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MRI Brain Tumor Segmentation and Feature Extraction Using GLCM

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Abstract: With the increase in world population, Cancer is the growing health problem. Brain tumor is the most dangerous disease among the others. Detection of brain tumor at an early stage is important to avoid death. Brain tumor arises due to the abnormal growth of the cells that have proliferated in an uncontrolled manner. Brain tumor segmentation is one of the challenging tasks in the medical field. Detection, segmentation and extraction of features of the infected region from the Magnetic Resonance images are a primary concern but a tedious and time taking task performed by radiologists and the accuracy of segmentation depends on their experience only. So the use of computer aided technology becomes necessary to overcome these limitations. In this paper, Brain tumor is detected and segmented using fuzzy k- means clustering algorithm. Various features of the segmented tumor were analyzed using GLCM. These features can also be used for the classification of the tumor. The proposed algorithm was tested on various MR brain images with tumor.
Key Words: MRI brain image, Brain tumor detection, segmentation, Fuzzy K- means, GLCM, feature extraction.

I. INTRODUCTION

Brain tumor is an uncontrolled growth of cancerous cells in the brain. Tumor may be either malignant or benign. The benign brain tumor has uniformity in structure and does not contain active cancer cells, whereas the malignant brain tumor have a non-uniformity structure and contain active cancer cells [1].

In recent years, many algorithms have been proposed for brain MRI segmentation. The most popular methods among the segmentation methods are thresholding, region-growing and clustering. Clustering is the most popular approach for segmentation of brain MR images and typically performs better than the other methods. Clustering is one of the most useful tasks in data mining process for discovering groups and identifying interesting distributions and patterns in the underlying data. Clustering problem is about dividing or partitioning a given data set into groups (clusters) such that the data points in a cluster are more similar to each other than points in different clusters [2]. In this paper, one of the clustering algorithm Fuzzy K-Means with Otsu thresholding method was implemented to segment the tumor from the MRI brain image and features of the segmented tumor is extracted using Gray Level Cooccurance Matrix (GLCM).

II. RELATED WORKS

Bhavana Ghotekar et al., proposed an approach for tumor detection and classification using SVM. They extracted fourteen features of the image and those features were fed as the input to the SVM classifier for the classification of the tumor [3].

Siva Sankari et al., presented Fuzzy k-means clustering algorithm for brain tumor segmentation and features were extracted using GLCM and Gabor feature extraction techniques [4].

Priyanka et al., proposed methods of edge detection. Among them they found that sobel method of edge detection is more suitable [5].

Anjum Sheikh et al., presented an approach for segmentation of brain tumor using Ant Colony Optimization. They discussed the energy efficiency of the algorithm with respect to transmission, execution time and energy cost [6].

Vishnumurthy et al., they proposed morphological techniques for the segmentation of MRI brain images and compared the result with Maximum expectation technique and Fuzzy C-Means with reference to performance measures and processing time [7].

III. PROPOSED METHOD

The system architecture of the proposed MRI brain tumor segmentation and feature extraction using GLCM is as shown below.

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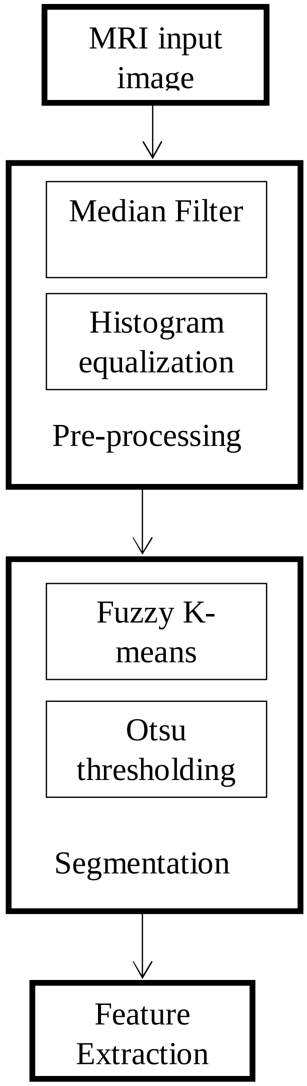

Figure 1: System architecture

A. *Pre-processing*

Pre-processing contains two sub divisions. One is the filtering and other is the image enhancing section. The main objectives of pre-processing are the suppression of redundant and irrelevant data before process into an application [8]. Median filter is used for smoothing and removing the noise from image. The median filter is often using to perform noise reduction in an image. It preserves the edges of the image while removing the noise. Image enhancement is the process of adjusting the images so that it is more suitable for further analysis. In the proposed method adaptive histogram equalization was done to enhance the contrast of the image.

