SEGMENTATION OF MAGNETIC RESONANCE BRAIN TUMOR USING INTEGRATED FUZZY K-MEANS CLUSTERING

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ABSTRACT

Segmentation is a process of partitioning the image into several objects. It plays a vital role in many fields such as satellite, remote sensing, object identification, face tracking and most importantly in medical field. In radiology, magnetic resonance imaging (MRI) is used to investigate the human body processes and functions of organisms. In hospitals, this technique has been using widely for medical diagnosis, to find the disease stage and follow-up without exposure to ionizing radiation.Here in this paper, we proposed a novel MR brain image segmentation method for detecting the tumor and finding the tumor area with improved performance over conventional segmentation techniques such as fuzzy c means (FCM), K-means and even that of manual segmentation in terms of precision time and accuracy. Simulation performance shows that the proposed scheme has performed superior to the existing segmentation methods.

KEYWORDS

MR image, Tumor, Thresholding, FCM, K-means and binarization.

1. INTRODUCTION

In radiology, magnetic resonance imaging (MRI) [1] is used to investigate the human body processes and functions of organisms. These images can be formed by using the magnetic fields and radio waves. In hospitals, this technique has been using widely for medical diagnosis, to find the disease stage and follow-up without exposure to ionizing radiation.MRI has a broad range of applications in medical diagnosis and in all over world there are over 25,000 scanners to be in use. It has an impact on diagnosis and treatment in many specialties although the effect on improved health outcomes is uncertain. MRT is more preferable over computed tomography (CT) since it does not use any ionizing radiation, when either modality could yield the same information. The sustained increase in demand for MRI within the healthcare industry has led to concerns about effectiveness of cost and over diagnosis. Segmenting an image is an effort to group similar colors or elements of an image into a cluster or group. This can be achieved by clustering, which clusters the number of colors or elements into several clusters based on the similarity of color intensities and gray intensities of an image. Main objective of clustering an image is dominant colors extraction from the images. By extracting the information from images such as texture, color, shape and structure, the image segmentation can be very important to simplify. Because of the information extraction in any images, the segmentation has been used in many fields such as Enhancing the image, compression, retrieval systems i.e., search engines, object detection, and medical image processing [2].

From the past decades, there are so many approaches developed for the image segmentation. Among those, Fuzzy c-means (FCM) is a well known method and very popular clustering scheme, which will segment the image into several parts based on the membership function [4] and [5]. After FCM, the K-means algorithm has been proposed to reduce the computational complexity of FCM. Because of its ability to cluster huge data points very quickly, K-means has been widely used in many applications [4], [7], [8] and [9]. Later years the Hierarchical clustering is also widely applied for image segmentation [12], [13] and [14]. Then after, Gaussian Mixture Model has been used with its variant Expectation Maximization for segmenting the images [17] and [18].

Here in this paper, we proposed characterization of MR brain tumorusing shaft algorithm for detecting the tumor and finding the tumor areausing number of white pixels in a segmented MR image with an improved performance over conventional segmentation techniques such as fuzzy c means (FCM), K-means and even that of manual segmentation in terms of precision time and accuracy.

