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Help system to diagnosis of melanoma by dermoscopy

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Abstract: - The aim of this work was to develop a new system to help and to reduce the mortality due to melanoma. We design an image processing system for classify a pigmented skin lesion. The clinical diagnostics are based on the ABCD rule for dermatoscopic images. The efficacy of this tool was tested on a data set of 74 dermatoscopic, compose by 14 melanomas, 54 nevi (benign melanocytic lesions) and 6 suspicious lesions. We are obtaining above 97% of success rate on the malignant and benign tumours.

Key-Words: - Skin tumour, melanoma, dermoscopy, epiluminescence, ABCD rule, image analysis, morphological image processing, and pattern recognition.

1 Introduction

Melanoma is increasing in frequency world-wide and this tumour remains practically incurable. Early diagnosis is therefore of utmost importance to reduce the mortality rate. However, recognising melanomas is not always easy. Although there are high expectations for a technique known as dermoscopy or epiluminescence microscopy (ELM), the evaluation of pigmented skin lesions with this method is often extremely complex and subjective. In order to overcome the problem of qualitative interpretation, methods based on the mathematical analysis of pigmented skin lesions, such as digital dermoscopy analysis, have recently been developed.

In this paper, we present an overview of the scientific research performed by the digital dermoscopy analyzer, Total Dermatoscopic Score (TDS), and related scientific works. Subjective algorithms will be replaced by computerized objective evaluations supervised by dermatologists.

ELM has proven to be an important tool in the early recognition of malignant melanoma [1][2]. In ELM, halogen light is projected onto the object, thus rendering the surface translucent and making subsurface structures visible.

The traditional diagnosis, dermatoscopy, evaluates and interprets shapes, dimensions, colours, textures and patterns. Terms used in diagnosis, such as "Asymmetry"(A), or "Borders" (B), or "Colours" (C), can be ambiguous because they are derived from different primitives of language and are difficult for standardizing. For these reasons they do not work. On the other hand, objective evaluations based on mathematical definitions offer stable and reproducible measurements.

An expert examination consists of deep analysis based on colours, shapes and patterns. The great limitation of subjective algorithms is the length of time required for each examination. It has been widely demonstrated that subjective algorithms are inefficient and lack concordance as compared to expert's common sense and experience.

The main goal of the aided diagnosis is to develop software that will help clinicians in their daily practice. For this reason, the system must be easy to use, fast and not based on subjective evaluation.

Telemedicine is a growing field for the application of the new technologies and deals mainly with the process of remote diagnosis, performed through proper media. In our context, diagnostic support comes from the patients' information, the series of images of their lesions, plus global-view pictures taken in order to document the general situation. The diagnostic process is based on many factors involving questions to the patient, touching of some lesion, looking at detailed views of a particular site as well as of the image of the lesion. Much of this important information is not available on the remote consultation site. In the last few years the continuous progress in computer technology has lead to the introduction of a revolutionary diagnostic tool, known as telemedicine, which is improving communication between physicians and medical specialists and will help decrease costs for the citizen and the health care system.

It is predicted that biology will become completely quantitative in the next ten to 20 years.

Dermatology is following the same route. All modern measurement devices, including ECGs, CAT scans and MRIs, provide quantitative results. Unless we envision a future role of the clinician as a calculating machine, computerized analysis of their results is the obvious consequence. Subjective algorithms will be replaced by computerized objective evaluations supervised by dermatologists.

2 The dermoscopic diagnosis

The use of dermoscopy has uncovered a new and fascinating morphological dimension of pigmented skin lesions, thus increasing the effectiveness of clinical diagnostic tools to differentiate melanoma from other pigmented skin lesions. Dermoscopy (epiluminescence microscopy, ELM) is a non-invasive diagnostic technique for the in vivo observation of pigmented skin lesions, allowing a better visualization of surface and subsurface structures. This diagnostic tool permits the recognition of morphologic structures not visible by the naked eye, thus opening a new dimension of the clinical morphologic features of pigmented skin lesions.

The dermoscopic diagnosis of pigmented skin lesions is based on various analytic approaches or algorithms that have been developed in the last few years, namely, pattern analysis, ABCD rule and seven-point checklist to quote but a few. The common denominator of all these diagnostic methods are particular dermoscopic features or, better, dermoscopic criteria that represent the backbone for the morphologic diagnosis of pigmented skin lesions.

