

Skin Cancer Image Segmentation Based on Symmetrical Threshold Contour Algorithm



B. Vasantha Lakshmi, K.Sridevi, D.Elizabeth Rani

Abstract: Image segmentation is a process of identifying sub patterns in a given image. The purpose of skin cancer image segmentation is to represent it in a meaningful way for effective analysis. Segmentation of skin cancer image is mostly used to detect the boundaries and objects present in a skin lesion. This approach describes the skin cancer image segmentation based on symmetrical threshold contour algorithm with similar thresholding values for segmentation of the accurate cancerous lesion. Skin cancer lesion shape and structure is the most important parameter in this method. In this paper, skin cancer image contour detection is based on symmetrical thresholding algorithm using MATLAB software.

Key words: cancerous skin lesion, contour, image segmentation, symmetrical thresholding

I. INTRODUCTION

Image segmentation is classification or identification of small patterns in the given images. Image segmentation is a fundamental step in image processing. Image segmentation is most widely used in various applications like medical imaging, automatic pattern recognition, CBIR (content based image retrieval), and object recognition. Skin cancer image processing includes various steps like pre-processing, segmentation, feature extraction, image classification, and finally detection of the cancer. The cases of melanoma and non-melanoma skin cancers have been increasing over the past decades, 1.32 million melanoma skin cancer and two to three million non-melanoma occur in each year globally. Melanoma is the deadliest form of skin cancer and the death rate is 75% approximately. A melanoma lesion can be detected by its structure and border. Skin cancer image segmentation is very difficult task among the skin cancer image processing steps. ABCD (Asymmetry, Border, Color and Diameter) rule was very powerful tool to detect the skin cancer. By applying contour models to the cancerous skin lesions we can achieve three parameters (ABD) except color. Snakes based on greedy algorithm are simple and efficient snake algorithm and its performance was high when compared to snakes model.

This algorithm has the same drawback of the original snakes i.e the energy function minimization does not work if its initial contour is not close to its target object in the shape and position [1]. Snakes based segmentation techniques have a number of applications in medical image processing. An adaptive snake model was implemented based on the attractable snake model to extend the snake's topological adaptability.

The results show that the new snake model was able to detect the objects, which handles topological changes similar to splitting and merging automatically [2]. B-snake model uses the statistics information for two dimensional objects segmentation by Yang Wang et.al [3]. Dynamic B-snake Model used for smoothen the curve and minimum mean square error function iteratively estimates the position of control points. It was very important in finding local minima. Dynamic B-snake Model was used to synthesize the shape of the object. A new image segmentation method was proposed and applied by Tim McInerney, Demetric Terzopoulos in [4], which was Topological Adaptive Snakes, for most complex shaped biological structures of medical images, an efficient and high automated process. Full automatic image segmentation methods have poor performance on biological images of low contrast, numerous structures, surrounding the object of interest. Snakes or Active contours used for finding the contours of biological images, the usage of open contours was also proposed in [5]-[7]. Texture Dependent Level Set algorithm gives high segmentation accuracy. A set of texture distributions were calculated from illumination correlated photographs and a distinctiveness of texture [8]. Gradient Vector Flow model was used for finding the edges, but this model cannot capture edges like Ω and U, because of counter action of some external forces and influences of local minimum external forces. Jing Yong Cheng et.al [9] used additional control force to Gradient Vector Flow Snake model, to detect the edges like Ω and U structure. The direction of control force was obtained by tracking the force field motion of snake control points, which used in detecting the thin boundaries of brain images. Skin lesion segmentation was a crucial job in dermoscopic images. Wavelet network algorithm for image segmentation was proposed by Amir Reza Sadri, Maryam Zekri et. al [10]. R,G,B values were given as inputs to networks and network structure formation. Fixed grid wavelet network was used for medical image segmentation. Ground truth estimation was a major constraint in image segmentation. A proper estimation approach should take into account and compensate for the inter-rate variation. Level set based approach solves the problem of ground truth estimation by probabilistic approach. A priori pattern information was included into the estimation model by adding a new term in energy function. Prior information gives accurate estimate of ground truth [11].

