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AN IMPROVED CLUSTERING 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. Clustering segmentation method is used for segmentation with Rank filter for de-noising.

Keywords: Clustering, Image segmentation, Pre-processing, De-noising.

1. INTRODUCTION

Medical images are generally used by the physicians to find the abnormalities in the human physical body and also for the treatment planning [1]. Various medical images and imaging technologies are available in the current medical science, like MRI (Magnetic Resonance Imaging), CT (Computerized tomography), and (US) Ultrasound imaging, etc. In such a case, physicians are in a need of a tool that makes the medical image analysis easier and it should help to make accurate decision about that corresponding image [1].

But unfortunately these images may not be convenient for the physicians to make a decision, because these images process some lack of clarity or irregularities. Generally medical images are noisy and have non-linear characteristics. So these images won't lead to accurate decision. This will create problem in identifying the tumours, tissues and its location, anatomical structure study and abnormal growth of glands [2].

These problems are lead to a need of computerized and automated processing technique, that will makes the analysis of medical images are easier. Segmentation is the solution for this problem. Segmentation technique simplifies or changes the representation of an image into something that is more meaningful and easier to analyse [1]. Segmentation is the process of subdividing the images into various subdivided parts. Each subdivided region or object is called segments and it collectively represent the original image. Different methods are available for the segmentation process for example thresholding, region growing, clustering, etc [1] [3].

Even though the segmentation helps to identify the ROI, there may be lack of accuracy because of noisy and nonlinear characteristics of the medical images. Pre-processing before the segmentation is the improved method, which will yield quality output. Pre-processed image will have fewer irregularities, which may lead to an accurate extraction of the ROI within images, which is also helps for the volume measurement of tissue or glands [6] [7].

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

2. 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.

2.1 Clustering segmentation

This is an iterative technique that is used to partition an image into clusters. Procedure of clustering method is explained in figure 1 [9].

Clusters can be selected manually, randomly, or based on some conditions. distance between the pixel and cluster center is calculated by the squared or absolute difference between a pixel and a cluster center. The difference is typically based on pixel colour, intensity, texture, and location, or a weighted combination of these factors. More

commonly used clustering algorithms are K – means algorithm, fuzzy c-means algorithm, expectation – maximization (EM) algorithm [1].

Clustering algorithms essentially perform the same function as classifier methods without the use of training data. Thus, they are termed unsupervised methods. To compensate for the lack of training data, clustering methods iteratively alternate between segmenting the image and characterizing the properties of each class. In a sense, clustering methods train themselves, using the available data.(EM) algorithm. The *K*-means clustering algorithm clusters data by iteratively computing a mean intensity for each class and segmenting the image by classifying each pixel in the class with the closest mean [9].

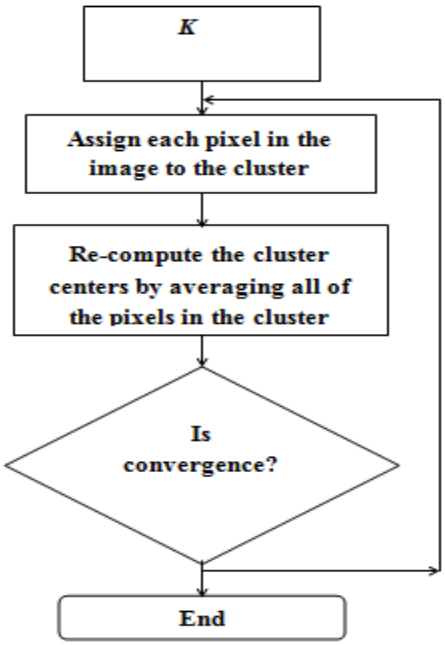


Figure 1 Flow chart showing computation of clustering method.

The quality of the final result of the clustering method depends mainly on the initial set of clusters. Since the algorithm is extremely fast, a collective method is to run the algorithm several times and select the best clustering. A drawback of the clustering algorithm is that the number of clusters k is an input parameter. A wrong choice of k may yield poor results. The algorithm also assumes that the variance is an appropriate measure of cluster scatter.

Proposed improved method for clustering segmentation is shown in figure 2 [6] [7].

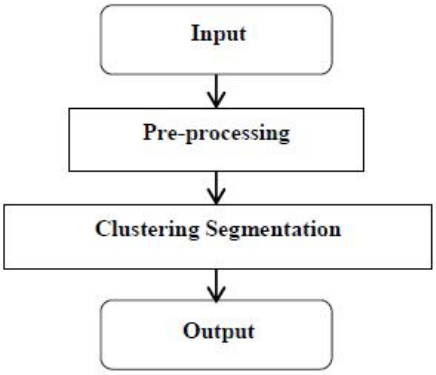


Figure 2 Flowchart of improved clustering segmentation

2.2 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]. Flowchart of the pre-processing step is shown in figure 3.

