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Effect Of Noise over MRI Segmentation Techniques

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Abstract: *this approach is basically used to compare the extracted patterns of internal body tissues which were affected by various noises during acquisition. Segmentation is a computational intelligence discipline which has emerged as a valuable tool for disease analysis, new knowledge discovery and autonomous decision making. The raw, unlabeled data from the MRI image can be clustered first and after that segmentation can be applied in order to obtain the pattern or outlook of a particular organ or tissue so that diagnosticians can use them for diagnosing and finally analyzing the tissues. There are various algorithms which are used to solve this problem. In this paper two important segmentation algorithms namely centroid based K-Means and representative object based FCM (Fuzzy C-Means) clustering algorithms are compared. These algorithms are applied to the MRI image of thoracic cavity and performance is evaluated on the basis of the efficiency they provide when they are affected by various types of noises.*

Keywords: *Clustering, C Means, Fuzzy, Image Noises, K Means, MRI, Segmentation.*

I. INTRODUCTION

Image segmentation is one of the most important steps leading to the analysis of image data. The goal is dividing the image into parts that have homogeneous attributes, and have a strong correlation with objects or areas of the real world contained in the image, for general physical images. Image segmentation is an important technology for image processing. There are many applications whether on synthesis of the objects or computer graphic images require precise segmentation. MRI segmentation has been proposed for a number of clinical Investigations of varying complexity. In the clinical context, medical image processing is generally equated to radiology or "clinical imaging" and the medical practitioner responsible for interpreting (and sometimes acquiring) the image is a radiologist. Diagnostic radiography designates the technical aspects of medical imaging and in particular the acquisition of medical images. The radiographer is usually responsible for acquiring medical images of diagnostic quality, although some radiological interventions are performed by radiologists. Nowadays, medical image processing is among the most popular programs and there is no doubt that diagnosticians need them in the enhanced form so as to achieve the higher understanding of the internal tissues. Therefore, demand for image segmentation of medical images is very high. In the field of software data analysis is considered as a very useful and important tool as the task of processing large volume of data is rather tough and it has accelerated the interest of application of such analysis. To be precise segmentation is the analysis of datasets or images that are observational, aiming at finding out unsuspected relationships among datasets and summarizing the data in such a noble fashion that are both understandable and useful to the data users, the diagnosticians [1].Segmentation is a process of partitioning an image space into some non-overlapping meaningful homogeneous regions. In general, these regions will have a strong correlation with the objects in the image. The success of an image analysis system depends on the quality of segmentation. In the analysis of medical images for computer-aided diagnosis and therapy,segmentation is often required as a preliminary processing task.Medical image segmentation is a complex and challenging task due to the intrinsically imprecise nature. We used a basic idea to achieve the image segmentation of the thoracic cavity, introduce different types of noises and then analyze which of the two techniques provide better segmentation in spite of noise[2].In this paper we analyzed, K-Means and Fuzzy C-Means clustering algorithms and affect on them under different types of noise: Gaussian noise, Poisson's noise and speckle noise.we are using the standard database of thoracic cavity and then segmenting the images using fuzzy c means and k means algorithm , introducing noises of various types and then analyzing the results to see which algorithm is segmenting nicely inspite of the noises present.

II. MRI SEGMENTATION ALGORITHMS

In this paper two basic algorithms used are: Fuzzy C- Means Segmentation algorithm and K Means algorithm.

A). K-MEANS ALGORITHM

K-Means is one of the unsupervised learning algorithms for clusters. Clustering refers to the process of grouping pixels of an image such that pixels which are in the same group (cluster) are similar among them and are dissimilar to the pixels

which belong to the other groups (clusters). It is a simple clustering method and gives fast outputs as well, but the problem of choosing the correct clustered image is a big issue in K- means clustering [2][3][4].
Mathematically, for a given image, compute the cluster means M,

