

# ELM image processing for melanocytic skin lesion diagnosis based on 7-point checklist: a preliminary discussion

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## **Abstract**

Early detection of melanoma is one of the greatest challenges of dermatologic practice today. A new diagnostic method, the “ELM 7 point checklist”, defines a set of seven features, based on colour and texture parameters, which describe the malignancy of a lesion. It has been presented as faster and with the same accuracy than the traditional ABCD criteria in the diagnosis of melanoma. In this paper a preliminary step to the automated diagnosis of melanocytic skin lesions, based on ELM 7 point checklist, is proposed. In particular, an image processing methodology focussed on finding the presence of two different parameters is set-up and characterized.

## **I. Introduction**

Malignant melanoma is nowadays one of the leading cancer cause among many white-skinned populations. Since the earlier the diagnosis, the lower the metastasis risk, many efforts are carried out to induce people having skin lesions to be continuously visited by specialists. Investigations have shown that the curability of skin cancer is nearly 100%, if it is recognized early enough and treated surgically. Unfortunately the visual examination of skin lesion images requires a significant time to be done accurately and in order to enhance the early recognition of malignant melanoma an automated system must be used. Consequently, the early diagnosis of skin cancer using digital image-processing methods is a very important issue.

Epiluminescence microscopy (ELM), also known as dermatoscopy or skin surface microscopy, is an *in vivo*, noninvasive technique that is often used to enhance visualization of microscopic structures of pigmented lesions. The technique uses a hand-held magnifying instrument, called a “dermatoscope,” and uses the optical phenomenon of oil immersion, which eliminates light refraction and makes subsurface structures of the skin more visible to the operator’s eye [1], [2]. The resulting images are much more detailed than clinical images, which are skin lesions seen under a magnifying lens, thus being considered the most suitable for digital processing.

The ELM criteria for distinguishing benign from malignant melanocytic skin lesion are not yet completely standardized. Two diagnostic models with similar reliability have become more widely accepted by clinicians: (i) pattern analysis, which is based on the “expert” qualitative assessment of numerous individual ELM criteria, and (ii) the ABCD-rule of dermatoscopy, which is based on a semi quantitative analysis of the following criteria: asymmetry (A), border (B), color (C) and different dermatoscopic (D) structures. Asymmetry depends on some shape features (area, perimeter, fragmentation index, circularity factor, asymmetry index, bulkiness score), as well as border on some indices that consider the structure and the irregularity of the border. As an example of meaningful border irregularity descriptors there are the sharpness of the transition from the lesion interior to the skin, mean value and standard deviation of these gradient values and fractal dimensions. A total number of six different colors, namely, white, red, light-brown, dark-brown, blue-gray, and black, are counted in order to determine the color score. The following five structural features have been selected by Stolz for the evaluation of differential structures: pigment network, structure-less or homogeneous areas, streaks, dots, and globules.

In order to calculate the ABCD score the ‘asymmetry, border, color, and differential structure’ criteria have to be assessed semi-quantitatively. Then, each of the criteria has to be multiplied by a given weight factor yielding a total dermatoscopy score (TDS). TDS values less than 4.75 indicate a benign melanocytic lesion, values between 4.8 and 5.45 indicate a suspicious lesion and values greater than 5.45 are highly suspicious for melanoma.

The ABCD rule was believed to be helpful also for clinicians not fully experienced in ELM

observation because of its lower complexity rather than pattern analysis.

The high number of ABCD features and the complexity of the scoring have led some dermatologists to study a lower complexity diagnostic method. Fabbrocini *et al.* [4] proposed the ELM 7-point checklist scoring diagnosis analysis, defining only seven standard ELM criteria: Atypical pigment network, Gray-blue areas, Radial streaming, Irregular diffuse pigmentation, Irregular dots and globules, Regression pattern.

The ELM 7-point checklist provides a simplification of standard pattern analysis because of the low number of features to identify and the scoring diagnostic system. As with the ABCD rule, it can be easily learned and easily applied and has proven to be reliable in diagnosing melanoma.