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Adaptive thresholding algorithm was applied for skin lesion segmentation [12], which consists of three main steps like histogram computation, peak detection and threshold estimation.

This paper is organized as follows: firstly the methods and metrics used for image segmentation including the snake models, contour methods, and filtering methods which are used in calculating the energy function. Second, the proposed methodology, third, results of image segmentation, and the last section describes the conclusion of our work.

II. METHODS and METRICS

The contour is a line joining path or curve along the boundary of an image which connects the similar intensity values. In the symmetrical threshold contour algorithm, the path joins similar intensity values continuously by considering the row and column intensity values along the boundary of the lesion with identical threshold values. In the greedy snake algorithm, a deformable contour $H(s)$ has arc length 's' as a parameter under regular mapping, and is given by

$$H: \Omega = [0,1] \Rightarrow \mathbb{R}^2$$

$H(s) = [i(s), j(s)]$, where $s \in \Omega$. The energy function $E_{snake}()$ of the curve has form $E_{snake}: A_d \Rightarrow \mathbb{R}$ where A_d space of admissible deformations. The final position is observed by mini of E_{snake} .

$$E_{snake}^*() = \min\{E_{snake}[H(s)]\} \min \phi \quad (4)$$

The attractable snake model is stimulated by feedback control theory to allow a deformable function to its target to find the contours convex/concave like structure [1-2].

This model is given by feedback function E_{fb} .

$$E_{snake}[H(s)] = \phi \quad (5)$$

$$E_{snake}[H(s)] = \phi \{ \alpha(s) E_{contour}[H(s)] + \beta s E_{curve} Hs + \gamma s P_{feature} Hs - f_{db} s \delta P_{field} Hs n s ds \} \quad (6)$$

$\mathbf{n}(s)$ is unit function projects on normal direction. $f_{db}(s)$ is the weight that controls the gain of the feedback mechanism, and $\delta P_{field}()$ is the difference in the potential energy function of a desired image between the deformable contour and a target object. The traditional snake is a point-based deformable model. In this model the curve represented as a set of discrete points, its deformation is represented by the internal and external forces, which were calculated from energy function. For representation of curve B-spline was utilized which reduces the number of state variables. In close cubic B-spline, $n+1$ points were controlled $\{Q_j = [x_j, y_j]^T, j=0,1,2,\dots,n\}$ and $n+1$ curve connected segments $\{g_j(k) = (x_j(k), y_j(k), j=0,1,2,\dots,n)\}$, energy function in B-snake model is given by

$$E_{B-snake} = \int_0^1 E \quad (7)$$

$$r(k) = \sum g_j(k), 0 \leq k \leq 1 \quad (8)$$

T-snake Description: A T-snake is defined as a set of M nodes, indexed by $j=0,1,\dots,M-1$, connected by a set of M edges. These are time varying functions act in image plane along with flexural forces $\beta_j(t)$, tensile forces $\alpha_j(t)$, inflammatory forces $\rho_j(t)$, and external forces $f_j(t)$. A periodic boundary condition was used to produce a complete contour model. The behavior of T-snake [3] is represented by the equation 9].

$$\gamma \frac{\partial v}{\partial t} + \frac{\mu \partial^2 y}{\partial t^2} - \frac{\partial}{\partial s} \left(w_1 \frac{\partial v}{\partial s} \right) + \frac{\partial^2}{\partial s^2} \left(w_2 \frac{\partial^2}{\partial s^2} \right) = \nabla \rho(\vartheta(s, t)) \quad (9)$$

Adaptive active contours method was applied for segmentation of complex structures in biological images. In this method, for finding the nearest edges Canny-Deriche operator was used. The regularization process involves smoothing of the shape of the snake and the internal energy function is given by [5]-[6].

