

# Automated Malignant Melanoma Detection Using MATLAB

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*Abstract* : Malignant melanoma, the most deadly form of skin cancer, has a good prognosis if treated in the curable early stages. Early diagnosis and surgical excision is the most effective treatment of melanoma. Well-trained dermatologists reach a high level of diagnostic accuracy but their performance is increased by using computer aided numerical imaging tools. This study is limited in the use of simple image processing algorithms, for the sake of clarity, in order to illustrate the use of MATLAB in the calculation of the ABCD Total Dermatoscopy Score (TDS) for potentially malignant melanomas. A high ABCD score means that a lesion is more likely to be a malignant melanoma.

Keywords : Melanoma, malignant, carcinoma, ABCD, Matlab, Dermatoscopy, image processing.

## 1. Introduction

The target of this study is the calculation of ABCD Total Dermatoscopy Score (TDS) for potentially malignant melanomas by using MATLAB. TDS is defined by  $TDS = A*1.3 + B*0.1 + C*0.5 + D*0.5$ , with a maximum score of 8.9, where: A = Asymmetry (0-2 points), B = Border (0-8 points), C = Colour (0-6 points), D = Diameter or Differential structures (0-5 points). A high ABCD score means that the lesion is more likely to be a malignant melanoma ( $TDS > 5.45$ , [1]).

In our approach, we are using MATLAB including the Image Processing Toolbox functions, [2], in order to create a "prototype" ABCD calculation program that will be later translated into C/C++ for producing a stand-alone executable. The most convenient way to achieve this is to use the built-in Matlab Compiler (version 2.2) mcc, which actually produces C language code and stand-alone exe files, [3]. However, special care should be taken when the Matlab code includes Image Processing Toolbox functions as our experiments with the mcc compiler have shown. In any case, the first step is always to convert a Matlab M-file script into a user-defined function and then compile it with mcc using the appropriate C/C++ libraries. The resulting program is not only a stand-alone application, that does not need Matlab to be installed in order to be executed, but it also

runs much more faster (40-50 times faster) than a Matlab M-file that is executed in the interpreter mode.

## 2. Description

Depending upon the implementation of the ABCD rule different degrees of accuracy can be expected, eg. there exists a variety of algorithms in order to find the axis of symmetry of images with different relative precision and robustness, [4-5]. The same applies to Border/Edge detection schemes and to determination of abruptness of pigment change at the border of a lesion. Colour and Diameter parameters can be calculated with less uncertainty. Our first approach is to use the simplest algorithms available that nonetheless produce fairly accurate results when compared to human visual assessment.

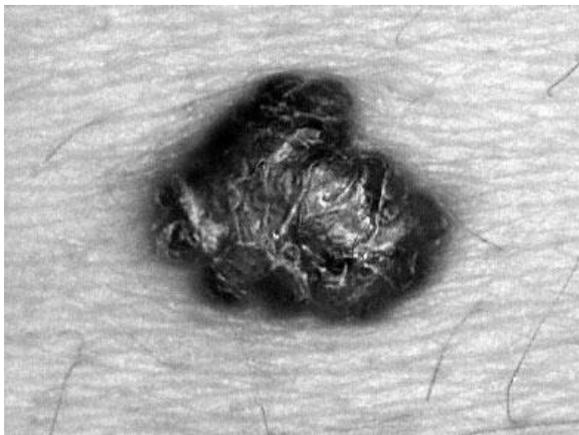
The steps that were programmed are those regarding the pre-processing of the image (steps 1-5), with the main calculations following (steps 6-10):

1. input of the image in RGB colour format (Fig.1),
2. transformation of the image in Gray-level format (Fig.2),
3. image histogram equalization to increase contrast (Fig.3),
4. converting image into black & white binary format using a fixed manually introduced threshold (Fig. 4),
5. edge & internal pattern detection using Prewitt method with fixed manually introduced threshold (Fig.5).
6. lesion bisection into two (orthogonal) axes –

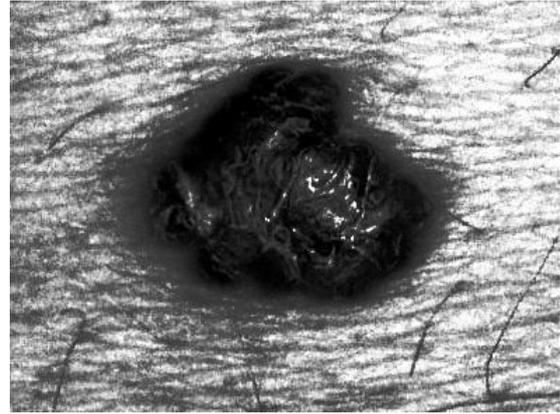
axes determination by moments method, principal components analysis, gradient & orientation histogram, etc. or some very simple sampling technique. 7. Asymmetry score A calculation by image overlapping, 8. division of lesion in 8 segments and determination of pigment change in each segment for calculating the B score (0-8 points). 9. Determination of presence of 6 basic colours inside the lesion (white, red, light brown, dark brown, blue-gray, black) giving 1 point to each for the calculation of the C score, and 10. calculation of the lesion diameter based upon the edge of the lesion found on step 5, and determination of the D score accordingly. Especially steps 6 & 8 can be implemented using from very sophisticated up to very simple algorithms and this is expected to greatly influence the future development effort. In our first approach, the simplest algorithms available have been used.



