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Original Article

CT Image Segmentation Based on clustering Methods

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Summary:

Background: image processing of medical images is major method to increase reliability of cancer diagnosis.

Methods: The proposed system proceeded into two stages: First, enhancement stage which was performed using of median filter to reduce the noise and artifacts that present in a CT image of a human lung with a cancer, Second: implementation of k-means clustering algorithm.

Results: the result image of k-means algorithm compared with the image resulted from implementation of fuzzy c-means (FCM) algorithm.

Conclusion: We found that the time required for k-means algorithm implementation is less than that of FCM algorithm.MATLAB package (version 7.3) was used in writing the programming code of our work.

Keywords: CT, Image Segmentation, k-mean Clustering, Median Filtering.

Introduction:

Today medical imaging technology provides the clinician with a number of complementary diagnostic tools such as X-ray, computed tomography CT, Magnetic resonance imaging MRI, positron emission tomography PET. Routinely, these images are interpreted visually and qualitatively by radiologists. Advanced research requires quantitative information such as the size of the anatomical structure or relative volume of the structure. This requires the study of theories and algorithms for getting a precise description of the regions of interest. One of such algorithms is the segmentation of images to isolate objects and regions [1]. Digital image processing refers to processing of 2 dimensional picture by a digital computer Various problems encountered in image processing are image representation and modeling, image enhancement, image restoration, image analysis, image reconstruction and image data compression. Segmentation is one of the most important part in image analysis. Segmentation refers to the process of extracting the desired object (or objects) of interest of an image [2, 3]. In this study, a proposed system is suggested for segmentation of computed tomography (CT) image of a human lung based on clustering methods. Before segmentation of CT image, it is very important to reduce the noise and artifacts that result from acquisition step of a CT image .The process of removal or reduction of the noise is called image enhancement which was performed here using median filtering, after that the segmentation of an enhanced image was performed using two clustering algorithms, that are : (k-means and fuzzy C-means) algorithms. The results section of this paper presented the region description of different images that resulted from implementation of enhancement and segmentation stages. Last two sections presented the results with their discussions and conclusions that were deduced from this study.

Selection of Method and Subjects:

Cases were selected from patients attending Baghdad Teaching Hospital (15 cases) at the same period of the study. The selection of cases was conducted over a period of 5 months from October 2008 to February 2009.

Image Enhancement

After obtaining a CT image of a human lung with a cancer, the next step considered here is the procedures applied to remove the noise and correct the defects in the acquired image. The sources of noise in a CT image are due to imperfect detector, non-uniform illumination, the quality of the operating voltage, type of film (original or copy), film processing and patient movement [4]. In this study the stage of noise removal (image enhancement) was performed using the median filtering. A median filter is a non-linear processing technique based on order statistics. In this filter the brightness of each pixel is replaced by the median of brightness in a neighborhood of that pixel as illustrated in figure1 .

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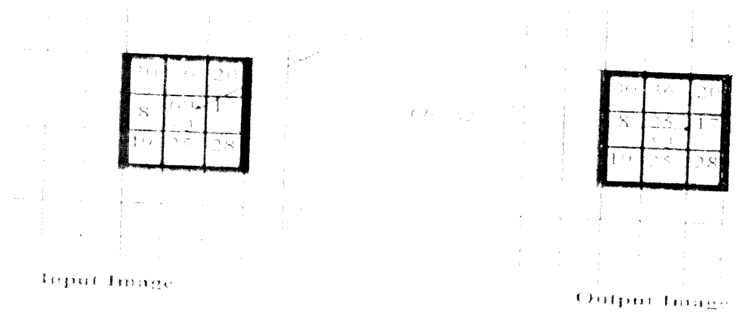

Figure1 Application of median filter on the pixel at location I(x,y) , creating the output at location O(x,y).

