

Probability Based Fuzzy C-Means for Image Segmentation

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Abstract

In computer-aided diagnosis and therapy, segmentation is often required at the preliminary stage of drug imagery. The segmentation work is complex and challenging due to the intrinsic nature of the images. Segmentation in brain imagery is considered very important for detecting tumors, edema, and necrosis. Magnetic resonance imaging (MRI) is used in the detection of abnormal changes in tissues and organs. Segmentation is all the more essential in analyzing human tissues, particularly in magnetic resonance (MR) images. Unfortunately, MR images often suffer noise caused due to operator performance, equipment handling, and the environment, which may lead to serious inaccuracies with segmentation. This paper is on solving the problem of overlapping. A probability based fuzzy c-means (PBFCM) is used to improve the segmentation technique based on the extension to the fuzzy c-means (FCM) clustering algorithm

Keywords- Magnetic resonance imaging (MRI), Fuzzy C-Means Threshold(FCMT), Fuzzy C-Means Clustering (FCM) and probability based fuzzy c-means (PBFCM)

I Introduction

Cancer curative is a challenge for medical researchers involving cost prohibitive advanced approaches with extended duration Cause, effects and therapy are to be well known for effective steps in the treatment. In a majority of the cases, surgical intervention and radiation treatments are considered as the treatment courses. The incidence of brain malignancy has increased in the recent past. Fast diagnostics, relevant and befitting treatment strategies are the success in the outcome of the treatment. Magnetic Resonance Imaging (MRI) offers high-quality medical evidence, particularly in brain imaging.

The detail thus obtained shall have the quality of being compared with any similar imaging modality. Therefore, the majority of research in medical image segmentation is concerned with MR images. ^[1] Clustering is the most accepted procedure in medical image segmentation. In normal sense phenomena of identical characteristics are grouped so as to draw a tangible and crisp conclusion. Cluster analysis stands on similarities of data having very close characteristics. Understandably a cluster is, therefore, a collection of objects which are identical in their nature but dissimilar to the objects belonging to other clusters. In the present work, Fuzzy C-Means Threshold, and Fuzzy C-Means clustering algorithms and the Probability based Fuzzy C-Means were examined based on their clustering quality.

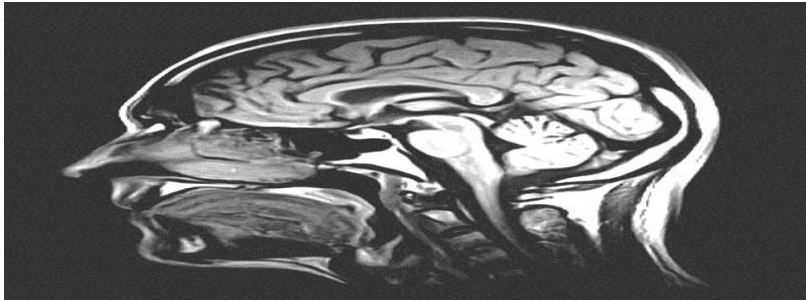


Fig 1.An MRI scan revealing the anatomical features of the human brain.

2 Literature review

Suhag and Saini.^[2] proposed MRI brain images for detection and classification of tumor and non-tumor by using classifier.

The preliminary image processing is carried out using any of the standard methods. Following that Fuzzy C-mean segmentation method, feature extraction using GLCM technique and SVM Classifier are used. Such combination gave an accuracy of around 94% in classifying whether the MRI image is normal or abnormal.

Hooda et al.^[3] dealt with the performance analysis of image segmentation techniques such as K-Means Clustering, Fuzzy C-Means Clustering and Region Growing for detection of a brain tumor. In this paper, performance evaluation of the above-mentioned techniques is done based on error percentage as compared to ground truth. After comparing all the three methods it was concluded that the error percentage value was lowest with FCM clustering and it outperforms another segmentation algorithm.

Funmilola^[4] presented a Clustering method, using k-means and fuzzy c-means algorithms. These algorithms provide a novel approach called fuzzy k-c-means clustering algorithm, which has a better result in terms of time utilization. Time, accuracy, and iterations were the major focus. Still, limitations like k-means segmenting with a pre-determined number of clusters and Fuzzy C-means in generating overlapping results persist which were not being able to segment colored images until they are converted into gray scale. Fuzzy K-C-Means operates on similar Fuzzy C-Means.