$$E_{internal} = \oint (\alpha(s) |v'(s)|^2 + \beta s v || s^2 ds \quad (10)$$

Where α and β are regularization parameters. A scaling factor of 0.05 is multiplied and an external energy is added to the above equation. Gradient vector flow field was used to minimize the energy function. Morphological dilation operation was applied to fill the small holes by expand the binary masks. In Texture dependent level set algorithm, the shape and amount of the mask expansion was controlled by a structuring element and it was a disc with a radius of 5 elements (pixels). The Non - Contiguous regions have been identified as part of the lesion class, the number of regions is reduced to one. To eliminate the small regions, the number of pixels in each contiguous region is counted. The region with large number of intensity values is considered as lesion class; whereas the other region is normal skin which gives the final segmentation. Six methods were proposed for segmentation of skin lesions in dermoscopy images. This set includes some techniques which have been efficiently used in medical images, Gradient Vector Flow (GVF), the Level set method, Adaptive Thresholding (AT), Adaptive Snake(AS), EM level set (EM-LS), and Fuzzy-Based Split and-Merge algorithm (FBSM)[13].

$$S(p) = - \sum_{k=0}^{L-1} h_p(k) \log h_p(k) \quad (11)$$

Equation (11) used to calculate the entropy based on color component, where $h_p(k)$ is histogram of color component.

If the subject image was a gray image, the intensity values varies from 0-255 and the histogram was calculated of length 10 from 25 bins. The color plane with highest entropy was calculated by equation (12).

$$j^* = \arg \max S(j) \quad (12)$$

From the selected color component histogram the threshold value was computed automatically. If two major components were found in the histogram, then the threshold can be calculated from the local minima between the maxima adding to an offset value for quantization purposes. In gradient vector-flow algorithm, the gradient vector flow snake is a renowned algorithm proposed in [6] which has been effectively used in many medical imaging applications. The boundary of the required object can be approximated by elastic contour

$f(s) = (f(s), g(s))$, $s \in [0, 1]$ which was calculated by the differential equation (13)

$$\frac{\partial f(s, t)}{\partial t} = F_i(f(s, t)) + V(f(s, t)) \quad (13)$$

Where, F_i is an internal force which tries to keep the smoothness and continuity of shapes. The gradient vector flow field is used to find the edge gradient of an image which helps in finding the contour towards the object boundary. If the contour is located in homogeneous region, the gradient will be zero. V is calculated by minimizing the energy.

$$E = \iint \mu(u_i^2 + u_j^2 + v_i^2 + v_j^2) + |\nabla g|^2 |V - \nabla g|^2 \quad (14)$$

Where, g is the edge map. The initialization of the gradient vector flow snake is automatic, the process involves a circle with a desired radius is located on the image such that the centre of the circle is given by the centre of the segmented region of an image. A fully automatic segmentation method for skin lesion was proposed and implemented [14] by leveraging 19-layer deep Convolution neural networks. They design a loss function based on Jaccard distance, to eliminate the need of sample re-weighting, a distinctive procedure used for cross entropy, because the loss function for image segmentation due to the considerable imbalance between the number of pixels of foreground and background. Cross entropy is usually used as the loss function and is given by equation (15).

$$L(u) = L(u) = \frac{-1}{N_i \times N_j} \sum_{i,j} t_{ij} \ln p\left(\frac{u}{x_{i,j}}\right) + (1 - t_{i,j}) \ln \left(1 - p\left(\frac{u}{x_{i,j}}\right)\right) \quad (15)$$

where $t_{ij} \in \{0, 1\}$ is the real class of x_{ij} with $t_{ij} = 1$ for tumor and $t_{ij} = 0$ for background.

