Selective Brain MRI Image Segmentation using Fuzzy C Mean Clustering Algorithm for Tumor Detection

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ABSTRACT
Brain MRI (Magnetic Resonance Imaging)[1] images are used to diagnose any abnormality associated with human brain by the physicians. But these images are often corrupted with noise which makes it difficult to diagnose any abnormality in initial stage of defect. Image processing techniques like image segmentation is used to extract important information out of noisy MRI images. But image segmentation process will also remove original minute details available in original image apart from noise because entire image will be clustered into few segments of same pixel intensity. In this paper a selective brain MRI image segmentation is proposed based on Fuzzy C Mean (FCM) Clustering algorithm [2] with image pixel weightage to retain necessary original image details intact.

General Terms
MRI, Brain Tumor[3], Image Segmentation, Clustering, Weightage, Pixel Intensity, CAT scan.

Keywords
K-Mean, membership matrix, Cluster center, Objective function.

1. INTRODUCTION
Brain tumor medically termed as Intracranial Neoplasm referring to a condition of abnormal cells growth in the brain. Brain Tumor can mainly of two types a) malignant (cancerous) tumor and b) benign tumor. Initial symptoms could be headaches, nausea, vision problem, seizures, behavior change etc. and if left unnoticed for long may leads to sudden unconsciousness. Proper diagnosis of Brain tumor in early stage is very important to start proper treatment to the patient which in turn safe patient's life.

MRI consider as the prime diagnostic tool available for brain tumor detection. The interruption of BBB (Blood Brain Barrier)[4] caused because of brain tumor or lesion can be detected by MRI as many traces (MRI Contrast Agents) like Gadolinium can very easy reach brain tumor or lesion region.

With proper image processing techniques or algorithm applied on MRI image helps to capture relevant detailed information for a physician. Which could make possible for early detection of brain tumor otherwise would be difficult to decide.

2. MRI
MRI is a powerful noninvasive medical imaging diagnostic tool for evaluating soft tissue body organs, blood vessels, nodes. MR imaging technique does not involve in any kind of radiation emission as compared to CAT (Computerized Axial Tomography) Scan[5]. MRI is based on the principle of nuclear Magnetic Resonance. MRI image is formed of the detected radio signal emitted by the hydrogen atoms present in human body organ under magnetic resonance.

MRI sequencing results in a set of particular appearance images contrasting brain matters. This is be obtained by changing MRI pulse sequence. The parameters mainly defining a pulse sequence are 1) Time to Echo (TE) 2) Flip angle 3) Inversion Pulse 4) Time to Repetition (TR) 5) Echo Train Length (ETL). Different standard brain MRI sequences are:

1) T1 weighted Sequences – grey matter appears as grey and white matter appears as white-ish.
2) T2 weighted Sequences – grey matter appears as grey and white matter appears as dark-ish.
3) PD (Proton Density)[6] Sequences – grey matter appears as white-ish and white matter appears as dark-ish.

MRI images are further subjected to image processing techniques for better contrast and noise reduction, which helps physicians in diagnosis.

3. DIGITAL IMAGE SEGMENTATION
Digital Image or Image Segmentation[7] is the process of converting a digital image entirely into sets of segments (or group). Segmented image will give more meaningful information compare to original image and make analysis easier. Application of image segmentation finds in medical imaging, face detection, object detection, satellite imaging etc.

Many algorithm are employed to perform image segmentation.

a) Thresholding method.
b) Clustering – K – mean[8] or Fuzzy C Mean clustering.
c) Edge detection method.[9]
d) Regional Growth method.
e) Graph Partitioning method.

This paper will discuss about Fuzzy C Mean cluster method for image segmentation.

3.1 Fuzzy C Mean (FCM) Clustering Algorithm
Fuzzy C mean algorithm is developed by Dunn in 1973 under the concept of data mining. This is an iterative optimization method[10] to find the center values for input data around which input data can be segmented into different clusters. Each input data sample shows some affinity towards every

cluster based on its membership value varying from 0 to 1. Then the input data samples are binned into different clusters depends upon its membership values. Input data sample having more membership value to a particular cluster will fall in that cluster and replace its value with the center value of that particular cluster.

The algorithm is composed of the following steps:

1. Get input data array x.

   x_i is the data element in array x.

   i is size of array x containing data.