Anandgaonka and Sable^[5] proposed a method for the same using a Fuzzy C-Means algorithm along with an algorithm to find an area of the tumor which is useful to decide the type of brain tumor whether it is benign or malignant.

3 Gaps in literature

Segmentation is just a process of dividing an image into a greater understandable format. Complex images are partitioned to several simple images thereby each pixel is assigned with a label. These procedures commonly capture each part in an image as well as convert them to suit the computer. There are two ways of segmenting an image. In the first method, discontinuities are detected wherever the intensity levels are favorable to be converted into images for segmentation. Similarities in images are detected based on prior rules of information. The segmentation has drawbacks such as overlapping which can be overcome by probabilities of fuzzy c-means algorithms. This is presented in fig2,

4 Proposed methodology

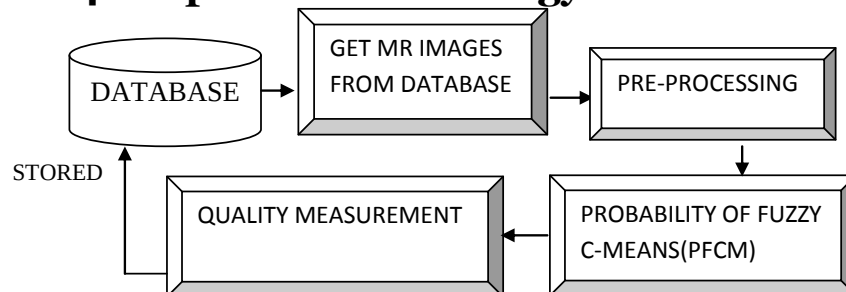


Fig 2: The flow chart of the proposed method

4.1 Image acquisition

The first phase of every vision system is the image acquisition. After the image is obtained various techniques of processing is to be applied to the image to execute the various vision tasks .. On the other hand, if the image, is not acquired satisfactorily, the intended tasks may not be achievable subsequently, even with the aid of certain enhancement procedures.

4.2 Preprocessing

It consists of the input MRI brain tumor image. One of the most famous image formats is the 8-bit color format. It has 256 completely different shades of colors. It is commonly known as a Grayscale image. The series of the colors in 8 bit varies from 0-255 Where 0 stands for black, 255 stands for white and 127 stand for gray color.

In image filtering, a number of different filters are used, but in the magnetic resonance image (MRI) it doesn't have noise. Hence, in this research, the Gaussian filter is used to remove the noise in the image. Here, the smoothed image will reduce the overlapping segmentation in the fuzzy c means threshold segmentation. As simple as a Gaussian filter removes the high-frequency components from the image *i.e.*, the low-pass filters. Finally, this smoothed image is used to operate the next step of the system as shown in the Equ.(1)

$$G_{\sigma}(x,y)=\frac{1}{2\pi\sigma^2}e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (1)$$

5 The Fuzzy C-Means Threshold (fcmt)

Fuzzy C-Means (FCM) Algorithm FCM is one of the most popular fuzzy clustering techniques, proposed by Dunn ^[7] in 1973 and eventually modified by Bezdek ^[8] in 1981. It is an unsupervised method of analysing the data which does not force an object to belong one class itself. This allows that a data point can take membership between 0 and 1 and it belongs to all group of the cluster. Class Center is used in membership function for which data close to that class is having more relationship.^[9,10] The FCM makes use of prior information in segmentation. The FCM algorithm consists of the following steps:

Let $X = \{x_1, x_2, x_3 \dots, x_n\}$ be the set of data points and $V = \{v_1, v_2, v_3 \dots, v_c\}$ be the set of centers.

- 1) Randomly select 'c' cluster centers.
- 2) Estimate the fuzzy membership ' μ_{ij} ' using in below equ.2.

$$\mu_{ij} = 1 / \sum_{k=1}^c (d_{ij} / d_{ik})^{(2/m-1)} \quad (2)$$

- 3) Work out the fuzzy centers ' v_j ' using in below equ.3

$$v_j = (\sum_{i=1}^n (\mu_{ij})^m x_i) / (\sum_{i=1}^n (\mu_{ij})^m), \forall j = 1, 2, \dots, c \quad (3)$$

- 4) Repeat step 2) and 3) until the minimum 'J' value is achieved or $\|U^{(k+1)} - U^{(k)}\| < \beta$.

where,

k refers the iteration step.

