SKIN CANCER DETECTION ALGORITHM, A NOVEL FRACTAL BASED APPROACH

Vahid Behravesh, S.M.R. Farshchi

Islamic Azad University, Bardaskan Branch, Department of Electrical Engineering, Bardaskan, Iran
shiveex@gmail.com

ABSTRACT

Today's the skin cancer and related cancer was interested among the researcher. Fractal and multi fractal method are widely-used for the analysis of textures, or any images with self-similar content. All traditional works have a big issue that called complexity time. We proposed a novel approach, in combination to the probabilistic algorithm for the computation of the fractal dimension and lacunarity. Our method was used the boundary irregularity, which can be quantified using fractal dimension. In this research, the dimension of mole and normal melanoma skin was calculated with the proposed method. We used this approach for the evaluation of the skin lesions, in case of psoriasis. The efficacy of these new descriptors was tested on a data set of 800 skin lesions, composed by 85 melanomas and nevi. The result showed the high accuracy of the developed GUI for melanoma detection.

KEYWORDS

melanoma; skin cancer; fractal; cancer detection; fractal dimension.

1. INTRODUCTION

Melanoma skin cancer (MSC) is a collective term for basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). They are the commonest epidermal malignancies and the most common types of cancer in the UK with a reported 67 500 episodes in 2003. Many other types of non-melanoma cutaneous malignancies are recognized across cancer registries, and several tumours, particularly those that are treated without histological sampling (such as superfi cial BCC), remain unreported. The true incidence of NMSC in the UK is there-fore much higher, estimated to be 100 000 per year and increasing at an annual rate of 3–8%. Although the incidence is high, NMSC accounts for < 400 deaths a year – the majority related to metastatic SCC. The importance of NMSC is often disregarded due to the relatively good prognosis, although delayed diagnosis and suboptimal management can lead to disfi gurement and loss of life. The large number of cases and the trends for increasing incidence underline the morbidity and economic burden of this growing public health problem.

Pigmented skin lesions appear as patches of darker color on the skin. In most cases, the cause is excessive melanin concentration in the skin. In benign lesions (e.g., common nevi), melanin deposits are normally found in the epidermis [see Fig. 3(c)]. In malignant lesions (i.e., melanoma), the melanocytes reproduce melanin at a high, abnormal rate (see Fig. 2). While they and their associated melanin remain in the epidermis, melanoma is termed "in situ". At this stage, it is not life threatening, and its optical properties make it conform to those of the normal, highly

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pigmented skin. When malignant melanocytes have penetrated into the dermis, they leave melanin deposits there, thus changing the nature of skin coloration.

The presence of melanin in the dermis is the most significant sign of melanoma. However, it cannot be used as a sole diagnosis criterion because in situ melanomas do not have dermal melanin. Moreover, some benign nevi have dermal deposits, although their spatial patterns tend to be more regular than in melanoma. Other signs, some of which can be indicative of melanoma in situ, are thickening of the collagen fibers in the papillary dermis (fibrosis), increased blood supply at the lesion periphery (erythematic reaction), and lack of blood within the lesion in the areas destroyed by cancer. The colors associated with skin, which has melanin deposits in the dermis, normally show characteristic hues not found in any other skin conditions. This provides an important diagnostic cue for a clinician. If the visual approach corroborates a suspicion of skin cancer, histology [4] is needed to make explicit diagnosis. Fig. 3 presents typical example skin lesions of melanoma, dysplastic (benign) nevus, and no dysplastic (common) nevus.

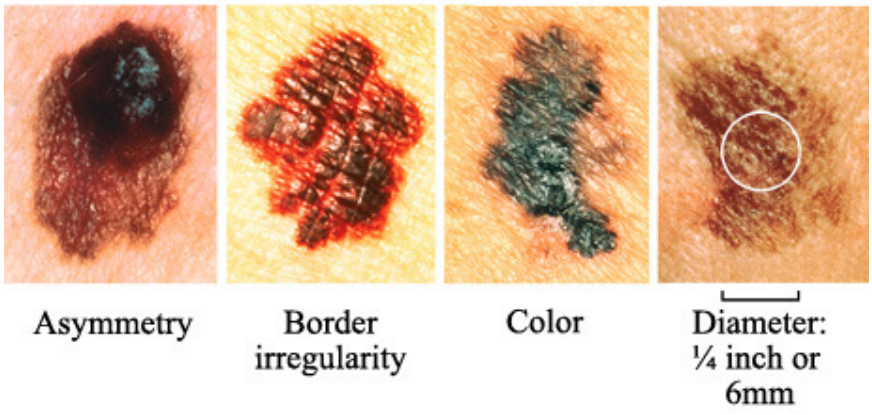

Figure 1. Normal skin lesions and main components.

