



A Comparative Study of Different Segmentation Techniques for Brain Tumour Detection

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Abstract: Brain tumour detection is one of the challenging tasks in medical image processing. The present study discusses in detail the segmentation process by means of histogram clustering, Global thresholding, Watershed segmentation and edge based segmentation. Six MRI images from radiologists were collected and the experiments were conducted for statistical analysis also. A comparative study is made and the results are of great interest and practical utility.

Keywords: Brain tumour, Segmentation, Magnetic Resonance Imaging, thresholding, histogram, edge detection, watershed segmentation

I. Introduction

In the computer scenario, **image segmentation** is the process of partitioning a digital image into multiple segments (sets of pixels, also known as superpixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region is similar with respect to some characteristic or computed property, such as colour, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s). When applied to a stack of images, typical in medical imaging, the resulting contours after image segmentation can be used to create 3D reconstructions with the help of interpolation algorithms like Marching cubes.

In medical image processing brain tumour detection is one of the challenging tasks, since brain images are complicated and tumours can be analyzed only by expert physicians. So in this paper brain tumour detection is discussed by various methods. Segmentation is done by means of histogram clustering, Global thresholding and watershed segmentation. In this paper, the histogram is calculated and the threshold value is obtained and fixed. The analysis is carried out by using MRI image.

The details of automated segmentation methods, specifically discussed in the context of CT and MR images, and the relative merits and limitations of methods are currently available for the segmentation of medical images. MRI is the most widely used technique in the field of radio imaging.[1,2]. MR is a dynamic and flexible technology that allows acquisition of variable image contrast by using different pulse sequences and by changing the imaging parameters corresponding to longitudinal relaxation time(T1), and transverse relaxation time (T2). Signal intensities on T1 and T2 weighted images relate to specific tissue characteristics. The contrast on MR image is a factor dependent on pulse sequence parameters. The most common pulse sequences are T1-weighted and T2-weighted spin-echo sequences. MR imaging of the body is performed to get the structural details of brain, liver, chest and pelvis which helps in diagnosis or monitoring the treatment.

The paper is organized as follows: section 2 deals with the literature survey, section 3 deals with the data set description, section 4 deals with methodology, section 5 deals with the experiments and results. Finally, the conclusions are drawn.

II. Related work

In this section, a brief review of the literature is presented. Quite a good amount of literature pertaining to the application of segmentation techniques to different area is available. Authors[3], have presented an efficient algorithm for detecting the edges of brain tumour, obtained through MRI scanning. Author[4], investigates an automatic brain tumour detection and segmentation framework that consists of techniques from skull stripping to detection and segmentation of brain tumours using fuzzy Hopfield neural network as its final tumour segmentation technique. A survey on available thresholding techniques is provided in [5], [6] and [7] Neural networks due to their ability of learning and generalization have attracted many researchers [8] and [9] in image

segmentation and for other image processing techniques [10]. In [11], the authors have presented two conventional algorithms i.e. Mean shift algorithm and Normalized cut (Ncut) method which provides automatic detection of exact surface area of brain tumour in MRI. Author[12] proposed PNN and LZQ models for image segmentation. In [13] proposed segmentation method consisting of two phases: in the first phase, the MRI brain image is acquired from patients database, in the second phase segmentation is done using Hierarchical self organizing map (Hsom). In [14] and [15] the authors have proposed an efficient algorithm for tumour detection based on segmentation and morphological operators. Finally the scanned image is enhanced and then morphological operators are applied to detect the tumour.

III. Dataset Description

MRI image was collected from radiologists. Image information are:

- Sample 1: 218X180, Sample 2: 207X244, Sample 3: 203X233, Sample 4: 201X231, Sample 5: 124x157 and Sample 6:221X228
- MRI can also be substituted for CT with contrast in patients with a high risk of contrast reactions.
- With MRI, contrast agents may be used to highlight vascular structures and to help characterize inflammation and tumours. The most commonly used agents are gadolinium derivatives, which have magnetic properties that affect proton relaxation times. MRI of intra-articular structures may include injection of gadolinium derivative into a joint.
- Functional MRI is used to assess brain activity by location. In most common type, the brain is scanned at low resolution very frequently (for every 2 to 3 sec). The change in oxygenated Hb can be discerned and used to estimate the metabolic activity.
- A morphology based pre-processing step is performed on these images to remove the skull which often interfere with the tumour tissues.

