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An Approach to Detect Bone Tumor using Comparative Analysis of Segmentation Techniques

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ABSTRACT

Bone cancer is a solitary, benign, intramedullary cartilage tumor that is usually located in the short tabular bones of the hands and the feet, the distal femur, the proximal humerus, and other bone. Medical image processing is the major exigent subject in the area of research. This paper presents the an approach for detection of bone tumor in MR images as MRI it has higher resolution. A projected approach integrates several pre-processing methods such as average filter to eliminate the blare and to flatten the images. This will raise the superiority of image. And pre-processing is also helpful for better segmentation of image. We have used Thresholding and morphological operations, k-means segmentation, fuzzy c-means segmentation, rough fuzzy c-means segmentation method to take out the tumor area.

Keywords - Medical Imaging, Segmentation of bone tumor; Thresholding and morphological; Clustering Techniques.

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I. INTRODUCTION

Cancer is an irregular growth of new tissues that can occur in the body organs recent years. There are several kinds of tumors in the body of humanoid like brain tumor, bone tumor, lung tumor, etc. which are perceived by doctors manually, but it takes more time. Medical imaging technique is accustomed to create humanoid body images for medical and investigation work. MRI is the best technique to obtain the images of human body as it is having high resolution. This paper suggests an approach for detection of bone tumor in MRI images. A suggested approach integrates pre-processing method and to remove tumor region we have used four image segmentation techniques, viz., Thresholding and Morphological operations, K-means segmentation, Fuzzy C-Means segmentation and Rough Fuzzy C-Means segmentation. An investigational result shows the evaluation of the segmentation methods used to recognize the bone tumor.

Medical image processing is an important field of research as its outcomes are intended for furtherance of health issues. Bone tumor grows when cells inside the bone split wildly creating a lump or mass of irregular tissues. There is a large class of bone tumor types which have different features. Two forms of tumors noncancerous and cancerous are there. The noncancerous tumor raises very large and press on adjacent tissues, once detached by surgery they don't usually reoccur. Cancerous tumor has a greater nucleus that looks different from a normal cell's nucleus and can also reoccur after they are detached.

Bone ailment has various stages which portrays its level of development.

- Stage I: the malignancy has not binge out of the bone. The cancer is not a influential one.
- Stage II: same as Stage I, yet it is a powerful tumor.
- Stage III: Tumors occur in various spots of the same
- bone (no less than two).
- Stage IV: The growth has binge to different body slices

II. RELATED WORK

In [1] author detected the bone tumor using k-means clustering from MRI scan imagery. To detect the tumor he used mean pixel intensity method. In this method he

defined the range for cancer. And those parts which falls out of thus range are non cancer part and he got 95% accurate result with less computational time. In [2] author does the proportional study on three segmentation methods to identify the brain tumor. The three methods are: histogram thresholding, K-means and fuzzy c-means segmentation. For detection of tumor he does the combination of three methods used. In [3] the bone tumor namely 'Enchondroma' is detected using the thresholding and morphological operations for accurate segmentation. In [4] Brain tumor is detected using three methods of segmentation: K-means segmentation, fuzzy c-means segmentation and region growing from MRI images. In [5] author used fuzzy set and rough fuzzy set theory. Then he combined these two methods and implemented modified rough fuzzy for detection of tumor. In [6] k-means clustering method is used and applied on MRI images. And then two morphological operations dilation and erosion are applied for accurate segmentation.

III.METHODOLOGY

A. Thresholding and Morphological Operations:

Thresholding method in segmentation is effective and very easy. This method converts the gray image into binary image that contains two values 1 and 0. So according to these two values such as min (0) and max (1) are decided to use for tumor detection. This method is effective for the high contrast images. Therefore we will take bone tumor images of high contrast. [3]

Algorithm:

1.) Take maximum vector from the image.

2.) If max>0.8 then

T=Max*0.7

3.) Else if Max<0.6%

It means that this image lies in dark range, So it will not be related.

T=0.6

4) Else

T= Max*0.6

5.) If b w(x y) is the threshold form of I (x y), then

b w(x y)= 1 if I(x y)>T
0 otherwise.

Thresholding is not sufficient for effective segmentation as in many cases the images may have false segmentation. So two morphological operations erosion and dilation are applied to the output of thresholded image. The erosion operation can be used to remove small objects and for this the MATLAB command imerode is used. Dilation operation can be used to extend the edges and the regions. And MATLAB command imdilate is used.

