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Implementation of Stolz's Algorithm for Melanoma Detection

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Abstract: Among the different types of skin cancers, Melanoma is one of the most threatening type of cancer. This cancer is most often caused by ultraviolet radiation from the sun which causes unrepaired DNA damage to skin cells which further develops into cancerous tumours. It affects the melanocytes, which are skin cells containing a pigment called melanin which is responsible for the colour of the skin, hence the name melanoma. If melanoma is recognised in the early stages it is proven to be curable. If not, the cancer advances and spreads to all other parts of the body and becomes incurable leading to death. Traditional method of analysing melanoma is biopsy, which is a painful and time consuming process. In this paper we have in detail studied the ABCD (Asymmetry, Border, Colour and Diameter) method and implemented a code using MATLAB for automatic melanoma detection using Dermoscopic images. Finally the Total Dermoscopic Score (TDS) is calculated based on which if the cancer is melanoma or not is decided. A brief study about different algorithms such as 7-point checklist, Menzies and pattern analysis which is based on computer aided automatic melanoma detection using image processing is also discussed.

Index Terms: Melanoma, ultraviolet, tumor, biopsy, asymmetry, computer aided.

I. INTRODUCTION

Cancer can be of two types, benign or malignant. Benign tumors aren't cancerous. In most cases, they do not come back. Cells in benign tumors do not spread to other parts of the body. Malignant tumors are cancerous and are made up of cells that grow out of control. Cells in these tumors can invade nearby tissues and spread to other parts of the body. Melanoma is a cancer that begins in the melanocytes. Other name for this cancer includes malignant melanoma and cutaneous melanoma**II.** [1]. Melanoma can develop anywhere on the skin, but they are more likely to start on the trunk (chest and back) in men and on the legs in women. The neck and face are other common sites.

Melanoma accounts for about 77% of skin cancer related deaths. However, early detection of melanoma is very important as it is curable at early stages, treatment works out to be inexpensive and ultimately it can save the life of the patient. There is a great need of an automatic detection system for skin cancer as it is more advantageous than the traditional biopsy method and dermoscopy which are non-invasive diagnosis techniques and is of great interest as it provides quantitative information about the lesion.

In this paper we propose a Computer Aided Automatic Diagnosis for classifying and identifying malignant melanoma. The different methodologies proposed for automatic diagnosis of melanoma are ABCD rule, 7-point checklist, Menzies algorithm and Pattern analysis. In all the methods we take an image of the affected area on the patient's body. Images are usually digital images captured using a epiluminescence microscope.

The digital image is pre-processed. The pre-processing stage includes filtering (removal of hair, noise, etc.). The standard approach consists of three stages: (i) Image segmentation, (ii) Feature extraction, (iii) Lesion classification [2]. In this paper, we have focussed more on ABCD method and developed a code using MATLAB for ABCD method. The other methods are studied and discussed in the following sections.

II. METHODOLOGY

A. STOLZ'S METHOD

ABCD rule which is also called as STOLZ's method which is developed by *Stolz et al* is used for the Dermoscopic differentiation between benign melanocytic lesions and melanoma.

Four features are extracted from lesion image. The features are Asymmetric(A), Border(B), Color(C) and Diameter(D).

The procedure of Stolz's method is to semi quantitatively assess each of the four mentioned categories and assign them a numeric score [4]. Each score is scaled by a weight factor indicating empirically determined importance, and then the sum of these weighted scores yields the total dermatoscopy score, or TDS.

B. 7-POINT CHECKIST

7 Point Checklist is one of the many methods that is being used to as a diagnostic aid for skin lesions. It is used to distinguish the skin lesions into two categories - benign lesions and malignant melanoma.

The 7 point check list criteria is divided into the following 2 criteria i.e. Major and Minor criteria

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Major criteria	Minor criteria
a. Atypical pigment network	a. Irregular streaks
b. Blue-whitish veil	b. Irregular pigmentation
c. Atypical vascular pattern	c. Irregular dots/globules
	d. Regression structures

Table 2.1: Major and Minor criteria

Diagnosis

The odds ratio for each of the criteria in the 7 point check list is obtained by multivariate analysis. Where a score of 2 is given to the 3 major criteria which have an odds ratio greater than 5; a score of 1 is given to the 4 minor criteria which have an odds ratio less than 5.