B. *Segmentation*

1) *K-Means clustering algorithm:*K-Means is the simple unsupervised learning algorithm for clusters. Clustering the image is grouping the pixels according to some features [9]. In K-means 'K' centers are defined, one for each cluster. These clusters must be placed far away from each other. The next step is to take a point fit in to a given data set and associates it to the nearest center. When no point is pending, the first step is completed and early grouping is done. In the second step, recalculate 'k' new centroids as barycenter of the clusters resulting from the previous step. After having 'K' new centroids a new binding has to be done between the same data set points and the nearest new center. A loop has been generated. Due to this loop, the k centers change their location until centers do not move any more [8]. This algorithm aims at minimizing an objective function given by,

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

Where,

$||x_i^{(j)} - c_j||^2$ is the Euclidean distance between x_i and v_j

'n' is the number of data points in the ith cluster.

'k' is the number of cluster centers.

Algorithmic steps for K-means clustering:

Let X = {x1, x2, x3, ...xn}be the set of data points and V = { v1, v2, v3, ...vc }be the set of centers.

Step1: Randomly select 'c' cluster centers.

Step2: Calculate the distance between each data point and cluster centers.

Step3: Allocate the data point to the cluster center whose distance from the cluster center is a minimum of all the cluster centers.

Step4: Recalculate the new cluster center using

$$V_j = \frac{1}{n} \sum_{j=1}^{n} x_i$$

Step5: Recalculate the distance between each data point and newly obtained cluster centers.

Step6: If no data point was reallocated then stop, otherwise repeat from step 3.

C. Otsu Thresholding Method

In the proposed method along with k-means clustering method Otsu segmentation is also used to improve the segmentation region. Otsu is a threshold segmentation method binarized the image broadly into two classes based on the pre-determined threshold. The Otsu method tries to find a single threshold for the whole image.

IV. FEATURE EXTRACTION

Features of the image were extracted using the Gray Level Cooccurance Matrix (GLCM). In this feature extraction technique, initially GLCM of the image was calculated then the features based on the GLCM were extracted. The extracted features include contrast, correlation, energy, homogeneity, mean, standard deviation, entropy, skewness, kurtosis, inverse difference moment.

A. Contrast (C_{on})

It is the measure of intensity of a pixel and its neighbour over the image and is defined as

$$C_{on} = \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} (x-y)^2 f(x,y)$$

B. Correlation (C_{orr})

It describes the spatial dependencies between the pixels and it is defined as

$$C_{orr} = \frac{\sum_{x=0}^{m-1} \sum_{y=0}^{n-1} (x,y) f(x,y) - M_x M_y}{\sigma_x \sigma_y}$$

where M_x and σ_x are the mean and standard deviation in the horizontal spatial domain and M_y and σ_y are the mean and standard deviation in the vertical spatial domain.

C. Energy (En)

Energy can be defined as the quantifiable amount of the extent of pixels of pair repetitions. It is a parameter to measure the similarity of an image. It is the sum of squared elements in GLCM. If energy is designed by Haralicks GLCM feature, then it is also referred to as angular momentum, and is defined as

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$$\text{En} = \sqrt{\sum_{x=0}^{m-1}\sum_{y=0}^{n-1} f^2(x,y)}$$

D. Homogeneity

Homogeneity returns a value that measures the closeness of the distribution of elements in the GLCM to GLCM diagonal.