The Jaccard distance is defined as,

$$d_i(P, Q) = 1 - J(P, Q) = 1 - \frac{|P \cap Q|}{|P| + |Q| - |P \cap Q|} \quad (16)$$

Image segmentation methods like thresholding, region based methods and edge based methods were used in [15]. Image segmentation is the classification of an image into various groups. Research has been done in image segmentation using image clustering methods like k-means clustering algorithm. It is an unsupervised algorithm and is used to segment the area of interest from the background. In K-means clustering algorithm partial stretching enhancement was applied before segmentation of an image. In subtractive clustering method, the centroid is calculated based on the potentials of pixels, and it generates the initial centers, these centers are used for segmentation of an image in k-means clustering algorithm. Median filters are used to remove any unwanted region from the segmented image [16]. Skin lesion border exhibits different structures, such as pigment networks and streaks, which opposes the normal skin region. Image segmentation was performed by contour method followed by K_L divergence between the lesion and the normal skin to correctly fit the curve at the lesion boundary [17]. For image segmentation, the distance between the lesion and normal skin was calculated by energy function that composed of length term, regularization term, and area of the lesion. Equation (17) describes the energy function.

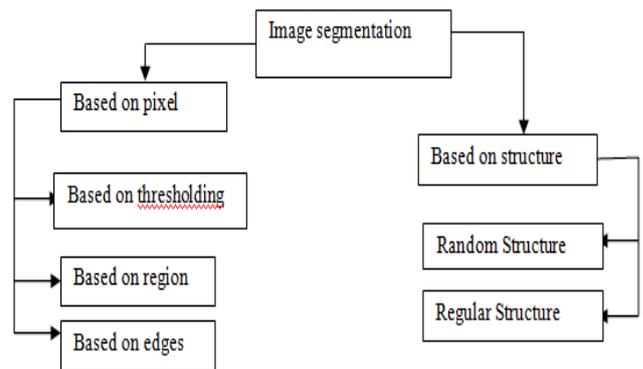


Figure 1. common methods of image segmentation

$$E(\phi) = \alpha R(\phi) + \beta L(\phi) + \gamma S(\phi) \quad (17)$$

$$R(\phi) = \frac{1}{2} \int (\nabla \phi - 1)^2 ds \quad (18)$$

Equation (18) represents the curve regular function, where as equation (19) represents the length function, $L(\phi) = \int \delta(\phi) \nabla \phi ds$ (19) $S(\phi)$ is

area of the lesion. The regularization function and length functions are adopted from distance regular level set estimation (DRLSE) algorithm.

III PROPOSED METHODOLOGY

Image segmentation is a process of partitioning an image in to small segments like sets of pixels. The main aim of the skin cancer image segmentation is to differentiate the skin lesion area from the rest for more efficient analysis. Figure (1) shows some commonly used image segmentation methods. The cancerous image is affected by impulse noise with noise density 20% and then de-noised by fixed form thresholding with soft thresholding algorithm using bi-orthogonal wavelet with 5-level decomposition. In the symmetrical contour image segmentation, boundary of the cancerous skin lesion is identified accurately by combining the thresholding and edge based methods. Symmetrical contour thresholding algorithm is the simplest one to identify the cancerous region. Edge detection algorithm, a well developed image segmentation algorithm is to extract the edges from the images is of disconnected. Edges and the region boundaries and are closely related to detect the edges/boundaries, whereas symmetrical contour thresholding is to detect the edges of any structure which is useful in finding the skin cancer lesion. To segment cancerous skin lesion it needs closed contour. In symmetrical contour algorithm the cancerous lesion is identified by symmetrical threshold value. The key role of this method is to select multiple levels of symmetric contour threshold values up to perfect segmentation of the lesion. The segmentation algorithm is as follows:

Step 1: Image acquisition: Melanoma image is taken from ISIC data base.

Step 2: Image conversion: RGB image converted in to gray scale image.

Step 3: Contour selection: Apply contour with symmetrical threshold values.

Step 4: Check for the skin cancer lesion (if the accurate contour is not obtained then go to step 5)

Step 5: Apply step 3 with new values until to get the perfect cancerous lesion.