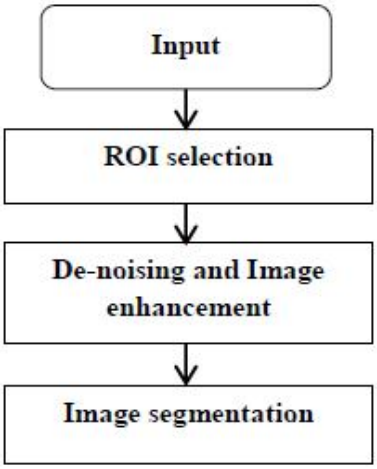


Figure 3 Flowchart of the pre-processing step

Pre-processing step which consist of region of interest selection, de-noising and image enhancement processes [7].

2.2.1 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.

2.2.2 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 $P_1 \leq P_2 \leq$ ……$P_n$output is then selected,

Rank (j) = $P_j 1 \leq j \leq n$ (2)

When this is done for all possible window positions,

$G = R_j(P)$ (3)

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.

$\min(P) = R_1(P)$ (4)

$\max(P) = R_n(P)$ (5)

2.2.3 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.

There are varieties of methods used for the image enhancement like transformation methods, local enhancement, nonlinear enhancement, and histogram equalization, etc. the main use of image enhancement technique is to improve the quality of the image.

3. EXPERIMENTAL RESULTS

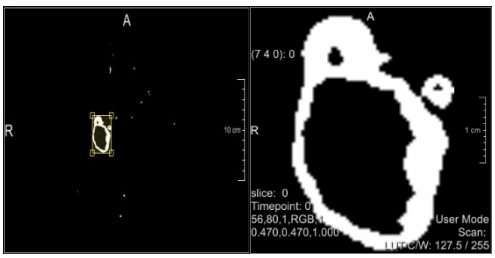
In this section discusses the performance of clustering segmentation algorithm for two cases, with pre-processing and without pre-processing. This section also describes the various steps in the pre-processing step and evaluation of the rank and median filter. Evaluation of the clustering segmentation method considered for the brain MRI.

3.1 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.

3.1.1 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 figure 4.



(a) (b)

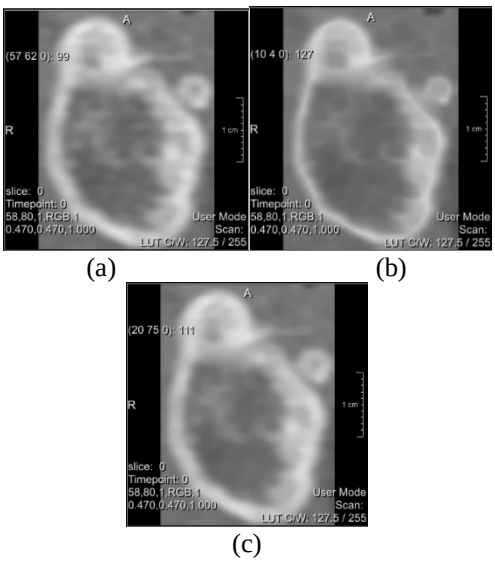
Figure 4 ROI selection process (a) ROI selection (b) extracted region

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.

3.1.2 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. Here for the de-noising order filter is used and compared the performance of the rank and median filter for the same brain MRI input.

De-noising for the particular ROI is shown in figure 5.In which de-noising is done with rank and median filter.



(a) (b)

(c)

Figure 5 De-noising process for the ROI (a) original image (b) Rank filtering (c) Median filtering

Parameters obtained for the de-noising process of the ROI by the rank and 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

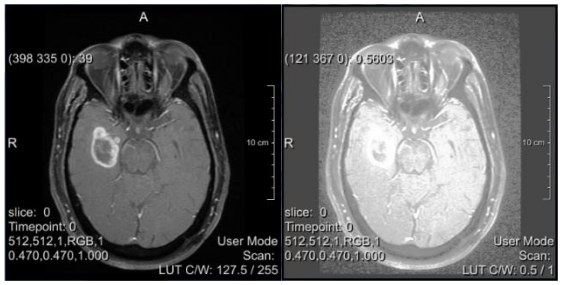
Parameter	**Rank filter**	**Median filter**
Pixel value	13920	13920
Volume(mm^3)	3079.78	3079.78
Mean	133.12	144.72
Standard deviation	30.62	34.96

From the experimental results, rank filter gave better output and de-noising. Rank filter provides better clarity of image after the de-noising. Generally the noise is caused by bit errors that occur during data capture or transmission. Since only a small proportion of pixels and tend to occupy the extreme rank positions. These pixels will not be selected if rank positions near the median are used.