Erode [6]:

$$(f \ominus b)(x) = \inf_{y \in B} \left[f(x+y) - b(y) \right]$$

where, f(x) is the image , b(x) is the structuring element, B is the space defined for b(x) and 'inf' means infimum that is greatest lower bound or minimum intensity value of the image[6].

Dilate [6]:

$$(f \oplus b)(x) = \sup_{y \in E} \left[f(y) + b(x-y) \right]$$

where, f(x) is the image , b(x) is the structuring element, E is the Euclidean space defined for b(x) and 'sup' means supremum that is least upper bound or maximum intensity value of the image[6].

The disadvantage of thresholding method is that it does not take into account spatial characteristics. The threshold image have only two values either 'white' or 'black' that is 0 or 1. But the bitmap image have gray scale values from 0 to 255. This will cause some of the tumor cells to be wrongly interpreted or falsely segmented.

B. Clustering:

Clustering is the approach in which pixels are grouped to form the cluster, which is most closest among all clusters. A cluster is the collection of the entities those are similar between cluster but dissimilar to the entities fitting to the other clusters. Pixels which are having homogenous characteristics must belong to the same cluster and pixels must follow the homogeneity criteria in the same cluster. Clustering techniques provide better results for exact shapes, range and area of tumors or any sort of abnormal growth. The segmentation techniques used in this project are discussed below.

1) K-Means Clustering:

K-means is the hard clustering algorithm [2]. It is related to unsupervised cluster analysis algorithm. and obtain partitional clustering method [2]. It can be used as preprocessing step for other types of algorithms. It is an important technique in pixel-based method where these methods based on k-means clustering are simple and less complex as compared to other region based or edge based methods. In k-means technique firstly defining of number of cluster is done. Then cluster center is chosen randomly . After this the distance between each data point and each center are measured. The distance is called Euclidian function. By using the distance formula, single pixel is compared to all cluster centers. The cluster which is having shortest distance among all the clusters, the pixel will be moved to that cluster. After that the recalculation of the center is done. Again each pixel is compared with the cluster center and this process will be continued until the center converges.

Mathematical Representation

Calculation of cluster means M [2],

$$M = \frac{\sum_{i.c(i)=k} x_i}{N_k}, \quad k=1,\ldots\ldots,K$$

Calculate the distance between cluster center and each pixel [2]:

$$D(i) = \arg\min \left\| x_i - M_k \right\|^2, \quad i=1,\ldots\ldots,N$$

Repeat the above two steps until mean value converges.

Algorithm:

1. Give the no of cluster value as k.
2. Randomly choose the k cluster centers.
3. Calculate mean or cluster center.
4. Calculate the distance between each data point and each cluster center.
5. If the distance is close to the center then shift to that cluster.
6. Otherwise go to next cluster.
7. Re-estimate the center.
8. Repeat the process until the center doesn't move.

This algorithm minimizes the total distance of data points to the center of cluster, they are assigned to it. K-means clustering has the big advantage of being faster and easier to implement., but here the clusters need to be predefined [11]. The final clustering quality will depends on random selection of initial center. If it is chosen randomly, it will have different for different initial centers. So it should be carefully chosen to get our desire segmentation [11].

2) Fuzzy C-Means Clustering:

Fuzzy c-means is the clustering technique which allow one data point to belong to more than two cluster [2]. It is a soft clustering technique and unsupervised clustering algorithm. Logic for fuzzy is the structure of probabilistic logic which contains only approximate values. The fuzzy logic is the method of data processing by assigning partial membership values to every data pixel in the image [2]. A membership is the function which defines mapping of each data point in the input image to value of membership or degree of membership and it lies between 0 and 1. The equivalent of all membership values for any given pixel is equivalent to 1. The membership function gives the fuzziness of the image and also to define the information contained inside an image [2]. The full membership function contains value 1. The non-membership function contains 0.The intermediate or partial membership value ranging from 0 to 1 [2].

Mathematical Representation,

Objective Function [2]:

$$J(U, c_1, c_2, \ldots, c_n) = \sum_{i=1}^{c} J_i = \sum_{i=1}^{c} \sum_{j=1}^{n} u_{ij}^{m} \, d_{ij}^{2}$$

u_{ij} is from 0 to 1.

c i is centroid of i clusterthe centroid of cluster

dij is the Euclidian distance between centroid i the Euclidian distance between *ith* centroid (*c i*) and *jth* data point..

