Brain Tumour Extraction Based On Segmentation

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Abstract—Detecting the tumour is a challenging task in Digital Image Processing. This proposed work, detects and extracts the tumour portion from the MRI (Magnetic Resonance Imaging) brain image which is affected by the tumour. This process includes pre-processing, image enhancement, segmentation, morphological operations, extraction of the tumour region and tumour area calculation. The pre-processed MR Image is used for image enhancement and segmentation. Then the morphological operations are used to extract the tumour region. The extracted portion of the tumour area is calculated based on the number of pixels in the tumour region. From this the number of cells in the tumour area is detected.

Keywords- *Magnetic Resonance Imaging (MRI); Brain tumour Segmentation; Morphological operations.*

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I.   INTRODUCTION

In recent years, it has been seen that the cancer patients are increased day by day. It is more difficult to detect tumour in early stage and also accurate measurements of brain tumour are quite hard because of its position, shape and size of the tumour in the brain. During the last few years brain tumour segmentation in MRI (Magnetic Resonance Imaging) has become an emerging field of medical image processing [8]. MRI technique is used in radiology to diagnose variety of medical conditions, including abnormalities of the brain, spinal cord such as tumour and other abnormalities in various parts of the body such as fracture. The differentiation of abnormal tissue from normal tissues is better with the MRI than with other imaging modalities such as x-ray, CT and ultrasound. The MRI brain image consists of three types: Axial (Top view), Coronal (Back view), Saggital (Side view) that are shown in the figure 1.

(a)   (b)   (c)

Figure 1: (a) Axial, (b) coronal, (c) saggital of brain images.

In medical imaging, removal of noise in image is very critical. This is because of inhomogeneous magnetic field, according to patient motion in imaging duration, external noise and other noises. It causes computational errors in automatic image analysis and brain tumour detection. So it is necessary to remove noise from the image enhancement processing. Basically MRI sets consists of several clips with this single clip can be taken, which clearly shows a tumour [11]. In this method, axial image is used for all process, which contains

affected area. There are two main types of tumour: malignant or cancerous tumour and benign tumour. Cancerous tumour can be divided into primary tumour that started within the brain and those that spread from somewhere else known as brain metastasis tumour. Brain tumour can have a variety of shapes and sizes and it may appear in different image intensities [1].

The main objective is to detect and extract the brain tumour using the result of segmentation and morphological operations. Region growing algorithm is iteratively refining such segmentation, with or without guidance from the clinicians. Manual segmentation is also using tools such as a paint brush to explicitly define the tissues in the class of each pixel, and it also remains the standard for many imaging applications. Automatic segmentation is needed for extracting the tumour. In this work automatic segmentation is performed for extracting the tumour region and calculates the tumour area which is used to know how many cells are affected in the tumour region. It contributes in segmentation of MR brain images which enhances the automated detection and extraction of brain tumour. A variety of artifacts may appear in the images. The performance of the segmentation algorithm may be affected by the appearance of the image, when there is a change. Inhomogeneities of intensity are the most important artifacts in image segmentation and the partial volume effect.

II.   RELATED WORKS

It is discussed in [1, 10] that the brain tumor segmentation based on watershed and threshold based segmentation and also used morphological operations [16] to detect the tumour in the scanned MR images [2]. The segmentation methods discussed in [3], that suggest the Region growing method provides a better solution for segmentation [14] and also vector quantization [4]. Bounding box as seed to level set [17], histogram based thresholding segmentation used to segment and detect the brain tumour [5, 6, and 12]. Automatically detecting the tumour and brain abnormalities [8] are used to

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extract the tumour [7, 11] on MR Images. Edge based methods are used to detect the region of the brain tumour [9] that is used to found the location of the tumour. Area had to calculate the tumour portion [11].

III. PROPOSED WORK

This proposed method has been used for MR brain images which are affected by the brain tumour. The input image is converted into gray scale image. Image enhancement is needed for further processing even though MR scan image having high contrast compared with CT scan. Contrast enhancement technique is applied on converted grayscale image for image enhancement. Region growing segmentation is used in this proposed system to segment the tumour. This algorithm starts from a *single seed*, which is defined by the user and similar seed point of neighborhood pixels are sequentially added in one separate region. Dissimilar seed point of neighborhood pixels are added in another separate region. Global threshold value is needed to segment the similar seed point of growing region. The result of segmentation is used to detect the tumour portion with help of the morphological operations such as dilation and erosion. The detected result is applied on gray image to dismiss the unused gray and white information. Eventually the tumour area is extracted and the number of tumour cells has been calculated.

