Detection of melanoma through image recognition and artificial neural networks

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Abstract— **The incidence of malignant melanoma has significantly increased in the last four decades. Dermatologists are rarely present in rural or remote areas to perform an early detection of malignant melanoma. Our contribution is a low cost software that automatically and objectively differentiates between a melanoma lesion and a benign nevus in a simple, non-invasive manner. Our approach is based on the "ABCDE" classification of lesions, image processing, and artificial neural networks. The software was developed using images of previously diagnosed malignant melanomas and non-malignant suspicious moles, obtaining a sensibility of 76.56% and a specificity of 87.58%.**

Keywords— **Cutaneous neoplasia, Skin cancer, Melanoma, Artificial intelligence, Artificial Neural Networks, Image Processing.**

I. Introduction

Malignant melanoma is a cutaneous neoplasia composed of abnormally multiplying melanocytic or nevus cells [1]. This is the most dangerous type of skin cancer derived from melanin producing cells [2, 3]. Its early diagnosis facilitates efficient treatment. However, if diagnosis is delayed the cancer may metastasize to other organs.

Melanoma may appear spontaneously, or as a mole (melanocytic nevus) that changes in form, size, color or texture. Generally, the primary physician or dermatologist detects a suspicious nevus as a melanoma by inspection of the nevus, using the "ABCDE of lesions" mnemonic: Asymmetry, Border, Color, Diameter, and Evolution. The ABCDE classification may be subjective due to the variety of diagnoses derived from a visual perception. Nevertheless, this mnemonic, when used by a specialist, is a highly sensitive tool for identifying suspicious nevi.

In Latin America, we appear to be fighting a losing battle in decreasing mortality associated with this cutaneous neoplasia. For many patients it is difficult to be evaluated by a dermatologist because of the low specialist/population ratio and low per capita income. This issue mostly affects rural areas [4].

Our contribution is a software that is easy to use, automated, non-invasive, and inexpensive. It can be used by doctors to facilitate the detection of suspicious nevi in rural or remote areas. The software detects characteristics of malignancy according to the ABCDE classification of lesions, specifically using image recognition and artificial neural networks (ANNs). The preliminary results are promising, with high sensibility and specificity.

This article consists of the following sections: I. A brief description of melanoma, II. Melanoma as a threat to public health, III. Related work, IV. Our proposal for the early detection of melanoma, V. The software evaluation, VI. Conclusions and further work.

II. Melanoma, a threat to public health

The incidence of melanoma is higher in people of lighter skin types rather than in those with darker complexions [1]. In 2008, 62,480 individuals in the United States were diagnosed with melanoma [2, 5]. In 2014, the estimated number of new cases and deaths from melanoma was approximately at 76,100 and 9, 710 respectively [6].

The incidence of melanoma has been steadily increasing in the past 40 years. While older men are at higher risk, 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 [3].

III. Related work

Although the dermatoscope is one of the main instruments used in dermatological inspection, its use is limited to specialists in this area. Consequently, in recent years, several tools have been created that facilitate the evaluation of suspicious nevi. These can be used not just by dermatologists, but also general practitioners, and even by patients in some cases [7, 8]. There are currently up to 300 applications (or *apps*) on the market for dermatological use, with 22% of them having diagnostic purposes [9]. For example, the Australian app *doctormole* performs image evaluation of nevi using the ABCDE method and indicates the risk of a new melanocytic nevus to being malignant or not [10].

Artificial intelligence is one of the many tools being developed for the evaluation of dermatological lesions. Taouil *et al*. for example report the design of a tool for the analysis of images through ANNs reaching a sensibility of 74.9% and a

D.A. Jaffray (ed.), *World Congress on Medical Physics and Biomedical Engineering, June 7-12, 2015, Toronto, Canada*,
IFMBE Proceedings 51, DOI: 10.1007/978-3-319-19387-8_204

specificity of 76.4% [11]. Other studies have reported mobile applications with a sensibility of up to 98% and a specificity of 30.4%, but do not specify the programming language used [12, 8]. A retrospective study that took place in Taiwan compared the diagnostic capacity of CADx (computer-aided diagnosis) to that of a group of dermatologists. This study showed a sensibility of 85.63% for CADx and 83.33% for the clinical diagnoses [13]. The disparity between the results of sensibility and specificity is one of the challenges in the creation of applications for dermatological diagnosis. Other challenges found in the literature are the development of user-friendly tools for health personnel and clear evidence of clinical effectiveness [14].

IV. Solution

In order to promote the early detection of melanoma, we have developed a software that analyzes photos of nevi and detects melanoma using image processing techniques and ANNs. Although our software is based on the ABCDE classification, the pictures used to train the software are analyzed in two dimensions and thus it omits the parameters of elevation and progression of the lesion over time.

Our software consists of two tools called "Melanoma Detector Trainer" and "Melanoma Detector". These tools were developed in Matlab version R2013B. Both of them combine image processing and ANNs to rule out melanoma in suspicious nevi. The use of **image processing** techniques eliminates the interference that may be produced by hair, illumination, wrinkles, and other elements around the nevus. **ANNs** learn through patterns or examples. In an ANN, knowledge is not directly programmed but acquired through training, which adjusts its parameters of weight and size over time, to optimize its performance [15].

