

## **Comparative Analysis of Different Brain Tumor Segmentation Methods**

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### **Abstract**

Medical images are widely used by physicians to find abnormalities in human body. The abnormalities can be tumor, cyst, blood clots, etc. Various medical imaging techniques are available for imaging these abnormalities. The findings can be used for further planning of treatment for the patient. Proper treatment planning plays a very important role in determining the success of the treatment, so image analysis has become very crucial in medical field today. MRI images of soft tissues contain multiplicative noise which makes it difficult to identify or segment tumor or cancerous tissue from normal tissues. The image has to be de noised prior to application of segmentation algorithm. Noise removal along with accurate segmentation is a challenging task in medical imaging. Image segmentation is a very important part of clinical diagnosis. It involves splitting of image into different regions based on predefined criteria. The splitting is based on similarities or discontinuities. Depending on the tissue property and anatomical location of tumor, various segmentation algorithms have been developed. The type of technique to be used for segmentation depends on the type of image and the area to be segmented. This paper deals with comparison of different techniques for segmenting brain tumor from MRI images. Segmenting of brain tumor is difficult and many algorithms have been developed for accurate segmentation of the tumor area. Threshold, clustering, region based, artificial neural networks, deformable models based algorithms can be used for tumor segmentation. Watershed and clustering algorithms like Fuzzy k-means and C-means are compared here. Dice coefficient is used to compare the findings and to determine the most efficient technique.

**Keywords:** MRI, Brain Tumor, Segmentation, watershed, clustering.

## Introduction

Medical images are normally used by physicians to detect abnormalities in human body and for treatment planning. Various medical imaging techniques are used to detect the abnormalities in the human body such as Magnetic Resonance Imaging (MRI), Computerized Tomography (CT), Ultrasound (US) and nuclear imaging techniques like PET and SPECT. Nuclear medicine is used in early diagnosis and treatment of various cancers by admission of radioactive material [1]. The selection of particular imaging technique is very requirement specific. CT Imaging is applicable and more efficient in performing full body scan, detecting muscles and bone injuries. However excess use of radiation in obtaining CT images can be harmful. MRI imaging is done by creating strong magnetic fields and RF pulses that can precisely visualize anatomical structure and soft body tissues. Magnetic Resonance Imaging generates different image scans for the T1 Weighted and T2 Weighted sequences. In this paper we have performed segmentation using T2 Weighted MRI images in which tumor tissue with high water content appear bright. MRI images can also clearly distinguish between the diverse normal tissues and abnormal tissues with high spatial resolution [2].

Tumor is an uncontrollable and abnormal growth of cells in a region that spreads into other healthy tissue. Tumors are of two types viz. benign and malignant. Benign tumors are incapable of growing to the surrounding regions, whereas malignant tumors spread through the surrounding areas. The detection of brain tumor by manual inspection is not an effective method and can lead to false results. Brain imaging techniques are used to monitor and detect brain activities. Based on the MRI scans, brain tumor can be segmented by applying certain computational algorithms which can detect accurate tumor region. Image segmentation is a procedure where regions of interest are delineated. It is an important procedure in terms of quantitative and qualitative analysis [3].

Segmentation of brain tumor involves separation of abnormal tissues like blastoma, glioma necrosis and edema from normal brain tissues such as cerebrospinal fluid, grey matter and white matter. This requires efficient and robust segmentation techniques for precise detection of brain tumors of varying size, shape and location. Manual segmentation by visualization alone requires highly skilled surgeons or radiologists and is also very time consuming. Many segmentation techniques such as mean shift, region growing, water shed, graph cuts, fuzzy connectivity etc. are available for brain MRI. Not all techniques are suitable for medical image analysis. Once regions of interest have been segmented, appearance and other structural features can be analyzed for diagnosis or treatment planning [4]. The segmentation algorithms compared in this paper are watershed and clustering algorithms.

## State of Art

Brain tumor is one of the most common diseases affecting many people. Despite many developments in the technology in detection and diagnosis, the survival rate of brain tumor is very low. The detection of tumor is done using many modalities such as MRI, CT, PET, SPECT among which MRI and CT are widely used because of

availability and ability to produce high resolution images. MRI is a method which is used in detection of tumors because it does not use ionizing radiation like CT, SPECT and PET. It has high contrast resolution. The ability to generate 3D images enables it to have superior tumor localization and obtain the anatomical and functional information about the tumor in the same scan. Currently there are many different treatment options for the brain tumor such as surgery, radiation therapy, chemotherapy etc. The choice of treatment depends on the size, type and grade of the tumor.