2.1 The ABCD rule

The ABCD rule is a diagnostic algorithm that has been introduced in the last few years with the aim to increase sensitivity in detecting cutaneous melanoma. For these methods, first a given pigmented lesion must be classified as melanocytic or non-melanocytic. Only when the diagnosis of a non-melanocytic lesion is ruled out and a melanocytic lesion is diagnosed, can these methods be applied.

This rule of dermatoscopy, based on a semi-quantitative analysis of the asymmetry, border, colour, and different dermatoscopic structures of a given melanocytic lesion [4]. The ABCD rule is thought to be helpful also for clinicians not fully experienced in dermoscopic observation, being simpler than pattern analysis [4].

For calculating the ABCD score the 'asymmetry, border, colour, and differential structure' criteria have to be assessed semi-quantitatively. Then, each of the criteria have to be multiplied by a given weight factor yielding a total dermatoscopy score (TDS). TDS values less than 4.8 indicate a benign melanocytic lesion; values between 4.8 and 5.5 indicate a suspicious lesion and values greater than 5.5 are highly suspicious for melanoma [4].

The description of these four criterions is:

- Asymmetry: In 0, 1, or 2 axes; assess not only contour, but also colours and structures (score 0-2).
- Border: Abrupt ending of pigment pattern at the periphery in 0-8 segments (score 0-8).
- Colour: Presence of up to six colours 1-6 (white, red, light-brown, dark-brown, blue-grey, black) (score 1-6).
- Differential structures: Presence of network, structureless or homogeneous areas, dots, globules and streaks (score 1-5).

The formula for calculating TDS is:

$$[(A \times 1.3) + (B \times 0.1) + (C \times 0.5) + (D \times 0.5)] \quad (1)$$

The goal of this research was to develop a new system to help clinicians reduce mortality due to melanoma. The tool had to be able to calculate automated the total dermatoscopy score (TDS) and with this score to indicate if a lesion pigmented is a melanoma or not.

3 Image Processing

Digital image processing concerns the transformation and processing of a two-dimensional image picture. It is related to the description and recognition of the digital image content. We apply techniques of morphological image processing. It is based on geometrically altering image structure. In the binary setting, an image is probed by one or more structuring elements to either extract information or to filter the image. Many typical image processing tasks can be accomplished morphologically, including feature generation for pattern recognition, edge detection, thinning, noise reduction, segmentation, and enhancement. Application areas include computer vision, target recognition, medical imaging, inspection, and texture analysis [3][4].

Terms used in diagnosis, such as "Asymmetry" or "Borders" or "Colours", can be ambiguous because they are derived from different primitives of language and are difficult for standardize. For these reasons they do not work. On the other hand, objective evaluations based on mathematical definitions offer

stable and reproducible measurements. The correct support gives the right background for early diagnosis.

The great limitation of subjective algorithms is the length of time required for each examination. It has been widely demonstrated that subjective algorithms are inefficient and lack concordance as compared to expert's common sense and experience.

In order to overcome the problem of qualitative interpretation, methods based on the mathematical analysis of pigmented skin lesions, such as digital dermoscopy analysis, have recently been developed.

3.1 Asymmetry

A given melanocytic lesion is bisected by two 90° axes that were positioned to produce the lowest possible asymmetry score. If both axes show dermocopically asymmetric contours with regard to colours and differential structures, the asymmetry score is 2. If there is asymmetry on one axis the score is 1. If asymmetry is absent with regard to both axes the score is 0.

We look for the rectangle, which surrounds the lesion and evaluates the asymmetric in three groups of axes. We calculate the histogram in both sides of the axes and decide if it is asymmetric. Image histogram provides useful information of the intensities of the image content [5]. It represents the relative frequency of occurrence of various grey levels in the image. With this information we can evaluate the first parameter of the ABCD rule [6].

