Detection of skin cancer "Melanoma" through Computer Vision.

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***Abstract*— In the last decades, skin cancer increased its incidence becoming a public health problem. Technological advances have allowed the development of applications that help the early detection of melanoma. In this context, an image processing was developed to obtain Asymmetry, Border, Color, and Diameter (ABCD of melanoma). Using neural networks to perform a classification of the different kinds of moles. As a result, this algorithm developed after an analysis of 200 images was obtained a performance of 97.51%.**

Keywords—Melanoma; Image Processing; Artificial Intelligence; Neural Networks.

I. INTRODUCTION

Cancer arises when the genes of one DNA cell, that control cell division and reproduction, are damaged. Damaged genes make the cells divide and grow without control or order, becoming a malignant tumor [1]. In the case of melanoma, the damage to DNA is caused by overexposure to ultraviolet rays (UV), and the affected cells are the melanocytes that produce melanin (pigmentation of the skin). Usually, the first tumor that develops is found on the skin. If melanoma is not detected, it grows and spreads along the first layer of skin before penetrating into the deeper layers and finally, comes into contact with the lymph vessels and the blood [2].

The early detection of skin cancer increases the chances of a cure unlike when it is discovered in advanced stages. In this way, it could reduce the mortality rate for this type of disease. Also, recent studies have shown that the values of performance on the classification of melanoma to a dermatologist, are in the range of 75 to 84 % [6].

Several researchers over time have created different methods and software for the detection of this disease by artificial vision. The National University of Colombia presented a tool supporting diagnosis of melanoma using dermatoscopic images. In which, by morphological operations quantifies the presence of three features: atypical reticular pattern, asymmetry of patterns and bluish-white veil. As a result of the classification of elements with the technique of vectors of support, the proposed system gets a performance of 90.62 - 100% for the values of sensitivity and specificity [9].

The Congress of biomedical engineering held in Toronto, Canada has presented the software for the detection of melanoma, based on artificial neural networks and computer vision. The software initially omitted the parameters of "color and evolution" of "alphabet of injury" because those photos are handled in two dimensions and are processed in grayscale [8].

Researchers from the Universities of Seville, Cordoba and Loyola Andalusia in Spain have developed a system capable of classifying melanomas from dermatoscopic images, to avoid the biopsy, which is of type invasive. The system developed gets 80 features of the images: texture, the shape, and the color, which vary in the different stages of melanoma [10].

II. METHODOLOGY

The program developed classifies the types of moles detecting melanoma, so that represents a tool of care and prevention for physicians and patients. A system of learning, recognition, and classification must consist of the so-called "ABCDE" or alphabet of melanoma [2] which consists of the following points:

- Asymmetry of the form: one-half of the mole is different from the other.
- Borders: blurry, irregular, festooned, diffuse or imprecise.
- Color: varied in the same place or multiple colors on the same mole as red, white, black, brown.
- Diameter: greater than 6 millimeters.
- Evolution in time: changes (growth, bleeding, itching, etc.)

In the present work was based only on the ABCD (Asymmetry, Border, Color, and Diameter), because the database used lacks information about the evolution of the moles at the time, a doctor should monitor this evolution.

III. ACQUISITION AND PROCESSING

The acquisition of images was carried out using the database. It should possess moles of different types, sizes, and colors. The database, also, should be free access; for these reasons

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the database of the multidisciplinary project ADDI (Automatic computer-based diagnosis system for Dermoscopy Images) of the University of Porto, University of Aveiro and the Technical Higher Institute of Portugal [4] was chosen. This database contains 200 moles classified in common (80) not common (80) and melanomas (40).

These medical images have the following characteristics:

- Resolution: 768x560 pixels.
- Bitmap format: BMP.
- 8-bit images RGB.
- The magnification factor of 20x.

The processing of the images is carried out in such a way as to draw the features for the classification of the mole according to the National Cancer Institute of the United States [1]. A mole is considered common when it has symmetry, is round or oval, smooth surface with defined edge, uniform color, and diameter of less than 6mm [5]. Fig. 1 shows a common mole belonging to the studied database.