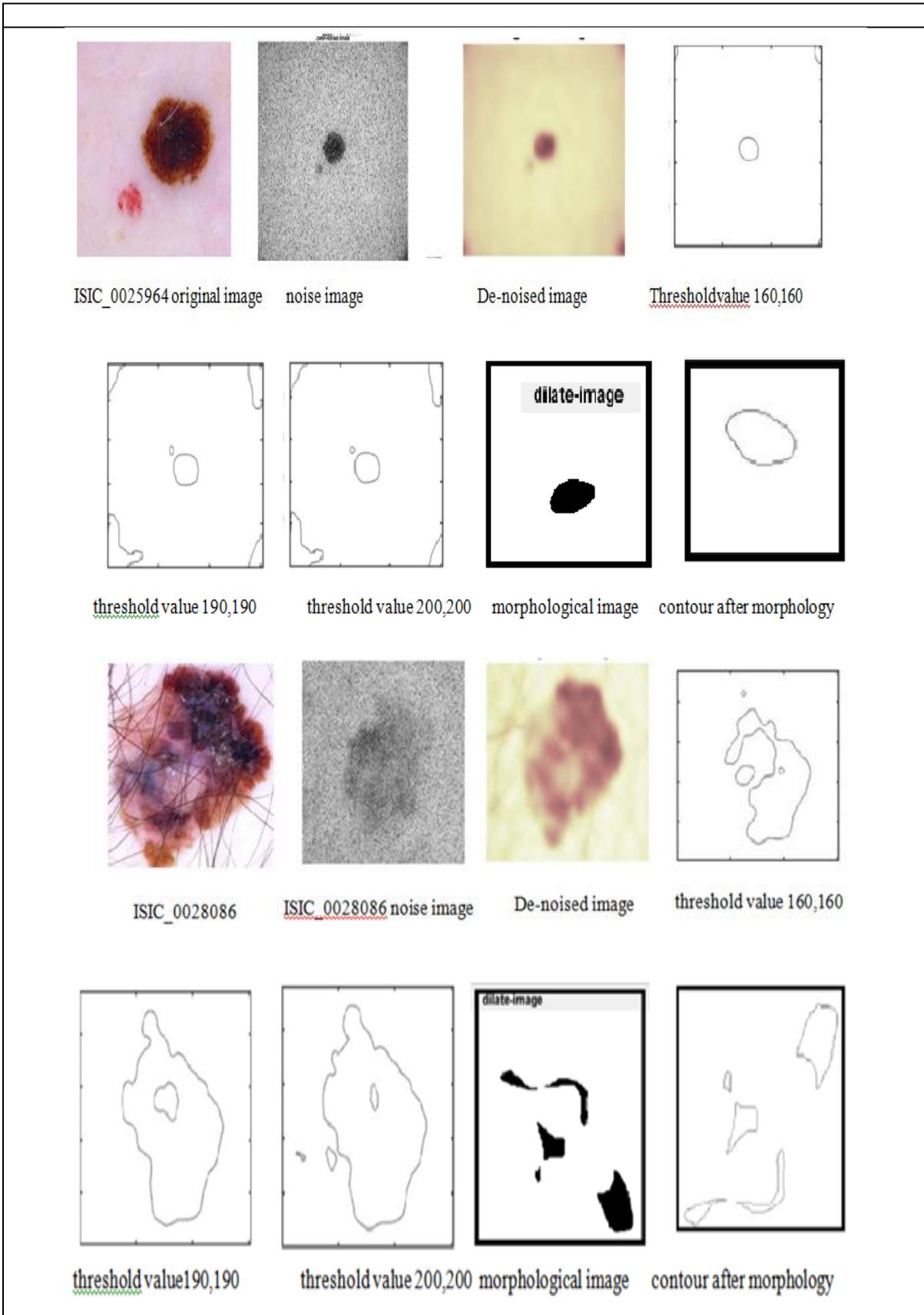
The symmetrical contour thresholding method is an subjective thresholding method. By observing the contour of the skin lesion, we can change the contour threshold values. In general, finding the contour of an image $f(i,j)$, where i -corresponds to column indices and j -corresponds to row indices, the contour threshold values are chosen automatically. By applying the proposed symmetrical threshold contour method a contour line is plotted for each level specified by the symmetrical threshold value.