2. RELATED WORK

Manisha *et. al.* in [3] proposed an improved watershed segmentation algorithm, which provides better results than the manually segmented algorithms but it includes few drawbacks like over-segmentation and sensitivity to false edges. Recent years, fazel in [4] proposed a fuzzy expert approach for segmenting the tumor cells from the MR brain images. However, that the fuzzy approach has produced good segmented results but it suffers from determining the membership function, which is used to cluster the similar pixels in MR image. Fuzzy will be worked with allocation of membership function to the pixels based on the initial centroids selected from the pixels of input image, which is to be segmented. Specifically, determining the number of the cluster is a considerable limitation with FCM. Since the regions are spatially discontinuous grey level similarity is only verified. Considering the experimental study FCM is converging to local minima of the squared error criterion [4]. Then after, Mohammed *et. al.* in [5] proposed an efficient brain tumor detection scheme based on the combination of spatial information with fuzzy c-means which overcomes the drawback found in [4], but it takes much time to segment the tumor and will suffer from false edges. To overcome, the drawbacks of manually segmented, watershed and FCM [3], [4], and [5] clustering algorithms, Mary Praveena in [6] proposed a fusion based image segmentation using k-means clustering, which is an extension to the above mentioned algorithms and will provide the best results within less computational time. Later years, there are so many algorithms such as histogram based approach, anisotropic diffusion and FCM have been merged with the k-means and given the best performance over conventional techniques [7], [8], [9] and [10]. However, this k-Means is limited to produce only hyper spherical clusters. It depends on initial centroids. To update the new centroids the mean of the pixel values of the respective clusters need to be estimated. The floating values obtained in some iteration are not favorable. Significantly, positive integers or scalars are required to replace the new centroids. Hence with K-means algorithm the optimal solution is difficult to achieve. In order to overcome the drawbacks of k-means, Barakbah*et. al.* in [11] proposed a pillar algorithm to solve the initial centroid designation problem, by considering the pixel maximization i.e., select maximum pixel value for centroid. Authors in [19] and [20] also proposed hybrid algorithms for detecting the tumor, but they were failed to detect the tumor with higher accuracy.However, the above mentioned algorithms have the drawbacks like more computational time, less accuracy and inaccurate area estimation.

3. PROPOSED ALGORITHM

Here in the proposed clustering algorithm, we optimized the k-means clustering by applying fuzzy algorithm.

3.1. K-means clustering

1. First we will select the number of centroids randomly i.e., depends on number of clusters
2. Now, partition the objects within each cluster
3. It finds partitions such that pixels within each cluster are as close to each other as possible, and as far from objects in other clusters as possible.
4. The objects are in the cluster or not will be calculated by measuring the distance between the cluster pixels. When the calculated Euclidean distance has minima value then the pixels will be grouped with the respective cluster.
5. Do the above process for remaining clusters also. Then, we will get three clusters with their similar pixels.
6. Now, calculate the mean of each cluster and replace the mean values with the centroids
7. Repeat the same process with these new centroids by giving the number of iterations until unless the convergence occurrence i.e., the mean value of clusters = cluster centroid value.

Flow chart of K-means clustering algorithm below Figure 1.

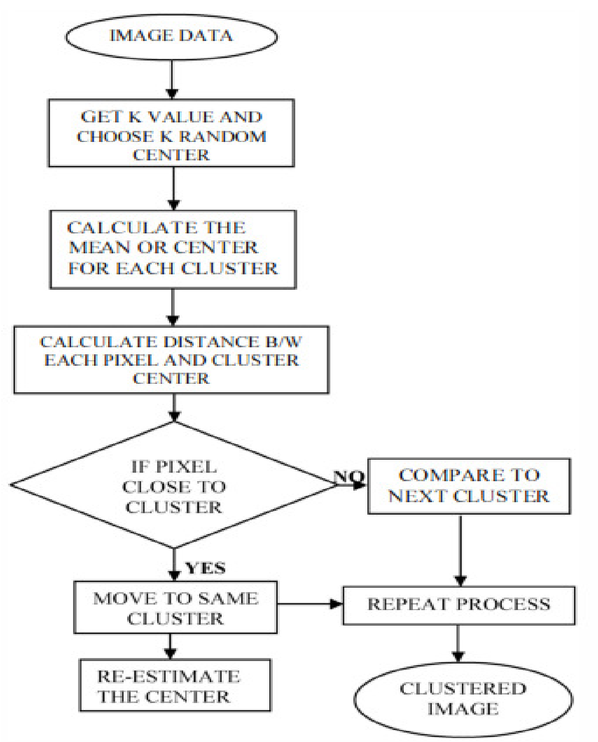

Figure 1. Flow chart of K-means clustering

3.2. Hybrid FKM Algorithm

Here in this section, we described our proposed hybrid fuzzy k-means (FKM) clustering in brief. First, the preprocessing has been done using median filter, which is used to remove the noise from digital images and will improve the quality of the image. Then the output of first stage will be given to the k-means clustering which gives the segmented output of de-noised image. Now, fuzzy clustering will be applied for the k-means segmented output to improve the segmentation accuracy and exact detection of tumor from MR brain images. Finally, binarization will be used to calculate the size of the tumor based on typography and digital imaging units [21].

