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Machine Learning Approach for MRI Brain Tumor Detection Techniques

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ABSTRACT

Many changes and noval approaches introduce in medical science .Tumor is a deformity in human body cells which, if not detected and treated, can even lead to damage of body part. Brain tumor is one such deformity which has been located by pathologists manually from past few years. Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Positron Emission Tomography (PET) and ultra sound are techniques which used to take images of brain cells. But MRI is widely used as it is multiplanar image capturing technique. It has always been a challenging task for automatically locating tumor and computing its dimensional parameter because boundaries or edges of different tissues in MRI brain images are unclear. Even intensities of light and dark intensity pixels are inseparable in maximum cases.

For brain tumor detection, clustering techniques are widely used. There is a vast variety of imaging tools such as in which the segmentation can be utilized. So in this work, K-Means clustering and Fuzzy C-Means Clustering techniques are implemented. Also one more technique which is Histogram Thresholding is implemented. Results of all these three unsupervised techniques are implemented over a collection of brain images which are gathered from open sources. Results of tumor location of these brain images are compared for three techniques and it is found that Fuzzy C-Means clustering outperforms other two techniques.

Keyword:— *FCM, K-Means Clustering, Histogram Thresholding and Mathematical Morphology*

I. INTRODUCTION

Brain is special organ of body which controls memory and learning, senses and emotion. It also controls other parts of the body, including muscles, organs, and blood vessels. Brain tumors are diseases in which cancer cells begin to grow in the tissues of the Brain. Brain tumors are unusual masses in or on the brain which can be due to result of uncontrolled cell growth and failure cell death in a normal manner. Tumors are broadly classified into primary and secondary tumor. Primary tumors are more like brain cells. Central nervous system tumors include heterogeneous diseases that may be benign, slow-growing injury to malignancies which may even cause death. However a malignant tumor grows very fast and affects large tissues. Secondary tumors have origin somewhere else in the body which then spread in brain. They are cancer cells actually that have spread into the brain. They can be diagnosed and may be removed easily by surgery.

Image segmentation is performed to detect any desired region which may be any object or some figure in the MRI image, which can be used for recognition, editing or image compression etc. In machine learning techniques, where computer is used to segment desired part of an image from its background, there can be broadly two types of algorithm. These are unsupervised and supervised algorithms. Unsupervised Algorithms are such algorithms where no information is previously available to generate membership function of any class in image. Such unsupervised learning can be implemented by methods like clustering (e.g., k-means, fuzzy c-means clustering and hierarchical clustering) and neural network models. Supervised algorithm is task of deducing a function from training data. Such training data are input images and a desired output.

II. Literature Review

In this section various latest techniques for Bain Tumor Detection techniques are studied.

Ed-Edily et. al. proposed brain tumor detection and localization framework which comprises five steps: image acquisition, pre-processing under a median filter, edge detection by sobel edge detection, modified histogram clustering to color threshold and morphological operations.

Selkar et. al. presented the detection and segmentation of brain tumor using watershed and thresholding algorithm.

Sivaramakrishnan et. al. proposed Fuzzy C-means clustering and histogram. The Fuzzy C-means clustering algorithm finds the centroids of the cluster groups.

Dhanalakshmi et. al. described k-means clustering algorithm for detecting the range and shape of tumor in brain MR Images.

Ali et. al. preprocessed T2 weighted modality, by bilateral filter to reduce the noise and maintaining edges among the different tissues. Gray level stretching and Sobel edge detection, K-Means Clustering technique based on location and intensity, Fuzzy C-Means Clustering, and An Adapted K-Means clustering technique and Fuzzy C-Means technique are applied.

Kowar et. al. presented detection of tumor in brain using segmentation and histogram thresholding.

Selvakumar et. al. implemented method which allows the segmentation of tumor tissue with accuracy and reproducibility comparable to manual segmentation. The stage of the tumor is displayed based on the amount of area calculated from the cluster.

On the basis of problems analyzed after literature review, objectives of this research work are being defined here:

Implementation of Unsupervised Brain Tumor Segmentation techniques like Histogram Thresholding, K-Means Clustering technique and Fuzzy C-Means clustering Technique.

Applying Morphological Operations to sharpen boundary of segmented tumor portion of image.

In the next section, methodology is being proposed to tackle problem which are analyzed in this section

III. Methodology

In this section, algorithms of three different unsupervised image segmentation techniques are being proposed to detect brain tumor.