IV RESULTS

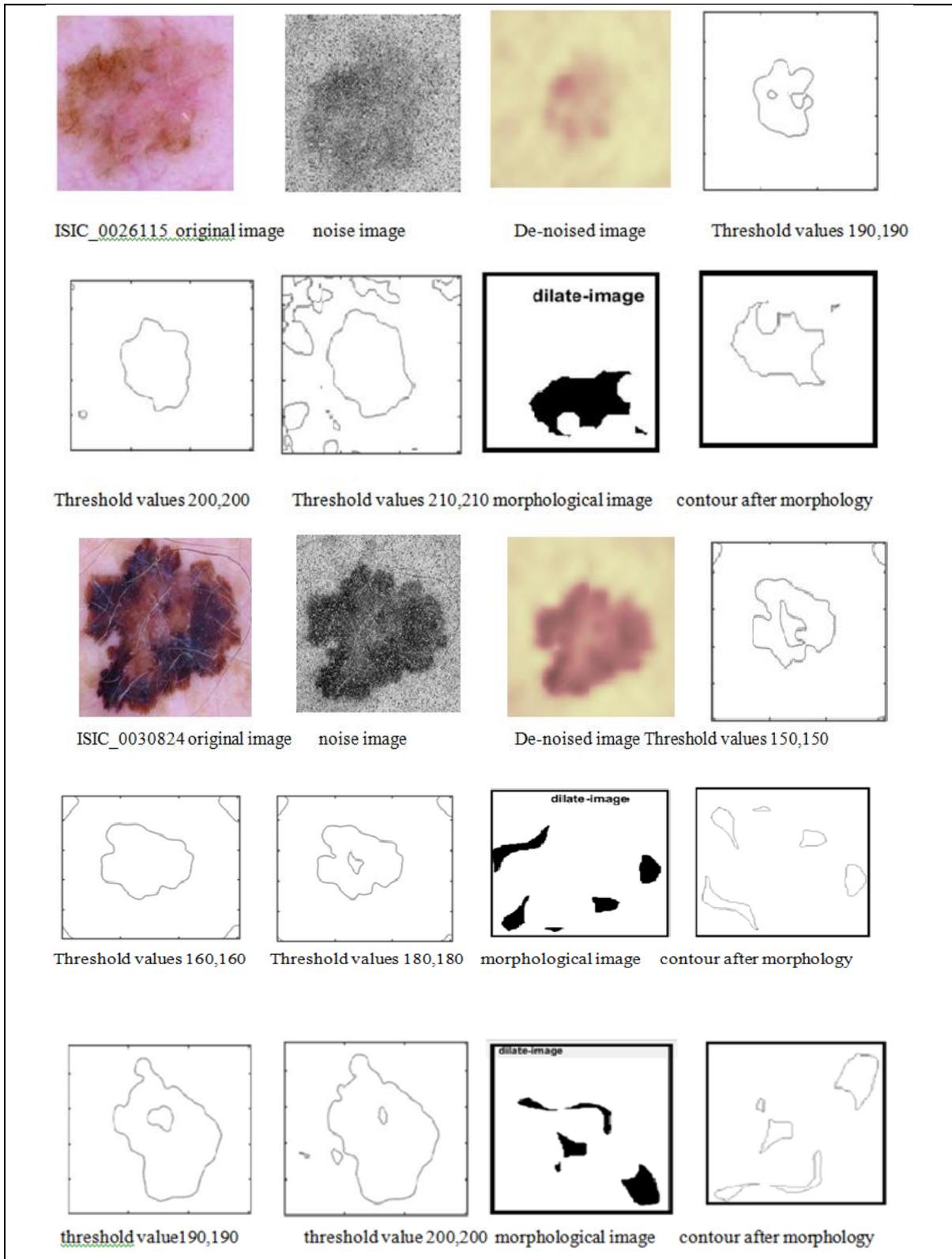
Melanoma skin cancer image segmentation was done by symmetrical threshold contour algorithm. Figure 2 represents the front part of the body with different age group from 40 years to 70 years of skin cancer images from ISIC data set[18], and also shown the noised images, de-noised images, and their contours with various threshold values. In the proposed method threshold values are chosen from the range 50-200 to acquire the desired contour. But all these values are not suited for effective segmentation. In the results, consider only the images represent accurate contour of cancerous lesion. By continuously modify the values, we obtain the segmentation of the lesion. In this symmetrical threshold contour method identical threshold values are applied for segmentation, i.e for i , and j pixels. Below figures represent images of only three different threshold values. One important observation from the result is same threshold values are not suited for all images to obtain the accurate contour. We can perform segmentation of same images using morphological image segmentation algorithm (dilation operation) and also adaptive thresholding algorithm (images were not shown). The proposed algorithm shows continuous closed contour which is preferred in skin cancer image segmentation.

