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## **Asymmetry Analysis of Malignant Melanoma Using Image Processing: A Survey**

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### **ABSTRACT**

Skin cancer is one of the cancers, which is not prominent and considered much like other cancers. Malignant melanoma is the third type or stage of skin cancer which leads to death. It can be prevented only when it is detected at a very early stage but that's the challenging task in melanoma diagnosis. Most of the clinicians are familiar with Asymmetry, Border, Color and Diameter (ABCD) analysis to predict and diagnose the melanoma. Asymmetry plays a major role and it will be one of the best indicators to confirm the presence of cancerous melanocytes. When the images of melanoma skin lesions are subjected to preprocessing and it is investigated with the help of emerging techniques such as Evolutionary Programming, Fuzzy Logic, Artificial Neural Networks and Genetic Programming and Algorithms, it will provide better assistance for the clinicians to predict the melanoma at a very early stage. The study presents a review on various soft computing techniques that exist in the literature to identify the asymmetry of the melanoma skin lesions with more precision.

**Key words:** Melanoma, preprocessing, border detection, asymmetry analysis, fuzzy borders

### **INTRODUCTION**

The key statistics of melanoma presented by American Cancer Society is "By 2013 nearly 76,690 new melanomas will be diagnosed and about 9,480 people may die because of melanoma" (ACS, 2013). Cancer Research UK, a charity states that: Melanoma is a less common cancer but it is a more serious type of skin cancer. They also presented a clear statistics by age, sex and demography (Cancer Research UK, 2013). The only pathway to stop these terrific statistics is to prevent it by predicting at early stage. This stage is called as proliferation stage, where the size of the melanoma is <1 mm. The skin lesions of melanoma can be captured using a technique called Dermoscopy and the acquired images are processed for further analysis using Soft Computing Techniques.

The common factors used in diagnosis of melanoma by clinicians are asymmetry, border irregularity (Bono *et al.*, 1999), color variation and diameter as shown in the Fig. 1. As asymmetry prediction can lead to very simple and ease diagnosis of melanoma, various methods to detect the border and finding the asymmetry of the skin lesion are discussed in the forthcoming report.

### **MATERIALS AND METHODS**

To measure the asymmetry with the help of irregular border of a melanoma skin lesion image, preprocessing of the image is done using various techniques. Preprocessing

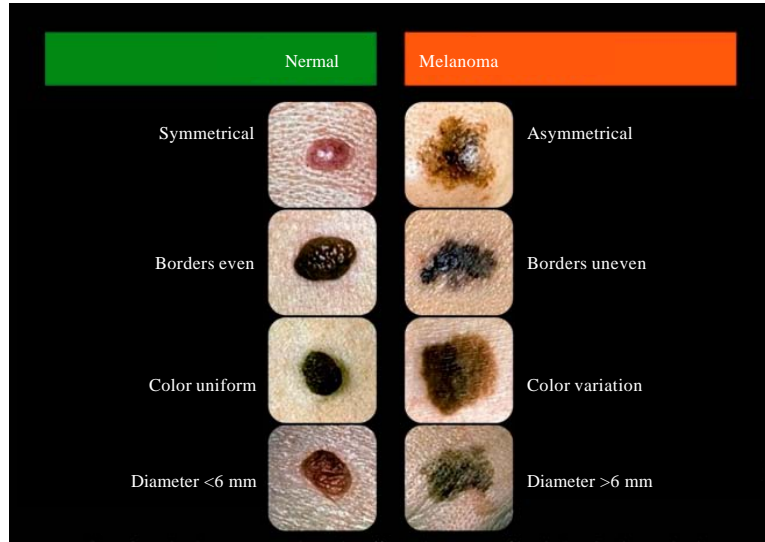


Fig. 1: Normal mole vs. melanoma

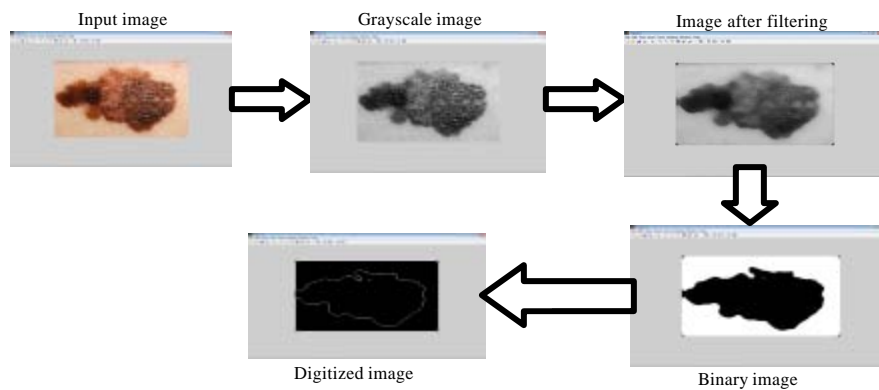


Fig. 2: Preprocessing steps

involves noise filtering and acquiring the accurate border of the image as shown in Fig. 2. Once the border is detected accurately, asymmetry can be predicted easily.