Accurate detection of brain tumor plays important role in the treatment planning in order to minimize the diagnostic errors. The segmentation of the tumors is a difficult task as there are many classes of tumor with variety of sizes and shapes and their location [5]. There are many segmentation techniques, the choice of one segmentation technique over another depends on the type of the image and characteristic of the problem and the level of the segmentation required. In spite of several decades of research on segmentation, it is a challenging job as all techniques are not applicable to all type of images. Segmentation is divided into two categories based on similarity and dissimilarity. Segmentation based on dissimilarity works on partitioning the image on abrupt change in the intensity such as edge detection. Whereas segmentation by similarity works on partitioning the image on some predefined criteria and the techniques involve thresholding, region growing, region splitting and merging [6]. There are various algorithms which can be used for segmentation. The choice of algorithm depends on the image to be segmented.

Most of the algorithms that belong to threshold category are based on the premise that the image can be partitioned based on features like intensity or gradient magnitude. The threshold can be set manually or automatically based on the image information. Threshold algorithms can be used to detect edges in an image. Threshold based algorithms basically divide the image according to the set threshold. Many threshold techniques have been proposed viz Mean method, Histogram dependent technique, P-tile method etc. However, there have been several new approaches to thresholding techniques. Edge detection is a basic step to image segmentation. It divides the image into object and background by looking for change in intensity of an image. The two main methods for edge detection are Gray histogram and Gradient method. Canny, Sobel and Laplacian edge detectors are commonly used for edge detection [7]. However the detected edges of the image are often not continuous and post processing is required to obtain a continuous edge.

Region based algorithms are based on the idea that the pixels inside a structure have similar intensities. It basically divides an image into different regions based on intensity, color etc. They are categorized into three main categories i.e., region growing, region splitting and region merging [8]. Karoui [9] proposed a new unsupervised image segmentation method using level set methods and texture statistics. This method is claimed to be different from other methods as it doesn't assume independent variable and also is not restricted to first order grey features. This method involves a feature selection step to readjust the weights of the feature for accurate segmentation. The experiment involves filter response histogram to calculate number of distributions and Haar wavelet is used to compute the energy of the image

wavelet in each band. The level sets are re-initialized using PDE. The method has been tried on images and has given correct segmentation.

Yu Xiaohan [10] proposed a new image segmentation technique which is a combination of region growing and edge detection methods. Their method makes the segmentation technique very effective as it avoids errors. The application of both techniques separately gives a good segmentation result. The gradient operators are used to for edge detection in an image and region growing algorithms are used to find the edge pixels. Experiments are conducted on 3D MRI image data Image smoothening can be achieved by Gaussian technique after the segmentation. This technique is better when edges need to be preserved and results have shown that.

Fuzzy set theory can be used for image analysis and segmentation. Fuzzification can also be done for noise removal from an image [11]. The two widely used methods in image processing are Fuzzy k-means and Fuzzy C-means [12]. Fuzzy set theory membership function for pixel distribution and to find the spatial relationship among the pixels. The image is divides into clusters and all the similar pixels belong to one cluster. Artificial neural networks can be used for image segmentation. The network is trained using training samples and the network is then used to segment images. Some of the most commonly used algorithms are Hopfield, BPNN, SOM etc. Neural networks based algorithms segment images based on pixel classification and edge detection [13].