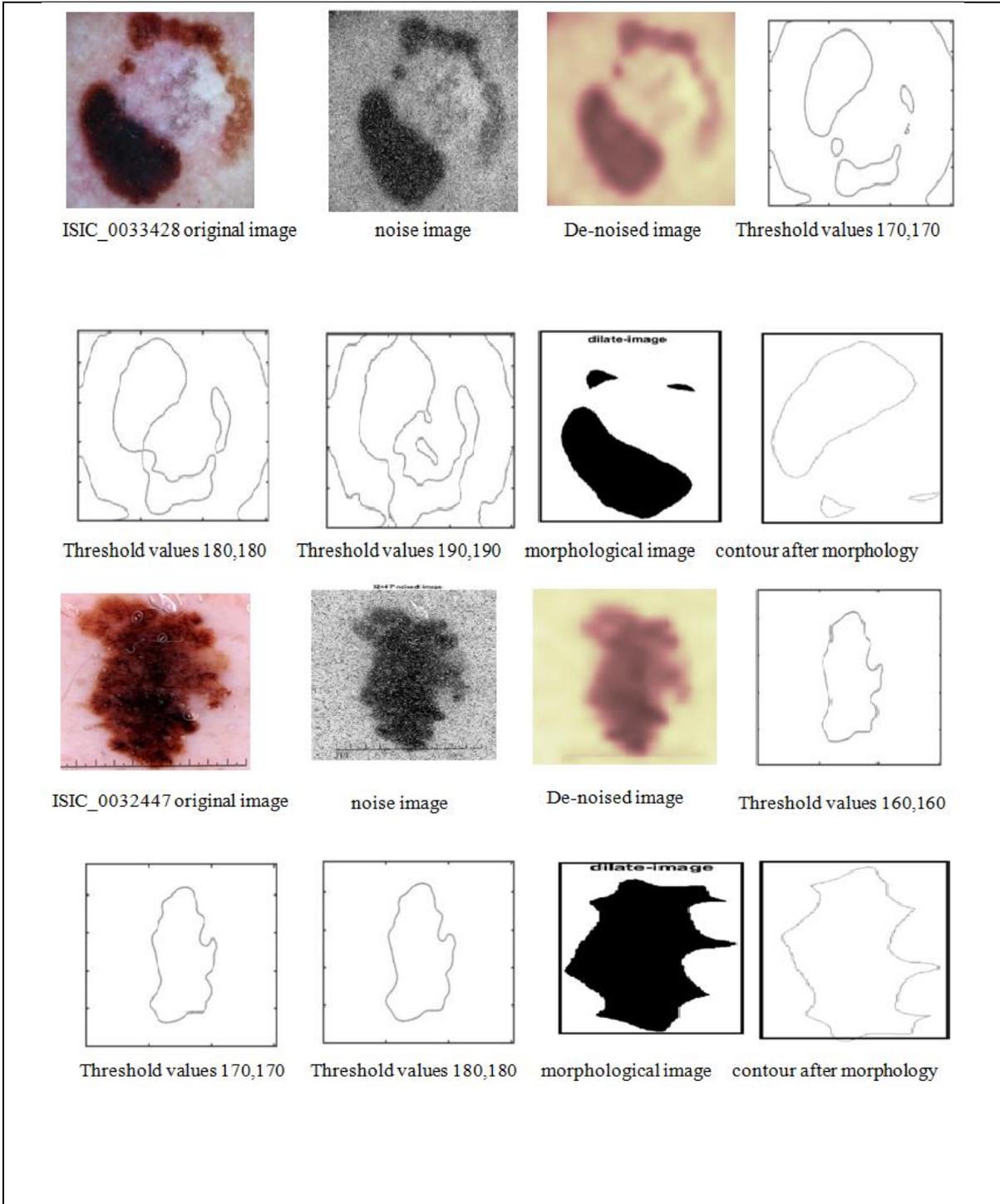
V CONCLUSION

In this paper symmetrical thresholding contour segmentation of skin cancer was discussed. The data set was selected from ISIC archive. From the data set front part of cancerous images with different age group were collected. These images were applied with an impulse noise of density 20% was applied and de-noised before segmentation. De-noising was performed using fixed form thresholding with soft thresholding algorithm, which was implemented by wavelet toolbox, and then the de-noised images were applied for segmentation using symmetrical thresholding contour method. Results of the proposed method are compared with dilation of