3.1 Histogram Thresholding Technique

In this technique histograms of two halves of brain images are plotted. Then symmetry between these two histograms is observed then there would be every chance of presence of any deformity or tumor in the brain image.

Step by step explanation of method is given as below:

- ***Preprocessing-*** RGB color image is first converted into gray color image
- ***Division the image-*** Gray image is then divided into two equal halves along its central axis. The column value is divided by 2. Divided images are halves of the original image.
- ***Plotting and Comparing histogram of two halves-*** A histogram is a plot between pixel and its intensity. Histograms of two halves brain images are compared to estimate the tumor.
- ***Selecting a threshold point-*** Resultant difference is selected as threshold point.
- ***Segmentation using threshold point-*** Intensity of image is compared with above calculated threshold point. If value is greater than the threshold, then its location is assigned a value 255 otherwise 0.
- ***Tumor Selection-*** The highest intensity pixel location is selected as tumor

3.2 K-Means Clustering Technique

K-Means Clustering works on the principle of clustering of each pixel according to its minimum distance with any cluster.

Step by step explanation of method is given as below:

- Assign the numbers of cluster value as *k*.
- Randomly choose the k cluster centers,
- Calculate mean or center of the cluster, such that cluster can be represented by C_a where $p=(1, 2, 3....k)$
- Calculate the distance b/w each pixel to each cluster center. It can be performed by nearest neighbor classification technique such as Euclidean Distance Calculation

$$d_{i,j} = || X_{i,j} - C_a || \qquad (1)$$

- If the distance is near to the center then move to that cluster. Otherwise move to next cluster.
- Re-estimate the center.
- Repeat the process until centroid movement stops.

3.3 Fuzzy C-Means Clustering Technique

The fuzzy clustering algorithm is an iterative clustering method which can produces an optimal *c* partition by minimizing the weighted within group sum of squared error objective function *J*

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} M_{ij}^{m} \|x_i - c_j\|^2 \qquad (2)$$

where $m > 1$, M_{ij} is membership degree of x_i in the cluster j, x_i is any d dimensional data, c_j is cluster centre such that $c_i=\{c_{i1}, c_{i2}, c_{i3}, \ldots\ldots c_{in}\}$, *c* is the number of clusters in xwith limit $2 \leq c < n$, *m* is a weighting exponent on each fuzzy membership. Cluster centre $C=[c_j]$ can be computed by

$$c_j = \frac{\sum_{i=1}^{N} M_{ij}^{m} \cdot x_i}{\sum_{i=1}^{N} M_{ij}^{m}} \qquad (3)$$

And membership matrix $M^{(k)}$ and $M^{(k+1)}$can be calculated by

$$M_{ij}^{m} = \frac{1}{\sum_{k=1}^{c}\left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|}\right)^{\frac{2}{m-1}}} \quad (4)$$

where $1 \le k \le N$ and $1 \le i \le C$

if $\{\|M_{ij}^{(K+1)} - M_{ij}^{(K)}\|\} < \varepsilon$ then iteration is stopped otherwise set $M^{(k+1)} = M^{(k)}$ and C is again calculated.

IV. Results and Discussions

Results of each algorithm are shown step by step and then tumor results of these algorithms are compared.

4.1 Histogram Thresholding Technique

Dividing Image – Gray Scale Resized image is now partitioned into two equal halves. This will be a vertical partition, with same amount of brain region in both halves.

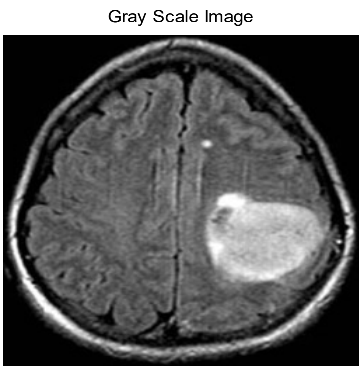

Figure 1: Resized Gray Scale Image

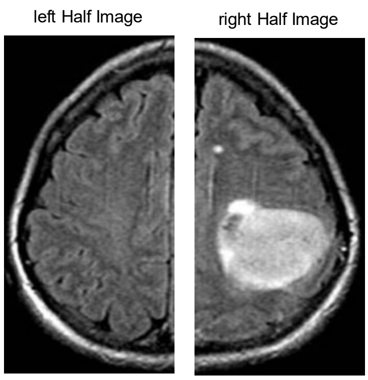

Figure 2:Partitioned Image in two halves (a) Left half, (b) Right Half

Histogram Difference- Now Figure 3 showing difference between thresholds which are calculated