Median filter is an excellent rejecter of noise that may occur in radiographic CT image, for instance "shot" noise in which individual pixels are corrupted or missing from image. There are two principle advantages of median filter over other methods such as the methods which use multiplication by weight [5]:

1) The method does not reduce the brightness difference across steps, because the values available are only those present in the neighborhood region, not on average between those values

2) Median filtering does not shift the boundaries as averaging may, depending on the relative magnitude of values present in the neighborhood.

Image Segmentation

Segmentation is the partitioning of a scene into different meaningful regions , by identifying regions of an image that have common properties while separating regions that are dissimilar [6,7]. Segmentation of medical imagery is a challenge task due to the complexity of the images, as well as to the absence of the models of the anatomy that fully capture the possible deformations in each structure [8, 9].Segmentation of CT image could be performed using clustering algorithms.

Clustering Algorithm

Clustering algorithm attempts to assess the interaction among patterns by organizing the patterns into cluster such that patterns within a cluster are more similar to each other than are patterns belonging to different cluster. Clustering algorithms can be divided into two classes: hard and fuzzy. In hard clustering, each data point is assigned to one and only one of the clusters. In fuzzy clustering each data point belongs to each cluster with a certain degree of membership or belonging in the interval [0-1] [10,11].

k-means algorithm

The k-means algorithm assigns each point to the cluster whose center (also called centroid) is nearest. The center is the average of all the points in the cluster-that is, its coordinates are the arithmetic mean for each dimension separately over all the points in the cluster. The algorithm steps are [12,13]:

- Choose the number of clusters , k.
- Randomly generate k clusters and determine the cluster centers, or directly generate k random points as cluster centers.
- Assign each point to the nearest cluster center
- Recompute the new cluster centers
- Repeat the two previous steps until some convergence criterion is met (usually that the assignment hasn't changed)

Fuzzy C-means (FCM) algorithm [ ]

FCM is a commonly used clustering approach . It is a natural generalization of the K-means algorithm allowing for soft segmentation based on fuzzy set theory. To classify a data set of N data items into C classes FCM can be formulated as a minimization problem of the objective function J with respect to the membership function u and centroid v, where J is given by:

$$J = \sum_{k-1}^{C} \sum_{j-1}^{N} u_{ki}^{D} D_{ki}^{2} \qquad \ldots\ldots 1$$

and it subject to

$$u_{ki} \in [0,1], \sum_{k=1}^{C} u_{ki} = 1,$$

$$0 < \sum_{i}^{N} u_{ki} < N,$$

$$1 \leq i \leq N, 1 \leq k \leq C.$$

Where D is the Euclidean distance. $D_{ki} = \|y_i - v_k\|, D_{k,j} = \|y_i - v_j\|$ are the Euclidean distances between the observed data y_i and the class centroides, v_k and v_j. u_{ki}^{D} is the membership value reflecting the degree of similarity between $y_i and v_k$.

Taking the first derivatives of J in (1) with respect to u_{ik}, v_k we can obtain the following necessary conditions to minimize the objective function J:

$$u_{ik} = \frac{1}{\sum_{j=1}^{N}\left(\frac{\|y_i - v_k\|}{\|y_i - v_J\|}\right)^{2/(m-1)}} \quad \text{..........2}$$

$$v_i = \sum_{i=1}^{N}(u_{ki})^m \cdot y_i \Big/ \sum_{i=1}^{N}(u_{ki})^m \quad \text{.........3}$$

Where m is a parameter determining the mount of fuzziness of the clustering results (here we used m≥ 1, if m=1, then the algorithm degenerates to the "crisp" K-means clustering algorithm, so we suppose m>1 in this study).After initialization of the centroids, u_{ki} and v_k are iteratively calculated until some stop criteria are reached. Finally, the segmentation can be obtained by the principle of maximum membership.

System Overview:

Now, we will introduce the system that was developed for processing of computed tomography (CT) image of human lung with abnormal tissues (cancer). All theories and algorithms that were used in implementation of this systems were described previously (image enhancement and image segmentation sections).