The 7-point checklist is a diagnostic method that requires the identification of only 7 dermoscopic criteria, the aforementioned seven ELM criteria are investigated and for each one a score is given. The diagnosis of melanoma is formulated if the total score (simple addition of the individual scores) exceeds a predetermined threshold. Compared with the ABCD rule, the 7-point method allows less experienced observers to obtain higher diagnostic accuracy values. However, even though the number of parameters further decreases, being the information content of dermoscopic images more complex than that of macroscopic images, the computer aided image processing is still a stringent need.

Some automated systems have been developed, all of them based on the ABCD rules. Ganster *et al.*[5] developed an automated melanoma recognition system based on ABCD-rule, but only 21 parameters are extracted from images. Schmid [6] proposed a color based segmentation scheme without extracting features. Umbaugh *et al.* [7] developed an automatic color segmentation algorithm with application to skin tumor feature identification. Nevertheless, until now no automated systems have been based yet on the 7-point checklist. Starting both from these considerations, and from previous experiences in digital processing of medical images [7][8], the authors have tackled the problem of defining suitable image processing algorithms implementing the 7-point checklist.

In the following after a brief recall on the “7-point checklist”, the algorithm for the detection, on the ELM images, of blue-whitish veil and regression patterns, is described in detail; and, finally, the first experimental results on ELM images of different skin lesion are reported.

## II. The ELM 7-point checklist

The 7-point checklist is a diagnostic method that requires the identification of only 7 dermoscopic criteria (these features were selected for their frequent association with melanoma). The seven features about the dermoscopic criteria are briefly described in Tab. I. They refer both to the chromatic characteristics and to the shape and/or texture of the lesion. The dermoscopic image of a melanocytic skin lesion is analyzed in order to evidence the presence of these standard criteria; from this analysis a score is calculated, finally, if a total score of 3 or more is given, the lesion is classified as melanoma otherwise is classified as nevus. As for the individual score (see Table II), there are three “major” criteria with an individual score equal to 2 and four “minor” criteria with an individual score equal to 1.

Tab. I The definition of the seven ELM criteria

ELM criterion	Definition
1. Atypical pigment network	Black, brown, or gray network with irregular meshes and thick lines
2. Blue-whitish veil	Confluent, gray-blue to whitish-blue diffuse pigmentation associated with pigment network alterations, dots/globules and/or streaks
3. Atypical vascular pattern	Linear-irregular or dotted vessels not clearly combined with regression structures and associated with pigment network alterations, dots/globules and/or streaks
4. Irregular streaks	Irregular, more or less confluent, linear structures not clearly combined with pigment network lines
5. Irregular pigmentation	Black, brown, and/or gray pigmented areas with irregular shape and/or distribution
6. Irregular dots/globules	Black, brown, and/or gray round to oval, variously sized structures irregularly distributed within the lesion
7. Regression structures	White areas (white scarlike areas) and blue areas (gray-blue areas, peppering, multiple blue-gray dots) may be associated, thus featuring so-called blue-whitish areas virtually indistinguishable from blue-whitish veil

Tab. II The dermoscopic criteria with related individual score

ELM criterion	Score
<i>Major criteria</i>	
1. Atypical pigment network	2
2. Blue-whitish veil	2
3. Atypical vascular pattern	2
<i>Minor criteria</i>	
4. Irregular streaks	1
5. Irregular pigmentation	1
6. Irregular dots/globules	1
7. Regression structures	1

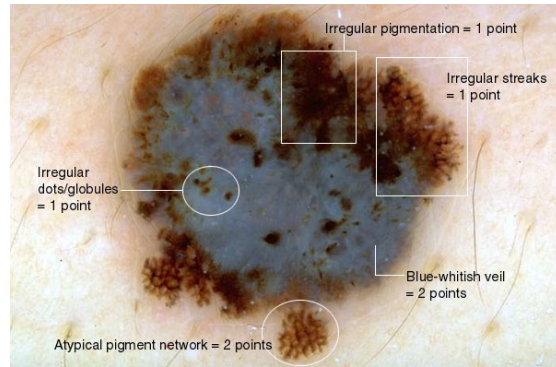


Figure 1. ELM image of a melanocytic lesion with several dermatoscopic criteria (7-point score = 7)

By a simple addition of the individual scores, the total score is obtained; as consequence, in order to diagnose a melanoma, the identification of at least 2 melanoma-specific dermatoscopic criteria (1 major plus 1 minor or 3 minor criteria) is required. In Fig.1 is shown a diagnosis example, for which different structures are present and a score of seven is reached.

