Valuable Pre-processing & Segmentation Techniques Used in Automated Skin Lesion Detection Systems

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Abstract — The bio-medical investigation from images through computational techniques is very common in these days. Automatic Lesion extraction from skin, is very important to aid the dermatologists in the diagnosis of cancer part from skin. Usually, some skin lesions are very subjective and small, there for not detected by the clinicians by visual examination or sometimes, the clinicians have some problems in their classification. This work presents a comparative study on different techniques to pre-process the lesion image to enhance its readability and the techniques that automatically segment skin lesions from images. Moreover, pros and cons of various methods are also focused to provide a help for the researchers starting work in automated lesion detection system.

Keywords - Pre-processing; Segmentation; Lesion; Automated System; Region based

I. INTRODUCTION

Automated lesion detection systems is the main idea used in the finding of pigmented skin lesions. By reason of the complication and difficulty of human understanding, automated analysis of dermoscopy images has turn into an important study and research area. An automated skin cancer detection system follows step by step procedure to detect lesion. Pre-processing is the first stage, which is primarily concerned to image enhancement, artifacts removal and after that performing possible refinements, the last step of this phase is image restoration. The next phase is identifying and separating the lesion part from the skin in the provided image. Segmentation is an important phase due to accuracy rate that measures success and failure rate of an automated system.

Skin cancer is one of a rising cancer type in numerous countries these days. Pigmented skin lesion can be in benign and malignant form. According to World Health Organization [1], about 132000 melanoma cases, a risky kind of malignant pigmented skin lesion, occur globally each year. It is very important to diagnose cancer at early stage for the patient prediction, since most malignant skin lesion cases can be treated successfully in their early stages. However, It is clearly shown from research work that classifying benign from malignant skin lesions is a difficult task [2, 3].

To help diagnosing pigmented skin lesions, high performance computer aided diagnostic systems help the physicians to avoid misdiagnosis. The common approaches to skin lesion early detection include different steps of Preprocessing and Segmentation[1]. The output of each step is the input of next step. Preprocessing as the first stage of computer aided cancer diagnostics has seriously effects on misleading the results [4]. The success of such systems critically depends on pre-processing [5], but only a few papers until now focusing on preprocessing techniques. In skin cancer detection, preprocessing step can be divided into image enhancement, image restoration and artifacts removal. Each stage includes different techniques which will be discussed in this paper. In figure I. a topology of automated skin lesion detection system is presented that describes the summarized information regarding pre-processing and segmentation techniques and the details of different researchers worked on it.

This paper is ordered in the following pattern. In Section II, we review the topology of automated lesion detection systems. In detail, preprocessing & segmentation stages are presented. Thereafter in Sections III, VI, V and VI, the different techniques of image enhancement, image restoration, hair removal and segmentation are discussed respectively, and also the most effective techniques are illustrated according to the literature. Section VII is conclusion of the paper.

II. PRE-PROCESSING TECHNIQUES

Image pre-processing is an essential step of detection in order to remove noises and enhance the quality of original image. It required to be applied to limit the search of abnormalities in the background influence on the result [8]. The main purpose of this step is to improve the quality of melanoma image by removing unrelated and surplus parts in the background of image for further processing. Good selection of preprocessing techniques can greatly improve the accuracy of the system [9]. The objective of the preprocessing stage can be achieved through three process stages of image enhancement, image restoration and hair removal. Here, the paper explains above techniques clearly for researchers who involves in preprocessing stages of automatic detections.

III. IMAGE ENHANCEMENT

Image Enhancement is a crucial procedure to improve the visual appearance of the image; it is defined as provider of the “better” transform representation for
Figure 1. Topology of Expository literature on Automated Lesion System Pre-Processing and Segmentation Techniques
further automated steps of detection [10]. The image enhancement can be categorized in three categories:

**A. Image Scaling**

Image scaling techniques are applied due to the lack of same and standard size of images. Since the skin cancer images may be gathered from different sources and sizes, the first step is to resize the images to have the fixed width pixels but variable size of height [11].

**B. Color Space Transformation**

Since color information plays an inevitable role in skin cancer detection systems, researchers try to extract the more corresponding color of images for further processing. Generally, the common color spaces include RGB, HSV, HSI, CIE LAB and CIE-XYZ. RGB is a color space which comprise the red, green, and blue phantom wavelength. The most often presentation of colors in image processing is RGB. Since RGB color space has some limitation in high level processing, so other color space representations are there as an alternative [12]. LAB is one of the useful color models which represent every color through three components of luminance, red/green and blue/yellow, it could be beneficial to transform the RGB to LAB using XYZ as an intermediate color space. The luminance would present the grayscale skin image [3].

**C. Contrast Enhancement**

Contrast enhancement is beneficial step to improve the perception for further processing; it can sharpen the image border and improve the accuracy by accentuating the brightness difference between background and foreground. Contrast enhancement plays a vital role in increasing the quality of an image [15]. The widely practiced methods are classified into “Linear contrast enhancement” and “Non-Linear contrast enhancement” techniques [16].

- Linear contrast enhancement mostly used in remotely sensed images. This type of contrast enhancement refers to contrast stretching techniques. The image can be transformed to higher contrast by remapping or stretching the gray-level values so that histogram spread over the full range [17]. Figure 2. shows the expand classification of Linear contrast Enhancement methods.