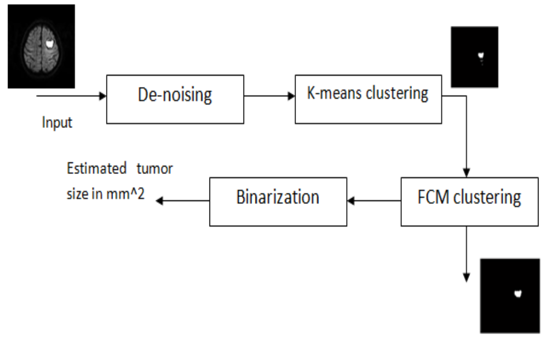

Figure 2. Proposed hybrid clustering algorithm

As mentioned in 3.1 section, while calculating the mean of cluster centroid pixels sometimes we might get the floating values, but the pixel values in an image will always be integers which does not have decimal values. Hence, we proposed a novel algorithm in figure 2 to fix this error. In the proposed approach, segmented k-means output will be further segmented by fuzzy clustering for improved accuracy. Then after, the binarization method will be applied to calculate the size of tumor which has been detected by using proposed hybrid clustering algorithm.

3.3. Binarization

Binarization is used to calculate the tumor area. 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.

$$M = \sum_{x=1}^{L} \sum_{y=1}^{L} [f_{x,y}(0) + f_{x,y}(1)], \text{ where L=1, 2, 3…256}$$

$f_{x,y}(0)$ = 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

Now, by using the above equation, we can calculate the area of the segmented tumor based on the typography and digital imaging units [21], where one pixel is equal to 0.264583 millimeters. i.e., 1 pixel = 0.264583 mm

Then the area of tumor can be expressed as follows:

$$A_{Tumor} = (\sqrt{P}) * 0.2646 mm^2$$

4. EXPERIMENTAL RESULTS

In this section, we had given an overview of conventional and proposed segmented results with the area of tumor. All the experiments have been done in MATLAB 2014a 32-bit version with

4GB RAM. We tested five set of images with various sizes such as 400x400, 512x512 and 600x600, which have the different stages of tumors. Then we evaluated the performance of conventional schemes Fuzzy c means, K-means and manually segmented algorithms with the proposed shaft algorithm for characterization of MR Brain tumors. The experimental results of MRI tumor detection using proposed algorithm and existing algorithms will be shown in below figure. By comparing the results our proposed approach for brain tumor detection will be more effective, accurate and reduced computational time. Figure 3 shows that the segmented outputs of manually segmented, FCM, K-means and proposed algorithms, we can observe that the proposed algorithm has detected the tumor more effectively with less computational time as shown in table-1.

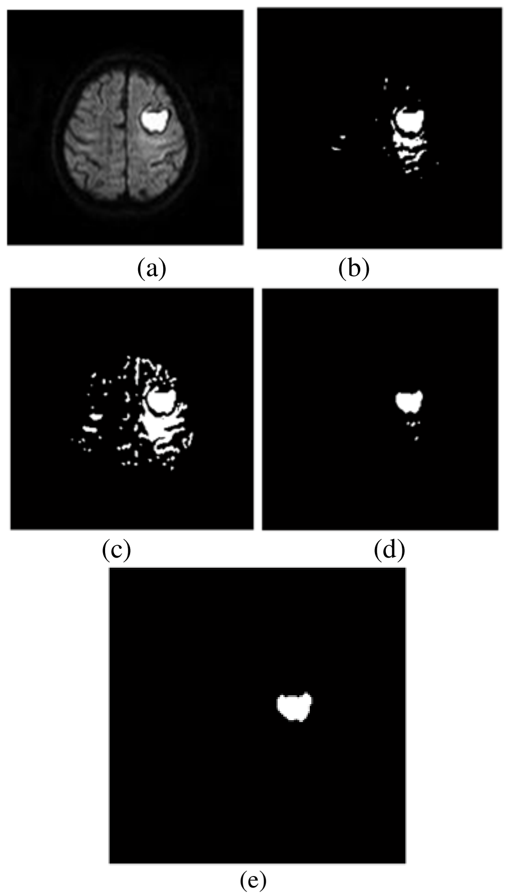

Figure 3. (a) Original Image (b) Manually Segmented Image (c) Fuzzy C Means Algorithm(d) K-means segmented image (e) Proposed method