IV. METHODOLOGY

The proposed work has following stages such as,
   1. Pre-processing
   2. Image enhancement
   3. Image Segmentation
   4. Morphological operations
   5. Extract tumour region and area calculation

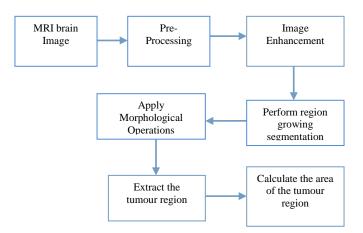The block diagram of above these five stages is given below.

Figure 2: Block of brain tumour extraction.

A. Pre-Processing

In this pre-processing, MRI brain image is taken as an input image. The creation of an input RGB image generated by red, green, blue light. An input image of M x N pixels into array of $R_i = \{R1, R2, R3, …., Rn\}$, $G_i = \{G1, G2, G3, …., Gn\}$, $B_i = \{B1, B2, B3, …., Bn,\}$, the value of i is 1,2,3….n is converted to grayscale digital image in which the value of each pixel is a single sample and it carries only intensity information. The range of intensity value may be 0 to 255. Then the output of grayscale image is generated which is composed exclusively of shades of gray [11].

B. Image Enhancement

Image enhancement is the process of highlighting the features of the image by removing noise.

(i) Contrast Enhancement

Contrast adjustment is done for increasing the brightness of image. If there is no sharp difference between black and white pixels, then contrast enhancement is applied. Enhancement provides more prominent edges and sharpened image and also it's improving the quality of the overall image. After gray scale image is given as an input for contrast enhancement. `Imadjust is` used to increases the contrast of the image by mapping the values of the input intensity image to new values such that, by default, 1% of the data is saturated at low and high intensities of the input data. This contrast adjustment is used for visualization purpose.

(ii) Median Filter

During contrast enhancement, salt and pepper noises may be arise due to the changes of image pixel values. Median filter is used to reduce this salt and pepper noise. It is able to run through the image entry by entry and then replacing each entry with the median of neighboring entries. So that it can able to preserves edges while removing noise [11].

C. Image segmentation

Segmentation is process to extract information from complex medical images. The main objective of the image segmentation is to partition an image into mutually exclusive and exhausted regions such that each region of interest is spatially contiguous and the pixels within the region are homogeneous with respect to a predefined criterion [6]. Single seed Region growing algorithm is used for segmentation for that threshold value and seed point are needed.

(i) Single Seed Region Growing

*S*eed point will be selected by the user for this segmentation. This single seed point is used to calculate the neighbor pixel values. If the single seed point's properties are similar to the neighborhood pixels, that are added into one region. Otherwise, that is added into another region. Then calculate the x co-ordinates and y co-ordinates of neighborhood pixels which are similar with the seed point. During region growing

2683

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method can have many regions but these regions are not similar with other. Stopping criteria should be efficient to discriminate neighbor elements in non-homogeneous domain. There are 4 and 8-connected neighborhoods for adjacent pixel relationship. In this system 8-connected neighborhood pixels adjacent relationship is used. In the region pixels are added which have the nearest intensity to the mean of the region. Then the new mean of the region is calculated. Finally it provides good segmented result.

D. Morphological operations

During segmentation, the image is converted into binary format based on the threshold value. Dilation and erosion of the morphological operations are applied on the segmented image. The purpose of the morphological operators is to separate the tumour part from the image. This portion has the highest intensity than other regions of the image [1]. The dilation "grows" or "thickens" the objects in a binary image. The Erosion "shrinks" or "thins" the objects in a binary image. In this morphological process, the commands imdilate, imerode and strel are used. By using this morphological operations able to get tumour recognized image [11].

E. Extract tumour region

The result of the morphological operations is applied in the pre-processed image. The recognized image is in the form of binary image. The white pixels are applied where is actually affected by the tumour and then remove the gray matters. Finally, the skull is removed. It can be used to extract the tumour portion easily.

F. Tumour Area calculation

The area is calculated with the total number of pixels present in the extracted tumour region. Calculate size of the input image e.g., 555 * 740. The Horizontal resolution of the output image is 96 dpi. The Vertical resolution of the output image is 96 dpi. From the horizontal and vertical resolution can find the area of a single pixel.