Fig. 1. Normal mole. [4]

Fig. 2 shows a mole not common also known as a dysplastic nevus, this type of injury may be larger than a common mole, and its color, surface, and edges can be different. It presents a mixture of several colors, from pink to dark brown, is flat with a smooth surface and has a jagged edge that may fade in the skin of surrounding, have a diameter of more than 5 millimeters wide.

Fig. 2. Mole not common. [4]

Usually, the first melanoma sign is a change in the form, color, and size [2]. Melanoma can also appear as a new colored area of the skin. The "ABCD" is a set of rules that describes the characteristics of melanoma in an initial state [3].

The color and diameter define melanoma, a mole can be symmetrical and have a regular edge, but if you have more than two colors and is greater than 6mm, it is a melanoma. Usually, if a mole changes the diameter of 6mm, it is considered melanoma (Fig. 3).

Fig. 3. Melanoma. [4]

IV. Feature Extraction And Classification Of The Injury

For the classification of the pigmented lesion, features are extracted according to the ABCD raised, from the examination of these characteristics it can be evaluated if a mole is a common injury, no common or melanoma.

A. Asymmetry

To determine the area of the image of the mole, we use the method called Mumford-Shah, this function allows to detect the area, center, and diameter of a binary image. These parameters are used for the obtaining of a quadrilateral that frames to the lesion. This method is defined by a convolution of characteristic function xi, with a square window w; as can be seen in equation (1).

$$\phi(x,y) = X_I(x,y) * w(x,y), i \in \{1, \ldots, N\} \quad (1)$$

The regions are identified by ϕi (x,y)=1and, the edge region is identified by 0<ϕi (x,y)<1. The region numbers are detected automatically, deduced by the algorithm that is presented below in the equation (2).

$$\begin{aligned} Ev_i\lambda = \textstyle\sum_{i=1}^{N} \int_{\lambda=1} [u(x,y) - c_i]^2 dxdy + \\ v \textstyle\sum_{i=1}^{N} \int_{0<\phi i<1} [u(x,y) - c_i\phi_i]^2 dxdy + \\ \lambda \textstyle\int_{\sum_I^N \phi i=0} [u(x,y) - c_0]^2 dxdy \end{aligned} \quad (2)$$

Where N is the number of objects detected in the image, u(x,y) is the input image, v and λ are adjustable parameters, and finally, ci and c0 are constants. The diameter is utilized for the incorporation of a circle within the binary image, for the purpose of making a comparison with the picture area. This difference determines whether the mole processed is symmetrical or asymmetrical [3].

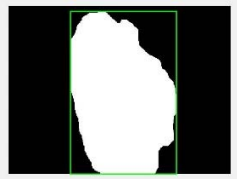

Fig. 4. Determination of asymmetry with the model Mumford-Shah.

B. Edge

Moles considered melanoma have jagged edges, unequal and blurred. So to determine if the mole image, has a regular

border or irregular, the methods of detecting edges are looked for in one image where the intensities of the pixels change between the object and the image of the edge to identify [1]. To determine the edge of the picture we used the Harris-Stephens algorithm. The method uses the equation (3)

$$S(x,y) = \sum_u \sum_v w(u,v)(I(u+x, v+y) - I(u,v))^2 \quad (3)$$

Where I_x and I_y are the partial derivatives of I. This algorithm identifies the corners of an object and returns the points of those corners; these points set the edge of the mole. Within these is the minimum and maximum point of the image, where the maximum point will be the most prominent peak. With these two points are applied the distance formula between two points so as to determine the distance from the centroid to the minimum, and maximum point with these distances is a relationship between the regular and irregular edges. So if this is a regular edge the distance between the peak and minimum must be a positive value. If the picture had more than 150 peaks it has a ragged edge, this algorithm is implemented based on the data obtained to process all the images acquired and checked the obtained with the original database [4].

