

A Review on Segmentation Techniques in Skin Lesion Images

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Abstract - — *Skin cancer is the most dangerous and a common type of cancer. The deadliest form of skin cancer is melanoma. Due to the costs for dermatologists to monitor every patient, there is a need for an computerized system to evaluate a patient's risk of melanoma using images of their skin lesions captured using dermatoscope. Segmentation have importance to detect skin lesion from images. Different method for segmentation of dermoscopic images of skin cancer and other pigmented lesions is presented. Segmentation is the classification of the input image into skin and non-skin pixels based on skin texture. In this paper consists of a review of five different types of skin lesion segmentation techniques. Main aim of segmentation is accuracy, speed and computational efficiency.*

Key Words: *Skin cancer, Image segmentation, Dermatoscope*

1. INTRODUCTION

Skin cancer is the most common cancer in the United States. There are two types of skin cancer: malignant melanoma which is less common but more serious; and non-melanoma skin cancer, which is very common but not so serious. Malignant melanoma on its own can sometimes be referred to as 'skin cancer'. Malignant melanoma is a type of skin cancer which is less common and most dangerous form of skin cancer. Malignant melanoma accounts for 75 percent of all deaths associated with skin cancer in United States [2]. A mole (nevus) is a benign skin tumour that develops from melanocytes which are found in uppermost skin layer epidermis. These skin cells make a brown pigment called melanin. Melanin gives the skin its tan or brown colour. Melanoma can originate in any part of the body that contains melanocytes. Visual analysis of a melanocytic lesion is segmentation of all points in the image as part of the lesion. A skin lesion is a part of the skin that has an abnormal growth or appearance compared to skin around it. Dermatoscope is a device used to take the skin lesion images. Images taken from

dermatoscope is called dermoscopic images. If melanoma detects earlier than almost at curable stage otherwise death occur.

Currently available digital dermoscopic systems offer the possibility of computer storage and retrieval of dermoscopic images. Some systems even display the potential for Computer Assisted Diagnosis (CAD). As diagnostic accuracy with dermoscopy has been shown to depend on the experience of the dermatologist, CAD systems will help less-experienced dermatologists and provides a lower impact for inter-subject variability. The standard approach in automatic dermoscopic image analysis has usually three stages: 1) image segmentation; 2) feature extraction and feature selection; and 3) lesion classification. The segmentation stage is one of the most important because accuracy is the main characteristics of segmentation. However, segmentation is difficult because of the variation of lesion shapes, sizes, and colors and also with different skin types and textures.

In addition to that, some lesions have irregular boundaries and in some cases there is a smooth transition between the lesion and the skin. In automated diagnosis of skin lesions, feature design is based on the ABCD rule of dermatoscopy. ABCD represent the asymmetry, border structure, variegated color, and dermatoscopical structures and define the basis for a diagnosis by dermatologist.

To address the segmentation problem, several algorithms have been proposed. They can be broadly classified as thresholding, edge based or region-based methods. In thresholding method a fusion of global thresholding, adaptive thresholding, and clustering is used. Thresholding methods can achieve good results when there is good contrast between the lesion and the skin, thus the corresponding image histogram is bimodal, but usually fail when the modes from the two regions overlap. Edge-based approaches perform poorly when the boundaries are not well defined, for instance when the transition between skin and lesion is smooth. In these situations, the edges have gaps and the contour may leak through them. Another difficulty is the presence of spurious edge points that do not belong to the lesion boundary. They are the result of artifacts such as hair,

specular reflections or even irregularities in the skin texture and they may stop the contour preventing it to converge to the lesion boundary. Region-based approaches have also been used. Region-based approaches have difficulties when the lesion or the skin region are textured or have different colors present, which leads to oversegmentation. From these type of classification of image segmentation includes different segmentation techniques.

2. CLASSIFICATION OF SEGMENTATION

Image segmentation is the process of partitioning a digital image into multiple segments. The goal of the image segmentation is to simplify or change the representation of an image into something that is more meaningful and easier to evaluate. It is characteristically used to find objects and image boundaries (lines, curves, etc.) in images and processed of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics. It is states to the splitting of an image into separate regions that are identical with respect to luminance, color, texture etc., and techniques can be categorized in to Histogram thresholding, clustering, Edge based detection, Region based detection, morphological detection, active contours etc. Texture based segmentation algorithms have been applied to dermoscopy images. Each classification contain different methods of segmentation.

