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Review

Bagged textural and color features for melanoma skin cancer detection in dermoscopic and standard images

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ABSTRACT

Early detection of malignant melanoma skin cancer is crucial for treating the disease and saving lives. Many computerized techniques have been reported in the literature to diagnose and classify the disease with satisfactory skin cancer detection performance. However, reducing the false detection rate is still challenging and preoccupying because false positives trigger the alarm and require intervention by an expert pathologist for further examination and screening. In this paper, an automatic skin cancer diagnosis system that combines different textural and color features is proposed. New textural and color features are used in a bag-of-features approach for efficient and accurate detection. We particularly claim that the Histogram of Gradients (HG) and the Histogram of Lines (HL) are more suitable for the analysis and classification of dermoscopic and standard skin images than the conventional Histogram of Oriented Gradient (HOG) and the Histogram of Oriented Lines (HOL), respectively. The HG and HL are bagged separately using a codebook for each and then combined with other bagged color vector angles and Zernike moments to exploit the color information. The overall system has been assessed through intensive experiments using different classifiers on a dermoscopic image dataset and another standard dataset. Experimental results have shown the superiority of the proposed system over state-of-the-art techniques.

1. Introduction

Malignant melanoma is one of the most aggressive form of skin cancer and its incidence has been rapidly increasing over the last few decades, causing the majority of deaths related to skin cancer (Korotkov & Garcia, 2012; Silveira et al., 2009). Fortunately, if melanoma skin cancer is detected at its early stages, it can be curative for the patient. However, distinguishing melanoma in its early stages from other pigmented skin lesions is still challenging. Many techniques have been used to predict and classify melanoma skin cancer. Image processing tools for skin cancer detection usually require pre-processing operations for enhancing images and segmenting the regions of interest to extract efficient features. Dermoscopic and standard images captured from skin usually have some noisy artifacts such as applied oil and hair and this should be removed prior to segmentation. In this context, Dull Razor medical software was first developed by Lee, Ng, Gallagher, Coldman, and McLean (1997) to remove hairs from pigmented areas. However, the system has been criticized for disrupting the normal skin pattern over the area covered by the hairs (She, Duller, Liu, & Fish, 2006). The fast median filtering was later adopted to remove noise from the acquired skin images (Tanaka, Yamada, Tanaka, Shimizu, & Oka, 2004). In Kiani and Sharafat (2011), an improved version of the Dull Razor medical software, called E-shaver, has been proposed. The technique mainly enhances hair detection and removals by identifying light-colored hairs in addition to dark hairs. Barata, Marques, and Rozeira (2012) proposed two important steps for reflective artifacts and hair detection and removals using a bank of directional filters. Once a skin lesion image is enhanced via artifacts and hair removal techniques, the lesion area is segmented (Lee & Chen, 2015). Many segmentation techniques have been developed in the literature for melanoma skin cancer diagnosis in dermoscopic images (Silveira et al., 2009). Among these techniques, the region-based approach selects a set of seed points and from each point a region grows up if the neighboring pixels have similar properties to that of the seed point. Region growing often generates irregular boundaries and small holes (Zhu & Yuille, 1996). It also has some drawbacks such as sensitivity to noise and often results in over segmentation (Tobias & Seara, 2002). In Nock and Nielsen (2004), a statistical region merging (SRM) algorithm has been proposed.

One of the common features used by dermatologists for diagnosing melanoma skin cancer is the rule-based approach, called

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ABCD, and based on morphological analysis of lesions in dermoscopic images. This is used to distinguish between melanoma skin cancer and non melanomas (Nachbar et al., 1994). It is a medical diagnostic method that is based on four criteria, i.e., asymmetry, border irregularity, color variegation, and different structure. The 7-point checklist is another medical diagnostic method that is widely used by researchers and is based on a set of different characteristics depending on color, shape, and texture (Argenziano et al., 1998). These features can be categorized into color and texture features. Barata, Ruela, Francisco, Mendonca, and Marques (2014) investigated the role of color and texture features for skin melanoma cancer detection and concluded that color features are more efficient than texture in dermoscopic images. They also showed that the features which are locally extracted from the images bring more information about the lesion than global features. Barata, Ruela, Mendonca, and Marques (2014) demonstrated, via experiments, that color descriptors deliver better performance in detecting melanoma skin lesions than texture descriptors. Barata et al. (2012) adopted a set of directional filters and a connected component analysis to extract five different features for pigment network detection in dermoscopic images. In Barata, Marques, and Rozeira (2013), the role of key-point sampling in a bag of features approach was investigated. The authors suggested that performance of the system can be influenced by the number of detected key-points. In Barata, Celebi, and Marques (2015), color constancy has been explored to overcome the problem of changes that may occur during the skin image acquisition process. Riaz, Hassan, Javed, and Coimbra (2014) proposed a combination of texture and color features for the classification of melanoma and non-melanoma skin images. A variation of the local binary patterns (LBP) was used for the texture features to extract scale adaptive patterns. As for the color information, the histograms of the HSV (Hue, Saturation, Value) color space was adopted. More recently, Ruela, Barata, Marques, and Rozeira (2015) have explored the importance of shape and symmetry features in Melanoma diagnosis in order to determine the type of features that play a crucial role in classification. Abuzaghleh, Barkana, and Faezipour (2015) proposed a combination of Lesion Variation Pattern Features (LVPF) with some extracted shape, color and texture features including the pigment network feature set, the lesion shape feature, the lesion orientation feature, the lesion margin feature, the lesion intensity pattern feature, and the lesion variation pattern feature. In Vasconcelos, Rosado, and Ferreira (2015), color features have been derived from the ABCD rule where the authors proposed a clustering approach to adjust the system to different datasets and image types. In Kruk et al. (2015), different texture and statistical features were adopted, including the numerical descriptors based on the Kolmogorov–Smirnov (KS) statistical distance, the classical Haralick descriptors and fractal texture analysis-based descriptors. In Giotis, Land, Biehl, Jonkman, and Petkov (2015), physician annotations for skin lesions, referred to as visual diagnostic attributes, were combined with lesion color and lesion texture for melanoma skin detection in non-dermoscopic images. Very recently, three types of features have been used in Chakravorty, Liang, Abedini, and Garnavi (2016), namely, geometry features, color features, and finally structural features. More recently, Oliveira, Marranghello, Pereira, and Tavares (2016) adopted asymmetry, border, color and texture features followed by an SVM classifier for the classification of pigmented skin lesions in macroscopic (standard) images.

