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AUTOMATIC SEGMENTATION OF LUNG CT IMAGES BY CC BASED REGION GROWING

A.PRABIN [1], DR. J.VEERAPPAN [2]
[1]Research scholar, Anna University, India
[2] Professor, Sethu Institute of Technology, India

ABSTRACT

Computer Aided Diagnosis (CAD) of CT lung image has been a revolutionary step in the early diagnosis of diseases present in the lung. Developing an efficient and robust algorithm for Lung computer tomography (CT) image segmentation has been a demanding area of growing research of interest during the last two decades. The initial step in computer aided diagnosis of lung CT image is generally to segment the Region of Interest (ROI) present in it and then to analyze each area separately inorder to find the presence of pathologies present in it. This research reports on segmentation of the ROI by segmenting the CT lung images using supervised contextual clustering along with the combination of region growing algorithm. Region growing has been combined with CC in this work since it reduces the number of steps in segmentation for the process of identifying a tissue in the CT lung image. The performance of this proposed segmentation is proved to be better when it is compared with other existing conventional segmentation algorithms like 'Sobel', 'Prewitt', 'Robertz', 'Log', 'Zerocross'. From the experimental results, it has been observed that the proposed segmentation approach provides better segmentation accuracy.
Keywords: *Contextual Clustering, Segmentation Algorithm, Computer Tomography, Pulmonary Lung Image.*

1. INTRODUCTION

Segmentation methods are useful for partitioning an image into multiple segments inorder to provide an effective representation of the objects present in it. Moreover, Image segmentation is also useful for locating objects and boundaries (lines, curves, etc.) and to assign a label to every pixel in an image such that pixels with the same label share certain visual characteristics. Moreover, each of the pixels from particular regions are similar with respect to some characteristic or computed property, such as color, intensity, or texture. At the same time, the adjacent regions are significantly different with respect to the same characteristic [5].

The various regions obtained by segmenting in an image can be further used for different types of analysis and interpretations. Therefore, segmentation of image involves extracting important features and deriving the relevant metrics to segregate regions of homogeneous intensities. In order to achieve this, it is necessary to choose a selective region of interest by considering the application requirements. In the past, many image segmentation methods have been proposed by various researchers for performing successive image analysis. In addition, many researchers have used the existing thresholding techniques for segmenting the various regions of interest. In short, the most frequently used techniques for segmentation are statistical methods, geometrical, structural, model based, signal processing methods, spatial domain filters, Fourier domain filtering, Gabor and wavelet models have also been used in most works present in the literature [6, 7].

A novel method for segmenting the lung CT images by combining the fuzzy logic based bitplane to locate the region of interest of medical images was proposed in [8]. This segmentation algorithm consists of three steps,

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namely identification, rule firing, and inference. In the first step, they begin by identifying the bitplanes that represent the lungs clearly. In the second step, the triple signum function assigns an optimum threshold based on the grayscale values for the anatomical structure present in the medical images. Fuzzy rules are formed based on the available bitplanes to form the membership table and are stored in a knowledge base. Finally, rules are fired to assign final segmentation values through the inference process.

In this paper, the combination of CC along with the region growing algorithm have been used for effective segmentation of the CT Lung image.

The remainder of this paper is organized as follows: Section 2 discusses the features and methods proposed in related works. Section 3 explains the problem definition obtained in this research work and highlights the advantages of segmenting lung CT images. Section 4 provides the results. Section 5 gives the conclusion on this work and also provides some possible future works.

2. RELATED WORKS

Accurately lung segmentation should be done since, the nodules present on it may be on the boundary of the lung parenchyma. Such lung nodules will be lost and it reduces the detection accuracy, if the entire lung is not segmented accurately. Main goal of lung region of interest segmentation is to separating the voxels corresponding to lung region from the voxels corresponding to the surrounding anatomy.

Lin DT et al [10] proposed a novel threshold based segmentation approach for segmenting lung region present in the CT lung images. In their method, they have used a 5x5 median filter for removing the noise present in it. The Foreground region is separated by omitting the rim of the image along with the background regions. A new threshold based method for segmenting the lungs from diseased CT lung images by selecting an optimal threshold for a given image by comparing the curvature of the lung boundary along with the ribs was proposed in [11] Antonelli et al [12] proposed a combination of background-removal operator and iterative gray level thresholding for segmenting the lung region. In their work, the background was not eliminated well due to the presence of noise.

An adaptive border marching algorithm proposed by Jiantao Pu et al [9] segments the lung region and reduces the under segmentation ratio. They used the gray-level thresholding to obtain the lung regions and a flood-filling methodology to remove non-lung regions present after the thresholding. Ozekes et al [11] segmented the lungs of the CT images using Genetic Cellular Neural Networks (G-CNN). In their work, the lung regions were specified using the 8 directional searches and +1 or -1 value were assigned to each voxel. In the work proposed by Cao Leiet al [8], a rough image of lung was acquired by a combination of optimal thresholding and mathematical morphology. A self-fit segmentation algorithm was applied on the segmented result to obtain a refined output.