**Fig. 1. Malignant Melanoma RGB colour image**



**Fig.2 Gray-level image.**



**Fig. 3. Image after histogram equalization.**

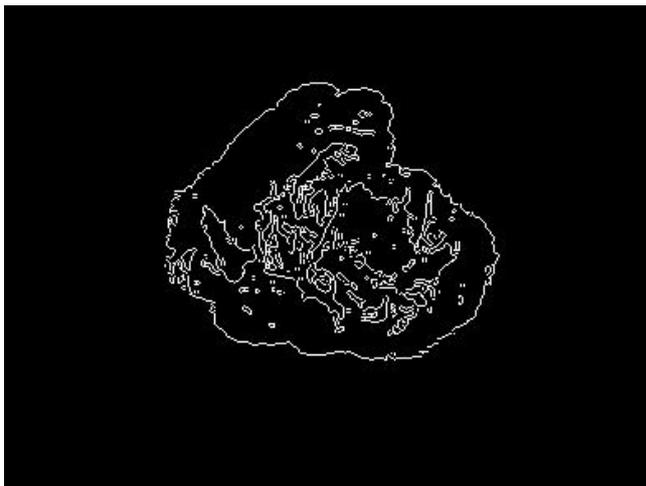
More specifically, at this point the focus is on step No. 9: determination of presence of 6 basic colours inside the lesion (white, red, light brown, dark brown, blue-gray, black) giving 1 point to each for the calculation of the C score. The above mentioned colours are described in RGB colour space as follows in Table 1.

colour	RGB	rgb
white	255,255,255	1.0,1.0,1.0
black	0,0,0	0.0,0.0,0.0
red	255,0,0	1.0,0.0,0.0
light-brown	205,133,63	0.80,0.52,0.25
dark-brown	101,67,33	0.40,0.26,0.13
Blue-gray	0,134,139	0.0,0.52,0.54

**Table1. RGB description of ABCD colours.**



**Fig. 4. Black & White image with threshold.**



**Fig. 5. Edge & internal pattern detection using Prewitt method with threshold.**

The RGB column above describes colours using integers in the 0-255 range (8bits), while the rgb column describes colours in normalised form in the 0.0-1.0 range using floating point representation ( $rgb = RGB/255$ ).

In the algorithm used, all the pixels constituting the lesion (i.e. excluding surrounding healthy skin) are scanned and the Euclidian distance in “rgb” coordinates  $D$  is calculated between their colour and the six reference colours mentioned above. For example, for the first colour, white  $r1g1b1 = [1.0, 1.0, 1.0]$  and thus:

$$D = \text{SQRT}((r-r1)^2 + (g-g1)^2 + (b-b1)^2) = \text{SQRT}((r-1.0)^2 + (g-1.0)^2 + (b-1.0)^2).$$

It is easily seen that the maximum value that the Euclidean distance  $D$  can assume is  $D_{max} = \text{SQRT}(3.0) = 1.732$ , and this for exactly opposite colours as, for example, black & white or blue & yellow (blue  $rgb = [0.0, 0.0, 1.0]$  & yellow  $rgb = [1.0, 1.0, 0.0]$ ). In our approach, the distance  $D$  of the pixel under test,  $rgb$ , and the specified colour, e.g.  $r1g1b1$  white, is compared to a somewhat arbitrarily chosen constant threshold value  $T$  (e.g.  $T=0.4 \ll D_{max}=1.732$ ) and if  $D < T$  it is concluded that the pixel under test is “white” or, more exactly, a “shade of white”. The exactness of colour matching depends upon the threshold value  $T$ . For smaller threshold values  $T$  we get

more exact colour matching. However, for practical purposes it is desirable to have a tolerance/margin around the exact colour definition.

When the above procedure is completed for all pixels in the lesion, percentages of colour appearance are calculated for each one of the six colours. If the percentage appearance of a specified colour, e.g. light-brown, is higher than a certain limit  $L$  (e.g.  $L=5\%$ ), it is concluded that this colour is present in the lesion and the  $C$  parameter is incremented by 1, up to a maximum value of 6 when all six colours are present in the lesion. Evidently, the performance of the algorithm crucially depends upon the 2 decision parameters  $T$  and  $L$ , which must be very carefully chosen.

In the example of Fig. 1 (malignant melanoma + surrounding healthy skin), the algorithm using  $T=0.4$  and  $L=5\%$  detects the presence of 4 out of the six colours, white (35.7%), black (9.5%), light-brown (15.9%), and dark-brown (18.2%), and thus  $C=4$ .



**Fig.6. Carcinoma RGB colour image**

In the example of Fig. 6 (carcinoma + surrounding healthy skin) that is a somewhat more benign case, the algorithm using  $T=0.4$  and  $L=5\%$  detects the presence of 3 out of the six colours, black (7.5%), light-brown (47.4%), and dark-brown (33.8%), and thus  $C=3$ .

However, the algorithm being very sensitive to the decision parameters  $T$  &  $L$ , more careful examination with the use of more medical images is highly recommended.

Finally two very illustrative examples from the general Digital Image Processing (and modeling) community and outside of the medical context are presented.



**Fig.7. Lena Sondeberg (256x256 JPEG image, 77 Kbytes).**

In the example of Fig. 7 (Lena Sondeberg), the algorithm using  $T=0.25$  and  $L=5\%$  detects the presence of 2 out of the six colours, light-brown (35.4%), and dark-brown (19.2%). In the example of Fig. 8 (Aisha), the algorithm using  $T=0.25$  and  $L=5\%$  also detects the presence of 2 out of the six colours, white (42.7%), the background, and light-brown (41.1%).



**Fig. 8. Aisha (267x383 JPEG image, 17 Kbytes).**

### 3. Conclusion

It has been demonstrated in this study that Matlab is a powerful tool for the early prediction and diagnosis of malignant melanoma by using numerical image

processing techniques. Only a few lines of compactly written code are enough in order to program the required algorithms. Furthermore, comparison between different algorithms becomes very easy and efficient with a minimal programming effort.

### References

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