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A new algorithm for melanomas contour detection based on morphological operators

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Abstract: This study proposes an algorithm for skin lesion or melanomas contour detection using morphological operators. The algorithm contains image processing steps such as binarization, morphological operators and segmentation based on active contours as well-established segmentation method and a new method based on morphological operations. The morphological operators use various structuring elements and arithmetic operations to process the images based on the shape and to produce erosion and dilatation in order to obtain effective reliable results for border detection of the melanomas. The results provided by the proposed segmentation method were compared with those of a well-established segmentation method, so called the active contour method. The efficacy of the proposed segmentation method was assessed based on the boundary precision and its performance based on run time.

Keywords: morphological operators, active contour method, runtime, boundary precision.

1. INTRODUCTION

The melanoma is a kind of skin cancer. The global assessing performed by Global Burden of Disease Study indicates that the incidence of melanoma has increased in the last twenty years. The Australasia, North America, Eastern Europe, Western Europe and Central Europe are major five world regions with the greatest melanoma incidence. The highest disease rate is for age group 75–79 years, 70–74 years and ≥ 80 years (C. Karimkhani et al. (2017)).

Early detection by means of fully automatic Computer Aided Diagnosis (CAD) tool is highly requested but still is a challenge. The implementation of a CAD system of melanoma detection requires knowledge about asymmetrical shape, border or boundary, colour, diameter, and evolution (or change). These characteristics are so called ABCDEs[1] of melanoma and are important features for a CAD system.

Usually, the detection of skin lesion boundaries and melanoma segmentation consists of five main steps, namely thresholding, partitioning the image into regions, edge detection, pixel intensity assessment and morphological operations. Contour is an edge between an object and the background into image and edge detection is used to find the discontinuities in the surface orientation, the changes in material properties and the variations in the scene illuminations (Suman Rani et al. (2014), S. Moldovanu et al. (2017)).

In many medical imaging application and CAD systems, the skin lesion boundaries, which usually represent the regions of interest ROIs, were detected using various image segmentation methods such as the histogram for RGB colour system (Alaa Ahmed Abbas Al-abayechi et al. (2014)), active contour models (R. Kasmi et al. (2015), M.E. Celebi *et al.* (2009)) or Canny method. (Jaseema Yasmin et al. (2015)).

In this paper, we propose a new algorithm that is mainly based on the morphological operations (implemented after the edges were detected) and on the boundary precision of the region of interest under investigation. The main reason for using these processing tools is that is an easier and meaningful way to discern between a common mole and a melanoma. The evaluation of the segmentation accuracy has been performed against the well-established method called the active contour method developed by Chan and Vese. (T. F. *Chan et al.* (2001).

In practice, the similarity between the processed and unprocessed images based on boundary precision criterion allows to check the robustness of the proposed algorithm (P. Neubert et al. (2012)) that establishes if the segmentation succeeded.

[1]https://www.melanoma.org/sites/default/files/u13882/ABCDEs%20of%20Melanoma_0.pdf

2. MATERIAL AND METHODS

The proposed algorithm was applied to 10 dermatological images from the DERMOFIT[2] database, which is a cognitive prosthesis to help focal skin lesion diagnosis. The images are RGB (red, green, blue) images and were labelled as: Image1 (332 Kb), Image2 (206 Kb), Image3 (447 Kb), Image4 (260 Kb), Image5 (672 Kb), Image6 (248 Kb), Image7 (308 Kb), Image8 (3.06 Mb), Image9 (391 Kb), Image10 (279 Kb). As an example, figure 1(a) shows the most serious type of skin cancer called melanoma.

For image segmentation, a method based on shapes in the image, i.e. erosion and dilation operations, has been used. Dilation and erosion allow to extract edge information from images and theses operations were applied only on greyscale images. A small shape called structuring element is used to implement the morphological operators.

The dilation process is performed by laying the structuring element B on the image A and sliding it across the image in a manner similar to convolution [3]. Dilatation is denoted $C=A \oplus B$ and the image objects are expanding. Similarly, the erosion of a binary image A by a structuring element B is denoted $C= A \ominus B$ and the image objects are shrinking. The active contours model detects objects in a given image, based on the theory of surface evolution that are not depend on the existing gradient into image. The method proposed by Chan and Vese is based on the minimization of the image energy. (T. F. Chan et al. (2001).

To quantitatively estimate the segmentation accuracy, an adapted boundary precision index BP is proposed.

$$BP=TP/(TP+FP) \quad (1)$$

where True Positives (TP) is the number of pixels detected using the proposed method as being a skin lesion pixel and False Positive (FP) is the number of pixels detected with the well-established method. (T. F. Chan et al. (2001).

The steps of the proposed algorithm are shown below.

