

Advanced Algorithm for Brain Segmentation using Fuzzy to Localize Cancer and Epilepsy Region

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Abstract— The research which addresses the diseases of the brain in the field of the vision by computer is one of the challenges in recent times in medicine, the engineers and researchers recently launched challenges to carry out innovations of technology pointed in imagery. This paper focuses on a new algorithm for brain segmentation of color images based on fuzzy classification to diagnose accurately the region of cancer and the area of epilepsy. In a first step it proceeds by a fine segmentation using the algorithm of fuzzy c-means (FCM). It then applies a test fusion of fuzzy classes. The result is a coarse segmentation, where each region is the union of elementary regions grown from FCM. The fuzzy C-Means (FCM) clustering is an iterative partitioning method that produces optimal c-partitions. The standard FCM algorithm takes a long time to partition a large data set. The proposed FCM program must read the entire data set into a memory for processing. Our results show that the system performance is robust to different types of images.

Keywords— Brain Segmentation, Classification, FCM, Merge regions, Epilepsy Optimal c-partitions.

I. INTRODUCTION

Brain tumor is an abnormal mass of tissue in which cells grow and multiply uncontrollably, seemingly unchecked by the mechanisms that control normal cells. Brain tumors can be primary or metastatic, and either malignant or benign. A metastatic brain tumor is a cancer that has spread from elsewhere in the body to the brain [1].

Epilepsy is a brain disorder in which clusters of nerve cells, or neurons, in the brain sometimes signal abnormally. Neurons normally generate electrochemical impulses that act on other neurons, glands, and muscles to produce human thoughts, feelings, and actions. In epilepsy, the normal pattern of neuronal activity becomes disturbed, causing strange sensations, emotions, and behavior, or sometimes convulsions, muscle spasms, and loss of consciousness [2].

Image segmentation was, is, and will be a major research topic for many image processing researchers. The reasons are obvious and applications countless. Most computer vision and image analysis problems require a segmentation stage in order to detect objects or divide the image into

regions, which can be considered homogeneous according to a given criterion, such as color, motion, texture, etc [3, 4].

It's necessary to adjust computer vision to human vision. When we are segmenting images, segmented by people to try to replace them with computers to help them in segmentation of images. Typical application is in medicine, e.g. segmentation of MRI images and dermatological images.

In this paper we used fuzzy c-means clustering method as a pre-processing method for basic region growing in segmentation. The basic difference from other approaches is extension of feature space, which results in better segmentation.

For test images we used five RGB color images. These images were firstly converted into $L^*u^*v^*$ color space [5, 6]. Fuzzy c-means method was applied to the converted images with extended feature space. Segmentation method based on region growing was applied at the end of segmentation process. The same method was used in [4, 5, 6]. It was used with simple defuzzification rule, the method was enhanced with thresholding parameter T , in [8] it was used with another defuzzification rule. The results were obtained by experimental simulations in Matlab.

The image segmentation is used to create a partition image in homogeneous subsets called regions according to some criterion [6]. In the case of segmenting a color image, the features used are the components of color pixels. Generally the methods of segmentation are in two approaches [5]: Contour approach and Region approach.

The two approaches are complementary [9,10,11,12,13], and none has proven its superiority over the other, each has advantages and application areas. The contour extraction usually has the advantage [14] of providing contour well located and works well when the zones on both sides of the contour have different average intensities.

The methods that extract regions are unclear on the contours. In approaches that extract regions, classification methods are widely used.

They are used to define a partition of color space [15], and do not take into account the spatial arrangement of pixels. In the data space, regions can be regarded as areas of high density separated by regions of low density.

II. RELATED WORK

A. The algorithm of fuzzy c-means (FCM)

The algorithm of fuzzy c-means (fuzzy c-means) is a classification algorithm based on fuzzy optimization of a quadratic criterion of classification where each class is represented by its center of gravity.

The algorithm requires knowing the number of classes in advance and generates classes through an iterative process minimizing an objective function. Thus, it provides a fuzzy partition of the image by giving each pixel a degree of belonging to a given region.

The algorithm uses all pixels $\Delta = \{x_1, x_2, \dots, x_n\}$ is a vector of three components (eg. RGB), and the number of region c . The values of the degrees of membership are grouped in a matrix $U = [U_{ik}]$ for $1 \leq i \leq n, 1 \leq k \leq c$ where U_{ik} means the membership degree of pixel i to class k .