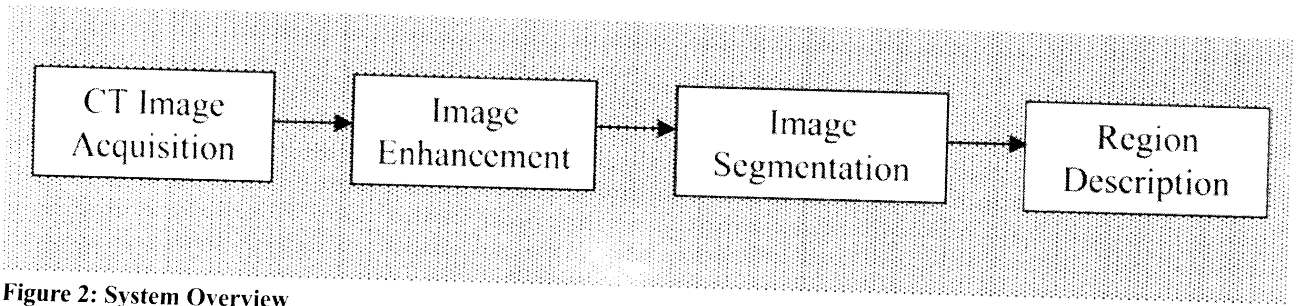

Figure 2: System Overview

The image acquisition step represents the first step in the proposed image segmentation system in this study. This step was performed through collection of 15 cases from patients attending Baghdad teaching hospital for a period of five months. In this step , the noise and artifacts were introduced to the CT image, Thus we denoised the noise through image enhancement stage which was performed using median filtering technique.

After image enhancement technique had been performed, the resultant image entered to the most important stage in the system that is image segmentation stage. In this stage the enhanced image segmented using two types of clustering : first: hard clustering that was implemented using k-means algorithm, second: fuzzy clustering which was performed using fuzzy C-means algorithm. Then we noticed the differences between two algorithms and presented these differences in the discussions of the obtained results.

Results:

1. Image Enhancement

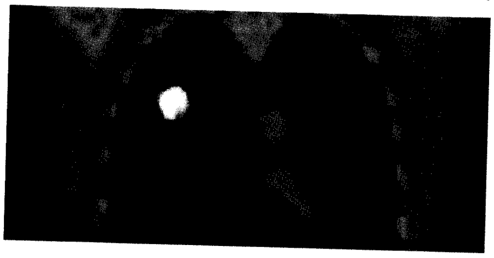

Figure (1.a) An Input CT image

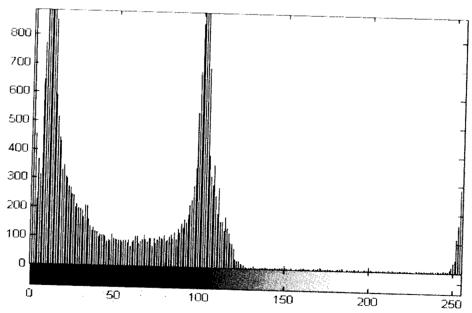

Figure (1.b) Histogram of an Input Image

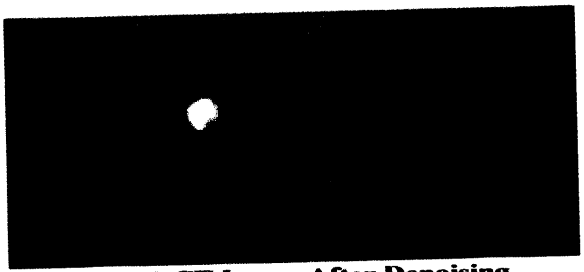

Figure (1.c) CT Image After Denoising

mage Segmentation

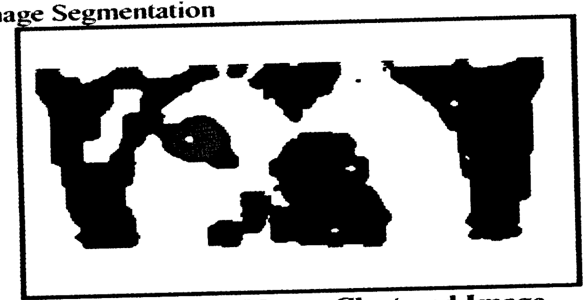

Figure 2.a CT k-Means Clustered Image (gray scale)

