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Melanoma: A Review On Various Segmentation Techniques

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Abstract— This paper highlights the various segmentation algorithms used in the automated melanoma detection .The application of biomedical image processing for diagnostic purpose is a non invasive technique. In order to identify skin cancer at an early stage without performing unnecessary biopsies, digital images of melanoma skin lesion have been investigated. Different segmentation techniques which aids in the efficient detection of malignant melanoma has reviewed in this paper. Among the implemented algorithms, wavelet network shows better segmentation results for skin cancer images. Automatic border detection is a challenging task in dermoscopic images.

Keywords— Melanoma, Segmentation, Dermoscopy, Thresholding, Clustering, Region Merging, Contour,Wavelet Networks

INTRODUCTION

Digital image processing plays a vital role in the area of research and has opened a wide range of new research prospects. Image processing is a profound key that can modify the outlook of many designs and proposals. Digital image processing refers to the automatic processing of digital image by means of digital computer. The basic steps involved in image processing are image acquisition, pre-processing , segmentation, enhancement of image, image compression, and restoration. In this, image segmentation has become a very significant task in today's scenario. Segmentation is usually the primary step in any computer aided analysis of images. The segmentation process converts an image into more easy and meaningful way to analyze. It is typically used to extract boundaries and curves in the images. Application areas of segmentation includes content based image retrieval, locating objects in satellite images, biometric recognition, detection of tumors, tissues in medical field.

Image segmentation is the process of dividing a digital image into multiple regions or set of pixels with homogenous properties.[2] This partitioning should be done until the region of interest in specified application has been separated. The objective behind segmentation is to simplify the representation of image for further processing. The result of segmentation is a set of segments that collectively forms the entire image. Accurate segmentation of medical images is very important for the analysis and diagnosis of abnormalities in different parts of the body. Segmentation becomes important since it further aids in the classification of extracted lesion as benign or malignant. Malignancy insists the need for analysis and thereafter medical examination. In order to avoid unnecessary biopsies. accurate classification which proceeds after accurate segmentation is needed. Performance of segmentation algorithm is greatly influenced by the properties of image selected .Thus it is not necessary that a segmentation algorithm suited for a particular medical image provides excellent results for other medical images also.

Skin cancer is considered as the most common type of cancer which accounts for considerable amount of death in human world wide. In U.S by current status, a skin cancer will develop in one in five people during their life time. Skin cancer can be broadly grouped as melanoma and benign skin cancers. Benign Melanoma is simply the appearance of moles on skin. These type of skin disease usually starts in the basal cells or squamous cells. Such cells are found at the base potion of the outer layer of the skin. [14]The continous exposure of skin to sunlight is considered as the major reason behind skin cancers. Basal cell or squamous cell cancers can be cured if found and treated early. Malignant Melanoma is the appearance of sores that cause bleeding. It is the most deadly and dangerous form of skin cancer. It arises from the cancerous growth in pigmented skin lesion. Malignant Melanoma is named after the cell melanocyte,from which it presumably arises,. If diagnosed at the primary stage ,the disease is curable. The World Health Organization approximates that more than 70230 people a year in the world die from too much sun ,mostly from malignant type skin cancer. Early detection of this cancer can help its curability.

Dermoscopy,also known as Dermatoscopy orEpiluminescence Light Microscopy is non-invading diagnosis technique for the in vivo observation of pigmented skin lesion[2].It is a new kind of imaging technique used to examine skin lesion with an equipment called dermatoscope. Analysis of dermoscopic images plays an important role in the early diagnosis of malignant melanoma. But this conventional method is time consuming and subjective even for trained dermatologists. Due to these limitations, there is currently a great interest in the development of computer aided diagnosis systems that can assist the clinical evaluation of dermatologists. The

standard approach in automatic dermoscopic image analysis has three stages like image segmentation ,feature extraction and feature selection and lesion classification. The segmentation becomes the most important stage since it affects the accuracy and precision of subsequent steps. Existence of great varieties of lesion shapes, sizes and colors along with different skin type and textures makes the task difficult. In addition, some lesions have irregular boundaries and shows a smooth transition between lesion and skin. Other difficulties include the presence of dark thick hairs covering the lesion, existence of specular reflections and spurious edge points.[12]. Basic steps involved in the computer aided diagnosis of melanoma detection are shown below

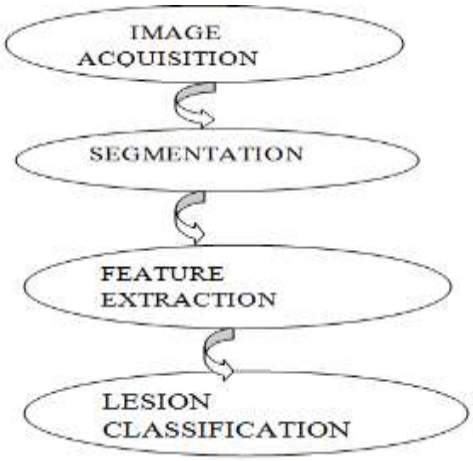

Fig: Steps for melanoma detection using CAD

In all image processing systems , the first step is to acquire an digital image from a random source defined as image acquisition. The collected image is then preprocessed for noise removal and segmented for obtaining the region of interest .Important features are extracted and are used for classifying the lesion as benign and malignant melanoma .These forms the elementary steps in all computer aided detection systems.

