COMPUTER AIDED SYSTEM BASED ON EFFICIENT BRAIN TUMOR SEGMENTATION AND CLASSIFICATION

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Abstract

The CT/MR brain image segmentation using fuzzy c-mean algorithm has the noise problem. To solve this problem a new method is introduced in this paper. By integrating the local neighborhood information the noise problem of FCM is reduced and for more accurate segmentation phase congruency is used. The analysis shows that the segmentation efficiency and noise robust is more than the standard FCM and K-mean clustering algorithm.

Keywords: **Fuzzy clustering, K-means clustering, Fuzzy c-means, Spatial FCM, Image Segmentation, Phase congruency, Spatial information**

1. INTRODUCTION

Spilting an image into multiple parts is known as image segmentation. One of the method used for automatic image segmentation is unsupervised fuzzy clustering. Separating a set of data and grouping into meaningful subclasses is known as clustering. The goal of cluster analysis is to group the data set that are similar to one another and different from the data in the other groups. The clustering techniques are used in image processing, data mining, economic science, pattern recognition, spatial data analysis and so on.

Nowadays, in medical image processing field many research works are based on modifying the original FCM algorithm to improve the efficiency of final segmentation results. N. Ahmed *et al.* [2] uses a modified version of fuzzy c-means algorithm for bias field estimation and segmentation of MRI data. This algorithm is formulated by modifying the objective function of the standard FCM algorithm to compensate for such in homogeneities. K. Chuang *et al*. [4] presented a fuzzy c means algorithm that incorporates spatial information into the membership function for clustering. The spatial function is calculated by adding the membership function of neighborhood of each pixel under consideration. J. H. Xue *et al*. [5] proposed an integrated method of the adaptive enhancement for an unsupervised global to local segmentation of brain tissues in three-dimensional MRI images. Y. Yang *et al.* [7] use an improved FCM clustering algorithm that indicates the spatial influence of the neighboring pixels on the center pixel plays a key role in this algorithm and can be automatically decided in the implementation of the algorithm by fuzzy membership.

In this paper a novel combination of the modified FCM based method and the spatial information was developed to reduce the noise impact obtain a smooth and slowly varying bias field and produce satisfying segmentation results. The results obtained are compared to some other methods on both simulated and real brain MRI images.

2. METHODOLOGY

2.1 Preprocessing

Preprocessing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing. In this paper, first resize the image by reduce or increase the number of pixels and then add noise. Medical images due to different reasons are affected by noise therefore segmenting them to obvious segmented clusters is difficult. When a pixel is affected by noise, intensity of the pixel is changed. In this situation neighborhood information should be used. In local neighborhood information is added in the similarity measure and membership function of FCM technique to remove the noise sensitivity and to get the exact image segmentation.

2.2 K- Means Clustering Algorithm

K-Means is one of the simplest unsupervised learning algorithm that solve the well known clustering problem. It's a method to automatically partition a dataset into k-groups. The partition done by selecting k initial cluster centers and then iteratively refining them as each instance d, is assigned to its closest cluster, each cluster center c is updated to be the mean of its constituent instances.

Procedure:

1. The number of cluster value is denoted as k
2. Centers of the cluster are picked randomly
3. Then find the value of mean or center of the cluster
4. Distance between each pixel to each cluster center are calculated
5. If the pixel distance is closer to the center then move that pixel to the corresponding cluster
6. Else move to next cluster
7. Again select the center randomly
8. Continue the process till the center value not change

2.3 Fuzzy C-Means Clustering Algorithm

The fuzzy c-means algorithm is a fuzzy clustering based on the minimization of a quadratic criterion. Clusters are generated based on their respective centers. For a set of data patterns X={x1,x2,….xn} partitioning the data space in the fuzzy c means clustering algorithm is by finding the cluster center, the membership function, and reducing the objective function based on the center and membership function. Fuzzy C Mean is the combination of fuzzy theory and K-means clustering algorithm. It introduces fuzziness of each object and obtain more information of data set. Clustering is done by minimizing the objective function subject to the probabilistic constraints. Problem in constraint is that the noise is treated the same points close to the cluster centers [6,8,12]. The minimization of the objective function is given as:

$$O_m = \sum_{i=1}^{x} \sum_{j=1}^{y} Q_{ij}^{m} \left\| A_i - B_j \right\|^2, \quad 1 \le m < \infty \qquad (1)$$

where,

m - fuzzification parameter

Q_{ij} - degree of membership of a_i in cluster j

B_j - j^{th} - cluster center

ll*ll - squared function for error

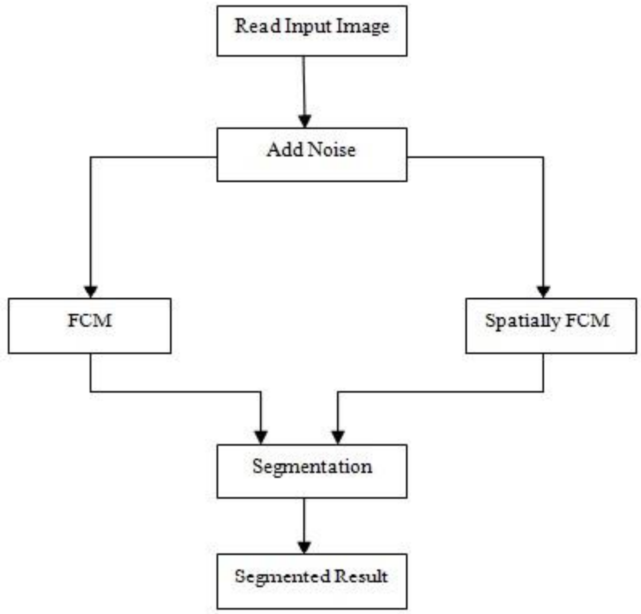


Figure 2.1: System Architecture of the proposed method

2.4 Spatially Coherent Fuzzy Clustering

To overcome the noise problem of FCM algorithm we integrate local neighborhood information and to obtain accurate segmentation the phase congruency features in the Spatially Coherent Fuzzy Clustering algorithm. To exploit the spatial information, a spatial function is defined as,

$$h_{ij} = \sum k \in NB(x_j) u_{ik} \quad (2)$$

where NB(xj) reprents a square window centered on pixel xj in the spatial domain.
where h_{ij}- the probability of spatial function
x_j – pixel of the cluster
If the majority of neighborhood belongs to the same cluster then the spatial function of the pixel in that cluster will be high. FCM clustering algorithm is incorporate the spatial neighborhood information with traditional FCM and updating the objective function of each cluster.

a) Local Neighborhood Information

In Fuzzy C-mean algorithm, for every iteration both the similarity measure and the membership degree values using the information of neighboring pixels are adjusted.

$$N_{ij} = x_{ij} \left\| A_j - P_i \right\|^2 \quad (3)$$

$$x_{ij} = 1 - \alpha B_{ij} \quad (4)$$

where,

x_{ij} - similarity weight that is based on B_{ij} value
α - parameter that controls the neighborhood attraction

The weighted similarity measure of the neighborhood information is as follows,

$$B_{ij} = \frac{\sum m \in \Omega_j a_{im} c_{jm} e_{jm}^{-2}}{\sum m \in \Omega_j c_{jm} e_{jm}^{-2}} \quad (5)$$

where,

Ω_j - neighbor set
a_{im} - neighbor membership degree
c_{jm} - intensity difference
e_{jm} - neighborhood attraction distance

The intensity difference is given as,

$$c_{jm} = |y_i - y_m| \quad (6)$$

The neighborhood attraction distance is calculated by,

$$e_{jm} = \max(|s_j - s_m|, |t_j - t_m|) \quad (7)$$

Based on the B_{ij} value, the membership value are calculated by,

$$O_m^* = \frac{O_m A_{ij}^{\beta}}{\sum_{x=1}^{B} O_m A_{xj}^{B}} \quad (8)$$

O_m^* - new membership value
B - number of clusters
A_{ij} - mean of membership value
β - the parameter that controls A_{ij}

$$A_{ij} = \frac{\sum m \in \Omega_j O_m e_{jm}^{-2}}{\sum m \in \Omega_j e_{jm}^{-2}} \quad (9)$$

The reciprocal distance e_{jm} is for influence the neighbor results. Parameter value 0 means, it lies as in standard FCM algorithm. If the parameter value is 1 the the attraction distance is maximum. Based on the noise level of image the optimal parameter value varies. The accurate segmentation is got if the distance attraction is maximum.

