

## Development and validation of an artificial neural network to support the diagnosis of melanoma from dermoscopic images

*Desenvolvimento e validação de rede neural artificial para suporte ao diagnóstico de melanoma em imagens dermatoscópicas*

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### ABSTRACT

**Introduction:** With the advancement of digital image analysis, predictive analysis, and machine learning methods, studies have emerged regarding the use of artificial intelligence in imaging tests such as dermoscopy.

**Objective:** Construction, testing, and implementation of an artificial neural network based on characteristics of dermoscopic images.

**Methods:** 1949 images of melanocytic nevi and melanomas were included, both from the authors' files and from dermoscopic image banks available on the internet, and routines and plugins were developed to extract 58 features applied to a multilayered neural network construction algorithm. Also, 52 dermatologists assessed 40 random images and compared the results compared.

**Results:** The training and testing of the neural network obtained a correct percentage of classification of 78.5% and 79.1%, respectively, with a ROC curve covering 86.5% of the area. The sensitivity and specificity of dermatologists were 71.8% and 52%. For the same images and a cutoff point of 0.4 (40%) of the output value, the application obtained 62% and 56% values, respectively.

**Conclusions:** Multilayer neural network models can assist in the dermoscopic evaluation of melanocytic nevi and melanomas regarding the differential diagnosis between them.

**Keywords:** Artificial intelligence; Diagnosis; Melanoma; Nevus

### RESUMO

**Introdução:** Com o avanço da análise digital de imagens, análises preditivas e métodos de aprendizagem de máquina, surgiram estudos referentes ao uso da inteligência artificial nos exames de imagem como a dermatoscopia.

**Objetivo:** Construção, teste e implementação de uma rede neural artificial baseada em características de imagens dermatoscópicas. **Métodos:** Foram incluídas 1949 imagens de nevos melanocíticos e melanomas, tanto de arquivos dos autores, quanto de bancos de imagens dermatoscópicas disponíveis na internet, e desenvolvidas rotinas e plugins para a extração de 58 características aplicadas a um algoritmo de construção de rede neural multicamadas. Quarenta imagens aleatórias foram também avaliadas por 52 dermatologistas e os acertos comparados.

**Resultados:** O treinamento e o teste da rede neural obtiveram uma porcentagem correta de classificação de 78,5 e 79,1%, respectivamente, com uma curva ROC abrangendo 86,5% da área. A sensibilidade e especificidade dos dermatologistas foi de 71,8 e 52%. Para as mesmas imagens e um ponto de corte de 0,4 (40%) do valor de saída, o aplicativo obteve valores de 62 e 56%, respectivamente. **Conclusões:** Modelos de rede neural multicamada podem auxiliar na avaliação dermatoscópica de nevos melanocíticos e melanomas, quanto ao diagnóstico diferencial entre eles.

**Palavras-chave:** Diagnóstico clínico; Inteligência artificial; Melanoma; Nevos e melanomas

## Original article

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## INTRODUCTION

Melanoma, like most cancers, has a better prognosis and availability of less morbid treatments if diagnosed early. There are several tools for the early diagnosis of melanoma. Dermoscopy is the most prominent one given the accessibility of the skin to visual assessment and the practicality of the exam. Also, it can be performed on an outpatient basis at the time of dermatological consultation.<sup>1</sup>

Despite being widely used, its increased diagnostic accuracy for melanoma compared to examination with the naked eye has been more effectively evidenced in the last two decades. A meta-analysis published in 2008 showed a significant increase in sensitivity, from 71% to 90%, but no significant difference in specificity. Likewise, Hoorens et al. identified a 3.5% reduction in specificity despite a substantial increase in the sensitivity for diagnosing malignant skin neoplasms.<sup>2-4</sup>

With the advancement of digital image analysis, predictive analysis, and machine learning methods, studies regarding the use of artificial intelligence in imaging exams such as dermoscopy have emerged. Thus, the results obtained by convolutional neural networks with thousands of neurons stand out, and recent studies indicate diagnostic accuracy for melanoma superior to the examination by specialists. On the other hand, such mathematical models and algorithms usually require high computational power to obtain the results.<sup>5,6</sup>

Less complex models of predictive analysis or artificial intelligence through machine learning have a lower computational cost. They can be applied as collaborative tools in dermatological assessment, although they may present less accurate results.<sup>7,8</sup>

In the present study, we constructed, tested, and implemented an artificial neural network based on global dermoscopic imaging of melanocytic nevi and melanomas to predict the type of image analyzed.