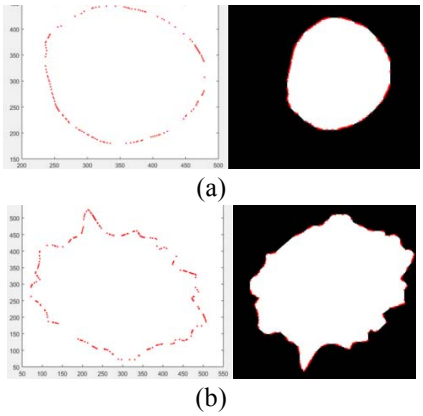

Fig. 5. Determination of edges with the Algorithm Harris-Stephens. (a) mole with a regular edge. (b) mole with a jagged edge.

C. Color

For the obtaining of the lesion is used two different methods. The first, converts an RGB image to HSV (hue, saturation, and value), with this is done a nonlinear transform of the RGB color space and from this determines the prevailing value so that you get the injury or mole. However, is not always the most efficient method to extract what needs due to this raises the second method that displays the image data converted to grayscale that predominate in the picture. This process has a disadvantage since the light colors not highlighted, i.e. is not shown well in a binary image, by this reason compares the areas of both methods to get the best result. The two cases include a pre-processing fill of "holes," and elimination of areas which are negligible for the obtaining of the binary image of the area to evaluate, in this way improves the processing of images [7].

The normal moles are composed of a uniform color [5] remains brown, cinnamon or black; due to this, it is important to set the colors not uniform to determine a melanoma. Hence the presence of colors such as white, brown or the mixture of uniform colors determines if the mole is common, not common or melanoma. To identify each color has obtained a range of colors using the conversion of HSV and obtaining the histogram.

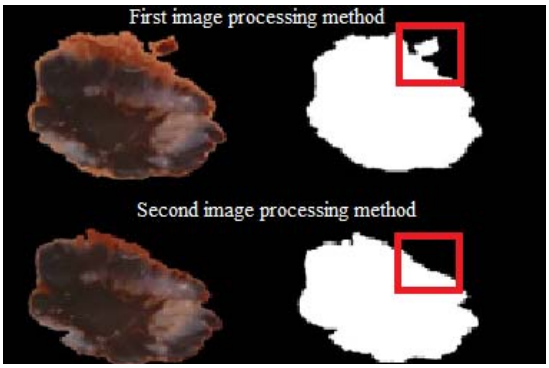

Fig. 6. Determination of color through conversion of HSV.

D. Diameter

The diameter of the moles is one of the most important parameters since melanomas commonly have a diameter greater than 6mm [2]. The model Mumford-Shah was used to determine the value of this diameter in pixels. To establish the real value of the diameter, you must divide the value obtained by 20, because the database used has a 20x magnification. For better visualization of the lesion, the result is multiplied by 0.2645, the value that represents the ratio of conversion of a pixel to mm then displays the equation (4) applied to determine the diameter of the moles acquired.

$$Diameter = \frac{D(obtained\ by\ image)}{Magnification\ of\ 20x} * 0.2645 \quad (4)$$

V. The Neural Network For Classification

At the end of the processing of medical images of moles, we have been able to extract the features of the ABCD, so that this data can be used by the neural network that is responsible for classifying the injuries. For the design of the neural network, we took the ABCD parameters from the PH^2 database because it was performed by an expert dermatologist [4]; the data for the training of the network was 30 images taken from the database, 10 of each type: common, not common, and melanoma. At first, we used a perceptron network, but it did not work correctly, so the final Neuronal Network developed was a feedforward backpropagation with four inputs (ABCD), three types of output (common, no-

common, and melanoma), one hidden layer with fifty neurons, and one output layer with a neuron.

VI. RESULTS

For the detection of melanoma, the algorithm designed must be able to classify common, not common, and melanoma. Fig. 7 shows a failed output from a wrong network, so the mole analyzed is not common because it has symmetry, irregular borders, uniform color, and the diameter is less than 6mm. However, the failed network interprets it as melanoma.