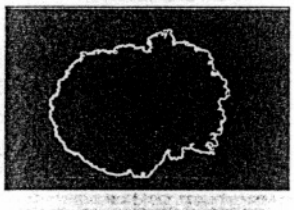

Fig.1 Lesion with its surrounded rectangle

3.2 Border

For semi-quantitative evaluation, the lesions are divided into eighths and a sharp, abrupt cut-off of pigment pattern at the periphery within one eighth has a score 1. In contrast, a gradual, indistinct cut-off within one eighth has a score of 0. So, the maximum border score is 8, and the minimum score is 0. In this study we transform the dermatoscopic colour image in a black and white image, but with two different thresholds. If we subtract these two images we are able to evaluate the abrupt cut-off.

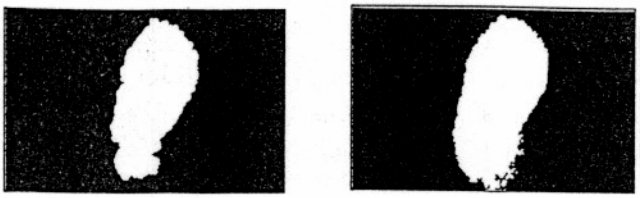

Fig. 2 Images with two thresholds

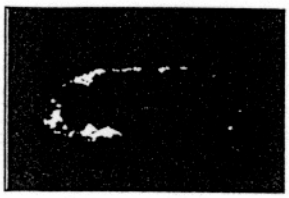

Fig. 3 Image divided into eights sharp. In white is gradual cut-off

3.3 Color

A total number of six different colours, namely, white, red, light-brown, dark-brown, blue-grey, and black, are counted for determining the colour score. The original RGB (red, green, blue) colour space was created by the digitizing of colour slides using red, green, and blue filters and a monochrome video camera. This process generates a 3-D vector for each pixel, where each component has a value ranging from 0 to 255. This RGB colour space was modelled mathematically by an orthogonal geometry. In this way, a pixel can be represented by the vector consisting of its RGB component values.

To detect the presence of the six group of colour, we describe six regions in the RGB space and evaluate the distance of each pixel to each group. The pixel is assigned to the nearest group [7][8].

3.4 Differential structures

The five structural features have been selected for evaluation of differential structures: pigment network, structureless or homogeneous areas, dots, globules and streaks. To evaluate these structures we based on morphological techniques, where the morphological attributes of objects within the image are of great importance [9]. We are able to label the objects as well as to separate them from each other.

In order to eliminate the objects that are not interested, we have to filter our image. This filter depends on the differential structures which want to be evaluated. This processing image can be seen in the following sections.

3.4.1 Network

The pigment network appears as a grid of thin brown lines over a diffuse light brown background.

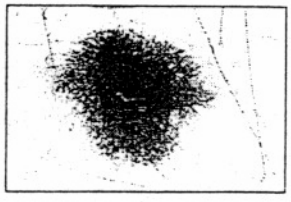
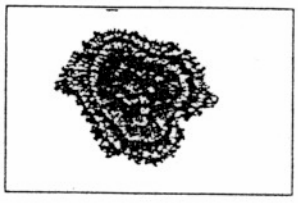

Fig.4 Lesion with pigmented network

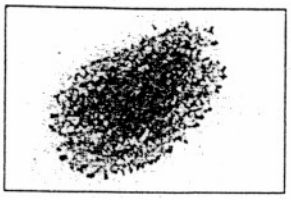
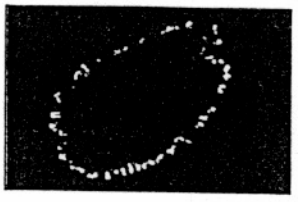

Fig. 8 Lesion with streaks

3.4.2 Structurless

The homogeneous pattern appears as a diffuse, brown, grey-blue to grey-black or reddish-black pigmentation in the absence of pigment network or other distinctive local features.

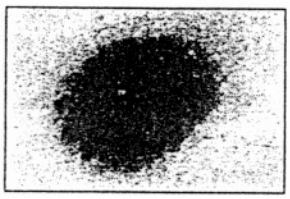
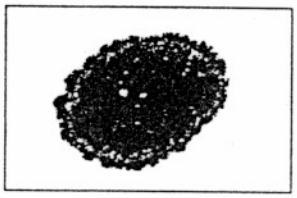

Fig. 5 Lesion with homogeneous pattern

3.4.3 Dots

Dots are sharply circumscribed, usually round or oval, variously sized black, brown or grey structures (see figure 6).

