Brain Tumor Detection and Identification from T1 Post Contrast MR Images Using Cluster Based Segmentation

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Abstract: ***This paper consists of implementation of a simple algorithm for detection and identification of brain tumor in brain MR Images. Traditional method for medical resonance brain images classification and tumors detection is by human inspection also segmentation is performed manually in clinical environment that is operator dependent and very tedious and time consuming work. Brain Magnetic Resonance Image (MRI) segmentation is a complex problem in the field of medical imaging despite various presented methods. MR image of human brain can be divided into several sub-regions especially soft tissues such as gray matter, white matter and cerebrospinal fluid. And using this segmentation, exact location and type of brain tumor can be found out. System implemented here uses cluster based segmentation i.e. Fuzzy C-Means clustering to divide original MRI in number of clusters. Then tumor is extracted using thresholding and type of tumor is decided based on its area.***

Keywords: Magnetic Resonance Imaging (MRI), Image segmentation, Fuzzy C-Means, T1 MRI, Clustering.

1. Introduction

This paper deals with an automatic system for brain tumor detection and identification. Basically, tumor is an uncontrolled growth of tissues in human brain. This tumor, when turns in to cancer become life-threatening. So medical imaging, it is necessary to detect the exact location of tumor and its type. For brain images, there are two ways of getting image of brain; from which presence of brain tumor is detected. One is using CT scan and other is using MR imaging. For detection and identification of brain tumor, MRI is better suited.

A brain tumor is an intracranial mass produced by an uncontrolled growth of cells either normally found in the brain such as neurons, lymphatic tissue, cells, blood vessels, pituitary and pineal gland, skull, or spread from cancers primarily located in other organs . Brain tumors are classified based on the type of tissue involved, the location of the tumor, whether it is benign or malignant. There are four grades as grade I to grade IV. Cells from low-grade tumors (grades I and II) look more normal and generally grow more slowly than cells from high-grade tumors (grades III and IV). Over time, a low-grade tumor may become a high grade tumor.

1) Benign brain tumor:
This type of tumor generally do not consist cancer cells and can be removed. Benign brain tumors usually have an obvious border or edge. They don't spread to other parts of the body. However, benign tumors can cause serious health problems. Grade I and II are benign brain tumors.

2) Malignant brain tumor:
This consists of cancer cells and hence also called as brain cancer. They are likely to grow rapidly and can affect nearby healthy brain tissues. This type of tumor can be a threat for life. Grade III and IV are malignant brain tumors.

2. Existing Methods

There are many conventional Methods of MRI segmentation that uses image processing techniques such as region growing, edge detection, and histogram Equalization, etc. The problem with all these methods is that, they need human interaction for accurate and reliable segmentation. The thresholding method was ignored the spatial characteristics. Normally spatial characteristics are important for the malignant tumor detection. In the thresholding based segmentation the image is considered as having only two values either black or white. But the bit map image contains 0 to 255 gray scale values. So sometimes it ignores the tumor cells also. In case of the region growing based segmentation it needs more user interaction for the selection of the seed. Seed is nothing but the center of the tumor cells; it may cause intensity in homogeneity problem. And also it will not provide the acceptable result for all the images. Also segmentation techniques like watershed segmentation gives problems of over segmentation.

3. Proposed Method

There are number of segmentation techniques used for segmentation of brain MRI. But as seen, all have some disadvantages. To minimise these disadvantages, a system is proposed here. The proposed system has mainly four modules: preprocessing, segmentation, Feature extraction, and tumor detection-identification. Pre processing is done by filtering. Segmentation is carried out by Fuzzy C-Means Clustering. Feature extraction is by thresholding and finally, Algorithm to calculate area of tumor in MR Image. Fig.1 shows the block diagram of the system for brain tumor detection and identification.

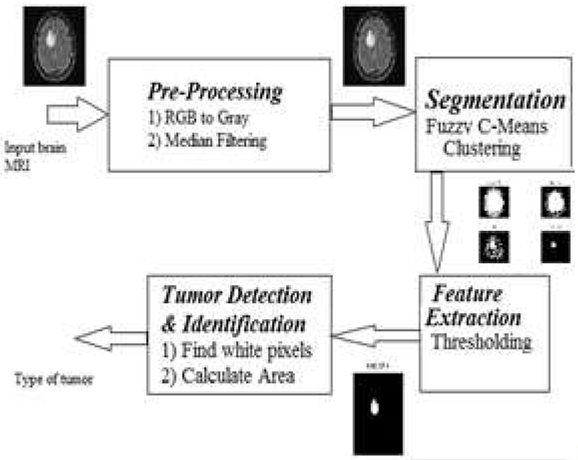


Figure 1: Block Diagram for tumor detection and area calculation system

The system is divided in two categories, pre-processing and post-processing. Pre-processing consist of three steps, namely RGB to Gray conversion, Median filtering and segmentation using FCM. Post-processing consist of feature extraction by thresholding, tumor area calculation and then decision for tumor type based on its area. Figure 2 shows the flowchart for proposed system.

