ABCD Rules Segmentation on Malignant Tumor and Benign Skin Lesion Images

Nurulhuda Firdaus Mohd Azmi[1], Haslina Md Sarkan[2], Yazriwati Yahya[3] and Suriayati Chuprat[4]
[2,3,4]Advanced Informatics School (AIS),
[1]UTM Big Data Centre,
Universiti Teknologi Malaysia (UTM),
Malaysia.
{[1]huda, [2]haslinams, [4]suriayati, [3]yazriwati.kl}@utm.my

***Abstract*—Skin lesion is defined as a superficial growth or patch of the skin that is visually different than its surrounding area. Skin lesions appear for many reasons such as the symptoms indicative of diseases, birthmarks, allergic reactions, and so on. Images of skin lesions are analyzed by computer to capture certain features to be characteristic of skin diseases. These activities can be defined as automated skin lesion diagnosis (ASLD). ASLD involves five steps including image acquisition, pre-processing to remove occluding artifacts (such as hair), segmentation to extract regions of interest, feature selection and classification. This paper present analysis of automated segmentation called the ABCD rules (Asymmetry, Border irregularity, Color variegation, Diameter) in image segmentation. The experiment was carried on Malignant tumor and Benign skin lesion images. The study shows that the ABCD rules has successfully classify the images with high value of total dermatoscopy score (TDS). Although some of the analysis shows false alarm result, it may give the significant input to search suitable segmentation measure.**

***Index Terms*—Image Processing, Image Segmentation, ABCD Rule, Skin Lesion Images, Automated Skin Lesion Diagnosis(ASLD)**

I. Introduction

Skin lesion is defined as a superficial growth or patch of the skin that is visually different than its surrounding area. Skin lesions appear for many reasons such as the symptoms indicative of diseases, birthmarks, allergic reactions, and so on. Skin lesions can be generally group into two categories namely primary and secondary skin lesions. Primary skin lesions include lesions that are present at birth such as moles and birthmarks, or those that appear during a lifetime due to causes such as symptoms of diseases, allergic reactions, or environmental agents such as sunburn. Secondary skin lesions are changes from primary skin lesions as a result of either natural progression or injury (e.g., due to scratching or picking).

To diagnose the skin lesion, various features can be used, including the shape, pattern, distribution of lesions, and color of skin and skin lesions. There are various digital images acquisition techniques used by medical experts for skin lesions such as those from digitized color slides [1], confocal scanning laser microscopy [2], ultrasound [2], dermatoscopy [3] and normal camera. For dermatoscopy images, it generally examined structures including pigment network, dots, globules, branched streaks, streaks, structureless areas, blotches, regression, blue-white veil, milia-like cycsts, comedo-like openings, fingerprint-like structures, moth-eaten border, fissure ridges or brain or leaf-like areas, spoke-wheel-like structures, large blue-grey ovoid nests, and multiple blue-grey globules [3]. From these features, various algorithms were proposed to evaluate the skin lesions such as pattern analysis [4], ABCD rule (Asymmetry, Border irregularity, Color variegation, Diameter) of dermatoscopy [5] and [6], the Menzies method [7], the 7-points checklist [8], and CASH (Color, Architecture, Symmetry, Homogeneity) algorithm [9].

In this paper we present some analysis of automated segmentation method namely the ABCD rules to classify the skin lesion images. The experiment was carried on Malignant tumor and Benign skin lesion images. The remainder of this paper is structured as follows. Section II briefly discuss on image segmentation consisting the related works on skin lesion images. Next, the section will describe further on the ABCD rules of dermatoscopy which will be implemented in this study. Later, Section III described the methodology and the algorithm used in the experiment. The result from the analysis is described and explained in Section IV. Finally, Section V concludes this paper and outlines the future work.

