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MRI Image Segmentation Using Active Contour and Fuzzy C-Means Algorithm

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Abstract-Interpretation of MRI images is difficult due to inherent noise and inhomogeneity. Segmentation is considered as vitally important step in medical image analysis and classification. Several methods are employed for medical image segmentation such as clustering method, thresholding method, region growing etc. In this paper, attention has been focused on clustering method such as Fuzzy C-means clustering algorithm that has been widely used for medical image segmentation. This algorithm was combined then with Active Contour method. Active Contours have been widely used as attractive image segmentation methods because they produce sub regions with continuous boundaries. The algorithms have been implemented and tested on MRI images. The comparison is made with existing conventional Fuzzy C-means method. Experimental results show that the proposed hybrid method significantly improves the Peak Signal to Noise Ratio (PSNR) and Mean Squared Error (MSE) for medical image segmentation.

Keywords---*Image Segmentation, MRI Images, Active Contour, Fuzzy C-Mean*

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I. Introduction

Image segmentation is an aspect of digital image processing. Segmentation is the process which partitions an image into its constituent parts or objects. It is used to locate and find object and boundaries in an image. It basically aims at dividing an image into subparts based on certain features. These features could be based on certain boundaries, contour, color or any other pattern. So it provides us an easy way to analyze and represent an image [1]. Image segmentation can be classified into various categories such as region based, edge based, clustering methods, PDE (Partial Differential Equations) based segmentation techniques [2].

Image processing is an important tool in medical image processing. MRI (Medical Resonance Imaging) is a method of obtaining images of the interiors of object, especially living things such as humans and animals. Medical images mostly contain noise, complicated structure so their precise segmentation is necessary. Medical image segmentation is an important technique in areas like diagnosis, detection of tumors, lesions, cyst etc.

Clustering is a process in which patterns or objects classify in such a way that samples of same group are more similar to one another than the samples belonging to different groups. Among the various clustering methods, Fuzzy C-Means (FCM) is the popular method due to its robust characteristics and can retain more information than other methods [4]. FCM is the soft segmentation method that has been widely used for image segmentation of MRI images. It is unsupervised clustering technique which allows one piece of data to belong to two or more clusters [10].

Active Contour or Snakes are computer generated curves that move within the image domain to find the object boundaries under the influence of internal and external forces [3].The contour is nothing more than an edge detection technique which helps in getting the complete detail of the components involved by segmentation.

In this paper ,an algorithm for MRI image segmentation has been proposed using Fuzzy C-means and Active Contour method and the results has been compared using conventional Fuzzy C-means algorithm used for image segmentation.

II. PROPOSED METHOD

The proposed system consists of different image segmentation techniques. It basically comprises of two major phases, which include Active contour and Fuzzy C-means. In it first of all a MRI image is taken. Then MRI image is segmented using FCM. After that a hybrid approach is used which uses active contour and FCM methods to segment MRI image. Fig.1 represents the complete system design of proposed hybrid method. Active contour is used to find the contour of an object by forming a snake around its boundary and FCM has been used to automatically segment different objects present in image data.

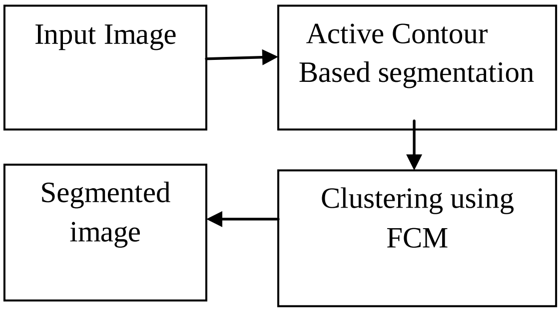

Figure 1: Block Diagram of proposed method

A. *FUZZY C-MEANS ALGORITHM*

FCM was first demonstrated by Dunn in 1973 and then improved by Bezdek [10]. It has the advantages of producing high quality segmentation compared to other available algorithms. The fuzzy c-means (FCM) method in particular, can be used to obtain segmentation via fuzzy pixel classification. FCM allows pixels to belong to multiple classes with varying degree of membership. The membership values, data point have will be updated iteratively. Fig. 2 shows the flow diagram of FCM

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algorithm. The FCM algorithm consists of the following steps.

Step 1: Let us suppose M dimensional N data points are represented by x_i (i=1, 2,….N) to be clustered.