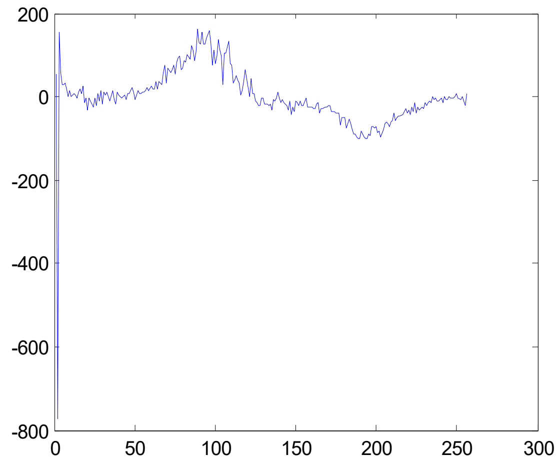

Figure 3: *Histogram Difference of Two Halves of Brain Image*

Threshold Calculation- Now that portion of image is selected as threshold which is greater that difference. This threshold will be segmented image considered for tumor portion of image. Figure 4 shows its result

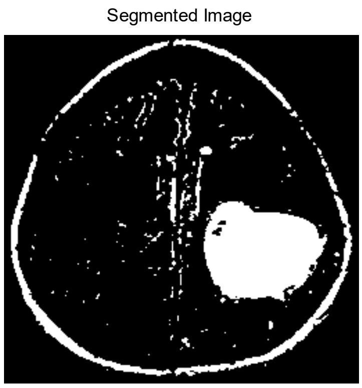

Figure 4:Threshold Image

Selecting Tumor- To select tumor region, all other light intensity region should be removed. It can be done by removing all connected components of image which are not part of tumor. So a threshold level can be defined below which these undesired components are removed. Figure 5 is selected tumor.

Tumor Region in Brain- In last step, intensity of region which is finally selected as tumor, is raised to highest intensity value and hence this region is marked in the sample brain image. Figure 6 is this image

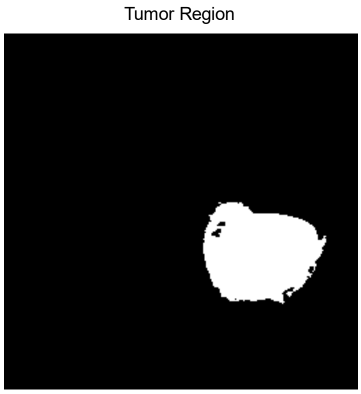

Figure ***5*** *Tumor Region of Brain*

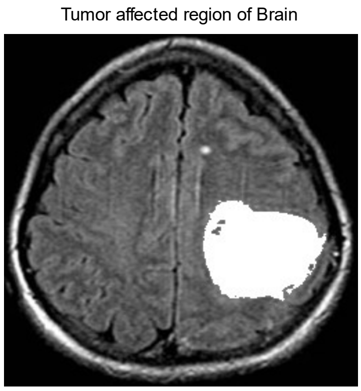

Figure ***6*** *Tumor Portion Projected in Brain by Histogram Thresholding*

4.2 K-Means Clustering Based MRI Brain Image Segmentation

K-Means Clustering – Gray scale image is then applied with K-Means clustering. Here K is number of clusters which is to be decided manually. K is taken 4 numbers. K-Means clustering calculates 4 numbers of centroid and all pixels of image are checked for distance (in terms of intensity) with these clusters. Pixel is assigned that particular cluster, with which it is nearest, i.e whose intensity matches best with that of pixel. Figure 8-10 shows 4 numbers of clusters of Figure 7 which is resized gray version of sample image