Figure 2.b CT k-Means Clustered Image (color scale)

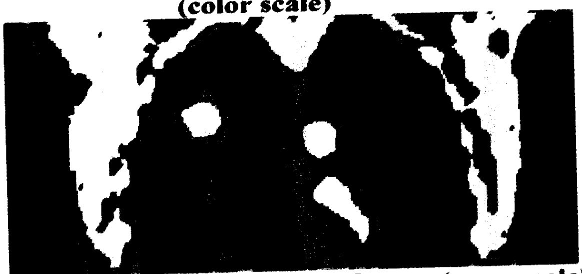

Figure 2.c FCM Clustered Image (gray scale)

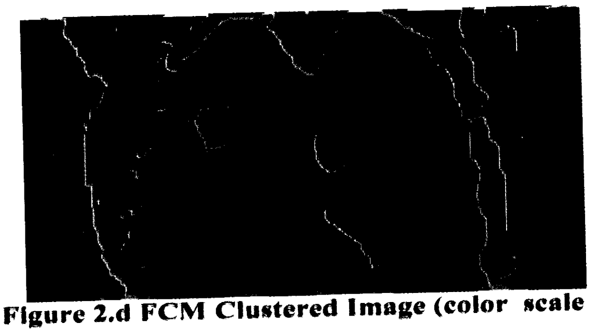

Figure 2.d FCM Clustered Image (color scale

Discussion:

1. Image Enhancement

Figure (1.a) show an input CT image of human lung with a tumor. The histogram of an input CT image figure (1.b) show the complexity of medical images. This complexity resulted from the limitations that found in the imaging CT equipment. Also, the complication may result from the overlapping of the classes of tissues of the lung. This complexity resulted in the noise and artifacts that were processed using median filter as shown in figure (1.c).One could notice that the edges of CT image were preserved using this type of filter and avoid the blurring of the image that may be result using another type of filter such as Gaussian filter. 2. Image Segmentation

From implementation of k-means algorithm, we noticed that there is no general solution to find the convenient and optimal number of cluster, this problem was solved using a comparison the results of multiple runs with different k(cluster) classes and choose the best one according to the result we want to obtain ,figure (2.a,b) with gray and color scales respectively show the CT image after implementation of k-means algorithm.

The second clustering method for segmenting CT image was implementation of fuzzy C-means clustering technique. We applied FCM algorithm and obtained image with 7 clusters figure (2.c) with gray scale, figure (2.d) with color scale. According to the membership, the data of CT image was clustered into 7 clusters (groups) depending on the Euclidean distance. The regions of normal tissues were obviously separated into different clusters from that of abnormal tissue (cancer).

Conclusion:

From implementation of the proposed system for segmenting CT image of the human lung several conclusions were deduced that are: the task of CT image segmentation is a complex task and still at the stage of laboratory research. K-means algorithm is simple and has short time for implementing it (i.e. high speed), this leads to the ability for running this algorithm on a large datasets, but, with each running , the result is change because k-means clustering algorithm depend on the initial random assignment. k-means clustering algorithm has clusters of membership 0 or 1(i.e. each point in the image belongs to the object or to the background), while in fuzzy C-means algorithm each point in the image belongs to each cluster with a certain degree of membership ranging in [0-1] interval. Thus, FCM is more flexible than k-means clustering but it takes longer time in implementation.. Median filter is a good technique for medical image enhancement because it is very effective in the reduction of noise and preserving the edges of the image. Generally, this work showed the ability for using of computer algorithm to describe the radiologist viewing that was very clear in the implementation of several digital image processing techniques on a CT image.

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