The ANN architecture used in this software is made up of artificial neurons interconnected and arranged in three layers (see Figure 1). Data enters through the "input layer"; each neuron in this layer contains the image of a nevus in binary format and each of the binary images is represented in a one-dimensional matrix. In the training process, the synaptic weights of connections between neurons are modified. Once the training is completed, the result is received by one neuron in the output layer. This neuron indicates whether or not the nevus is suspicious.

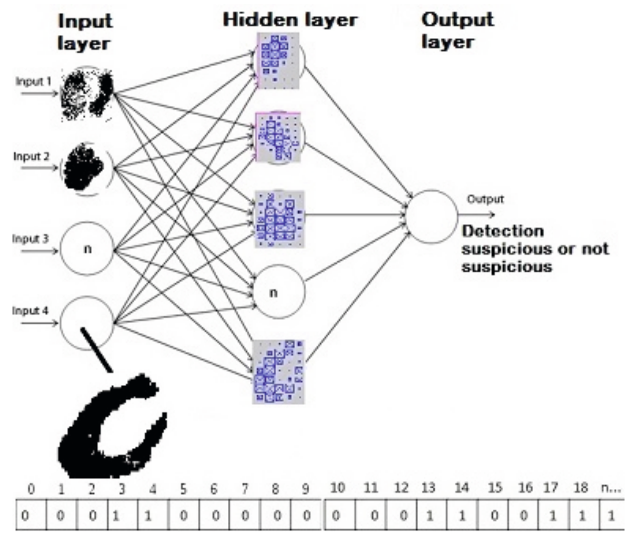

Fig.1 Structure of the artificial neural network.

A. Melanoma Detector Trainer

The "Melanoma Detector Trainer" (see Figure 2) trains the ANN using the following steps:

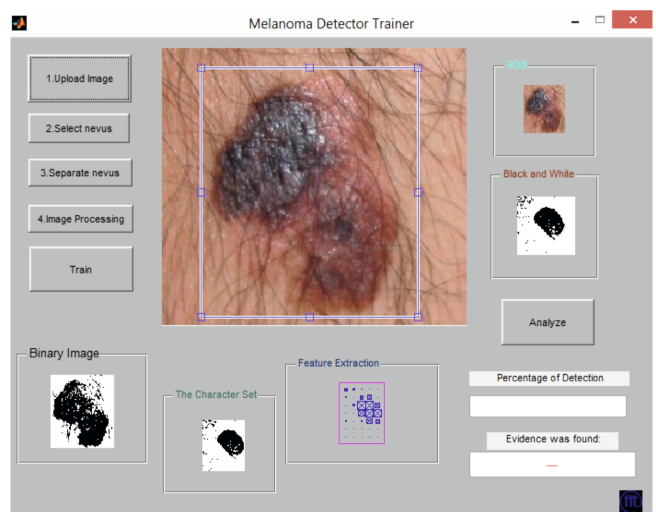

Fig.2 Melanoma Detector Trainer.

Step 1: Upload images of nevi. The software is trained with 50% of melanoma images and 50% of non-melanoma images. This percentage is used in order to balance the training and increase the probability of true positives and true negatives. The uploaded nevi photos must be captured from a distance of approximately 8 cm, thus allowing for adequate image size and minimal distortion. It is also recommended to avoid shadows or excessive brightness in the image.

Step 2: Select the nevus. On each of the uploaded images the nevus is selected by a rectangle in order to omit skin and hair around the lesion and reduce interference. 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 contains the image in binary format, which is more easily processed, and smaller in size than bi-dimensional matrices in RGB (Red Green Blue) format.

Figure 3 shows the code used for processing the image from RGB format to binary format. Once the image is uploaded, selected, and separated from the nevus, it is changed to greyscale. This image is then transformed to binary format.

```
img_crop = handles.img_crop;
imgGray = rgb2gray(img_crop);
bw = im2bw(img_crop, graythresh(imgGray));
axes(handles.binaryImage);
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. This piece of code goes through the directory with the photographs. The processed images are kept in variable *P*. Then, variable *T* is used to keep the extracted features from the images. Afterwards, the ANN is created and trained with *P* and *T*. Finally, the trained ANN is stored in a file.

