

Detection and Analysis of Skin Cancer from Skin Lesions

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Abstract

Skin cancers are the most common form of cancers in human, a physician faces many difficulties for accurate diagnose of lesion through its characteristics and in the naked eye. For that it is necessary to develop automatic methods in order to increase the accuracy of the diagnostic.

In this paper, initially, skin images are filtered to remove unwanted particles, then a new method for automatic segmentation of lesion area is carried out based on Markov and Laplace filter to detect lesion edge, followed by convert image to YUV color space, U channel will be processed to remove thick hair and extract lesion area. Diagnosis of melanoma achieved by using ABCD rules with new method for determine asymmetry based on rotation of lesion and divide lesion to two parts horizontally and vertically then count the number of pixels mismatched between the two parts based on union and intersection between the two parts. New method to determine the number of colors based on suggestion of color regions for each color shade was suggested in this paper. The performance of the proposed method is tested on 220 different images. Accuracy for this method was encourage and reach up to 95.45%. The proposed method shows best accuracy when compared with other methods.

Keywords: Classification, ABCD rules, Segmentation, Image Processing, Otsu's, Skin Cancer.

INTRODUCTION

There are many types of human cancers, the most common type of these cancers is the skin cancer [1]. It is severe among the faired-skinned population in Europe, North America, and Australia. There are two major types of skin cancer, name malignant melanoma and non-melanoma (basal cell, squamous cell, and Merkel cell carcinomas, etc.) [2].

Melanoma is more dangerous and can be fatal if not treated. If melanoma is detected in its early stages, it is highly curable, yet advanced melanoma is lethal.

Each year there are significant increase in the annual rates of all forms of skin cancer, which lead to increase the public concern. The most dangerous of these forms is Malignant melanoma which report a high deadly and increase rapidly in

the world among the other forms of skin cancers. In Canada there are more than 5500 people affected by Melanoma and about 17.35% of these people deaths in the year 2010. While in the United States there are about 22000 people affected with Melanoma in the year 2012, and about 49.4% of them deaths [3].

Based on the Cancer Trends Progress Report by National Institute of Health of United States (NIH) [4], it is estimated that nearly half of all Americans who live to age 65 will develop skin cancer at least once [5].

Many times it is impossible to a physician to diagnose a pigmented lesion through its characteristics, even if it is an experienced professional, in the naked eye. For this, additional criteria are necessary for a clinical diagnosis.

The diagnostic can be performed without any support, in the naked eye, although the result isn't always reliable, therefore dermoscopy was created. It consists in using a device to take a picture of the lesion in order to analyze its features to determine whether the lesion is benign or not. As some people don't have access to a dermatologist, and even with an experienced eye the result can be false, it is necessary to develop automatic methods in order to increase the accuracy of the diagnostic.

Early detection is the most effective tool for controlling this kind of cancer. The main criterion to differentiate between benign and malignant skin lesion is the so-called ABCD rule. This criterion evaluates the asymmetry, edge, color and size of the skin lesion to generate a diagnostic [6].

RELATED WORKS

(Sumithra R, and et. al., 2015)Introduce new method for automatic extract lesion area and classified them as benign or malignant. Current paper start with the process of de-noising and removing the unwanted parts such as hair, prior to segment the lesion. The author proposed a region growing way to segment the lesion which initialized seed point automatically. Extracted lesion is represented by texture features and colors. Two types of classifier (SVM and k-NN) are used or classification of extracted features. The proposed system tested with 141 images for 5 different classes of diseases [7].

(N.Razmjoo, et. al., 2013) Proposed new way to extract the lesion area from the malignant melanoma images. Edge detection used to remove hair and scales; lesion segmentation based on intensity threshold which determined by convert color image to intensity image. Some morphological operations are used to focus on an image area where a melanoma boundary potentially exists. Finally, a series of attributes which expected to contain more information to help differentiate malignant from benign melanomas are measured by image analysis. The selected features are applied to a SVM to classify the melanomas as malignant or benign [8].

