Segmentation of Skin Lesions' Macroscopic Images for Cancer Diagnosis

Mahdi Hariri*[1], Sanaz Rahmatian[2]

[1,2] Department of Electrical and Computer Engineering
University of Zanjan
Zanjan, Iran,
[1]Ma.Hariri@znu.ac.ir
[2] Rahmatian.Sanaz@znu.ac.ir

Abstract

Skin cancerous lesions are more effectively treated and the disease's spread can be prevented if they are diagnosed in the early stages. Specialized tests have demonstrated accurate skin cancer diagnosis based on images of skin lesions. So far, the majority of processing and diagnostic activities have relied on dermoscopic skin images, with high resolution and high separation accuracy, that a small group of skin and hair specialists examine. In today's societies, with widespread access to mobile phones, patients have the opportunity to take their skin photos to identify skin lesions and their probability of being cancerous. This early detection can prompt quicker treatment. In this study, we aim to apply intelligent image processing techniques for the segmentation of skin lesions in macroscopic images, which are low-quality images taken by mobile phones, to facilitate basic analysis. For cancer diagnosis, better segmentation of lesions leads to greater diagnostic accuracy. In this research, by tracing the neighboring points of the lesion border with Moore's edge detection method, we extract the lesion borders with good accuracy from the macroscopic images. The application of the proposed algorithm to macroscopic and dermoscopic images demonstrates reasonable segmentation accuracy in comparison. The proposed processing method warrants further investigation.

Keywords: Dermoscopic, Macroscopic image, Moor Neighbor tracing, Segmentation, Skin lesions,

1- Introduction

According to the studies, skin cancer is one of the most common types of cancer among humans. Diagnosing skin cancer in the early stages of the disease and often before the stage of metastasis can significantly prevent deaths from this deadly cancer. Ultraviolet radiation, UV, plays the main role in the common type of cancer, namely skin cancer.

The head of the National Center for Forecasting and Crisis Management of Weather Risks of the Iran Meteorological Organization recently announced that according to meteorological maps, the amount of ultraviolet radiation in the country will increase in the afternoon, from 14:00 to 17:00, and reaches more than 11 and close to 12, which is more than the safe threshold which is between 8 and 10 [1].

Research that was conducted intuitively in 2016 on about 300 patients referred to the tumor clinic of Razi Skin Hospital in Tehran has shown that there is a statistically significant relationship between skin cancer and the type of occupation, socio-economic status, smoking, preventive behavioral habits, age/sex and weight variables, so for the prevention and early detection of this disease, in the first stage, screening programs should be conducted in middle-aged men, especially those who are being exposed to sunlight a lot due to their jobs [2].

Segmentation and lesion border detection is the first and most important step in automatic detection systems. The segmentation of objects in the image plays an essential role in identifying them, this process works by specifying the edges of the objects, which are a set of border pixels of the object. Recently, different edge detection methods have been used in different areas for images.

Lin et al. have used quasi high-pass filter based on local variances to detect edges in medical images [3]. In another research, the iterative method of fuzzy edge detection is used for edge detection of blurred satellite images [4]. Biswas and Hazra have used the modified Moore's neighborhood algorithm as a robust method for segmentation based on edge detection. The introduced method can correctly extract the edges and features of an object and at the same time be resistant to noise [5].

Segmentation of skin lesions is an important technique for early detection and diagnosis of various types of skin diseases, including melanoma and other types of skin cancer. Due to the difference in the appearance of the lesion, its surrounding tissue, and surrounding skin, the correct and efficient classification of skin lesions is a challenging task. To deal with this challenge, researchers have investigated different image-processing methods to increase the accuracy of the classification performance of these lesions [6]. Analyzing skin lesions is an important subfield of medical imaging that helps to quickly diagnose and identify spreading skin cancer. Therefore, there is a need for efficient image analysis methods to help physicians accelerate and improve the process of timely and accurate identification of this disease [7].

1-1- Macroscopic and dermoscopic images

Dermoscopic images are obtained by dermoscopy devices that provide light and high magnification. This technique is especially useful for observing fine details of the surface and subsurface structures of the skin. These features are very important for the early diagnosis of cancerous skin complications of melanoma and squamous cell carcinomas. Macroscopic images refer to images that provide a general and wide view of the skin area. These images are usually taken using conventional digital cameras or mobile phone-like imaging tools. These images are used in monitoring long-term treatments and evaluating changes in large areas of the skin. Dermoscopic images are more suitable for detailed analysis of skin structures and diagnosis of skin lesions such as moles and skin cancers due to the ability to provide detailed details and high magnification. In comparison, macroscopic images are mostly used to monitor the general condition of the skin and continuously evaluate skin changes [8]. Fig. 1 shows an example of dermoscopic and macroscopic images of a skin lesion.

