹Department of Signal Theory and Communications, School of Engineering, C\ Camino de los Descubrimientos s/n 41092, Seville, Spain

²Department of Computer Science, National Textile University, Faisalabad, Pakistan.

³Center for Biomedical imaging and Bioinformatics, Key Laboratory of Image Processing, Faisalabad, Pakistan.

⁴Department of Computer Science, Louisiana State University, Shreveport, Louisiana, USA.

irenef@us.es, drqaisar@ntu.edu.pk, eecelebi@lsus.edu, waqar@ntu.edu.pk, qaisarmushtaq@ntu.edu.pk

Abstract. In this paper we present a software tool for melanoma border detection (*MBD*). It has been designed to be incorporated in any Computer Aided Diagnosis Tool (*CAD*) for early detection of melanoma in mass screening programs. The tool is completely automatic, possesses a user-friendly interface and does not require any specific hardware. The main steps followed by the implemented algorithm are: uneven illumination correction, color contrast improvement and color image segmentation. All of them are performed in the uniform color space $CIE L^*a^*b^*$ in order to achieve a complete adaptation to human color perception. The program is able to provide not only the final obtained segmentation result but also intermediate graphical outcomes, guiding the user in the process of melanoma detection. This simple, friendly but powerful interface can serve as a support for the medical personnel in the melanoma diagnostic process. The *MBD* software and some samples of the dermoscopy images used can be downloaded at <http://cs.ntu.edu.pk/research.php>.

Keywords. Software tool, skin cancer, melanoma border detection, dermoscopy, contrast enhancement, hill-climbing

1 Introduction

Malignant melanoma is the most dangerous type of skin cancer [1]. However, when early detected, the survival rate of patients increases about 99 percent [2]. In this sense digital dermoscopy, that is, a skin imaging technique widely used for pigmented skin lesion inspection, constitutes a powerful tool [3] mainly because its non-invasive nature and its capability of optical magnification that reduces the surface reflection and makes the subsurface structures more visible [4]. However, even for an experienced dermatologist, an accurate classification rate of skin lesions based only in the use of digital dermoscopy is less than 90% [5]. Stated this, a computer diagnosis (*CAD*) tool is highly recommended and adopted to improve skin lesion classification accuracy [6]. These computerized tools usually begin with the isolation of the desired region, cancerous skin, from the background, usually healthy skin. An effective segmentation can dictate the eventual success of the analysis. However, melanoma border detection (*MBD*) is a difficult task due to low contrast and color variations [7]. A variety of techniques have been proposed in the past for skin lesion detection or segmentation [8]–[11] mainly based on three well-known techniques: thresholding, clustering, and region growing. Most of these lesion area detection methods are limited to grayscale image processing or non-uniform color spaces. They are not designed to effectively deal with the important color information present in the images. To overcome this problem a new technique was proposed in [12]. In this article, a novel automatic *MBD* technique was developed based on a perceptually oriented color space, i.e. $CIE L^*a^*b^*$ to achieve a complete adaptation to human perception of color. The *MBD* technique followed three steps. In the first one, the original *RGB* color image is transformed to the uniform color space $CIE L^*a^*b^*$. Afterwards, a contrast improvement algorithm was applied adjusting and remapping the intensity values of the pixels in the specified range. The second stage is the color segmentation by the Hill-Climbing technique [13]. As a result a labeled image is obtained where the region of interest (*ROI*) is detected. The last step, consist on the isolation of this *ROI* applying the Otsu thresholding technique and providing the

final melanoma region. The method was proved to be effective through the comparison with three state-of-the-art techniques with experiments performed on a total of 100 dermoscopy images. On the other hand, as the field of image processing is suitable for the use of visual techniques, advanced graphical user interface (*GUI*) tools have been designed with a scientific research purpose in the past [14]-[16]. Following the philosophy behind these user-friendly tools, this paper presents a *GUI* that implements the perception adapted technique of [12]. The structure of the paper is the following: Section 2 describes the method with further detail. In Section 3 the software tool is presented and finally, Section 4 concludes the article.