β refers the termination criterion between 0 and 1.

$U = (\mu_{ij})_{n \times c}$ is the fuzzy membership matrix.

J refers the objective function.

The advantage of FCM is the best result for overlapped segmentation. After performing FCM clustering, each pixel is assigned to the cluster for which its membership value is maximum.

Based on the intensity distribution obtained using the histogram of the image, the threshold value is calculated by taking the mean of a maximum of cluster 1 and minimum of cluster 2 or maximum of cluster 2 and minimum of cluster 3. This technique of threshold variety takes into an account of the intensity distribution of the image. This choice helps in obtaining optimum threshold values for different images obtained under dissimilar conditions. The overall FCM thresholding algorithm is presented in fig. 1. The output of this stage is a binary image (B_i).

5.1 Overlapping Segmentation

Fuzzy C-Means threshold doesn't give high-quality segmentation of accuracy and also have the overlapping as a drawback as shown in figure 3(a),(b). The image has undergone probability instead of threshold in fuzzy c-means.



Fig.3(a) original image (b)Fuzzy C-means (c)Fuzzy C-Means threshold Segmentation

Probability

Frequently we involve in the grouping of two or more events. This is capable of standing for use in set theoretic operations. Assume a sample space S and two events A and B :

- complement A^c (also A^0): all elements of S that are not in A ;
- subset $A \subseteq B$: all elements of A are also elements of B ;
- union $A \cup B$: all elements of S that are in A or B ;
- intersection $A \cap B$: all elements of S that are in A and B .

If A plus B are two events, subsequently the conditional probability of B given A is:

$$\text{PROBABILITY} = A + B/2$$

6 Experimental Results and Analysis

The present work segmentation of probability based fuzzy c-means gives high accuracy. In order to evaluate the performance, the proposed method takes into account 7 gray level brain tumor images: I1 to I7. The result obtained is compared with Fuzzy c-means threshold segmentation. The output of the segmentation regions and the extraction tumor portion is shown below. The proposed system gives high accuracy for different kinds of MR Image of a brain tumor as shown in fig..4.

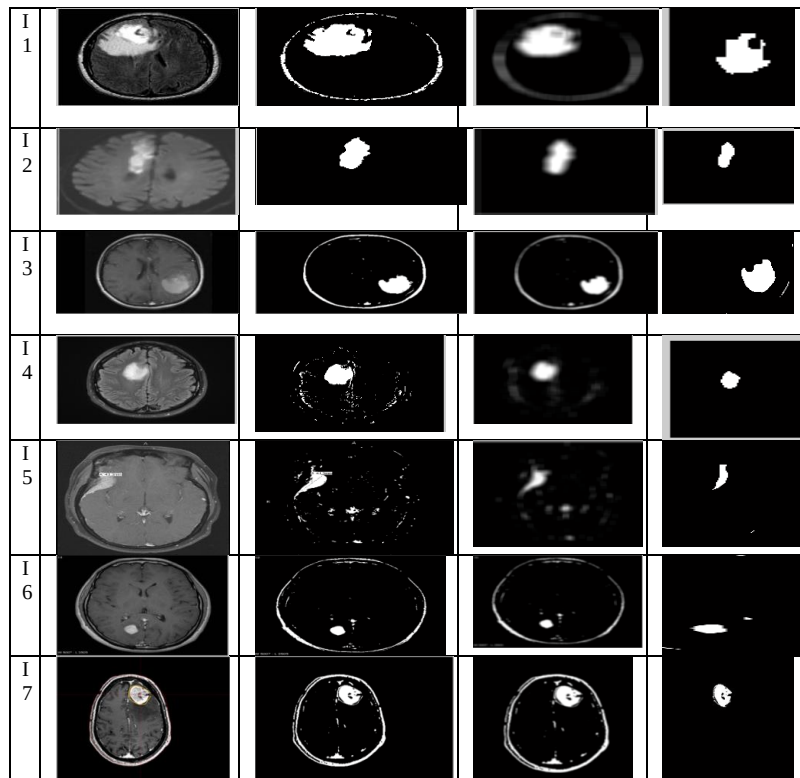


Fig 4. I1 to I7 in the 1st column are input of MR Brain Images, which is referred as tumor. The 2nd column refers to Black & White images. The 3rd column refers to Gaussian filter. The 4th column refers the segmentation of the brain tumor.

