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# An improved region growing based segmentation algorithm for brain MRI

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**ABSTRACT**

Present medical science very much depends on the medical images and medical imaging technology like MRI, CT, US, etc. Doctors are using these medical images for the anatomical structure study and for the treatment planning. But generally medical images are complex and noisy. This paper discuss about the segmentation and pre-processing which reduce the complexity of medical image analysis and eliminate noise and unwanted region without any loss of important information in the image. Region growing segmentation is considered for the segmentation and compared the performance with pre-processing.



## Introduction

Medical images possess very important and useful information about the anatomical structure of the human body and it has the high level application in the medical science. But it is more important to represent the medical images in a simple format or in a manner which is easier and meaningful for analysis. The images from the medical imaging technologies like MRI, US, CT are more complex to understand and noisy.

In most of the cases the doctors are depend on the medical images. It indicates that medical images are very important key factor in the medical science, because it has valuable information about location of tissue or tumour, information about volume of the tissue and its growth. It shows the need and importance of image processing in medical images.

Segmentation is the important tool in medical image processing which helps to make a simple format of medical image which is easier and meaningful to analyse. Segmentation is the process of partitioning the image into subdivided segments or objects. It is used in the medical images to identify the tissue or tumour, to measure the volume of tumour, for the radiation therapy and to locate the object and boundaries. Varieties of methods are available for the medical image segmentation like thresholding, region growing, clustering, etc [1].

Even though the segmentation helps to identify the region of interest and for other application, there may be lack of accuracy because of noisy and nonlinear characteristics of the medical images [1][6]. These undesirable characteristics of the medical image will lead to partial volume effect, presence of artifacts, and Intensity inhomogeneity, etc. It is not expected from the images so the pre-processing step is needed before the segmentation. Pre-processing before the segmentation is improving the performance method, which will yield quality output [6][7]. Pre-processed image will lead to an accurate extraction of the region of interest within images, which is also helps for the volume measurement of tissue or glands [6] [7]. Pre-processing can be added to any segmentation method. In this work region growing is analysed with and without pre-processing and compared the performance.

This paper is organized as follows. Section II describes segmentation method used for evaluation with pre-processing steps. Section III discusses the experimental results. In Section IV conclusion of paper is discussed.

## II. Image Segmentation Algorithm

Image segmentation algorithms widely used as a crucial technique for high-level image understanding, and it significantly reducing the complexity of content analysis of images. This usage of segmentation can be widely applicable for medical image processing and this commonly preferable by doctors.

### *A. Region Growing Method*

Region growing is a classical segmentation method. This method tries to extracting an image region that is connected based on some predefined criteria. These criteria can be based on intensity information and/or edges in the image. One example for the region growing method is seeded region growing method [1]. It works on the assumption that, the intensity values within each region/object conforms to Gaussian distribution, the mean intensity value for each region/object is different [3]. The procedure for the same as follows:

1. This method takes a set of seeds as input along with the image. (The seeds spot each of the objects to be segmented).
2. The regions are iteratively grown by comparing all unallocated neighbouring pixels to the regions.
3. The difference between a pixel's intensity value and the region's mean, $\delta$, is used as a measure of similarity.
4. The pixel with the smallest difference measured this way is allocated to the respective region.
5. This process continues until all pixels are allocated to a region.

The main goal of segmentation is to partition an image into regions. Some segmentation methods such as Thresholding achieve this goal by looking for the boundaries between regions based on discontinuities in gray levels or color properties.

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The region based segmentation is a technique for determining the region directly. The basic formulation or mathematical description for Region-Based Segmentation is.

- $\cup_{i=1}^{n} r_i = r$
- $r_i$ is a connected region, i = 1, 2, …,n
- $r_i \cap r_j = \emptyset$ for all i = 1,2,…,n.
- P ($r_i$ ) = TRUE for i = 1,2,…,n.
- P ($r_i \cup r_j$) = FALSE for any adjacent region $r_i$ and $r_j$.

$P(r_i)$ is a logical predicate defined over the points in set $P(r_k)$ and $\varnothing$ is the null set.

(a). Means that the segmentation must be complete; that is, every pixel must be in a region.

(b). It requires seed points in a region, that must be connected in some predefined sense.

(c). Indicates that the regions must be disjoint.

(d). Deals with the properties that must be satisfied by the pixels in a segmented region. For example P($r_i$ ) = TRUE if all pixels in $r_i$ have the same gray level.

(e). Indicates that region $r_i$ and $r_j$ are different in the sense of predicate P.

Advantages of the region growing methods are

- Region growing methods can appropriately distinct the regions that have the same properties.
- Region growing methods can provide the segmented output with clear edge.

