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An Effective Segmentation Technique for Brain Medical Resonance Images

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Abstract: *In the field of medical resonance image processing the image segmentation is an important and challenging problem in an image analysis. The main purpose is to diagnose the problems in the normal brain anatomy and to find the location of tumour. Many of the algorithms have been found in recent years which aid to segment the medical images and identify the diseases. This paper aims to compare previous algorithms for image segmentation and also identifies the better algorithm to extract the MRI brain image for further processing. Three types of MRI images are produced for brains which are based on proton density (PD), longitudinal relaxation time (T1) and transverse relaxation time (T2). Specialists continuously mix multispectral MRI information of a patient to require a call on the location, extension and prognosis and diagnose the brain abnormalities. Neuroradiological research consists of several brain extraction algorithms which are useful for several post- automatic image processing operations like segmentation, registration and compression. The result of proposed algorithm is validated by comparing proposed algorithm with the results of the existing segmentation algorithm used for the same purpose.*

Keywords: *segmentation; clustering; k-means clustering; fuzzy c means clustering; mean shift; canny edge detection; BEA; brain extraction algorithm.*

I. Iintroduction

The main reason of image segmentation is to partition an input image into meaningful regions with respect to our particular application. The major significance of applying segmentation technique is to obtain coarse and fine details of tissues of brain MRI images in detail (Atkins and Mackiewich, 1998). Image segmentation is mainly used to detect objects and boundaries like lines, curves, edges etc. Image segmentation is the process of assigning a label to every pixel in an image which then assigned the same label who shares the same particular characteristics. The result of image segmentation is a set of segments that collectively cover the interested region in an image, or a set of contours extracted from the image (Gonzalez and Richard, 2007). Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic. The success or failure of computerized analysis procedure is specified by segmentation accuracy. The resulting contours after image segmentation of MRI images can be used to create 3D (Raya, 1990) reconstructions with the help of interpolation algorithms. Major applications of medical image processing are: detect and locate tumours and other pathologies issues (Brummer and Mersereau, 1993) measure tissue volumes, diagnosis, study of anatomical structure, surgery planning, virtual surgery simulation, and intra-surgery navigation.

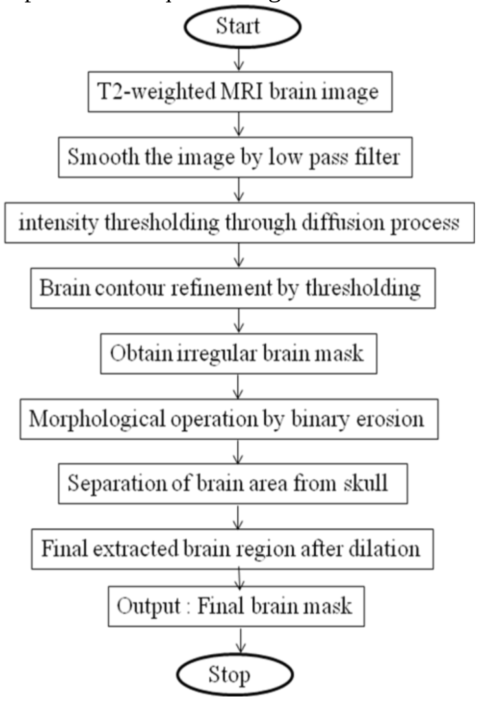
In general, there are three advantages in image segmentation. The first advantage is the speed of the algorithm. The segmentation of image should not consume much time. The second advantage is good edge connectivity of its segmenting result (Perona and Malik, 1990). The third advantage is good shape matching. Consequently, it will be reliable (Somasundaram and Kalaiselvi, 2011). The limited disadvantages of segmentations could be fatal problem, the computation time and over segmentation. The result is sensitive to the selection of the initial random centroids in some of the segmentation techniques. Some region segmentation techniques can produce blocky segments.