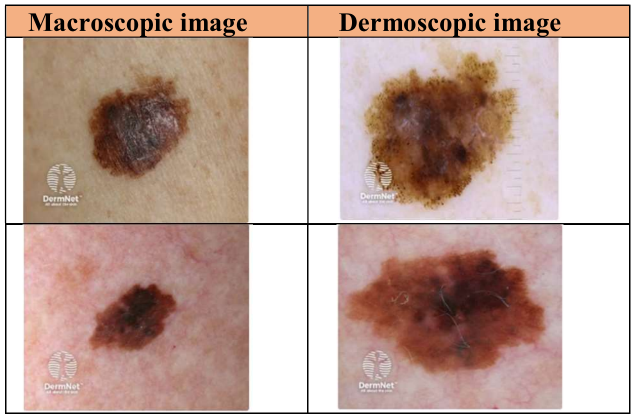


Figure 1: An example of dermoscopic and macroscopic images of melanoma skin lesions[9]

A malignant tumor caused by the abnormal growth of melanocytes is known as melanoma. Because pigmented lesions appear on the surface of the skin, melanoma can be detected early through proper visual inspection by a Clinical specialist [7]. Due to the high resolution and accuracy of dermoscopic images, most of the segmentation and diagnosis works have been done on these images and for the cancerous lesions of melanoma and carcinoma. Soruwka et.al. have used morphological methods of region growing, with adaptive threshold and background skin to segment melanoma lesions and reveal their borders. They have reported the performance of their proposed method on two sets of dermoscopic images [10].

The variety of macroscopic imaging methods and the lower resolution and accuracy of them compared to dermoscopic images make it difficult to reveal the details of skin lesions in the image. Utilizing macroscopic images for diagnosis can offer a straightforward approach to diagnosis and remote healthcare.

In this research, our goal is to conduct a comparison of skin lesion segmentation in dermoscopy high-quality images with segmentation in images captured using standard cell phone cameras and macroscopic lesion images. Furthermore, we aim to assess the effectiveness of a simple, computationally efficient method for the segmentation of lesions in macroscopic images. Additionally, we visually represent skin lesion segmentation in both kinds of images for comparison. The acceptable accuracy of this segmentation method, against its low computational load, makes its possible usage in a variety of applications and medical aid tools, such as a useful application in common smartphones.

2- Methodology

Due to the relative lack of research works on macroscopic images and the need to pre-process and prepare image data in various imaging conditions compared to dermoscopic images, macroscopic data sets are limited. On the other hand, the specialized imaging centers that provide a collection of dermoscopic images do not have the corresponding collection of macroscopic images. Of course, few specialized sites for skin diseases, such as Dermnet, have posted a limited number of dermoscopic and macroscope images of a lesion, as shown in Fig. 1, to describe and compare different imaging methods. The practical steps of the proposed method until the evaluation of results and conclusion are mentioned in the following sections.

2-1-Dataset

The PAD-UFES-20 dataset is a dataset collected in 2020 alongside the Dermatology and Surgery Support Program by the Federal University of Espírito Santo (UFES-Brazil), a non-profit program for the treatment of skin lesions, especially for Low-income people who are unable to pay for private treatment. This collection contains thousands of images of 6 different types of skin lesions, which are divided into cancerous lesions and skin diseases. The images in the dataset have different sizes because they were collected using different smartphones and all images [11]. Fig. 2 is an example of the images of this database.

2-2-Image Preprocessing

The border shape of skin lesions is one of the important features to identify their type; Therefore, to maintain the shape of the border, we first remove the noise of the images using the median method, then for matching, the lesion images are resized and prepared for the next processing steps.

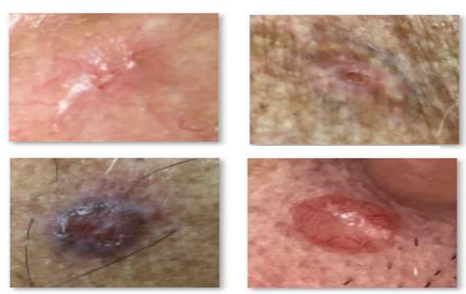


Figure 2: An example of PAD-UFES-20 database images [11]

2-3- Lesion edge detection by Moore-neighbor tracing

Moore-neighborhood tracing method is a method to find the contour around the lesion based on edge detection with Moore's neighborhood. Moore neighborhood is a two-dimensional square grid, which, according to Fig. 3, includes the diagonal neighborhoods of the central cell in addition to the main four-way, von Neumann neighborhoods.

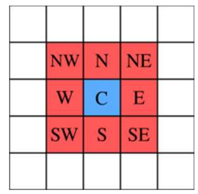


Figure 3: Moore's neighborhood of the central cell c, which includes 8 neighbors that surround it.

To find the borders of the lesion, we use Moore's neighborhood survey method. Despite its efficiency, this method is one of the simplest border scanning methods for extracting border edges of the lesion, which has a lower computational load compared to other methods, especially deep learning methods, and is performed on binary images. This algorithm starts from an arbitrary border pixel, a white pixel on a black background, or vice versa, and looks for other border pixels through Moore's neighborhood, as shown in Fig. 3, which includes 8 pixels around the central pixel.