IV. Methodology

Representation of Medical Images:

Images are presented in 2D as well in 3D domain. In the 2D domain each element is called pixel while in 3D domain it is called voxel. In certain cases we represent 3D images as a sequential series of 2D slices. The main advantages associated with this type of representation include lower computational complexity and lesser memory [16,17].

Segmentation is the process of dividing an image into regions with similar properties such as gray level, colour, texture, brightness and contrast [18-20]. The role of segmentation is to subdivide the objects in an image. Medical image segmentation aims at:

- a. Study the anatomical structure
- b. Identify the Region of interest, that is, the location of the tumour.
- c. Measure the tissue volume to measure growth.
- d. Help in the treatment planning prior to radiation therapy.

Segmentation of MR and CT images involves 3 main image related problems, that is, noise that can alter the intensity of a pixel such that its classification becomes uncertain, intensity inhomogeneity where the intensity level of a single tissue class varies gradually over the extent of the image, and images having finite pixel size are subject to partial volume averaging where individual pixel volumes contain a mixture of tissue classes so that the intensity of a pixel in the image may not be consistent with any one class.

Methods based on gray level features:

- i) Global image threshold using Otsu's method
- ii) Watershed Segmentation
- iii) Histogram Thresholding
- iv) Edge-based segmentation

A. Global image threshold using Otsu's method

This method uses the function **graythresh**, which chooses the threshold to minimize the intraclass variance of the black and white pixels. Multidimensional arrays are converted automatically to 2D array using reshape. The graythresh function ignores any nonzero imaginary part of input image. This function returns two arguments that is effectiveness metric and global threshold level. The level is used to convert an intensity image to binary image with im2bw. Level is a normalized intensity value that lies in between 0 and 1. Graythresh function also gives another output argument i.e, EM(Effective Metric), a value in the range 0-1, which indicates the effectiveness of the thresholding of the image. Steps required for global thresholding:

Step 1: Read the MRI image.

Step 2: Convert to read image to gray scale.

Step 3: Use the graythresh function to obtain the level and effectiveness metric.

Step 4: Using the level value convert the input image to black and white.

Step 5: Display the segmented image.

B. Watershed segmentation

Segmentation using the watershed transform works better if you can identify, or 'mark', the foreground objects and background locations. Marker-controlled watershed segmentation follows the basic steps:

Step 1: Compute a segmentation function; this is an image whose dark regions are objects, which we are trying to segment.

Step 2: Compute the foreground markers, which are connected blobs of pixels within each of the objects.

Step 3: Compute background markers; these pixels are not part of any object.

Step 4: Modify the segmentation function so that it has minimum values at the foreground and background marker locations.

Step 5: Compute background markers; these are pixels that are not the part of any object.

Step 6: Visualize the segmented image.

C. Histogram thresholding

Amplitude segmentation based on histogram features:

This includes segmentation of an image based on thresholding of histogram features and gray level thresholding and perhaps the simplest technique. This is particularly suitable for an image with region or object of uniform brightness placed against a background of different gray level. A threshold can be applied to segment the object and background. Threshold is defined mathematically as shown below:

$$C(i,j)=\begin{cases} 255 & p(i,j) \geq T \\ 0 & p(i,j) \leq T \end{cases} \quad \dots (1)$$

Where $c(i,j)$ is the resulting pixel at co-ordinate (i,j) ; $p(i,j)$ is the pixel of the input image and T is the threshold value.

Equation 1 gives excellent results for segmentation of image. Thresholding operation, defined by equation-1 is very basic and simple, and works well only when the object and background have uniform brightness of distinct gray level values respectively. This threshold operation does not work well at segmentation of images with multiple objects each having distinct gray level value varying over a band of values. To overcome this limitation, band thresholding based multiple thresholding operation is applied:

$$C(i,j)=\begin{cases} 1 & \text{for } T_1 < p(i,j) \leq T_2 \\ 2 & \text{for } T_2 < p(i,j) \leq T_3 \\ k & \text{for } T_k < p(i,j) \leq T_{k+1} \\ 0 & \text{otherwise.} \end{cases} \quad \dots (2)$$

Here, the k^{th} band corresponds to the object or region having pixel values in the range of T_k to T_{k+1} where T_k is the lower limit of gray level and T_{k+1} is the upper limit of gray level band.

For application of thresholding based segmentation technique, it is required to apply the correct threshold values in order to achieve proper segmentation results, otherwise results are poor.

Algorithm for segmentation through histogram thresholding:

Step 1: The MRI image of the brain is divided into two equal halves around its central axis and the histogram of each part drawn. This will detect the infectious side of the brain.