2. Method

2.1 Preprocessing

In any type of dermoscopy image, the first step includes a preprocessing to facilitate the subsequent stages correcting uneven illumination and improving contrast. In this approach, we have used the three planes of the *CIE L*a*b** uniform color space. The advantage introduced by this selection is its adaptation to color human perception, that is, in this space color distances are correlated to perceived color differences. To achieve the adjustment of uneven illumination in the preprocessing step, we updated the luminance (L^*) channel by using a sigmoidal function. When the luminance component is corrected contrast is enhanced by using intensity remapping and Gaussian filter techniques in the a^*b^* color planes. The image pixels of both channels are remapped to their minimum and maximum values and then the image is rebuilt by combining the three updated planes

2.2 Hill-climbing segmentation

After contrast improvement step, the *ROI* is detected by the use of the Hill-Climbing algorithm (*HCA*) [13] in three color channels of *CIE L*a*b**. *HCA* takes an image and the number of histogram bins in each dimension as input parameters, and returns a labeled one, where each label corresponds to one color cluster on it. More specifically, the method consists on a *K*-means clustering automatically initialized, that is, in contrast to the traditional *K*-means technique, the numbers of clusters, *K*, does not need to be manually specified. Moreover, the better initial centroid positions are automatically detected. To this purpose, the 3*D* color histogram of the input image is computed. With an uphill climbing move the most relevant peaks are detected. Its number and mean position in the color space correspond to the value for *K* and the position of the centroids respectively. The original image is usually divided with this procedure into two (*K*=2) regions (healthy and cancerous skin).

2.3 Melanoma region identification

To recognize the lesion from the labeled image, a simple thresholding algorithm is applied. In practice, a thresholding is a method to extract objects from their background. In our proposed tool, we make use of the well-known Otsu technique. The idea behind it is to find a global threshold in order to reduce the weighted intra-class variance. Using this global threshold the *ROI* map is then converted to a binary image where the pixels belonging to the melanoma region are set to one. Moreover, the light structures that are connected to the borders of that binary image are eliminated or reduced based on eight-connected neighborhood connectivity.

3. User friendly software tool

The software approach presented in this paper has been developed with Mathworks Matlab 7.8.0.347 and its Image Processing, GUI and compiler toolboxes. The interface structure is clear and simple with two different areas:

- Images display area: where the intermediate and final results are shown. The images resulting of the different steps of the method are shown in this area. Here the user can

observe the original image and its histogram, the contrast enhanced image and its histogram, the final segmented image with the melanoma border superimposed to the original image and the manually annotated image.

- Interaction area: with buttons and editable text boxes. The user can load the image to be analyzed with the *Load the input image* button, see Figure 1 (a). The image will immediately appear in the left axes along with its histogram and some options will be enabled such as *Load the ground truth file* or *Enhance the selected image*. If this second button is pressed, Figure 1 (b), the image illumination is corrected and its contrast is improved. The enhanced image and its histogram will be shown in the display area, Figure 2 (a). At this moment, the *Segmentation* button is enabled and, if it is pressed, the segmentation is carried out. When the program is finished the resulting image is displayed with the tumor border marked in blue over the original one, Figure 2(b). There is an option of displaying the ground truth image (if available) in order to compare the obtained results.

It must be noticed that the different buttons needed to perform the desired operations are disabled in the initial call to the program and are automatically activated during the process, see Figures 1 and 2. In this way the program guides the specialist in the procedure of melanoma segmentation. There are two experimental parameters that are initially fixed by the algorithm. However, if the expert considers the result as non satisfactory, these parameters can be changed and a new value can be introduced in the corresponding edit boxes, see Figure 2.