Disadvantage of the region growing method are

- The computation is expensive, no matter the time or power.
- Noise or variation of intensity may result in holes or over segmentation.
- This method may not distinguish the shading of the real images.

Proposed improved method for segmentation is shown in fig.1.

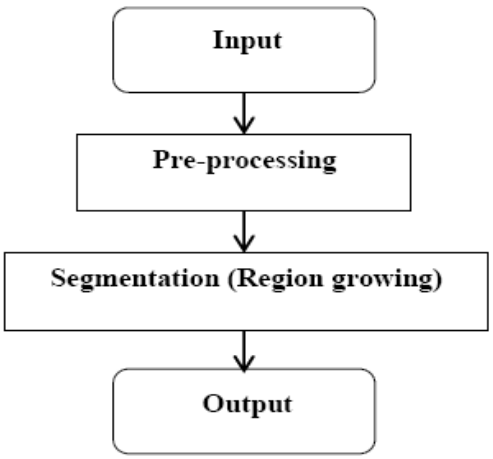



**Fig.1 Flowchart of improved threshold segmentation**

### B. *Pre-processing*

Medical images are generally exhibiting non-linear characteristics and also noisy. Pre-processing steps which added before the segmentation process for the improved output and segmentation process will not affected by the noise and won't cause any undesirable changes in the segmented output. To get better segmentation output pre-processing is necessary for the medical image [6] [7]. Pre-processing step which consist of region of interest selection, de-noising and image enhancement processes [7]. Flowchart of the pre-processing step is shown in fig.2.

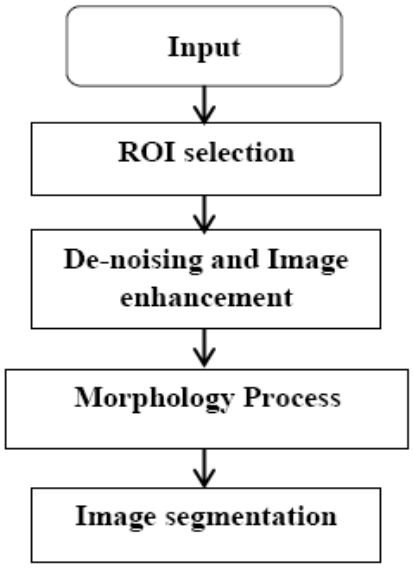



**Fig.2 Flowchart of the pre-processing step**

#### a) *ROI Selection*

ROI stands for Region of Interest selection. ROI selection helps the end user to extract or cut the needed region [7]. Because medical images more commonly have identical regions which will have same gray level, intensity level and same shapes for example thyroid image and scanned image of brain. In the thyroid image there will be same identical glands around the thyroid gland, so the correct thyroid gland around the trachea alone should select and the ROI selection will helps to extract the thyroid region alone. It will avoid the unwanted region of the medical images and reduce complexity.

#### b) *De-noising*

Medical images are more used by the doctors, because it has major applications like anatomical structure study, for treatment planning, to identify the tissues and glands and also for its volume measurements. Medical images are the output of the medical imaging technology like MRI, CT, US, etc. But the medical images are generally complex in nature and also noisy. Medical images contain several noises like salt and pepper noise and speckle noise, etc. therefore these noises are should remove before the segmentation process for the correct output. For the de-noising process, considered rank and median filtered.

Rank and median filters are the order filters in which the adjacent pixels or the neighbourhood pixels are arranged in an ascending order based on the gray level value and using this order to select the correct value or position. The placement of the value or position within this order set is referred as the rank [8].

n-pixels be sorted into numerical order ($P_1$,$P_2$,$P_3$,……$P_n$) where $P_1 \leq P_2 \leq \ldots\ldots P_n$ output is then selected,

$$\text{Rank}(j) = P_j \quad 1 \leq j \leq n \qquad (1)$$

When this is done for all possible window positions,

$$G = R_j(P) \qquad (2)$$

where P is the input image, G is the processed image and j is the rank position [8].

Special case of the rank filter is, when the pixel value is odd is the median filter where the median rank position is selected. Other two cases are selecting extreme rank position, one is min filter and other is max filter as shown in equation 4 and 5.

$$\min(P) = R_1(P) \qquad (3)$$

$$\max(P) = R_n(P) \qquad (4)$$

***c) Image Enhancement***

The module Nonlinear Enhancement enhances the contrast of images with wavelet transformations. This technique decomposes the input image into the four sub-bands by using Discrete Wavelet Transform (DWT). The low frequency sub-band is smoothed and the high frequency sub-bands are sharpened by using non-linear piecewise filter. The enhanced image is obtained by applying inverse DWT to the smoothed low frequency sub-band and sharpened high frequency sub-bands. 1-level decomposition is used in this system.

