BRAIN TUMOR SEGMENTATION USING ASYMMETRY BASED HISTOGRAM THRESHOLDING AND K-MEANS CLUSTERING

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Abstract

Segmentation has become an important objective and still remains as a challenging area in medical image analysis. An accurate segmentation of the objects in medical images helps the doctors for proper diagnosis, surgical and treatment planning. The result of segmentation can be used by other processing techniques such as classification techniques to make the scope of segmentation wider. Segmentation result can also be used for quantification (volume calculation) purpose. An accurate segmentation is required for further manipulation of the problem. Moreover a small error in the segmentation process may get magnified in subsequent steps of processing. Segmentation extracts specific regions of interest from an image. The segmentation depth depends on the problem being solved. Several techniques exist for the segmentation of medical images. Various combinations of techniques have also been tried. Still the problem remains as a challenge. Even though it is simple, thresholding in its pure form does not give an accurate segmentation result in many cases, but when combined with other techniques of segmentation, it produces a highly accurate result. Human brain consists of soft tissues and Magnetic Resonance Imaging provides a better contrast for the same compared to other imaging modalities. Hence MRI is widely used in brain studies. Unlike other imaging modalities MRI is based on magnetic property of water molecules in human body and does not use radiation making it safer. This paper focuses on segmenting tumour affected region of brain from a Magnetic Resonance Image using thresholding and k-means clustering techniques. The proposed method contains eight important steps after which a segmented tumor region is obtained.

Keywords: *Brain Tumor, MRI, Segmentation, Histogram Thresholding, K-means clustering*

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1. INTRODUCTION

A brain tumour is an uncontrolled and abnormal growth of tissues in the brain. Human skull in which brain is enclosed is very rigid. So any growth inside such a restricted space can cause damage to the parts which provide vital functionalities . Brain tumours can be cancerous (malignant), which grows in a rapid manner or non-cancerous (benign) which is less harmful.

Magnetic resonance imaging (MRI), which is one of the widely used imaging modality for brain, makes use of magnetic fields and radio waves to produce high quality two- or three-dimensional images of brain structures without using ionizing radiation (X-rays) or radioactive materials. Images of brain are taken from different planes and they can be combined to form a 3D image of brain The MRI detects signals emitted from tissues of brain which provides clear images of most tumours [2].

Segmentation divides an image into easily analysable regions. Segmentation partitions a 2 dimensional digital image f(x, y) into continuous, non overlapping and nonempty subsets f1, f2, f3, f4… fn, for easy extraction of features [3]. Image segmentation remains as a challenging and complex issue even though there exist a number of algorithms in this field. So many factors including application area, imaging modality etc. decides the required segmentation algorithm. Hence segmentation of various organs demands for different methods. General segmentation methods that can be applied to various data do exist, but there does not exist a single segmentation method which can be applied to every image. [4].

Khotanlou *et al*. [13] suggests a combined region and contour based method applied to T1-weighted acquisition data. Saha *et al*. [11] utilizes the dissimilarity between the left and right halves of brain in their unsupervised search method. Bhattacharyya *et al*. [6] proposes a set of image segmentation algorithms based on thresholding. Biji *et al*. [7] proposes a method based on modified fuzzy thresholding and minimum error thresholding. Gibbs *et al*.[8] uses a segmentation procedure in which edges are first detected using morphological operations and then segmentation is carried out using region growing method. Ratan *et al*.[9] uses a watershed algorithm for segmentation. . Hsieh *et al*.[10] integrates FCM and region growing method for segmentation. Iscan *et al*. [12] uses incremental supervised neural network and wavelet band for segmentation.

The following section describes methodology implementation details and results of the proposed method.. The study is carried out on 30 images which are taken from the database in "http://www.med.harvard.edu/AANLIB/home.html".