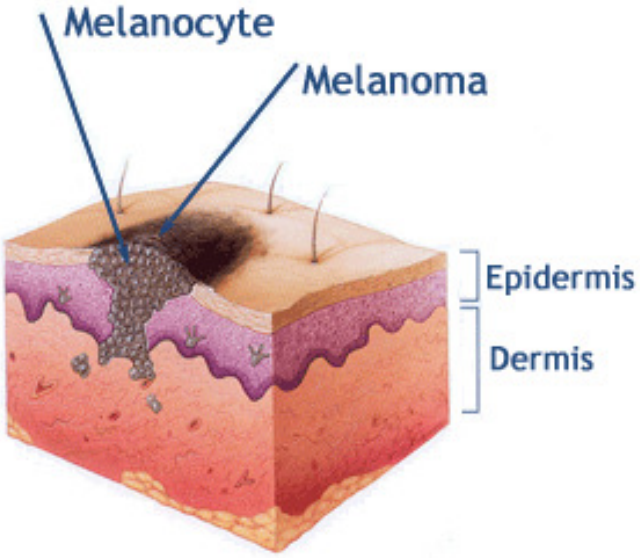

Figure 2. Illustration of Melanocytes and Melanoma on skin.

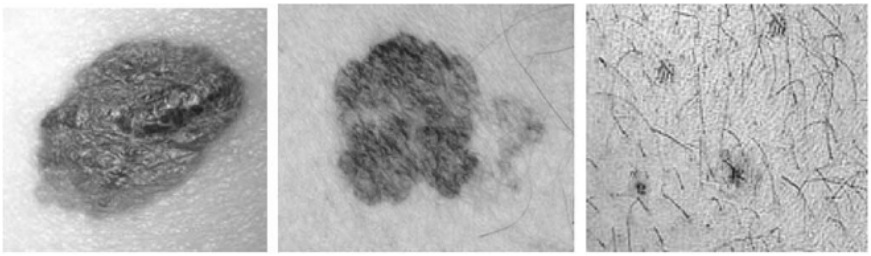

Figure 3. Illustration of (a) typical melanoma, (b) dysplastic nevus, and (c) nondysplastic (common) nevus.

2. COMPUTER AIDED IMAGE ANALYSIS IN MELANOMA RESEARCH

As with most cancers, the key role for primary care is early diagnosis and referral, or appropriate immediate management, of suspicious presenting lesions (Fig. 3.1).

If you see any moles that are bigger than 6 milliameters seek immediate attention.The actual classification is the final step in automated analysis of skin lesions. In some of the skin lesion applications mentioned in previous sections, some classical statistical methods like nearest neighbor classification [6], [1] or discriminant analysis [7], [1], [4], as well as neural networks [3], [11], have been applied for the purpose of skin lesion classification.Motivation of this paper is to combine the fractal dimension and multi scale analysis for enhancing inter-class feature differences. Conventional fractal analysis takes a contour as a whole without finer information while the proposed fractal dimension could indicate local roughness.

The novelty of the paper on analysis of contour irregularity and asymmetry lies on: (1) multi scaled fractals dimension are taken for extraction of boundary roughness features for irregularity and asymmetry analysis; (2) structural irregularity is described in a fractal space to measure the key component with respect to melanoma diagnosis in clinic. (3) A criterion on boundary

asymmetry measures is proposed using fractals dimension at given scale to enhance feature differences between melanomas and benign moles.