SEGMENTATION

Segmentation is the one of challenging tasks in digital image processing. The segmentation technique is employed to separate the lesion pigment from the healthy skin. Dermoscopic images are a great challenge for segmentation algorithms due to the different diversities in skin and lesion. In some images there is a low contrast or smooth transition between lesion and the surrounding skin. More over ,these images usually contains some intrinsic skin features like hairs ,black frames ,skin lines, blood vessels and air bubbles. Large number of segmentation algorithms have been suggested to overcome these difficulties .These algorithms cam be broadly divided into 4 types[16]

A.Thresholding based Segmentation: Thresholding is one of the easiest method of segmentation where a gray scale image is transformed into binary image. Thresholding techniques have the advantage of being computationally simple and fast, and produce good results on images where there is good contrast between the lesion and the surrounding skin/ however, in the dermoscopic images these methods generally produce inconsistent results, since there is low contrast and a smooth transition between the lesion and the skin, which leads the algorithm to fail.[2]

B. Region-Based Segmentation: In this method the image is separated or clustered into small regions based on common properties of an images. Generally, region-based methods have difficulties when the pigmented skin lesions resent a great variety of colors or textures along with different skin types which leads to over segmentation.[16]

C. Edge Based Segmentation: This technique selects weather the pixels of an image belong to the edge or not. It is one of the simple segmentation method in image processes. The existence of weak edges in the images resulting from a smooth transition between lesion and skin is the main problem behind the edge based approach. Another drawback of this is the presence of noise points in the image which can be derived from some image artifacts like hairs, air bubbles and skin lines. The result can be convergence of contour to noise points and incorrectly segmented skin lesion.[8]

D.Clustering based segmentation: This is based on grouping of samples known as clusters, directly applied or extended to the high dimensional data. This technique is mostly used for gray scale images. Clustering mainly involves the partitioning of a feature space

into homogeneous regions. [12]

EXISTING ALGORITHMS

Thresholding Algorithm

H Gangster presents a thresholding based segmentation technique for melanoma recognition in [17]. Thresholding is one of the simplest segmentation technique used for melanoma detection. It comes under similarity based approach. It can be sub divided into two types global thresholding and adaptive (local) thresholding. Global thresholding uses a single threshold value throughout the entire image. It is a iterative process which considers the mean of all pixels as the initial threshold after grouping based on this initial threshold a new threshold value which is the average of mean of pixel intensities of each group is calculated. Then the pixels are regrouped based on the new threshold. This iterative process continuous till the difference between the new threshold and the previous one becomes negligibly small. The local thresholding works by dividing the image into small regions and using separate threshold value for each sub regions. The output is a binary image showing the segmented portions. Thresholding method performs fairly well for images with good contrast between foreground and the background but not for images with sharp peaks. Another advantage is that they does not require any prior knowledge about the image. This method usually fails due to the over lapping of two regions of the images. [1][19]

K Means Clustering

In K means method developed by MacQueen [18], the image pixels are divided among the clusters based on some distance metrics between cluster centroids and all pixels. The objective of K means clustering is to partition and image into mutually exclusive clusters. This is done by minimizing the selected distance metrics. The number of clusters is fixed with a prior knowledge of the image. Initially the distance between each pixels and all cluster centroids including the one pixel is located is calculated. Based on this distance metric, the pixels are reassigned to the nearest centroid, thus a new centroid is obtained based on this pixel relocation. This iterative process continuous till all the pixels have been grouped into their nearest centroid and the centroid value changes no further. K means algorithm is easily programmable and computationally economical. The output is sensitive to initial choice of clusters. [2]

Fuzzy C Means clustering

Fuzzy C means proposed by Besdek [20] is a soft computing technique and a variant of K means. Fuzzy C means is an unsupervised technique that finds application in feature analysis, clustering, and classifier designs. FCM is robust and retains more information from the original image than K means algorithm. The main objective of Fuzzy method is to minimize an objective function iteratively by introducing certain fuzziness for the belongingness of each image pixels into each cluster [21]. The degree to which each pixel belongs to a cluster is given by the membership value. The crucial problem associated with this clustering is the assignment of clusters approximately by the user that is the user may not assign the correct number of clusters for the specific application. Although this is an effective method the resulting membership value does not correspond well to the degree of belonging of the data. Also becomes inaccurate in noisy environment [2].