### III. The segmentation algorithm

The segmentation is the first, as well as the more critical, skin lesion image processing step. The aim of the segmentation step task is to extract the lesion border from the skin image. Boundary detection is a difficult problem in dermatoscopic images because the transition between the lesion and the surrounding skin is smooth and difficult to see accurately, even for a trained dermatologist. The realized segmentation algorithm for the skin lesion border extraction is composed by four-steps: (i) Color to monochrome image conversion; (ii) multi-stage median filter to suppress noise; (iii) image binarization using an adaptative threshold; (iv) border identification.

(i) The first step of the segmentation algorithm converts the source image (RGB standard color, 24 bits per pixel) in a standard monochrome image (8 bits per pixel). Because the contrast lesion-skin is more evident in the plane of the blue of the source image, it has been chosen to use it as the image on which to make the segmentation.

(ii) The image filtering removes noise caused by the imaging process while preserving image details such as fuzzy edges.

(iii) At first the optimal threshold value is searched, using the image color histogram, and, then, the image pixels with gray level less than the threshold become black whilst the pixels greater than the threshold are set to white; moreover morphological operations are applied to remove isolated points (Fig. 2 (b)).

(iv) Finally, a tracking algorithm collects and sorts the edges of the black-white image into ordered lists (Figure 2(c)).

The binary image is also used to calculate the lesion dimension (number of white  $N_{tot}$ ) that will be used in the lesion analysis.

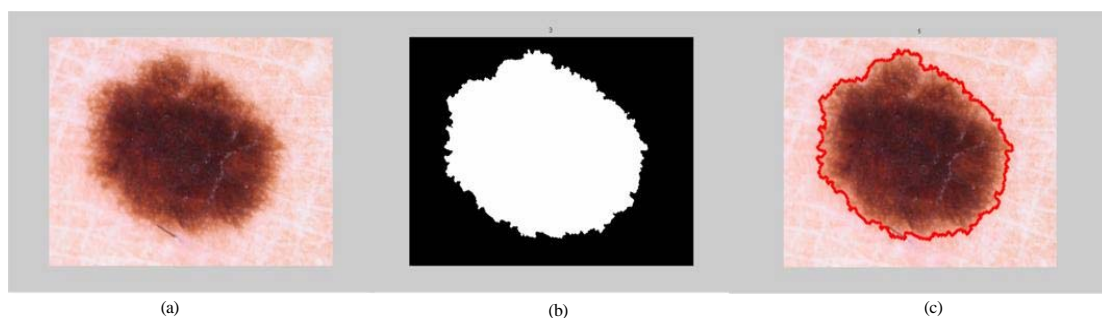


Figure 2: Steps of the segmentation algorithm:  
(a) source image, (b) binary image (c) detected border

#### IV. Algorithm for the detection of: Blue-whitish veil and regression

Two features can be detected in the same step are: blue-whitish veil and regression structures. In fact, both are characterized by the presence of gray areas, blue areas and a combination of both: regression structures can be seen like one previous phase to the blue-whitish veil. The distinction between them is made based on the different distribution of the color areas.

In order to discover these two criteria in the lesion is necessary, at first, to identify the colors of the pixel that can be classified as blue-gray. To this aim many ELM images have been analyzed together with the dermatologists that have evidenced the blue-gray regions. Both the RGB components of the pixels concerning the so identified areas and those components concerning areas of the lesion that have not to be considered blue-gray have been collected in two distinct sets. These two sets (of about 50000 and 150000 samples, for the “blue-gray” and the “non-blue-gray” sets respectively) were used in order to train a feed-forward backpropagation Artificial Neural Network, ANN.

