An Improved Iterative Segmentation Algorithm using Canny Edge Detector for Skin Lesion Border Detection

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Abstract: *One of the difficult problems recognized in image processing and pattern analysis, in particular in medical imaging applications is boundary detection. The detection of skin lesion boundaries accurately allows, skin cancer detection .There is no unified approach to this problem, which has been found to be application dependent. Early diagnosis of melanoma is a challenge, especially for general practitioners, as melanomas are hard to distinguish from common moles, even for experienced dermatologists. Melanoma can be cured by simple excision, when diagnosed at an early stage. Our proposed improved iterative segmentation algorithm, using canny edge detector, which is a simple and effective method to find the border of real skin lesions is presented, that helps in early detection of malignant melanoma and its performance is compared with the segmentation algorithm using canny detector [16] developed by us previously for border detection of real skin lesions. The experimental results demonstrate the successful border detection of noisy real skin lesions by our proposed improved iterative segmentation algorithm using canny detector. We conclude that our proposed segmentation algorithm, segments the lesion from the image even in the presence of noise for a variety of lesions and skin types and its performance is more reliable than the segmentation algorithm [16] that we have developed previously that uses canny detector, for border detection of real skin lesions for noisy skin lesion diagnosis.*

Keywords: *Melanoma, canny edge detector, border detection, segmentation, skin lesion.*

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1. Introduction

In the general population worldwide, the prevalence of melanoma is escalating. An imperative step toward mortality reduction is early detection by means of accurate screening, since advanced cutaneous melanoma is still untreatable. In the adult population, melanoma is a common cancer that accounts for a substantial number of deaths in fair skinned people worldwide [17].

The appearance of common moles and melanomas has a significant discrepancy. The diameters of moles and melanomas range from a few millimeters up to several centimeters and they both appear as spots on the skin. Color normally is brown or black, but red and blue also exists. In the majority of the situations the normal neighbouring skin appears lighter than the pigmented lesion, so the lesions can easily be identified. Early diagnosis is a challenge, especially for general practitioners, as melanomas are hard to discern from common moles, even for experienced dermatologists. Melanoma can be cured by simple excision, when diagnosed at an early stage [17].

In the last two decades, a lot of attempts has been made to improve the clinical diagnosis of melanoma, by the dermoscopy technique which is a non-invasive in clinical examination which allows for a magnified and lucid visualization of the morphological structures of the skin that are not visible to the naked eye and by the introduction of several clinical diagnostic algorithms such as pattern analysis, ABCD rule of dermoscopy, menzies method, 7-points checklist and the cash algorithm. Compared to simple naked-eye examination, copious studies have revealed that using these algorithms along with dermoscopy and digital monitoring improves the diagnosis of melanoma. Quantitative and objective evaluation of the skin lesion is provided by computer aided diagnosis of melanoma, as opposed to visual assessment, which is subjective in nature. The inter-observer and intra-observer inconsistency that could be found in dermatologists examinations can be diminished by computer aided diagnosis and it allows for reproducible diagnosis [6].

To endow with quantitative information about a lesion, which can be of significance for the clinician, and as a stand alone early warning tool automatic image analysis methods for dermoscopy is currently of enormous interest. The effective execution of such a tool will do good to both the patients and to the health care system. The standard approach in automatic dermoscopic image analysis has usually three stages: Image segmentation, feature extraction, feature selection and lesion classification [11].

For automatic feature extraction, where the rationale is automatic diagnosis of melanomas, delineation of the contour of pigmented skin lesions (segmentation) plays a pertinent role. Image segmentation is the process of adequately grouping pixels into a few regions, whose pixels share some similar characteristic, like color, texture or shape. An imperative first step in any computer aided diagnosis system is automated analysis of edges, colors and shape of the lesion, which relies upon an accurate segmentation [17].

In many systems of computer vision, image segmentation plays an vital role. The good performance of recognition algorithms depend on the quality of segmented image. When it satisfies the observer's objectives, according to the opinion of many authors the segmentation concludes and the more valuable methods being the iterative [12].