Step 2: The threshold point of the histograms is calculated based on a comparison technique made among the two histograms.

Step 3: Segmentation is done using the threshold point for both the halves.

Step 4: The detected image is cropped along its contour to find out the physical dimension of the tumour.

Step 5: Create an image of the original size, check the segmented images pixel value; if its value is greater than threshold value, assign 255 else 0.

Step 6: Segmented image is displayed.

Step 7: The tumour area is cropped.

Step 8: In the case of quadrant approach, the image is divided into four quadrants, and the above steps are repeated.

Step 9: Find the physical dimension of the tumour, using the following algorithm.

- (i) Total number of the pixels, having pixel value 255 is found using the following command.
total=bwarea(segmented image)
- (ii) Resolution of X and Y axis is found.(Resolution is obtained from image information)
a=1/xresolution*1/yresolution
- (iii) Area of the tumour is found by the following statement.
area of the tumour=total*a

D. Edge-based Segmentation

Edge based segmentation is the most common method based on detection of edge, i.e boundaries which separate distinct regions.

Generalized algorithm for edge based segmentation has the following steps:

Step 1: Apply the derivative operator to detect edges of the image.

Step 2: Measure the strength of edge by measuring amplitude of the gradient.

Step 3: Retain all edge having magnitude greater than threshold value T.

Step 4: Find the position of crack edge; the crack edge is either retained or rejected based on the confidence it receives from its predecessor and successor edges.

Step 5: Repeat step 3 through step 4 with different values of threshold so as to find out the closed boundaries; segmentation of an image is obtained.

V. Experiments and Results

In this section the results of the experiments conducted on the data set(image) are presented and discussed. Codes are written and using MATLAB the desired results are obtained.

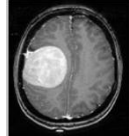
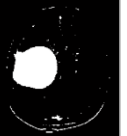
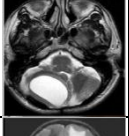
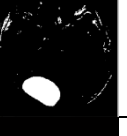
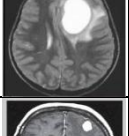
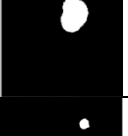
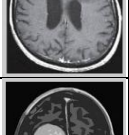
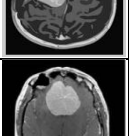
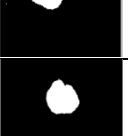
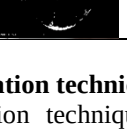
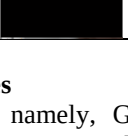
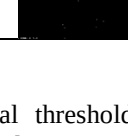
Sample No.	Samples	Global Thresholding	Watershed Segmentation	Histogram Thresholding	Edge-based segmentation
S1 218X180					
S2 207X244					
S3 203X233					
S4 201X231					
S5 124X157					
S6 221X228					

Figure 1: Different Image segmentation techniques

Figure 1, presents four segmentation techniques namely, Global thresholding, Watershed segmentation, histogram thresholding and edge detection. Experiment was conducted using six samples.

Figure 2, shows the histogram and cumulative histogram obtained from wavelet transformation using wavelet 2D tool. The cumulative histogram is a variation of the histogram in which the vertical axis gives not just the counts for a single bin, but rather gives the counts for that bin plus all bins for smaller values of the response variable. Both the histogram and cumulative histogram have an additional variant whereby the counts are replaced by the normalized counts. The names for these variants are the relative histogram and relative cumulative histogram.