The ANN presents three input nodes (the three RGB components), and one output node (whose value is equal to 1 if the pixel is blue-gray and 0 otherwise). The hidden layer structure and the activation function are obtained in a trial and test design phase. Many ANN architectures were developed and tested. The best performances were achieved by considering the ANN constituted by a single 7-nodes hidden layer and using the hyperbolic tangent sigmoid transfer function and the natural logarithm sigmoid transfer function as activation functions for the hidden and output layers, respectively.

Thus, the obtained ANN is used in order to classify all the pixels inside the lesion. The so identified blue-gray pixels (ANN output greater than 0.5) are counted ( $N_{bg}$ ) and, then, analyzed in order to classify the detected regions as blue-whitish veil, regression or normal color area.

To this aim, the neighborhood of each blue-gray pixel is further investigated, in order to classify the pixel itself as “isolate” or “nearby”. In particular, for each pixel if there are at least twenty other blue-gray pixels in the 5x5 region neighborhood, it is classified as nearby otherwise as isolate. Counting the number of “isolated” ( $N_i$ ) and of “nearby” ( $N_n$ ) it is possible to make the classification.

If the ratio between the number of nearby pixels is greater than a 75% of the total number of blue-gray pixels ( $N_n/N_{bg} > 0.75$ ) then a blue-whitish veil is identified – score equal to 2.

Viceversa, if the number of nearby blue-gray pixels is less than 75% of the total number of pixels ( $N_n/N_{bg} < 0.75$  and consequently  $N_i/N_{bg} > 0.25$ ), the ratio between the gray-blue pixels and the total number of pixels, ( $N_{bg}/N_{tot}$ ), is investigated. A ratio greater than 0.1 is symptom of a regression - score equal to 1, otherwise the pixels can be ignored and consequently are classified as normal color: score equal to 0.

#### IV. The first experimental results

The automatic procedure performance are verified on ELM images of 38 lesions, provided by researchers of the University of Naples, different from the ones used in the ANN training phase and that including all the three possible cases: blue-whitish veil, regression, no blue-gray areas. For almost all the images, the results of the automatic system agree with the dermatologist diagnosis, but only in two lesions presenting regression a blue-whitish veil is detected wrongly.

In Figures 4-6 some results of the automatic system are summarized.

In Figure 4(b) the results on a lesion image with blue-whitish veil (evidenced in Fig. 4(a)) are shown. As you can see the blue-gray pixels (indicated in Figure 4(b) with white color) constitute a dense set, and, consequently, a high number of “nearby” points is obtained, and a ratio  $N_n/N_{bg} = 0.78$  is measured. Regression areas are present on the lesion of Fig. 5(a). The automatic system correctly identifies the

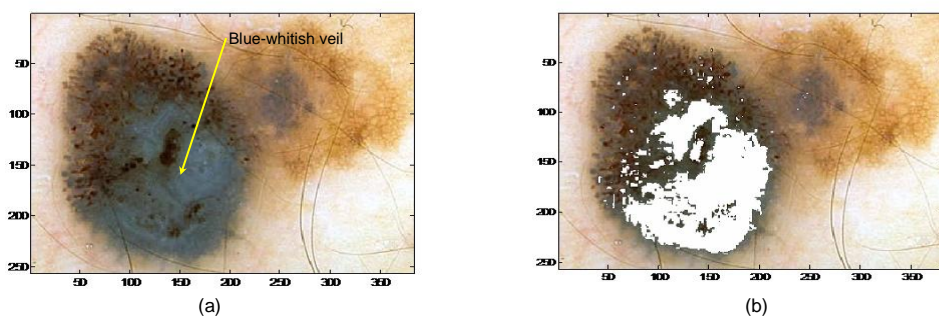


Figure 4: Lesion with blue-whitish veil: (a) ELM original image, (b) system output  $N_n/N_{bg}=0.78$

