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Segmentation of MRI Image for the Detection of Brain Tumour

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Abstract: **During past few years, brain tumor segmentation in magnetic resonance imaging (MRI) has become an emergent research area in the field of medical imaging system. Brain tumor detection helps in finding the exact size and location of tumor. Computer aided detection of abnormal growth of tissues is primarily motivated by the necessity of achieving maximum possible accuracy for the purpose of initiating and speeding up the recovery process. The Medical Image segmentation deals with segmentation of tumor in MR images for improved quality in medical diagnosis. It is very important and a challenging problem due to noise present in input images while doing image analysis. An efficient algorithm is proposed in this paper for tumor detection based on segmentation and morphological operators. Firstly quality of scanned image is enhanced to remove noise and then morphological operators are applied to detect the tumor in the scanned image. Here the segmentation is carried out using k-means and fuzzy c-means clustering algorithm for better performance. Tumour can be found with more precision and also fast detection is achieved with only few seconds for execution and the area of the tumour can also be analyzed.**

Keywords: **Brain tumor, image processing, K-means clustering, Fuzzy c-means clustering, MR image, Segmentation.**

1. INTRODUCTION

The word tumor is a synonym for a word neoplasm which is formed by an abnormal growth of cells. Tumor is something totally different from cancer. A brain tumour is an abnormal growth of the cells inside the brain, which can be cancerous or non cancerous. It is generally caused by abnormal and uncontrolled cell division. Brain tumours are of two types: primary and secondary. Primary brain tumour includes any tumour that starts in the brain.

Primary brain tumours are classified as benign, Pre-Malignant and malignant.

A) Benign tumor:

Benign tumours can be removed and the seldom grow back. Benign tumours usually have a border or an edge. They do not spread to other parts of the body

B) Pre-Malignant tumor:

Premalignant Tumor is a precancerous stage, considered as a disease, if not properly treated it may lead to cancer.

C) Malignant tumor:

Malignant brain tumours are generally more serious and often are a threat to life. They grow rapidly in crowd and invade the nearby healthy tissue. Cancer cells may break away from malignant brain tumour and spread to the other parts of the brain or to the spinal cord but it rarely spread to other parts of the body.

Any brain tumor is inherently serious and life-threatening because of its invasive and infiltrative character in the limited space of the intracranial cavity. However, its threat level depends on the combination of factors like the type of tumor, its location, its size and its state of development. Because the brain is well protected by the skull, the early detection of a brain tumor occurs only when diagnostic tools are directed at the intracranial cavity. Usually detection occurs in advanced stages when the presence of the tumor has caused unexplained symptoms. Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to investigate the anatomy and physiology of the body in both health and disease. MRI scanners use magnetic fields and radio waves to form images of the body. The technique is widely used in hospitals for medical diagnosis, staging of disease and for follow-up without exposure to ionizing radiation. MRI has a wide range of applications in medical diagnosis and over 25,000 scanners are estimated to be in use worldwide. MRI has an impact on diagnosis and treatment in many specialties although the effect on improved health outcomes is uncertain. Since MRI does not use any ionizing radiation, its use is generally favored in preference to CT when either modality could yield the same information. MRI is in general a safe technique but the number of incidents causing patient harm has risen. Contraindications to MRI include most cochlear implants and cardiac pacemakers, shrapnel and metallic foreign bodies in the orbits.

In Design Procedure topic explains, what is the basic idea behind the implementing of this algorithm, in proposed algorithm topic explains, what are the steps followed to implement this algorithm, in Results and discussion topic explains, the output of this algorithm for different techniques, finally conclusion and future scope explains, conclusion of this algorithm and what are the future works will going to do.

II. DESIGN PROCEDURE

The algorithm has two stages, first is pre-processing of given MRI image and after that performs morphological operations and then segmentation. A step by step algorithm is shown in fig 1.