In medical imaging applications, boundary detection has been renowned as one of the intricate problems in image processing and pattern analysis, in particular. The problem is complex because of other information corrupting the lucidity of the image. We collectively refer to this other information, some of which may well be extraneous features, as noise. Due to this noise, it is obscure to differentiate the correct borders of the objects of interest from the borders outlined. Accurate automatic image segmentation has proved to be difficult and complex but, the identification of object and surface boundaries comes naturally to a human observer. The first and the most important low level processing to be done on the image is detecting the tumor border, for without finding borders successfully, much of the information used in the diagnosis higher level processing cannot be accurate. Devising techniques to detect uniformity among the feature values of the picture points and then isolating the areas of the picture exhibiting these uniformities is an important thing in achieving an adequate segmentation result. Techniques such as edge detection, region growing, histogram thresholding and clustering have been used. To allow skin cancer detection, researchers have sought to detect tumor boundaries accurately [5].

Due to the following reasons automated border detection is a exigent task: They are low contrast between the lesion and the surrounding skin, irregular and fuzzy lesion borders, features such as skin lines, blood vessels, hairs and air bubbles, variegated coloring inside the lesion and fragmentation due to various reasons such as scar-like depigmentation [4].

To considerably reduce morbidity and mortality, detection of malignant melanoma should be done in its early stages. We can also hoard hundreds of millions of dollars by early detection that otherwise would be spent on the treatment of advanced diseases. There is a very high likelihood that the patient will survive, if cutaneous melanoma is detected in its early stages and removed. Asymmetry, border irregularity, color variegation and diameter greater than 6 mm are the ABCDs of melanoma. First the lesions have to be detected and localized in an image for the measurement of image features for diagnosis of melanoma. For the measurement of features such as for e.g., maximum diameter, asymmetry, irregularity of the boundary and color characteristics it is essential that lesion boundaries has to be determined accurately. Various image segmentation methods have been developed for delineating lesion boundaries [15]. In spite of all efforts, none of the proposed methods have been reported to be adequately reliable on hefty numbers of tumor images. There is no unified approach to this problem, which has been found to be application dependent [5].

In this paper, we propose a new iterative segmentation approach using canny edge detector for skin lesion border detection that helps in diagnosis of melanoma from their color images. The rest of the paper is organized as follows: Section 2 states about the related work regarding this topic, section 3 states the proposed methodology, section 4 demonstrates the results to show the effectiveness of new method and the conclusion is drawn in section 5.

2. Review of Related Work

In medical image analysis image segmentation is a vital task. By minimizing the effect of noise, intensity in homogeneity and other factors in low level image signals, the main challenge is to retrieve high level information from low level image signals. The design of robust and efficient segmentation algorithm is still a very challenging research topic, however, because of the diversity and complexity of images [13]. To address the challenges, a variety of image segmentation methods have been proposed for this purpose.

An edge is a set of connected pixels that lie on the boundary between two regions [8]. An image can be segmented by detecting those discontinuities. The key to a satisfactory segmentation result lies in keeping a balance between detecting accuracy and noise immunity. If the level of detecting accuracy is too high, noise may bring in fake edges making the outline of images unreasonable. Otherwise, some parts of the image outline may get undetected and the position of objects may be mistaken if the degree of noise immunity is excessive [10].

Edge detection is a most common approach for detecting meaningful discontinuities in grey level. Such discontinuities are detected using first order and second order derivatives [4]. The first order derivative of choice is the gradient. The gradient of the 2D function $f(x, y)$ is defined as a vector. The magnitude of this vector is given by:

$$g=[Gx^2+Gy^2]^{1/2} \tag{1}$$

Where $Gx=\partial f/\partial x$ and $Gy=\partial f/\partial y$.