$m \in [1, \infty]$ is weighing exponent

Update of membership function is given by [2],

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \left[\frac{d_{ij}}{d_{kj}} \right]^{2/(m-1)}}$$

Clusters centers given by:

$$c_i = \frac{\sum_{j=1}^{n} u_{ij}^{m} x_j}{\sum_{j=1}^{n} u^{m}_{ij}}$$

Fuzzy c-means segmentation algorithm is efficient than other algorithms of clustering. But FCM is having major drawback that it takes more computational time.

Algorithm:

1.) Initialize $U = [\, u_{ij} \,]$ matrix, $U^{(0)}$

2.) matrix, k^{th} iteration, calculate center vectors c_i with u_{ij}

$$c_i = \frac{\sum_{j=1}^{n} u_{ij}^{m} x_j}{\sum_{j=1}^{n} u^{m}_{ij}}$$

3.) Update the membership matrix u for the kth step and $(k+1)^{nth}$

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \left[\frac{d_{ij}}{d_{kj}} \right]^{2/(m-1)}}$$

Where, $d_{ij} = x_j - c_i$

4.) If $\left\| U^{(k+1)} - U^{(k)} \right\| < \delta$ then stop, otherwise go to step number 2 [2].

Here, δ is the termination criterion from 0 to 1. FCM algorithm is efficient than other algorithms of clustering. But the main disadvantage of the FCM algorithm is takes more computational time required.

***3) Rough Fuzzy c-means Clustering*:**

Rough fuzzy C-Means segmentation gives the novel approach for management of uncertainty that is used for discovery of data dependencies, importance of the characteristics, sample data patterns, reduction of feature space dimensionality, and the objects classification. By using the rough fuzzy logic we are able to find the elements those completely belong to the particular cluster and also the set of elements which partially or probably belongs to that cluster. Thus the main function of this hybrid algorithm can be improved by applying method of fuzzy and rough fuzzy set. This algorithm can provide enhanced segmentation result than traditional algorithm.

Rough fuzzy algorithm is implemented by incorporating both methods, fuzzy and rough fuzzy sets by Jun-Hao Zhang, Ming- Hu Ha, Jing Wu. The rough fuzzy C-Means algorithm adds the logic of fuzzy membership of fuzzy method and upper and lower approximation of rough fuzzy set into c-means algorithm. While the fuzzy sets membership enables the capable management of overlapping partitions, the rough set deals with vagueness, uncertainty and incompleteness in class definition. The rough fuzzy C-Means partitions the set of n objects into c clusters by reducing the main objective function.

$$J_m(U,V) = \sum_{j=1}^{n} \sum_{i=1, x_j \in upper(w_i)}^{k} \mu_{ij}^m d_{ij}^2$$

Constraint conditions are:

$$\mu_{ij} \in [0,1], \quad 0 \le \sum_{j=1}^{n} \mu_{ij} \le N, \quad \sum_{i=1, x_j \in upper(w_i)}^{k} \mu_{ij} = 1$$

We also get membership formula RFCM algorithm as follows:

$$\mu_{ij} = \frac{1}{\sum_{l=1, x_j \in upper(w_i)}^{k} \left(\frac{d_{ij}^2}{d_{ij}^2} \right)^{\frac{1}{m-1}}}$$

Centroid calculation is done as follows:

$$v_i = \frac{\sum_{j=1}^{n} \mu_{ij}^m x_j}{\sum_{j=1}^{n} \mu_{ij}^m}$$

***Algorithm*:**

1.Determine the class number k(2 ≤ c ≤ n) , parameter m, initial matrix of member function, an appropriate number ε>0 and s = 0.