The individual scores obtained are summed. If the total is a score of 3 or greater than the skin lesion is said to be diagnosed with melanoma else it indicates that the skin lesion is of non-melanoma.

C. MENZIES METHOD

According to Menzie's method for the diagnosis of Melanoma, a lesion must have neither of the negative features and 1 or more of the positive features.

The negative features are: (i) Symmetry of pattern, (ii) Presence of a single colour. If the lesion consists of any of these features it is considered to be benign lesion.

The positive features are: (i) Blue-white veil, (ii) Multiple brown dots, (iii) Pseudopods, (iv) Radial streaming, (v) Scar like depigmentation, (vi) Peripheral black dots/globules, (v) Multiple colors, (vi) Multiple blue/gray dots, (vii) Broadened network.

D. PATTERN ANALYSIS

Pattern Analysis, considered to be the classic approach for diagnosis in Dermoscopic Images. This analysis seeks to identify specific patterns, which may be global or local.

Local Pattern Analysis:

The presence of specific Dermoscopic features in different regions of the same lesion combining to make a diagnosis of melanocytic lesions and are called local patterns.

Various local patterns are Pigment Network, Dots and Globules, Streaks, Blue-Whitish veil, Blotches, Vascular pattern.

Global Pattern Analysis:

The global features allow a quick preliminary categorization of a given pigmented skin lesion prior to more detailed assessment, and they are presented as arrangements of textured patterns covering most of the lesion.

Global pattern are classified into Reticular pattern, Globular pattern, Cobblestone pattern, Homogeneous pattern, Parallel pattern.

III. IMPLEMENTATION

Stage1: Image acquisition

Images of melanoma are captured using an epiluminescence microscope.

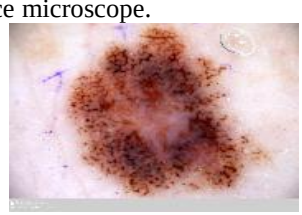

Fig 3.1 Original Image

Stage2: Image pre-processing

Captured image may not be in clear resolution. Human skin surface is accumulated by hairs, scars and skin tone difference. Image pre-processing is thus required to remove noise and access the affected skin lesion accurately.

We employed an inbuilt function *imfilter* an averaging filter to performing filtering. Filtering of the images is done by correlation operation.

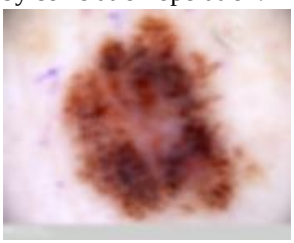

Fig 3.2 Filtered Image

Stage3: Image segmentation

The segmentation is the most important stage to obtain the accurate results at the subsequent steps. It is performed to separate the ROI from the background [3]. Image after processing contains cancerous region and healthy skin only. The ROI is the cancerous region. It has to be separated from the background skin.

Otsu's segmentation technique is used in this paper to obtain the ROI. Otsu's thresholding is

Clustering based image segmentation technique or reduction of a gray level image to a binary image. This algorithm assumes that the image to be threshold has two classes of pixels or bi-modal histogram (foreground and background pixels) and then it calculates the optimum threshold that separates those two classes in such a way that it has minimum variance.

In Otsu's method the threshold that minimizes the intra-class variance (the variance within the class) is selected by trial and error. Within class variance is defined as a weighted sum of variances of the two classes:

$$\sigma_2 w\,(t) = \omega_1\,(t)\,\sigma^2{}_1\,(t) + \omega_2\,(t)\,\sigma^2{}_2\,(t) \ldots\ldots\ldots\ldots\ (1)$$

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Weights ω_i are the probabilities of the two classes separated by a threshold t and σ^2_i are variances of these classes.