The second derivative in image processing is computed using the laplacian. The laplacian is soldem used by itself for edge detection because as a second order derivative it is unacceptably sensitive to noise, its magnitude produces double edges and it is unable to detect edge direction. However, laplacian can be a powerful complement when used in combination of other edge detection techniques. The basic idea behind edge detection is to find places in an image where the intensity changes very rapidly using one of the two general criteria:

1. Find places where the first derivative of the intensity is greater in magnitude than a specified threshold.
2. Find places where the second derivative of the intensity has zero crossing [7].

Beevi and Sathik [2] proposed a segmentation algorithm in which to improve the robustness against noise, the spatial probability of the neighboring pixels is integrated in the objective function of FCM. The noisy medical images are denoised with the help of an effective denoising algorithm, prior to segmentation to increase further the approach's robustness.

Tsai *et al.* [14] developed a Cytoplast and Nucleus Contour (CNC) detector to split the nucleus and cytoplast from a cervical smear image. This paper proposes the bi-group enhancer to make a clear-cut separation for the pixels laid between two objects and the Maximal Color Difference (MCD) method to draw the aptest nucleus contour. The CNC detector adopts a median filter to remove noises, the bi-group enhancer to restrain the noises and brighten the object contours, the K-mean algorithm to differentiate the cytoplast from the background and the MCD method to extract the nucleus contour.

Garnavi *et al*. [6] proposed a novel automatic segmentation algorithm using color space analysis and clustering based histogram thresholding, which is able to find out the optimal color channel for segmentation of skin lesions.

Zortea *et al*. [17] proposed a segmentation methodology which is characterized by three main processing stages:

1. *Initialization*: Under assumptions on the approximate location of the lesion and the usual lighter nature of the skin color compared to the lesion, automatic search for seed regions are done. The seed regions provide training samples for the binary classification between background skin and lesion.
2. *Classification*: A linear and quadratic classifier, the two distinct base classifiers are made available to the classification procedure. Using optimization of the classification accuracy, the decision of which classifier to use for each particular lesion or possibly a combination of both classifiers (weighting) is automatically decided. This classification strategy can be seen as a hybrid classifier, here defined in terms of the combination of the posterior classification probabilities. To facilitating robust selection of new training samples and segmentation, the classification is iterated.
3. *Iteration*: The automatically chosen training samples are updated and the classification is repeated iteratively until convergence [17].

Ercal *et al.* [5] proposed a simple and yet effective method to find the borders of tumors as an initial step towards the diagnosis of skin tumors from their color images. The method makes use of an adaptive color metric from the Red, Green and Blue (RGB) planes that contain information to discriminate the tumor from the background. Using this suitable coordinate transformation, the image is segmented. The tumor portion is then extracted from the segmented image and borders are drawn [5].

Xu *et al*. [15] developed a three step segmentation method using the properties of skin cancer images. The steps of their method are as follows:

1. *Preprocessing*: A color image is first transformed into an intensity image in such a way that the intensity at a pixel shows the color distance of that pixel with the color of the background. The median color of pixels in small windows in the four corners of the image is taken to be the color of the background.
2. *Initial Segmentation*: A threshold value is determined from the average intensity of high gradient pixels in the obtained intensity image. To find approximate lesion boundaries, this threshold value is used.
3. *Region Refinement*: Using edge information in the image, a region boundary is refined. This involves initializing a closed elastic curve at the approximate boundary and shrinking and expanding it to fit to the edges in its neighbourhood [15].

We have previously developed a segmentation algorithm [16] to extract the true border that reveals the global structure irregularity, which may evoke excessive cell growth or regression of a melanoma. The steps of this algorithm [16] are as follows: This algorithm is applied to the input image containing the lesion, where the input RGB image is converted to grayscale image. Salt and pepper noise is added to the grayscale image and background noise reduction techniques are used to filter noise. The noise filtered image is converted to a binary image based on threshold. Then, the binary image is converted to xor image. The canny edge detector is used to find the edges in the xor image. We get the edge detected image. The pixel on the border of the object is found. Using this pixel found on the border of the object (Lesion) as the starting pixel, the border of the lesion is traced, using the segmentation algorithm [16] using canny detector.

