RESEARCH ARTICLE OPEN ACCESS

A Survey on Image Segmentation Techniques Used In Leukemia Detection

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ABSTRACT
Image segmentation commonly known as partitioning of an image is one of the intrinsic parts of any image processing technique. In this image processing step, the digital image of choice is segregated into sets of pixels on the basis of some predefined and preselected measures or standards. There have been presented many algorithms for segmenting a digital image. This paper presents a general review of algorithms that have been presented for the purpose of image segmentation.
Keywords: Segmentation, K-means, Leukemia

I. INTRODUCTION

Segmenting or dividing a digital image into region of interests or meaningful structures in general plays a momentous role in quite a few image processing tasks. Image analysis, image visualization, object representation are some of them. A formal definition for image segmentation can be defined as the technique to divide the an image f (x, y) into a non empty subset f1, f2, ..., fn which is continuous and disconnected. The prime objective of segmenting a digital image is to change its representation so that it looks more expressive for image analysis. During the course of action in image segmentation, each and every pixel of the image segmentation is assigned a label or value. The pixels that share the same value also share homogeneous traits. For example color, texture, intensity etc. There are quite a few applications where image segmentation plays a pivotal role. These applications vary from image filtering, face recognition, medical imaging (for example locating tumors, diagnostics etc), finger print recognition, satellite imaging etc.

The remaining paper is structured in following manner. The next section describes the different types of segmentation that are generally used. This section also contains brief description of the related work carried out in respective areas. Concluding remarks are provided in section 3. Section 4 contains references that are used in this paper.

II. SEGMENTATION TECHNIQUES

Over the years, plenty of work has been done in the area of image processing and so is the case for image segmentation. Different researchers have come up with varied segmentation algorithms but till date there is not a single algorithm that could be said as appropriate for all variants of images. As a result, algorithm that is developed for one set of images cannot be applied to a different set of images. Hence there exists a major challenge of developing a single and unified approach of image segmentation that could be used for all sorts of images.

There are multiple segmentation techniques available and they can be used individually or in combination with others. These approaches can broadly be divided into two categories on the basis of following properties that an image possesses.

(a) Image's Discontinuities

In this the image is segmented based on the discontinuities or abrupt changes for example intensity that appears in a digital image. This includes algorithms like edge detection.

(b) Image's Similarities

In this the image is divided based on the similarities existing in a digital image. Thresholding, region growing, splitting and merging are some examples of segmentation in which regions are defined and segregated on the basis of some criteria.

Other than the above approach, the segmentation techniques can be divided as follows.

2.1 Edge Based Segmentation

In this, edges of objects in an image are identified that are assumed to be the objects' boundaries. These boundaries are used for segmentation. The drawback of this technique is that the edges do not guarantee to form closed boundaries. To avoid this after the first step when the object boundaries are detected, these edges are processed so that only closed boundaries remain. Then these object boundaries are filled to produce segmented image. Example is Canny Edge detection algorithm.

A segmentation technique based on extracting the region of interest from a larger image around thresholded cell nuclei was proposed by Katz [9]. The process of segmentation into cell or non-cell regions was carried out using canny edge detection followed by a circle identification algorithm.

In [16] a shape based approach is proposed to extract thin structures like lines and sheets from 3D biomedical images. These thin structures are modeled using ellipsoidal model. The existing filters which incorporate Gaussian filters are simplified and applied for getting segmentation results.

In [19] segmentation is performed using CIELAB color space and various edge detection algorithms. The edge detection methods incorporated were Sobel, Prewitt, Roberts, Laplacian of Gaussian and Canny edge detectors. Out of the different edge detection algorithms, canny edge detector's results were best. Canny uses two different threshold values to identify strong and weak edges and includes weak edges only if they are connected to strong edges.

A new method for segmentation is proposed in [13]. It makes use of Gabor Filters for extraction and segmentation of tagged cardiac images. Gabor filters can be used to design adaptive filters for different local regions because they are wavelet like local filters in spatial domain. An advantage of Gabor filter is that they use Gaussian envelopes. Due to this, these filters always achieve minimum space bandwidth. This advantage contributes in getting full constraints in spatial as well as frequency domain. Therefore Gabor filters are used widely in image processing applications like texture segmentation and edge detection.

2.2 Region Based Segmentation

In this type of segmentation the objective is to group pixels into regions that share similar characteristics. A disadvantage of this technique is that it may lead to failure if the definition given for region uniformity tends to be too strict. For example if brightness has to be approximately constant but actually it varies linearly, different threshold values are applied for these sub regions. Local thresholding is effective when the gradient effect is small with respect to the chosen sub image size.