(Mariam A.Sheha, et. al., 2012) new study proposed based on texture analysis. The origin image resizes to fixed scale before it converts from RGB to grey scale image. Co-occurrence matrix applied on gray image to extract the important features. The extracted features are based on combination between Multilayer perceptron classifier and gray level Co-occurrence matrix to classify between non-melanoma and malignant melanoma [9].

THE ABCD RULE

The ABCD rule was introduced by Stolz et al. [10] and used by dermatologists in detection of skin lesions to assess the risk of malignancy of a pigmented lesion. This way is able to provide a more objective and reproducible diagnostic of skin cancers in addition to its speed of calculation. It is based on four parameters:

(A) stands for **ASYMMETRY**: One half of a mole or birthmark doesn't match the other. two orthogonal axes bisect the lesion. For both axes, asymmetry is assessed regarding shape, colors and/or dermoscopic structures. A score of two is given if there is asymmetry along both axis, it is scored one if there is asymmetry along one axis, and zero otherwise.

(B) stands for **BORDER**: The edges are irregular, ragged, notched or blurred.

(C)stands for **COLOR**: The color is not the same all over, but may have different shades of brown or black, sometimes with patches of red, white or blue. We look for the occurrence of the six colors (white, red, light brown, dark brown, blue-grey and black). The score is incremented by one for each existing color.

(D)stands for **DIAMETER**: where is larger than 6 millimeters (about ¼ inch or the size of a pencil eraser) or is growing larger.

To calculate the final score (Total Dermoscopy Score – TDS) the following formula is used:

$$TDS = [(A \text{ score} \times 1.3) + (B \text{ score} \times 0.1) + (C \text{ score} \times 0.5) + (D \text{ score} \times 0.5)]$$

After the TDS is calculated the diagnosis is obtained from the table 1:

Table 1: Diagnosis of cancer according to TDS.

| Total Dermoscopy Score TDS | Interpretation |
|----------------------------|-----------------------------------|
| < 4.75 | Benign melanocytic lesion |
| 48.– 5.45 | Suspicious lesion |
| >5.45 | Lesion highly suspicious melanoma |

METHODOLOGY

The main steps of proposed methodology to Skin Cancer segmentation and diagnosis show in figure 1.

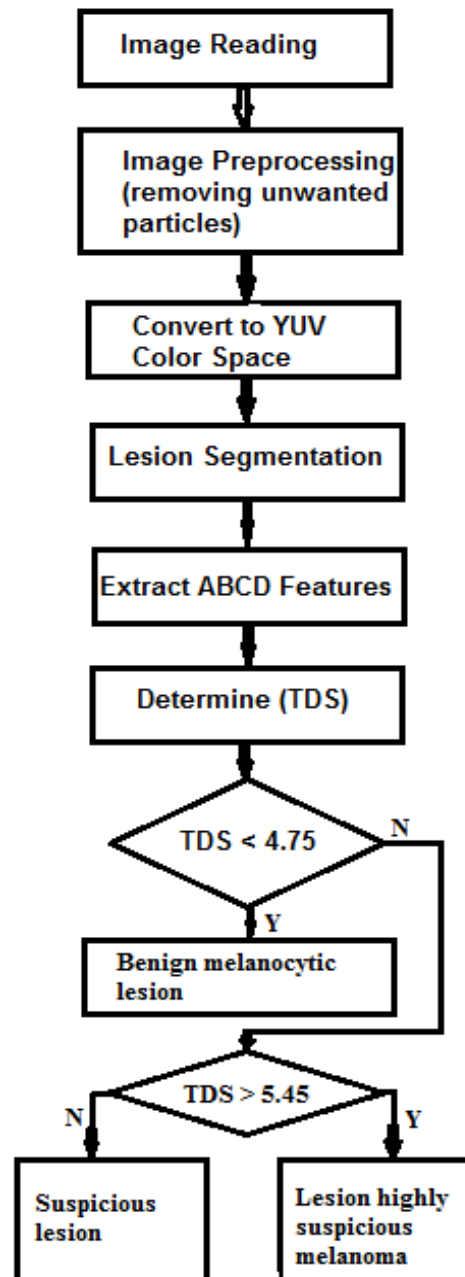


Figure 1: Flow chart for proposed method

Suggested method follow the following steps:

Step 1: Pre-processing

Most of dermoscopic images may contain some unwanted particles such as thin and thick hair, air bubbles, gel and sometimes different effect of illumination. For that, the need emerged for robust ways to remove noise and unwanted particles. With the development of dermoscopes some of these particles becomes less common such as air bubble or oil.