6.1 Definitions and Conversions of Overlap Measures

Most generally used measures to report segmentation overlap outcome in brain tumor segmentation literature are Jaccard Index (J), Dice Overlap (D) and accuracy. The **Jaccard index**, also known as the **Jaccard similarity coefficient** by Paul Jaccard, is a statistic used for comparing the similarity and diversity of sample sets. Jaccard Index (J) of two sets A and B is defined as in Equ 4.

$$J(A,B)=\frac{S(A\cap B)}{S(A\cup B)} \quad (4)$$

and could be converted to Dice Overlap score by

$$J(A,B)=2 \frac{J(A,B)}{1+J(A,B)} \quad (5)$$

Images	Fuzzy C-Means	Fuzzy C-Means Threshold	Probability based Fuzzy C-Means
Img1.jpg	0.7759	0.7031	0.5653
Img2.jpg	0.6024	0.3381	0.4086
Img3.jpg	0.1444	0.5274	0.6430
Img4.jpg	0.2192	0.6411	0.4096
Img5.jpg	0.0407	0.0422	0.0920
Img6.jpg	0.0293	0.1844	0.2869
Img7.jpg	0.1859	0.0422	0.3321
Average	0.2854	0.35407	0.3910

Table 1: Comparison of Jaccard Index (Similarity)

In Table 1, Jaccard index expresses high similarity and it offers better segmentation. Jaccard index was in the range of 0 to 1. The table indicates the comparison of Fuzzy C-Means, Fuzzy C-Means Threshold, and Probability based Fuzzy C-Means of Jaccard index. Table 2 describes the Dice overlapping segmentation which outperforms disjoint segment in the low false alarm rate to concentrate on the boundary of the segments. The dice overlap is defined as $2 * \text{Jaccard index} / (1 + \text{Jaccard index})$. Here Jaccard index is used for evaluating the similarity. The Dice overlap is high.

Images	FuzzyCMeans	Fuzzy C Means Threshold	Probability based Fuzzy C-Means
Img1.jpg	0.8738	0.8253	0.7223
Img2.jpg	0.7519	0.5053	0.5801
Img3.jpg	0.2524	0.6906	0.7827
Img4.jpg	0.3961	0.7813	0.5812
Img5.jpg	0.0783	0.081	0.1685
Img6.jpg	0.0569	0.3113	0.4458
Img7.jpg	0.3135	0.4507	0.4986
Average	0.3889	0.5207	0.5398

Table 2: Comparison of Dice Overlap

In Table 3, the accuracy is defined as the condition or the quality of the result being true *i.e.*, as simple as freedom from error or the defected portion of an object.

Images	Fuzzy C-Means	Fuzzy C-Means Threshold	Probability based Fuzzy C-Means
Img1.jpg	90.35	91.42	91.46
Img2.jpg	94.18	90.95	95.05
Img3.jpg	81.29	88.16	97.16
Img4.jpg	86.41	91.28	96.79
Img5.jpg	75.24	76.93	97.25
Img6.jpg	76.47	89.33	98.68
Img7.jpg	93.23	89.85	97.22
Average	85.31	88.27	96.23

Table 3: Comparison of Accuracy

From the above Table 1,2 and 3 .describe Jaccard Index, Dice overlap, and Accuracy are found in the proposed method *i.e.*, probability based fuzzy c-means. On seeing the overall performance, improved probability based fuzzy c-means proves to be better than the fuzzy c-means threshold and fuzzy c-means. The overall accuracy of a fuzzy c-means is 85.31%, a fuzzy c-means threshold is 88.27% and the probability based fuzzy c-means is 96.23%.

7 Conclusions

This research work on the probability based fuzzy c-means segmentation technique and implemented with MATLAB tool.

The efficiency of the proposed technique is compared with that of the existing fuzzy c-means threshold segmentation technique and established that the proposed model is performing well in terms of Jaccard index, Dice overlap, and classification Accuracy. In future, there is a scope for designing an image representation for detecting based on probability-based fuzzy c-means segmentation.

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