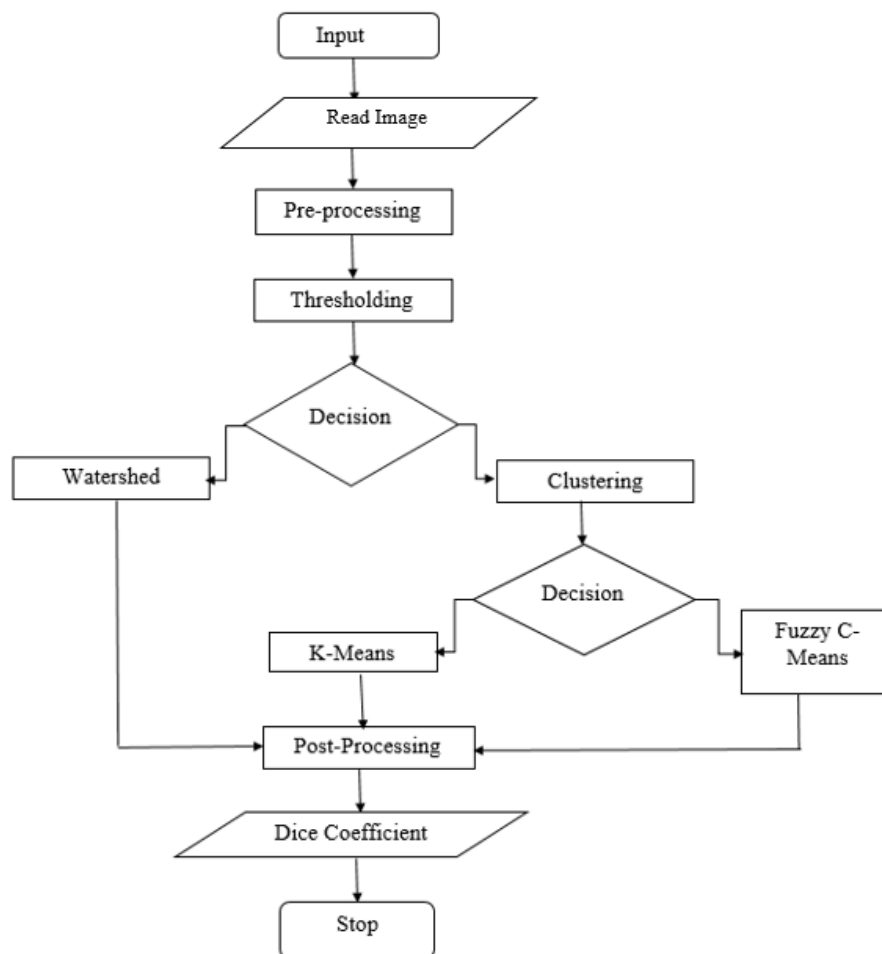
There are some algorithms based on deformable models which are used for image segmentation. They are very flexible and can be used for complex segmentations. Deformable models can be modelled into parametric and geometric models. Parametric deformable models are very similar to snake method [14]. Geometric deformable models are based on level set methods [15]. Due to the various advantages like being able to handle structures with complex topology, easy to combine with other techniques, sub-pixel accuracy, noise insensitive and intuitive interaction mechanisms, the deformable models have been intensively investigated in the last few decades.

Brain tumor cells have high proteinaceous fluid which has high density and high intensity, therefore watershed segmentation is good tool to classify tumors and high intensity tissues. This is not possible with snake and level set methods [16]. Several authors suggest various segmentation algorithms such as fuzzy classification which allows for the development of methods and algorithms to perform the tasks related to human behaviors. This system is automated using the intensity histogram analysis which works well for two types of brain tumor like glioblastoma and meningioma. Various algorithms have been suggested for brain tumor segmentation, however not all are effective for all types of tumors. The choice of algorithm depends on the tumor. Many techniques require a lot of post processing for getting a smooth segmented image. The post processing usually involves morphological operations.

## **Methodology**

The proposed work is based on segmentation of the tumor and its extraction, which can be further used by the radiologist for the analysis on the growth, size and position

of the tumor. The images are obtained from MRI scanner. The whole work deals with acquisition of the images, noise removal, segmentation of the tumor using varies techniques, extraction and calculation of dice coefficient to find the efficient technique among the given techniques. The experiment has been implemented using MATLAB. Fig1 show the overall process of the experiment. Among the varies techniques ,the region growing techniques are more efficient .The region growing segmentation methods deal with formation of the seed, which is the Centre of tumor cell. Region growing involves manual selection of seed image. It is not an automatic process and can cause in homogeneity of tumor intensities. Thresholding is basic segmentation technique however it alone cannot be used for brain tumor detection as it is limited in distinguishing multiple intensity regions [17]. In the proposed work thresholding method is used in combination with watershed and clustering methods for extraction of tumor region and its further analysis. The method is divided into pre-processing followed by segmentation and post processing.



**Figure 1:** Proposed Methodology

**Image Acquisition**

Magnetic Resonance Image (MRI) of brain is one of the tool used in detecting the abnormality of the brain. MRI images are used for extracting the precise tumor region in the brain. T2 weighted MRI images are used here. MRI images appear as black and white images [17]. Due to high water content, tumors in these images appear bright. The brain tumor images are obtained from online cancer database. Grey-scaling operation is performed on images to obtain intensities in the range from 0 to 255 in the MRI image.

**Pre-processing**

The images obtained from the scanner has many different types of noise, artifacts and in homogeneities which need to be eliminated using many different types of filters[18].Pre-processing is done in order to reduce the noise and eliminate the geometric distortion that occurs during image acquisition. High pass filter is applied to sharpen the image by adjusting the contrast. The high pass filter eliminates the low frequency information in the image. Laplacian filter is applied to the MRI image to eliminate the background noise [19].