II. Image Segmentation

For an automated skin lesion diagnosis (ASLD), it involves five steps that include acquisition of an image, image preprocess, image segmentation, image feature selection and image classification. According to Celebi et. al [10], for skin image segmentation it need features such as:

1) Lesion Boundary - to provide important information about image.
2) Lesion Extraction - to extract clinical features which depends on the accuracy of the boundary.
3) Lesion Analysis - to find meaningful information about an image from low level of data.
4) Lesion Classification - to classify an image according to the correct classes.

The goal of image segmentation is to find regions that represent meaningful parts of an images based on the interest of the study. Thus, it needs methods or algorithms to look either the images have measurement of the homogeneity (within themselves), or heterogeneity (contrast with the objects on their border). Most of these image segmentation's algorithms can be divided either as modifications algorithms, extensions of the algorithm, or combination of both (modification and extension).

 978-1-5090-2549-7/16/$31.00 ©2016 IEEE

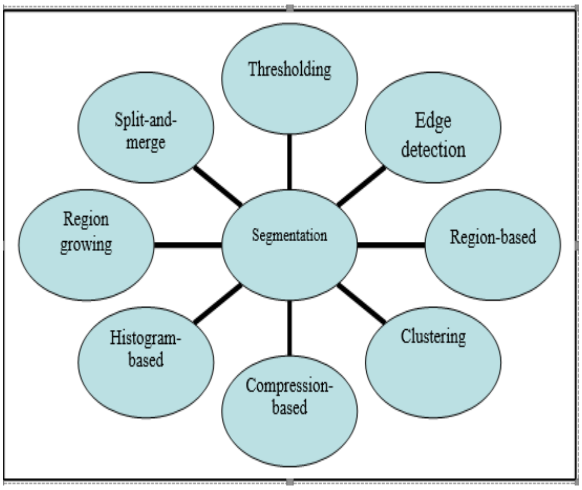

Fig. 1. The Segmentation Method

Figure 1 illustrate some of the popular image segmentation approach. Details of each of the segmentation method can be directed to [11].

A. Skin Lesion Recognition based on ABCD Rules

In order to calculate the ABCD score, the asymmetry, border, colors, and diameter criteria are evaluated. Each of the criteria is then multiplied by a given weight factor to yield a total dermatoscopy score (TDS). Detail of the each criteria is explained below based from the work by Messadi et. al in [12].

1) Asymmetry: Asymmetry (A) is one of the important parameters used in differentiating malignant tumors from benign lesions. In this method, an asymmetry index is calculated from the smallest difference between the image area of the lesion and the image of the lesion reflected from the principal axis (see Fig. 2). According to dermatologists, four axis are sufficient to determine the rate of symmetry (vertical, horizontal and two diagonal axis). To calculate these parameter, the symmetry rotation of skin lesion through a $180°$ angle from first axis and second axis (see Fig. 3). Let $A(x, y)$ be the initial surface, and $B(x, y)$ the surface obtained after symmetry rotation. The ratio between the intersection of $A(x, y)$ surfaces and $B(x, y)$ surfaces and their merging quantifies the recovery rate of the two surfaces, and therefore the degree of symmetry is calculated based on Equation 1. The calculation of these indexes is illustrated in Fig. 3, where the region in blue (refer to Fig. 3) refers to the intersection of the surfaces and the external line defines their merging. The more the indexes approaches 1, the more the lesion will be considered as symmetrical. Figure 4 summarize the overall asymmetry evaluation process.

$$IS = \frac{A \cap B}{A \cup B} \tag{1}$$

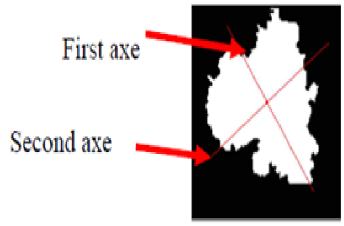

Fig. 2. The Principal Axis Illustration [13]

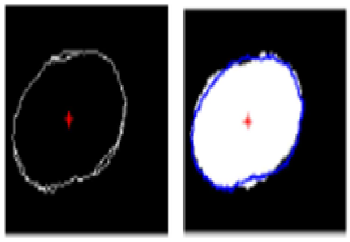

Fig. 3. Mask Overlaid on its Symmetrical (180° center rotation) [13]