N. H. Abd Halim, M. Y. Mashor, A. S. Abdul Nasir, N. R. Mokhtar, H. Rosline [2] used this technique to segment nucleus using S component of HSI model for leukemia detection. For this the histogram of S component of image is developed to get the threshold value.

Emad A. Mohammed, Mostafa M. A. Mohammed, Christopher Naugler, Behrouz H. Far [10] proposed a technique for chronic leukemia cell segmentation. In the proposed approach for segmenting a nucleus first an optimal threshold value is obtained using Otsu's method. Canny edge detector is applied followed by erosion and dilation.isolated pixels are removed and a segmented nucleus mask is obtained.

The advantage of seeded region growing for small objects is discussed in [11]. If only limited number of objects are to be considered in an image, only smaller number of pixels are to be visited. Therefore combining seeded region growing together with pixel classification yields a better performance with respect to time (shorter execution time) and a guaranteed connectivity is approached.

A region growing segmentation method is proposed in [18]. The paper focuses on multi scale local features which are selected as the characteristic for region growing in image. As good features assure good segmentation results, therefore a multi-scale local energy feature is constructed and segmentation is performed using seed point in region growing based segmentation.

A region growing based segmentation is proposed in [22]. The technique incorporates a two step process for segmentation of abnormal white blood cells and nucleus. The first phase consists of enhancing the quality of the image using partial contrast, contrast stretching and dark stretching. Then a segmentation process based on HSI color model, filtering and region growing is carried out to get a fully segmented image. The results show that the combination used for segmentation improves the accuracy of the result.

2.3 Threshold Based Segmentation

This is one of the most popular techniques that are used for segmentation. Thresholding maps a grey valued image to a binary image. Many algorithms exist to find the optimum threshold value. Thresholding can be defined as

Grey value remapping operation, $g(v) = \begin{cases} 0 \; if \; v < t \\ 1 \; if \; v \geq t \end{cases}$

Where v & t represent grey value and threshold value respectively.

Ghosh et al. [7] proposed a threshold detection scheme using fuzzy divergence for leukocyte segmentation. Various fuzzy membership functions i.e. Gamma, Gaussian and Cauchy functions were evaluated for the test images. While this method is able to segment the nucleus accurately, there is no provision for cytoplasm extraction which is also an essential morphological component for ALL detection.

Neerad Phansalkar et al. proposed a new local thresholding segmentation method to solve the problem of non-uniform staining using different color spaces [6].

Fabio Scotti [17] presented an approach for WBC segmentation of blood microscopic images. Herein first the image of interest is presented in L*a*b color space and a local threshold is applied.

Following this a fully supervised clustering is applied to achieve segmented regions.

2.4 Clustering Based Segmentation

Clustering is nothing but an attempt in which measurement points or patterns are grouped together. This technique is generally applied for data of n dimension. This n corresponds to an arbitrary number, i.e. it can be two, three or more. The clustering technique is best suited for sparse type of images. This technique includes methods like k-means, fuzzy c-means etc.

Subrajeet Mohapatra & Deepti Patra [1] proposed an automated nucleus segmentation method. In the proposed technique, two step segmentation is done to segment a WBC nucleus from rest of the image objects. In first stage an initial segmentation is performed by executing a semi supervised k-means clustering. The next stage is a follow up of first step in which a second stage of segmentation is done using nearest neighbor classification in L*a*b space.

In [17], a clustering based approach is used to segment white blood cells in blood microscopic images. In the proposed system, first the image is converted into Lab color space. Then a fuzzy k-means clustering is carried out that divide the image into 3 clusters. Simultaneously an automatic histogram based thresholding is also performed on the Lab color image. The two results i.e. clusters and the reference image (obtained after applying threshold) are compared, selected and a logical AND operation is performed. The resulting image is a clean segmented image.

The approach presented in [21] is used to detect AML (Acute Myelogenous Leukemia) in microscopic images of blood. Three clusters are identified which represent nucleus, background and other cells like erythrocytes, leukocytes etc. Every pixel of the image is assigned to one of these clusters based on the cluster property. The technique performs some preprocessing followed by k-means clustering for segmentation purpose. The segmentation is performed to extract the leukocytes' nuclei using color based clustering.

