Software for the detection of melanoma through the recognition of images and artificial neural networks

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Abstract— **Malignant melanoma has increased in the past decades. In rural or remote areas is hard to have dermatologists that perform an early detection of malignant melanoma. The objective of this study is to develop a software that detects melanoma in nevus in a way that is automatic, easy, noninvasive, objective and at a low cost using as the basis of the analysis the "ABCDE" of lesions along with the processing of images and artificial neural networks. The software's evaluation was made with cases previously diagnosed with malignant melanoma and with cases of suspicious moles. The evaluation showed a sensibility of 76.56% and specificity in 87.58%**

Keywords— **Cutaneous neoplasia, Melanoma, Artificial intelligence, Artificial Neural Networks, Processing of images.**

I. INTRODUCTION

Malignant melanoma is a cutaneous neoplasia with melanocytic or nevus cells, multiplying abnormally [1].

This is the most dangerous type of skin cancer that is developed from melanin cells [2, 3]. Its early diagnosis makes possible its healing. However, if it is diagnosed late it may extend through metastasis to other body organs.

Melanoma emerges spontaneously or on a mole (melanocytic nevus) that changes form, size, color or texture. Generally, the doctor or dermatologist detects a suspicious nevus of melanoma through visual inspection of the nevus by using the mnemonic "ABCDE of lesions" (from this point on "ABCDE"). This rule is translated in: Asymmetry, Border, Color, Diameter and Evolution. The ABCDE may be subjective due to the variety of opinions derived from a visual perception. Nevertheless, this mnemonic applied by a specialist, is a tool with high sensibility in finding suspicious nevi, which needs to be assessed for its excision, and receive through the biopsy the diagnosis of melanoma.

In Latin America, the pursuit of decreasing deaths due to this cutaneous neoplasia is facing the fact that there are patients who have the difficulty of having a dermatological appointment because of the low and general specialist/population proportion and the low per capita income, affecting mostly the rural areas [4].

Our contribution is a software that is easy to use, automated, noninvasive, and at a low cost to facilitate the detection of suspicious nevi in a more objective way and with more specficity for the diagnosis of melanoma en rural or remote areas. The software looks for the characteristics of malignancy, according to the ABCDE. We want our software to be very accessible to the general population through any health personnel. The software uses techniques of recognition of images and artificial neural networks (ANNs) The preliminary results are positive, with a scrutiny of high sensibility and specificity.

This article consists of the following sections: Section I presents a brief description about melanoma. Section II shows melanoma as a threat to public health. Section III describes related work. Section IV presents the solution to the early detection of melanoma. Section V presents the evaluation of the software. Section VI contains the conclusions and further work in develop.

II. MELANOMA, A THREAT TO PUBLIC HEALTH

The incidence rates of melanoma increase more in people of Caucasian skin rather than in those with darker complexion, Hindus or Orientals [1]. In the United States itself, in 2008 melanoma was diagnosed in 62, 480 individuals [2,5]. In the year 2014, the estimated number of new cases and deaths by melanoma was approximately 76, 100 and 9, 710 people respectively [6].

The incidence of melanoma has been increasing in the past 40 years [3]. Older men are in more risk. Nevertheless, melanoma is the most frequent cancer in young adults between the ages of 25 and 29, and the second most frequent cancer in those between 15 and 29 years old.

III. RELATED WORK

The instrument used in the dermatological physical examination is the dermatoscope. However, its use is specifically for dermatologists. For this reason, over the past years, several tools that facilitate the evaluation of patients with skin lesions have been created so that the evaluations can be made by not only dermatologists, but general practitioners, and even some can be used by the patient itself to receive orientation [7,8]. Some authors mention up to 300 apps in the market with dermatological purposes, with 22% of them having diagnostic purposes [9]. An example of this is the Australian app *doc-*

tormole that performs image evaluation of nevi through the ABCDE and it indicates the risk of a new melanocytic nevus to be malignant or not [10].

Among the works made in this area, artificial intelligence has been used in the evaluation of images with dermatological lesions. For example Taouil *et al*. report the design of a tool for the analysis of images through ANNs [11]. The sensibility reached in this work was of 74.9% and the specificity of 76.4%. Other authors, who do not specify the language of programming used, report mobile applications with a sensibility up to 98%. However, the specificity remained in 30.4% [12,8]. A retrospective study that took place in Taiwan compared the diagnostic capacity of CADx (computer-aided diagnosis) and a group of dermatologists. This study showed a sensibility of 85.63% in the diagnosis made by the CADx and an 83.33% in the clinical diagnosis [13]. The disparity between the different results of sensibility and specificity is one of the challenges to defeat in the creation of apps for dermatological diagnosis. Another challenge found in the literature consists of creating tools that are both friendly for the health personnel and that show a clear evidence of its clinical effectiveness [14].