### Preprocessing steps:

- Step 1:** Acquisition of image as input
- Step 2:** Obtaining the grayscale image
- Step 3:** Noise filtering
- Step 4:** Binary image generation

**Related works on preprocessing:** Initially the borders of the melanoma skin lesion image are drawn manually in the study of Claridge *et al.* (1998). Skin lesion image is examined for dark and thick hairs and are removed using a program called dull razor (Lee *et al.*, 1997) as a preprocessing method. Further, in the study of Piantanelli *et al.* (2005) they segregated the pigmented skin lesion

from normal skin lesion using its chromatic characteristics and proceeded with the border extraction. In the study of Aribisala and Claridge (2005) the skin lesions are assumed to be circular or elliptical pattern. Based on the pattern approximation, measure of irregularity is calculated. Asymmetry analysis proposed by Cudek *et al.* (2011) processed the black and white skin lesion images for prediction, considering the white dots as lesion area and black dots as an area of healthy tissue. Cudek *et al.* (2012) proposed a work on automatic estimation of asymmetry. In that proposal, preprocessing is done by converting the real analyzed image into grayscale image algorithmically using the Eq. 1:

$$Yr = 0.299 \times \text{Red} + 0.587 \times \text{Gr} + 0.114 \times \text{Blue} \quad (1)$$

where, Yr is grayscale value and Gr is green value. After this conversion, the contrast of the image is enhanced using adaptive histogram equalization. After enhancement, the blurred image of the same lesion is also created to be used for further segmentation.

### ASYMMETRY ANALYSIS

After preprocessing, the obtained image is subjected to detect the border using various techniques. Some widely used techniques or measures to quantify asymmetry are presented here. Asymmetry of a lesion image is quantified by identifying the center of gravity (Cudek *et al.*, 2011) of the preprocessed image. Then, an array of radii is created to assess the potential axis of symmetry, based on which the lesions are classified. Asymmetry of the skin lesion is the behavior of lesion shape about the chord of shape (She *et al.*, 2007). One of the ways to measure the asymmetry is by folding the outline of the lesion outline about its chord of the best-fit ellipse, finding the difference and the percentage of the difference over the area of lesion is calculated, that is presented in Eq. 2:

$$AS = \frac{\Delta T}{T} \times 100\% \quad (2)$$

where,  $\Delta T$  is No. of pixels in area of difference. Asymmetry of a skin lesion can be quantified with the help of following measures.

**Symmetry representation using fourier domain:** In this method (Clawson *et al.*, 2007a), nearly 30 dermoscopic skin lesion images are taken and boundaries of the lesion are acquired as 64 boundary points per lesion. The mean difference between minimum percentage asymmetry and percentage asymmetry is acquired by calculating the Principle Fourier Axis.

**Bi-axial pigment asymmetry:** Bi-axial asymmetry (Clawson *et al.*, 2007b) of the pigment distribution can be calculated and it will be more indicative for the malignancy of the skin cancer. Measure of per quadrant color distribution is given in Eq. 3:

$$\lambda_i = \frac{A_i^P D_i^P}{A_i^L D_i^L} \quad (3)$$

Where:

$A_i^P$  = Total area of dark pigmented region within quadrant

$A_i^L$  = Area of the lesion in the quadrant

$D_i^L$  = Distance between centroid of the lesion and centroid of the quadrant

$D_i^P$  = Distance between centroid of the dark pigment and the centroid of the lesion

Asymmetry measure per lesion is calculated by Eq. 4:

$$\alpha = \sum_{i=1}^4 \frac{(\lambda_i - \mu_i)^2}{4} \quad (4)$$

where,  $\mu_i$  is mean pigment asymmetry value.

**Circularity index:** To measure and quantify the asymmetry of the skin lesion, circularity index (Ng *et al.*, 2005; Ng and Cheung, 1997) can also be calculated and used as an indicator. This CIRC value is calculated using the area (A) and perimeter (P) of the skin lesion (Eq. 5) as:

$$\text{CIRC} = \frac{4A\pi}{p^2} \quad (5)$$

This is the measure gives how far the skin lesion is being circular or symmetric. CIRC measure is independent of the lesion's extent.