Medical Resonance Image segmentation is very essential feature in most of image processing methods, which reflects anatomical structure of segment (brain tissue). The usefulness of these methods in clinical environment significantly depends on the ease of computation and the reduction of human intervention. The proposed method is based on histogram based gradient calculation, which segments out primary objects from T2 brain MR image (Gilanie and Attique, 2013). The applicability of this algorithm has been practically verified giving satisfactory results. It is established that the proposed method can be applied on other medical imaging modalities or other image processing domains and is quite efficient.

II. Proposed Algorithm for Brain Region Extraction

The main purpose of the flow chart shown in figure 1 is to detect the region of brain with many pre-processing steps. The input MRI image is in JPEG form which selects one of the slices from more than 100 slices of patient's data. That has to be T2 weighted image for fine analysis of the brain. Before finding tumour it is important to segment the region of interest. Over here the region of interest is only brain area which has to be removed from skull. 2D-BEA is one of the techniques which extract the brain area from skull and boundary. In 2D-BEA first of all in the first stage the background noise from the brain image will be removed using low pass filter and the output is further diffused to enhance the brain boundaries. This will be forwarded by thresholding in which mask for the coarse brain is generated. In the second stage, morphological based segmentation operation is performed with connected component analysis to extract the fine brain from the coarse brain portion obtained in first stage of 2D-BEA.

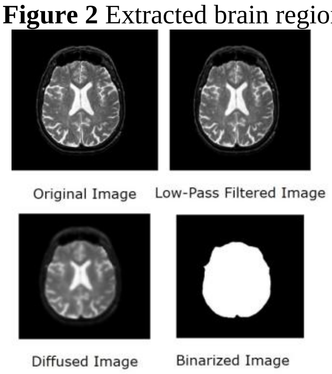
Figure 1: Proposed technique for Segmentation of brain MRI image



The scalp-skull boundaries are very weak in T2-weighted images (Somasundaram and Kalaiselvi, 2011) and hence they are not preserved. The diffusion process helps to compute an intensity threshold value automatically to segment the brain from non-brain tissues. Thus stage one is preserving brain borders. Thresholding helps to produce the rough mask brain. In the second stage main shape characteristics of object will be identified. Erosion and dilation produced the curve boundaries of brain regions of binary image. As per the figure 1, the segmented brain region will be further given to 3D-BEA because the 2D-BEA has limitation for largest connected component identification (Somasundaram and Kalaiselvi, 2011). 3D-BEA may remove that limitation and could be implemented for further research.

2.1 Implementation of developed segmentation algorithm.

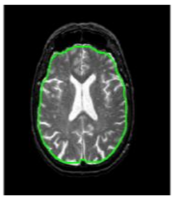
Figure 2 Extracted brain region



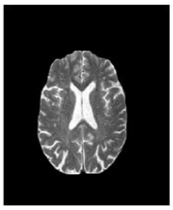
Result of Morphological Operation
Erosion

Morphological Operation:
Opening with horizontal structuring Element

Morphological operation
Opening with Disk shaped structuring element



Brain Region in the Main Image



Extracted brain region

The results in figure 2 shows that using 2D-BEA method the interested brain region is extracted and it removes the unwanted area like skull and other boundaries. It is fulfilling the main purpose of finding out the different possible locations of tumour for the later research.

III. Comparative Analysis Of Developed Algorithm With Different Segmentation Techniques For MRI Brain Images

In addition to the analysis of developed algorithm, the comparative analysis is also carried out with the existing algorithms. It would be easy to identify the efficient algorithm after this analysis. In this section total five segmentation algorithms have been implemented. Mainly cluster based algorithms are compared to validate developed algorithm. Below shows the algorithms and their steps with their importance in different aspects.

3.1 Threshold based image segmentation

The threshold technique is simplest in segmentation methods. To set two thresholds on the histogram of the image, we can classify between the two thresholds in the histogram as the same region and classify the others as the second region (Gonzalez and Richard, 2007).

3.2 Edge based segmentation

This includes detection of edges using Prewitt based, Sobel based, Robert Cross edge, Laplacian edge, Canny based edge detection. Detected edges in an image are assumed to represent object boundaries, and used to identify these objects (Fritz, 2010).