3.4.4 Globules

The globular pattern is characterized by the presence of numerous, variously sized, round to oval structures with various shades of brown and grey-black coloration (see figure 7).

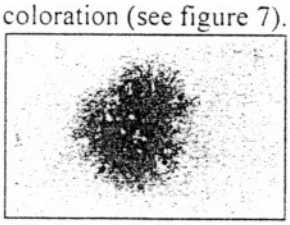


Fig.6 Lesion with dots


Fig. 7 Lesion with globular pattern

3.4.5 Streaks

Streaks are basically nothing but brownish-black linear structures of variable thickness, not clearly combined with pigment network lines.

4 Results

The skin lesion data used in this work has been provided by the *Department of Dermatology* at the *Insular Hospital from Las Palmas de Gran Canaria (Spain)*. This department gave us an Atlas of dermatoscopy, where the imaging was performed by a hand-held CCD camera (one chip colour sensor) that is combined with an epiluminescence microscope in order to produce digitized ELM images of skin lesions. The images have a spatial resolution of 632 x387 pixels with 1pixel to 22 μm^2. They are available as true colour images in the *RGB* colour system with a radiometric depth of 8 bits per colour channel [10].

In order to evaluate the efficacy of our designed tool, it was tested on a data set of 74 dermatoscopic, composed by 14 melanomas, 54 nevi (benign melanocytic lesions) and 6 suspicious lesions. We obtain above 97% correct classification of the malignant and benign tumours. The correlation between the dermatologic diagnosis and the automated diagnosis is represented in the table 1.

PARAMETER	CORRELATION
asymmetry	80%
border	81%
color	58%
network	91%
structurless	87%
dots	88%
globules	85%
streaks	77%

Table. 1 Results from our experiments

5. Discussion

The main goal of the aided diagnosis is to develop machines that will help clinicians in their daily practice. For this reason, the instrument must be easy to use, fast and not based on subjective evaluation. When a System-aided interpretation is based on clinician's assessments the results are obviously based on a poor engine. Moreover the hidden trap is the fact that a clinician himself can not be the "gold standard"

for the diagnosis. A real false negative has not been seen by the dermatologist. For this reason many scientific studies are not very useful when reporting high accuracy with machines that depend on previous expert examination because he is a filter for the reality of facts. Plus we also know that Systems with poor quality only "see" trivial melanoma. For this reason, it is apparently easy to reach very high sensibility on such machines, but the results are false. Some studies report a sensitivity of 100%, forgetting that the histology itself, which is the "gold standard", does not reach such value. If a study is based on a previous clinician's examination, we must consider his error and multiply the sensibility for a correction factor. We develop a easy and fast system, which accurate in the clinical daily practice.

Increasing sub-specialization in medicine results in a concentration of experts in few medical centers and a lack of expert knowledge in other, predominantly rural areas.

Physicians in these areas may have problems with the diagnosis and management of equivocal pigmented skin lesions. The patient has to be sent to an expert in a medical center for further diagnosis and, depending on the results, for adequate treatment. This transportation means inconvenience for the patient and costs for the medical care system due to re-examination by the expert. Finally, the whole procedure of patient transportation and re-examination that is cost- and time-consuming might have been unnecessary if the expert could have been consulted beforehand.

In the last few years the continuous progress in computer technology has lead to the introduction of a revolutionary diagnostic tool, known as telemedicine that is improving communication between physicians and medical specialists and will help decrease costs for the citizen and the health care system. In several medical specialties, where digital images are crucial in diagnosis and management decisions, such as radiology or internal medicine (endoscopy; ultrasound) to name but a few, telemedicine already represents a well-integrated part of daily medical life. In addition, it has recently been shown that teledermatology is a useful and suitable diagnostic tool, especially in communities where dermatologists are not available.

In a second step this system is a perfect teacher for university students. They can see hypothetical examples of all relevant dermoscopic criteria and their underlying histopathologic structures which will be demonstrated in order to teach students of the subject the letters of the dermoscopic alphabet. These letters help for learning and understanding dermoscopy. Also, knowledge of dermoscopic criteria yields a basic source for further studies in this field and may help communicate the method of dermoscopy to the clinical dermatologist. In order to achieve this goal we will focus on already well established criteria while refining some not clearly elaborated ones.