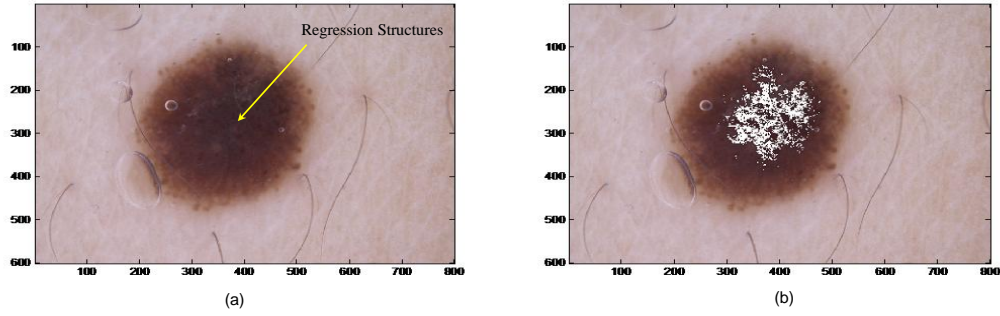


Figure 5: Lesion with regression structures: (a) ELM original image, (b) system output  $N_n/N_{bg}=0.27$ ,  $N_i/N_{bg}=0.73$  and  $N_{bg}/N_{tot}=0.34$ .

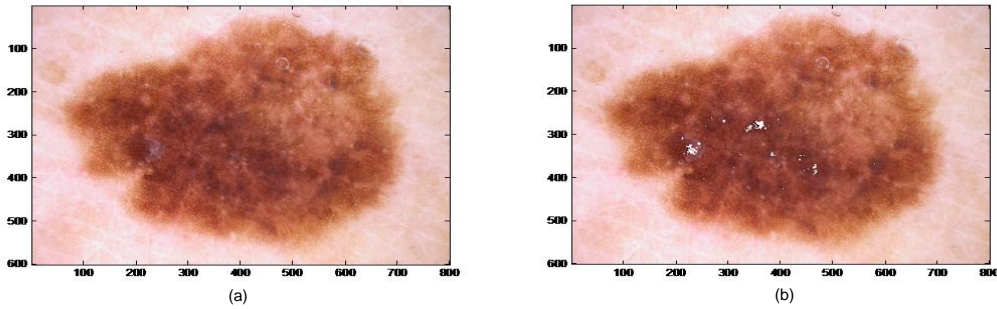


Figure 6: Lesion without blue-whitish veil and regression structures: (a) ELM original image, (b) system output  $N_n/N_{bg}=0.16$ ,  $N_i/N_{bg}=0.82$  and  $N_{bg}/N_{tot}=0.003$ .

areas (see Fig. 5(b)), since the two ratios values  $N_n/N_{bg}=0.27$  and  $N_{bg}/N_{tot}=0.34$  are calculated, the automatic system classify the areas as regression.

Finally, the lesion of Fig.6 (a) does not present either blue-whitish veil or regression. The system identifies some isolated blue-gray pixels (see Fig. 6(b)) but their number (0.3% of the total number of the lesion pixels) is less than the threshold (1%) and they are discarded correctly.

## V. Conclusions

In the paper the preliminary stages in the realization of an automatic measurement system for the melanocytic skin lesion diagnosis based on 7-point checklist is proposed. The image processing set-up allows the automatic detection of two specific dermoscopic criteria: blue-whitish veil and regression. The regression is characterized by blue-whitish areas virtually indistinguishable from blue-whitish veil, thus determined more difficulty in the software realization. The first experimental demonstrated the reliability of the automatic diagnosis in these two criteria evaluation. Future work will be focused both on the performance enhancement of color pixel classification procedure and on the improvement of system capability. An effective procedure for the color pixel allows not only a reliable detection of blue-whitish veil and regression but also the detection of other dermoscopic criteria. Furthermore, in order to realize a system for the automatic diagnosis of melanocytic lesions the procedure has to be able to implement all the seven ELM criteria.

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