An efficient and robust segmentation algorithm against noise is needed for medical image segmentation. Accurate segmentation of medical images is therefore highly challenging however, accurate segmentation of these images is imperative in correct diagnosis by clinical tools [1].

In this paper, we have developed and compared the performance of our proposed methodology, the improved iterative segmentation algorithm using canny detector for border detection of real skin lesions for noisy skin lesion images with the segmentation algorithm using canny detector for border detection of real skin lesions for noisy skin lesion images [16] developed by us previously.

This paper, demonstrates the use of our proposed method, the improved iterative segmentation algorithm as a tool for border detection of real skin lesions of noisy skin lesion images as an aid to skin lesion diagnosis.

3. Proposed Methodology

In order to, separate the lesion from the surrounding normal skin, a new improved iterative segmentation algorithm, to detect the border of the lesion, has been developed and discussed in this paper. This algorithm is applied to the image containing the lesion. The proposed algorithm consists of several steps, which are explained below.

Algorithm 1: An improved iterative segmentation using canny edge detector for skin lesion border detection

Step 1: The RGB image is converted to grayscale image.
Step 2: Salt and pepper noise is added to the grayscale image. The noisy image is the input image.
Step 3: Median filter used as the background noise reduction technique to filter noise.
Step 4: After noise reduction, the image is converted to a black and white image, based on threshold.
Step 5: The black and white image got is converted into xor image.
Step 6: The canny edge detector is used to find the edges in the xor image. We get the edge detected image (Figure 2-h).
Step 7: Creation of skin lesion border traced image in any of the iterations from 1 to n.

The flowchart for the proposed methodology is given in Figure 1.

After getting the edge detected image, then for each iteration i, for i=1 to n, n={2, 3, 4, ...}. The border of the object (Lesion) is traced the border traced image is got as output for iterations i=1 to n , as following:

1. *For Iteration 1*: In the first iteration the edge detected image shown in Figure 2-h, is given as input to the canny edge detector. We get the edge detected image for the iteration 1 as shown in Figure 2-i. Next the pixel on the border of the object is found. For that the row and column co-ordinate of the pixel on the border of the lesion is to be found. To find the row co-ordinate of the pixel on the border of the object the black and white image is used and the row co-ordinate of the pixel on the border of the object is found and to find the column co-ordinate of the pixel on the border of the object to be traced, the edge detected image got for iteration 1 Figure 2-i is used. To find the column co-ordinate, for the selected row, indices and values of none zero elements are found and the indices having the minimum value is selected as the column co-ordinate of the pixel on the border. Now, the row and column co-ordinates of the pixel on the border of the object is found. Using this pixel found on the border of the object (Lesion) as the starting pixel, the border of the lesion is traced for iteration 1, using the improved iterative segmentation algorithm using canny detector, as shown in Figure 2-j, successfully.
2. *For Iteration 2 to n*: The output of the canny edge detector in the previous iterations (Iteration 1 to Iteration (n-1)) are given as input to the canny edge Detector. Next, the pixel on the border of the object is found as said above. Using this pixel found on the border of the object (Lesion) as the starting pixel, the border of the lesion is traced for each iteration 'i', for i=2 to n, using the improved iterative segmentation algorithm using canny detector, successfully and the process ends when i>n. The border detection sequence using the Algorithm 1 is shown in Figure 2.