The median filter suggested to use for removing undesirable objects (like small air bubbles and thin hair).

Step 2: Segmentation

The most important stage when analyzing the lesion properly is the segmentation since the accuracy of all the subsequent steps depend on its. However, perfect segmentation is difficult due to the great verities of the lesion shapes, sizes, and colors along with different skin types and textures. We proposed segmentation process based on the following steps:

- (1) Median filtering is applied to minimize the effects of thin hair, removing noise and unwanted objects (like small air bubbles).
- (2)The important step in segmentation is edges detection; this can be implemented by suggestion new filter based on combination of Markov and Laplace filter, figure 2.

$$\begin{bmatrix} 0 & -3 & -1 \\ -3 & 14 & -2 \\ -1 & -2 & -1 \end{bmatrix}$$

Figure 2: Mask used for edge detection

We process each band of color image (Red, Green, and Blue) as a separated image (matrix) to detect the edge.

- (3) The current method for lesion segmentation based on converts the color image to YUV color space and select the U channel for processing. Thick hair is removed from U channel by combining both morphological operation and median filter.
- (4)Find threshold based on Otsu’s thresholding to separate the image to two regions: one for lesion and the other for skin. The result image is binary image or can be color lesion with black background.
- (5)Fill the small holes and removing the small objects by using mathematical morphology such as close which used to join narrow breaks regions in an object. Figure 3 show the steps of segmentation.

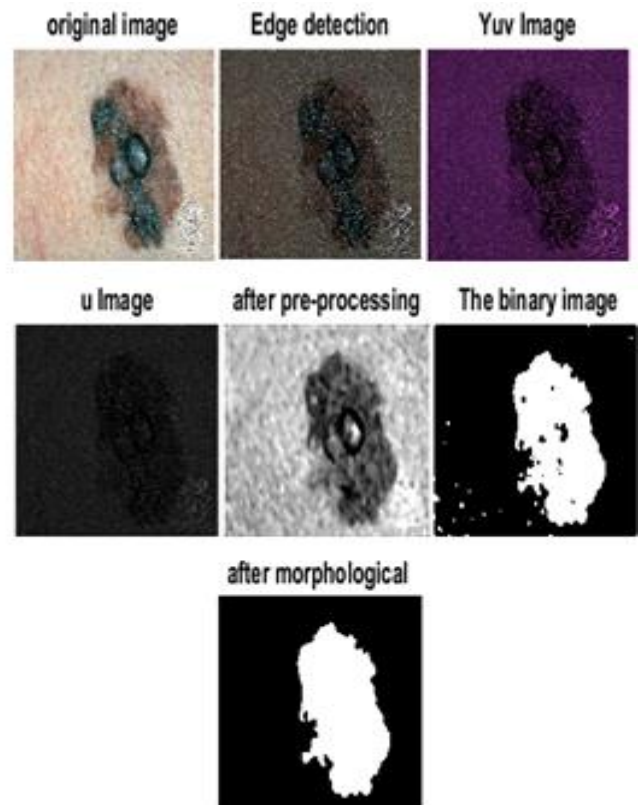


Figure 3: Phases of segmentation process of skin lesion

Step 3: Classification

The important step is the classification of lesion based on ABCD rule. In this paper we suggested new methods to detect colors and asymmetry.

1) Asymmetry(A)

At first stage the program checks the lesion whether it is diagonally or skewed with some angle, at this case it should be determine the angle by the equation1, then rotate the lesion to make its aligned horizontally or vertically as in figure 4.

$$\phi = \frac{1}{2} \tan^{-1} \left(\frac{2\mu_{1,1}}{\mu_{2,0} - \mu_{0,2}} \right) \dots\dots\dots 1$$

where the $\mu_{p,q}$ is central momentcan directly be derived from the spatial moments defined by equation (3)

$$Moment (M_{p,q}) = \sum_{(u,v) \in R} u^p v^q \dots\dots\dots 2$$

$$\mu_{p,q} = \frac{M_{p,q}}{M_{0,0}} - (xc)^p * (yc)^q \dots\dots\dots 3$$

where (xc, yc) is The centre of lesion.