Otsu shows that minimizing the intra-class variance is the same as maximizing inter-class variance (between class variance).

$$\sigma^2_b(t) = \sigma^2 - \sigma^2_w(t) \quad \text{..... (2)}$$
$$= \omega_1(t)\,\omega_2(t)\,[\mu_1(t) - \mu_2(t)]$$

The class probability $\omega_1(t)$ is computed from the histogram as t:

$$\omega_1(t) = \Sigma^t_0 p(i) \quad \text{..... (3)}$$

While the class mean $\mu_1(t)$ is:

$$\mu_1(t) = [\Sigma^t_0 p(i)\, x(i)] / \omega_1 \quad \text{..... (4)}$$

Where $x(i)$ is the value at the center of the ith histogram bin. Similarly, you can compute $\omega_2(t)$ And μ_2 on the right-hand side of the histogram for bins greater than t.

Fig 3.3 Black and White

Stage4: Feature extraction

Feature extraction is a method where unique features of skin lesion images are extracted from the region of interest (ROI) to differentiate malignant melanoma from benign melanoma.
In ABCD algorithm following features are extracted

Asymmetry:

One-half of the lesions do not match the other. Asymmetry is calculated by dividing the image over its closest line of symmetry (i.e. centroid) as shown in fig 3.4. Finding the area of the non overlapping sections and then the difference between these areas. The obtained result is divided by total area.

The mathematical expression used to calculate percentage of asymmetry is:-

$$\text{Asymmetry} = (\Delta P / P) * 100 \quad \text{..... (5)}$$

Where, ΔP = Pixel difference
P =Total Pixel count of lesion

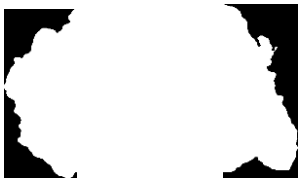

Fig 3.4 Asymmetry calculation

Border:

In case of melanoma the borders of the lesion are irregular, ragged, notched, or blurred. So, the edge or the border are first recognized and then fetched from the image excluding the inner, outer parts of the mole.

The border irregularity is calculated using

$$CI = [(\text{perimeter})^2 / 4\pi A] \quad \text{..... (6)}$$

Where, A= Area of the lesion, $\pi = 22/7$
Compactness index (CI), estimates the roundness of a 2D object.
Region props function is used to compute the area and perimeter of the image.

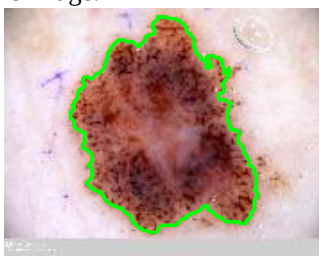

Fig 3.5 Border detection

Color:

The color of the lesion varies over with different shades of brown or black, red, white or blue. A score of one is assigned on presence of each colour in the image.

Diameter:

The diameter larger than 6 mm or growing is classified to be melanoma. A score of 5 is assigned for diameter greater than 6mm.

Criterion	Description	Score	Weight Factor
Asymmetry	In 0, 1, or 2 axes. 0- biaxial symmetry, 1- monaxial symmetry 2- biaxial asymmetry	0-2	x 1.3
Border	Abrupt ending of pigment pattern at the periphery in 0-8 segments	0-8	x 0.1
Color	Presence of up to six colors 1-6 (white, red, light-brown, dark-brown, blue-gray, black)	1-6	x 0.5
Diameter	Diameter greater than 6mm	1-5	x 0.5

Table 3.1: ABCD Rule algorithm score

Stage5: TDS calculation

For final diagnosis result, classification is done using TDS (Total Dermoscopy Score)

$$TDS = [(A* 1.3) + (B* 0.1) + (C* 0.5) + (D* 0.5)] \quad \text{.....(7)}$$

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Total Dermoscopy Score(TDS)	Interpretation
<4.75	Benign melanocytic lesion.
4.8 – 5.45	Suspicious lesion
>5.45	Lesion highly suspicious for melanoma

Table 3.2: Final classifications for ABCD Rule

Stage6: Classified result

The final result is displayed on a dialog box

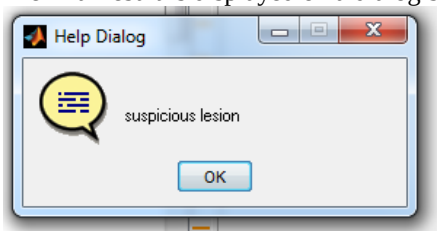


Fig 3.6 Displayed Result

The flow of the entire ABCD algorithm is summarized in a flow chart.