To get a good partition, it requires elements of U the following constraints:

$$U_{ik} \in [0, 1]$$

$$\sum_k U_{ik} = 1, \text{ and } \forall i$$

In this work the robust and fast segmentation of the image color, the FCM algorithm is changing the partition (U matrix) by minimizing the following objective function:

$$J_m(U, C) = \sum_i \sum_k (u_{ik})^m \cdot \|x_i - c_k\|^2 \quad (1)$$

Where $m > 1$ is a parameter controlling the degree of fuzzy (generally $m = 2$);

c_k : the center of Class k .

B. The FCM algorithm

1. Choose the number of classes: c // a priori information, supervised algorithm.

2. Initializes the matrix U , and centers c_k (random initialization)

3. Changing the partition matrix and the two centers following equations.

$$u_{ik} = 1 / (\sum_{j=1, c} (d_{ik} / d_{ij})^{(2/(m-1))}), // \text{ for the degrees of belonging} \quad (2)$$

$$\text{Where: } d_{ij} = \|x_i - c_j\|$$

$$c_k = (\sum_i (u_{ik})^m \cdot x_i) / \sum_i (u_{ik})^m, // \text{ for the centers} \quad (3)$$

$$4. \text{ Test of experimentation } |J^{(t+1)} - J^{(t)}| < \text{threshold}$$

III. PROBLEM SOLVING

In this section we illustrate a different method used by fuzzy FCM and analysis to solve the problem.

Most classification methods used, including FCM, suffer from two defects [3]:

1. The number of clusters must be provided in advance (supervised algorithms).

2. Each region is characterized by a center, and the membership degrees are calculated involving the Euclidean distance from which a form necessarily hyper-spherical.

- Criterion fusion: fuzzy compactness criterion and overlapping classes.

Intuitively, two regions should be merged if they are close (in the color space), and if their union is a homogenous region. To do this, we identified two known quantities: overlapping and compactness.

- Cardinal, meeting (union), and intersection of fuzzy sets:

Let A , and B be two sets of fuzzy membership functions f_A and f_B respectively. We can extend the notions of cardinal meeting and the intersection of fuzzy sets "naturally" using the membership functions by:

$$\text{Cardinal: } \text{Card}(A) = \sum_x f_A(x)$$

$$\text{Intersection: } f_{(A \cap B)}(x) = \text{Min}(f_A(x), f_B(x))$$

$$\text{Reunion: } f_{(A \cup B)}(x) = \text{Max}(f_A(x), f_B(x))$$

- Overlap of two classes:

$$O_{ij}(c_1, c_2) = \frac{\text{card}(c_1 \cap c_2)}{\text{card}(c_1 \cup c_2)} \quad (4)$$

Disjoint classes $\leftarrow 0 \leq O_{ij} \leq 1 \rightarrow$ (classify completely confused)

Compactness of a class:

$$C = K_1 U K_2 U \dots \dots U K_p. \quad (5)$$

The compactness of a class is defined as the average of overlap between its elementary components.

$$CP(C) = (1/p) \cdot \sum_i \text{Min}_{j \neq i} (O_{ij}) \quad (6)$$

Classifying compacts, $\leftarrow 0 \leq CP \leq 1 \rightarrow$ (classify compacts).

-The average compact between two clusters:

The average compactness of two classes C_1 and C_2 is the average compactness of individual weighted by the Cardinals.

$$CP_{12} = (Card(C_1).CP_1 + Card(C_2).CP_2) / (Card(C_1) + Card(C_2)) \quad (7)$$

Fusion Rule:

Consider two classes C_i and C_j , $\alpha \in [0,1]$ threshold to choose

$$\text{If: } O_{ij} > \alpha.CP_{ij} .$$

Then to amalgamate C_i and C_j ,

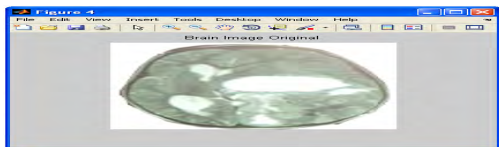
It merges with two classes, considering that their overlap is quite high compared to the threshold dependent on natural classes in question.

Fewer classes are compact, if they are less demanding than the threshold of fusion, and tend to merge and vice versa.