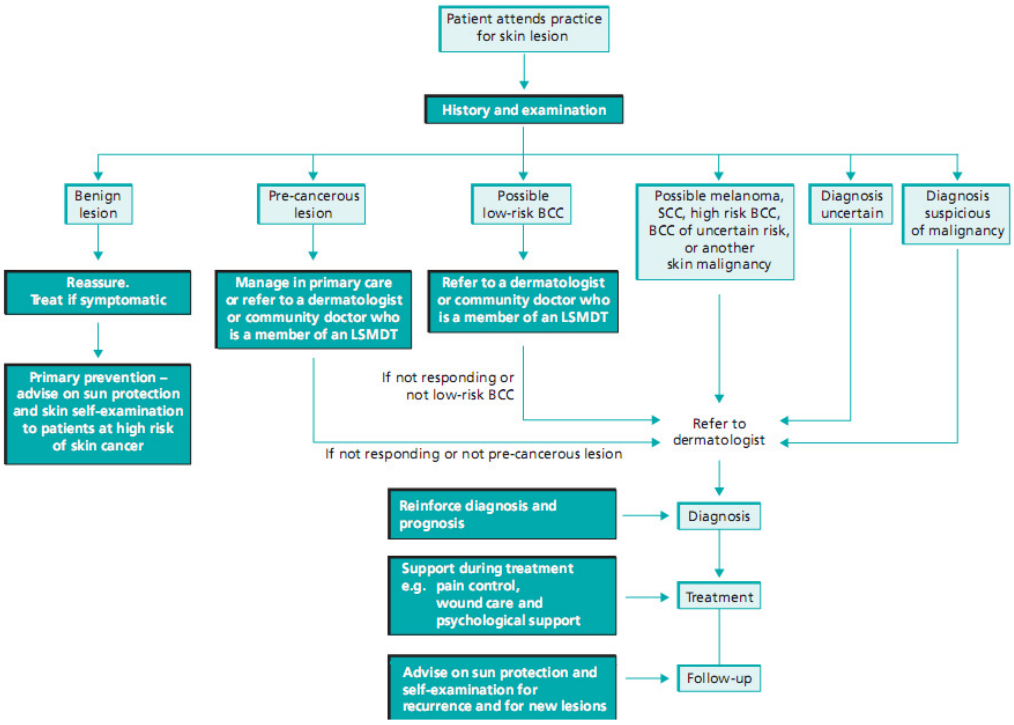

Figure 3.1. Flow chart showing the key roles for the general practitioner (green) in diagnosing, managing and preventing skin cancer

2.1. Fractal Dimension (FD)

When an object in a space of dimension D is reduced in a factor ε, $N \in \varepsilon^D$ new objects will be needed to cover the original one. Hence, the dimension of an object can be calculated as:

$$D = \frac{\log N}{\log \varepsilon} \qquad (1)$$

When dealing with images, the space dimension is D=2.

Applying the same concept to complex structures, the relation given by (1) may turn out to be a non-integer number, leading to what is called Fractal Dimension (FD). The FD gives an idea of how an object fills the space in which it "lives". These structures are called fractals and one example is shown in Fig. 4.

The FD can be used to quantify the roughness or smoothness of a curve in a given space, such as the boundary of a mole in a picture. The border of a healthy mole can be seen as a smooth curve, like an empty circle, which fails to fill the image. On the other hand, melanomas borders, due to their irregularity, are more similar to fractals, such as Koch Snowflake (Fig. 4). Therefore, it is expected for melanomas boundaries to have a higher FD than regular moles.

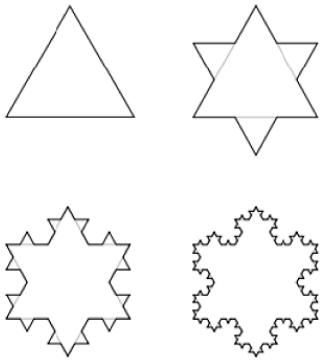

Figure 4. Example of fractal: the koch Snowfake, with FD=1.26. The image shows the first four iteration of its construction. The structure of melanomas boundary is similar to the Koch Snowfake, that is why the melanomas FD should be higher than normal moles FD.

3. Simulation Result

In this section we present the experimental results of the proposed scheme with lots of skin lesion images from MediceNet. During the experiments, objectives of our study focus on two aspects: the effectiveness of skin lesion detection and accuracy performance on medical images. We developed medical software for detecting and analyzing the skin lesion cancer with Microsoft C++. Fig. 6 showed the proposed software.

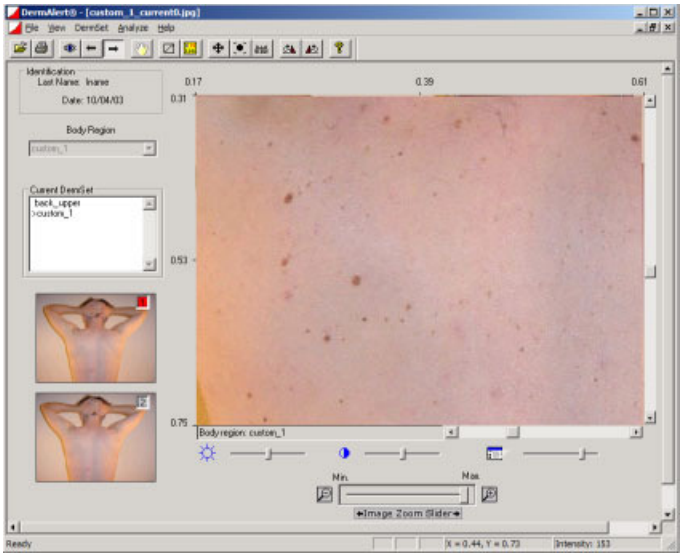

Figure 5. The proposed GUI for melanoma detection.

4 Common Measurements

For a uniform color image, the fractal dimension is 2.0, indicating zero complexity. In the case of healthy skin, the color fractal dimension is usually less than 3.0, being comprised between 2.5 and 2.8, depending on the complexity of the texture of the skin. Such values express a great complexity in the grey-scale domain, but as the value is less than 3.0, they are close to a complex surface in the color domain.