- Area of single pixel = $(1/96) \times (1/96)$ inch
- Area of the tumour = Area of single pixel $\times$ total number of pixel (cm^2) [6].

V. RESULTS AND ANALYSIS

In figure 3, fig (a), fig (b) and fig (c) denotes input grayscale image, enhanced image of fig (a) and result of region growing segmentation of fig (b) are respectively. the results of morphological operations are represented as fig (d), fig (e), and fig (f), that denotes eroded image with disk shape structuring element and the size is 1, eroded image with disk shape structuring element and the size is 6 of fig (d), dilated image with disk shape structuring element with the size is 6 of fig (e) are respectively.
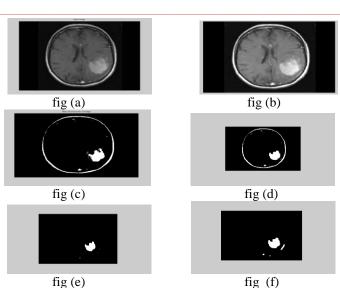

fig (a)   fig (b)

fig (c)   fig (d)

fig (e)   fig (f)

Figure 3: Results of grayscale image, enhanced image, segmented image and tumour extracted image.

The white pixels are applied where is actually affected by the tumour and then remove the gray matters shown in figure 4(h). The recognized image is in the form of binary image shown in (g). Finally skull is removed, after that the tumour portion has been extracted shown in (i).
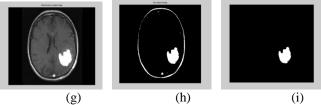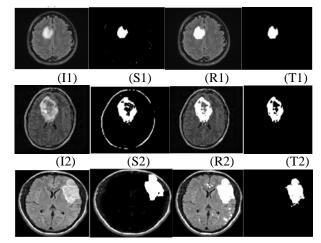

(g)   (h)   (i)
Figure 4: Output images of tumour extraction.

Analysis

This work is detects and extracts the location of the tumour portion, and calculate the area of the tumour portion. The output of the segmented regions and the extracted tumour portion and its area is shown below. The proposed system gives very reasonable results for different kind of MR Images.
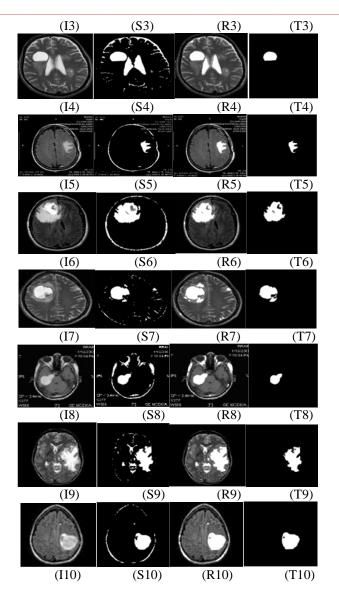

(I1)   (S1)   (R1)   (T1)

(I2)   (S2)   (R2)   (T2)

(I3)	(S3)	(R3)	(T3)
(I4)	(S4)	(R4)	(T4)
(I5)	(S5)	(R5)	(T5)
(I6)	(S6)	(R6)	(T6)
(I7)	(S7)	(R7)	(T7)
(I8)	(S8)	(R8)	(T8)
(I9)	(S9)	(R9)	(T9)
(I10)	(S10)	(R10)	(T10)

Figure 5: I1 to I10 in the 1st column are Input of MRI brain image, which is contains tumour. S1 to S10 in the 2nd column are the results of region growing segmentation. R1 to R10 in the 3rd column are the results of morphological operation and that results are applied into the gray input image. T1 to T10 in the 4th column are the results of the tumour portion extracted from the R1 to R10 images.

Global threshold values, Number of pixels in the tumour portion and area of the tumour of the ten different images are mentioned in the below table and its bar chart also shown in figure 6.

Brain Image	Global Threshold value	Number of pixels in tumour	Area of Tumour (cm^2)
I1	0.4471	8773	0.9519
I2	0.4157	19702	2.1379
I3	0.5216	24829	2.6942
I4	0.5725	24981	2.7107
I5	0.6118	9389	1.0188
I6	0.4157	18868	2.0474
I7	0.4196	5504	0.5972

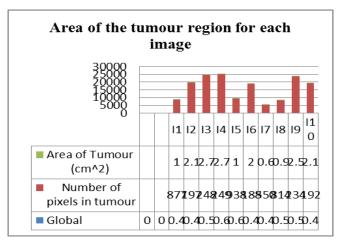| I8	0.4706	8140	0.8833
I9	0.4627	23422	2.5415
I10	0.4471	19224	2.0859

Figure 6: Bar chart for area calculation of tumour region.