From the figure 5 it is obtained that rank filter which preserved the shape and edge of the region and it smooth noise. Rank filter changed the mean intensity of the image and no new intensity value is generated. While using median filter there is a spreading of region and produces blurred the image. Also shape and edges are not conserved. Rank filter gave better performance than median filter and it is apt for this application.

3.1.3 Image enhancement

Image enhancement is the improvement of digital image quality (wanted e.g. for visual inspection or for machine analysis), without knowledge about the source of degradation. In this work histogram equalization method is used for image enhancement, which provides intensity and gray level enhancement of the image and this is more suitable for the MRI.Histogram equalization of the brain MRI shown in figure 6.



(a) (b)

Figure 6 Histogram equalization of brain MRI, (a) original image, (b) enhanced image.

Histogram equalization gave a normalized image with uniform intensity and gray level. The corresponding histogram is shown in figure 7 and 8.

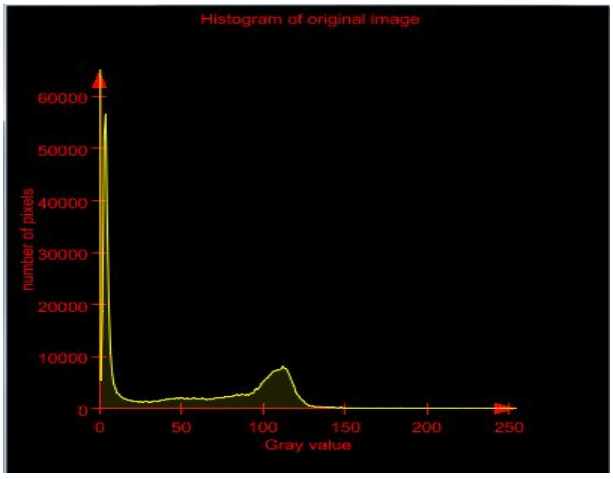


Figure 7 Histogram of the original image.

Histogram equalization is a common technique for enhancing the appearance of images. Histogram of the original image shows the variation of intensity or gray level in figure 7, which may cause intensity inhomogeneity in

segmentation. It can avoid by the normalized intensity in the histogram equalization.Normalized image provide uniform intensity throughout image.

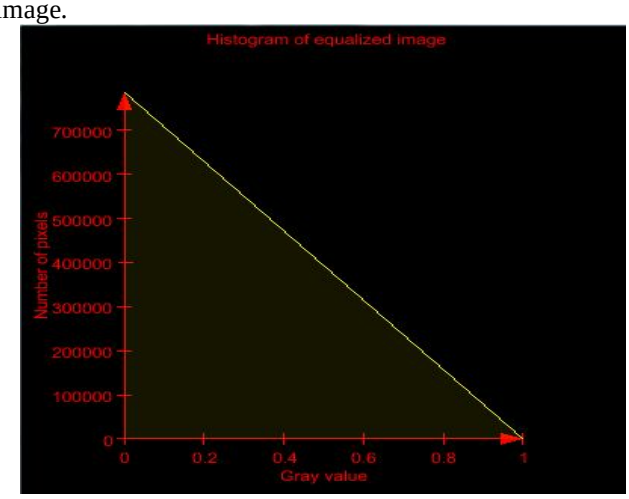
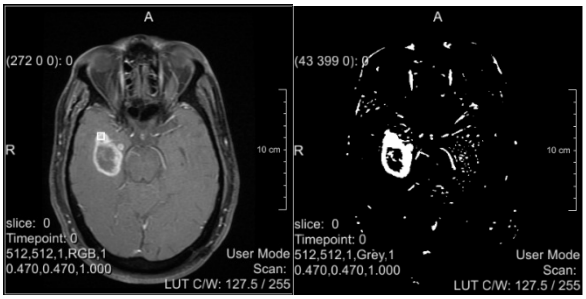


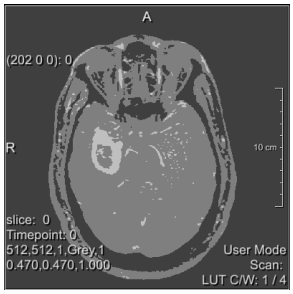
Figure 8 Histogram of the normalized image.

3.2Clustering segmentation method

Output of the pre-processing step gives to the clustering segmentation. The pre-processed image is filtered image, which contain less irregularities provide good quality of image. K-means clustering method is used for the segmentation. K-means clustering is done for brain MRI with and without pre-processing. Performance of both cases is compared. K-means clustering without pre-processing is shown in figure 9.