A novel three step segmentation process for the analysis and segmentation of lung CT images was proposed in [16]. In this approach, if the area occupied by GGO in the CT image is large, then a medical doctor extract the features. However, the possibility of overlooking the light gray shadows present in the image becomes higher when there exists these GGO in a small area. In the first step, the extraction of region of interest is done inorder to segment the lung area. Preprocessing such as labeling, shrinking and expansion done in the CT by employing the process of binarization inorder to achieve a better segmentation accuracy. In the second step of their work, characteristics of GGO shadows such as mean value, standard deviation, and semi interquartile range are carried out. In the final step, the GGO shadow's regions were extracted by the process called linear discriminant function. Suspicious shadows are extracted by Variable N-Quoit (VNQ) filter from GGO. The suspicious shadows are classified into a certain

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number of classes using feature values calculated from the suspicious shadows.

3. CONTEXTUAL CLUSTERING WITH REGION GROWING

Region growing [1] is an iterative technique employed to identify connected regions of interest (contiguous sets of voxels) in images, obeying some inclusion rule (generally based on threshold values), and according to the notion of discrete connectivity [2]. Initially, the region growing starts by choosing an initial pixel as a seed point which is present in the region to be grown and, after checking its inclusion of neighbors in the growing region based on the threshold value. Each included voxel becomes in turn a seed point for the following iteration. The above process continues until all the pixels are added in the grown region based on the set of rules and threshold.

In our approach, a region growing approach along with the clustering is used to fix the threshold inorder to segment the region of interest present in the CT lung images. The initial seed point is a voxel (3x3 or 5x5 pixels) belonging to the lung region, and the fuzzy rule fixes a value by selecting the voxels with intensity values lower than the given threshold. In this way the entire lung parenchyma is connected which present in the CT lung image is starting from the bronchi, carena, and the trachea. The initial seed point is automatically chosen by selecting the 3x3 pixel which is present in the central slice of the CT image and grows towards the entire lung region present in the image.

Recently, there has been considerable interest among researchers in statistical clustering techniques [3] in image segmentation. In a clustering technique along with the region growing, each pixel is associated with one of the finite number of threshold is grown to form disjoint regions. The contextual clustering method proposed by [4, 9] is a supervised algorithm. It uses a 3 X 3 overlapping windows of pixels to form a segmented image. The quality of segmented image depends upon 1) A defined threshold value (T=140) by the user which is used to choose the nearest regions for segmentation, 2) a controlling parameter β which is in the range of 0< β <1, 3) the median value of the 9 pixels in the window, 4) the total number of intensity values (u) >1 inside the window, excluding the already identified median value.

The contextual clustering segments a data into category 1 (ω_0) and category 2 (ω_1) based on the grown region.

The following are the steps adopted for implementing the contextual clustering algorithm for segmenting the lung region from CT lung images.

Step 1: The decision parameter T (positive) and weight of neighborhood information β (positive) are defined. Let N_n be the total number of data in the neighborhood. Let Z_i be the data itself, 'i'.

Step 2: The data is classified when Z_i>Tα to ω_1 and data to ω_0. The classification is stored to C_0 and C_1.

Step 3: For each data 'i', the number of data u_i is counted, belonging to class ω1 in the neighborhood of data 'i'. The data outside the range belong to ω_0.

Step 4: The data with is assigned to ω_1 and other data to ω_0. The classification is stored to variable C_2.

Step 5: If $C_2 \neq C_1$ and $C_2 \neq C_0$, copying of C_1 to C_0, and C_2 to C_1 are done and returned to step 3, otherwise the process is stopped and returned to C_2.

The region growing based contextual clustering implementation is as follows:

Step 1: Read CT lung image.

Step 2: Sort the values of the block of pixels and create Patterns.

Step 3: Find the Median value of the Pattern.

Step 4: Find the number of values greater than the Median Value.

Step 5: Calculate CC using equation (1)

Step 6: Assign CC as the segmented values.

Step 7: Compare the segmented values with the Region growing threshold

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The contextual value V_{cc} is calculated by the below equation

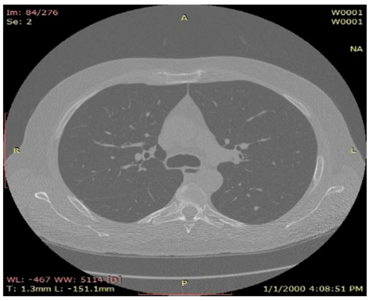
$$V_{cc} = \text{Median value} + \frac{\beta}{\text{threshold}} \times \left\{ u - \frac{\text{Windowsize}}{2} \right\} \quad (1)$$

The value obtained is compared with a set threshold (Threshold=140) which is fixed inorder to choose the pixels for region growing. If the obtained contextual value is less than or equal to the set threshold, then 0 is assigned to the center of window else, 1 is assigned to the center of the window. The presence of 1 in a region in the image shows the segmented region of interest.