S. Schupp et al. presented a system of automatic microscopic image segmentation combining fuzzy clustering and active contour model. An automatic initialization algorithm based on fuzzy clustering is used to robustly identify and classify all possible seed region in the image. This seed are propagated outward simultaneously to localize the final contour of all objects [5].

In [12] numerous medical images are used to exemplify the effectiveness of relative fuzzy connectedness. A framework based on theory and algorithm is discussed to define objects via fuzzy relative connectedness. Then using the proposed theory it is shown that defined objects are independent of the referring elements chosen, if they are not part of the fuzzy boundary between objects.

In [14] a fuzzy approach for segmentation of WBC color images is proposed. Here a representation of colored WBC microscopic images is used that avoids colors' low saturation and illumination problems that arise because of shadows and illumination. In the proposed technique first the RGB image is converted to Smith's HSI transformation. Then a membership function is assigned to each color pattern. After obtaining the membership degree for color patterns, pixel classification is carried out for segmentation purposes.

A fuzzy approach for leukemia detection is proposed in [23]. In the proposed paper, at first some preprocessing is done using selective median filtering followed by unsharp masking. Then the RGB image is converted to lab color space for further processing. A two step segmentation approach using fuzzy is then instated for segregating WBCs from other blood components. Then a classification using SVM classifier is done after a set of features are extracted. These features work as input sets for the classifier.

A clustering based segmentation is performed in [24]. After performing the preprocessing and color conversion of RGB to Lab color space, the segmentation is performed. The process for segmentation here is a two step process. In the first step a clustering based segmentation using fuzzy c-means is done. The idea is to classify each object into one of the four classes corresponding to RBC, background, cytoplasm and WBC nucleus. To overcome any overlapping of regions, a second segmentation is performed using nearest neighbor classification.

In [25] an unsupervised machine learning approach is proposed for the selection of significant genes of leukemia using k-means clustering. The proposed approach is used to discover the unknown patterns from the dataset. The k-means algorithm is carried out for cluster values of 5, 10 & 15. The resultant values are compared for leukemia gene identification.

2.5 Morphological Watershed Based Segmentation

This type of segmentation is applied when mathematical morphology needs to be applied. The algorithm considers any gray image as topographic surface. The surface is flooded from its minima and the water is prevented from coming out of different sources. This leads to division of image in two sets, watershed lines and catchment basins.

Dorini et al. [16] used watershed transform based on image forest transform to extract the nucleus. Concurrently, size distribution information is used to extract the cytoplasm from the background including

RBC. While effective for nucleus segmentation this method fails when the cytoplasm is not round.

The technique proposed in [10] makes use of watershed to segment blood cell images for identification of chronic lymphocytic leukemia. In the proposed method, after applying Otsu's method to obtain an optimal threshold, the edges of cell's objects are identified using canny edge detector. Then watershed is applied for segmentation purpose.

In [20], two stages of watershed transform is used for acute leukemia image segmentation. In the proposed approach, the initial step is to convert the image from RGB to HSV color model. In the next step, the saturation component is extracted and the gradient magnitude is determined. Then on the resulting binary image (which is obtained by applying Otsu's global threshold) the first level of watershed transformation is applied. This is done for dam construction (watershed ridge line). Then the gradient magnitude is imposed on this first level of segmentation and a second watershed transform is performed.

2.6 Neural Network Segmentation

Generally a neural network is used for classification purposes, however it can be used for segmentation as well. In general, a small area (of an image), is processed using what we call artificial neural network/s. examples are perceptrons, kohonen map etc.

Subrajeet Mohapatra, Dipti Patra, Sunil Kumar and Sanghamitra Satpathy [4] proposed a new technique that incorporates neural network for segmentation purpose. In the mentioned approach, segmentation is considered to be a pixel classification problem. The neural network is used to segment each pixel into cytoplasm, nucleus and background.

Rodrigues P, Ferriera M, Monteiro J [8] used an unsupervised and another supervised neural network simultaneously for segmenting gray scale leukocytes images. However, the use of two classifiers increases the time complexity and the segmentation accuracy can also be further improved.

III. CONCLUSION

In this paper, different segmentation techniques are classified and discusses. The advantages and disadvantages for various techniques are also mentioned wherever applicable. Image segmentation has evolved as a basic technique for image processing and computer vision, however no unified algorithm that can be generalized over all types of images exists. Therefore a universal and unique segmentation algorithm for researchers has vast future prospects.

A common framework for evaluation of segmentation in introduced in [15]. In here a metric unit that is based on the distance between segmentation partitions is recommended. This is done to mitigate the shortcomings of existing approaches.

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