Segmentation of MR Brain Images using Unified Iterative Partitioned Fuzzy Clustering

Kalyanapu Srinivas, Bhaskar Kantapalli

Abstract*: *Detection of tissues from MR brain images is quite difficult task in medical field applications. Segmentation is utilized to detect the tissues accurately. Many algorithms have been presented to detect the tissues from the MR brain images. Most of them were remained failure due to their inaccurate results. To resolve this problem, an analysis of tissues detection in MR images using unified iterative partitioned fuzzy clustering (U-IPFC) is presented. Our proposed methodology consists of pre-processing, detection of multi-tissues from MR brain images and computation of tissue area. Extensive simulated analysis shown that the effectiveness of proposed U-IPFC approach. Our main concentration is on detection of multi-tissues with an enhanced accuracy over existing fuzzy c- means (FCM) and K-means clustering algorithms.

Index Terms*: *Magnetic resonance imaging, brain tumor, clustering, thresholding, fuzzy c-means, K-means and iterative partitioned clustering.

I. INTRODUCTION

Basically, MR imaging [1] is utilized to examine the processes of human body and organisms functioning. It influences the treatment and diagnosis in several particulars, even the impact on enhanced outcome of health is unsure. These sorts of imaging are desirable over the CT methodologies due to that they don't employ any ionizing rays, when either mode could concede the similar info. Brain tissue is an uncontrolled growth in any part, which causes serious death to the human. Detecting these tissues in an early stage is a vital and quite difficult task to the medical diagnosis persons. Detection of tissues in MR images can be done by segmenting the images. Grouping of similar elements is known as segmentation. Clustering is a process to do the segmentation, which clusters the number of elements into few clusters based on the similarity of intensity values or pixel values and their gray intensities. The clustering outcome consists of number of segmented objects in which it has extracted information of input image. Due to the feature of extracting information from any sort of image, there are many application areas for segmentation like image enhancement, detection of objects, compression, processing of medical images and retrieval systems [2]. Over past decades there have been many algorithms implemented for segmenting images. FCM is a well-known approach among those and it's a very popular clustering technology, that can segment source image into number of objects by utilizing the membership functions [4] and [5]. However, these sort of algorithm suffering from higher complexity due to the membership values assignment. Later years, to reduce the computational complexity a simple and effective clustering algorithm was proposed. It has been utilized widely due to its capability of clustering meta data very faster [4] and [7-9]. Then after segmentation of images was done by utilizing hierarchical clustering [12-14] and Gaussian Mixture Model with its variant Expectation Maximization [15,16]. However, the algorithms presented in the literature have been suffering from inaccuracy in finding the exact tissue, higher computational complexity and lack of stability. To overcome these problems, U-IPFC algorithm for detecting multi-tissues in MR brain images and calculating the estimated area using number of white pixels in a segmented MR image with an enhanced performance over existing FCM and K-means clustering algorithms.

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II. RELATED WORK

Author in [3] presented a segmentation algorithm that was based on improved watershed approach. This approach provided some better enhancements over manual segmentation algorithms, but it was suffering from few restrictions like over grouping and sensitive to fake edges. In [4], a fuzzy implementation has been presented by the author named fazel. Fuzzy is a set of rules and regulations, in which the segmentation depends on the membership values. However, fuzzy wasn't without drawbacks, it suffers from the computational complexity due to its dependency on membership function. Later, many researchers tried to implement hybrid combos with the integration of FCM algorithm. Author in [5] presented an effective segmentation of tissue in brain images by utilizing the combo of spatial information and FCM, this resolved the issue found in [4], but it also consumes higher computational time to cluster an image and suffer from fake edges. To defeat the limitations of above-mentioned segmentation algorithms, the author in [6] proposed an efficient segmentation algorithm which utilized k-means clustering for segmenting MR brain image. This approach was an extended version for the watershed, manual segmentation and FCM based algorithms. Segmented output of k-means is quite better over those algorithms and this takes very less time to compute the segmented images. From then many researchers tried to implement the integrated algorithms with the combination of k-means clustering to get the enhanced performances in [7-10].

However, this K-means depends on the selected centroids initially. It needs new centroids to be updated by calculating the mean of obtained clustered points in the first iteration. The mean of these values provides the floating values which were not favorable for replacing as a new centroid.