2. METHODOLOGY

The eight important steps involved in segmentation process is shown as flow chart in fig .1

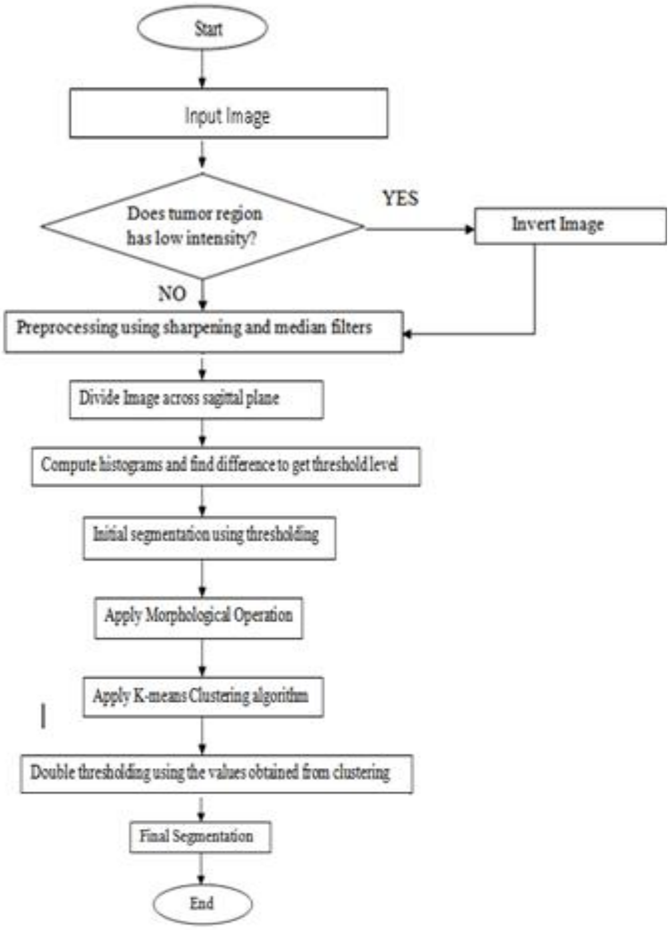


Fig -1: Flowchart of the proposed method

The proposed method consists of 8 important steps. After getting the input image, the image is inverted if the tumour region has low pixel values than other regions. A sharpening filter is then applied to enhance the high frequency components. Noise is removed using a median filter. In the next stage make the tumour region bright by inverting, if it is not. The image is divided across the sagittal plane before computing histograms of each half. Histogram difference is used to calculate the threshold value. Morphological operation is done to extract tumour region. In order to fine tune the result a thresholding is applied using the value obtained after K-means clustering.

2.1 Image Pre-processing

Input image is pre-processed using Sharpening filter and median filter after converting it into gray-level. Sharpening filter highlights the fine details in the image. It enhances the high-frequency components. The spatial mask is set such that there is a positive coefficient at the center and negative coefficients in the periphery.

$$1/9 * \begin{array}{|c|c|c|} \hline -1 & -1 & -1 \\ \hline -1 & 8 & -1 \\ \hline -1 & -1 & -1 \\ \hline \end{array}$$

Fig -2: Typical mask of a linear high pass spatial filter

For the removal of noise a non linear median filtering technique can be used. Median filtering is very widely used in digital image processing , as it removes noise while preserving edges under certain conditions. In median filter each pixel value is replaced by the median of the neighboring pixels [5].

2.2 Histogram

Image histogram is a useful tool for thresholding. Histogram represents pixel distribution as a function of intensity variation. It is a graph of p(r) versus r, where p(r) is the probability of occurrence of gray level r and is defined as

$$P(r) = \frac{n(r)}{n} \qquad (1)$$

where n is the total number of pixels in the image and n(r) is the number of pixels in the image with gray level r [5].

2.3 Thresholding

If N is the set of natural numbers, (x, y) is the spatial coordinate of a digitized image, and G = (0, 1, . . . , I - 1) is a set of positive integers representing gray levels, then an image function is defined as the mapping f: N x N → G. The brightness (i.e., gray level) of a pixel with coordinate (x, y) is denoted as $f(x, y)$. Let t be a threshold and B = { b0,b1} be a pair of binary gray levels and b0,b1 ∈ G. The result of thresholding an image function f(x, y) at gray level t is a binary image function f : N x N →B, such that

$$f(x, y) = \begin{cases} b0, \text{if } f(x, y) < t \\ b1, \text{if } f(x, y) \geq t \end{cases} \qquad (2)$$