Moore's neighbors usually search and navigate clockwise around the central pixel from the NW neighborhood, NorthWest side of the central pixel, according to Fig. 3 until the first pixel with the same color as the central pixel is found. In this algorithm, after finding the next border pixel, the center is transferred to that pixel, and the same process is repeated. This process continues until it returns to the starting pixel or all border pixels are visited. When the algorithm returns to the starting pixel, a closed loop of the boundary has been detected. Due to its simplicity and high efficiency in identifying and following boundaries, this algorithm is widely used in identifying geometric shapes and image processing [12].

4-Results and evaluation

To evaluate the performance of the proposed method in the segmentation of macroscopic images of the lesion, we use the comparison of the diagnosed area with the actual area of the lesion as diagnosed by the expert. Considering the problem of segmentation of the lesion into two classes of lesion (B), background (B'), and diagnostic lesion (A) and its background (A'), according to Fig. 4 We define the following confusion matrix parameters.

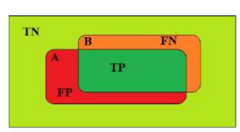


Figure 4: Different parts of segmentation evaluation parameters: TP, TN, FP, FN

TP: part of the image that is correctly recognized as the lesion, bold green part
TN: parts right from the background of the image that are not part of the lesion, pale green part
FP: parts of the background of the image that are wrongly detected as the lesion, the dark red area
FN: Parts of the real lesion that are wrongly detected as background. Orange section

Based on the defined parameters of the confusion matrix above, according to the following relationships, we use the basic criteria of segmentation sensitivity, segmentation accuracy, and its Dice similarity coefficient, *DSC* for evaluation and comparison.

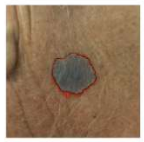
$$Sensitivity = TP/(TP + FN) \quad (1)$$
$$Accuracy = (TP+TN)/(TP+TN+FP+FN) \quad (2)$$
$$DSC = 2*TP/(2*TP+FP+FN) \quad (3)$$

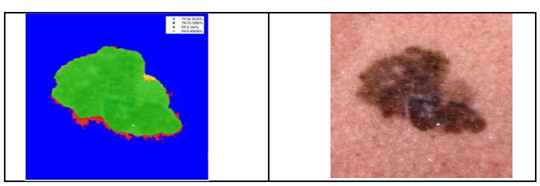
The sensitivity criterion shows the ratio of the correctly segmented lesion area, to the total real area of the lesion, which is shown in Tab. 4 with a red border compared to the black border, the actual border of the lesion, which is above ninety percent in all cases. Considering the relatively low computational load, it is a suitable value. In general, the accuracy parameter shows the accuracy of the segmentation of the lesion and its background areas, which has a suitable value of over 90% for the segmentation of macroscopic images.

In the segmentation of cancer lesions, diagnosis errors are very important and have various risks. Dice's coefficient criterion has more emphasis on the effect of these errors, FP and FN, in the conclusion, which generally shows a suitable value above 90%. Due to the significant difference between FP and FN segmentation errors, we have shown them more precisely in Fig.5 with red and yellow colors, respectively. It can be seen that the amount of yellow color, which indicates the inability of the segmentation method to detect cancer cells, with high risk, is much lower than the amount of red color, which is related to wrongly diagnosed cancerous cells, with lower risk.

Fig. 5 shows the results of the implementation of the proposed method on macroscopic images and compared to the segmentation results of the dermoscopic sample image. Due to the many types of skin lesions and the great variety of forms of one type of lesion, different numerical results are obtained for their segmentation. Since the beginning, this research aims to evaluate the segmentation capability of macroscopic images with the proposed method, it shows the range of accuracy of the evaluation parameters of the segmentation of macroscopic images, melanoma and carcinoma, compared to dermoscopic images. By considering the last column of Tab. 1 we see that the evaluation parameters are close to the evaluation parameters of segmentation of dermoscopic images, which promises the ability of this method to extract acceptable borders of lesions for the next stages of diagnosis.

Table 1: Evaluation and Comparison of the implementation of segmentation on macroscopic and dermoscopic images of skin lesions

Evaluation Parameters	Lesion border, red Grand Truth border, Black	Segmentation Results	Original images	Image
SE = 0.9967 ACC = 0.9935 DSC = 0.9545				Macroscopic
SE = 0.9396 ACC = 0.9956 DSC = 0.9560				Macroscopic
SE = 0.9063 ACC = 0.9785 DSC = 0.9455				Macroscopic
SE = 0.8545 ACC = 0.9323 DSC = 0.9216				Dermoscopi c



(B) (A)

Figure 5: An example of macroscopic image segmentation with Moore neighbor tracing method with a colored display of evaluation parameters of section 4
A) macroscopic image of the lesion with dimensions of 200x200, b) segmented image of the lesion (A)

5- Conclusions

In this research, to facilitate the care of skin health and accelerate treatment measures in the early and suspicious stages of the disease, we examined the segmentation of macroscopic images. Moore neighbor tracing as a method with low computational load, was used to segment macroscopic images compared to dermoscopic images, which have a relatively higher quality. The sensitivity and accuracy criteria show acceptable results on the segmentation of macroscopic images. Also, the high Dice similarity coefficients indicate the low error of the research segmentation method on the macroscopic images of the lesion.

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