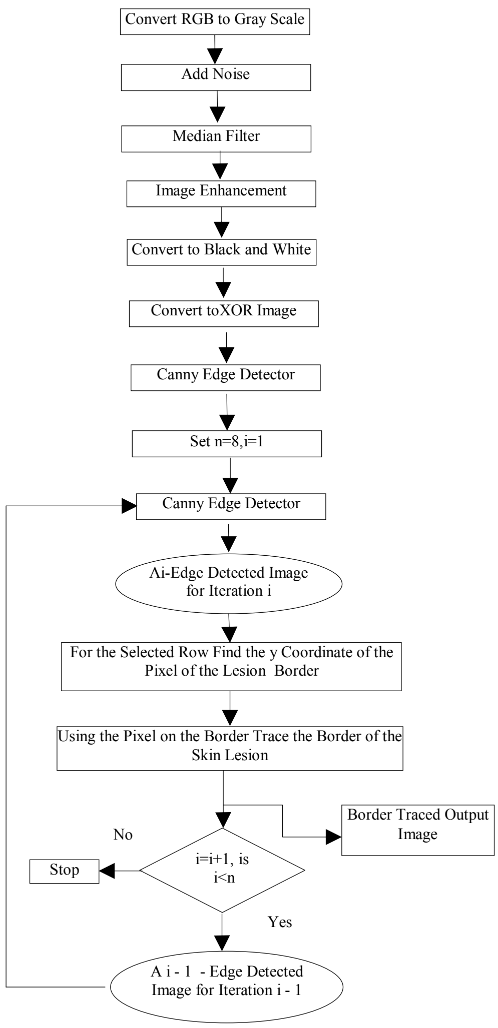
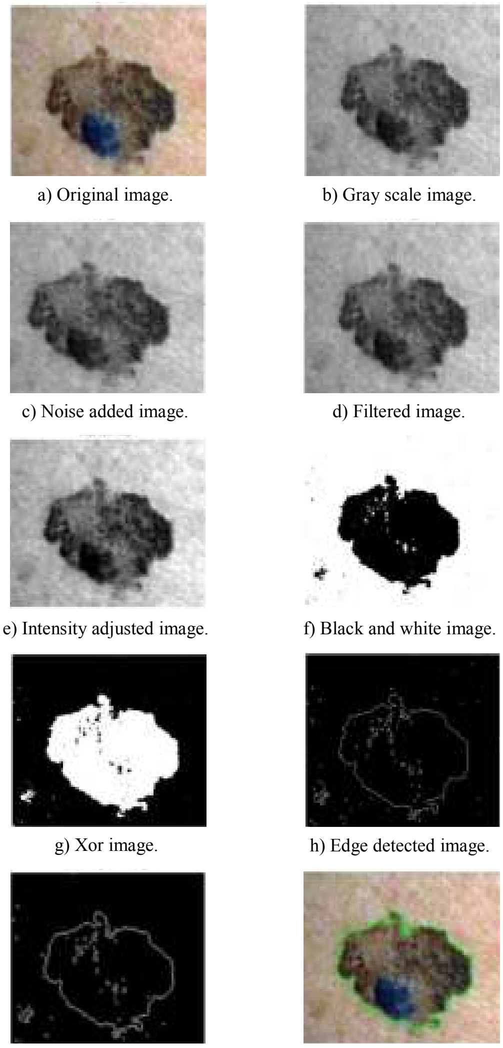


Figure 1. Flowchart for the proposed methodology.



a) Original image. b) Gray scale image.
c) Noise added image. d) Filtered image.
e) Intensity adjusted image. f) Black and white image.
g) Xor image. h) Edge detected image.
i) Edge detected image of iteration 1. j) Border detected image.

Figure 2. Border detection sequence using the proposed improved Iterative segmentation algorithm using canny edge detector.