(a) (b)

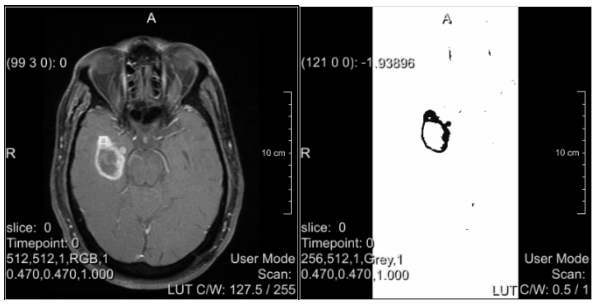


(c)

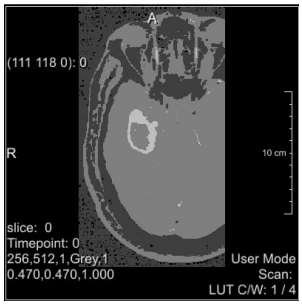
Figure 9 Clustering segmentation without pre-processing
(a) Original image, (b) and (c) segmented image.

Value of cluster center for without pre-processing case is 5.90833 and the number of iterations used is4. Due to the presence of noise and other disorder in the image leads to the inaccurate segmentation which is visible in the above figure 9 and make the sense of importance of the pre-processing. There is some spreading of the ROI (Tumour) to the neighbour pixel, which leads to the inaccurate volume extraction of the tumour in brain. The segmentation with pre-processing is shown in figure 10.

Value of cluster center for with pre-processing case is 16.2736 and the number of iterations used is 3. There is a big difference in segmentation of brain MRI in both cases. The ROI (tumour) extracted from brain MRI is much more accurate in segmentation using pre-processing. Above figure 10 shows the perfection of segmentation with pre-processing. Table 2 shows the comparison of clustering segmentation with and without pre-processing.



(a) (b)



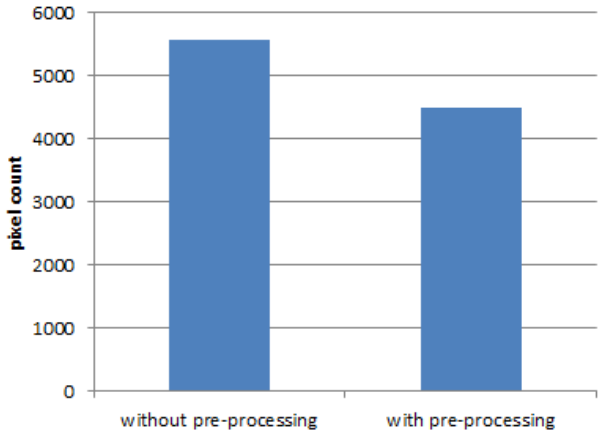
(c)

Figure10 Clustering segmentation with pre-processing (b) Original image, (b) and (c) segmented image.

Table 2 : comparison of the clustering segmentation

Parameters	**Segmentation without pre-processing**	**Segmentation with pre-processing**
Pixel count	5580	4503
Volume (mm^3)	1234.57	996.281
Mean	124.57	65.61
Standard deviation	127.48	103.19

Mean of the image simply indicate the average intensity of the pixel and standard deviation is the common way to describe the range of deviation. Pixel count and volume extracted are reduced in segmentation with pre-processing. This is due to the loss of unwanted pixels like noise pixel, spreaded pixel which are present in the without pre-processing segmentation. Pre-processing with segmentation gives correct edge or boundary detection and it preserve the shape of the tumour. The comparison of both cases are shown in below figure 11. The plots are plotted for the pixel count and the volume extracted, which is mainly considered
For the comparison.



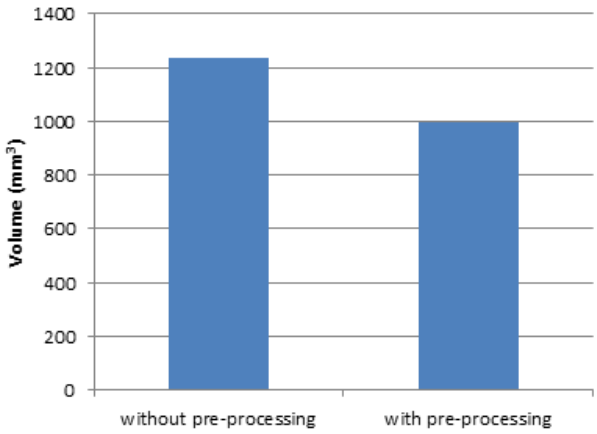


Figure 11 Comparison of clustering segmentation for both cases with and without pre-processing.

4. 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. Clustering segmentation is a simple method which mainly depends on the initial set of clusters and it decide the quality of segmentation. 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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