2.1 Edge-Based Segmentation

Edge-base or boundary-based segmentation methods [3] commonly refer to segmenting an image based on the edges among regions, by searching for edge pixels and connect them to form image contours. However for applying such methods two approaches are founded; manually, by using the mouse to draw lines that represent image boundaries among regions, and automatically, by implementing some edge detection filters, where the pixels classified into edge or non-edge according to the filter output result. Examples of some edge detection filters are: Laplacian of Gaussian filter, watershed segmentation algorithm [4].

2.1.1 Laplacian of Gaussian Filter

The Laplacian filter is a derivative filter applied to find the regions of rapid intensity change [5] in an image to detect the edges. Laplacian filter is a derivative filter, it is usually applied to images that have smoothed using some filters (such as a Gaussian smoothing filter) to minimize the noise sensitivity. The filters procedure normally carried out on a gray level image and produce new edged gray level image.

2.1.2 Watershed Segmentation Algorithm

Watershed segmentation algorithm considered as a hybrid method between edge-based and region-based segmentation. The aim of watershed segmentation algorithm is to discover the watershed lines [4] in the input image to segment the prominent regions [4]. The basic idea of the watershed algorithm can be explained as flooding water process in the topographic surface, streaming form the lowest basin to the highest peak, the water move through holes and flood the surface. To prevent merging of two different basins a dam is constructed, so that finally the boundaries of connected dam considered as the watershed edges. The main advantage of this method is the continuity of region's boundaries, however the the resultant segmented image suffer from over-segmented regions and it is time-consuming as well [4].

2.1.3 Canny Edge Detector

Canny edge detector defined as the standard benchmark for comparing with other edge detection methods [6], canny detector algorithm consists of four steps as mentioned in: (1) uses Gaussian convolution to blur the image and reduce noise effects, (2) uses sobel operator and find the 2D spatial gradient to determine the edge directions and strength, (3) uses edge direction to search along the edges and suppress any non-edge pixels, and (4) eliminates the broken edges using two high and low thresholds [6], pixels above the high threshold are edge pixels and between the high and low thresholds which are adjacent to the edge is considered as edge pixels also. However canny edge detector can find pixels near the edge, but less in finding the exact edges [3].

2.2 Region-Based Segmentation

Region-based segmentation partitioned an image into regions or groups of similar pixel depending on some properties [7]. Its principle depends on the idea that neighbouring pixels within the same region have same value [4]. This idea can be implemented by comparing each pixel with its neighbours in a particular region [4], and according to the crucial similarity condition the pixel is decided to belong to a specific region [4]. In the segmentation process feature image is used instead of original input image, the feature image is represented with small neighborhoods which forms a regions [8]. Region-based segmentation technique required the use of proper thresholding methods [6], and the noise has great impact on the output result [4]. Some skin classification methods based region based are: region growing, region splitting, region merging, split and merge, Neural Networks (NNs).

2.2.1 Region growing Techniques

In this method, uniform or homogenous regions of an image are obtained using growth techniques [9], to join the surrounding neighbourhoods together and recognize this region from other regions [9]. The idea behind the growth process begins from a preselected pixel (seed) [10], gradually agglomerates pixels that achieve homogeneity characteristic between the joined pixels, this operation stops when number of points that can be added to the region is zero [10].

2.2.2 Split-and-merge Techniques

This method is the inverse to region growing techniques in which it starts from nonhomogeneous image classification and continue splits the image into subdivided regions until homogeneous regions are obtained by applying some data structure algorithms [10]. The merging process joined the neighbouring regions to achieve homogeneity demands on a uniform image region.

2.3 Threshold Based Segmentation

Point based or pixel based segmentation, also known as thresholding. It is the simplest approach for segmenting images, depending on gray-level values to segment image pixels. For skin color classification several algorithms have been suggested, which include piecewise linear classifiers, histogram based thresholding, Neural Networks (NNs).

2.3.1 Piecewise Linear Classifiers

Piecewise linear classifiers are classified as non-parametric method that divides skin and non-skin colors using a piecewise linear decision boundary. It is also known as explicit skin cluster classifier which defines clearly the boundaries of clusters in properly selected color space. Suggested a set of fixed thresholds in six color spaces YCbCr, RGB, HSV1, HSV2, HSI, and rgb, using piecewise linear classifier and use genetic algorithm to decide the boundaries of these six classifiers [11].