Quality Measurement

The mean squared error (MSE) of an estimator measures the average of the squares of the "errors", that is, the difference between the estimator and what is estimated. PSNR (Peak Signal to Noise Ratio) is most commonly used to measure the quality of reconstruction of an image. Figure 7 is drawn based on the values of MSE and PSNR.

Brain Image	MSE	PSNR
I1	84.67	28.89
I2	372.16	22.46
I3	275.37	23.77
I4	89.39	28.65
I5	120.60	27.35
I6	166.42	25.95
I7	269.85	23.85
I8	183.89	25.52
I9	164.76	26.00
I10	273.21	23.80

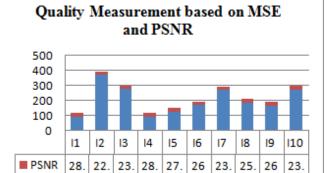**Figure 7:** Bar chart for MSE and PSNR.

The **mean** gives an idea where the image pixels are (i.e. is the white, black, 50% gray). The mean will give an idea of what pixel color to choose to summarize the color of the complete image. The **variance** gives an idea how the pixel values are spread: e.g. if the mean pixel value is 50% gray, are most of the other pixels also 50% gray (small variance) or do have 50 black pixels and 50 white pixels (large variance). The **standard deviation** (**SD**) measures the amount of variation or dispersion from the average. A low standard deviation indicates that the data points tend to be very close to the mean (also called expected value); a high standard deviation indicates that the data points are spread out over a large range of values.

Images	Input Images			Output Images		
	Mean	Variance	Std Deviation	Mean	Variance	Std Deviation
I1	47.79	2239.46	47.32	48.98	2651.01	51.49
I2	46.03	2357.45	48.55	50.17	3698.87	60.82
I3	88.92	5009.62	70.77	93.17	6121.34	78.24
I4	41.43	3393.52	57.03	44.25	4413.69	62.82
I5	64.45	3251.92	51.76	66.53	3946.48	55.91
I6	58.40	2843.09	58.25	61.51	3781.53	66.44
I7	38.99	2678.58	53.32	40.38	3126.18	61.49
I8	40.63	3124.79	55.89	43.21	4018.73	63.39
I9	45.02	4301.78	65.59	47.51	5170.63	71.91
I10	52.75	3501.69	59.18	56.49	4725.38	68.74

Bar chart shown in below is drawn based on the above table values of mean, variance and standard deviation.
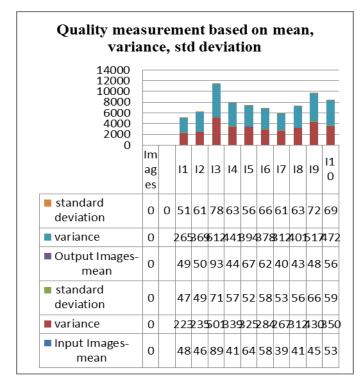

Figure 8: Bar chart for the values of mean, variance and standard deviation.

The segmentation and tumour extraction results of region growing segmentation after applying the salt and pepper noise and filtered by the median filter.
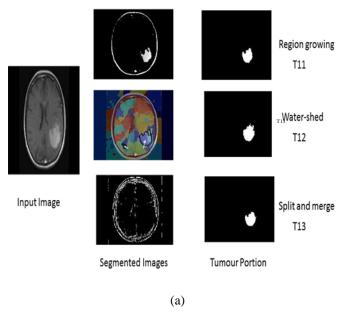

Figure 9: Segmented image and Extracted tumour region after applied the noise in the input image.

The figure 10 shows the results of the segmentation and tumour extraction of water-shed algorithm, after adding the salt and pepper noise and filter out by the median filter.
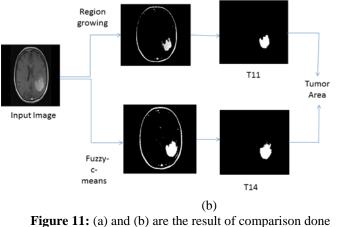

Figure 10: Segmented image and Extracted tumour region after applying the noise in the input image.