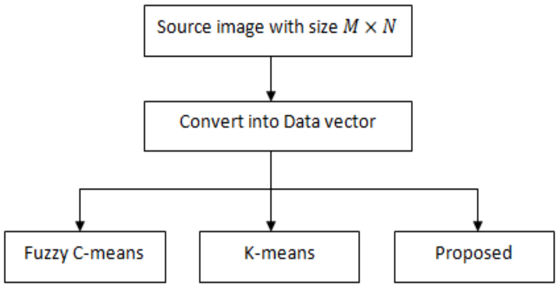


Fig. 1 Brain tissue segmentation flow diagram

Therefore, K-means must need to optimize for the integer or scalar centroid to be replaced with the existed centroid. In [11], the author has proposed a pillar- based approach to optimize the K-means clustering, in which the maximum value is selected instead of calculating the mean value to replace the initial centroid. Authors in [17-19] presented a hybrid algorithm for tumour detection and extraction from brain images, but they were failed to detect the tumor with higher accuracy. However, the above-mentioned algorithms have the drawbacks like less accuracy and inaccurate area estimation.

III. PROPOSED METHODOLOGY

Proposed segmentation algorithm consists of both iterative partitioned (IP) clustering and fuzzy clustering (FC) approaches. First, IP clustering is applied to the pre-processed MR brain image to obtain the segmented output having tissue in it. As discussed in earlier sections, IP clustering doesn't provide the accurate segmentation results. Since IP clustering depends on the selected centroids initially. and requires new centroids to be updated by computing the obtained clustered points mean in the primary iteration. Usually, mean values render the floating-point values which are not suggestable in digital imaging to reposition as a new centroid.

Algorithm1

Step 1: First, source image 'I' is to be chosen and read.
Step 2: Convert it into a data sets of column vector for grouping of similar elements.
Step 3: Choose the cluster quantity i.e., centroids.
Step 4: Now, compute the distance of every picture element form the cluster element.
Step 5: Calculate the number of data points those are near to the chosen clusters.
Step 6: Choose the cluster with a minimal distance and then mover the data point to the relevant cluster centroid.
Step 7: Now, re-estimate the new centroid by finding the mean of obtained data from step 6 and replace the initial centroid with the new one.
Step 8: Repeat this process iteratively until the attainment of symmetry of previous and new cluster point.

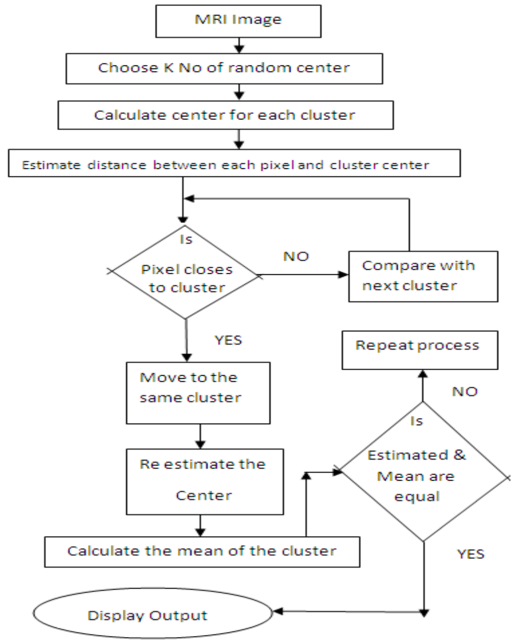


Fig. 2 Iterative partitioned clustering

Algorithm 2

Source image = 'J'
Segmented image = 'O'
Step 1: Recall the outcome of algorithm 1 and read as an input MR brain image.
Step 2: Now, employ fuzzy clustering and apply it to the obtained image of Step 1.
Step 3: Show the obtained multi tissues of MR brain image and separate them as primary (T1) and secondary (T2) tumors.
Step 4: Apply 3D rendering and compute the volume of each tumor.
Step 5: Finally, compute the execution time to disclose the comparative analysis with existing clustering algorithms.