**Symmetry distance:** Asymmetries of skin lesions can be quantified measuring Symmetry Distance (SD) (Ng *et al.*, 2005; Ng and Cheung, 1997). It is the calculated result of typical displacement among the number of vertices when the skin lesion shape is transformed into its symmetric shape. Conventional base formula for calculating SD is presented in Eq. 6:

$$\text{SD} = \frac{1}{N} \sum_{i=0}^{n-1} \|P_i - \tilde{P}_i\| \quad (6)$$

Adaptive fuzzy technique in Symmetry Distance measurements is introduced in (Ng *et al.*, 2005) and it requires only the implicit definition of the border irregularity to exhibit the differentiation between the symmetric and asymmetric lesion. Discriminative powers of the symmetric distance measure can be improved if its numerical range is widened.

**Fragmentation index:** As similar to circularity index, Fragmentation index (FRAG) (Green *et al.*, 1994; Aitken *et al.*, 1996) is relates the lesion's perimeter to a circle as a benchmark, by assigning a value of 1, if the lesion is being a perfect circle, with fewer values for many fragmented lesions (Eq. 7):

$$\text{FRAG} = \frac{4A\pi}{p^2} \quad (7)$$

**Bulkiness score and fractal dimensions:** In (Claridge *et al.*, 1992) the shape measures used to identify and quantify the melanoma skin lesions are bulkiness score and the fractal dimensions. With these two measures the asymmetry of the lesion is quantified:

- **Bulkiness:** Bulkiness is one of the factors of a shape which is dimensionless. It is used in the characterizing the dynamics of rigid bodies. For a skin lesion it is calculated by Eq. 8:

$$\text{Bulkiness} = \frac{\text{Area of equivalent ellipse}}{\text{Area of original figure}} \quad (8)$$

where, Equivalent ellipse is an ellipse having same moment of inertia as the taken input lesion image. It can be used to describe the particle's shape in different types of materials. It is implemented by finding the center of gravity of the skin lesion and then the moment of inertia is calculated with the corresponding center of gravity. The area of equivalent ellipse is calculated, with that area bulkiness score is estimated. With the help of bulkiness measure nearly 76.6% of skin lesions are termed as malignant.

- **Fractal dimension:** In Cartesian space, Fractals characterize the abilities of a curve such as plane filling. It is derived by using different step lengths to measure the perimeter of a given input image. If  $s$  is the steps given, the perimeter  $L(s)$  is given by Eq. 9:

$$L(s) = s N(s) \quad (9)$$

where,  $N(s)$  is the No. of sides of length  $s$  of a polygon approximates the perimeter. Fractal dimension is implemented by extracting the outline of the image by using some edge detectors and applying the algorithm (Claridge *et al.*, 1992). Both structural and textural fractal dimensions are derived for different lesions. Based on the fractal dimensions, 72% of malignant skin lesions are textural fractals (irregularities) and 73.3% are of structural fractals. The method proposed does translation of differences in structural to differences in color. As per the clinician's assessment by applying semi quantitative methods, a lesion is said to be structural asymmetry when the color distance is larger between the blocks.

**Asymmetry in terms of form:** For measuring asymmetry on the basis of form (Smaoui and Bessassi, 2013), we can follow the calculations for finding index of asymmetry by Eq. 10:

$$AI = \sum_{k=1}^2 \frac{\Delta A_k}{AL} \quad (10)$$

Where:

$k$  = Minor and major axes

$\Delta A$  = Non-overlapping zone's area

$AL$  = Lesion area

**Asymmetry in terms of color:** For measuring asymmetry on the basis of color (Smaoui and Bessassi, 2013) we can adopt calculations on the basis of chi square distance and lesions each parts histograms of RGB components (Eq. 11):

$$D(h1, h2) = \sum_{i=1}^N \frac{(h1(i) - h2(i))^2}{h1(i) + h2(i)} \quad (11)$$

where, h1,h2 is N size histograms.

The average between the asymmetry score on the basis of form and color, asymmetry score A is calculated.