**Variable Thresholding**

Thresholding is one of the simplest methods of segmentation where the pixels of the region are partitioned based on difference in the intensity level. Here the pixels whose intensity value are above a given threshold are set to foreground value and all the remaining pixels are set to the background value. The adaptive thresholding deals with changing the threshold dynamically over the image. This method is used due to non-uniform background in the images. It works by calculating the threshold which is the weighted mean of the local neighborhood minus the offset value [19].

**Segmentation Techniques****Watershed**

It works on the principle that when two water bodies meet, a dam is built between them. The image gets segmented by the dams which are called as the watersheds and the segmented regions are called as catchment basins. This method works on difference in the intensity levels of the neighboring regions.

By default, watershed uses 8-connected neighborhoods for 2-D inputs and 26-connected neighborhoods for 3-D inputs. In this method the pixels are grouped based on their intensity level to separate the tumor from the image. It is followed by the morphological operations to segment the tumor. Morphological operations probe an image with a small shape called as structural element, which is placed on the possible regions on the image to compare the intensity difference [19].

**Clustering**

Cluster is a group of similar objects. Cluster analysis is a set of data-driven partitioning techniques designed to group a collection of objects into clusters. it

perform the operation by iteration method. Depending on the nature of the data and purpose, using the similarity measure such as distance, connectivity, intensity the clusters are formed. Although clustering algorithm don't require training, they require an initialization [20]. Clustering is preferred for biomedical image segmentation as the number of clusters is known for images of particular region of human body. The basic clustering algorithms are K-means and Fuzzy C-means [21].

K-means is a well-known iterative partitioning method where the objects are divided into k number of clusters, randomly choosing the centers. Euclidean Distance between each cluster Centre and pixel is calculated. The pixel is moved to the nearest cluster. The centroid is adjusted and again compared with each pixel until the Centre converges [22].

Fuzzy c-means is clustering algorithm in which one pixel can belong to two or more clusters at the same instance. It is based on fuzzy logic which processes data by giving partial membership value in the range of 0 to 1 to each pixel in an image. Membership function defines the fuzziness and information contained in an image. It improves accurate results for noisy images [22].

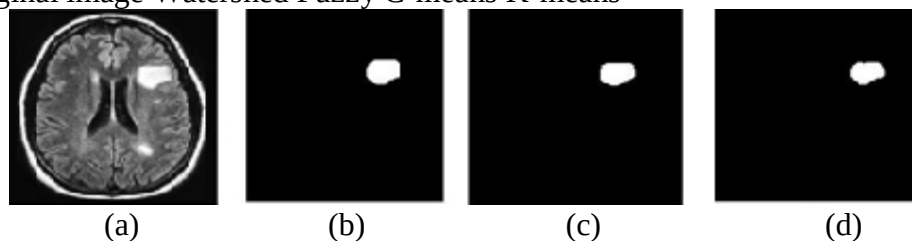
### Morphological operations

Morphological operations often deal with binary image and the structural element as input and combining them using a set operator to process the object on the image. Usually the structural element is sized  $3 \times 3$  and has the origin at the centre, it is shifted over the image and each pixels of the elements are compared with the pixels of the image. A morphological operator is defined by its structural element and the applied operator. The basic operations are erosion and dilation. The operation used here is the erosion followed by dilation to extract the tumor using a specific structuring element.

### Results and Discussions

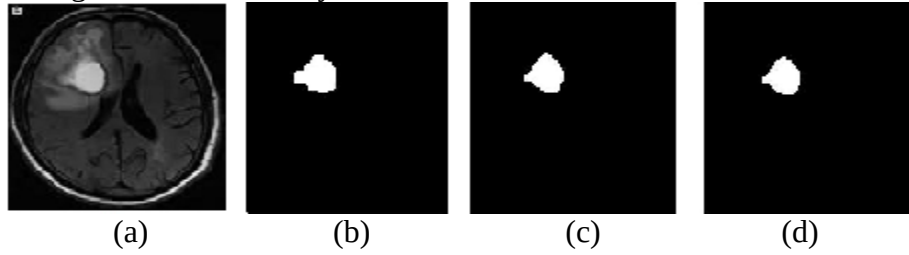
In the proposed method, MRI brain tumor images were segmented using watershed and clustering algorithms. The tumor with high water content gives higher intensity in the image. These maximum intensity regions have been segmented by initially applying high pass filter and thresholding techniques. Different T2WI were considered to check the efficiency of the algorithm. The results obtained after applying watershed, Fuzzy C-means and K-means clustering algorithms are shown in the figure.