Algorithm

Input: RGB image

Output: Edge image

{Step 1} Import image *–imread('input_image')*

{Step 2} RGB image is converted to a grayscale image *rgb2gray(input image)*

{Step 3} Binarization of the grayscale image using Otsu Method I=*im2bw (input_image)*

{Step 4} Choose the structuring element *s* for erosion and dilation operations

{Step 5} Erosion of a binary image I *IE=imerode(bw,s);*

{Step 6} Dilatation of a binary image I *ID=imdilate(bw,s);*

{Step 7} Pixel subtractions EdgeOut =ID-I

{Step 8} Pixel subtractions EdgeIn =I-IE

{Step 9} Pixel subtractions I_out1=EdgeOut-EdgeIn

{Step 10} Repeat the Steps 5 and 6 and initiate segmentation using the contour active method IC1=*imcontour(IE),* IC2=*imcontour(ID),*

{Step 11} Repeat the Steps 7: EdgeOut= IC1-I, and Step 8: EdgeIn =I-IC2 and initiate segmentation using the contour active method IC3=*imcontour(*EdgeOut*),* IC4=*imcontour(*EdgeIn *),*

{Step 12} Pixel subtractions I_out2=IC3-IC4

{Step 13} Calculate the Boundary Precision index between I_out1 and I_out2

The algorithm was implemented in high-level language and interactive environment MATLAB R2018a with Toolbox Processing Image on both personal computers.

The algorithm was tested on two hardware experimental environments, as follows:

PC1: Processor: Inter(R) Core(TM) i5-4200U, CPU 1.6 GHz, 2.3 GHz, Installed memory (RAM): 4 Gb, System type: 64-bit Operating System, x64-based processor.

PC2: Processor: Inter(R) Core(TM) i3-4005U, CPU 1.7 GHz, Installed memory (RAM): 4 Gb, System type: 64-bit Operating System, x64-based processor.

3. RESULTS AND DISCUSSION

The segmentation using the morphological operators (i.e. the proposed method) allows detecting the melanoma boundary with the same precision as the active contour method. The pre-processed and post-processed images are shown in the figure1. A visual comparison between the segmented image obtained by the proposed algorithm (fig. 1f) and image segmented using the active contour method (fig. 1i) shows that the proposed algorithm performs better.

In Table 1, the steps of the algorithm are corroborated with the segmentation flowchart.

Table 1. The links between algorithm and segmentation process

figure 1.a	step1
figure 1.b	step 2
figure 1.c	step 3
figure 1.d	steps 4,5,6,7
figure 1.e	steps 4,7,8
figure 1.f, 2.c	Step 8
figure 1.g	step 10
figure 1.h	step 11
figure 1.i, 2.d	step 12

[2] https://homepages.inf.ed.ac.uk/rbf/DERMOFIT/

Boundary precision index was adapted to our goal. Thus, TP is the number of pixels detected using the proposed method as being a skin lesion pixel (pixels in fig. 1f) which also exists as a boundary pixel in figure1(i) (segmented using the contour active method). Accordingly, FP is the number of pixels detected using the proposed method as being a skin lesion pixel (pixels in fig. 1f) which does not exist as a boundary pixel in figure1(i) (segmented using the contour active method).

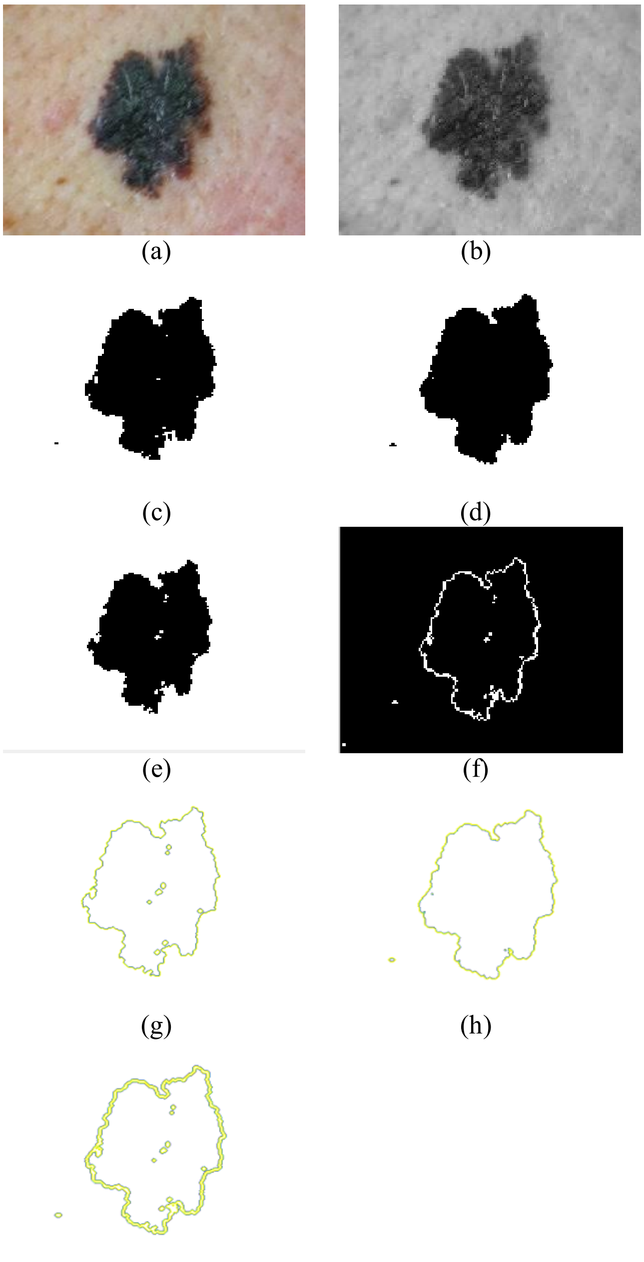

Fig. 1. (a) Melanoma image; (b) Grayscale image; (c) Binary image by thresholding method; (d) Dilation: a 1×1 disk structuring element- proposed method; (e) Erosion: a 1×1 disk structuring element–proposed method; (f) Edge detected image –proposed method; (g) Dilation: a 1×1 disk structuring element and contour active method; (h) Erosion: a 1×1 disk structuring element and contour active method; (i) Edge detected image –contour active method