Experimental results and discussion

Lung CT images have been considered in this paper. Computed tomography images of different patients have been taken from the LIDC database. The CC segmented results for different region growing threshold along with its original images has been presented in Table 1

Table 1 Segmented Results of Block Size 3x3 for Threshold 20 to 140

Threshold	Image	Description
		Original image
		Cropped original
80		No segmentation output for threshold < 100.

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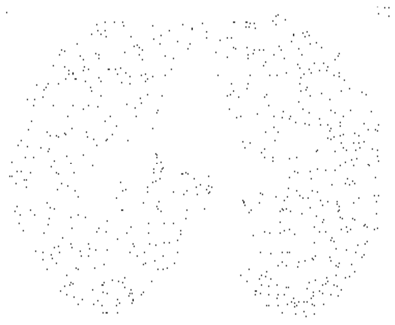
100		Slight segmentation appears with lungs visible.
120		The lung is clearly demarcated from the background. However, more segmented dots are present inside the lungs. The dots are not required.
140		The lung is clearly separated from the background with more dots as noise.

Table 1 shows the segmented images from cropped image obtained from the original CT lung image. The parameters given for the variables of CC algorithm are block size of the moving window is 3x3. The region growing threshold is varied from 20 to 140.

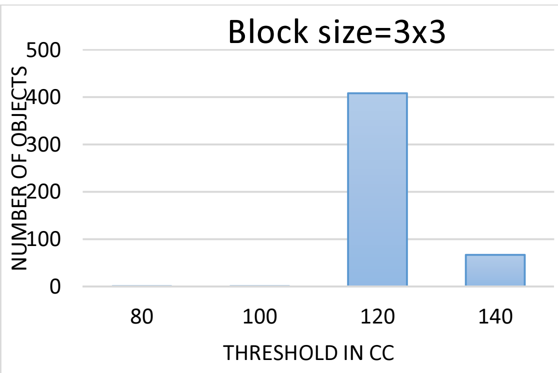


Figure 1 Segmented Objects for Different Threshold at Block Size 3x 3

Figure 1 shows the number of objects calculated using region properties of Matlab for a block size of 3x3 moving window. The number of objects obtained from segmented images for CC based region growing threshold changed from 20 to 140. More number of segmented objects is present when the image grown to a threshold of 120. Only one object is obtained when the threshold is less than 120. Correct number of objects that is 67 is obtained when the threshold is 140.

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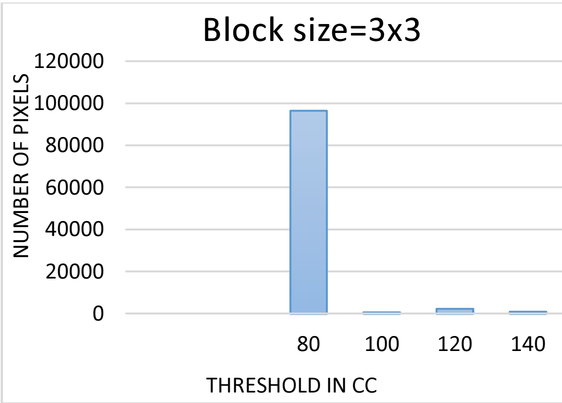

Figure 2 Segmented Pixels for Different Threshold at Block Size 3x 3

Figure 2 shows the number of pixels calculated using region properties of Matlab for a block size of 3x3 moving window. The number of pixels obtained from segmented images for region growing threshold changed from 20 to 140. More number of segmented pixels is present when the image is segmented with threshold less than 100. All the segmented pixels correspond to one object only. Keeping the ground truth image into consideration, the number of pixels corresponding 67 objects are found to be the correct number of segmented pixels (999).

Matlab 'Region props' function has been used and the number pixels and number of objects are shown in figure 1 and 2. Earlier researchers had used different metrics to evaluate the segmentation accuracy. In this report, we have used the 'Region props' function to evaluate the accuracy of segmentation and it has been found that the proposed segmentation approach is much better when compared to that of remaining segmentation approaches mentioned in the literature.

4. CONCLUSION

In this paper we have proposed a new method for segmenting brain MR images using the supervised contextual clustering based region growing method. The main purpose of proposing this approach is to improve the segmentation accuracy by reducing the false segmentation. Main features of the proposed algorithm is the use of region growing along with the supervised contextual clustering. This method is applied to different types of CT lung datasets inorder to validate the efficiency of the proposed algorithm. In this proposed framework, segmentation of the normal tissues is not degraded since the unwanted section other than the region of interest is removes exactly.

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