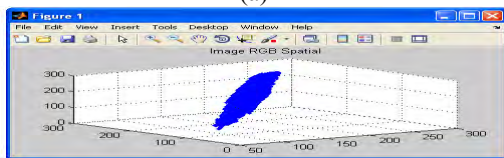
IV. RESULTS AND DISCUSSION

We have shown our experimentation with the Method used by fast segmentation of the color Image using fuzzy classification C-means to perform the matrix calculations. The images were read into the Matlab command window and converted successfully to matrices representations. The parameters below allowed succeeding the following results:

- The number of unique pixel 15855; -giving time of elimination redundancy: 0.34
 - The time of Fuzzy: 1.657; - number of Fuzzy after cluster is FCM: 3
 - The number of clusters after the melting stage: 3
- Fig1 (a, b, c, d) show under mentioned illustration:



(a)



(b)

(a)Original Image;(b)-Image RGB Spatial;(c)-Image after fusion with alpha=0.2; (d)-data after fcm 3class

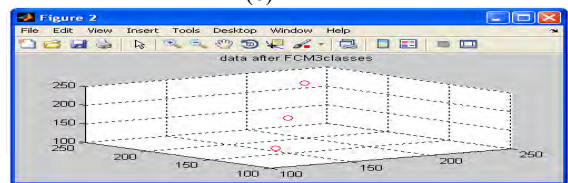
-The figure1(c) represents the initial segmentation in figure1 (a) and obtained after the melting step for alpha=0.2.

The merger, by reducing the number of regions, yields a good segmentation for the homogenous regions. It is best visualized in the color space figure1(b), and figure 1(d)

-We have experimented with other images, the first observation we can remark is the number of regions of the final segmentation increases with alpha. This is quite normal for small tolerate fusion, and therefore the number of initial classes form the alpha threshold FCM decreases. The figure2(b) yellow color and red color represent the repartition of pixel in homogenous regions. The figure2(c)



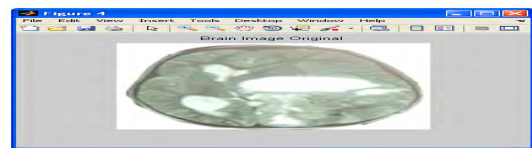
(c)



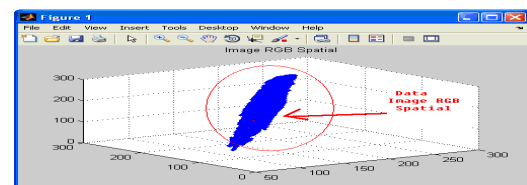
(d)

and figure2 (d) respectively image after fusion with alpha=0.2 and data after FCM 3classes.

Fig2 (a, b, c, d) show mentioned illustration:



(a)

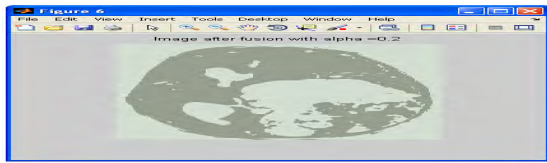


(b)

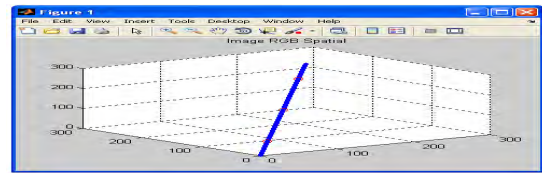
Fig2(a)-Original Image; (b)-Image RGB Spatial; (c)- Image after fusion with alpha=0.2; (d)-data after fcm 3class.

The number of clustering show that the repartition of pixel follow the number of region dominate by color homogeneous.

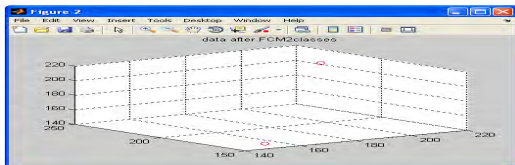
We can remark when the number of classes increases, respectively the fig3 (b and c) illustrate the number of cluster



(c)



(b)



(d)

The numbers of clustering shows the repartition of pixel

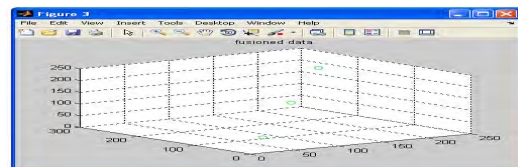
We can observe the effect of the merger on figure2(b) and figure2(c), where the merger eliminated the uncertainty around the image, giving classes more precise and distinct.