**Fuzzy blotch asymmetry:** A quadrant asymmetry method is been used to compute a set of new four features of asymmetry (Khan *et al.*, 2009). Asymmetry feature set is calculated after dividing the border of lesion mask into 4 quadrants by Eq. 12:

$$Asym_i = \left( \frac{Q_i}{L_i} \right) \left( \frac{oQ_i}{oL_i} \right) \quad (12)$$

Value of i lies between 1 and 4 which represents the asymmetry feature for a particular quadrant:

Where:

$Q_i$  = Blotch area

$L_i$  = Lesion area

$oQ_i$  = Distance between centroid of blotch and lesion's center

$oL_i$  = Area of lesion in a specific quadrant

**Lesion asymmetry measure:** When a symmetric lesion is folded with respect to the Inertia's principle axis (Chang *et al.*, 2005), the difference between the lesions two halves is less, whereas when a malignant lesion is folded with respect to principal axis of inertia, a wide range of disparity is found. On the basis of the above statement measure of asymmetry can be defined on the basis of calculating the principal axis of inertia and lesions reflecting half across the principal axis. Measure of asymmetry can be denoted by Eq. 13:

$$E = \frac{A_x}{A_t} \quad (13)$$

Where:

$A_x$  = Area that lies between lesions two halves which is the outcome of folding

$A_t$  = Area of the lesion

**Geometrical asymmetry:** Geometric asymmetry (D'Amico *et al.*, 2004) can be found by dividing the lesion into 2 parts by straight line that passes through the center of mass, after that a comparison is made between the 2 parts by calculating the distance present between the size functions. This size functions distance also determines the qualitative asymmetry.

## RESULTS AND DISCUSSION

In ABCD analysis, out of other three parameters, asymmetry analysis predicts better and also it assists the clinicians to diagnose the melanoma before its proliferating stage. Asymmetry analysis using center of gravity (Cudek *et al.*, 2011) and the radius based on the gravity identified 82-94%

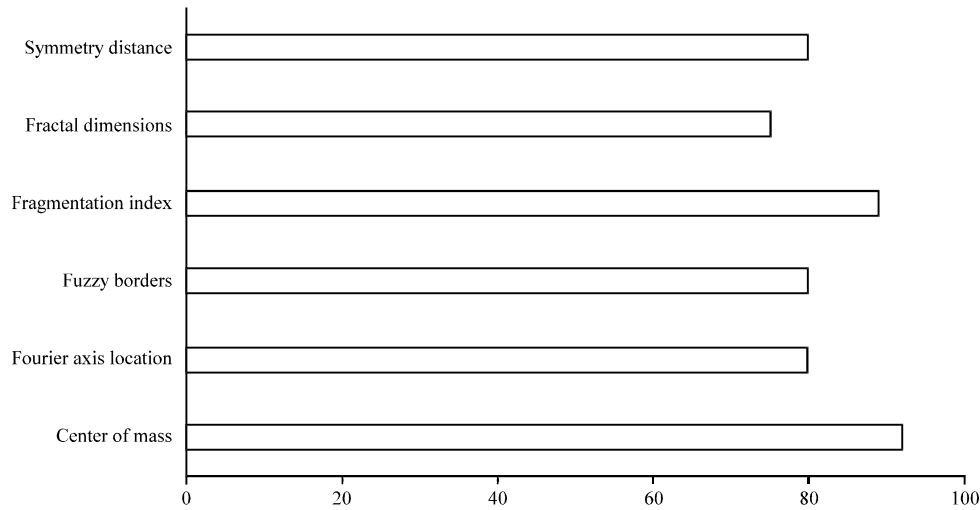


Fig. 3: Comparative analysis of asymmetry measurements

of symmetric lesions and 64-92% of asymmetric lesions. When the asymmetry is represented using Fourier axis location, 80% of accuracy is achieved. Asymmetry quantification using fuzzy borders results in 80% of accuracy. Melanoma image analysis using image analysis measurements like fragmentation index results in 89% of accuracy. The method proposed in (Seidenari *et al.*, 2006) for asymmetry evaluation, gave a good accuracy of 71-75% melanocytic discrimination. The comparative analysis of various measures and its percentage of accuracy is illustrated in Fig. 3.

Comparative analysis of various methods to measure asymmetry is depicted in Fig. 1. It concludes that the method using the center of mass to find the asymmetry is better than other approaches and higher level of accuracy obtained. Next to the center of mass, stands fragmentation index in good level of accuracy. Fourier axis location, symmetry distance and fuzzy borders providing almost same level of accuracy. Other parameters like geometrical asymmetry, Fuzzy blotch asymmetry, lesion asymmetry and color asymmetry, bulkiness and circularity index were also helpful in quantifying the asymmetry of melanoma skin lesion.

## CONCLUSION

Thus, various measures to identify various aspects of asymmetry exist in the melanoma skin lesions are discussed in the presented study and the methodologies are stated clearly. The results drives home the point that asymmetry plays a major role in diagnosing the melanoma at a greater extent compared to other features to diagnose the melanoma skin cancer at early stages.

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