2) Border: The border irregularity is used to give an overview of the edge type that can be found. The irregularity parameter in a lesion is important factor when evaluating a malignant lesion. In this study, we calculated the border irregularity based on three special features mentioned by Messadi et. al in [12] which are:

- *Compactness* - The compactness is calculated based on the Equation 2.

$$c = \frac{p^2}{4\pi A} \tag{2}$$

  where p is the perimeter of the lesion and A indicate as the area of the lesion.
- *Fractal dimension* - Fractal dimension has characteristics of roughness and self-similarity and properties to the scale or size. The fractal dimension measures is used to separates important classes of images and characterizes information which is not characterized by other texture analysis methods [14]. In this study, the lesion borders, L is evaluated using the fractal dimension, D. Then it is used to count the number of boxes $N(r)$ contained in the border. The value D is estimated using two terms, (r and $N(r)$) presented by Equation 3:

$$D = \frac{log(N(r))}{log(1/r)} \tag{3}$$

- *Mean and Variance of Gradient magnitude* - The study compute the directional gradients, G_x and G_y with respect to the $x-axis$ and $y-axis$. The $x-axis$ is defined along the columns going up while the $y-axis$ is defined along the rows going down. The gradient magnitude and direction are then computed from their orthogonal components G_x and G_y.

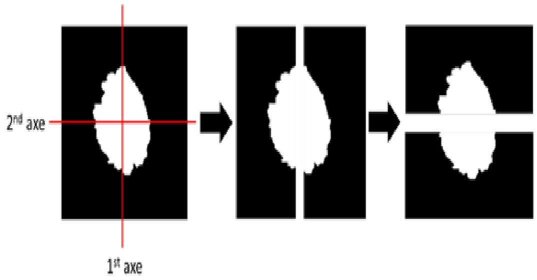

Fig. 4. Overall Illustration of Asymmetry Process [13]

3) Color: Six different colors are counted in determining the color score: white, red, light brown, dark brown, blue-gray, and black. For each color present, add +1 to the score. White should be counted only if the area is lighter than the adjacent skin. The maximum color score is 6, and the minimum score is 1.

4) Diameter: Diameter is the long axis of the lesion which is obtained by determining the coordinates and calculating the distance between each points.

- Determine the coordinate (x, y) of each pixel of the lesion perimeter.
- Calculate the distance between each pair of points. Maximum of these distance is the diameter.

III. Experiment Methodology

Previous section have explained each of the ABCD rules implemented in the recognition of the skin lesion images (in this case the Malignant Tumor and the Benign skin lesion). Next, we explained the experimental methodology to process the image of skin lesion. The experiment started with activated the contour using the Chan-Vese segmentation algorithm. It is used to partition an image into a set of distinct regions. The algorithm begins with a contour in the image plane defining an initial segmentation then evolves the contour according to some evolution equation. The purpose is to evolve the contour in such a way that it stops on the boundaries of the foreground region. Then, visual diagnosis is carried using ABCD rules which consisting of four features namely, Asymmetry (A), Border (B), Color (C) and Diameter (D) which are computed and used to construct a classification module for the recognition of malignant melanoma.

Later, the weight factor[1] criterion and the formula for calculating the total of dermatoscopy score is identified. To summarize, Table I shows the weight factor and the sub-score range of the ABCD rule applied in the study. From the ABCD score obtained, then, the total dermatoscopy score (TDS) of the skin lesion image is calculated. TDS is based on the overall total of each rule's score with each weight factor. Later, from the result, the skin lesion images is classify based on the TDS range identified in Table II.

Finally, classification of the skin lesion images is done and, at this stage the false alarm result will be identified. Figure 5 shows an overview of the methodology used in this study. The detail of the task will be described in the preceding sub section.

