Design of a System for Melanoma Detection Through the Processing of Clinical Images Using Artificial Neural Networks

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Abstract. Skin cancer is one of the most important challenges in modern medicine, especially skin melanoma, being the main causer of deaths for this disease. Images analysis is one of the most transcendental techniques for Melanoma early detection as a prevention method. Artificial neural networks are one of the many developed techniques for images digital processing and characteristic similarities detection. In this work a graphic processing unit (GPU) is developed for clinical skin images analysis getting through an artificial neural networks system for similar patterns detection through processing in a collection of modules tasked of silhouette detection of the object to analyze into the image, and tasked to study borders or contour to determinate a final diagnostic, the dataset used for the training of the artificial neural network designed is gotten from the MED-NODE project and project of international skin images collaboration (ISIC) with 730 images of positive and negative cases as full, the proposed system presents finally an accuracy level of 76.67%, with a level of success of 78.79% in melanoma specific cases, and 74.07% in benign lesions cases.

Keywords: Neural networks, Deep learning, Clinical diagnosis, Patterns recognition.

1 Introduction

In last 40 years the progressive increase of people affected by cutaneous melanoma in the world has been seen, because of this, the interest in the study of this disease has evolved to become the focus of a large number of scientists around the world. Cutaneous melanoma is supposed as the leading cause of death from skin cancer actually, producing 3 of every 4 deaths due to such, and representing the 1-2% of all death causes in the world[1]. In Colombia there is not specific statistical data official on the affectations of neoplasms or cutaneous abnormal formations associated with melanoma on the population of the country, although cancer is a disease of priority concern, as set out in the Act 1384 of 2010[2].

Medicine is one of the elements that most beneficiaries can see by near interaction with computer systems, different computing algorithms have been developed with the aim of preventing the cutaneous melanoma disease, besides a lot of methods have been developed in dermatology for skin cancer prevention as ABCD (asymmetry, borders, color, diameter) rules that describe a set of general elements for recognition of positive cases of melanoma, or the seven points of Glasgow[3] which determines a set of criteria for the detection of skin cancer, it's used as a method of complementation to the analysis made by the use of the ABCD rules.

This paper proposes a deigned system in base of artificial neural networks for melanoma detection through the processing and analysis of clinical images, the main objective is to develop an automated system using computation tools for to do diagnostics associated with skin cancer. In the previously raised context, it's designed a structure for the analysis of skin lesions based on investigations made by different institutions and the progress made on the issue until today.

2 Related works

In recent years there is a significant number of works focused on the detection of Melanoma and techniques of image processing to prevent skin cancer, different models of analysis have been developed on different platforms and with different approaches to the treatment of medical information.

Joseph and Panicker[4] propose a system of analysis of skin lesions for quick melanoma detection with an effective method of segmentation through techniques of image processing and mobile technologies, they develop a series of stages of image preprocessing, subsequent to the detection and extraction of the hair to make a direct analysis on the skin, with the obtained information in the processing of images designed, a rating system for the results obtained is done in a set 3 possibilities (benign, atypical and melanoma) producing results with a high degree of effectiveness. A very similar work is made by Soumya et al[5] where they propose an algorithm of early detection of melanoma through the use of a system of description and colour analysis, here the develop a set of phases for the image processing which includes different filters and segmentations for the analysis of them, finally they conduct tests with a set of 200 images with highly effective results (91.5%) on the implemented system.

Lugo, Maldonado and Murata[6] perform an study of artificial intelligence to assist clinical diagnosis, within the research made a brief overview of the uses of different systems of machine learning in the history of medicine, they also do a study related to the advantages offered by these systems to the traditional statistics, within the work an specific section is made to refer to the use of artificial neural networks in medicine, foregrounding the flexibility and dynamism offered by these systems and explain generally the operation.

Mentioned related works have a high interrelation with the work of the proposed investigation of this document, there is a lot of progress in image processing, however the most common method, thanks to its effectiveness over several years are neural networks, in this context, different scanned works provide a set of tools associated with the management of this technique in areas of medicine as [6][7], other revised research papers analyze different characteristics associated with the identification of cutaneous melanoma, and determining techniques of segmentation of images for the recognition and classification, allowing the production of a more effective final result, in conclusion, the literature review provides an important set of tools that allow to make a work guided as a full element of possibilities, and where it's possible to explore different techniques to maximize the efficiency of the project.

3 Proposed system design

There are many methods for Melanoma detection through images processing through the determination of characteristics, Barata et al [8] do a work for the detection of Melanoma through the use of two systems based on the analysis of the characteristics of texture and color respectively, within the work is taken as a fundamental base the analysis of the features provided by the ABCD criteria, from which information can be fully relevant for the early detection of skin cancer [9].

