Optik 140 (2017) 749–761

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Original research article

Segmentation and classification of melanoma and benign skin lesions

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ARTICLE INFO

Article history:
Received 24 September 2016
Received in revised form 16 April 2017
Accepted 23 April 2017

Keywords:
Computer-aided diagnosis
Melanoma
Segmentation
Ant colony
Feature extraction
Dermoscopy
K-Nearest Neighbor
Neural network

ABSTRACT

The incidence ofmalignant melanoma has been increasing worldwide. An efficient non-invasive computer-aided diagnosis (CAD) is seen as a solution to make identification process faster, and accessible to a large population. Such automated system relies on three things: reliable lesion segmentation, pertinent features' extraction and good lesion classifier. In this paper, we propose an automated system that uses an Ant colony based segmentation algorithm, takes into consideration three types of features to describe malignant lesion:geometrical properties, textureand relative colors from which pertinent ones are selected, and uses two classifiers K-Nearest Neighbor (KNN) and Artificial Neural Network (ANN). The objective of this paper is to test the efficiency of the proposed segmentation algorithm, extract most pertinent features that describe melanomas and compare the two classifiers. Our automated system is tested on 172 dermoscopic images where 88 are malignant melanomas and 84 benign lesions. The results of the proposed segmentation algorithm are encouraging as they gave promising results. 12 features seem to be sufficient to detect malignant melanoma. Moreover, ANN gives better results than KNN.

1. Introduction

Malignant melanoma is the inhomogeneous growth of skin cells caused by DNA break. It is the deadliest skin cancer [1]. Worldwide, in 2012, there were about 160 000 cases of malignant melanoma and about 41 000 deaths. The statistics show the incidence of skin cancer has been rising in many countries for the last decades [2]. In the United States, there were an estimated 73 870 new cases and 9 940 deaths from melanoma in 2015 [3].

Dermatologists use many procedures to distinguish malignant melanomas from benign lesions such as ABCD rule [4,5], seven point checklist [6], three point checklist [7] or CASH algorithm [8]. These methods are based on three types of features' lesion:geometrical, color, structural and texture. To increase the efficiency and makethe diagnosis process faster, accessible for non expert practitioner, many researchers have been attempting to develop a non-invasive imaging computerized diagnosis. Theselection of relevant features is a crucial step in an automatic diagnosis. Numerous algorithms have been proposed to distinguish malignant melanoma from benign lesions. Rastgoo et al. [9] proposed an automatic algorithm to differentiate

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http://dx.doi.org/10.1016/j.ijleo.2017.04.084
0030-4026/

melanoma from dysplastic nevi. Three classifiers were used and three types of features wereextracted including shape, color and texture of the lesion. The features were tested individually and combined. The paper reported that using texture features and random forest achieved the highest sensitivity 98% and specificity 70%. Kasmi et al. [10] automated the ABCD rule. The algorithm was tested on 200 dermoscopic images and achieved an overall accuracy of 94.0%. Ferris et al. [11] extracted 54 features including border irregularity, eccentricity, length of major and minor axes, and color histogram properties. They tested their algorithm on a set of 159 dermoscopic images (39 melanomas and 120 benign lesions), the decision forest classifier achieved sensitivity of 97.4% and the specificity of 44.2%. LeAnder et al. in [12] extracted relative-color from dermoscopic images to differentiate automatically among malignant melanoma.

In this paper, we propose an approach to differentiate malignant melanoma from benign lesions. First, the lesions are automatically segmented using Ant Colony Optimization, then three types of features are extracted based on the geometrical properties of the lesion as described by the ABCD rule, textures features calculating first-order histogram based features, and relative color. 112 features are extracted and 12 pertinent attributes are selected using Relief algorithm. Two classifiers are used, the K Nearest Neighbor (KNN) and a Neural Network (NN).

The remainder of the paper is structured as follow. In Section 2, a novel algorithm is proposed to skin lesion segmentation based on Ant Colony Optimization. Feature extraction and selection inspired from ABCD rule, including geometrical properties, texture and relative colors are described in Section 3. In the fourth section classification, experimental method and results are reported and discussed. Finally, conclusion is given in the fifth section.

2. Segmentation

In this paper, we used an automatic segmentation algorithm based on Ant Colony optimization (ACO) [13,14]. It is an optimization algorithm inspired by the natural behavior of real ants. It consists of a number of ants (nodes) moving on an image seen as a multidimensional graph to identify pixels where an abrupt variation of intensity occurs. Ants' move is guided by the local intensity variation of the pixels and traces of the pheromone. At the end of the process, a map contours of the original image is established.

2.1. ACO algorithm

The stages followed by the ants while moving are illustrated by the following algorithm:

```
Radom initialization of K ants' position
    Initialization of pheromone matrix with an initial value τ0
        L=40, number of construction
    Construction of visibility matrix
    For eachiteration n=1 : N, do
        For each construction step l=1 : L, do
            For eachant k= 1 : K, do
                Random distribution of K ants
                Choose and go towards the next close pixel
                Update pheromone trail of visited pixel
            End
        End
        Update the visited pixels
    End
```

2.1.1. Process of initialiazation

Initially a matrix having the same size as the image is built. It is called initial matrix of traces of pheromones « τ_0». In all its positions (pixel),the same pheromone value (between 0 and 1)is added. Each ant is assigned a random position (pixel)on the image which has a dimension M*M (Table 1).