Edge detection very seldom gives you the perfect unambiguous and closed boundaries you need for a direct segmentation. There will frequently be spurious edges detected where they shouldn't be, and gaps occur where there should be edges. An advanced and versatile technique for clustering-based segmentation is presented. Below images shows the results of Matlab simulations for different segmentation techniques.

3.3 Fuzzy c means based clustering

One family of segmentation algorithms is based on the idea of clustering pixels with similar characteristics. Fuzzy c-means has been shown to work well for clustering based segmentation (Benjamin, 2012), however due to its iterative nature this approach has excessive computational requirements. Below shows the algorithm of Fuzzy c means.

Step 1: Initialize the membership Matrix
Step 2: Calculate the degree of membership

Step 3: Compute the centroid and update the new membership and Recalculate the degree of membership
Step 4: If the difference of centroid matrix between new and previous iteration is less than the predefine value then recalculate the degree of membership.

3.4 K-means clustering

It is one of the easiest methods of unsupervised learning algorithm that solve the well-known clustering issue (Funmilola and Adedeji, 2012). K-means is purposed by Macqueen in 1967. K-means is a simple clustering method which is having low computational complexity as compared to Fuzzy C-means. K-means clustering do not overlap the clusters.

$$J = \sum_{i=1}^{c} \left(\sum_{k, Xk \in Gi} d(X_k - C_i) \right) \qquad (1)$$

Below shows the algorithm of k means clustering algorithm for MRI brain image segmentation.

Step 1: Select K points as the initial centroids.
Step 2: Repeat
Step 3: Form K clusters by assigning all points to the closest centroid
Step 4: Recompute the centroid of each cluster.
Step 5: Until the centroids don't change.

Simplicity and easy implementation are some advantages of k-means but it has several drawbacks as well. There is no standard for a good set of initial centres. Instead of random choices, initial k-means results can provide the initial points for the next run of the algorithm.

3.5 Mean shift clustering

Mean Shift is defined as finding modes in a set of data samples, manifesting an underlying probability density function (PDF) (Pilar and Manuel, 2011). Hence the Certain problem occurred in the above techniques has been solved by Mean Shift. Mean shift clustering is one of the most non-parametric clustering techniques which do not require any prior knowledge of the clusters.
Kernel density estimation (known as Parzen window technique in pattern recognition) is the most popular density estimation method. The Parzen-window estimate is defined as

$$P(x) = \frac{1}{n} \sum_{i=1}^{n} \frac{1}{h_n^d} k\left(\frac{x - x_i}{h_n}\right) \qquad (2)$$

Where k(x) =window function (Kernel in D-dimensional), $h_n > 0$ =Width of the Kernel.
Where k(x) is the window function or kernel in the d-dimensional space such that

$$\int_{R^d} K(x)\, dx = 1 \qquad (3)$$

$$\int_{R^d} xK(x)\, dx = 0 \qquad (4)$$

The algorithm for Mean Shift segmentation is as below.

Step 1: Take an input image and fine each point Xi
Step 2: Choose a search window for finding out maximum dense area.
Step 3: Compute the mean shift vector
Step 4: If Mean shift is Optimum then stop the process or again find new point Xi. There are certain advantages for mean shift. I.e. good general-practice segmentation, flexible in number and shape of regions, robust to outliers.