Theoretically, the clinical and dermoscopic diagnosis of melanocytic skin lesions is rather easy, because reliable and reproducible criteria exist allowing the differentiation between the many faces of benign and malignant melanocytic skin lesions to be made with confidence. Obviously, there are a certain number of lesions defying clinical and also dermoscopic diagnosis, and in those instances histopathology, especially when performed by well-trained and competent dermatopathologists, is the ultimate standard for diagnosis.

Real life, however, is different and, at least in our opinion, a definitive clinical and dermoscopic diagnosis, also when using reliable and repeatable criteria is often difficult and sometimes simply a guessing game. This statement is true not only for the clinical and dermoscopic diagnosis of melanocytic skin lesions, but also for the histopathologic ones. Especially in the realm of junctional melanocytic proliferations, whether situated on sun-damaged skin or not, the border between benign lesions, e.g., junctional type of Clark nevus, and malignant lesions, e.g., melanoma in situ or lentigo maligna, can be drawn neither with competence nor with indoctrination.

Nevertheless, patients with single and, even more, with multiple melanocytic skin lesions have to be managed by physicians with carefulness and responsibility and, in our estimation; dermoscopy is a helpful tool to achieve this goal. Melanocytic skin lesions within this 'gray zone' simply should be excised or followed up closely by using the newly available digital technologies.

As we know melanoma is increasing in frequency world-wide and this tumor remains practically incurable. In the past many video devices have been used. The video offers a very poor quality of image and for this reason many of the industries are moving toward digital firewire cameras. A video camera has many limitations respect to a digital device. When a dermatologist is involved in the digital analysis he should ask himself how many pixels does his instrument provide for the digital dermatoscopic imaging of moles. A good camera represents a complete solution for the early detection of melanoma.

With this research we want to give new instruments for a good early detection.

6 Future Research

For the diagnosis of the melanoma, first a given pigmented lesion must be classified as melanocytic or non-melanocytic. Only when the diagnosis of a non-melanocytic lesion is ruled out and a melanocytic lesion is diagnosed, can these methods be applied. So we want to work in this firs step and develop a system for classify a pigmented lesion.

Another future line to continue our research is the study of the photos called "body map". In these pictures we can see a complete view of the patient's body. It could be very interesting to research a system which is able to classify the pigment lesion. In this way the specialist only has to do the dermatoscopic and the whole study in a few cases and not in all lesions.

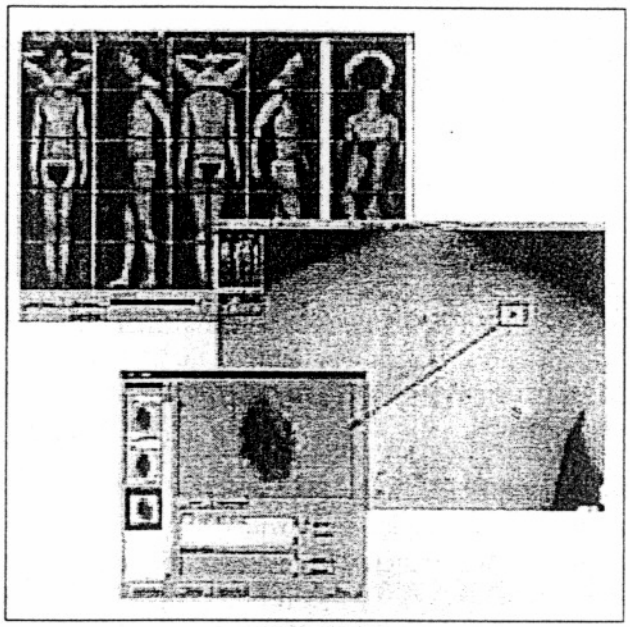

Fig.9 Body map system

7 Conclusions

We have developed an image processing system for calculate automated de Total Dermatoscopic Score (TDS) for classify a pigmented skin lesion. Our system will provide a useful tool for the early diagnosis of melanoma, it will decrease costs for the citizen and the health care system. This system can help clinicians in their daily practice. It is easy to use, fast and not based on subjective evaluation.

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