2. Initialise $U^{(k)}$, ($U^{(0)}$) = $[u_{ij}]$ matrix with random value.

   U(k) is the membership matrix of size i x j

   i is size number of input data element.

   j is the number of cluster required.

   k is iteration cycle number starting from zero.

   u_{ij} is the

3. Calculate the centers vectors $C^{(k)} = [C_j]$ with $U^{(k)}$

$$C_j = \frac{\sum_{i=1}^{N} u_{ij}^m x_i}{\sum_{i=1}^{N} u_{ij}^m}$$

   Where m = 2, is fuzzification degree,

   c_j is the center of the cluster

4. Update, $U^{(k)}$, $U^{(k-1)}$

$$u_{ij} = \frac{1}{\sum_{k-1}^{c} \left(\frac{||x_i - c_j||}{||x_i - c_k||}\right) \left(\frac{||x_i - c_j||}{||x_i - c_j||}\right)}$$

5. If $\| U^{(k+1)} - U^{(k)} \| < \varepsilon$ then exit; otherwise goto to step 3 with k = k+1.

   ε is the constant value (ε = 0.0001)

3.2 Image segmentation with FCM

An digital image is represented by a 2-D array matrix contain its pixel intensity as its element. Let a gray image ***I*** of size p x q pixels.

I(p,q) = pixel intensity value of *pth* row and *qth* col pixel.

Steps involved for image segmentation using FCM algorithm:

1. Convert 2-D ***I*** matrix to Row Vector ***D*** (1-D array)
2. Apply FCM clustering algorithm upon ***D*** with specified number segments required ***N***.
3. Replace ***D*** elements values with corresponding Center values according to the membership matrix.
4. Now ***D*** is a segmented vector. Convert back ***D*** into 2-D matrix ***S***.
5. ***S*** will the segmented image.

If compare with the original image ***I***, the segmented image ***S*** looks multiple partitioning of original image ***I.***

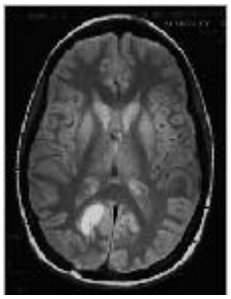


Figure:1 Original Brain MRI Image *I*

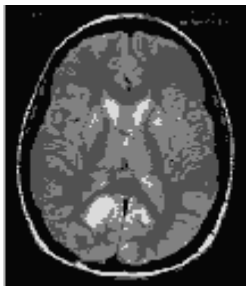


Figure:2 Segmented MRI Image *S*

4. MRI IMAGE SELECTIVE SEGMENTATION

Segmented MRI image ***S*** is the multiple segmentation of original image ***I*** with homogenous value of each segment. This highlights different brain matter present with in the image. But detailing of the original image is lost.

The idea is to keep the details available in the original image as good as possible and at the same time enhancing the desired image segment. This can be done by generating multiple (number of cluster required) segmented image which contains its selected center pixel values only and later to perform weightage image addition with original image.

Let number of segmentation required = ***N***

Therefore ***N*** number of segmented images will be generated $\boldsymbol{M}_{1,2,\ldots N}$ with same dimension of ***I***

$\boldsymbol{M}_j$ will contains segment only having pixel value with corresponding center value $\boldsymbol{C}_j$.

The selectively segmented images S1,2,…N (Output images) will be a weightage function of $\boldsymbol{M}_j$ and orginal image ***I.***

$$S_j = \mathbf{a} M_j + \mathbf{b} I \quad {\scriptstyle j = 1 \text{ to } N}$$

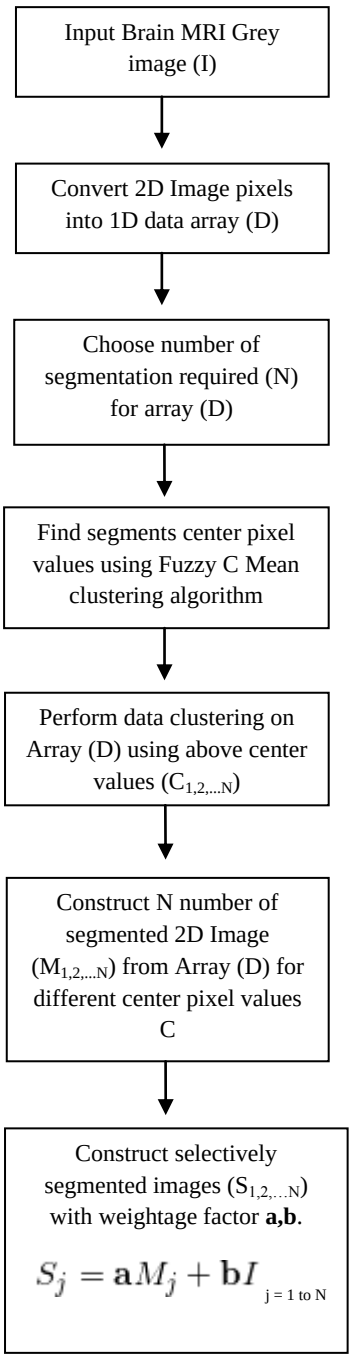
a , b are the weightage tuning parameter**.** Value for **a , b** lies between 0 to 1**.**

5. MATLAB IMPLEMENTATION

The MRI image taken for simulation in Matlab is of size 157 x 196 pixels. Number of required cluster ***N*** = 4.