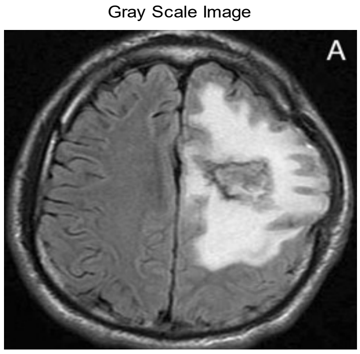

Figure ***7:*** *Resized Gray Scale Image*

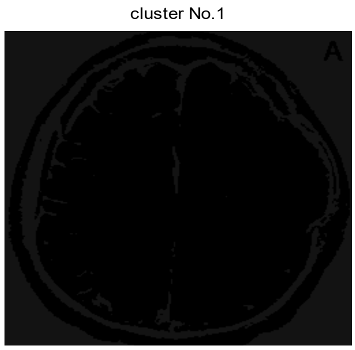

Figure 8: Cluster No. 1 with intensity Value 19.45

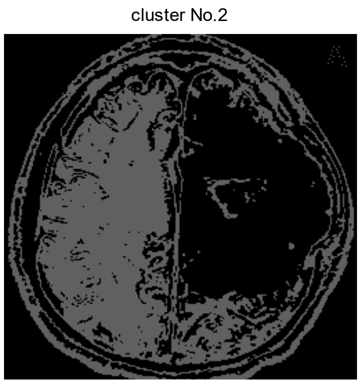

Figure 9: Cluster No. 2 with intensity Value 95.67

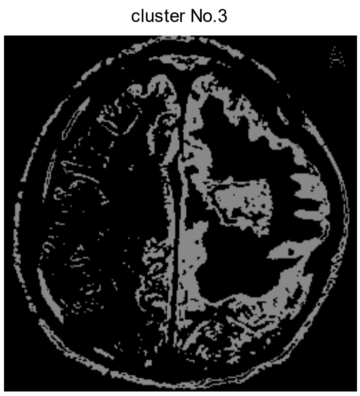

Figure 10: Cluster No. 3 with intensity Value 136.64

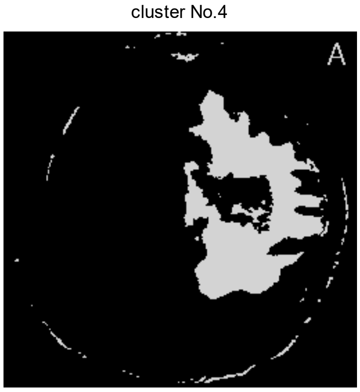

*Figure **11:** Cluster No. 4 with intensity Value 211.43*

Selecting Segmented Image- In a tumor affected brain, tumor is bright in color as compared to its surrounding. So that particular cluster is selected which is having highest intensity value among all 4. Selected cluster is shown in Figure 11

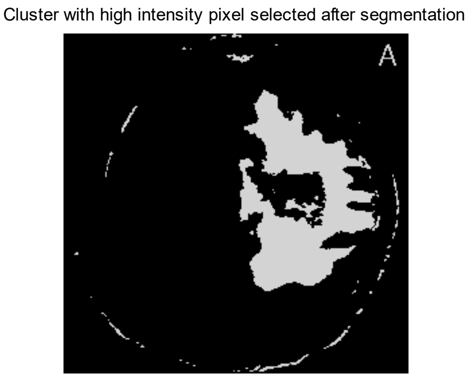

Figure 11:Selected Cluster with Tumor

Clearing Border –In the selected cluster image, it is first targeted to found out boundary of selected cluster image. Region inside boundary will be kept dark so that tumor inside it can be highlighted and region outside boundary is kept light so that that region can be removed in next step. Figure 12 is showing this particular image.

Filling Holes- In this step any small dark region, surrounded completed by lighter region, are filled, i.e they are also converted into lighter region. Figure 13 is clustered image with hole filled.

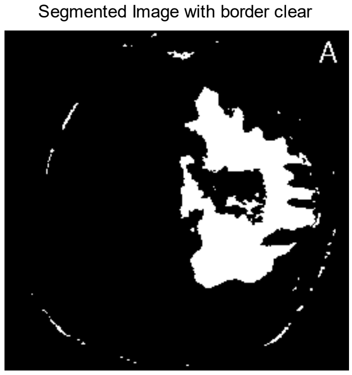

Figure 12: Border Cleared Image

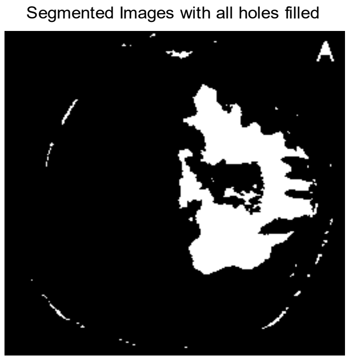

Figure 13: Image After Holes Filling

Selecting Tumor- To select tumor region, all other light intensity region should be removed. So a threshold level can be defined below which these undesired components are removed. Figure 14 is detected tumor.

Tumor Region in Brain- In last step, intensity of region which is finally selected as tumor, is raised to highest intensity value. Fig. 15 is brain image with tumor.