[1] http://www.dermoscopy.org/consensus/2b.asp

TABLE I
Weighting Factor for ABCD rule for dermatoscopy

Rule	Weight Factor	Sub-score Range
Asymmetry	1.3	0 - 2.6
Border	0.1	0 - 0.8
Color	0.5	0.5 - 3.0
Differential Structure	0.5	0.5 - 2.5
	Total Score Range	1.0 - 8.9

TABLE II
Range for Skin Lesion Classification

Total Dermatoscopy Score (TDS)	Interpretation
≤ 4.75	Benign melanocytic lesion
4.75 - 5.45	Suspicious lesion
≥ 5.45	Lesion highly suggestive of melanoma

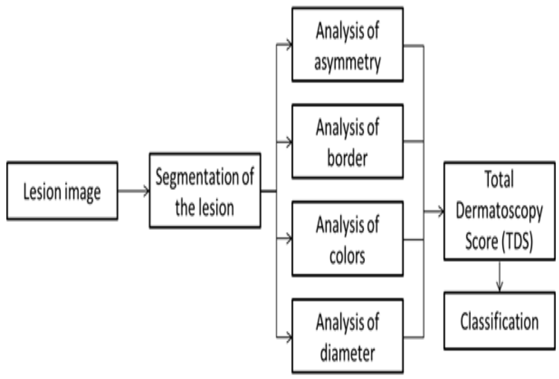

Fig. 5. An Overview of the Methodology Used in Skin Lesion Detection

A. Identification of Significant Number of Iteration for Segmentation

The well known Chan Vese segmentation algorithm [15] is an example of active contours. This technique deforms an initial curve so that it separates foreground from background based on the means of the two regions. The technique is very robust to initialize and gives accepted results when there is a difference between the foreground and background means. The curve begins as a square. As time goes on the square changes shape so that it does a better and better job of separating the image into a light area and a dark area. Algorithm 1 shows the process in detail. Figure 6 illustrate some of the segmentation of the skin lesion image.

B. Data Set and Pre-processing

The dataset is obtained in a literature which consists of 68 pairs of skin lesion images. These images is divided into 2 set depending on how the image captured. The first image type is an images captured only surface pigmentation, while

begin
  Given an image, I ;
  Initial level set function Φ_0, and parameters μ, ν, p, λ_1, λ_2, dt, h ;
  Set $\Phi = \Phi_0$;
  for k = *1: numIterationsOuter* **do**
    Compute c_1 and c_2 for the current Φ ;
    for l = *1: numIterationsInner* **do**
      Update Φ using the ChenVese Iteration ;
      Reinitialize Φ to the signed distance function to its zero contour;
    end
  end
end

Algorithm 1: Chan Vese Segmentation Algorithm

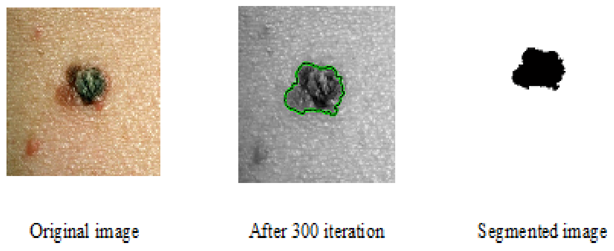

Fig. 6. Step by Step for Segmenting the Input Image

the second set is images which can visualize both surface pigmentation and the increased blood volume and vasculature around the lesion (if present). Each image undergoes most of the pre-processing procedures namely, masking, color space conversion, and resizing. In the final step of pre-processing, the image is resized and converted from rectangular to square at a lower resolution, which reduces computational cost.

IV. Result and Discussion

The analysis of the skin image lesion is carried out in a MATLAB application and the user interface for skin lesion detection is created to ease the computation and processing. Figure 7 to Figure 10 illustrate the process of the experimentation.

From the analysis done in MATLAB, the result of the skin lesion image detection is exhibit in Table III. From the table, it shows that the ABCD segmentation rule successfully classify the images with high value of total dermatoscopy score (TDS). However, some of the analysis shows a false alarm result whereby it has wrongly classify the images.