2.3.2 Neural Network

For any artificial system application, some aspects should be considered; 1) System robustness against noise and imperfection environments, 2) Simulate the human information, 3) and real time output application system [12]. NNs tried to achieve these aims [12]. Neural networks have a huge connected processors working in parallel. Several researches have proposed the use of NNs in segmenting image. self-organizing map (SOM) and multilayer perceptron (MLP) which is feed-forward neural network (classified as nonlinear model) have been used widely in classification, compression, and regression. classified the image using self-organizing map (SOM) using HSL color space with considering only chrominance components hue and saturation, and ignoring the

luminance component. Applied SOM algorithm on medical images, empirically discovered that increasing network neuron numbers will improve the performance of segmentation process [21].

3. DIFFERENT SEGMENTATION TECHNIQUES

This paper includes survey of five different skin lesion segmentation techniques from dermoscopic images. The methods are:

- Evolutionary Strategy
- K-means clustering
- Mimicking Experts Dermatologists
- Mean Shift automatic segmentation
- Joint Statistical Texture Distinctiveness

3.1 Evolutionary Strategy (ES)

Evolutionary strategy [13] based segmentation has the property of seeking global optimum and getting out of local optimum automatically. ES is used for feature identification in natural and synthesis of images with multiple features. The lesion area is segmented by an ellipsoid, whose parameters are optimized by ES algorithm with respect to the defined objective function. Based on the inherent properties of ES algorithm, the ES-based segmentation algorithm has three distinct advantages: first, it is an unsupervised segmentation algorithm whose performance does not depend on initialization or threshold values; second, robustness to artifacts and noise; third one is based on the statistical property of the image. Because of these properties, images fed into the ES based segmentation algorithm do not need to go through the above full pre-processing steps. In specific, ES based segmentation method does not need hair removal procedure. Also ES-based method does not require manually selected threshold and is robust to the initial values.

The lesion area is segmented by an ellipsoid, whose parameters are optimized by ES algorithm with respect to the defined objective function. The main reason chose to use an elliptic template for segmentation is because it can be fully defined by using five parameters (population of candidate solutions, objective function, selection operator, mutation operator and a recombination operator). This makes it easy to implement an ellipsoid region based objective function. Advantages of this ES technique are ES not use threshold values, robustness to noise, and No preprocessing steps used. Disadvantages are: Low computational efficiency and less segmentation accuracy.

3.2 K-means clustering

K-means is a learning method for the easier implementation on set of data to classify it to a number of clusters suggested in k cluster. K-means solve the

clustering problem by simply define number of centroids (k), each one will be generated using cluster. The algorithm assumes that the data features form a vector space and trying to find a compilation of the natural. According to the K-means algorithm basic assembly and groups rely on the choice of the midpoint kits. Euclidean distance used to determine the distances of the data elements suggested as K initial centers. The data elements assigned to the proper cluster according to the distance from the data elements to the centroids. The process is continued until no more changes occur in groups.

This method attempts to identify similar groups of respondents based on selected characteristics. As compared to other segmentation techniques, k-means clustering requires that the analyst specifies the desired number of clusters or segments. During the procedure the distances of each respondent from the cluster centers are calculated. The procedure repeats until the distance between skin lesion cluster centers is maximized. Respondents are assigned to the cluster with the nearest center.

By using k-means clustering conversion of RGB to any other color space can easily done [14]. Advantages of k-means clustering techniques are: Computationally faster than hierarchical clustering, simple and easy to implement, it is versatile, and linear time and storage complexity. Demerits are: it requires number of clusters and sensitive to noise.

3.3 Mimicking Experts Dermatologists (MEDs)

MEDS includes mainly five stages [15]. The first stage is optional preprocessing stage, which simply preprocesses the image to rebalance its colors and to automatically remove any hair. The second stage is PCA in color space, reduces the dimensionality of the color space to one through principal component analysis (PCA) of the color histogram. The third stage is noise reduction applies a blur filter to the resulting image to reduce noise. The fourth stage is color clustering, separates pixels into two clusters through a novel thresholding algorithm which is the heart of MEDs technique and mimicks the cognitive process of dermatologists; this effectively partitions the original image into regions corresponding to lesional and nonlesional skin. The final and fifth stage is postprocessing, morphological postprocessing to remove spurious patches and to identify lesional areas in the image.