2. we can calculate centroids {vi(s)} by using equation

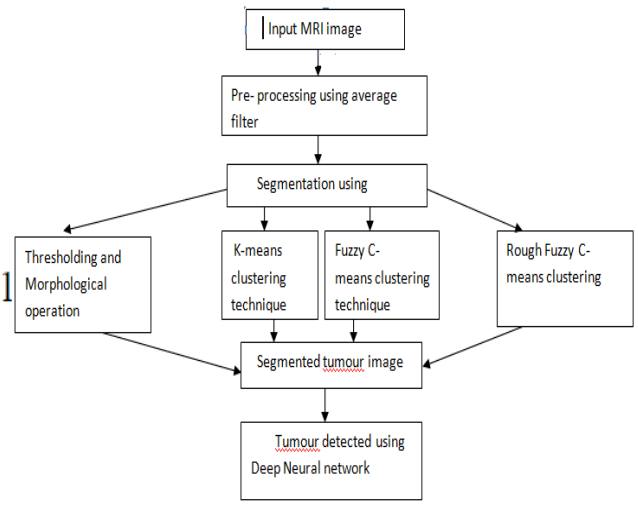
$$v_i = \frac{\sum_{j=1}^{n} \mu_{ij}^m x_j}{\sum_{j=1}^{n} \mu_{ij}^m}$$

3. If xj≠upper(wi) , then μij =0 . Otherwise, we can update μij(s) by using equation

$$\mu_{ij} = \frac{1}{\sum_{l=1, x_j \in upper(w_i)}^{k} \left(\frac{d_{ij}^2}{d_{ij}^2} \right)^{\frac{1}{m-1}}}$$

4. If ||U(s) −U(s+1) ||<ε , then stop, else s = s +1, go to the step (2).

IV. PROPOSED ALGORITHM



A. Dataset:

We have used the dataset from Radiopedia.org. We selected T1W, T2W, STIR, PD contrast enhanced images. It gives tumor in bright range. The reason for the selection of these type of images is that this techniques can be smeared on images to the tumor which is having higher intensity rather than other parts in bone. A set of MRI image contains two types of tumor, that are Enchondroma, Giant Cell Tumor are used for investigational result

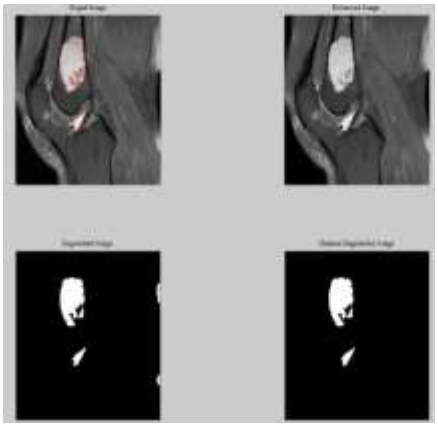
B. Pre-processing:

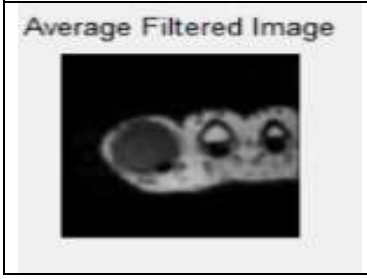
The proposed experimentation is started by performing preprocessing on MRI images having bone tumor. The major purpose of preprocessing is to enhance the superiority of images which make segmentation precise. To eliminate the noise filters are used because captured image has poor quality. And they are also essential for sanitization and stabilizing edges and smoothing faulty images made by MR imaging system. Average filter is chosen to execute preprocessing

C.Image Segmentation:

Partitioning image into many regions is called image segmentation. Aim of the segmentation is to remove beneficial information from images in medical imaging applications as well. Image segmentation algorithms are depends on two fundamental assets of image intensity values: that are incoherence and resemblance. In the formal category, the segmentation approach is depend on separating the processed image based on intensity changes. It includes methods like edge detection which segments an image which have diverse in intensity between the different regions. The second one is based on dividing an image into areas that are similar due to a set of predefined criteria. It includes region based segmentation and clustering techniques as it has some predefined criteria. Bone tumor segmentation means segregating tumor from non tumors tissues. Image segmentation is very challenging as it is difficult to select appropriate technique for a particular kind of image. Thus, there is no universally accepted method for image segmentation. Each technique has its own advantages as well its drawbacks, so it depends on the user which technique he uses to solve his problem to the best extent

Steps of segmentation:



Average filtered image	Thresholding and morphological operations
	

D. Thresholding and morphological operation:

Thresholding technique in segmentation is easy and effective. It converts the gray image into binary image which contains two values 1 and 0. So to detect the tumor minimum and maximum values are decided according to threshold values. It is very effective with the images with high level of contrast. So we will take the bone tumor images with high contrast.