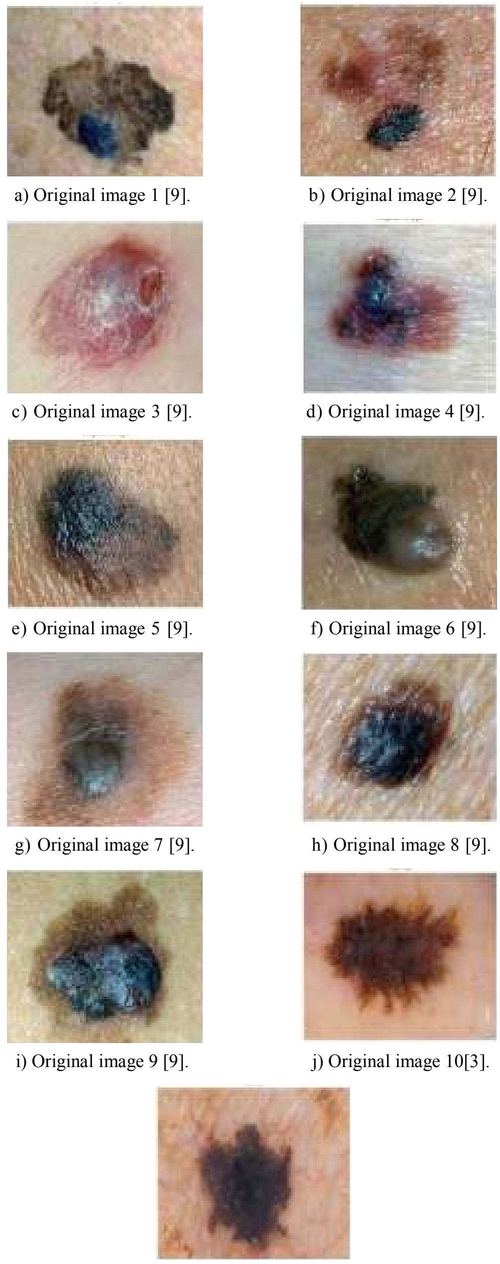
4. Results and Discussion

An image segmentation algorithm to extract the border of the skin lesions has been implemented using matlab. We tested our border finding technique on original skin lesion images shown in Figure 3.

Our aim is to select an image and the system should impart an automatic identification (or segmentation) of the lesion, which aims at identifying the lesion and separate it from the background.

Our proposed segmentation algorithm works well even in the presence of noise, to detect the border of the lesion. Figure 3 illustrates different types of original skin lesions. Figure 4 shows the final output results of the segmentation algorithm using canny edge detector by Yasmin *et al.* [16] when they are applied to the different types of skin lesions with noise.

For the different types of skin lesions taken, Yasmin *et al*. [16] method poorly delineates the boundary for of the skin lesions as shown in Figure 4-a, b, d and k and demonstrates the failure of this method [16] to delineate the boundary of the lesion of various types.



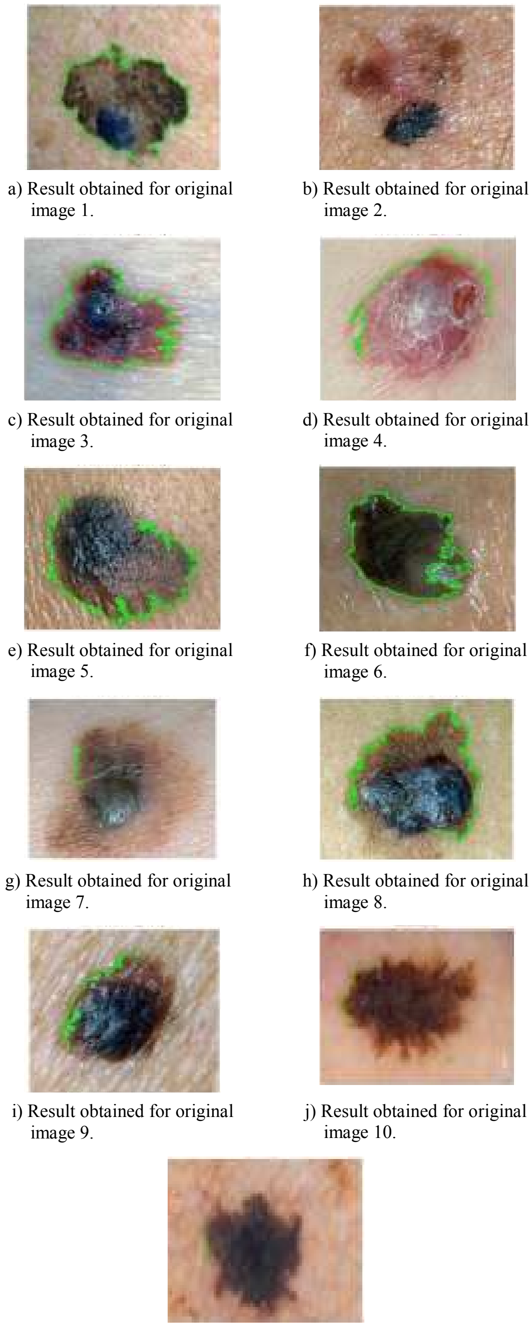
a) Original image 1 [9]. b) Original image 2 [9].
c) Original image 3 [9]. d) Original image 4 [9].
e) Original image 5 [9]. f) Original image 6 [9].
g) Original image 7 [9]. h) Original image 8 [9].
i) Original image 9 [9]. j) Original image 10[3].
k) Original image 11 [3].