Measurement of the ABD (asymmetry, borders and diameter) criteria can be obtained through the analysis of the generation of the mask at the binary level of the analyzed image, however to obtain an image with a high amount of information is required a preprocessing phase allowing to improve quality through a set of filtering techniques that enable to obtain a better result of the characteristics seeking to analyze, and at the same time eliminate the noise of photography [10].

In Figure 1, can be seen the scheme of the structure for the stage of analysis and classification of the analyzed image.

Fig. 1. Scheme of the main stages of the system. Source: Authors

3.1 Preprocessing

For the development of the system a preprocessing phase is performed which seeks to apply a set of fixes to the image before the phase of analysis conducted with the expert system, the target is to make the generation of a mask from the image that allows to define the texture of the lesion in a base of white and black that can be represented in binary form (0 and 1) to ensure the elimination of noise in the image and obtain the texture defined edges is used the Canny's method, an algorithm developed with the aim of achieving the elimination of noise by three mathematical threads that involve the calculation of the magnitude and orientation of the gradient vector at each pixel within the first phase known as the obtaining of the gradient , the thinning of the width of edges obtained with the gradient until edges of a pixel of width within the second phase known as non-maximum suppression, and the application of a function of hysteresis based on two thresholds in the final phase known as threshold hysteresis; This process is intended to reduce the possibility of appearance of false contour[11].

Figure 2 shows the stage of preprocessing the image with the help of software MATLAB R2016a and its Toolbox for image processing [12], where applies corrections series based on the phases of input, correction of lighting, step to grayscale and generation of mask in black and white for the segmentation of the image serving the process specified in Figure 1.

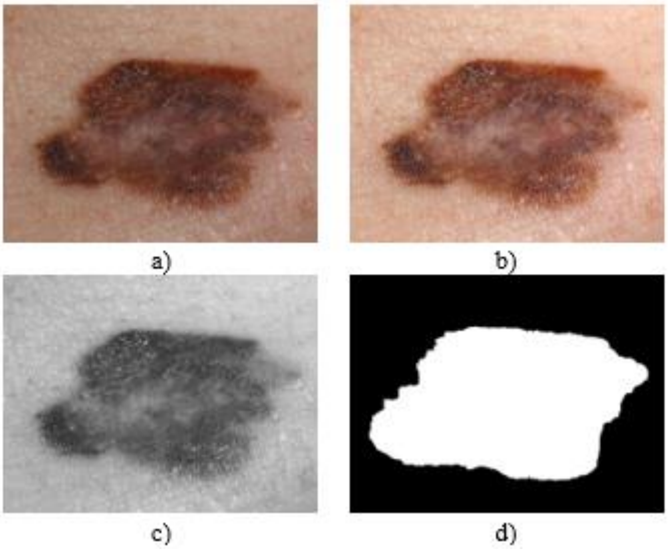


Fig. 2. Preprocessing of the image. a) Input image. Source:[13] b) Illumination correction. c) Grayscale. d) Gaussian filter and mask generation.

3.2 Artificial neuronal network architecture

For the image processing is necessary use a convolutional neural network system, these systems are designed for machine vision tasks, and have a high degree of efficiency in the recognition of characteristics in digital images and their subsequent classification [14].

The neural network Convolutional posed to implement for the recognition and diagnosis of Melanoma consists of six layers, each layer has an output consisting of a set of images or drawings, which is commonly awarded them the name "features maps", which are composed of sets of neurons, neurons located within a map of features connect with neurons hosted on the following maps only through connections called fields of projection also normally known as convolution masks [15].

In Figure 3 can be seen the scheme of the layered architecture in the convolutional neural network designed for Melanoma detection system:

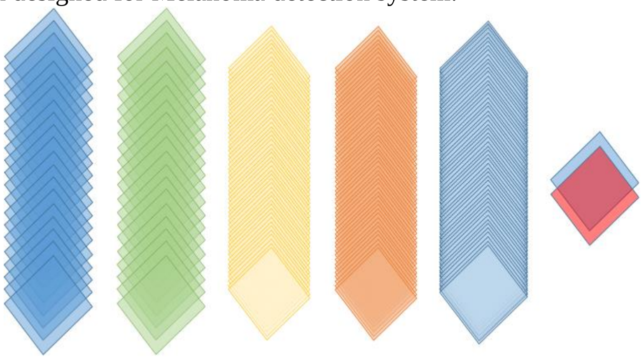


Fig. 3. Convolutional neural network architecture. Source: Authors.