b) Phase congruency

It's the feature detection method based on frequency using the energy and local phase. Phase congruency method is developed to enhance the feature localization. The phase congruency function was developed from the fourier amplitude by scaling their sum. From this it is clear that the phase congruency is equal to the local energy.

$$LE_x = P(x) \sum_n FA_n \quad (10)$$

where,

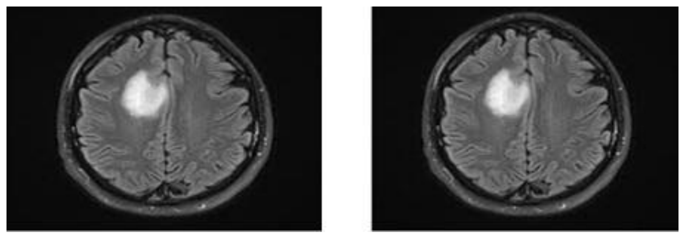
LE(x) - Local energy
P(x) - phase congruency

FA$_n$ - Fourier Amplitude

3 RESULTS AND DISCUSSION

The simulation results of the proposed noise intensity improved FCM algorithm are depreciated here.The algorithms were developed in Matlab 2013 and executed in laptop with specifications of Intel Core i3 processor with 4GB RAM, 64bit windows 8 operating system.

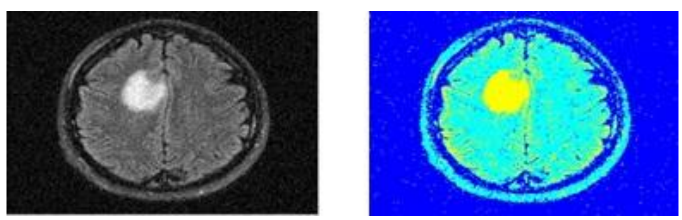
The real time CT/MR images of brain were used for the analysis of the algorithm. The input images were corrupted by guassian noise and the performance of the proposed algorithm was verified.



(a) (b)

Figure 3.1: (a) Input MR Image (b) Convert RGB to Grey Image

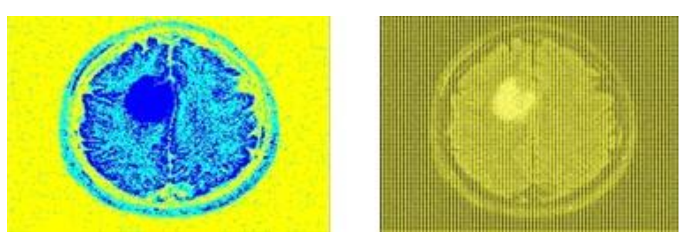
The result of the proposed algorithm for a CT image of brain is in 4% of Gaussian noise is deposited in figure 3(c).



(c) (d)

Figure 3.2: (c) Adding Gaussian noise (d) K- Means Clustering

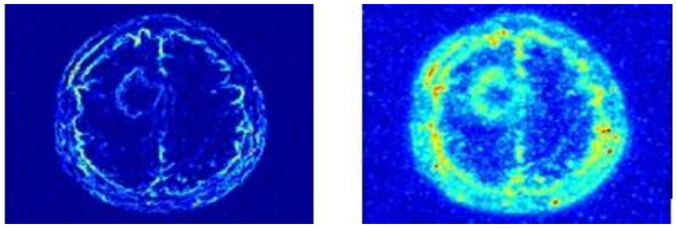
The performance of the proposed algorithm was validated by comparing it with the conventional segmentation approaches like, k-mean clustering algorithm and Fuzzy C Mean clustering algorithm the result of the input CT image of the brain form K-Mean clustering algorithm and Fuzzy C Mean algorithm are depreciated in figure 3(d) and 4(e).



(e) (f)

Figure 3.3: (e) Fuzzy C-Means Algorithm (f) Block division

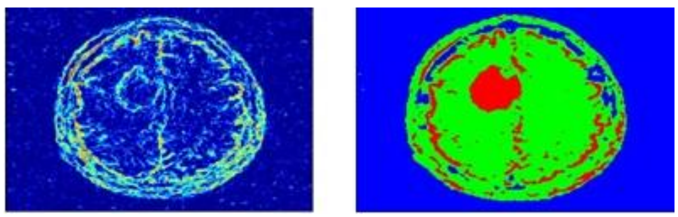
By visual inspection its clear that the segmentation result was affected by noise in case of noisy images a separate preprocessing module have to be employed prior to segmentation.



