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A decision support system for the diagnosis of melanoma: A comparative approach

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ABSTRACT

Melanoma is the most deathful of all skin cancers and the number of cases grows every year. The extirpation in early phases implies a high degree of survival so it is fundamental to diagnose it as soon as possible. In this paper we present a clinical decision support system for melanoma diagnosis using as input an image set of the skin lesion to be diagnosed. The system analyses the image sequence to extract the affected area, determinates the characteristics which indicate the degree of damage and, according to them, it makes a decision. Several methods of classification are proposed: a multilayered perceptron, a Bayesian classifier and the algorithm of the *K* nearest neighbours. These methods work independently and also in combination making a collaborative decision support system. The classification rates obtained are around 87%.

1. Introduction

The incidence of melanoma skin cancer has been increasing over the past decades. Since the early 1970s, melanoma incidence has increased significantly, for example an average 4% every year in the United States. Currently, 132,000 melanoma skin cancers occur globally each year (World Health Organization, 2010).

Melanoma is the most deathful of all skin cancers. The main cause of melanoma is due to a long exposition to ultraviolet radiations, although skin type or other genetic factors can influence too. The most effective treatment is an immediate extirpation, but just when the melanoma had been detected in early phases (Geller, Swetter, Brooks, Demierre, & Yaroch, 2007). In other cases, if it is not diagnosed in time, the life expectancy is reduced up to less than one year. Therefore, it is fundamental to distinguish as soon as possible between benign lesions (as a simple spot or a mole) and melanomas. Dermatologists employ for their diagnosis several techniques which have been developed based on experience, among which it is emphasized to obtain the total dermatoscopy score based on the mnemonic ABCD (Stolz, Rieman, & Cognetta, 1994), the rule of 7 points (Argenziano et al., 1998) and the method of Menzies (Menzies, Ingvar, Crotty, & McCarthy, 1996). All these techniques allow identifying symptom of a malignant lesion based on the observation of a set of characteristics using dermoscopy images. Even so, in some cases it could be a hard task, the interpretation of these properties visually, and therefore, to make a right diagnosis.

We propose a clinical decision support system that classifies images with suspicious skin lesions in order to manage a referral list to the specialist. The patients whose images present a high probability of being a melanoma will be referred to the dermatologist as soon as possible. There are other clinical decision support systems implemented with this idea of managing a referral list; one example is the ERA (Early Referral Application), a system to support family doctors in identifying patients with suspected cancer that should be referred to a specialist in a short time period (Coiera, 2003). The system can also be used by a dermatologist as a second expert opinion to complement and compare his decision. It is important to bear in mind that the clinical diagnosis of melanoma depends on the dermatologist's experience (Kittler, Pehamberger, Wolf, & Binder, 2002) so a second opinion can be important for a dermatologist in a training period or at the beginning of the professional activity.

The system bases its automatic diagnosis in three phases: detection, description and classification of the lesion (Fig. 1). In the first phase a preprocessing of image is done which allows us to identify the affected area. Afterwards, in the description phase, the image to determinate the optimum set of characteristics which indicate the degree of malignant tissue is analysed. Finally, this characteristics vector is used as the input of an artificial entity that is able to offer a diagnosis of the lesion, classifying it as a melanoma or a benign lesion. The entities proposed here are the method of the *K* nearest neighbours, a parametric classifier based on the decision theory of Bayes, a multilayer perceptron and the combination of these three methods in a voting collaborative system.

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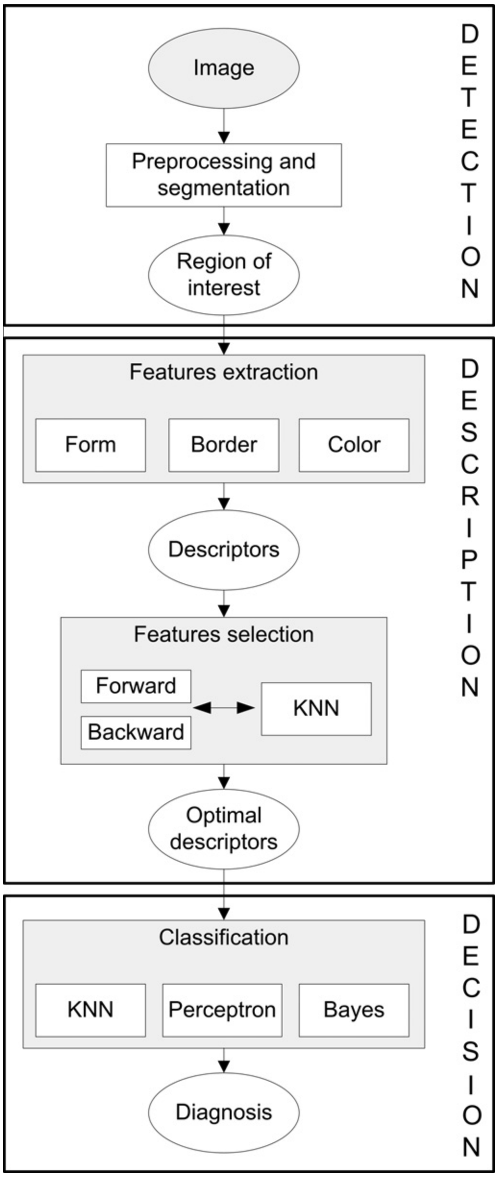