In figure 4, we can see that the CPU computational time of existing and proposed algorithms for sample 1. It shows that the proposed algorithm has taken 0.2496 seconds to detect the tumor accurately as shown in fig 2 (e), and the existing algorithms have taken 11.2633 and 0.4056 seconds respectively. Area of tumor had given in figure 5, it shows that the proposed algorithm has got the accurate area compared with the existing algorithms FCM, k-means and even manual segmentation.

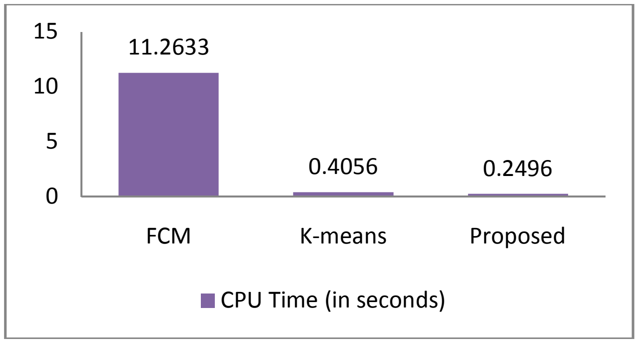

Figure 4 CPU time comparison of existing and proposed algorithms for sample 1

Table-1 Existing and proposed algorithms computational time (in seconds)

S. No.	Cluster algorithm	CPU Computation time (Seconds)				
		Sample1	Sample2	Sample3	Sample4	Sample5
1	Fuzzy C Means	11.2633	3.4008	2.9328	2.9172	4.4772
2	K-Means	0.4056	0.5148	0.4368	0.3432	0.9828
3	Proposed	0.2496	0.2340	0.2652	0.2808	0.2496

Table-2 Proposed and Conventional algorithms Tumor area inmm^2

S. No.	Clustered algorithm	Area of the tumor(mm^2)				
		Sample1	Sample2	Sample3	Sample4	Sample5
1	Manual Segmentation	8.8035	18.3038	18.8829	19.6782	22.6656
2	Fuzzy C-Means	13.6746	13.5954	13.4899	13.1497	18.9235
3	K-Means	6.1291	13.7077	13.5363	13.2053	19.0721
4	Proposed method	6.1462	12.1898	12.3602	11.6758	14.0442

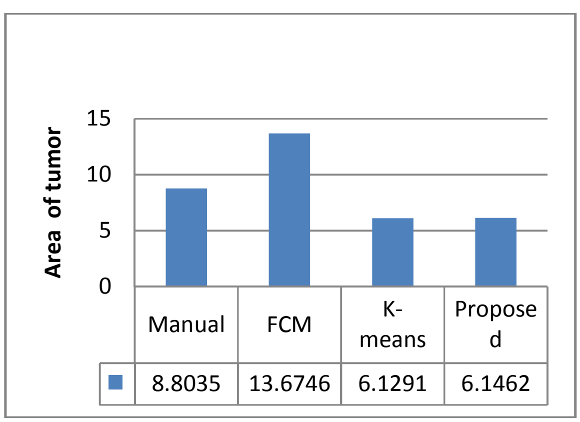

Figure 5 Comparison of tumor area for sample 1

5. CONCLUSION

Here in this paper, we had proposed a novel MR brain image segmentation for detecting the tumor and to find the area of the tumor with improved accuracy and reduced computational time. This paper deals with the new shaft algorithm for reducing the computational time and binarization method to calculate the area interms of mm^2 based on the typography and digital imaging units. We compared the simulation results with the existing algorithms with the proposed shaft algorithm then after we found the area of tumor and calculated the CPU computational time. Finally, the proposed algorithm has performed far better than the existing algorithms with reduced computational time.

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