Figure 3 Thresholding based segmentation

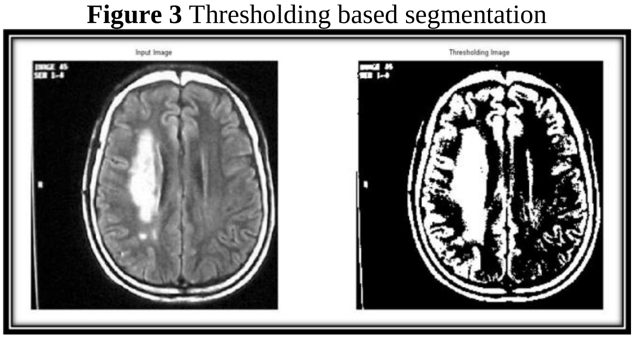


Figure 4: Edge based segmentation

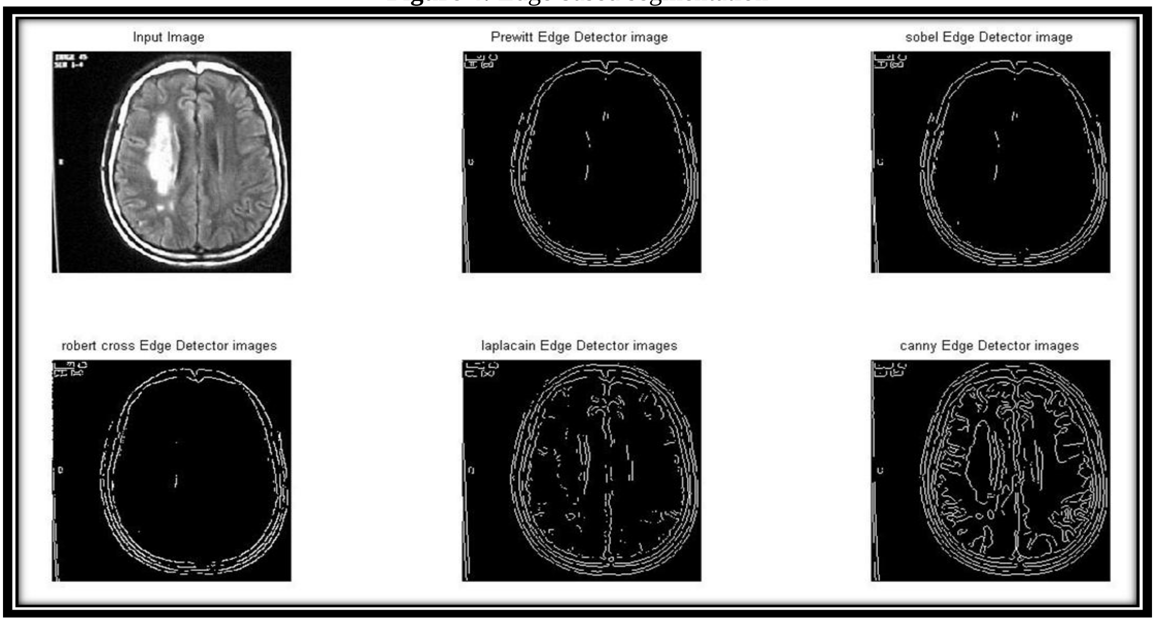


Figure 5 K means clustering based segmentation

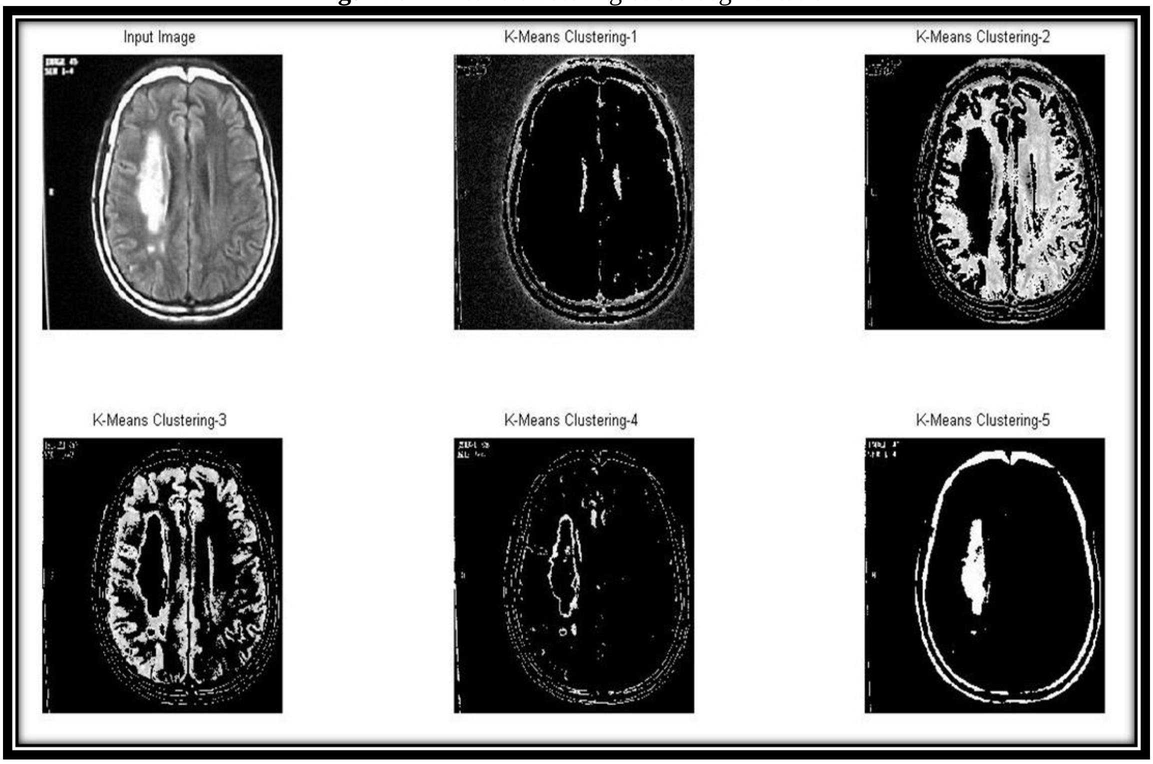


Figure 6 Fuzzy C Means clustering

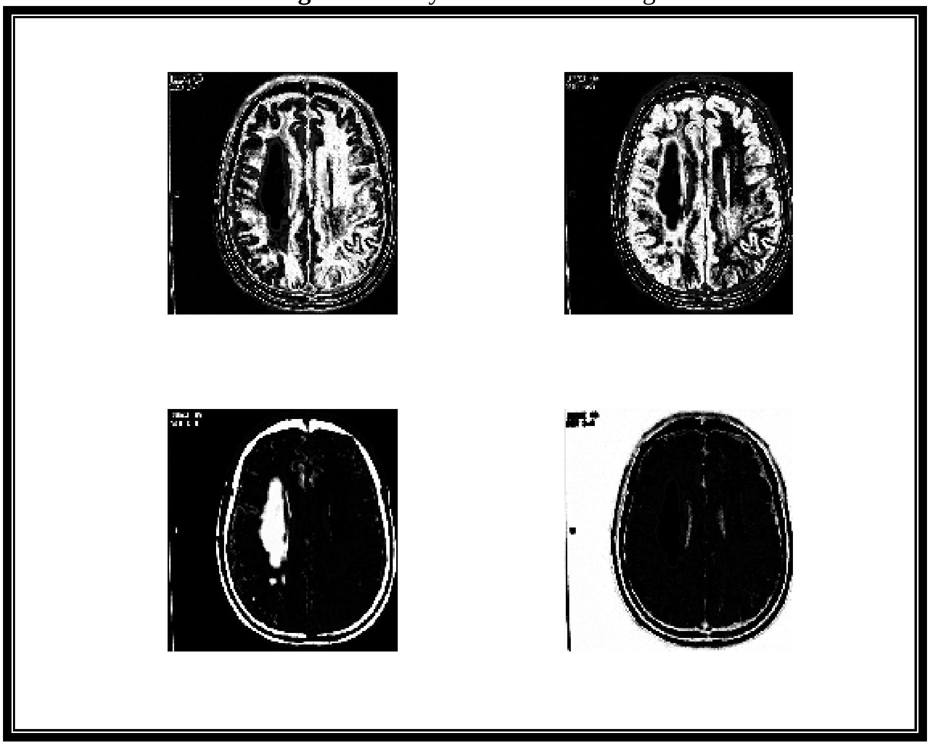


Figure 7 Mean Shift clustering

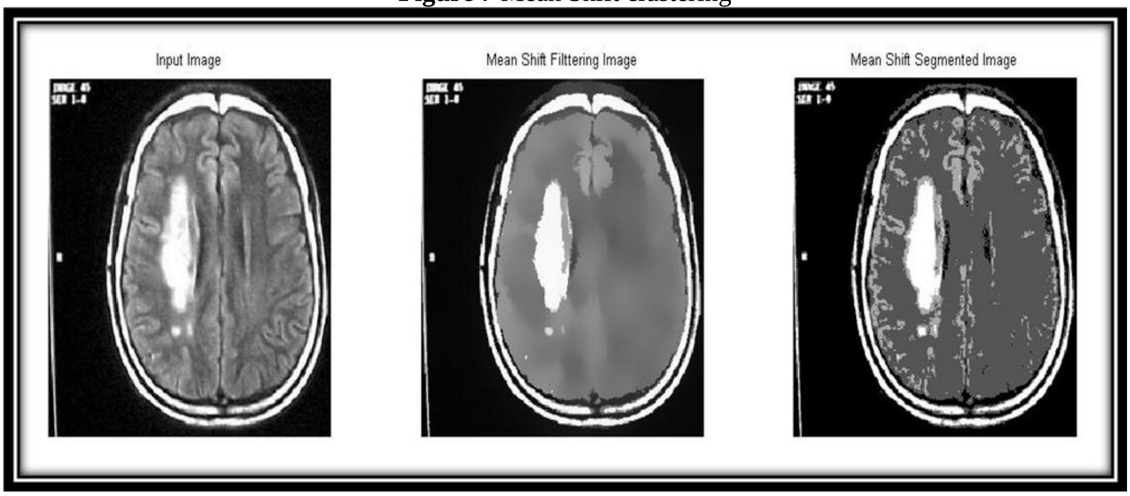


TABLE 1 Comparison of different image segmentation techniques for MRI images of brain

Parameter	**Mean Shift**	**Fuzzy C-Means**	**K-Means**	**Canny Edge detector**	**Thresholding**	**Brain Extraction algorithm 2D-BEA**
Noise	Removing the noise by filtering.	Cannot remove noise	Cannot remove noise.	Only Detected the boundary of that image.	Not involve the spatial information of the images, so it will bring about noise, blurred edges.	Removing the noise by filtering.
Smoothing	More Smoothed image is produced.	Doesn't smooth the image	Different initial centroids will bring about the different results.	Smoothed Image but Less Compare to Mean Shift.	Outlier in the images.	More Smoothed image is produced.