***d) Morphology Process***

The field of mathematical morphology contributes a wide range of operators to image processing, all based around a few simple mathematical concepts from set theory. The operators are particularly useful for the analysis of binary images and common usages include edge detection, noise removal, image enhancement and image segmentation. Morphological techniques typically probe an image with a small shape or template known as a structuring element. There are variety of morphological process like erosion, dilation, opening and closing. In this work morphology is used as optional for the region growing method. Erosion and dilation is used depends on the image characteristics in the pre-processing step. In this work erosion is used for the image.

Dilation, in general, causes objects to dilate or grow in size, erosion causes objects to shrink. The amount and the way that they grow or shrink depend upon the choice of the structuring element. Dilating or eroding without specifying the structural element makes no more sense than trying to low pass filter an image without specifying the filter.

***C. Volume Measurement***

Volume measurement of particular gland, tumour, and tissue using medical images are very important and also critical. Wrong calculation may lead to the wrong interpretation of the doctors for the treatment. There are many methods for the volume estimation like particle swarm optimization method, but the general method used for the volume estimation is, sum all pixels in the region and multiplies the value with the corresponding pixel area. The result is multiplied by the distance between medical image slices and computing the region volume. This method is less complex and takes less time for the computation.

**III. Experimental Results**

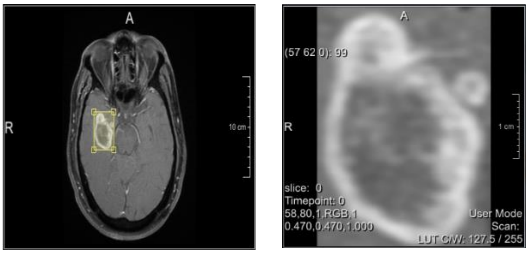
In this section discusses the performance of region growing segmentation and compared the performance of this method, with pre-processing and without pre-processing . This section also describes the various steps in the pre-processing step. Evaluation of the segmentation method considered for the brain MRI.

***A. Pre-processing***

The pre-processing is done before the segmentation process for the quality output. Pre-processing reduce the noise and avoid the unwanted regions in the image. Pre-processing step includes ROI selection, de-noising and image enhancement.

***a) ROI Selection***

ROI selection extracts the region that needed for the analysis. It avoids the other parts in the image which reduce the complexity. An example for the ROI extraction is shown in fig.3.



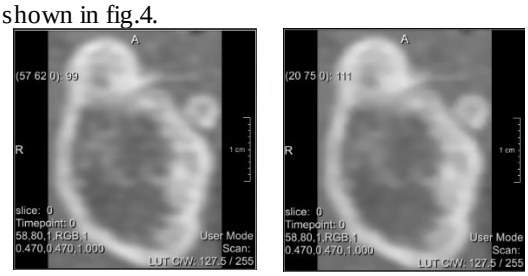
**(a) (b)**

**Fig.3 ROI selection process (a) ROI selection (b) extracted region**

A rectangular shape is using to select the region of interest. Region inside the rectangular box only get as output and regions outside the rectangular box will eliminate. It effectively reduces the complexity. It helps to analyse the needed region alone.

***b) De-noising***

It is essential to reduce or eliminate the noise from the medical images before further process. Noise in the medical images may lead to an incorrect segmentation and edge or shape of tissue or any region will not preserve. Noises are generally occurred due to the bit error in the capturing and transmission of images. Here for the de-noising, order filter is used. Rank, median, min, and max are the order filters. In which rank and median are the well using filters. De-noising for the particular ROI is shown in fig.4.



**(a) (b)**

**Fig.4 De-noising process for the ROI (a) original image (b) Median filtering**

Parameters obtained for the de-noising process of the ROI by the median filter is shown in table.1. Pixel value, volume, mean, and standard deviation are considered as the parameter for the analysis. Volume is measured in $mm^3$. Region of interest in the brain MRI is the tumour part. Parameters are measured for the ROI.

**Table1 Parameters obtained for de-noising of ROI**

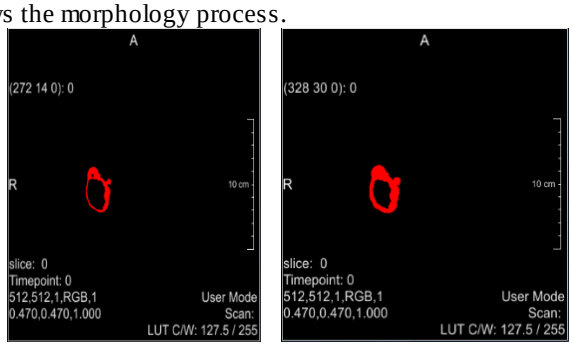
| Parameters | Median filter |
|---|---|
| Pixel count | 13920 |
| Volume($mm^3$) | 3079.78 |
| Mean | 144.72 |
| Standard deviation | 34.96 |

Number of pixel counted and the volume extracted in both rank and median filter are same. But the mean value and standard deviation is high for the median filter, mean stand for the average intensity value and standard deviation is the common way to describe the range of variation.