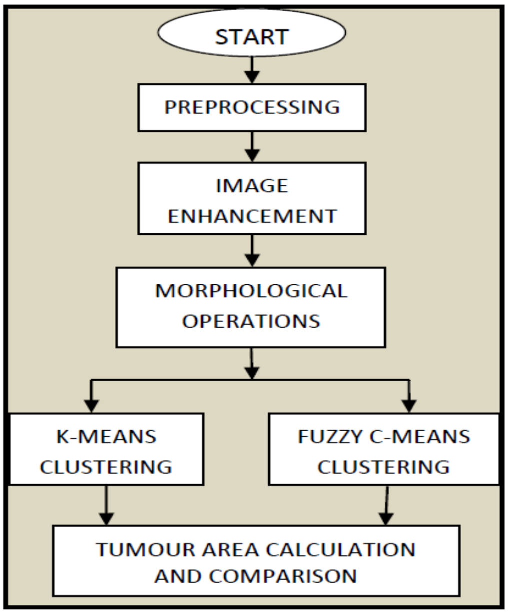


Fig.1

2.1 Image Acquisition:

MRI images are magnetic resonance images which can be acquired on computer when a patient is scanned by MRI machine. We can acquire MRI images of the part of the body which is under test or desired.

2.2 Gray Scale Imaging:

Generally when we see MRI images on computer they look like black and white images. In analog practice, gray scale imaging is sometimes called "black and white," but technically this is a misnomer. In true black and white, also known as halftone, the only possible shades are pure black and pure white. Gray scale is a range of shades of gray without apparent color. The darkest possible shade is black, which is the total absence of transmitted or reflected light. The lightest possible shade is white, the total transmission or reflection of light at all visible wavelengths. So because of the above reasons first we convert our MRI image to be pre-processed in gray scale image.

2.3 Image Enhancement:

Image enhancement is a process principally focuses on processing an image in such a way that the processed image is more suitable than the original one for the specific application. These are the *frequency* and *spatial* domains. The frequency domain methods works with the Fourier Transforms of the image. Spatial domain methods are procedures that operate directly on the pixels. Some enhancement techniques exist in the spatial domain are histogram processing, enhancement using arithmetic, and logical operations and filters. Image enhancement operation improves the qualities of an image. They can be used to improve an image's contrast and brightness characteristics, reduce its noise content or sharpen its details.

In signal processing, it is often desirable to be able to perform some kind of noise reduction on an image or signal. The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise.

2.4 Morphological Operations:

Morphological image processing is a collection of nonlinear operations related to the shape or morphology of features in an image. Morphological operations rely only on the relative ordering of pixel values, not on their numerical values. Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighbourhood of pixels. Some operations test whether the element "fits" within the neighbourhood, while others test whether it "hits" or intersects the neighbourhood:

A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value only if the test is successful at that location in the input image.

The structuring element is a small binary image, i.e. a small matrix of pixels, each with a value of zero or one:

- The matrix dimensions specify the *size* of the structuring element.
- The pattern of ones and zeros specifies the *shape* of the structuring element.
- An origin of the structuring element is usually one of its pixels, although generally the origin can be outside the structuring element.

The purpose of the morphological operators is to separate the tumour part of the image. The portion of the tumour in the image is visible as white color which has the highest intensity then other regions of the image. Some of the commands used in the morphing are strel which is used for creating morphological structuring element, imerode which is used to erode or shrink an image and imdilate which is used to for dilating i.e. expanding an image.

3. PROPOSED ALGORITHM

3.1 Segmentation:

Segmentation refers to the process of partitioning a digital image into multiple segments. Image segmentation is typically used to locate objects and boundaries in image. Image segmentation can also be considered as a process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. It can also be defined as a technique which partitions a given image into a finite number of non overlapping regions with respect to some characteristics, such as gray value distribution, texture. Segmentation subdivides an image into its constituent region or objects. The level of detail to which the subdivision is carried depends on the problem being solved. Most of the segmentation algorithms depend on one of two basic properties of intensity values: discontinuity and similarity. In the first category the approach is to partition an image based on abrupt changes in intensity, such as edges. The second category approaches is based on partitioning an image into regions that are similar according to a set of predefined criteria. In this project second approach is used.