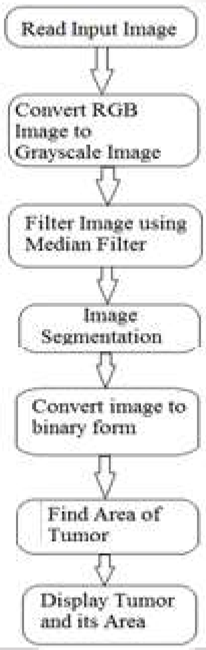


Figure 2: Flowchart for tumor detection and area calculation

3.1 Pre-Processing

The main aim of this proposed work is to detect and segment the tumor cells. According to the need of the next level the pre processing step convert the image. It performs following steps:

Step 1: Input image
Input MR Image of brain of size 256x256 is read and stored in variable in matrix form.

Step 2: RGB to gray conversion
RGB to grey conversion is required for MR images because the processing takes place on gray scale image. This conversion is carried out by eliminating hue and saturation information while retaining the luminance information of image.

Step 3: Median Filtering
Filtering of noise and other artifacts in the image and sharpening the edges in the image. It includes median filter for noise removal. The possibilities of arrival of noise in modern MRI scan are very less. It may arrive due to the thermal effect. But for the complete system it needs the process of noise removal. For better understanding the function of median filter, we can add the salt and pepper noise artificially and removing it using median filter.

3.2 Segmentation

The fuzzy logic is a way to processing the data by giving the partial membership value to each pixel in the image. The membership value of the fuzzy set is ranges from 0 to 1. Fuzzy clustering is basically a multi valued logic that allows intermediate values i.e., member of one fuzzy set can also be member of other fuzzy sets in the same image. There is no abrupt transition between full membership and non membership. The membership function defines the fuzziness of an image and also to define the information contained in the image. These are three main basic features involved in characterized by membership function. They are support, Boundary. The core is a fully member of the fuzzy set. The support is non membership value of the set and boundary is the intermediate or partial membership with value between 0 and 1. This clustering algorithm allows one piece of data may be member of more than one clusters. It is based on reducing the equation 1,

$$Y_m = \sum_{i=1}^{N}\sum_{j=1}^{C} M_{ij}^{m} \left\| x_i - c_j \right\|^2 \qquad \text{........... (1)}$$

Where,
m- Any real number greater than 1.
Mij- Degree of membership of X; in the cluster j
xi- Data measured in d-dimensional.
Cj - Dimension centre of the cluster.
$\|$Xi-Cj$\|^2$- Induced norm (Euclidean norm)

Center and membership values obtained in each cluster are used to calculate level for thresholding. This system uses four level segmentation i.e. for four levels of thresholding, image is divided in to five clusters.

3.3 Feature Extraction

The feature extraction is extracting the cluster which shows the predicted tumor at the output. The extracted cluster is given to the thresholding process. It applies binary mask over the entire image. It makes the dark pixel become darker and white become brighter. In threshold coding, each transform coefficient is compared with a threshold. If it is less than the threshold value then it is considered as zero. If it is larger than the threshold, it will be considered as one. The thresholding method is an adaptive method where only those coefficients whose magnitudes are above a threshold are retained within each block. Let us consider an image 'g' that have the k gray level. An integer value of threshold T, which lies in the gray scale range of k. The thresholding process is a comparison. Each pixel in 'g' is compared to T. Based on that, binary decision is made. The threshold image g(x,y) can be represented as below:

g(x,y) = 1 if g(x,y) > T
g(x,y) = 0 if g(x,y) ≤ T

3.4 Tumor Area Calculation

For area calculation, the binary image which is output of previous stage is used as input. Now binary image have only two intensity levels i.e. black or white. Pixels from tumor area will be having white color in binary image. For area calculation, we find number of white pixels in image. Fig.3 shows the flowchart for tumor area calculation.

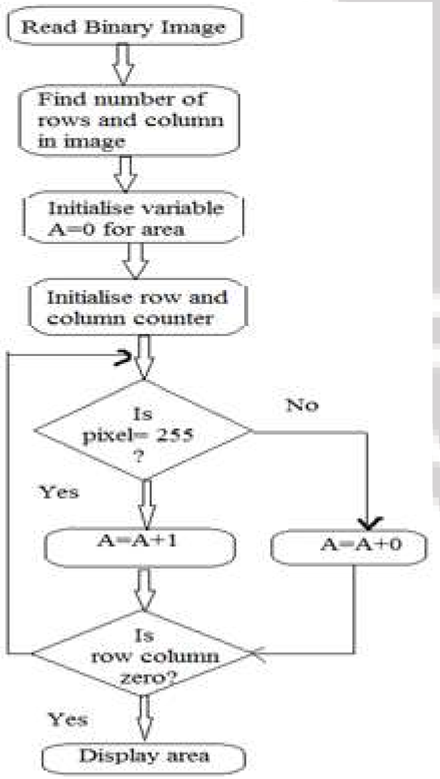


Figure 3: Flowchart for tumor area calculation

Tumor area is given as,

ar=sqrt(ar);
a=ar*0.264;

Where,
ar: number of white pixels.
a: Calculated area of tumor.
Here, first square root of number of pixels is found out. This square root value is then multiplied by 0.264. And 0.264 is area for one pixel. Table 1 consists of ranges of tumor area depending on which the final decision for type of tumor is made.