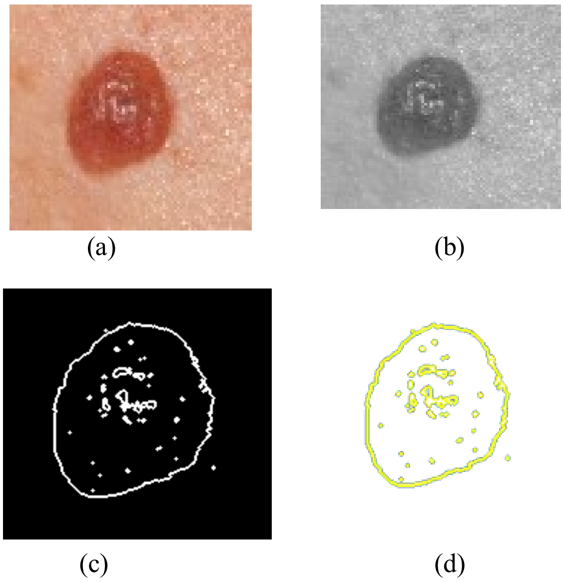

Fig. 2 (a) Melanocytic image; (b) Grayscale image; (c) Edge detected image –proposed method; (d) Edge detected image –contour active method.

The values of the boundary precision (BP) for all tested images are close to 1. This finding means that the proposed method has almost the same performance as active contour method (fig. 3). The only one exception has been found, i.e. BP = 0.88 for the ninth image.

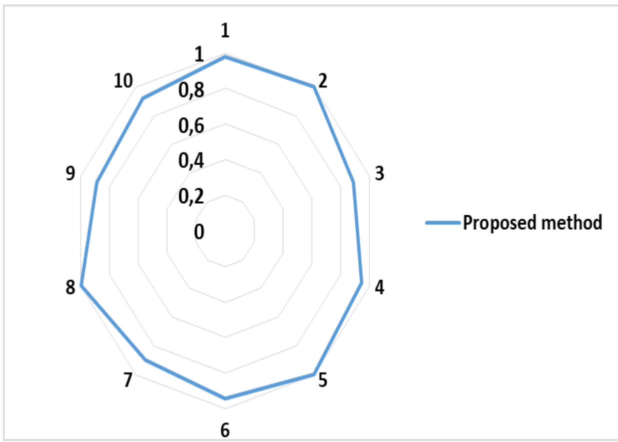

Fig. 3. Boundary precision index values for tested images

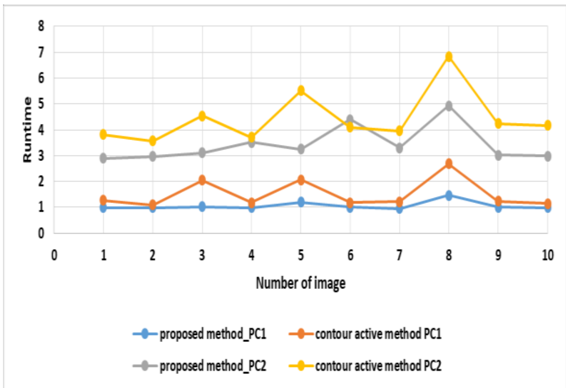

Figure 4. Run time for all images from database

In order to validate the efficiency of the proposed method, the run time for both methods, namely the necessary time for an algorithm to complete work on a set of data, is presented in figure 4.

The input RGB images database has the size ranged between 206Kb and 3.06 Mb. The run time ranges between 1.46s and 6.84s for all tested image. For the proposed method, the run time varies between 0.96s and 1.46s for the first PC and between 2.9s and 4.93s for the second PC. For the active contour method, the value of the runtime is higher. For the first PC, it spans in the interval [1.09s; 2.68s] and for the second PC, the runtime value falls in the interval [4.93s; 6.84s]. For both PCs, the variation of the run time depends by the resolution and the hardware platforms.

4. CONCLUSION

The effective algorithms for boundary detection of the skin lesions has become a crucial step in an earlier diagnostic. The performance of the proposed algorithm was compared with the performance of a well-established method known as active contour. The experimental results show a good boundary detection the performance in the case of the proposed method. It is very close to the performance of the active contour method. The run time obtained using the method is shorter in comparison to contour active method for both hardware platforms so, it is expected that the proposed method would be an alternative to the active contour method in medical imaging in dermatological field.

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