The first layer of the convolutional neural network (C1) has twenty five features maps, each unit present in twenty five maps of features are connected with a set of 20 units or pixels in the input image represented by neighborhoods of 5 x 5, each connection with the elements of the image has a trainable and shared weight for each of the units on the map each map feature consists of a set of 255 x 255 units, within this first layer is made using Gabor filters that allow the segmentation of texture and is often the first stage of processing of images within convolutional neural networks systems [16], After the first layer follows a stage of subsampling, also known in some cases as a grouping layer, belonging to this stage, next layer (S2) has fifteen maps of features with a size of 60 x 06 units, the connections of this stage are carried out with a set of 20 units of the previous layer formed by a neighborhood of 5x5 elements, subsampling layers have functions of averaging, in this layer each unit is responsible for calculating the sum of the four pixels corresponding stage or layer above (C1), the number of connections between the S2 and C1 there are not trainable elements or changes or functions on images.

4 Results and discussion

When the stage of training is done nest is to determine the proper functioning of the network and a respective percentage of accuracy, for the realization of these tests it's used a processor Intel core-i5 3337U, with RAM memory 6GB and graphics processing (GPU) with NVIDIA GeForce GTX graphics card unit.

To perform the test on the implemented system of neural networks used a random number generator that selects the sample used in initial tests of efficiency on the network, so the images are tested within the system in a non-concurrent order and with uniform distribution by simulation of the system in accordance with the Royal field of data entry the algorithm used for the selection of the images is the congruential mixed method, this method is the most widely used for the generation of random numbers, and most suitable to use with the necessary parameters to each test image is assigned an index that is associated with the number obtained through generator.

The generator based on mixed congruential used the following equation:

$$X_i = (aX_{i-1} + b)mod(m) (1)$$

Where m = 256, b = 191, c = 31, and seed Xo = 255, these values are defined, since they meet the basic conditions for the achievement of a maximum period, which ensures the non-existence of repeated numbers.

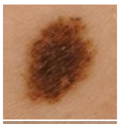
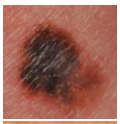
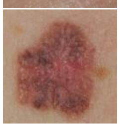
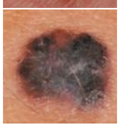
In table 1 can be seen some of the images used for the analysis with the order given by the random number generator, with their respective test within the network mounted, and the evaluation of the result on the basis of the actual values of classification, the set of test images is obtained from the project MED-NODE[7] and the international collaboration of melanoma images project (ISIC)[17]

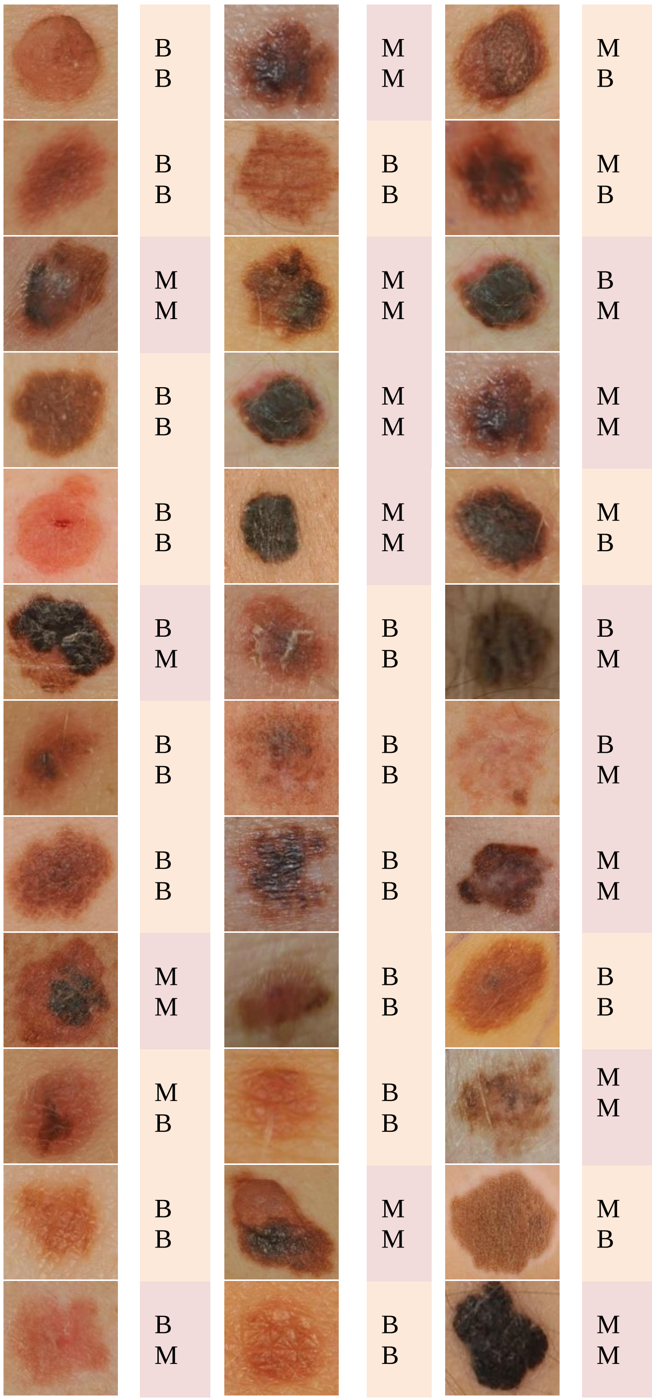
The notations used in the table are:

- M: Malignant
- B: Benign

The first abbreviation represents the classification given by the system to the image, the second abbreviation represents the actual classification.

Table 1. Results of test on designed neural network.

	M M		B B		B B
	M M		M B		M M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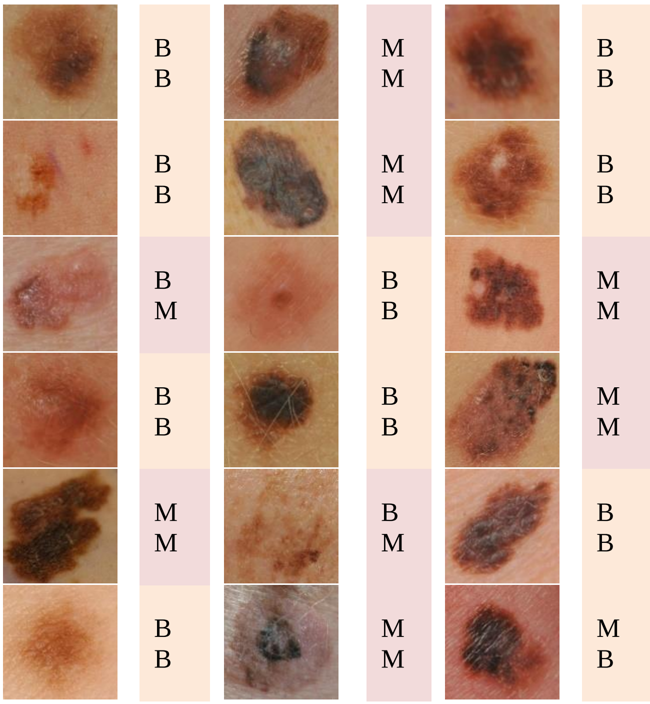

The results of the analysis of the network show efficiency of 77.50% of analyzed images, with a correct result in 155 of the 200 analyzed images, in this context, the Internet presents a good average in the classification of the images, however the results present a level of less than some of the work effectiveness as detailed later defined in table 2 results obtained with respect to the level of success for each classification:

Table 2. Percentage of accuracy in results

	# images	# correct classification	% accuracy
Benign	89	67	75,28%
Malignant	111	88	79,27%
Total	200	155	77,50%

Comparing the level of effectiveness of the implemented neural network with techniques as Delaunay triangulation[18] arises where a percentage of success of 66.7% for Melanoma images, greater efficiency is presented in the accuracy of records of melanoma, about to the approach by natural computing technique [19], similar results are gotten, with a percentage of success of 80%, the detection of melanoma through geometric characteristics project [20] obtained a level of success to 89% with a rate of success higher than the proposed project, the technique of color correlogram [5] has a level of 91.5% efficiency with the use of a Bayesian classifier, as same than the segmentation technique for classification of the nearest neighbors[21] presenting even a level of highly superior efficiency compared to other work of the project and the proposed system, however these projects are analyzed only with efficient lighting condition images, leaving in doubt the level of efficiency in other conditions.