***c) Morphology Process***

Morphology is an elective process in the pre-processing included for region growing process. In the region growing segmentation the tumour part alone extracting using the seed point, it may not preserve shape and edge of the tumour because of the closeness in gray level of different tissue and due to the presence of noise. Tumour region may spread over the neighbourhood pixel, so dilation or erosion is done for the correct boundary extraction. It will helps for the correct volume

measurement. But in the case of threshold segmentation, threshold value is enough to extract the correct region. Fig.5 shows the morphology process.



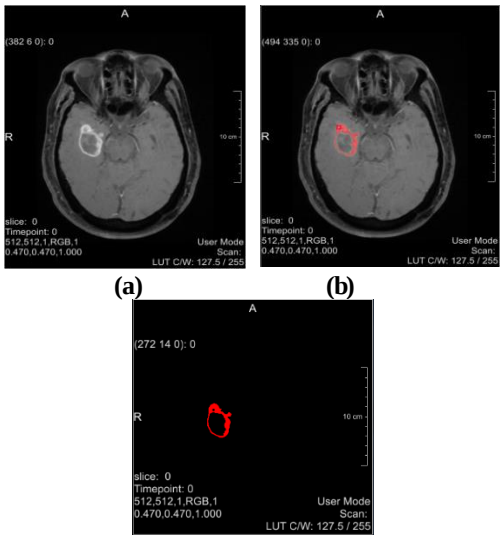

**(a) (b)**

**Fig.5 Morphology operation (a) Region growing after erosion, (b) Region growing after dilation.**

In this case erosion is suited for the region growing segmentation, because erosion helps to exactly extract the region with preserved shape and edges. Dilation cause spreading of region to neighbourhood pixel.

***B) Region Growing***

Region growing based segmentation models shares the following assumption about the image pixels properties. The intensity values within each region/object conforms to Gaussian distribution, the mean intensity value for each region/object is different.




**(a) (b)**

**(c)**

**Fig.6 region growing segmentation (a) pre-processed image (b) seed point selection (c) region extraction.**

Seeded region growing method is used for the region extraction.

**Table 2 parameters of the region growing segmentation**

| Parameters | Without Pre-processing | With Pre-processing |
|---|---|---|
| Pixel value | 13680 | 13440 |
| Volume($mm^3$) | 3076.68 | 2973.58 |
| Mean | 29.15 | 22.81 |
| Standard deviation | 81.15 | 72.77 |

The primary disadvantage of region growing is that it requires manual interaction to obtain the seed point. Region growing can also be sensitive to noise, causing extracted regions to have holes.

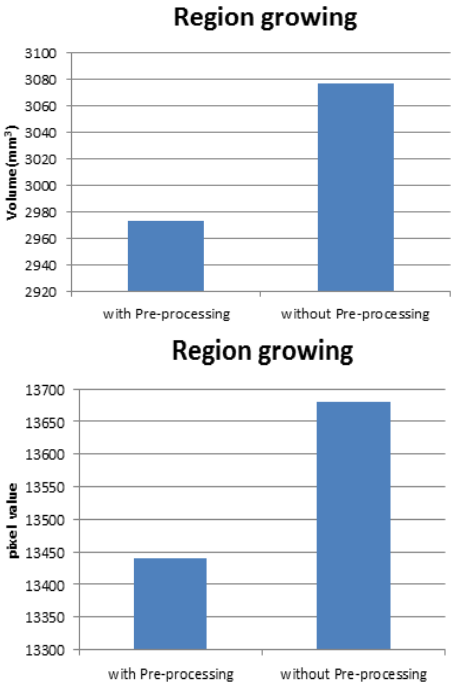



**Fig.7 Comparison between the region growing segmentation with and without pre-processing**

## IV Conclusion

Medical image segmentation is a very important tool in the medical imaging. Segmentation is a tool which reduces the complexity in the medical images and makes the analysis easier and meaningful to understand. Region growing segmentation is a simple method which extracts the tumour exactly. Pre-processing which eliminate the noise and unwanted region which leaded to a better output. Segmentation with pre-processing gives good quality and accurate output than the segmentation without pre-processing. Performance of the segmentation can improve by using the pre-processing before the segmentation.

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