3.2 K-means based Segmentation:

In the year 1967 MacQueen developed the K-means algorithm. K-means is the clustering method which forms k clusters of n pixel objects, wherein each pixel object belongs to the cluster of the nearest mean. Given a set of observations (x1, x2, ..., xn), where each observation is a d-dimensional real vector. K-means clustering aims to partition the n observations into k sets (k ≤ n) S = S1, S2,...,Sk so as to minimize the within-cluster sum of squares

$$J = \sum_{j=1}^{k}\sum_{i=1}^{n}\left\|x_i^{(j)} - c_j\right\|^2$$

Where C_j is the mean of points in Si.

m=$xj \in Si$

It is a simple clustering method and gives fast outputs as well. The k-means algorithm is an iterative technique that is used to partition an image into *K* clusters. Algorithm for K means Clustering:

Step 1: Choose K centroids at random from input MR image.

Step 2: Make initial partition of objects into k clusters by assigning objects to closest centroid

Step 3: Calculate the centroid (mean) of each of the k clusters.

a. For object i, calculate its distance to each of the centroids.

b. Allocate object i to cluster with closest centroid.

c. If object was reallocated, recalculate centroid based on new cluster.

Step 4: Repeat 3 for object i = 1,...., N

Step 5: Repeat 3 and 4 until no reallocations occur.

Step 6: Assess cluster structure for fit and stability:

Step 7: Separate Image into K sub images according to clustered indexed Image

Step 8: Apply intensity and area based threshold to extract exact tumour part from image. This algorithm is guaranteed to converge, but it may not return the optimal solution. The quality of the solution depends on the initial set of clusters and the value of *k*.

3.3 Fuzzy C Means Segmentation:

In the year 1973 Dunn developed the Fuzzy C Means algorithm and later in 1981 it was enhanced by Bezdek. However the Fuzzy logic was proposed in 1965 by Lofti A Zadak a professor of Computer Science at University of California, Berkeley.

Fuzzy logic is a form of many-valued logic or probabilistic logic. It by definition only means approximate values rather than fixed and exact. Let X be a space of points, with a generic element of X denoted by x. Thus, X=$\{x\}$.A Fuzzy set A in X characterized by a membership function $\mu A(x)$which associates with each point in X a real number in the interval [0,1], with value of $\mu A(x)$ at x representing the grade of membership of x in A.

This algorithm works by assigning membership to each data point corresponding to each cluster centre on the basis of distance between the cluster centre and the data point. More the data is near to the cluster centre more is its membership towards the particular cluster centre. Clearly, summation of membership of each data point should be equal to one. After each iteration, the up-gradation of the membership and cluster centres is done.

Main objective of fuzzy c-means algorithm is to minimize:

$$J(U,V) = \sum_{i=1}^{n}\sum_{j=1}^{c}\left(\mu_{ij}\right)^m \parallel x_i - v_j \parallel^2$$

Where $\|xi - vj\|$, is the Euclidean distance between ith data and jth cluster centre.

Parameters:

n : is the number of data points.

: represents the cluster centre.

m : is the fuzziness index m ∈[1, ∞].

c : represents the number of cluster centre.

μij: represents the membership of data to cluster centre.

dij: represents the Euclidean distance between ith and jth data and cluster centre.

Algorithmic steps for Fuzzy c-means clustering:

Let X ={x1, x2, x3 ..., xx}be the set of data points and V = {v1, v2, v3 ..., vv}be the set of centres.

Step 1: Randomly select c cluster centers.

Step 2: Calculate the fuzzy membership function μijusing:

$$\mu_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{d_{ij}}{d_{ik}}\right)^{\frac{2}{m-1}}}$$

Step 3: Compute the fuzzy centers vj using:

$$v_j = \left(\sum_{i=1}^{n}(\mu_{ij})^m x_i\right) \div \left(\sum_{i=1}^{n}(\mu_{ij})^m\right)$$

$\forall j$=1,2,..c.

Step 4: Repeat Step 2&3 until the minimum 'J' value is achieved or $\|Uk+1-Uk\|<\beta$ where,

k: is the iteration step.