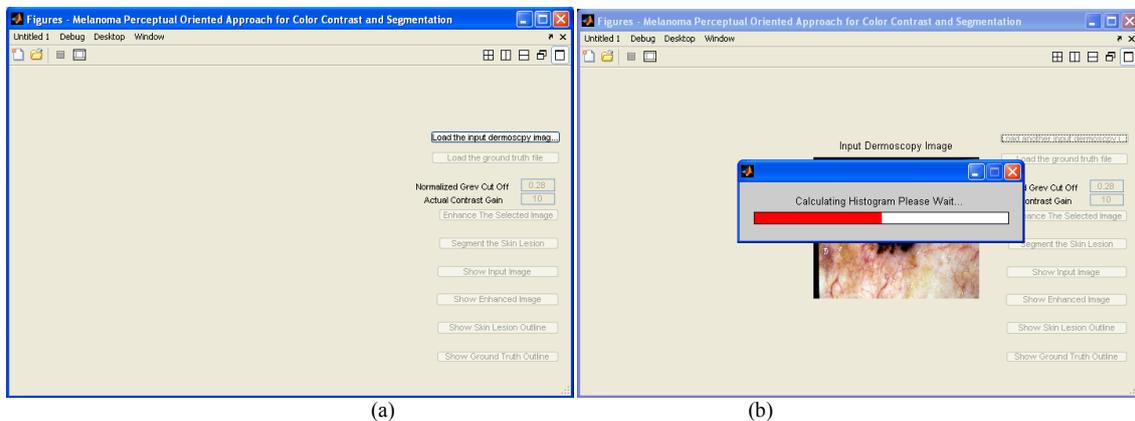


Figure 1. The software tool at the beginning of the segmentation process (a) and at the histogram computation step (b). The buttons and options are enabled progressively guiding the user in the process.

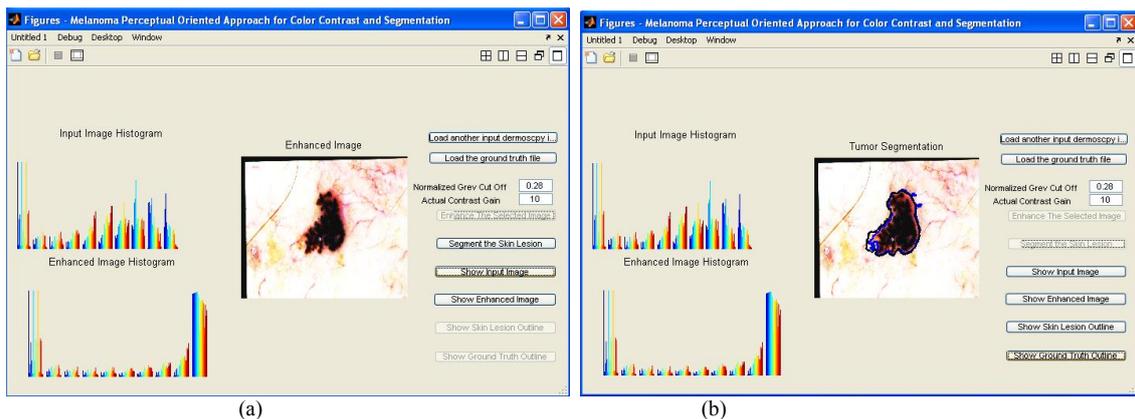


Figure 2. The original image is enhanced (a) and the segmentation is performed (b). The final segmentation result is shown in blue along with the ground truth in black.

The implemented software, some sample dermoscopy images and the corresponding ground truth annotated by an expert dermatologist are freely available at: <http://cs.ntu.edu.pk/research.php>.

4. Conclusion

A new interactive software tool for contrast enhancement and segmentation of melanoma images has been presented. Through the use of a friendly interface, the medical expert can be helped in the difficult task of early melanoma diagnosis. All the image processing is performed in the uniform color space $CIE L^*a^*b^*$ to achieve an adaptation to human perception. The original image is initially preprocessed in order to correct uneven illumination and improve contrast. The segmentation is performed with *HCA* where color histogram processing is used to initialize a *K*-means clustering technique. An Otsu thresholding procedure is applied to the labeled image to identify the melanoma area from the others. The tool, simple and powerful, is intended to be integrated in a more complex *CAD* tool for mass screening programs.

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