Fig. 1. Phases of the clinical decision support system to diagnose melanoma.

2. Related work

The importance of the topic is patent if we analyse the enormous quantity of researches related with the melanoma diagnosis using different ways to analyse the images automatically (Malene, Vestergaard, & Menzies, 2008). Sometimes, it is possible that software can recognize features when the eye cannot and therefore improve the diagnostic accuracy. In this section we will show some of these researches, related with the work we present.

Dermoscopy is a non-invasive examination technique based in the use of incident light and oil immersion to make possible the visual examination of subsurface structures of the skin. The rate of detection of melanoma using dermoscopy is higher than detection only with unaided observation (Kittler et al., 2002). In any case, the diagnostic accuracy of dermoscopy is also depending on the training of the dermatologist.

We can find several methods that use dermoscopy images. For example, the method presented in (Ganster et al., 2001) implements a segmentation of the affected area applying different types of algorithms (thresholding in the blue plane, searching 3D colour sets, etc.); afterwards they calculate a set of radiometric characteristics, and global and local parameters to describe the malignity of the lesion; finally, the more significant characteristics are selected using statistical methods. The work presented in (Schmid-Saugeon, Guillod, & Thiran, 2003) consists on a system for melanoma diagnosis taking into account border detection and quantification of asymmetry rate; its outline detector employs a technique based on clustering with fuzzy *C*-means algorithm and classification is based on a rate of symmetry quantification uniquely with a six dimensions vector. Other works, as the presented in (Zagrouba & Barhoumi, 2005), use the segmentation by pixel adding with a previous processing based on fuzzy sets; an attribute series is extracted from the detected area and processed by a neuronal network to distinguish between melanomas and benign lesions.

An interesting approach is the use of different techniques combined to improve the accuracy of the classification. For example, in (Sboner et al., 2001) the system introduced detects the lesion using a thresholding technique based on the red component and the saturated component; the system extracts a colorimetric and geometric characteristic set, with which a diagnosis is performed using a voting system, taking into account the produced results by different instances of the *K* nearest neighbours algorithm. In (Kreutz et al., 2001) a classification method for tissue lesions based on the use of artificial expert entities is proposed; a set of characteristics related to the lesion asymmetry, uniformity of outline and tissue, is determined and they will be employed for training a multi-agent classifier. This multi-agent is composed by a series of neural networks managed by a master entity that gives input vectors and generates a final diagnosis adjusted to the output of its different components.

A modern method for the assessment of melanoma is the lacunarity analysis (Gilmore, Hofmann-Wellenhof, Muir, & Soyer, 2009). Lacunarity is a measure used to characterize a property of fractals and quantifies aspects of patterns that exhibit changes in structure; lacunarity measure can reveal additional information regarding the geometric structure of melanocytic lesions and it is possible to distinguish melanoma from non-melanoma lesions with a 91% of sensibility and a 61% of specificity. The main problem of this algorithm is the low specificity; this means that the algorithm can diagnose a non-melanoma as a melanoma so it is not very useful to reduce the number of useless biopsies.

As we can appreciate, most of the researches related to an automatic melanoma diagnosis are based on techniques such as the algorithm of nearest *K* neighbours or neuronal networks, although there are other techniques that use lineal classifiers or image interpretation methods. Nevertheless, we have not found any work incorporating classifying methods based on statistics. In our work, we propose a classifier method based on Bayes theorem, and we compare his results with a multilayer perceptron and the algorithm of *K* nearest neighbours. Furthermore, very few works are found where different individual methods are used to constitute a voting system in which each input brings its decision with a determined weight. We also analyse a voting system combining the methods developed in the work.

3. Detection of the lesion

3.1. Preprocessing

In order to do a diagnosis, before the image processing, we must solve several important problems related to the image type which the system is dealing with. In the first place, captures of human tissues could present hair or pores, which may mislead the segmentation process. The immediate solution would be shaving the hair before imaging sessions, but it is a process that, apart from increasing costs and time for obtaining samples, it is uncomfortable for the patient and it is impractical in many cases. In these