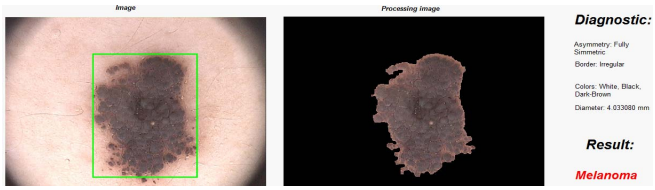

Fig. 7. Test result failed.

Fig. 8, shows the same mole studied with the failed network, but this time the result is right since the final neural network used what has been classified as not common. Moreover, the results are as observed favorable for a normal mole (Fig. 9) and melanoma (Fig. 10).

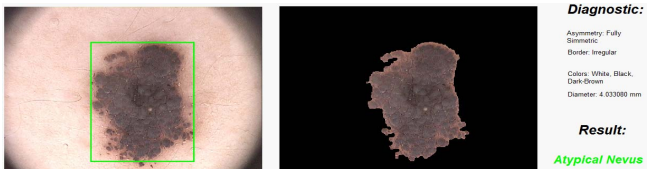

Fig. 8. Favorable outcome of this type is not normal.

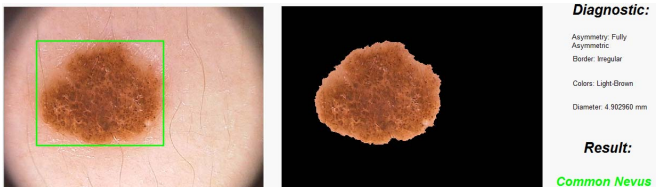

Fig. 9. The favorable result of the final neural network.

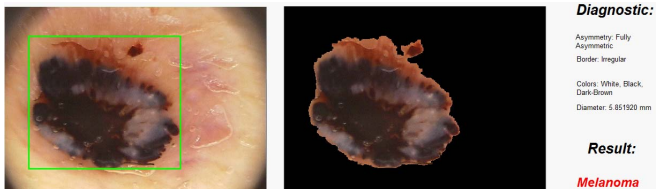

Fig. 10. Favorable outcome of melanoma.

To test the system developed, it raised the possibility of processing an image that does not belong to the original database. Fig. 11 shows the test performed with a picture of melanoma obtained from the Internet. The result is positive because it is successful in parameters such as asymmetry, border, and color, but the resulting diameter is not correct because it has a higher resolution.

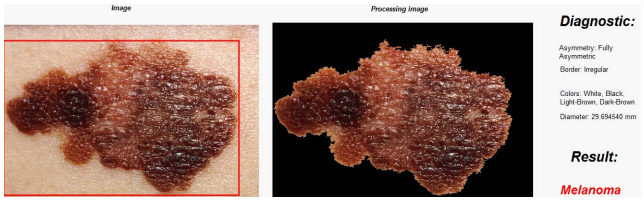

Fig. 11. Test result with an image obtained from the internet.

Table I. shows the final results of all images from database and one image from internet. The system developed in this paper has a high efficiency of 97.51%.

TABLE I. RESULTS AFTER IMAGE PROCESSING

Type	Real data	Data from image processing
Common mole	80	79
No-common	80	78
Melanoma	41	39
Total	**201**	**196**

VII. CONCLUSIONS

The system for the detection of melanoma may be developed as an instrument to provide a second opinion for the diagnosis of this disease, due to the analysis of the ABCD, giving a high degree of reliability. In the same way, the system gives a result with greater efficiency, due to the analysis and image processing being done in small intervals at time, limited by the type of computer and the processor that has at its disposal, obtaining a timely and efficient result. After an analysis of 201 images in the algorithm developed a performance of 97.51% was obtained; if we compare a doctor (75 to 84 %), the system achieves a high degree of efficiency.

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