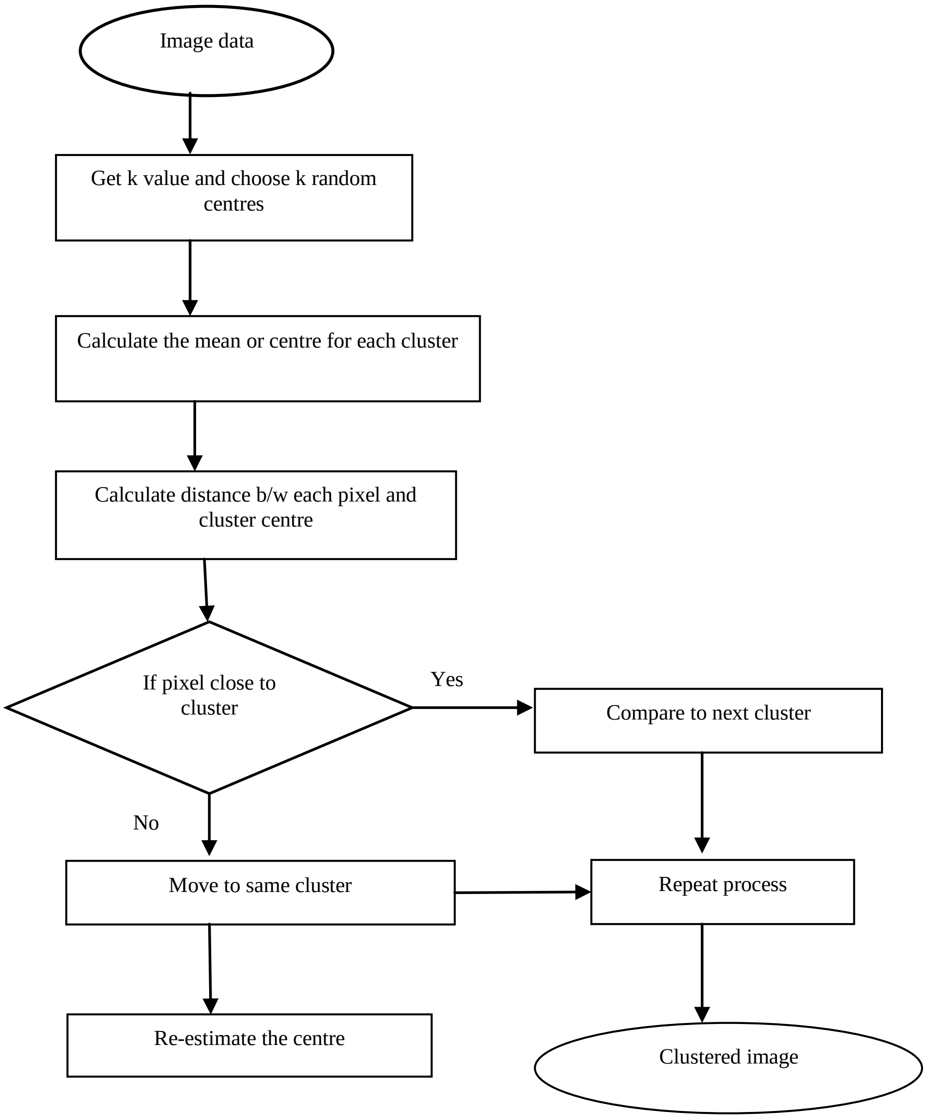
$M = \frac{\sum_{I:c(i)=k} x_i}{N_k}$, k= 1,…,k

Calculate the distance between cluster centres and each pixel:

$D(i) = \arg\min||x_i - M_k||^2$, i = 1 … N

Repeat the above two steps until mean value convergence .
This algorithm is shown through flowchart (Fig. 1).
The algorithm proceeds as:

1. Give the no of cluster values as k.
2. Randomly choose the k cluster centres.
3. Calculate mean or centre of the cluster.
4. Calculate the distance between each pixel to each cluster centre.



5. If the distance is near to the centre then move to that cluster.
6. Otherwise move to next cluster.
7. Re-estimate the centre.
8. Repeat the process until the centre doesn't move.

B). FUZZY C- MEANS SEGMENTATION ALGORITHM

The Fuzzy C- Means Algorithm was developed by Dunn in 1973 and later in 1981 it was enhanced by Bezdek. Fuzzy logic is a form of many-valued logic or probabilistic logic. It by definition only means approximate values rather than fixed and exact [4]. The fuzzy logic is a way to processing the data by giving the partial membership value to each pixel in the image. The membership value of the fuzzy set ranges from 0 to 1. Fuzzy clustering is basically a multi valued logic that allows intermediate values i.e., member of one fuzzy set can also be member of other fuzzy sets in the same image. There is no abrupt transition between full membership and non-membership. The membership function defines the fuzziness of an image and also to define the information contained in the image. There are three main basic features involved in this concept characterized by membership function. They are support, boundary and the core. The core is a fully member of the fuzzy set. The support is non-membership value of the set and boundary is the intermediate or partial membership with value between 0 and 1 [5].