(g) (h)

Figure 3.4: (g) calculating total energy (h) anisotropic neighborhood

The proposed segmentation approach does not require any preprocessing module. Since it's taken in account of a spatial information of local image features (Local neighborhood information).



(i) (j)

Figure 3.4: (i) Phase congruency (j) Spatially FCM

The qualitative analysis was also done by means of the performance metric dias co-efficient. From this its observed that our segmentation approach yields a dias co-efficient values in the range of .8 to .95 which indicates the efficiency of the approach. The dice coefficient is

$$\rho_{avr} = \left(\sum_{i}^{c} \rho_i \right) \Big/ i \qquad (11)$$

The ground truth image was obtained by careful declination by expert radiologists. The proposed approach was also tested in input CT/MR images of various noise variance and satisfactory results was obtained.

Noise level	0.02	0.04	0.06	0.08
K-means	0.75	0.69	0.68	0.67
FCM	0.76	0.74	0.73	0.70
SCFCM	0.91	0.90	0.86	0.84

Table 1: Quantitative coefficients results of various algorithms

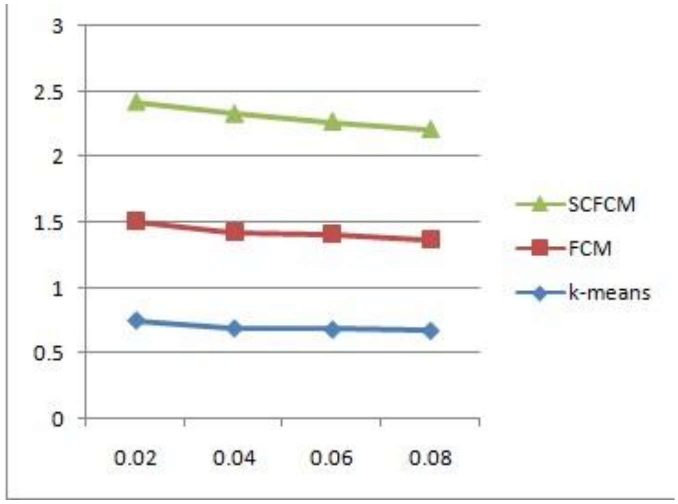


Figure 3.5: Analysis of various algorithms

The above figure shows that our proposed spatially fuzzy c-means clustering algorithm more efficient than the standard FCM algorithm and K-means algorithm.

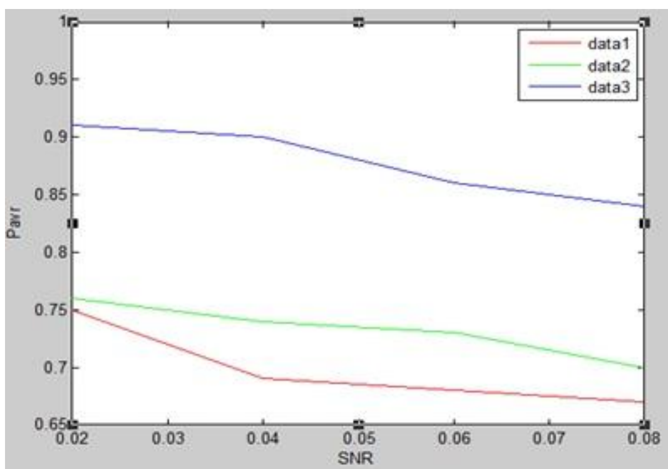


Figure 3.6: Quantitative comparison results of k-mean, FCM, SCFCM algorithms. In the above figure data 1 represents k-means, data 2 represents FCM and data 3 represents SCFCM.

4 CONCLUSION

In this paper, we propose a spatially fuzzy c-means clustering algorithm for segmentation and for noise robustness we integrate the local neighborhood values. The camparison among the k-mean algorithm, standard fuzzy c-means clustering algorithm and the proposed spatially coherent fuzzy c-means clustering algorithm shows that the performance efficiency of the proposed algorithm is much better than the compared algorithm.

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