## METHODS

Images of melanocytic nevi and melanomas were included, both from the authors' files and from dermoscopic image banks available on the internet (The International Skin Imaging Collaboration - ISIC - <https://www.isic-archive.com/>). We included only images of lesions with a histopathologically confirmed diagnosis, and non-pigmented lesions. We excluded non-pigmented lesions, with coarse hair, of the mucosa, in the nail or palmoplantar region, or those that extrapolated the image field of the dermoscopic photo for better performance of the model. Images that showed peripheral objects, such as dermoscope edges, were cut in a rectangular shape to exclude them (Figure 2-A, D).<sup>9</sup>

The study was conducted between April and July 2018. The images were pre-processed using the imageJ 1.48 software, and routines and plugins were developed to extract 58 image characteristics. After segmentation between lesion and background, image features included the distribution, variability and

color entropy (25 items), histogram (16 items), shape (five items), borders (four items) and size (two items), and the distribution of shape filters applied to the image (six items). Each image was assessed in two different dimensions to reduce the effects of cropping objects. However, overall, the lesions covered more than one-fifth of the pixels in the images submitted to feature extraction.

The 58 characteristics obtained from each of the 1,949 images (50.3% melanoma) were tabulated and analyzed using the IBM SPSS 20v software (Multilayer Perceptron Network) with the standardization of input data. The sample was divided into 80% training and 20% testing, with hyperbolic tangent activation function, softmax function output, and optimization conjugate gradient method, obtaining a network with a hidden layer of seven perceptrons.

A percentage value (pseudoprobability) resulting from the softmax function in the output layer, ranging from 0-100%, characterizes the result of the neural network. So values higher than 50 were predicted as melanoma and values lower than 50, as nevus (Figure 1).

With an average of 9.3 years of dermatological practice and 7.6 years of dermoscopy use, 52 dermatologists randomly selected 40 images from the image bank excluded from the neural network training. The evaluators were informed that these were melanocytic lesions and answered whether each lesion was benign or malignant (including in situ).

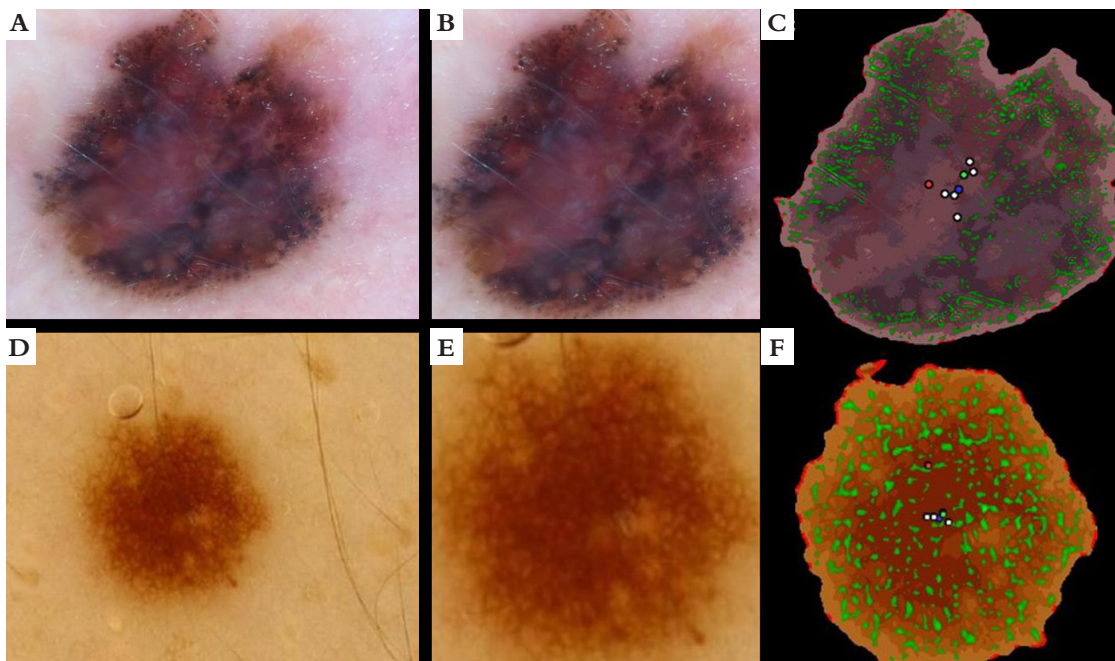
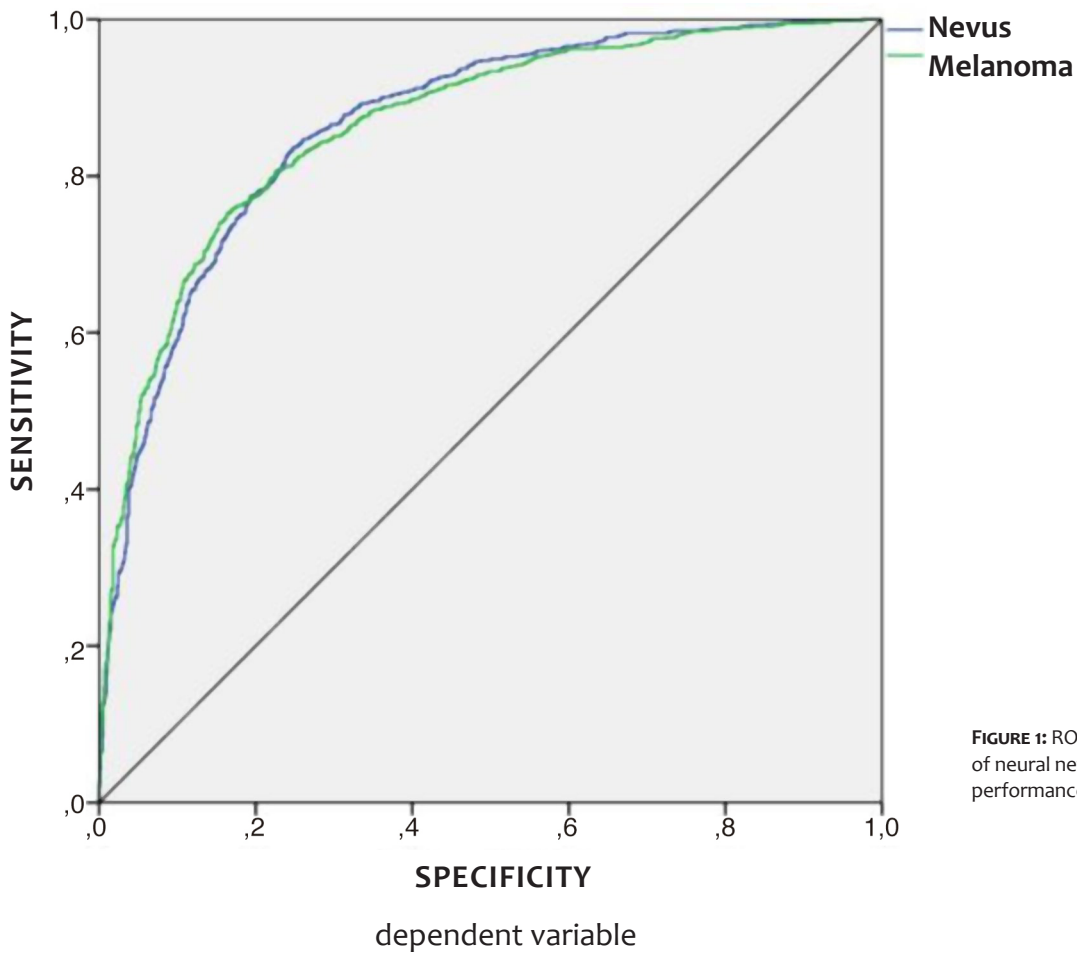
## RESULTS