V. Conclusion

This paper presents some analysis of automated segmentation method namely the ABCD rules (Asymmetry, Border irregularity, Color variegation, Diameter) to recognize skin lesion images. The experiment was carried on Malignant tumor

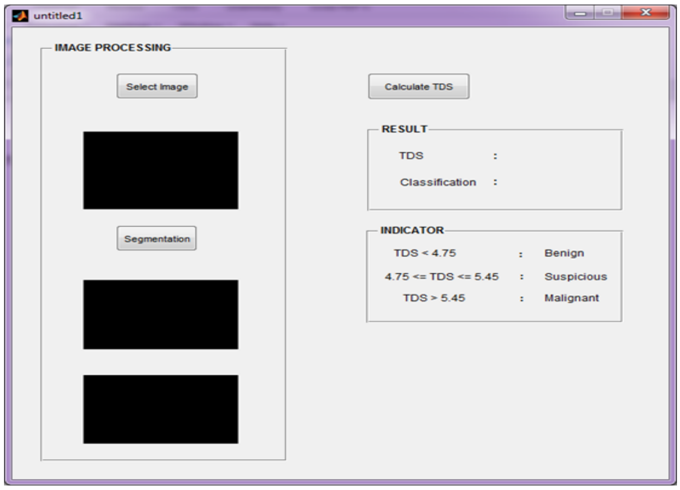

Fig. 7. The User Interface for Skin Lesion Detection

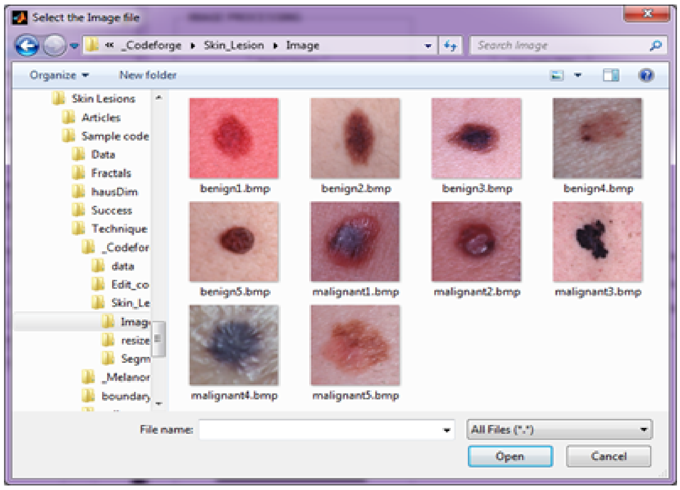

Fig. 8. The Selection of Input Image

and Benign skin lesion images. The study shows that the ABCD segmentation rules has successfully classify the images with high value of total dermatoscopy score (TDS). Our next focus is to explore and experiment the evolutions strategy (ES) to segment and classify the skin lesion images. Various study have shown that the ES based segmentation performs well even in the presence of large amounts of noise, such as, hair and markings. Without the pre-processing steps such as background correction and hair removal, ES method was able to identify an accurate lesion region. We hope we achieved the objectives to have an effective image segmentation algorithm for extracting features from the images of skin lesion. This is because selecting the most suitable segmentation measure is highly important so that as much relevant features can be identified and extracted.

Acknowledgment

The authors would like to thank the medical team of the Pusat Perubatan Universiti Malaya and Hospital Universiti

```
clc;close all;clear;
% Read file image
[FileName,PathName] = uigetfile('*.jpg','Select the Image file');
input = imread([PathName '\' FileName]);

% Main part
[bw]=segmentation_mainModule1(input);
[AI,Compact]=asymetry(bw);
[VI]=radial_var(bw);
[fractal]=fractal_dimesion(bw);
[l,lg] = pigment_transition(input);
[b,w,r,bl,d,li] = colorhistogram(input);
[DIA,dm] = diameter(bw);

% Total Dermotalogy Score(TDS)
% ABCD rule
A = 1.3*AI
B = 0.1*(Compact+VI+fractal+l+lg)
C = 0.5*(w+b+r+bl+d+li)
D = 0.5*dm
tds = A+B+C+D

 if tds < 4.75
     h = msgbox('Benign');
 elseif tds >= 4.75 & tds <= 5.45
     h = msgbox('Suspicious');
  else
     h = msgbox('Malignant');
 end
```