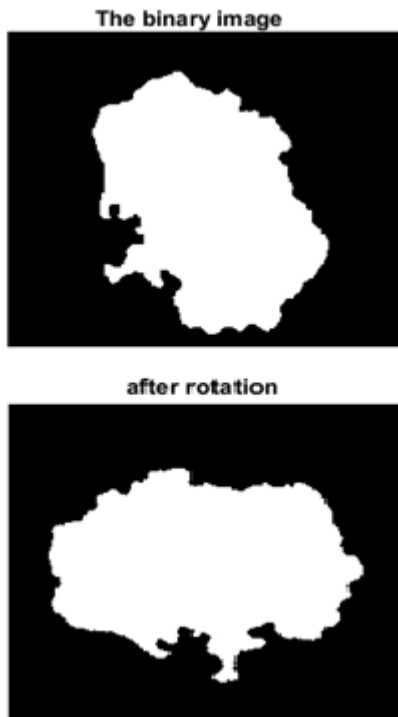


Figure 4: Align the lesion

After align the lesion we have to divide it to two parts (A and B) once by vertical line and the again by horizontal line as in figure5. In both cases we will determine the vertical and horizontal asymmetry.

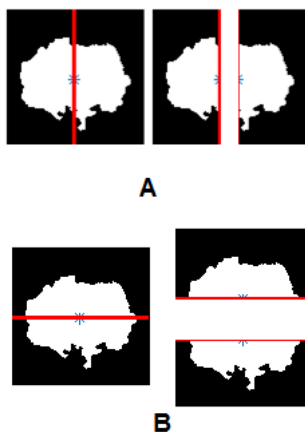


Figure 5: Divide lesion to two parts. (A) vertically. (B) horizontally.

- Let us check the vertical asymmetry.

To count the symmetry factor we need to find how the left and right part similar. Visually if we rotate the left part of lesion with 180 degree around vertical line to overlap left part on the right part, then both parts either they almost identical or there is different between them as in figure6.

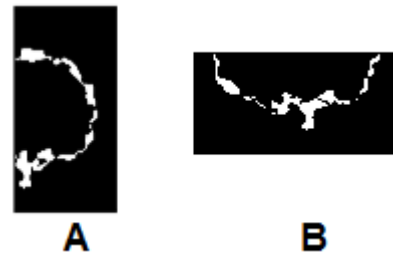


Figure 6: Overlapping the two parts. (A) vertical parts. (B) horizontal parts.

The union ($A \cup B$) and intersection ($A \cap B$) of the two parts will be determined. Final result for asymmetry (A_s) determine by the **Hammoude Distance (HM)**.

$$HM = \frac{N(A \cup B) - N(A \cap B)}{N(A \cup B)} \dots\dots\dots 4$$

Where (N) represent the number of pixels. The scale value of (HM) compared with suggested threshold, from experiments we found the threshold (0.165) gives the best results. When (HM) less than threshold then lesion regards as symmetry lesion in vertical direction and the vertical asymmetry (VAS) equal (0) otherwise the vertical asymmetry (VAS) equal 1.

The same process implement with horizontal line to determine the horizontal asymmetry (HAS).

Asymmetry factor (A) will be equal to sum of vertical and horizontal asymmetry as follow

$$A = VAS + HAS \dots\dots\dots 5$$

The value of (A) will be

$$\begin{cases} A = 0 & \text{when the lesion symmetry in both directions} \\ A = 1 & \text{when the lesion symmetry in one direction} \\ A = 2 & \text{when the lesion asymmetry in both directions} \end{cases}$$

2) **Border Irregularity (B)**

Lesion circularity is measured from equation (6), Its value ranges from (0 to 1).

$$B = \frac{4\pi A}{P^2} \dots\dots\dots 6$$

Where A is the lesion area and P is the perimeter of lesion. When the edges are uneven, blurred, and Border Irregularity B value will approaching to zero, which mean Irregularly shape.