Segmentation of anatomical structures is a critical task in medical image processing, with a large range of applications going from visualization to diagnosis.

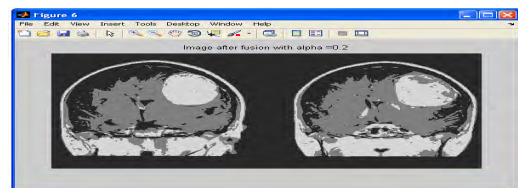
For example, to delineate structures in the mid-sagittal plane of the brain in the context of a pre-operative planning, an accurate segmentation of the hemispheres, and especially of their internal faces, is needed. In such a task, the main difficulties are the non-homogeneous intensities within the same class of tissue, and the high complexity of anatomical structures such as white and gray matter, as well as their large variability.

In this work Fig3 (a, b, c, d) show the mentioned illustration:

Fig3 : a)-Original Image; (b)-Image RGB Spatial; (c)- Represent fusionned data after FCM =3 classes, and (d)- Image after fusion with alpha=0.2

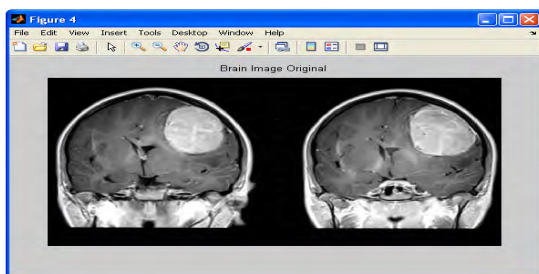


(c)

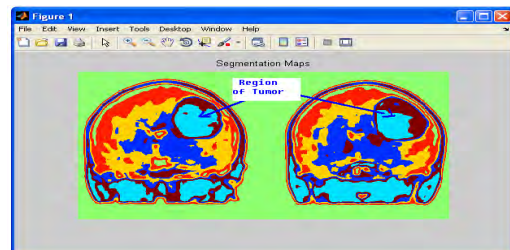


(d)

follow the number of region dominated by color homogeneous. When we increase the parameter, the fusionned data, the distribution Gaussian realize follow the dominate of RGB color in the different region.



(a)



(e)

(e)-Localization Tumor Brain Color Image Segmented.

Fig3:(c) Represent fusion data after FCM =3 classes.

Fig3:(d) Image after fusion with $\alpha=0.2$

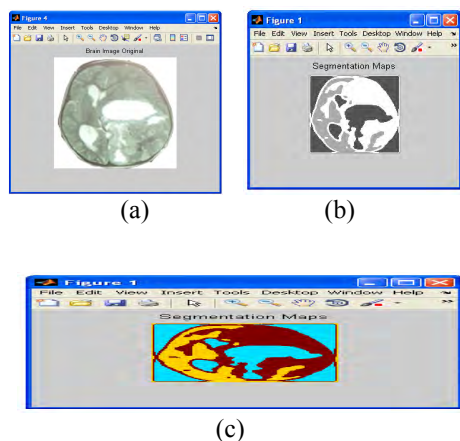


Fig: (a)-Original Image; (b)-Image Segmented
(c)-Color Image Segmented.

V. CONCLUSIONS AND FUTURE WORK

We have presented a new method for Brain Segmentation to localize Tumor and Epilepsy region. The method for segmenting color images based on fuzzy classification of color. It uses a fine initial segmentation obtained by applying the FCM algorithm, the merger process, based on a criterion introduced for fuzzy regions.

The main advantage of this novel method is that, first it requires no prior information on the images to segment, and it's fast. Moreover, the threshold of fusion can easily control the fineness of the segmentation depending on desired uses. However, we can criticize this method by the following points:

- to emphasize the color properties of pixels compared to the spatial properties (defects common to all methods based on classification);

- Involves a merger threshold often difficult to adjust;

- using the RGB color space which imperfectly reflects our perception of color;

- we can question the validity of segmentation called unsupervised in the sense that the method involves introducing a threshold in a certain manner of information on numbers of color classes to build.

- to emphasize the color properties of pixels compared to the spatial properties (defects common to all methods based on classification);

- fusion involves a threshold often difficult to adjust;

- using the RGB color space which imperfectly reflects our perception of color to analysis and improving the different algorithm in the future work.

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