Fig. 1 Flowchart of K- Means Clustering Algorithm

Mathematically; Fuzzy c-means (FCM) is the clustering algorithm which allows one piece of data may be member of more than one clusters. It is based on reducing the following function:

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ij}^m \, ||x_i - C_j||^2$$

where m is any real number > 1, u_{ij} is the degree of membership of x_i in the cluster j, x_i *is the*ith of d-dimensional measured data, c_j is the d-dimension center of the cluster, and ||*|| is any norm expressing the similarity between any measured data and the centre.
Then, Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership u_{ij} and the cluster centres c_j by:

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|}\right)^{\frac{2}{m-1}}}, \quad C_j = \frac{\sum_{i=1}^{N} u_{ij}^m . x_i}{\sum_{i=1}^{N} u_{ij}^m}$$

This iteration will stop when $max_{ij}\left\{||u_{ij}^{(k+1)} - u_{ij}^{(k)}||\right\} < \delta$ where δ is a termination criterion between 0 and 1, whereas k is the iteration step.
The algorithm consists of following steps:

1. Initialize U = [u_{ij}] matrix, $U^{(0)}$
2. At k-step, calculate the centre vectors $C^{(k)} = [c_j]$ with $U^{(k)}$

$$C_j = \frac{\sum_{i=1}^{N} u_{ij}^m . \, x_i}{\sum_{i=1}^{N} u_{ij}^m}$$

3. Update $U^{(k)}$ to $U^{(k+1)}$

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|}\right)^{\frac{2}{m-1}}}$$

4. If $\left\|U^{(k+1)} - U^{(k)}\right\| < \delta$ then STOP; otherwise return to step 2. [6][7].

III. EFFECT OF VARIOUS NOISES ON IMAGES

During the acquisition of the MRI images various types of noise gets introduced into the images which are not desirable as they degrade the quality of the image and hinder the efficient diagnosis. Is random (not present in the object imaged) variation of brightness or color information in images, and is usually an aspect of electronic noise. It can be produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector [6]. In this paper we will see the effect of three basic types of noise: gaussian noise, speckle noise and salt and pepper noise..

Gaussian noise in digital images arise during acquisition e.g. sensor noise caused by poor illumination and/or high temperature, and/or transmission [1] e.g. electronic circuit noise. A typical model of image noise is Gaussian, additive, independent at each pixel, and independent of the signal intensity, caused primarily by Johnson–Nyquist noise , including that which comes from the reset noise of capacitors . Fat-tail distributed or "impulsive" noise is sometimes called salt-and-pepper noise or spike noise. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions. This type of noise can be caused by analog-to-digital converter errors, bit errors in transmission, etc. It can be mostly eliminated by using dark frame subtraction and interpolating around dark/bright pixels. Dead pixels in an LCD monitor produce a similar, but non-random, display. Is a granular 'noise' that inherently exists in and degrades the quality of the active radar and synthetic aperture radar(SAR) images. Speckle noise in conventional results from random fluctuations in the return signal from an object that is too bigger than a single image-processing element. It increases the mean grey level of a local area. Speckle noise in SAR is generally more serious, causing difficulties for image interpretation. It is caused by coherent processing of backscattered signals from multiple distributed targets. In SAR oceanography, for example, speckle noise is caused by signals from elementary scatterers, the gravity-capillary ripples, and manifests as a pedestal image, beneath the image of the sea waves[8].

Figures below in the tables shows the effect of these noises on the MRI images. After that we will see the effect of each algorithm on each type of image affected by these three types of noises with three different types of noise variations The algorithms are applied on the noises taken at different variations and then analyzed.

IV. SOFTWARE REQUIREMENTS

There are two software requirements for this project. One is the platform or the simulator required to code and evaluates the algorithms which areMATLABS and the second one is the DATASET. Here a standard DICOM dataset is used. Specifications of the dataset used: - Modality: MRI, Dataset size: 41 MB, Alias name: CETAUTOMATIX, Description: cardiac MRI and MRA studies [9].