Comparison is done with various segmentation algorithms that are region growing, watershed and split and merge algorithms. The differences of the mean and variance values are high, compared with the result of region growing segmentation so that, it suggest the water-shed and split and merge algorithm are not that much efficient since it will detected the tumour area correctly.

(a)

Region growing segmentation algorithm is compared with the fuzzy-c- means segmentation.

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(b)

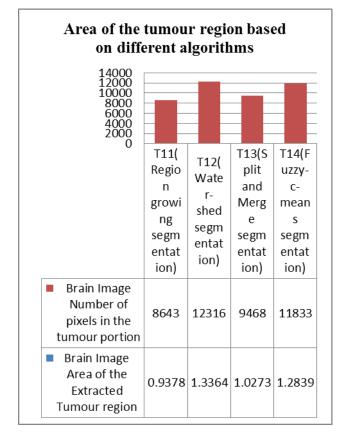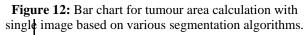**Figure 11:** (a) and (b) are the result of comparison done on various segmentations.

Comparison table of various segmentation algorithms

The Single seed region growing is used in this proposed system. This segmentation result is compared with the fuzzy - c- means, water shed, and split and merge segmentation algorithms. These algorithms having grater difference compared with the region growing segmentation. Through this result can suggest the single seed region growing algorithm is suitable for this proposed system. Area of the extracted tumour region based on the number of pixels present in the tumour portion are mentioned in the below table and also represented diagrammatically in figure 12.

Brain Image	Area of the Extracted Tumour region	Number of pixels in the tumour portion
T11(Region growing segmentation)	0.9378	8643
T12(Water-shed segmentation)	1.3364	12316
T13(Split and Merge segmentation)	1.0273	9468
T14(Fuzzy-c-means segmentation)	1.2839	11833

Figure 12: Bar chart for tumour area calculation with single image based on various segmentation algorithms.

Comparison is done in the below table with the values of mean and variance of the four different segmentation algorithms.

Brain Image	Input Image		Output Image	
	Mean	Variance	Mean	Variance
I11(region growing segmentation)	41.2591	2056.0105	43.7729	2856.3602
I11(water-shed segmentation)	41.2591	2056.0105	112.5577	3918.9944
I11(split and merge segmentation)	41.2591	2056.0105	112.1910	3830.5139
I11 (Fuzzy-c-means segmentation)	41.2591	2056.0105	60.2863	4845.5730

Diagrammatic representation of comparison done on various algorithms for quality measurement based on mean and variance of the images.
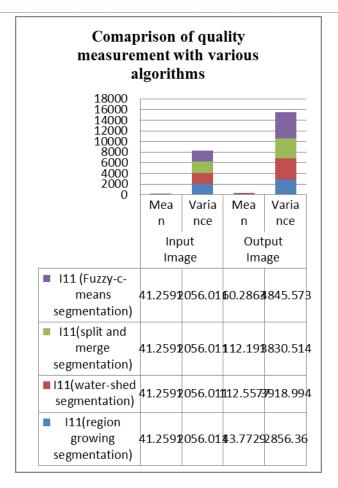
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Figure 13: Comparison of quality measurement with various segmentation algorithms.

Comparison of execution time

The single seed region growing segmentation algorithm is a time consuming task compared with other algorithms. Even though it took more time for execution but it gives extracted results of the tumour portion. So the single seed region growing segmentation algorithm is more suitable for this work. The below table is used for comparing the execution time on various segmentation algorithms.

Brain Image	Execution time
I 11 (region growing segmentation)	10.347042 seconds
I11 (water shed segmentation)	5.813602 seconds
I11 (split and merge segmentation)	4.435671 seconds
I11(Fuzzy-c-means segmentation)	4.598712 seconds

V. CONCLUSION AND FUTURE ENHANCEMENT

In this work, it is mainly focused on segmentation and extraction of brain tumour. The single seeded region growing algorithm and morphological operations are applied on enhanced gray scale image to get tumour part of MR brain image. The tumour area and the total number of tumour cells are calculated successfully. The area of the tumour portion and number of pixels in the tumour are also has been tabulated. This work is applied on various images and thus giving successful results.

In future, the extraction of brain tumour will be extended to find tumour stages based on tumour area and what type of the stage it is (i.e.) benign or malignant tumour. The proposed work is now focusing on the reduction of time complexity of the dissimilarity matrix and it will lead towards improving the speed of the segmentation methods.

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