Skin lesions are of particular interest from the point of view of color fractal analysis: the erythema, the scaliness and the thickness determine random variations in the shape and size of ditches, as well in the local contrast of the image.

As shown in Table 1, the fractal dimension computed for images of skin lesions have a higher complexity than healthy skin images. As visually perceived, the texture complexity is due to the addition of some new characteristics of lesions on the skin texture, and this increased complexity is well captured by the fractal dimension. Due to the color formalization of our approach, the probability measure is more sensitive to important local contrast compared to the natural skin color. In these images, such contrasts are produced by the alternation between redness and scaliness of the lesions.

To validate our color fractal dimension and lacunarity as objective measures, we compare them against the scores evaluated by the dermatological specialist for three characteristics of the lesions: the erythema (redness), the scaliness and the induration (thickness) (see Table 1) The three scores are on a severity scale from 0 to 4, in accordance with the PASI score widely-used to evaluate the severity of lesions [5]. The last row represents the global severity, by taking into account all three characteristics of the lesions. We compared the four images by pairs: (a, b), (c, d) and (e, f). As we can see, the relationship between the severity–either global or for each of the three characteristics–of the lesions and the fractal dimension is direct.

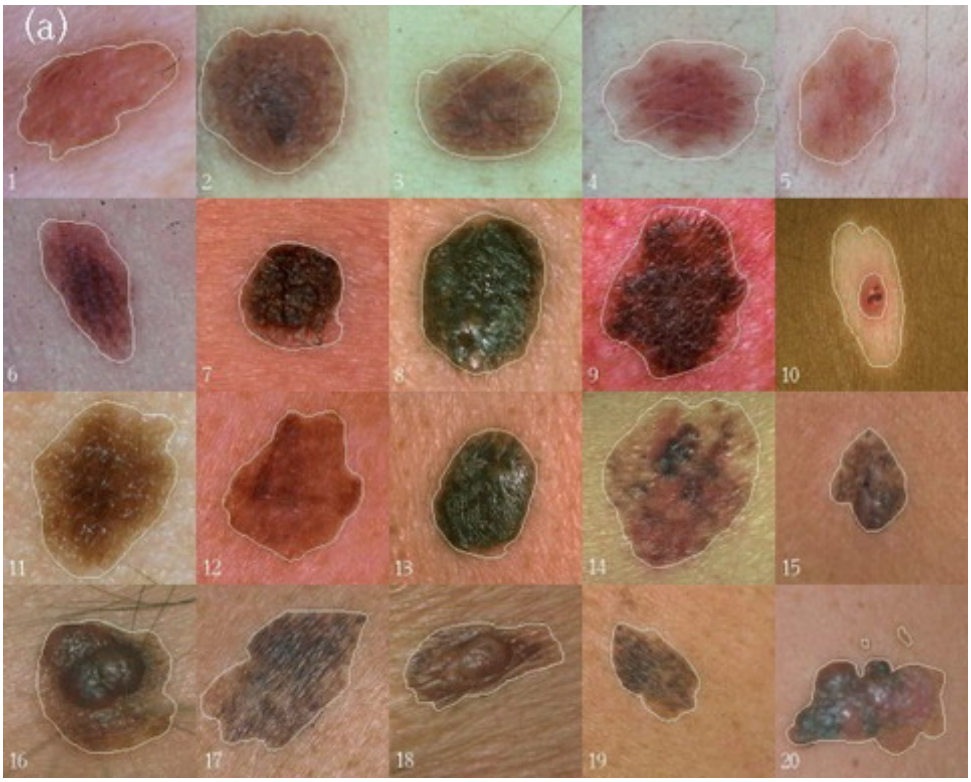

Figure 6. Some skin lesions (http://www.dermnet.com).

5. CONCLUSIONS

According to the literature [1], [2], it is often difficult to differentiate early melanoma from other benign skin lesions. This task is not trivial even for experienced dermatologists, but it is even

more difficult for primary care physicians and general practitioners [3]. On the other hand, the early diagnosis of skin cancer is of severe importance for the outcome of the therapeutic procedure and the basis for reducing mortality rates. Usual systems employ a variety of methods for the image acquisition and preprocessing, and feature definition and extraction, as well as lesion classification from the extracted features.

In this paper, algorithms of Contour irregularity and asymmetry measures for skin lesion diagnosis are proposed based on multi-scaled fractal dimension. In terms of contour irregularity measure, multi-scaled Gaussian filtering is implemented to remove textural irregularity on contours and two types of structural irregularity measure are proposed. Furthermore, some irregularity features derived from fractal dimension at multi scales are given. On the other hand, asymmetry analysis is discussed by presenting partition of symmetric axes and features on asymmetry measures that benefit the inter-class discriminating power from skin tumors.

The result of more than 96% correctly segmented lesion images (in a set of 4000 skin lesions) reflects a very reliable detection module for the special task of skin lesion detection and classification.

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