Original image Watershed Fuzzy C-means K-means



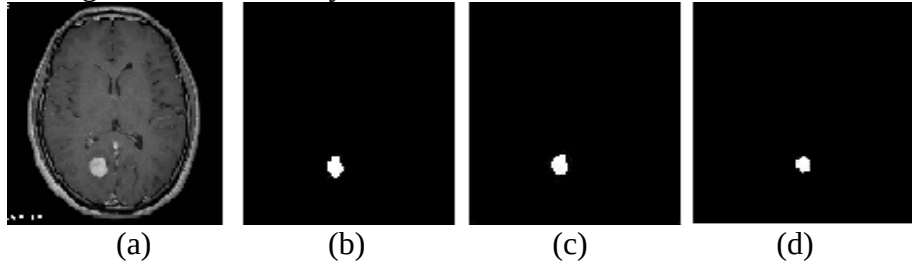
**Figure 2:** (a) T2WI of brain tumor1 (b) Segmentation using Watershed (c) Segmentation using Fuzzy C-means (d) Segmentation using K-means

Original image Watershed Fuzzy C-means K-means



**Figure 3:** (a) T2WI of brain tumor2 (b) Segmentation using Watershed (c) Segmentation using Fuzzy C-means (d) Segmentation using K-means

Original image Watershed Fuzzy C-means K-means



**Figure 4:** (a) T2WI of brain tumor3 (b) Segmentation using Watershed (c) Segmentation using Fuzzy C-means (d) Segmentation using K-means

Ground truth image is obtained of the T2WI brain tumor to compare it with the segmented image of the three algorithms. High pass filtering is performed as a preprocessing step in order to eliminate background image noise, thus enhancing the image. Thresholding of image is done to initially differentiate between tissues of different intensities. Clustering algorithm segregates the image intensities into clusters. K means algorithm implemented as shown in above fig. forms 3 clusters in order to segment the tumor region. Fuzzy C means algorithm also differentiates pixels based on intensities, however as one pixel can be a part of multiple clusters, it gives a better segmentation of the tumor region. Apart from basic segmentation algorithms, morphological operations aid in obtaining close to ground truth image. Based on tumor shape, the shape of structuring element to be used is determined.

Analysis and comparison of the results obtained from the three algorithms is performed by using the Dice coefficient, it is a segmentation validation engine. It gives the spatial overlap of segmented image and the ground truth image. Performance of segmentation is evaluated using Dice Coefficient by assigning 0 to no overlap and 1 to perfect match between ground truth and segmented image [23]. The Dice Coefficient is expressed as

$$D(A, B) = 2|A \text{ and } B| / (|A| + |B|) \dots\dots\dots \text{equation} \quad (1)$$

Where A is the ground truth image and B is the segmented image. Higher Dice coefficient number indicates better segmentation result. The Dice Coefficient analysis



performed on Watershed and Clustering algorithms for four brain tumor images gives result as shown in table 1

**Table 1:** Dice Coefficient analysis performed on result of three segmentation algorithms.

| SEGMENTATION TECHNIQUES  | TUMOR 1 | TUMOR 2 | TUMOR 3 | ACCURACY        |
|--------------------------|---------|---------|---------|-----------------|
| K-MEANS CLUSTERING       | 62.5201 | 49.9198 | 88.94   | LESS ACCURATE   |
| WATERSHED                | 70.6397 | 53.9146 | 99.22   | MEDIUM ACCURATE |
| FUZZY C-MEANS CLUSTERING | 73.2284 | 55.9794 | 99.45   | MORE ACCURATE   |

The above analysis shows that among the clustering algorithms Fuzzy C means algorithm gives better result compared to K means algorithm for brain tumor segmentation using T2WI MRI scans. Watershed algorithms perform faster segmentation with the least processing time. However it is unable to segment the precise tumor region, hence additional post processing using morphological operations is essential while using watershed algorithm. Varying morphological operations are to be implemented taken into consideration the tumor size and shape. Fuzzy C means clustering algorithm performs better segmentation of tumor region, minimizing the need for further post processing. Thus there is a tradeoff between accuracy and speed while implementing Fuzzy C means and watershed algorithm.

## Conclusion

In this paper we have compared and evaluated the segmentation result of Watershed and Clustering algorithms on brain tumor images. Among these algorithms Fuzzy C means gives the highest dice coefficient value, indicating better segmentation result. This analysis can be useful for researchers and medical personnel for deciding the best segmentation algorithm to be applied for extracting the precise shape and location of brain tumor. The result of analysis significantly depends on Morphological operations, hence more efficient segmentation algorithms are needed to reduce this dependency. In spite of various segmentation techniques and algorithms produced over the years, brain tumor segmentation still remains to be a challenging task. The major drawback lies in the fact that one algorithm cannot be used for all types of brain tumors. A hybrid generic algorithm can be developed from the combination of many segmentation techniques to increase the efficiency.

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