E. Clustering Techniques:

1) K-means clustering:

K-Means clustering is a type of hard clustering algorithm. It belongs to unsupervised cluster analysis algorithm and achieves partitioned clustering method .K-means algorithm can be used as a preprocessing step in the other types of algorithms.. It is a important technique in pixel-dependent methods, where the pixel based methods which are based on the k-means clustering are simple and they are having relatively low computational complexity compared with other region based or edge based methods, the application is more practicable.

2) Fuzzy c-means clustering:

Fuzzy c-means method of clustering allows one pixel to belong to two or more clusters. It is a soft clustering technique. Fuzzy logic is a form of probabilistic logic which contains only approximate values. The fuzzy logic is method of processing the data by giving a partial membership value to each pixel in the image.

3) Rough fuzzy c-means clustering:

Rough fuzzy c-means provide the novel approach for management of uncertainty that is used for discovery of data dependencies, importance characteristics, patterns in sample data, reduction in feature space dimensionality and objects classification. We able to find out the essentials which belongs to particular cluster also the set of essentials which partially belongs to that cluster.

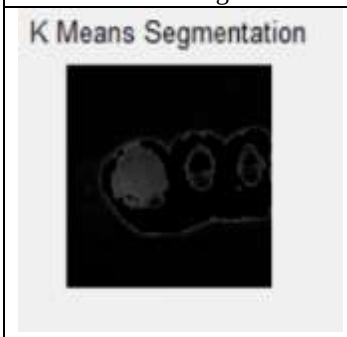
F. Tumor detected using neural network:

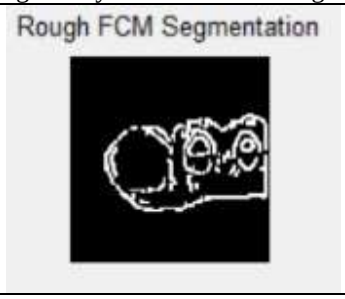
The clusters which is having high intensity data points are separated from the MRI image forms the tumor image. Some of the characteristics such as area, centroid and perimeter can be calculated from the tumor image. The neural network will shows that the image is affected or not.

V. EXPERIMENTAL RESULTS AND COMPARISONS

For investigational results we have taken the tumor images such as Enchondroma, giant cell tumor images from radiopedia.org. The proposed approach is

implemented in MATLAB14a. Following figures shows the comparison of all the segmentation methods used in this project.

K-Means clustering	Fuzzy C-Means clustering
	

Rough fuzzy C-Means clustering


From the above results, thresholding and morphological operations gives better result as per the location of the tumor, but segmentation is false as tumor and the other cartilage present in MRI images contains same intensity level, which can not be eliminated by morphological operations as it is big. In k-means method, it gives good results as per the location and shape, but segmentation is false as it depends on number of initialized clusters. In fuzzy c-means method we get better result as per the location but the shape is ineffective and it takes more time for computation. Lastly the rough fuzzy c-means gives best segmentation of image among all the methods and it takes less computation time than fuzzy c-means method.

The time comparison between four segmentation methods used is shown in following table. Here this time is measured in seconds. We observed that K-Means and Thresholding technique takes less computational time comparatively to Fuzzy C-Means and Rough Fuzzy C-Means.

	Time Taken In Seconds			
Images	Thresholding and morphological operations	K-Means clustering	Fuzzy C-Means clustering	Rough Fuzzy C-Means clustering
Enchondroma Tumor	0.0282	0.984	0.9193	0.0445
MRI RGB Tumor image	0.0497	1.4716	1.6652	0.4856
Osteoblastoma Tumor	0.1407	1.1167	1.1947	0.1569
Giant Cell Tumor	0.0404	1.7536	1.8712	0.1012

VI. CONCLUSION AND FUTURE WORK

After studying results we realize that rough fuzzy c-means gives more accurate results. In fuzzy c-means method false segmentation occurs and it takes more computation time. Thresholding and morphological takes less time for computation but the segmentation is false. The rough fuzzy method can be modified for further for medical imaging field and it segments the tumor cells more accurately. There is much scope for further research work and results can be improved by combining the algorithms of segmentation techniques. The features such as area, location, shape, stage can be calculated. Program can be enhanced to get more faster software possible. To have the more reliable system more security can be added by removing the problems that are faced in this system.

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