This type of segmentation is done by using 60 images of melanocytic lesions at 768×576 resolution were taken with a Fotofinder digital dermatoscope [19]. 12 copies of each image were printed on $13 \text{ cm} \times 18 \text{ cm}$ photographic paper. A copy of each image and a special marker pen were given to each of four junior, four senior, and four

expert dermatologists (having, respectively, less than one year of experience, more than one year but no specific dermatoscopic training, more than one year and specific dermatoscopic training). Each dermatologist was asked to independently draw with the marker the border of each lesion. The results were scanned and realigned to the same frame of reference, and the contours provided by the markers were then extracted and compared identifying, for each pixel of each original image, the set of dermatologists classifying it as part of the lesion or of the surrounding nonlesional skin. This "pen-and-paper" approach aimed at maximizing the comfort of dermatologists, thus minimizing the noise in border localization caused by the use of unfamiliar software drawing tools [20].

In this technique melanocytic lesion segmentation is performed by highly expert human dermatologists. Advantages are: it provide accuracy, extremely robust, and extremely fast. Drawback is availability of highly expert dermatologists.

3.4 Mean Shift automatic segmentation

Mean Shift segmentation technique is a non-parametric clustering technique [16]. It means it does not require the number of clusters as a priori information. This represents a major advantage because, generally, when using automatic segmentation, one can easily obtain incorrect results, since the classical segmentation techniques are often based only on assumption of guessing the number of classes existing in the image. Another important advantage of the Mean Shift method is its excellent tolerance to non-uniform background [17]. Due to intrinsic complexities of the lesions, such as blurriness, noise, the overlapping hair and other factors mentioned in the section above, and also due to a large variability in the texture and color and the non-homogeneous nature of lesions, there is a number of problems associated with the accuracy of Mean-Shift segmentation results.

3.5 Joint Statistical Texture Distinctiveness

This method is a texture based segmentation algorithm. This segmentation algorithm based on texture distinctiveness (TD) to locate skin lesions in photographs. This algorithm is referred to as the TD lesion segmentation (TDLS) algorithm. The main contributions are the introduction of a joint statistical TD metric and a texture-based Region classification algorithm. TD captures the dissimilarity between learned representative texture distributions. This region classification algorithm incorporates the texture information captured by the TD metric [1].

The TDLS algorithm mainly consists of two main steps. First, a set of sparse texture distributions that represent

skin and lesion textures are learned. A TD metric is calculated to measure the dissimilarity of a texture distribution from all other texture distributions. Second, the TD metric is used to classify regions in the image as part of the skin class or lesion class [1].

The grouping of lesion features are done by using k-means clustering. K-means clustering is used as an initial step to increase the robustness and to speed up the number of iterations required for the finite mixture model to converge. K-means clustering finds K clusters of texture data points that minimizes the sum of squared error between cluster members and the cluster mean. To improve clustering efficiency Expectation and Maximization algorithm is used. Then use the SRM (Statistical Region Merging) method to extract cluster features. SRM contains two main steps: a sorting step and a merging step.

SRM sorts pixels in an image to determine the order in which pixels are compared, and then merges pairs of pixels into regions based on their similarity. To maximize lesion region adaptive thresholding technique is used. After the regions are classified as being normal skin or lesion, postprocessing steps are applied to refine the lesion border such as morphological dilation and region selection. First, the morphological dilation operator is applied to fill holes and smooth the border. Morphological dilation is a process that expands binary masks to fill small holes.

Morphological dilation to remove non lesional area from the image. Second, since multiple noncontiguous regions may have been identified as part of the lesion class, the number of regions is reduced to one. While it is possible to have multiple lesions in a single image, it is necessary to reduce the number of lesions for the feature extraction step. To eliminate the small regions, the number of pixels in each contiguous region is counted. The contiguous region with the largest number of pixels is assumed to correspond to the lesion class and any other regions are converted to the normal skin class. This gives the final lesion segmentation.

Advantages are: high accuracy, high sensitivity to noise and much faster. As compared to other techniques this method provides greater segmentation accuracy and more effective one.

4. CONCLUSION

Segmentation is the classification of the input image into skin and non-skin pixels based on skin texture This paper includes a review of five different skin lesion segmentation techniques. Each have different properties. Segmentation of image is mainly classified as three types: Edge base segmentation, Region based segmentation, and Threshold based segmentation. Most commonly used segmentation

classification technique is of threshold based. Main characteristics of segmentation is accuracy. As compared to five different technique each have advantages and disadvantages. In which greater segmentation accuracy is provided by Joint statistical texture distinctiveness method.

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