- Non-Linear contrast enhancement techniques: This type of contrast enhancement mostly deals with histogram equalizations and algorithms [16]. The most imperfection of such techniques is losing the correct brightness of an object due to the multiple values of output image against each value in an input image [16]. In medical purposes, non-Linear contrast enhancement techniques are commonly used [18]. The different methods of non-Linear contrast enhancement are in figure 3.

**IV. IMAGE POST PROCESSING & RESTORATION**

Image Restoration is defined as the procedure to recover the degraded image from a blurred and noisy one [25]. It can restore the degraded images in different ways. The image degradation can happen by various defects such as imperfection of imaging system, bad focusing, motion and etc. which make an image usually noisy or blur [25]. Since the corrupted images lead to fault detection, hence, it is essential to know about noises present in an image to select the most appropriate de-noising algorithm. The image noises can be divided into four groups of Gaussian, Salt and Pepper, Poisson and Speckle [26].

**A. Restoration from different noise**

Image de-noising is an essential step in preprocessing of an image. It is extremely difficult to apply an effective de-noising algorithm for different types of noisy images. The essential property of a good image de-noising method is to suppress the noise as well as preserving the edges [27]. There are many existing methods for de-noising an image. The basic methods can be classified as Spatial Filtering and Transform Domain Filtering [28]. Spatial filtering such as Mean filters, Median filters, Wiener filter, Lee filter, Anisotropic diffusion filter, Total variation filter and etc. include neighborhood and a predefined operation which change the grey value of each pixel according to the pixel values of square neighborhood centered at that pixel [29]. The description of more common spatial filters for removing noises and smoothing the image are in the following [26 and 30-32].

- Mean filters: It works best with Gaussian noise and could be effective for salt and pepper noise. Although this filter reduces the noise, blur the image and reduce sharp edges.
In medical applications, Wiener filter has been applied as an algorithm technique, Inverse filter, Wiener filter techniques for de-blurring such as Lucy-Richardson original image and camera [40-42]. There exist different types of an image. It occurs by bad focusing or motion between degradation which owe to the imperfect formation process.

B. Restoration from blur

As mentioned earlier, blur is a kind of image degradation which owe to the imperfect formation process of an image. It occurs by bad focusing or motion between original image and camera [40-42]. There exist different techniques for de-blurring such as Lucy-Richardson algorithm technique, Inverse filter, Wiener filter de-blurring technique, and Neural network Approach [40-42]. In medical applications, Wiener filter has been applied as one of the most powerful and common de-blurring technique which also remove the noise as well [43-46].

V. REMOVING THICK HAIRS ARTIFACTS

Thick hairs in automated analysis of small skin lesions are considered as a common impediment which are able to mislead the segmentation process [47]. To remove the thick hairs in skin cancer images, researchers applied other methods such as mathematical morphology methods [48], curvilinear structure detection [49], an in-painting based method approach [50], automated software called DullRazor [51] and Top Hat transform combined with a bicubic interpolation approach [19]. The hair-free images are acquired using the operations. At the end of preprocessing step of skin cancer detection system, the resulting images are distinguishable from those initial images and almost are ready to feed the segmentation stage.

VI. SEGMENTATION TECHNIQUES

The process of segmentation is to make things easier or change the representation of an image into something that is more meaningful and easier to analyze. Segmentation means to the separation of an image into disjoint regions that are uniform with respect to some property such as color, luminance, and its texture. Some researchers argued that manual border detection is better than computer-detected borders in order to separate the problems of feature extraction from the problems of automated lesion border detection. However, for the development of automated diagnostic system for skin lesion detection, it is very important to develop automatic segmentation algorithms. As segmentation is a crucial early step in the analysis of lesion images, it has become one of the important areas of research and many algorithms and segmentation techniques are available in the literature [52-60]. We have briefly provided an overview of various segmentation algorithms being used for dermoscopic image analysis.

A. Thresholding

Determining threshold and then the pixels are divided into groups based on that criterion. It include bi-level and multi thresholding. Thresholding method includes: 1) Histogram 2) Adaptive thresholding

B. Color-based segmentation algorithms

Segmentation based on color discrimination. Include principle component transform/ spherical coordinate transform

C. Discontinuity-based segmentation

Detection of lesion edges using active contours / radial search techniques / zero crossing of Laplacian of Gaussian (LoG). It covers: 1) Active contours 2) Radial search 3) LoG

D. Region-based segmentation
Splitting the image into smaller components then merging sub images which are adjacent and similar in some sense. It includes Statistical region merging, multi scale region growing, and morphological flooding [59-60]. It is based on the following techniques: 1) Split and merge 2) Statistical Region Merging 3) Multi-scale 4) Morphological flooding

E. Soft computing

Soft computing techniques do the categorization of pixels using soft computing techniques [60-62]. It includes: 1) Fuzzy logic 2) Neural Network 3) Optimization algorithms

VII. CONCLUSION

This paper explores the pre-processing and segmentation techniques needed for designing the automated skin lesion detection system. It is a study that combines the research being done in this field. It presents knowledge that help the researchers judge the importance of high level techniques and algorithms for pre-processing, segmentation, feature extraction and selection which needs more effort for making correct diagnosis of melanoma. It will be a great help and preliminary guide for the researchers starting work in skin lesion detection systems.

REFERENCES


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