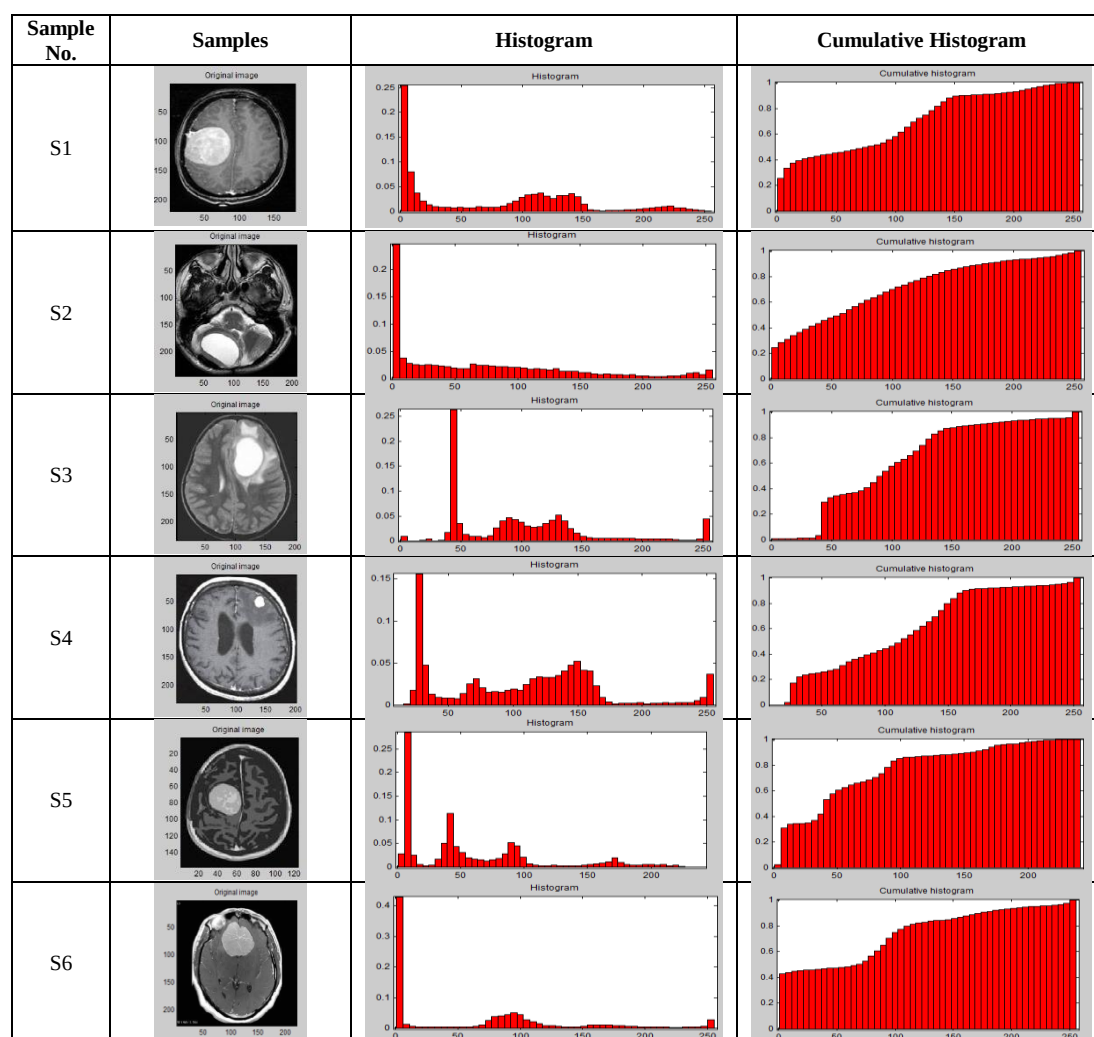


Figure 2: Histogram and Cumulative histogram.

Table 1: Statistical Analysis

Sample No.	Mean	Median	Mode	Max	Min	Range	STD	Median abs. dev	Mean abs. dev	Max norm	Threshold value	Area
S1	76.76	80	3.54	255	1	254	67.47	65	61.37	255	162	0.4198cm ²
S2	73.24	58	3.54	254	1	254	70.55	53	58.29	255	200	7.0204 cm ²
S3	99.08	93	44.18	255	1	254	56.55	44	44.3	255	242	0.4507cm ²
S4	107.4	114	27.15	255	10	245	61.63	42	51	255	241	0.3239cm ²
S5	58.82	43	8.2	241	1	240	54.73	34	43.49	241	145	6.6596 cm ²
S6	67.8	71	3.54	255	1	254	72.28	69	60.66	255	130	9.2774cm ²

Table 1, gives the detailed results pertaining to the statistical analysis. The threshold values are computed for each of the six samples and the area computed indicates the size of the tumour. The present results will be of great importance in the medical image analysis pertaining to brain tumour detection and is one of the challenging tasks.

VI. Conclusion

Computer-aided segmentation is a key step for finding application in computer aided diagnosis, clinical studies and treatment planning. In recent years a variety of approaches have been proposed to segment MR and CT images, which has its own merits and limitations. This study provides the results of different segmentation approaches and their respective statistical analysis.

The algorithms were applied on six sample images and the results obtained were found to be extremely good and efficient. The proposed algorithm can be applied with certain modification for detection of lungs cancer. In all the cases codes are written and implemented meticulously. Finally, it is concluded that the results of the present study are of great importance in the brain tumour detection which is one of the challenging tasks in medical image processing.

VII. References

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