Taken value for **a** = 0.5 and **b** = 0.8.

Output Selectively Segmented Images will be S_1, S_2, S_3,S_4



From Fuzzy C Mean clustering the center values (pixel values) $\boldsymbol{C}_j$ (j = 1 to 4) are: C_1 = 218, C_2 = 128, C_3 = 6, C_4 = 81.

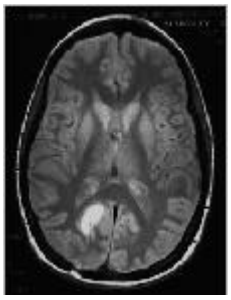


Figure:3 Original Brain MRI Image ***I***

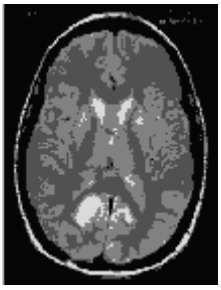


Figure:4 Segmented MRI Image ***S***

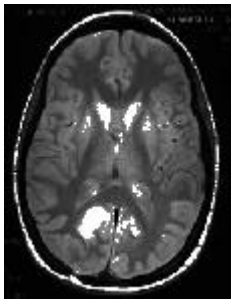


Figure:5 S_1 **Image**

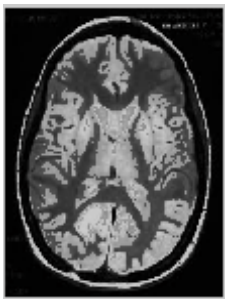


Figure:6 S_2 **image**

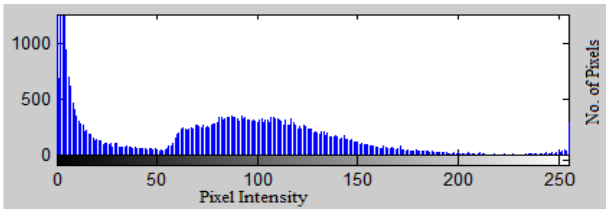


Figure:7 Original MRI Image *I* Histogram

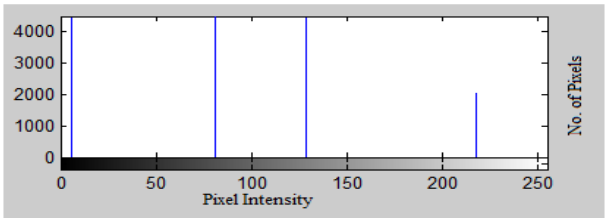


Figure:8 Segmented Image *S* Histogram

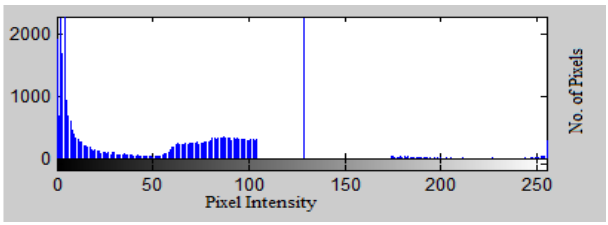


Figure:9 Selectively Segmented Image S_2 Histogram

A digital gray image can only contain 256 levels of pixel intensity ranging in between 0 to 255. The original MRI ***I*** contain all the possible 256 pixel intensity levels ranging from 0 to 255. But the FCM segmented image ***S*** contains only 4 pixel intensity levels (center values $\boldsymbol{C_1}$ = 218, $\boldsymbol{C_2}$ = 128, $\boldsymbol{C_3}$ = 6, $\boldsymbol{C_4}$ = 81) which reducing richness of the image. While selectively segmented images S_1, S_2, S_3, S_4 contain more pixel intensity levels which result in better correlation with original MRI image I.

Table 1. Table showing degree of Correlation of segmented images with original MRI image *I*

Images	**No. of Pixel Intensity Levels**	**ρ Correlation Coefficient[11] with Original MRI Image *I***
Original MRI Image *I*	256	1.0000
FCM Segmented Image	4	0.9713

S		
Selectively Segmented S_1	175	0.9949
Selectively Segmented S_2	188	0.9895
Selectively Segmented S_3	213	0.9955
Selectively Segmented S_4	196	0.9917

6. CONCLUSION

It is predominantly visible the abnormal area of brain in selective segmentation image S_1 also retain the information available in the original image I evident in high correlation coefficient value. Same Segmentation approach can be used to find defects in X-Ray images for industrial or medical application. In this paper FCM cluster method is used for initial segmentation of image and finding center pixel values. A best clustering algorithm like Particle Swan Optimization (PSO)[12] can be used to overcome local maxima, minima issue in FCM algorithm.

7. REFERENCES

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