3) **Color(C)**

One early sign of melanoma is the emergence of color

variations in lesion color. Because melanoma cells grow in grower pigment, they are often colorful around brown, or black, depending on the production of the melanin pigment at different depth in the skin.

Regarding the color evaluation, six shades are taken in consideration: red, light-brown, dark-brown, dark-blue, black and white (only if it is lighter than the surrounding skin).

Most of the previous research depend on converting the lesion image into gray scale image and applying the law of Euclidian distance between each pixel in lesion and the six reference colors to find the colors count in the lesion. In this paper we suggest six ranges (according to range of (R) red, (G) green, and (B) blue values) to represent the six colors shades in the lesion image as in table 2. The entire image will be scanned and we count number of pixels which belong to each region. The shade color regards as one of lesion colors when the number of pixels for corresponding range exceed 0.1% of total number of pixels in lesion image, figure 7 as example.

Table 2: Six colors ranges for six shade colors.







| Color | RGB ranges | Example of color |
|-------------|---|---|
| Black | (R ≤ 62), (G ≤ 52), (B ≤ 52) |  |
| White | (R ≥ 205), (G ≥ 205), (B ≥ 205) |  |
| Red | (R ≥ 150), (G < 52), (B < 52) |  |
| Light-Brown | (150 ≤ R ≤ 240), (50 < G ≤ 150), (0 ≤ B ≤ 100) |  |
| Dark-Brown | (62 < R < 150), (0 ≤ G < 100), (0 < B < 100) |  |
| Blue-Gray | (0 ≤ R ≤ 150), (100 ≤ G ≤ 125), (125 ≤ B ≤ 150) |  |



Figure 7: 4 colors show in lesion (Black, Blue-Gray, Light-Brown, Dark-Brown)

4) Diameter(D)

The average diameter for the lesion can be determined by using the equation (7).

$$D = \sqrt{\frac{4A}{\pi}} \dots\dots\dots 7$$

Where A is the lesion's area, the diameter should be less than 6 mm for benign lesion. Malignant growth more than 6 mm in diameter.

TDS of this lesion = 7.8014 which is greater than 5.45 hence the lesion is malignant melanoma.

THERESULTS.

To test the performance of proposed diagnosis method we used 220 images, where 113 image are cancer and 107 image are non-cancer. Source of the images was (120 image from PH2 database and 100 image from the websites [11,12,13].

1. We compared the segmented images resulted by proposed method with expert segmented images in PH2 database. Figure 8 shows the comparing results for some images.

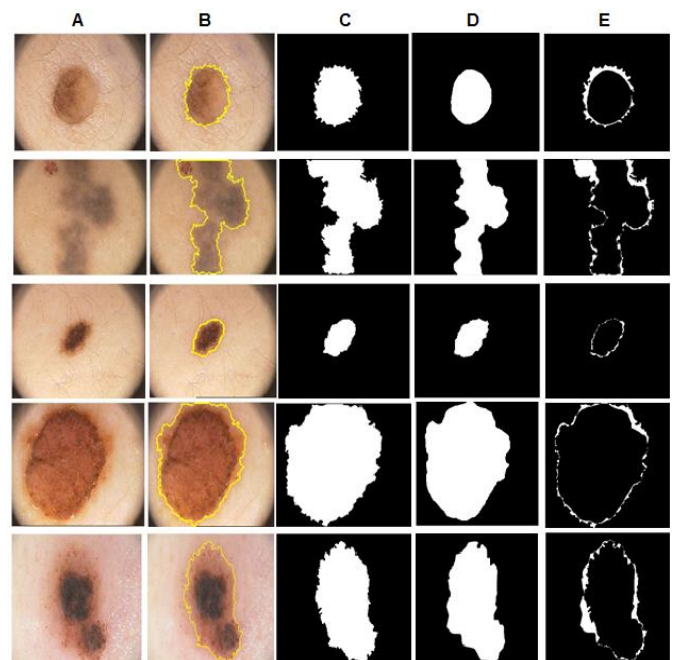


Figure 8: Comparing the lesion segmentation between expert and proposed method. A. Original image. B. edge detection by the suggested method. C. Segmented lesion is obtained by the suggested method. D. Segmented image by expert physician. E. Difference between expert and proposed method.