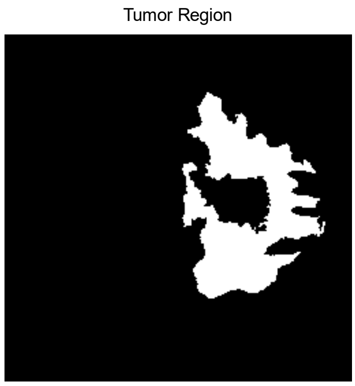

Figure 14: Tumor Region of Brain

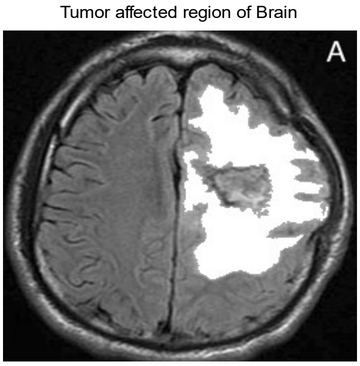

Figure 15: Tumor Portion Projected in Brain by K-Means Clustering

4.3 Fuzzy C-Means Clustering Based MRI Brain Image Segmentation

Fuzzy C-Means Clustering is a multi valued logic that allows, within the same image, intermediate components i.e., member of one fuzzy set to be member of other fuzzy sets.

Fuzzy C-Means Clustering –Here degree of membership function, dimension in which brain image will be worked upon and a positive real value greater than 1 has to be defined for membership function. Figure 17 is the clustered images after segmentation.

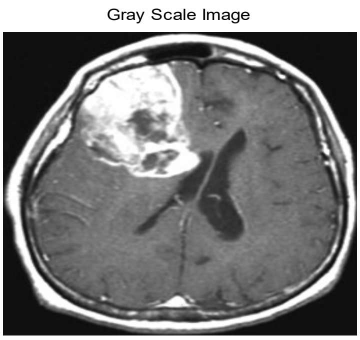

Figure 16: Resized Gray Scale Image

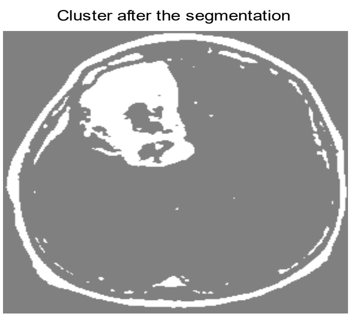

Figure 17: FCM Clustered image after segmentation

Clearing Border – In the selected cluster image, region inside boundary will be kept dark so that tumor inside it can be highlighted. Figure 18 is showing this particular image.

Filling Holes- In this step any small dark region, surrounded completed by lighter region, are filled, i.e they are also converted into lighter region. Figure 19 is showing filled hole image.

Figure 18: Border Cleared Image

Figure 19: Image After Holes Filling

Selecting Tumor- To select tumor region, a threshold level can be defined below which these undesired components are removed. Figure 20 is tumor region of this brain image.

Tumor Region in Brain- Intensity of tumor is raised to highest value and hence marked in the sample brain image. Figure 21 is brain image over which tumor is highlighted.

Tumor Region

Figure 20: Tumor Region of Brain

Tumor affected region of Brain

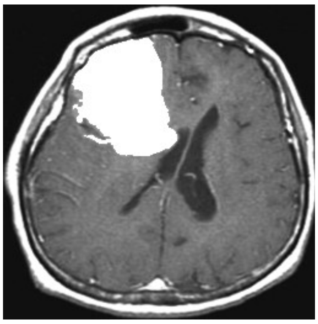

Figure 21: Tumor Portion Projected in Brain by Fuzzy C-Means Clustering

V. CONCLUSIONS

In this work, Input MRI brain image is RGB color image which is first transformed input gray-scale images and resized to 256 x 256. Then this image is separately applied with Histogram Thresholding, K-Means Clustering and Fuzzy C-Means Clustering Technique. In histogram thresholding, a brain image is partitioned into equal halves vertically and their histogram is compared for intensity of tumor in either of these two halves. In K-means clustering brain image is distributed in 4 clusters on the basis of their intensity. Tumor cluster intensity will be high which helps in selection of this particular cluster. Similarly in Fuzzy C-Means clustering, image is distributed in two clusters and then tumor cluster is selected. Tumor location in input brain image is compared for three unsupervised technique. On comparing these algorithms by applying over various brain images, it is found out that Fuzzy C-Means clustering is giving good results all the time as compared with other two works. In some brain images, Histogram Thresholding and K-Means clustering are even unable to produce any tumor image which is very clearly shown by FCM.

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