The training and testing obtained a correct rating percentage of 78.5% and 79.1%, respectively, with a ROC curve covering 86.5% of the area (Figure 1). The weights and parameters obtained from the neural network were used to develop an application (Figure 2) hosted on a public web server, allowing the experimental online evaluation of dermoscopic images (<http://200.145.131.197/mmview/index.php/>).

Difficulty or uncertainty in analyzing lesions by dermatologists had a mean value of 3.3 on a scale of 0 to 5. The overall sensitivity and specificity of the 2,080 assessments by dermatologists were 71.8% and 52%, respectively. For the same images and a cutoff point of 0.4 (40%) of the output value, the application obtained 62% and 56% values, respectively.

## DISCUSSION

The study results demonstrate that less complex predictive methods such as artificial neural networks can bring significant results despite their limitations. The online and open availability of the studied algorithm can add information in decision-making about melanocytic lesions, mainly when more extreme values are obtained. Nevertheless, it should be recognized that the tool has performance limitations. It was trained only with selected images of nevi and melanoma, not with coarse hair or pigmented lesions.



**FIGURE 2:** Examples of analyzed melanoma and nevus images

A - Melanoma image submitted;  
B - Selected area cropped;  
C - Illustration of characteristics found, including distribution of color clusters, sharp edges, and shape filters (final score = 98,4%);  
D - Nevus image submitted;  
E - Selected area cropped;  
F - Illustration of characteristics found (final score = 7%)

Other classification algorithms such as k-nearest neighbors algorithm (k-NN) and Support Vector Machine (SVM) may have different performances than the artificial neural network, and the group will explore them later. Also, extracting new variables from image analysis can lead to system performance gain.<sup>10</sup>

Computer vision methods have evolved significantly with cloud computing-based systems, spreading the use of convolutional neural networks with up to billions of neurons. Still, they depend on a high number of images for learning and sig-

nificant maintenance costs. Nevertheless, machine learning will probably become more frequent in medical activities, especially in image analysis, as it is in other human activities.

## CONCLUSIONS

We developed and implemented a neural network based on dermoscopic images, which can collaboratively assist in the differential diagnosis between melanocytic nevus and melanoma. ●

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