Statistical Region Merging

In statistical region merging proposed by Nock and Neilson [10] regions are considered as set of pixels with homogenous properties. These are iteratively grown by combining smaller regions. It is a merging segmentation where the merging of two or more regions is based on a statistical test. This statistical test works with a predicate which specify the deviation in the intensities of test regions. Thus the basic components of the algorithm can be defined as the merging predicate and the order of the merging. It is very important that any two regions in an image can be merged if and only if they satisfy the statistical test conditions. So the test conditions need to be applied for all regions before merging which will be time consuming. The algorithm has an advantage of ease to implement and it can handle images with multiple channels and noises [5].

Active Contour Models

Active contour models are parametric snake models presented by Kass [22]. This contour models locks on to the nearby edges under the influence of a user imposed constrained energy and the energy of the image. Snake is a spline which is controlled by an energy minimizing function. And it relies on the image gradient for edge detection. Active contours are often attracted by spurious edges due to artifacts and reflections which does not belong to the lesion boundaries. Therefore robust methods which are able to discard the influence of edges introduced ,defined as adaptive snakes that employs estimation based on expectations maximizations algorithms for detecting contour segments. But disadvantage is that the capture range of the snake is limited and requires experts initialization also the snake do not detect curvatures in the images [8].

Gradient Vector Flow

Automatic lesion boundary detection in dermoscopic images using gradient vector flow segmentation is introduced by B Erkol in [3]. The gradient vector flow is an well known algorithm successfully used in medical imaging applications. The object boundaries are

approximated by an elastic contour which is initialized by the user. The contour is then modified based on differential equations. The gradient vector flow field allows long range attraction of the contour towards the object boundaries. The initialization of this algorithm is automatic. The method works by placing a circle with a given radius on the images. Here the circle center is given by the center of the segment region which is obtained by adaptive thresholding [23].

Fuzzy-Based Split and Merge Algorithm (FBSM)

J Maeda introduces a Fuzzy based split and merge segmentation technique in [25] . The algorithm originally aims at unsupervised perceptual segmentation of natural color images. First, the algorithm extracts color and texture features from an original image. Chrominance is used as color features and statistical geometrical features are used as texture features. Then a split and merge technique is executed in four steps: simple splitting, local merging, global merging and boundary refinement. A fuzzy based homogeneity measure is used to estimate the similarity of any adjacent regions. This combines the resemblance of color and texture features with different degrees of importance. This measure simplifies the complex mechanism of integrating different features by symbolic representation[12]

Iterative Thresholding

A novel approach for analyzing melanoma images using thresholding segmentation is proposed by Abbas Hussien Miry in [26]. In iterative segmentation the RGB image space is transformed into two intensity images. For that initially image is transformed into HVC color space, since the human color perception is closely related to HVC color space. Subsequently this is converted into intensity images. After rescaling the image with gray level histogram the higher and lower values in the lesion are compared. Two membership values are obtained which specifies the degree of certainty of pixels. Threshold values for two intensity images are then calculated, finally resulting to a binary image. Morphological operations are also performed to obtain the final lesion.[11]

Otsu's Algorithm

Otsu's algorithm is one of the oldest segmentation techniques presented by Scholar Otsu in 1979.It is a kind of global thresholding which depends on gray value of image. It is a widely used simple and effective thresholding method[27].It is one of the leading ways for automatic thresholding which transforms the gray scale image to binary image. Otsu supports pixel density of an image and iterates the set of all values by measuring the pixel range of each side of an image. Otsu method was one of the efficient thresholding segmentation methods for general real world images considering uniformity and shape dimension measures but takes too much time to be practical for multilevel threshold selection

Wavelet Network Method.

Komal Lawand introduces a new concept of wavelet Networks for segmentation of dermoscopic images in [9]. Wavelet network is a novel approach that combines the wavelet decomposition and neural network capacity of self learning. That is neurons in the conventional neural network are replaced by wavelets in wavelet networks. For the wavelet network formation ,the Mexican hat wavelet is first selected as the mother wavelet and the lattice structure is formed by choosing different shift and scale parameters. The set of effective wavelet is obtained by using two stages of screening. Finally the network weights are calculated using the orthogonal least square algorithm. Red, Green and Blue matrix value of the dermoscopic images are given as the input to the wavelet network. Then the image is segmented and the exact boundary of the skin lesion is obtained as the output. Wavelet networks take the full advantage of characteristics of wavelet transform and neural network ability of universal approximation which makes them a excellent segmentation technique for melanoma images.

CONCLUSION

The research in dermoscopic images has been increased considerably for the early detection of severe skin cancer. This paper evaluates different segmentation techniques used for tracking the boundary of skin cancer lesions. The result of each algorithm is greatly influenced by type of images used for analysis .Among the implemented algorithms, wavelet Network gives accurate segmentation results for dermoscopic images. Due to the time-frequency localization of wavelet transform and self learning characteristics of Neural Networks ,Wavelet Network is more effective and robust.

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