Figure 3. Original images.

Our proposed improved iterative segmentation algorithm using canny edge detector, converts the original skin lesion image into a gray scale image. 10% salt and pepper noise was added to the original image.

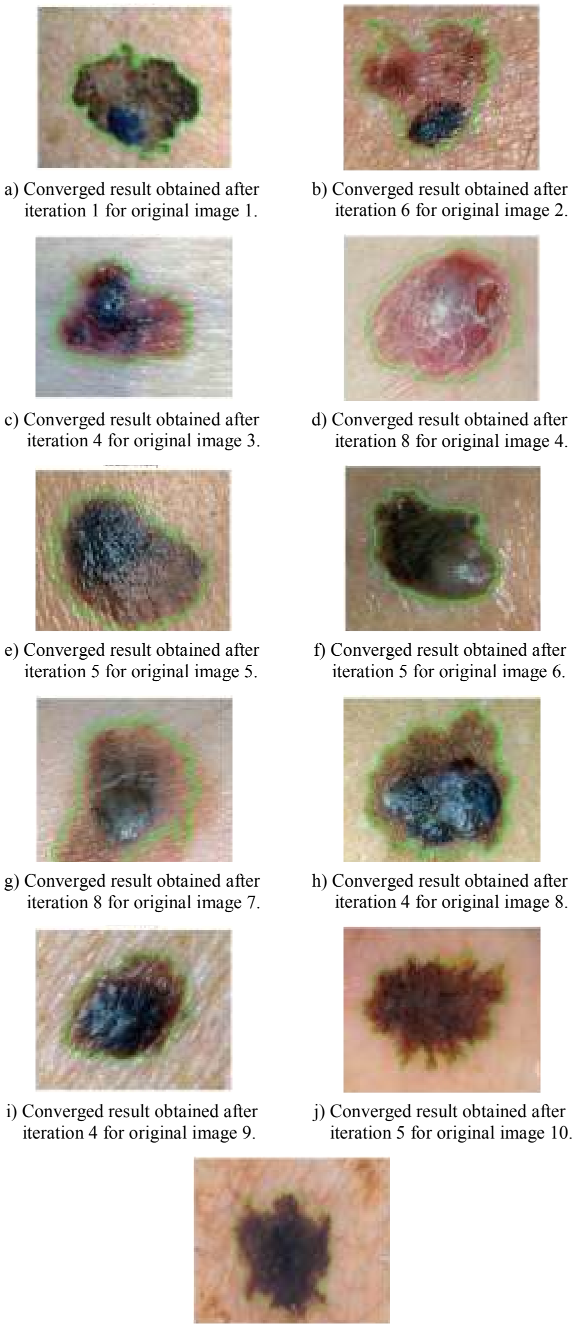
The noisy image is the input image to the proposed algorithm. The median filter is applied and the noise is removed. After noise removal the image is enhanced.

Based on a threshold value the enhanced image is converted to black and white image. This algorithm converts the black and white image into XOR image and using canny edge detector, we get the edge detected image.



a) Result obtained for original image 1.
b) Result obtained for original image 2.
c) Result obtained for original image 3.
d) Result obtained for original image 4.
e) Result obtained for original image 5.
f) Result obtained for original image 6.
g) Result obtained for original image 7.
h) Result obtained for original image 8.
i) Result obtained for original image 9.
j) Result obtained for original image 10.
k) Result obtained for original image 11.