In this paper, an automatic skin cancer diagnosis system that combines different textural and color features is proposed. New textural and color features are introduced in a bag of features approach for efficient and accurate skin cancer detection. We particularly claim that the Histogram of Gradients (HG) and the Histogram of Lines (HL) are more suitable for the analysis and classification of dermoscopic and standard skin images than the conventional Histogram of Oriented Gradient (HOG) and the Histogram of Oriented Lines (HOL), respectively. This is because the orientation of melanoma edges and texture is not a discriminating feature when compared to non melanoma lesions. Therefore, the use of edge and line orientation in skin images reduces the inter class dissimilarity, and this causes an adversary effect on classification. The HG and HL are bagged separately using a codebook for each and then combined with other bagged Color Vector Angles (CVA) and Zernike moments to exploit the color information. Experimental results demonstrate the efficiency of the proposed texture and color features as well as the superiority of the overall system over state-of-the-art melanoma skin cancer detection techniques. The rest of the paper is organized as follows. Section 2 describes the proposed system and the features extracted whereas Section 3 provides a discussion of experimental results obtained. Conclusions are drawn in Section 4.

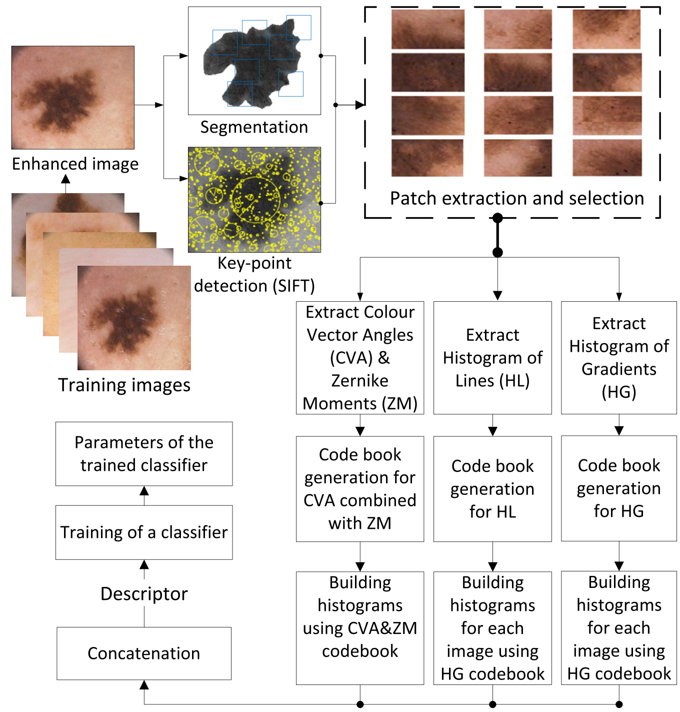

Fig. 1. The training phase of the proposed system.

2. Proposed system

The proposed system consists of six main stages at the training phase, namely: preprocessing, key-point detection, segmentation, patch extraction and selection (region of interest), feature extraction, codebook generation, histogram building, features concatenation, and classification. Fig. 1 illustrates the proposed approach.

2.1. Pre-processing

For efficient feature extraction, a process of image enhancement is first conducted. The reason for this is that the original acquired images may have some air bubbles and artifacts caused by gel applied before the capture of the images in addition to hairs and other noise. The same procedures that have been implemented in Alfed, Khelifi, Bouridane, and Seker (2015) which is based on method proposed by Barata et al. (2012) which consists of detecting and removing two undesirable patterns: reflective artifacts and hair. To detect artifacts reflection, a simple thresholding algorithm is adopted where every pixel with a certain brightness in the image is compared against its neighborhood. If the pixel of interest