2.4 Morphological Operation

The morphological operation used here is the opening operation which combines dilation and erosion. Dilation of an image A by structuring element B is defined as:

All z in A such that B hits A when origin of B=z.

$$A \oplus B = \{z | (\hat{B})_z \cap A \neq \Phi\} \qquad (3)$$

Erosion of a set A by structuring element B is defined as:

All z in A such that B is in A when origin of B=z

$$A \ominus B = \{z | (B)_z \subseteq A\} \qquad (4)$$

The opening of image A by structuring element B, denoted A ○ B is simply an erosion followed by a dilation.

$$A \circ B = (A \ominus B) \oplus B \qquad (5)$$

2.5 K-means Clustering

K-means clustering is one of the simplest unsupervised learning algorithms that solves clustering problem. This algorithm classifies a given data set into k number of clusters. The algorithm first defines k centroids, one for each cluster. In the next step each point in the data set is taken and it is associated to a particular cluster so that it has the minimum distance to that cluster. New cluster centers are calculated iteratively until no change occurs to the cluster centers.

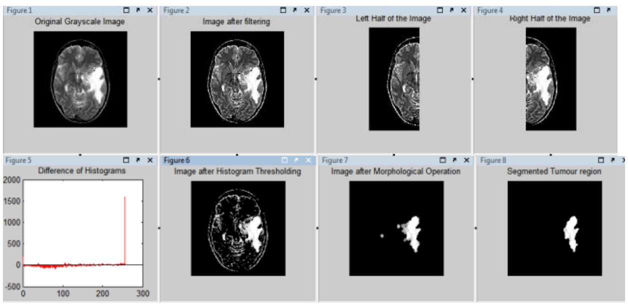
$$d = \| x_i^{(j)} - c_j \|2 \qquad (6)$$

is a chosen distance measure between a data point $x_i^{(j)}$ and the cluster centre c_j

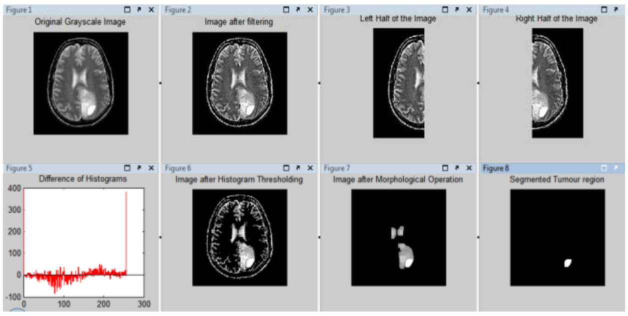
This paper is implemented in Matlab 2012a.To invert the image each pixel is subtracted from the highest intensity value. For median filtering the built in function in Matlab is used. The structural element ‘disk’ is selected for morphological operation. The k value in clustering is set to 4.The threshold value for the second thresholding is taken as the average of the two highest intensity cluster centroids. The processes are carried out through 30 MR images which are taken from 10 people with tumours. These images are obtained from AANLIB (Harvard Whole Brain Atlas) database.

2.6 Results and Discussions

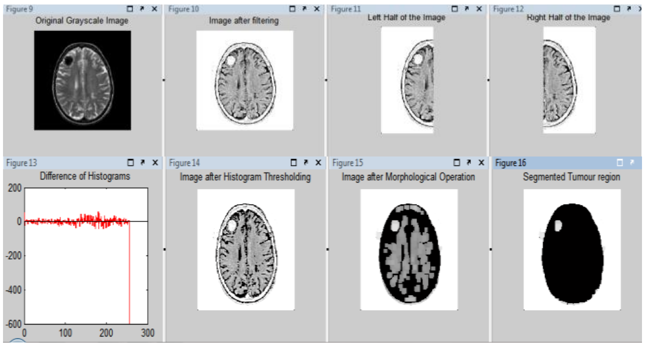
The tumour affected MRI images were processed and the tumour region is segmented. The results of the method executed in 8 different images (a) to (h) are given below. The first row consists of original gray level image, Filtered image, Left and right half of the filtered image. Second row contains Histogram difference of the left and right half, image after thresholding, morphologically operated image and final result.