E. Mean (M)

The mean of an image is calculated by adding all the pixel values of an image divided by the total number of pixels in an image

$$\text{M} = \frac{1}{m\ x\ n}\sum_{x=0}^{m-1}\sum_{y=0}^{n=1} f(x,y)$$

F. Standard Deviation (SD)

The standard deviation is the second central moment describing probability distribution of an observed population and can serve as a measure of inhomogeneity.

$$\text{SD}\ (\sigma) = \frac{1}{m\ x\ n}\sum_{x=0}^{m-1}\sum_{y=0}^{n=1}(f(x,y) - M)^2$$

G. Skewness (S_k)

Skewness is a measure of symmetry or the lack of symmetry.

$$S_k(X) = \frac{1}{m\ x\ n}\frac{\sum(f(x,y) - M)^3}{SD^3}$$

H. Kurtosis (K_{urt})

The shape of a random variable’s probability distribution is described by the parameter called Kurtosis.

$$K_{urt}(X) = \frac{1}{m\ x\ n}\frac{\sum(f(x,y) - M)^4}{SD^4}$$

I. Inverse Difference Moment (IDM)

It is a measure of the local homogeneity of an image.

$$\text{IDM} = \sum_{x=0}^{m-1}\sum_{y=0}^{n=1}\frac{1}{1+(x-y)^2} f(x,y)$$

The following quality assessment parameters were also analysed to ensure the result analysis of the MRI brain image.

J. Mean square Error (MSE

It is a measure of signal fidelity or image fidelity.

Peak Signal to Noise Ratio (PSNR): It is the measure used to assess the quality of reconstruction of processed image.

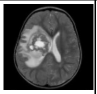
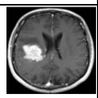
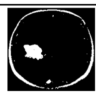
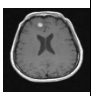
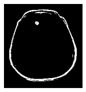
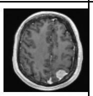
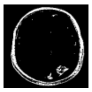
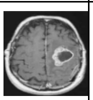
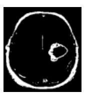
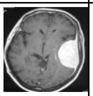
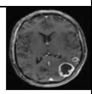
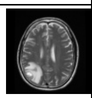
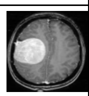
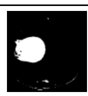
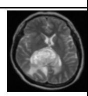
Structural Similarity Index Map (SSIM):

It is a perceptual metric that signifies that the degradation in image quality may be caused by data compression or losses in data transmission or by any other means of image processing.

V. EXPERIMENTAL RESULTS

Table1: The extracted feature values of the segmented regions

S. No.	Original image	Segmented image	Contrast	Correlation	Energy	Homogeneity	Mean	Standard Deviation	Entropy	Skewness	Kurtosis	Inverse Difference Moment

1.			0.0159	0.8577	0.8528	0.9921	0.0590	0.2357	0.3236	3.7424	15.0055	114.8550
2.			0.0207	0. 8753	0.8140	0.9897	0.0908	0.2873	0.4391	2.8485	9.1140	19.5593
3.			0.0173	0.7582	0.9112	0.9913	0.0371	0.1890	0.2288	4.8993	25.0027	17.0156
4.			0.0367	0.7719	0.8039	0.9817	0.0877	0.2829	0.4288	2.9146	9.4951	31.1006
5.			0.0371	0.8409	0.7308	0.9814	0.1390	0.3460	0.5816	2.0869	5.3553	105.2227
6.			0.0305	0.8577	0.7561	0.9843	0.1215	0.3267	0.5336	2.3171	6.3691	152.1472
7.			0.0071	0.7448	0.9649	0.9964	0.0141	0.1180	0.1071	8.2333	68.7876	0.0819
8.			0.0170	0.7525	0.9147	0.9915	0.0354	0.1848	0.2209	5.0272	26.2728	23.9167
9.			0.0053	0.9671	0.8346	0.9974	0.0874	0.2824	0.4278	2.9215	9.5351	115.2553
10.			0.0103	0.7914	0.9409	0.9948	0.0269	0.1619	0.1788	5.8445	35.1586	64.2902

VI. CONCLUSION

In this paper, an approach based on fuzzy k-means with Otsu thresholding method was used for the segmentation of the brain tumor from the MRI brain image and various features were extracted using the Gray Level Cooccurance Matrix (GLCM) was implemented. The proposed method was tested on various MRI brain images with tumor. Figure:1 shows the system architecture of the proposed system. Table:1 shows the extracted feature values of the segmented regions. In future, extracted features can be used for the classification of the tumors.