2. After the segmentation process we compute the (TDS) for each image. According to the value of (TDS) we classified all

images correctly except 10 images (3 cancers and 7 non cancers) did not diagnosis correctly. Figure 9 show TDS value for sample of malignant and benign lesion image.

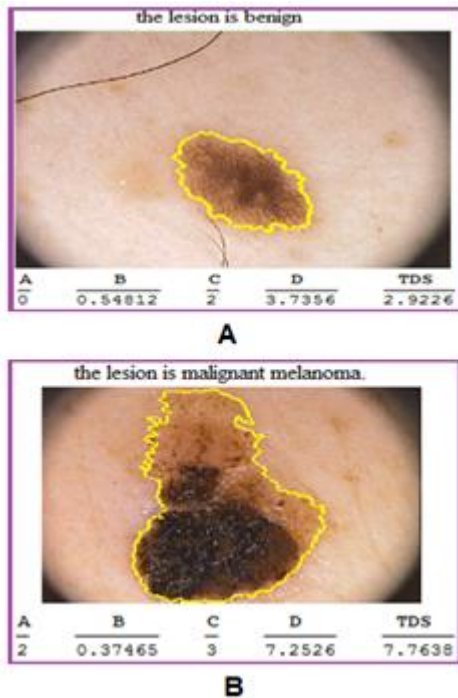


Figure 9: Values of (A, B, C, D and TDS) for benign and malignant lesion sample.

3. We measured the specificity, sensitivity and accuracy according to equations (8, 9, 10). The results show in table 3.

$$\text{Specificity} = \frac{TN}{TN + FP} \dots \dots \dots 8$$

$$\text{Sensitivity} = \frac{TP}{TP + FN} \dots \dots \dots 9$$

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN} \dots \dots 10$$

Table 3: Results of Accuracy of the proposed method

| | Classified as benign | Classified as Melanoma | Specificity | Sensitivity | Accuracy |
|---------------|----------------------|------------------------|-------------|-------------|----------|
| Benign (107) | TN = 100 | FN = 7 | 97.08% | 94.02% | 95.45% |
| Melanoma(113) | FP = 3 | TP = 110 | | | |

Where (TP) True positive, (TN) True negative, (FP) False positive, (FN) False negative.

The results in table 2 are promised results.

4. The accuracy of proposed method compared with other methods, the results show in table 4.

From table 3, it is clear that the proposed method gives more accuracy to diagnosis of cancer than the other methods.

CONCLUSION

In this paper, we used image processing techniques for ABCD rule implementation to distinguish benign lesions from malignant melanoma. The contribution of proposed method was to use Markov and Laplace filter for edge detection prior to convert image to YUV color space. Segmentation gives more accurate segmentation which help to increase the accuracy of diagnosis lesion images. Second contribution was in determine the TDS value when using the ABCD rules, we introduced new technique to determine the asymmetry factor based on rotate the lesion and count the number of pixels mismatched between two parts of lesion. Also we suggested new method to count number of colors appear in the region based on suggestion new ranges for each color shade. The accuracy of detection skin cancer improves to up of 95.45% which is promised result comparing with other algorithms.

Table 4: The Comparison Results of the Proposed method with the previously Works

| Reference | year | Method name | Accuracy |
|-----------|------|--|----------|
| [14] | 2005 | An Accelerated System for Melanoma Diagnosis Based on Subset Feature Selection | 77.7% |
| [15] | 2009 | Extraction of specific parameters for skin tumor classification | 74.5% |
| [16] | 2011 | A decision support system for the diagnosis of melanoma: A comparative approach | 87% |
| [9] | 2012 | Automatic Detection of Melanoma Skin Cancer using Texture Analysis. | 92% |
| [17] | 2014 | Segmentation and Classification of Skin Cancer Images | 91.66% |
| [18] | 2014 | Skin Cancer Detection and Diagnosis using image Processing and implementation using neural networks and ABCD Parameters. | 92% |
| [19] | 2015 | Detection of skin cancer by image processing techniques. | 92% |
| | 2017 | Proposed method | 95.45% |

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