V.RESULTS AND ANALYSIS

The standard database is used for finding the final results. Both the algorithms, FCM and KMC are applied on the database. The simple segmentation of image is done by using both the algorithms, after that noise of three type:

- Gaussian
- Salt and pepper
- Speckle

are applied on each set of original image and then segmented to analyze the effect of noise on segmentation of images. Results obtained are tabulated ahead.
Each type of different noise used here is applied by changing the variation.

- Gaussian noise with variation 0.2, 0.02 and 0.002.
- Salt and pepper noise with variation 0.2, 0.02 and 0.002.
- Speckle noise with variation 0.2, 0.02 and 0.002.

Then segmentation at each variance is done as under:

GAUSSIAN NOISE with variance 0.2, 0.02, 0.002 has been applied to the images which are then segmented by using both fuzzy c means and kmeans segmentation algorithms. We can see that segmentation using kmeans is better for this very noise type for the high variance that is 0.2 and if noise of higher variance is added in case for fuzzy c means then a time will come when image will not be viewed any more. Still, k mean will still be able to show a little of segmented image. Higher effect of GAUSSIAN NOISE comes for fuzzy c means starts coming from 0.02 variance and for K MEANS from 0.002 and for kmeans the effect is not much higher at .02 and at 0.002 more effect is added but is still lesser than that of fuzzy c means (table 1).
SALT AND PEPPER NOISE with variance 0.2, 0.02, 0.002 has been applied to the images which are then segmented by using both fuzzy c means and kmeans segmentation algorithms. We can see that segmentation using fuzzy c means is better for this very noise type. As the effect of higher variance increases more for kmeans algorithm at 0.002 and for fuzzy c means the effect is still lesser at this very point (table 2).
This is crystal noise and effect of crystal noise is omitted to some extend by fuzzy c means algorithm as it is using membership values for assigning values to the clusters while in case of the k means algorithm, it is using the binary values or the crystal cut values ,the effect at 0.002 is very very high as compare to that of the fuzzy c means and thus the effect of noise is much more in this case.
SPECKLE NOISE with variance 0.2, 0.02, 0.002 has been applied to the images which are then segmented by using both fuzzy c means and kmeans segmentation algorithms. We can see that for the particular noise variance range that we have chosen here i.e. from 0.2, 0.02 and 0.002 ,the effect of this very noise is same for both the algorithms .However if we go on increasing the variance of the noise greater than that of the 0.2 may be .5, we can see that the effect of noise is again same .Therefore we can say that noise has same effect on both the algorithms (table 3).
As we can view and analyze from the images above that in each case, different noises have different effect on both the algorithms fuzzy C means and K means
ForGaussian noise K meansalgorithm is showing better results even at higher variance
For salt and pepper noise fuzzy C means is showing better results even at higher variance.
Forspecklenoise both the algorithms take same effect.

It can also be analyzed that Gaussian noise has greater effect on MRI images and image segmentation algorithms.

salt and pepper has lesser effect and speckle has the least effect.

VI. CONCLUSION

IF somehow salt and pepper and speckle noises get introduced during the acquisition of MRI, the segmentation using fuzzy C means and K means segmentation both take different effects of different noises.
For Gaussian noise K means segmentation algorithm is better.
For salt and pepper noise fuzzy c means algorithm is better.
For speckle noise both the algorithms have same effect.
Therefore we can conclude that with the range of noises that we used in our work, fuzzy C means and K means segmentation algorithms are providing different results with the effect of different noises.

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Table 1: Results of Comparison for Image affected by Gaussian noise.