Figure 4 expresses the results in base of images of melanoma and benign on the proposed system, and works taken as help, next notations used are described:

- TD: Delaunay triangulation
- CN: Natural computing
- CG: Geometric features
- CC: Color correlogram
- VC: Nearest neighbors
- RN: Neural networks

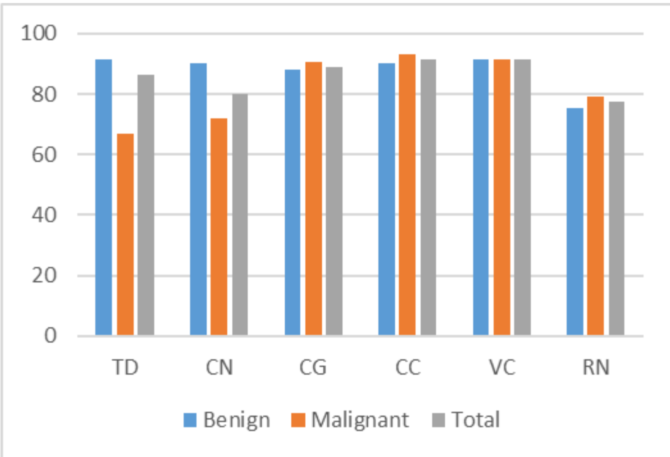

Fig. 4. Accuracy percentage in images classification. Source: Authors

In the presented context, results obtained in the study presented a suitable percentage of approximation of 77.50% through the structure of the proposed network, however, other techniques far outweigh it, being necessary to specify that performance tests are performed using different conditions and ideal illumination states, artificial neural networks are one of the techniques of most renowned for the digital processing of images, every day new techniques and models based on different algorithms that can exceed the normal functioning of these and their efficiency in the classification of images appear.

5 Future works

Deep learning trends have allowed to develop new techniques aimed at improving the capacity of the systems in the accuracy of the results, one of the elements that emerged recently within the study of artificial intelligence systems is the concept of auto-organization which represents through unsupervised learning process which will let discover features, relations, significant patterns or prototypes in the dataset used[22], within the framework of convolutional neural networks, the concept of auto-organization is an important approach in processing images in convolutioa neural networks systems, as it allows to increase the level of representation of the features extracted by the expert system through the use of maps features auto-organized[22]. Currently it is a little-known, still under development and under research model, however its implementation can be a key element to improve the level of accuracy of the systems of images processing, which could represent future work with significant influence within the study of medicine.

6 Conclusions

Image use dermatological as element base for medical studies of skin cancer has allowed dealing with large property diseases of high relevance and care through telemedicine, making it an essential tool for the creation of new replacements trends in conventional medicine. This work has dealt with a complex method of deep learning based on clinical images getting a percentage of success on the analysis of images of 77,50%, the factor in conditions of illumination in the figures has been the main element affecting the effectiveness of the system, however the results are satisfactory in a large percentage , in Figure 5 can be seen some examples of images with incorrect results, in them is shown illumination conditions that affected the efficiency of the system.

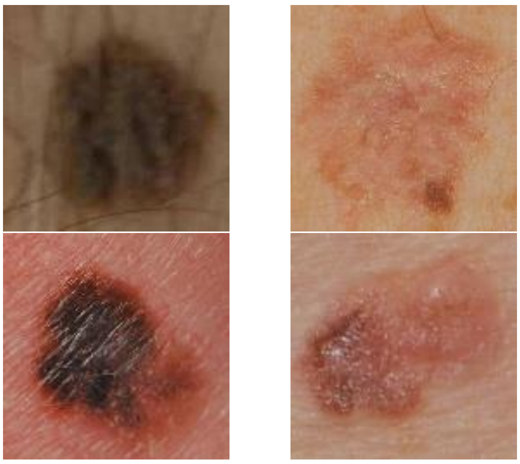

Fig. 5. Incorrect results images. Source: Authors.

Features extraction method used in the proposed project is implemented Convolutional neural network task, while in all projects related, the characteristics of the lesions are extracted data direct, which represents an important advantage over the related work, however most of the works used in the comparison of results have a higher level of accuracy based on the metric used However in the case of melanoma detection system presents a broad improvement over method of Deulanay's triangulation and natural computing, which represents an important element considering that these cases are those who represent the real cause of the alert in the context where the project develops.

In table 3 we can see a quantitative comparison of the obtained results with other related works.

Table 3. Quantitative comparison of results

	Benign	Malignant	Total
TD[18]	91.5%	66.7%	86.6%
CN [19]	90%	72%	80%
CG [20]	88%	90.5%	89%
CC[5]	90%	93%	91.5%
VC [21]	91.5%	91.5%	91.5%
RN	75.28%	79.27%	77.50%

Having in mind the problem with the illumination conditions of the images and their negative effect on the analysis of them, work to assess such as improvement of the current system proposed must focus fully on image preprocessing stage, rather than in the network architecture, this implementation would increase the accuracy of the system.

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