A.U-IPFC algorithm

Our proposed U-IPFC is described in this section briefly. Figure 3 show that the block diagram of proposed segmentation methodology. Algorithm 1 and 2 explained the complete procedure for obtaining the segmented tissues of brain images by utilizing the proposed approach. Median filter is utilized as a pre-processing step to eliminate the noise from input MR brain image. Obtained denoised MR brain image is converted into data vector then k-means clustering is applied to segment this vector into several clusters. Now, the segmented output is optimized by fuzzy algorithm to enhance the segmentation accuracy and perfect tissue detection. At last, estimate arguing is applied to estimate the area of obtained tissue image by utilizing the typography and digital imaging units [18]. Here, we considered the images of size 256 x 256 and the pixels in the segmented image having only two values i.e., either black or white, where the pixel value 0 denotes the black and 1 denotes the white. Hence, we can represent the segmented output image as a summation of total number of white and black pixels.

$$M = \sum_{x=1}^{L}\sum_{y=1}^{L}[f_{x,y}(0) + f_{x,y}(1)] \quad (1)$$

where L=1, 2, 3…256

$f_{x,y}(0)$ = black pixel having the value of zero,

$f_{x,y}(1)$ = white pixels having the value of one

$$P = \sum_{i=1}^{L}\sum_{j=1}^{L} f_{x,y}(1)$$

Where,

P = number of white pixels

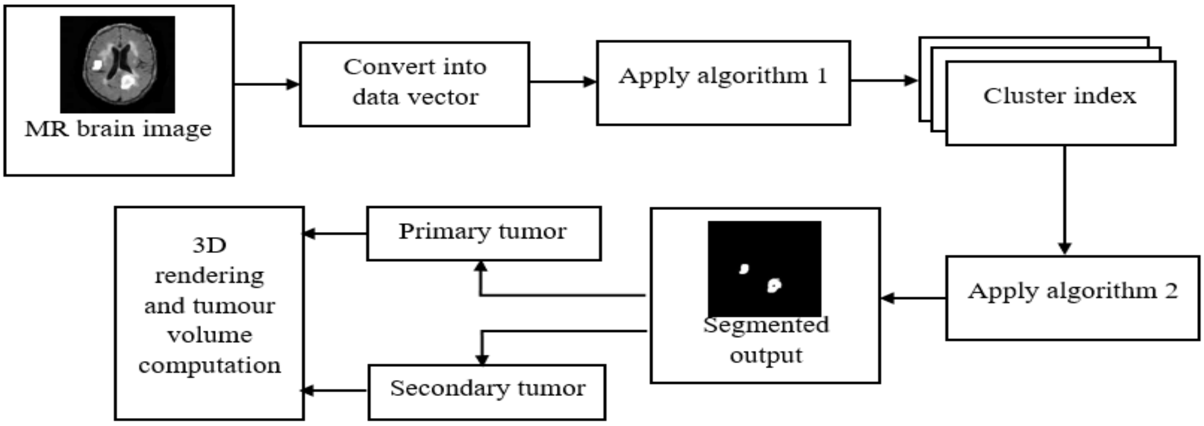


Fig. 3 Proposed block diagram of segmentation of MR brain images with multi tissues

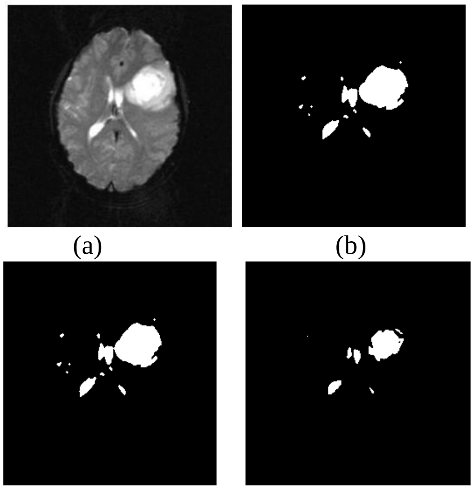
Now, by utilizing eq. (1), area of segmented tissue is calculated, where one pixel is equal to 0.264583 milli meters. i.e., 1 pixel = 0.264583 mm

Then the area of tissue is expressed as follows:

$$A_{Tumor} = (\sqrt{P}) \times 0.264 mm^2 \quad (2)$$

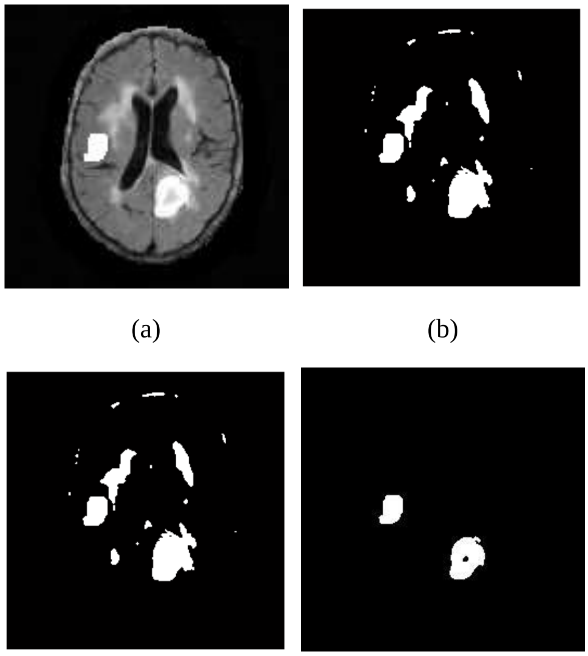
IV. RESULTS AND DISCUSSION

This section describes the simulated analysis of proposed U-IPFC with comparison to conventional clustering algorithms for detection of multi-tissues from the MR brain images. Various MR images have been utilized with different sizes and different stage of tissues for testing the effectiveness pf proposed clustering algorithm.



(a) (b) (c) (d)

Fig. 4 (a) original image and obtained segmented images with (b) fuzzy C means (c) K-means (d) proposed U-IPFC



(a) (b) (c) (d)

Fig. 5 Segmented multi tissues obtained (a) original image (b) manual segmentation (c) FCM clustering (d) K-means clustering and (e) proposed U-IPFC

Then the execution of existing FCM and K-means clustering algorithms is done with comparison to the proposed U-IPFC algorithm for multi-tissues detection in MR brain images. For instance, it is also considered that the single tissue brain image, which is shown in Fig. 4. Example of multi tissues MR brain image is disclosed in Fig. 5, which demonstrates the segmented outputs of FCM and K-means clustering algorithms with proposed U-IPFC algorithm. From the obtained outputs, we can observe that the proposed U-IPFC algorithm has detected the tumour more effectively with higher accuracy.

Although, our proposed algorithm running time will be quite bit of more than the k-means clustering but however the accuracy of segmented output will be more i.e., tumour area will be estimated more precisely to diagnosis further.

Fig. 6 and Fig. 7 demonstrates that the performance evaluation of proposed U-IPFC algorithm with comparison to the conventional clustering algorithms presented in the literature. We calculated execution time in seconds and tissues area in mm^2. Further, it also provided that the 3D rendering of segmented image in Fig. 8.

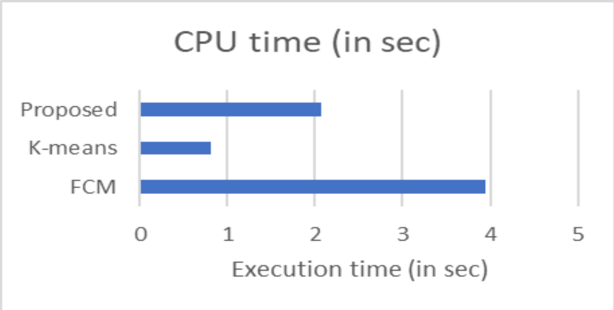


Fig. 6 Performance evaluation with CPU running time for multi tissues detection

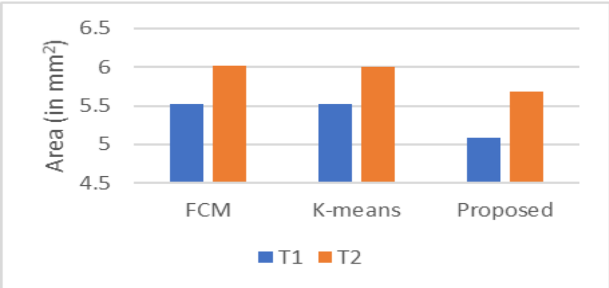


Fig. 7 Estimated area of segmented tissues T1 = tissue 1 and T2 = tissue 2

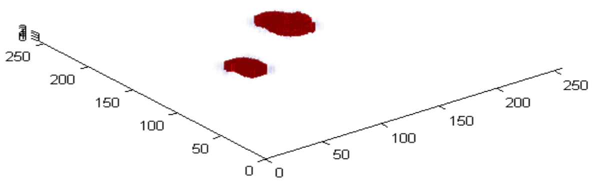


Fig. 8 3D rendered image of segmented multi tissues of MR brain image

V. CONCLUSION

The implementation of detecting single and multi-tissues in MR brain images and to estimate the area of the tissue has done with an improved accuracy and reduced computational time. Utilization of U-IPFC and estimation of the area in terms of mm^2 based on the typography and digital imaging units has done successfully. Further, it is also given that the 3D rendered image of segmented output and compared the simulation results with the existing algorithms.

Furthermore, this can be extended to 3D multi modal medical image segmentation with more effective and accurate clustering algorithms.

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