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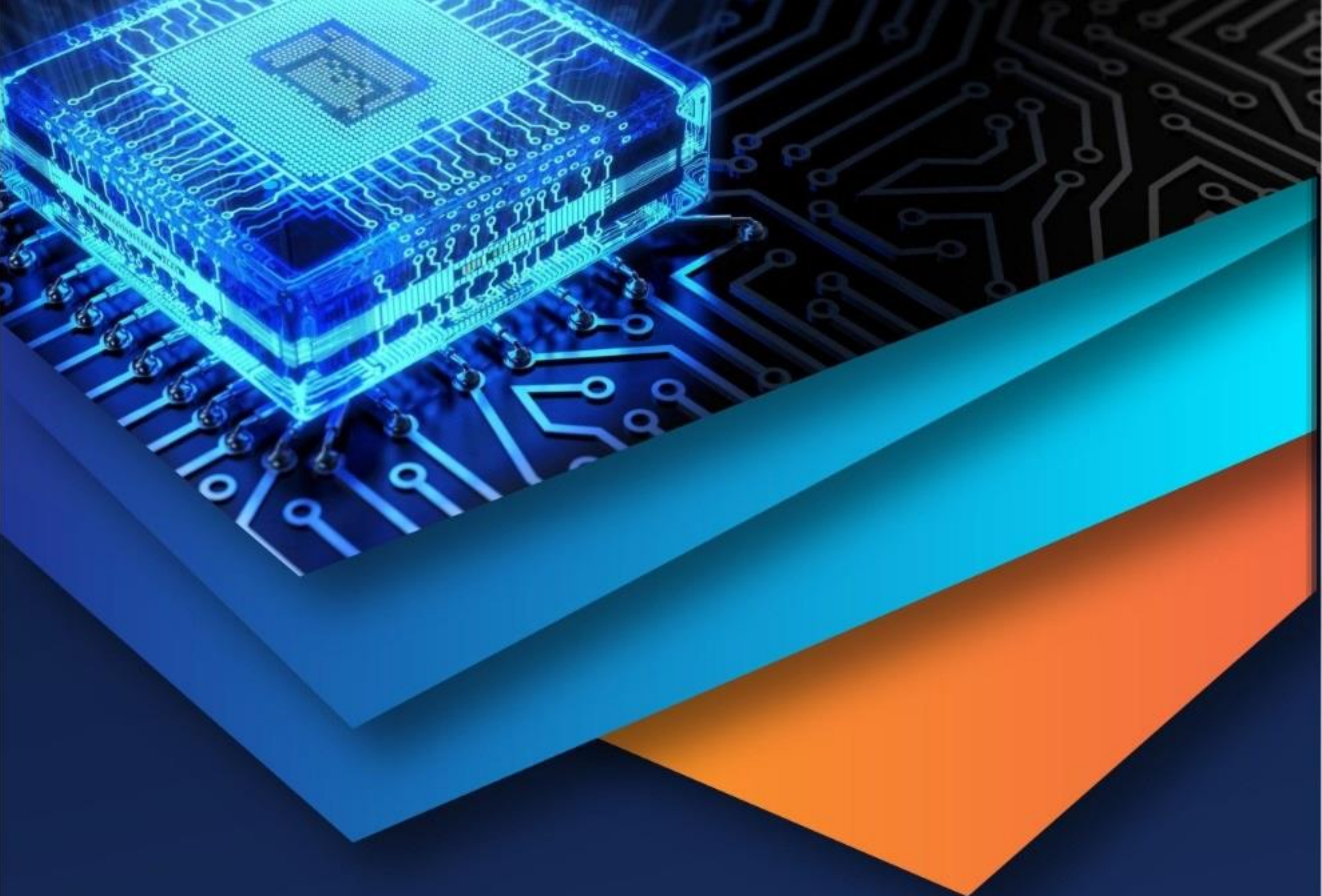

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