Fig. 9. MATLAB code for calculation the TDS

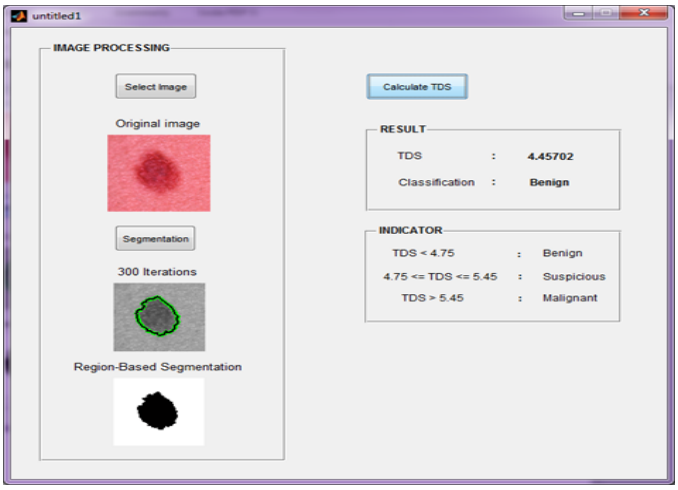

Fig. 10. The TDS and Classification Result Display on the Screen

Sains Malaysia from the Ministry of Health Malaysia for contributing the data on skin lesion images. An acknowledgment also goes to Universiti Teknologi Malaysia for the support of the resources. This work is currently funded by a FRGS Grant from Ministry of Higher Education Malaysia (Vot Number:4F266).

TABLE III
THE RESULT OF SKIN LESION CLASSIFICATION

Image	A Score	B Score	C Score	D Score	TDS	
Benign1	0.1485	0.3085	1.5	2.5	4.4570	√
Benign2	0.0996	0.3371	1.5	2.5	4.4366	√
Benign3	0.1256	0.3939	2.5	2.5	5.5195	X
Benign4	0.3099	0.4301	2	2.5	5.24	√
Benign5	0.0523	0.3145	1.5	2.5	4.3668	√
Malignant1	0.2916	0.48	2.5	2.5	5.7716	√
Malignant2	0.0836	0.3111	2	2.5	4.8946	√
Malignant3	0.3220	0.4175	2.5	2.5	5.7395	√
Malignant4	0.1609	0.3842	1.5	2.5	4.5452	X
mdq1	0.1764	0.3721	2	2.5	5.0485	√
mdq2	0.1495	0.3759	3	2.5	6.0253	√
mdq3	0.1132	0.3561	2.5	2.5	5.4692	√
mdq11	0.2329	0.4637	2	2.5	5.1966	√
mdq5	0.2098	0.3626	2	2.5	5.0724	√
mdq6	0.1977	0.3735	2	2.5	5.0711	√
mdq7	0.2324	0.4099	2	2.5	5.1423	√
mdq8	0.4963	0.4116	3	2.5	6.4079	√
mdq9	0.1721	0.4082	3	2.5	6.0802	X
mdq10	0.2065	0.3653	3	2.5	6.0718	√
nmdq1	0.0915	0.3205	2	2.5	4.9120	√
nmdq14	0.0765	0.3681	2	2.5	4.9446	√
nmdq3	0.1120	0.3435	1.5	2.5	4.4554	√
nmdq12	0.2619	0.3341	2	2.5	5.0960	√
nmdq5	0.1226	0.2983	2	2.5	4.9208	√
nmdq6	0.3778	0.4212	1.5	2.5	4.7990	√
nmdq7	0.2509	0.3712	1.5	2.5	4.6221	√
nmdq8	0.2941	0.3499	1.5	2.5	4.6440	√
nmdq9	0.0793	0.3551	1.5	2.5	4.4344	X
nmdq10	0.2393	0.3509	2.5	2.5	5.5902	X

REFERENCES

[1] I. Maglogiannis and C. N. Doukas, "Overview of advanced computer vision systems," *IEEE Transactions on Information Technology in Biomedicine*, 2009.