Separation	Cannot separate unwanted area like skull	Used for MRI image segmentation	Other region can also separate.	Can separate all edges of particular image.	Only separate binary image.	Can separate unwanted area like skull

No. of Cluster	Does not require prior knowledge of the number of clusters.	Apriori Specification of the number of cluster	A problem of choice of numbers of cluster N.	-	-	Does not require prior knowledge of the number of clusters.
Over segmentation	Guarantees an over-segmented image while keeping fine image details.	Does not over segmented image.	Does not over segmented image.	Does not over segmented image.	Does not over segmented image.	Does not over segmented image.

Above table 1 depicts the importance of proposed algorithm 2D-BEA in all aspects towards better segmentation of brain MRI images. As compared to other segmentation algorithms searched by previous researchers the 2D-BEA algorithm is removing noise from the input image with minimum computational time. Proposed algorithm is also efficient to identify the smooth edges as well as preserving information. This developed algorithm does not over segment the image so that blur effect comes down to null. Moreover it is so user friendly and automated that it does not expense time to diagnose unwanted area and only extract the desire region of brain MRI images.

IV. Conclusion

Brain extraction algorithm is a general category of algorithms used to extract/evaluate features of a given brain scan. It also performs the very same task of post processing. In first stage, coarse brain is generated using filtering and thresholding. In second stage, morphological operations performed on binary image to segment the fine brain mask. It has been observed from the comparative analysis that existing methodology of segmentation is not able to remove noise as well as blur the images and moreover it does not extract brain area which is the main interest for further research and for finding out the tumour in the later stage. In future to overcome the failure of 2D-BEA, 3D-BEA will be used. For the current research the partial algorithm of proposed technique has been implemented. Further study will be taken up in near future for image classification and other pre-processing. Results show the validity of the 2D-BEA algorithm and its advantages through comparison.

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