```
P = trainingSet(:,1:68);
T = [eye(2) eye(2) eye(2) eye(2) eye(2)…
handles.net = createANN(P,T);
net = createANN(P,T);
save trainingANN net;
```

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

Step 5: Validate the trained ANN. In this step, the results of the trained ANN are validated for accuracy (i.e., to determine if the ANN recognizes melanoma). If the results are not satisfactory, the ANN must be re-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 the healthcare professional to evaluate nevi for suspicious signs and differentiate them from non-suspicious nevi. This tool uploads the ANN that has been previously trained by the "Melanoma Detector Trainer" (See Figure 5).

Fig. 5 Melanoma Detector.

The "Melanoma Detector" follows the first three steps that are carried out by the "Melanoma Detector Trainer". In order to detect a melanoma, the user asks this tool to determine if a particular nevus is suspicious for melanoma or not. The result states if there is any sign of melanoma with a confidence level that goes from 0% to 100%.

V. Evaluation

The evaluation was made with a set of nevi images taken from open access medical sites, dermatology books, and free online clinical images. The first test was made with a sample of 48 nevi, where 24 of them were diagnosed as malignant melanoma and 24 as benign nevi, having a sensibility of 76.06% and a specificity of 87.18%. The second test was carried out with a sample size of 30, of which 50% were diagnosed as malignant melanoma and the other 50% as healthy nevi. The sensibility and specificity achieved were 76.75% and 87.74% respectively. The last test was carried out with a sample of 50 nevi where the first half presented melanoma and the second half were healthy nevi. The sensibility reached in this third test was 76.89% and the specificity 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 confidence level increased when the Melanoma Detector Trainer was trained with a larger number of images. In other words, the error in the training of the ANN decreases with a larger amount of images.

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

In order to improve the detection efficiency for melanoma, the ANN was trained with pictures of pathological nevi that included at least one of the characteristics in the ABCDE classification method (e.g. one image fulfilled the asymmetry criterion while another fulfilled the border criterion). In some results, nevi were not able to be identified. For these cases, the software displayed the caption "nevus not identified". Only 3% of the images were not recognized by our software.

VI. Conclusions and future work

This article describes a software that enables the analysis of suspicious skin lesions for the detection of melanoma with image recognition techniques and ANNs. We plan to freely distribute this software to medical doctors in rural or remote areas. The software will allow them to carry out objective evaluations of suspicious nevi in spite of limited experience in the area of dermatology and/or the lack of state-of-the-art equipment. Other variables will be added to the software´s evaluation of the patient, such as: geographical location, skin tone, location of the nevus on the body, and the patient´s age. We hope to exclusively use normal nevi pictures taken by our team for software training in order to obtain a more solid nevus triage system. Alongside the acquisition of normal nevi pictures, we hope to develop a bank of clinical images with biopsy-diagnosed melanoma in people of Latin American origin. This will be of great importance in Latin America because as far as we know, there is still no such bank of clinical images of melanoma for our population.

References

1. Du Vivier, A., P. H. McKee, et al. (2002). Atlas of clinical dermatology, Churchill Livingstone Edinburgh.
2. Díaz-González, J., A. Peniche-Castellanos, et al. (2010). "[Skin cancer in adults younger than 40 years at the General Hospital of Mexico]." Gaceta medica de Mexico **147**(1): 17-21.
3. Siegel, R., J. Ma, et al. (2014). "Cancer statistics, 2014." CA: a cancer journal for clinicians **64**(1): 9-29.
4. Sortino-Rachou, A. M., M. P. Curado, et al. (2011). "Cutaneous melanoma in Latin America: a population-based descriptive study." Cadernos de Saúde Pública **27**(3): 565-572.
5. Erdmann, F., J. Lortet-Tieulent, et al. (2013). "International trends in the incidence of malignant melanoma 1953–2008—are recent generations at higher or lower risk?" International Journal of Cancer **132**(2): 385-400.
6. Corona, R., A. Mele, et al. (1996). "Interobserver variability on the histopathologic diagnosis of cutaneous melanoma and other pigmented skin lesions." Journal of clinical Oncology **14**(4): 1218-1223.
7. Börve A, Terstappen K, Sandberg C, Paoli P. Mobile teledermoscopy—there's an app for that! Dermatol Pract Conc. 2013; 3(2):5.
8. Wolf J., *et al*. Diagnostic Inaccuracy of Smartphone Applications for Melanoma Detection. JAMA Dermatology. 2013; 149(4):422-426.
9. Chang-Brewer, *et al.* Mobile Applications in Dermatology. JAMA Dermatology. 2013 Nov; 149(11):1300-1304.
10. Revosoft. Doctor Mole - Skin Cancer App [Internet]. http://www.doctormole.com/
11. Taouil K., Chtourou Z. Romdhane N. A robust system for melanoma diagnosis using heterogeneous image databases. Biomedical Science and Engineering. 2010; 3: 576-583.
12. Seidenari S., Pellacani G, Grana C. Asymmetry in Dermoscopic Melanocytic Lesion Images: a Computer Description Based on Colour Distribution. Acta Derm Venereol. 2006; 86: 123–128.
13. Chang W-Y, Huang A, Yang C-Y, Lee C-H, Chen Y-C, et al.Computer-Aided Diagnosis of Skin Lesions Using Conventional Digital Photography: A Reliability and Feasibility Study. PLoS ONE. 2013; 8(11): e76212.
14. Ferrero NA, Morrell DS, Burkhart CN. Skin scan: a demonstration of the need for FDA regulation of medical apps on iPhone. J Am Acad Dermatol. 2013 Mar; 68(3):515-6.
15. Rajasekaran, S. and G. V. Pai (2011). Neural networks, Fuzzy logic and Genetic algorithms, PHI Learning Private Limited.

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