[2] S. Q. Wang, H. Rabinovitz, A. W. Kopf, and M. Oliviero, "Current technologies for the in vivo: Diagnosis of cutaneous melanomas," *Clinics in Dermatology*, 2004.

[3] H. S. Rabinovitz, R. P. Braun, M. Oliviero, A. W. K. J. Saurat, and L. Thomas, *In colour Atlas of Melanocytic Lesions of the Skin*. Springer-Verlag Berlin Heidelberg, 2007, ch. Dermoscopic Examination.

[4] S. Seidenari, G. Pellacani, and P. Pepe, "Digital videomicroscopy improves diagnostic accuracy for melanoma," *Journal of the American Academy of Dermatology*, 1998.

[5] W. Stolz, A. Riemann, A. Cognetta, L. Pillet, W. Abmayr, D. Holzel, P. Bilek, F. Nachbar, and M. Landthaler, *ABCD rule of dermatoscopy-a new practical method for early recognition of malignant-melanoma*. John Libbey Eurotext Ltd 127 Ave De La Republique, 1994.

[6] F. Nachbar, W. Stolz, T. Merkle, A. B. Cognetta, T. Vogt, M. Landthaler, P. Bilek, O. Braun-Falco, and G. Plewig, "The abcd rule of dermatoscopy: high prospective value in the diagnosis of doubtful melanocytic skin lesions," *Journal of the American Academy of Dermatology*, vol. 30, no. 4, pp. 551–559, 1994.

[7] S. W. Menzies, K. A. Crotty, C. Ingvar, and W. H. McCarthy, *An atlas of surface microscopy of pigmented skin lesions: Dermoscopy*. McGraw-Hill Roseville, 2003.

[8] G. Argenziano, G. Fabbrocini, P. Carli, V. De Giorgi, E. Sammarco, and M. Delfino, "Epiluminescence microscopy for the diagnosis of doubtful melanocytic skin lesions: Comparison of the abcd rule of dermatoscopy and a new 7-point checklist based on pattern analysis," *Archives of Dermatology*, 1998.

[9] J. S. Henning, S. W. Dusza, S. Q. Wang, A. A. Marghoob, H. S. Rabinovitz, D. Polsky, and A. W. Kopf, "The cash (color, architecture, symmetry, and homogeneity) algorithm for dermoscopy," *Journal of the American Academy of Dermatology*, 2007.

[10] M. E. Celebi, G. Schaefer, H. Iyatomi, and W. V. Stoecker, "Lesion border detection in dermoscopy images," *Comput Med Imaging Graph*, 2009.

[11] N. F. M. Azmi, M. H. A. Ibrahim, L. H. Keng, N. K. Ibrahim, and H. M. Sarkan, "Quantitative measure in image segmentation for skin lesion images: A preliminary study," in *Proceedings of the 3rd International Conference on Quantitative Sciences and Its Applications*, 2014.

[12] M. Mahammed, C. Hocine, and B. Abdelhafid, "Segmentation and ABCD rule extraction for skin tumors classification," *Journal of Convergence Information Technology*, 2014.

[13] M. Messadi, M. Ammar, H. Cherifi, M. Chikh, and A. Bessaid, "Interpretable aide diagnosis system for melanoma recognition," *Journal of Bioengineering and Biomedical Sciences*, vol. 4, p. 1, 2014.

[14] T. Lowe, "Improving image clarity using local feature dimension," *IET Image Processing*, 2015.

[15] C. T. F and V. Luminita, "Active contours without edges," *IEEE Transactions on Image processing*, vol. 10, pp. 266–277, 2001.