Table 1: Tumor area ranges

Tumor area range in mm²	*Tumor type*
0-6	No brain tumor.
6-11.5	Benign brain tumor.
11.5 above	Malignant brain tumor.

3.5 Database

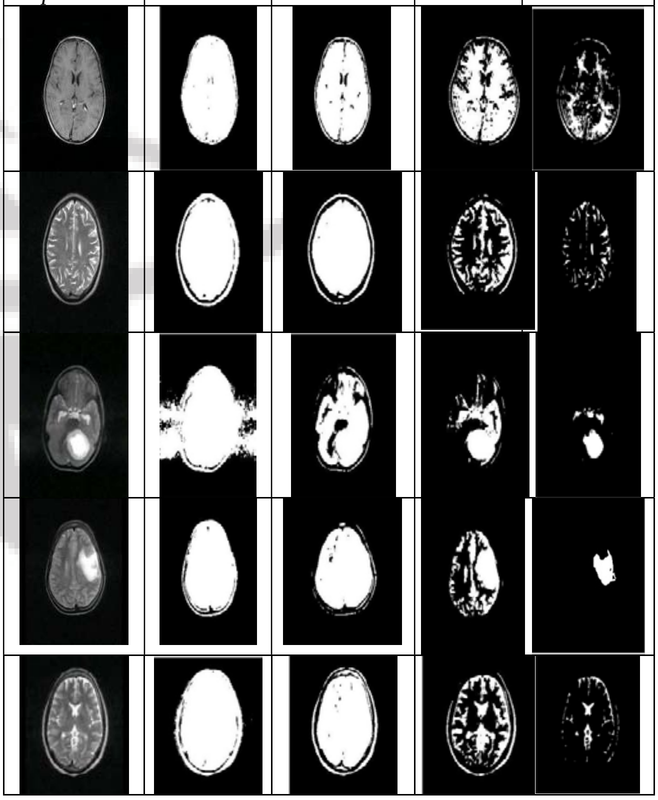
For this work, 10 MR images of 35 patients are collected from hospital. Out of which only one sample is considered for experimentation, thus here we have used total 35 sample brain MRI for experimentation. These images are of type .jpeg with fixed size 256x256. MR Images used ate T1 weighted and post contrast.

4. Experimentation

For the execution of this system, a GUI is developed in MATLAB. Execution was performed for all 35 MRI samples and different parameters were noted down. Now, firstly input MRI is divided in number of clusters. For this work, we have considered FCM clustering and 4 clusters. Table 2 gives the detailed segmentation of input images

Table 2: FCM Segmentation Results

Input MRI	*Cluster1*	*Cluster2*	*Cluster3*	*Cluster4*



For every patient, different parameters were estimated. These parameters consists of tumor area, tumor type and computation time. Table 3 gives the details of these parameters for some patients.

Table 3: Experimentation Results

Sr. No.	*Patient Name*	*Tumor Area in mm²*	*Experimental Diagnosis*	*Doctor's Opinion*	*Time In Sec.*
1	Kale	13.5	Malignant	Malignant	22
2	Keshav	11.4	Benign	Benign	33
3	Mahale	10.2	Benign	Benign	28
4	Pandit	15	Malignant	Malignant	20
5	Pralhad	11.4	Benign	Benign	20.6

4.1 Accuracy

For accuracy calculation, diagnosis result of FCM and doctor's opinions are compared. Based on this comparison, different parameters are found out. These parameters are described below:

TP: True Positive: Tumour Present and true detected.
TN: True Negative: Tumour not present and not detected.
FP: False Positive: Tumour not present and detected.
FN: False Positive: Tumour present and false detected

Then, after experimentation for 35 patients we got,

TP = 25, TN = 0, FP = 8, FN = 2
And,
Accuracy = ((TN+TP)/(TP+TN+FP+FN))
= (25+0)/ (25+0+8+2)
=0.72
Accuracy in % = 72%

5. Conclusions

In this paper, a system that can be used as a second decision for the surgeons and radiologists is proposed. In this system brain tumors have been segmented with the help of Fuzzy C means clustering and conventional global thresholding. Regarding the number of tumor pixels, Fuzzy C means gave a better result than the global thresholding. The segmentation algorithms were tested with a database of MRI brain images. For non-medical format images (.jpg), Fuzzy C means clustering achieved about 72% accuracy

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