IV. Solution

With the purpose of an early detection of melanoma, a proposition of a software that analyzes pictures of nevi and makes the detection of melanoma using processing of images and ANNs, is made. This software is based on the ABCDE for the detection of lesions. However, the software omits the parameters of evolution and elevation because the pictures are handled in two dimensions. The software uses two-dimensional pictures that can be taken with low-cost and easy access equipment.

Our software consists of two tools called "Melanoma Detector Trainer" and "Melanoma Detector". These tools were developed in Matlab version R2013B, and they both combine the processing of images and ANNs to detect or determine suspicious nevus of melanoma. On one side, the use of the **processing of images** helps in the elimination of noises like hairs, illumination, wrinkles and other elements around the nevus that generate noise to the training of ANNs. On the other side, the **ANNs** learn through patterns or examples. In an ANN, knowledge is not directly programmed but it is acquired through a rule of learning which adjusts over time its parameter, weight and sometime the size of ANNs to optimize its performance [15].

The ANNs' structure used on in these tools is constituted by artificial neurons interconnected and arranged in three layers (see figure 1). The data enters through the "input layer". Each neuron in this layer has the image of a nevus in binary format. Each of the binary images is represented in a one-dimensional matrix. In the training, the synaptic weight of the different unions between the neurons and the hidden layer is modified. Once the processing period is finished, the information gets to the output layer, which has the mission of giving the result: suspicious or not suspicious of melanoma.

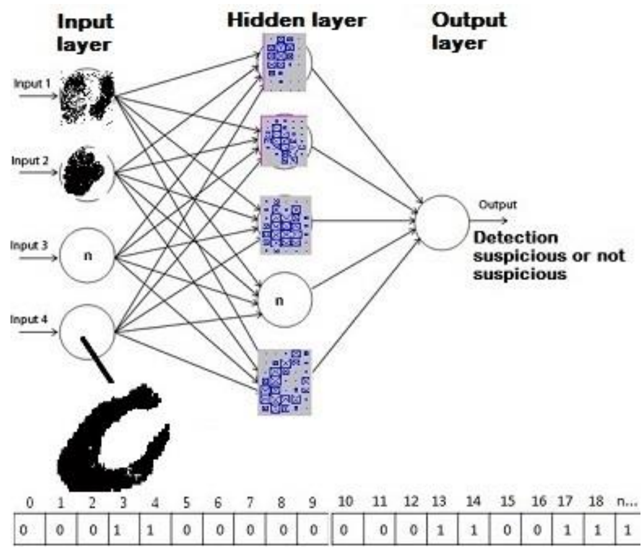

Fig.1 Structure of the artificial neural network.

A. Melanoma Detector Trainer

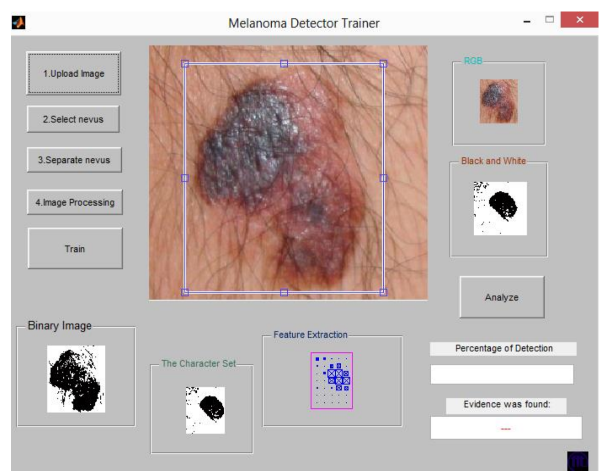

Fig.2 Tool to train the ANN with image recognition of nevi.

The "Melanoma Detector Trainer" (see Figure 2) has the function of training the ANN. However, once the training is finished, it can be tested by analyzing pictures of nevi. To use this tool follow the next steps:

Step 1: Upload image of the nevus. The tool is trained with 50% of images with melanoma and 50% with images without melanoma. This percentage is used in order to balance the training of the tool with the possibility of real positives and negatives. The pictures uploaded must be captured from a distance approximate to 8 cm; this allows the nevus to appear with a good size and without distortion. It is also recommended to avoid shadows or excessive brightness in the image.

Step 2: Select nevus. On each of the uploaded images the nevus is selected through a rectangle. This is done to omit skin and hairs to appear around the nevus which may cause noise. Once the nevus is selected, it is separated from the rest of the image.

Step 3: Image processing from RGB to binary format. This step is performed in order to have a matrix that consists of the image represented in binary format. Images in this format are fast to process and they have a smaller size than the bidimensional matrices in RGB (Red Green Blue) format.

Figure 3 shows the code used for the processing of the image from RGB format to a binary format. Once it is uploaded, selected and separated from the nevus, the portion of the nevus is changed to greyscale. Then, this image is transformed to binary format.

```
img_crop = handles.img_crop;
imgGray = rgb2gray(img_crop);
bw = im2bw(img_crop,graythresh(imgGray));
axes(handles.imagenbinaria);
imshow(bw);
```

Fig. 3 Code for the conversion from RGB to binary format.