β : is the termination criterion between [0, 1].

U = □μij□$n+c$ is the fuzzy membership matrix.

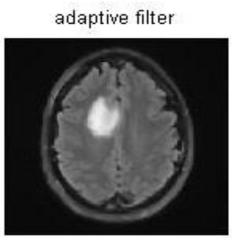
J: is the objective function

4. RESULTS AND DISCUSSION

The Clustering algorithms like K means, Fuzzy C means were applied on the database of brain tumour images in non-medical format (.jpg, .png, .bmp etc.) and the following figures shows the output images as gray scale image, enhances image(median and wiener filter output), morphological output image and the tumour part.

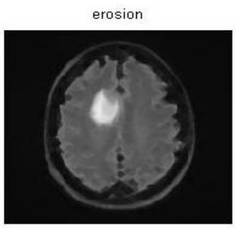
(a) Original image

(b) Gray scale image

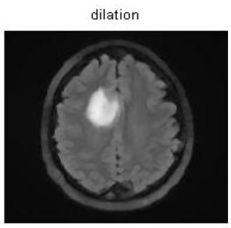


(c) image after using adaptive filter

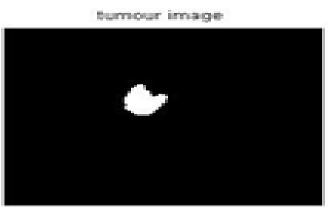
(d) image after using median filter



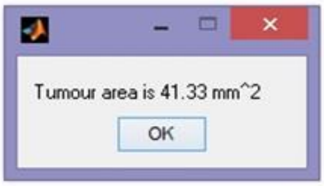
(e) image after erosion



(f) image after dilation



(g) output tumor image



(h) Tumor area in sq.mm

Fig.2 Tumour area calculation in K-means based Segmentation

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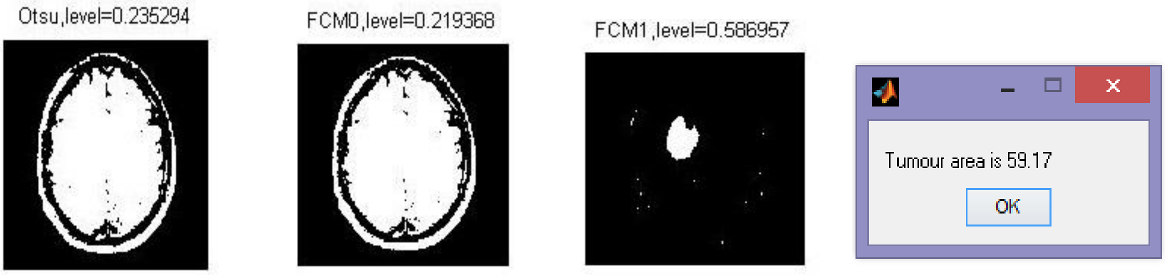

(a) Image after Otsu method **(b) image after FCM 0** **(c) image after FCM 1** **(d) Tumor area in sq.mm**

Fig.3 Tumour area calculation In Fuzzy C- means

The outputs at different stages are shown in Fig 2 and Fig 3. The proposed algorithm has been successfully implemented and tested using wide range of images. The algorithms are similar when compared to the time taken to segment the tumor. The tumor segmented using K-means clustering is faster and shows the tumor boundaries more prominently when compared to tumor segmented using Fuzzy C-Means clustering.

5. CONCLUSION

The main technique used was segmentation which is based on thresholding and morphological operators. Segmentation algorithms used were k-means and fuzzy c-means which made segmentation process easy. Samples of human brains were taken which were scanned by using MRI process and then processed through segmentation methods both k-means and fuzzy c-means clustering methods, thus giving efficient end result. After the detection of the tumour in given MRI image the area of the tumour is calculated. Proposed method is easy to execute with less execution time and thus can be managed easily.

6. FUTUREWORK

In future this programme can be done more advanced so that tumour can be classified according to its type. Also tumour growth can be analysed by plotting graph which can be obtained by studying sequential images of tumour affected patient.

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