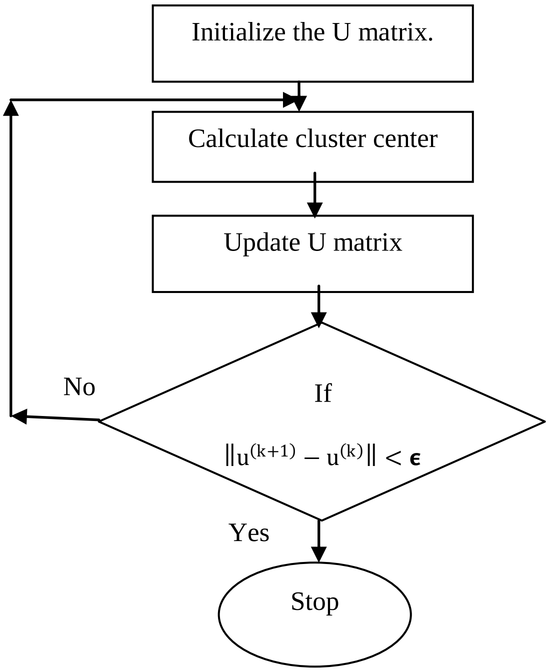


Figure 2: Flow diagram of FCM algorithm

Step 2: Assume number of clusters, that is C, where 2≤ C≤ N.
Step 3: Choose the level of cluster fuzziness f>1.
Step 4: Initialize membership matrix U with size N×C×M, such that $U_{ijm} \in [0,1]$ and $\sum_{j=1}^{c} U_{ijm} = 1.0$ for each i and m.
Step 5: Calculate cluster centers CC_{jm} for j^{th} cluster and its M^{th} dimension by using expression:

$$CC_{jm} = \frac{\sum_{i=1}^{N} U_{ijm}^{f} x_{im}}{\sum_{i=1}^{N} U_{ijm}^{f}} \qquad (1)$$

Step 6: Determine Euclidean distance D_{ijm} between i^{th} data point and j^{th} cluster center.

$$D_{ijm} = \left\|\left(x_{im} - CC_{jm}\right)\right\| \qquad (2)$$

Step 7: Update membership matrix according to D_{ijm}. If $D_{ijm} > 0$, then

$$U_{ijm} = \frac{1}{\sum_{c=1}^{C} \left(\frac{D_{ijm}}{D_{icm}}\right)^{\frac{2}{f-1}}} \qquad (3)$$

If $D_{ijm} = 0$, then data point will coincides with data point of j^{th} cluster center and has full membership value, $U_{ijm} = 1.0$.
Step 8: Repeat step 5-7 until changes in U≤ ϵ where ϵ is termination criterion.

B. Active Contour Method

The concept of active contour was first introduced by Kass et.al. [3]. In it the snake is a curve which tries to move at position where energy function is minimized. The procedure is as follows:

1) Snake is placed near the contour of region of interest (ROI).
2) During an iterative process, due to internal and external forces, the snake is attracted towards the target.
3) Energy function is constructed which consists of internal and external forces to measure the contour of ROI. Then minimize the energy function, which will represent the active contour's total energy. The energy function is as follows :

$$E_{snake} = E_{int} + E_{ext} + E_{con} \qquad (4)$$

The snake energy consists of three terms. First term represents the internal energy, second term E_{img} denotes image forces and the last term E_{con} gives external constraint forces. So the sum of image forces and constraint forces known as external snake forces.

Internal Energy(E_{int}): It depends upon the intrinsic properties of a curve and it is the sum of elastic and bending energy.

$$E_{int} = E_{elastic} + E_{bending}$$
$$= \frac{1}{2}\int (\alpha|v_s|^2 + \beta|v_{ss}|^2)ds \qquad (5)$$

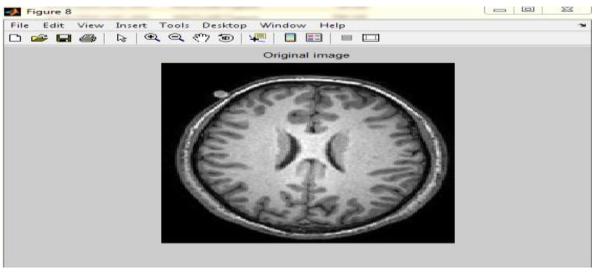
External Energy(E_{ext}): This energy is derived from the image so that is takes on its smaller values at the function of interest such as at the boundaries.

$$E_{ext} = \int E_{image}\,(v(s))ds \qquad (6)$$

The internal forces are responsible for smoothness while the external forces guide the contour towards the contour of ROI.

III. RESULTS AND DISCUSSIONS

The proposed method is implemented by using the MATLAB environment. This method is tested on the images taken from brain web and some images obtained from internet. The proposed hybrid method is applied to segment objects in MRI images using hybrid method which uses Active Contour and Fuzzy C-means techniques. Proposed technique is robust and adaptive, since it works on medical as well as on conventional images. Fig.3 shows the result of proposed hybrid technique when applied to Brain MRI image. It shows that using the proposed method image get segmented more accurately and precisely and get improved values of PSNR and MSE.