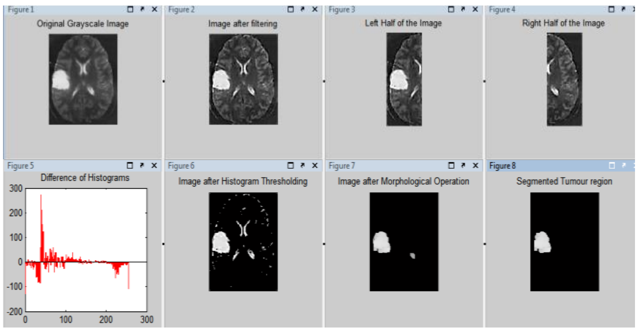
(a)



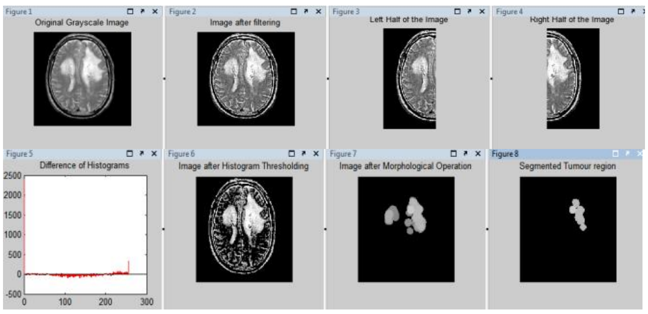
(b)



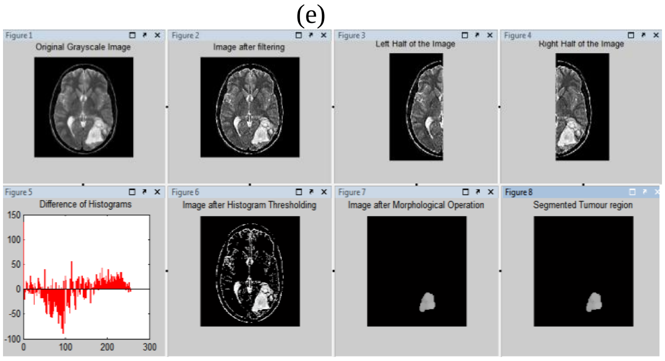
(c)



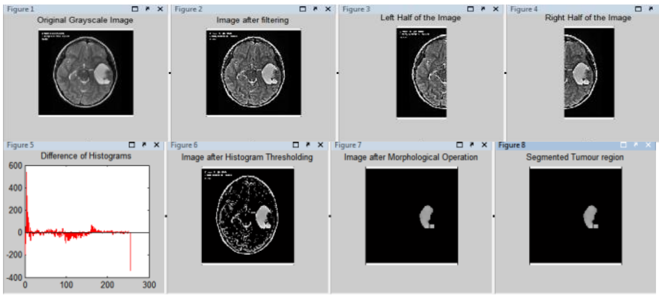
(d)



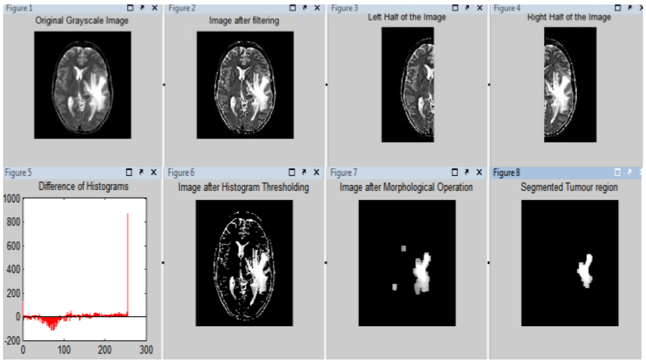
(e)



(f)



(g)



(h)

Fig -3: Images after executing each step in the algorithm on 8 different data

3. CONCLUSIONS

In this paper we have presented a tumour segmentation method which combines both histogram thresholding and k-means clustering method. The method is implemented to segment brain tumor from MRI images. Size of the tumour can be assessed by incorporating area calculation for future work. The work can be further extended to extract features from the segmented area whose output can be given to a classifier in order to develop a computer assisted diagnostic system which can be used to predict the type of tumour.

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BIOGRAPHIES

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