Step 4: Training of the ANN. In this step the ANN is trained with the images of the nevi in binary format. Figure 4 shows the code used to create the ANN. The parameter perceives both the image of the training and the parameter T and it saves the images in one-dimensional vectors.

```
%% Vectors for employers and their respective output () are created
P = conjunto DeEntrenamiento (:, 1: 68); % Loop to the number of images
%Two vectors size= 56 %
T = [ eye ( 2) eye ( 2) eye ( 2) eye ( 2) eye ( 2) eye ( 2) eye ( 2) eye ( 2) eye ( 2) eye ( 2)]
%% Create and train the neural network
handles.net = crearRedNeuronal (P, T);
net= crearRedNeuronal  = ( P , T) ;
save tranningAnn net % Save the training and created the archive tranningAnn
guidate ( hObject , handles) ;
```

Fig. 4 Code used in the training of the Melanoma Detector Trainer

Step 5: Test of the trained ANN. In this step the results of the trained ANN are tested with the purpose of knowing if they are satisfactory (i.e., if it recognizes melanomas). If the results are not satisfactory, the tool must be trained with a larger amount of images or the quality of the images must be improved.

B. Melanoma Detector

The "Melanoma Detector" tool is used by health personnel to evaluate a nevus and find signs of suspicious or non-suspicious nevus. This tool loads the ANN previously trained by the "Melanoma Detector Trainer" (See Figure 5).

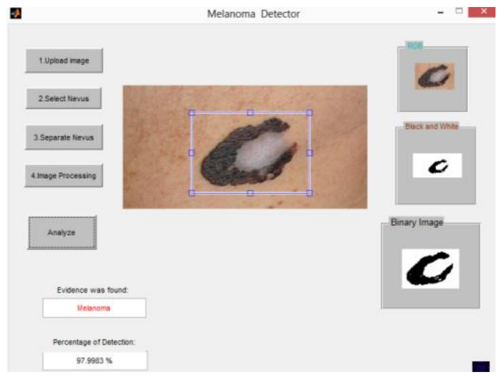

Fig. 5 Tool used for the detection of melanoma in nevi.

The use of the "Melanoma Detector" is similar in the first three steps followed with the "Melanoma Detector Trainer". With the purpose of detecting melanoma, health personnel indicate the tool to determine if the nevus is suspicious of melanoma or not. The result states if any sign of melanoma or non-melanoma exists, with its respective percentage with a trust level according to the ANN.

V. Evaluation

The evaluation was made by using images of nevi with melanoma taken from medical public sites, dermatology books and from public clinical images. The pictures with absent nevi melanoma were acquired from public bank of clinical images. The first trial was made with a population of 48 nevi, where 24 of them were diagnosed with malignant melanoma and 24 with benign nevi, having a sensibility of 76.06% and a specificity of 87.18%. The second trial was made with a population of 30 individuals from which 50% of the nevi were diagnosed with malign melanoma and the other 50% with healthy nevi, the amount of sensibility reached was 76.75% and the specificity of 87.74%. The last trial made consisted of a population of 50 nevi where the first half presented melanoma and the second half healthy nevi. The sensibility reached in this third trial was 76.89% and a specificity of 87.82%. The "Melanoma Detector" has a positive predictive value (PPV) of 80% and a negative predictive value (NPV) of 74.19%.

Figure 6 shows that the level confidence level increases when the Melanoma Detector Trainer is trained with a rising number of images. In other words, the error in the training of ANN decreases with a larger amount of images.

Figura 6. Detection percentage of melanomas of the Melanoma Detector Trainer according to the number of images used in the training

With the purpose of improving the detection percentage of melanomas, the ANN was trained with pictures of nevi that included at least one of the different characteristics in the ABCDE (e.g. an image shows the asymmetry criterion in the nevus while another one shows the border criterion).

In some results of the tool, nevus was not able to be identified. For these cases, the software displays the caption "nevus not identified". Out of all the trials, 3% of the images received as a result this caption.

VI. Conclusions and future work

This article described a software that enables the analysis of nevi that are suspicious of being melanoma, by applying techniques of recognition of images and ANNs. The tool may allow medical doctors in rural or remote areas, without a broad knowledge in dermatology and without a state-of-the-art technology to obtain objective evidence of suspicious nevi.

As future work, other items will be added to the software, such as: the location where the patient lives, tone of skin, location of the nevus on the body and the age of the patient. Furthermore, we hope to use exclusively our own pictures to train the software in order to obtain a more solid nevus triage system. At the same time, along with the acquisition of the pictures of the nevi, a bank of clinical images of nevi diagnosed with melanoma in Latin people is being designed. This will be of great importance in Latin America because as far as we know, there is still no bank of clinical images of Latin people with melanoma.

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Los que abajo firman, están de acuerdo en que la versión de informe de investigación está terminada en su versión final y puede agregarse a los archivos de la facultad.

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