(a) Input Image (Brain.tif)

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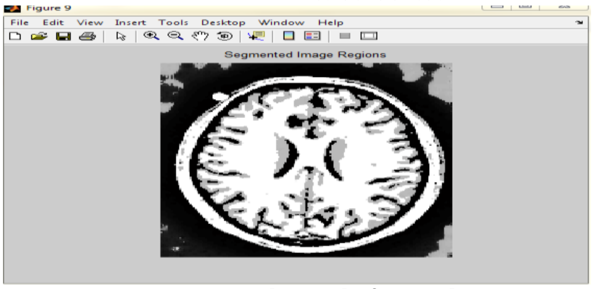
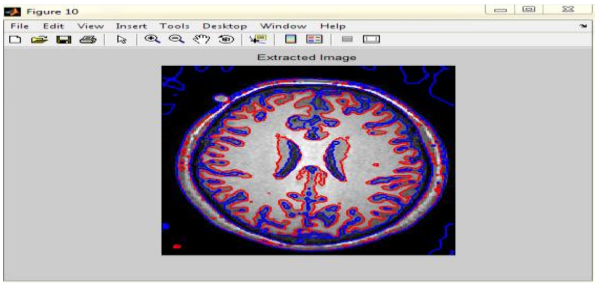
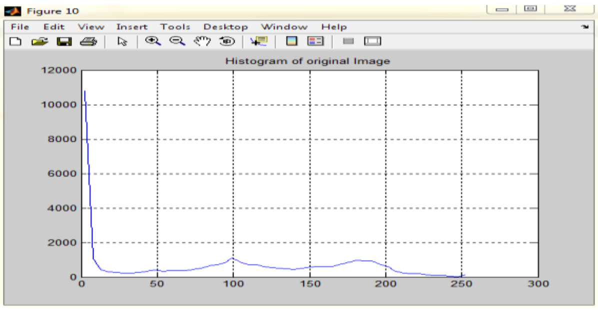
(b) Image Obtained at 10 iterations after applying Active Contour



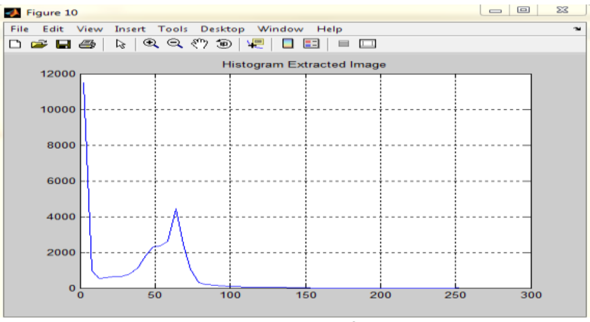
(c) Image obtained after applying FCM



(d) Extracted Image



(e) Histogram of original image



(f) Histogram of extracted image

Figure 3: Segmentation results of Proposed Method

The quality of segmentation results of different MRI images are evaluated using PSNR and MSE. PSNR and MSE are the two error matrices used to compare image segmentation quality. The MSE represents the cumulative squared error between the original and the extracted image whereas PSNR represents a measure of peak error. Lower the value of MSE, the lower the error. Higher the value of PSNR, better the quality of reconstructed image.

$$\mathrm{PSNR} = 10\ \mathrm{LOG}\left(\frac{\mathrm{MAX}^2}{\mathrm{MSE}}\right) \quad (7)$$

Whereas

$$\mathrm{MSE} = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left\|I(i,j) - I_q(i,j)\right\|^2 \quad (8)$$

MAX is the maximum possible value of the image. I is original image and I_q is the reconstructed image. m and n are the number of rows and columns in input image. Comparison of the proposed method with the conventional FCM method is shown in Table I and Table II.

Table I. Performance Comparison using MSE

Input Images	MSE	
	FCM	Active Contour and FCM
Brain.tif	0.1739	0.0501
Heart.tif	0.1495	0.0441
Head.gif	0.1132	0.0846

Table II. Performance Comparison Using PSNR

Input Images	PSNR	
	FCM	Active Contour and FCM
Brain.tif	55.7286	61.1389
Heart.tif	56.3284	61.6816
Head.gif	57.5927	58.8546

IV.CONCLUSION

The segmentation and analysis of medical images are very important task in diagnosing several diseases. This research work represents a robust and efficient approach for segmentation of medical images. The proposed approach firstly makes use of Fuzzy C-means Clustering algorithm. Then a hybrid technique is used that makes use of Active Contour and Fuzzy C-means. Active Contour has proven to be very attractive approach and have produced good results in medical image segmentation. Results of proposed methods Contour along with FCM and conventional FCM

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have been compared and it is observed that hybrid method provides better results as compare to FCM on the basis of PSNR and MSE values. In future other techniques can be used to further enhance edge details before segmentation.

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