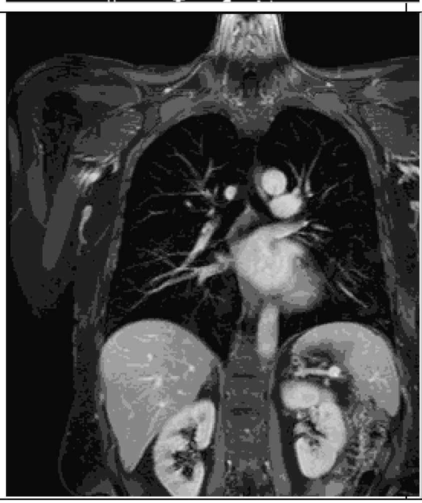
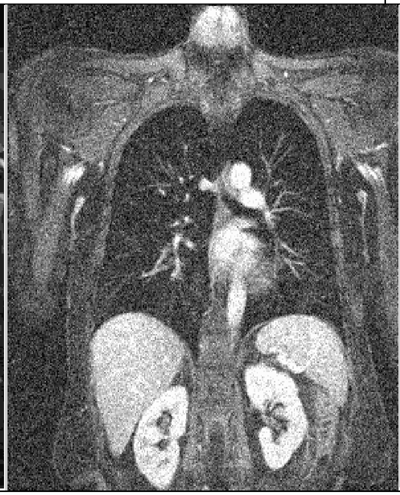
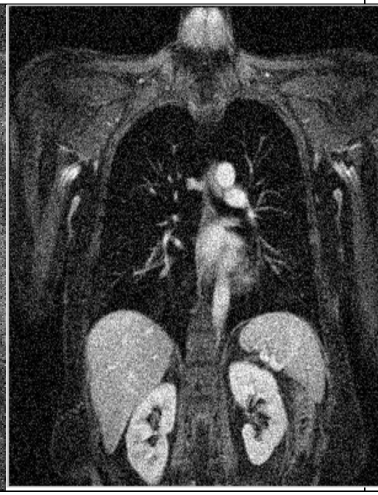
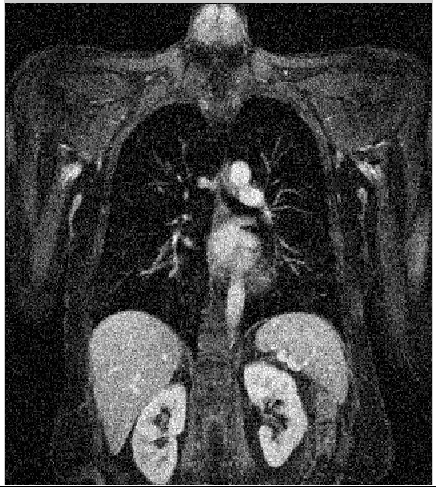
Variance		.2	.02	.002
Fcm				
Kmeans				

Table 2: Results of Comparison for Image affected by the salt and pepper noise.

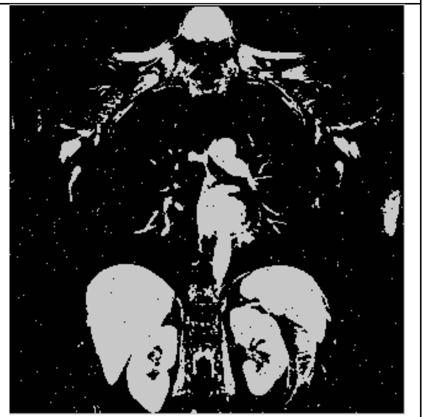
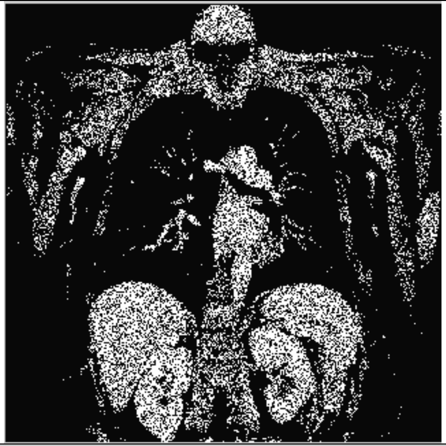
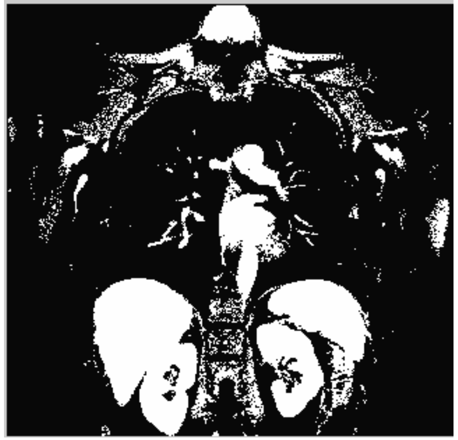
Variance		.2	.02	.002
Fcm				
Kmeans				

Table 3: Results of Comparison for Image affected by speckle noise.

Variance		.5	.2	.02
Fcm				
Kmeans