image morphological algorithm and its contour. By observing the dilated image and its contour, the proposed method gives continuous and accurate contour. The results were verified experimentally by using MATLAB soft ware. The importance of image segmentation in skin cancer image segmentation for accurate diagnostic of the cancerous lesion. The contour detection is used in finding Asymmetry, Border, and Distance, of the ABCD parameters used for detection of melanoma skin cancer.



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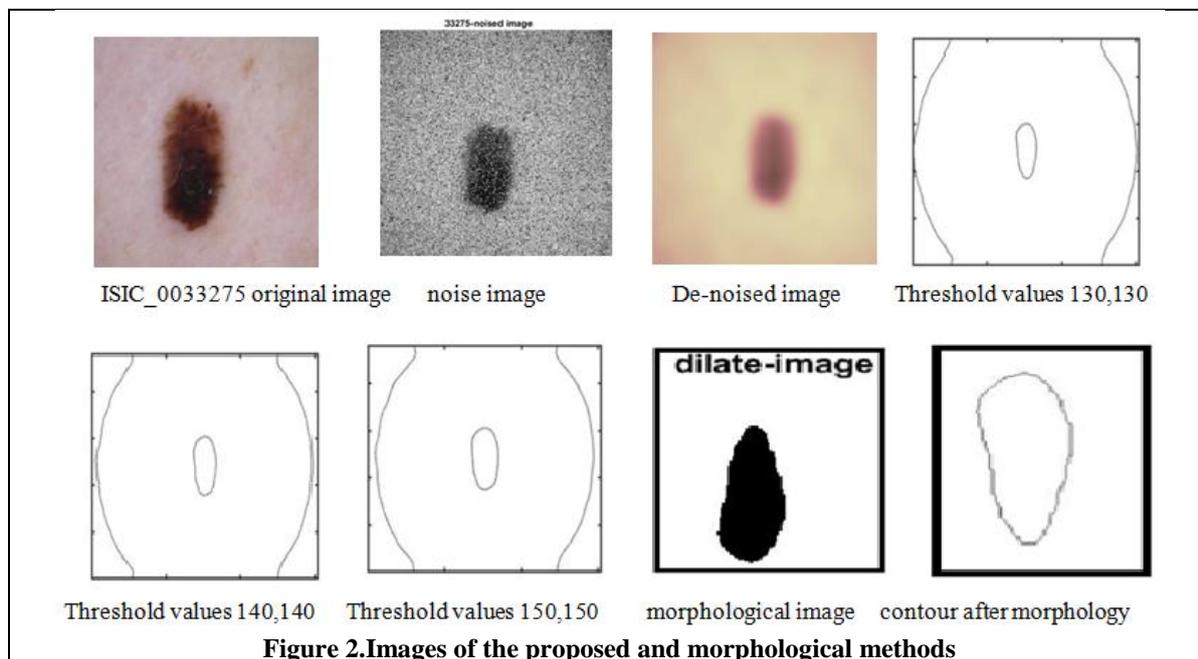


Figure 2. Images of the proposed and morphological methods

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