Figure 4. Border detection results of various original skin lesions shown in Figure 3 by the segmentation algorithm using canny edge detector [16] for various original skin lesions.



a) Converged result obtained after iteration 1 for original image 1.
b) Converged result obtained after iteration 6 for original image 2.
c) Converged result obtained after iteration 4 for original image 3.
d) Converged result obtained after iteration 8 for original image 4.
e) Converged result obtained after iteration 5 for original image 5.
f) Converged result obtained after iteration 5 for original image 6.
g) Converged result obtained after iteration 8 for original image 7.
h) Converged result obtained after iteration 4 for original image 8.
i) Converged result obtained after iteration 4 for original image 9.
j) Converged result obtained after iteration 5 for original image 10.
k) Converged result obtained after iteration 10 for original image 11.

Figure 5. Final converged border detection results obtained for various original skin lesions in Figure 3 by our proposed improved iterative segmentation algorithm using canny edge detector.

To improve the reliability of the algorithm in detecting the border of the skin lesions, the edge detected image is applied iteratively to the canny edge detector and for each iteration we get a border detected image. Then, the various iterations at which we obtain the final converged results (skin lesion border traced image) for various original skin lesions by our proposed method are as shown below.

For Figure 5-a iteration 1, Figure 5-b iteration 6, Figure 5-c iteration 4, Figure 5-d iteration 8, Figure 5-e iteration 5, Figure 5-f iteration 5, Figure 5-g iteration 8, Figure 5-h iteration 4, Figure 5-i iteration 4, Figure 5-j iteration 5, Figure 5-k iteration 10.

The performance comparison chart of the segmentation algorithm using the proposed algorithm and the segmentation algorithm using canny edge detector [16] for tracing the border of noisy skin lesion images is shown in Figure 6. Here, performance means ratio of well segmented Lesions. The segmentation algorithm which uses canny detector [16] to trace the borders of the noisy skin lesion fails to detect the border for the original skin lesion images taken as shown in Figure 4-a, b, d and k. The proposed segmentation algorithm successfully detects the border of the noisy skin lesions in all of the cases as shown in Figure 5-a and k.

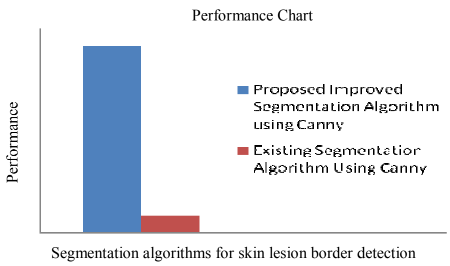


Figure 6. Performance comparison chart of the proposed improved iterative segmentation algorithm using canny edge detector and segmentation algorithm using canny edge detector [16] for tracing the border of noisy skin lesion images. Here, performance means ratio of well segmented lesions.

So, the performance of the proposed improved segmentation algorithm using canny edge detector for tracing the border of noisy skin lesion images is better than the performance of the segmentation algorithm using canny edge detector [16] for tracing the border of noisy skin lesion images.

5. Conclusions

In conclusion, this paper presents a simple yet effective border finding algorithm (improved iterative segmentation algorithm using canny edge detector) for noisy skin lesions and it compares, its performance with that of the segmentation algorithm using canny detector [16] in the border detection of real noisy skin lesions. The detection of skin lesion boundaries accurately allows, skin cancer detection. There is no unified approach to this problem, which has been found to be application dependent. To validate the capability of the segmentation algorithm in detecting the border of the lesions for skin lesion diagnosis, the algorithm was applied on variety of clinical skin image containing lesions with noise. The experimental results demonstrated the successful border detection of real skin lesions by our proposed improved iterative segmentation algorithm using canny edge detector for clinical skin lesion images with noise and make them available for further analysis and research. We conclude that our proposed improved iterative segmentation algorithm using canny edge detector is successful in detecting the border of the skin lesions, even in the presence of noise for a variety of lesions, and skin types and we conclude that its performance is more reliable than the segmentation algorithm that uses canny detector [16] for border detection of noisy real skin lesions.

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