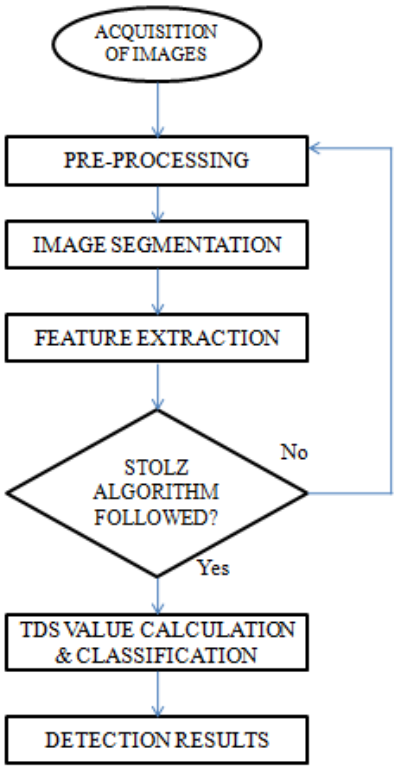
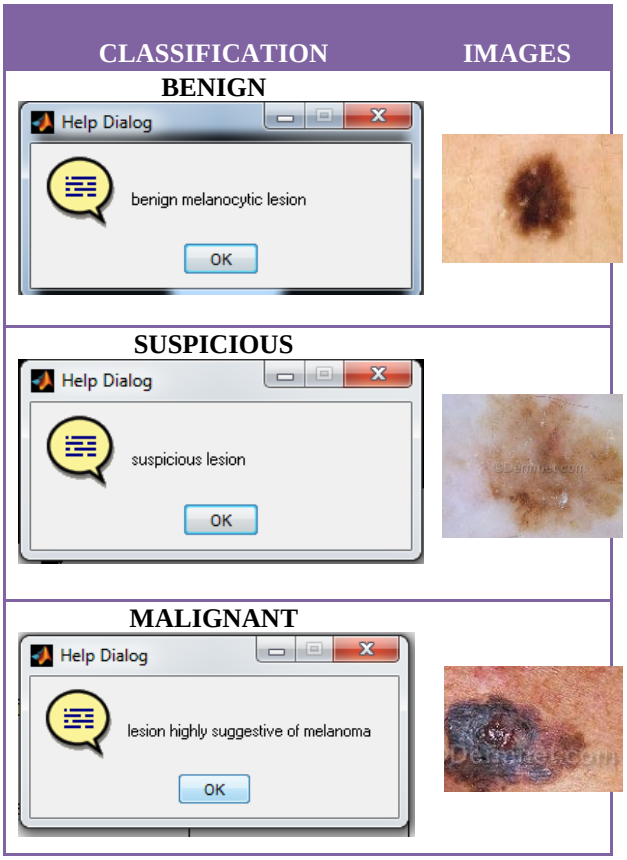


Fig 3.7: Design Flow of ABCD algorithm

IV.RESULT

50 images were taken into consideration whose results were known previously. All the images considered were high resolution Dermoscopic images. Out of these 50 images, 15 images were classified as benign, 10 were suspicious lesion and 25 were classified as malignant. 20% of error was observed due to miscalculations. Hence this paper proposes a computer aided method for skin cancer detection with an accuracy of 80%.



V. CONCLUSION

In this paper, we have implemented ABCD rule and have made comparative studies on 7 point checklist, Menzies Method and Pattern Analysis. We chose ABCD rule because it is very simple and fast algorithm, useful for the effective and automatic detection of melanoma. We have developed a code for ABCD rule in MATLAB. We have implemented computer aided image processing techniques. The results obtained have demonstrated the ability to classify cancerous and non-cancerous lesions. This computer aided detection has proven to be quick, spontaneous and cost effective.

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