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INVESTIGATION ON CLUSTERING ALGORITHMS IN MRI IMAGES

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ABSTRACT

Brain tumor is an accumulation of abnormal cells in the brain. Detection of tumor from magnetic resonance imaging (MRI) brain scan is one of the most promising research topics in medical image processing. This paper presents a novel tumor detection system in MRI images using k-means technique integrated with Fuzzy c-means (FCM) clustering algorithm and artificial neural network (ANN). ANN is used to classify the MRI images into two categories; normal and tumor image. The proposed system takes benefit of both integrated algorithms in the aspect of minimal computation time and accuracy. The method proposed in this paper is fuzzy c-means (FCM) and is compared with K-Means segmentation. Followed by tumor detection which will display the presence of a tumor as Abnormal brain whereas the absence of tumor as a normal brain. In the different clusters obtained, it shows different elements of the brain such as white matter, gray matter, edema and CSF (Cerebrospinal fluid) and tumor. A user-friendly environment is created by using GUI in MATLAB which in turn saves the precious time of doctor to diagnose the tumor automatically. Performance analysis using various parameters such as PSNR, Global Consistency error (GCE), Variation of Information (VOI), area, elapsed time, reproducibility, and Rand Index (RI) is done.

INTRODUCTION

Nowa day‟ssegmentation of medical images is very important as the images are large in number for diagnosis by radiologist. Image segmentation method is utilized to find objects and boundaries in an image. It is an important tool in medical image processing [1,2,3]. A segmentation of the brain structure from magnetic resonance imaging (MRI) has received much importance in recent times as MRI distinguishes itself from other modalities.MRI has as additional advantage as it can be applied in the analysis of brain tissues. Segmentation technology has greatly increased knowledge of normal and diseased anatomy for medical research and is a vital component in diagnosis and treatment planning. The objective of division is to improve and change the representation of a picture into something that is more genuine and easier for analysis. The basic attribute for segmentation are edges and texture. The result of segmentation method gives a set of regions that altogether cover the whole image which are extracted from the image. There are many conventional methods of MRI segmentation such as seed based region growing, partial differential equation (PDE) level set segmentation, graph based segmentation, split and merge based segmentation, edge based segmentation, clustering based segmentation. The problem with all these methods is that they need human interaction for accurate and authentic segmentation.

This paper deals with an automatic approach for brain tumor segmentation and detection. Basically, the tumor is an unconstrained growth of tissues in the brain. This tumor, when turns into cancer become potentially fatal. So in medical imaging, it is necessary to detect the perfect location of a tumor and its type. For detection and identification of brain tumor, MRI is the better option. A brain tumor is an intracranial mass produced by an unconstrained growth of cells either normally found in the brain such as neurons, cells, blood vessels,

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pituitary and pineal gland, lymphatic tissue, skull or spread from cancers predominantly located in other organs. Brain tumors are classified based on the location of the tumor, the type of tissue involved whether it is benign or malignant [1] [3]. 1) Benign brain tumor: This type generally does not consist cancer cells and can be removed. It usually has an obvious border or edge. They don't spread to other parts of the body. However, benign tumors can cause serious health issues. 2) Malignant brain tumor: This consists cancerous cells and hence also called as brain cancer. They grow rapidly and can affect nearby healthy brain tissues. This can be a threat to life. Depending on the type of cell causing tumor, doctor groups brain tumor by grades. Over time, a low-grade tumor may become a high-grade tumor. For diagnosis of brain tumor, MRI provides rich information about the basic structure, enabling quantitative pathological or clinical studies. The fundamental aspect that makes segmentation of medical images difficult is the complexity and instability of the anatomy that is being imaged. It may become impossible to locate certain structures without detailed anatomical mastery. This makes general segmentation complicated, as the information must either be built into the system or provided by the operator. For this, Matlab R2014b version 8.4 is used over the 64-bit operating system on intel (R) core i5 processor with inbuilt 4 GB RAM and 500GB hard disk.

Brain tumors are formed by collection of abnormal cells that grows uncontrollable. Diagnosis of brain tumors is done by detection of the abnormal brain structure. The internal structure of brain can be viewed by magnetic resonance imaging (MRI) and computed tomography (CT) scans. Compared to CT scan, MRI scan is more efficient and it doesn’t affect the patient body as no radiations are used. MRI scanning is done by using radiofrequency and magnetic field [1]. MRI images are analyzed by the radiologists to diagnose the tumor. Segmentation of images is important as large numbers of images are generated during the scan and it is unlikely for clinical experts to manually divide these images in a reasonable time.

Image segmentation refers to segregation of given image into multiple non-overlapping regions. Segmentation represents the image into sets of pixels that are more significant and easier for analysis. It is applied to approximately locate the boundaries or objects in an image and the resulting segments collectively cover the complete image [2]. The segmentation algorithms works on one of the two basic characteristics of image intensity; similarity and discontinuity [3]. In the former, segmentation technique is based on dividing an image into set of pixels that are similar to the some predefined criteria. The latter partitioning works on the changes in intensity of an image, such as corners and edges. Segmentation has a significant part in clinical diagnosis and can be useful in pre-surgical planning and computer assisted surgery. Therefore, numerous segmentation techniques are available which can be used widely, such as threshold based segmentation, histogram based methods, region-based (region growing, splitting and merging methods), edge-based and clustering methods (expectation maximization, k-means, FCM and mean shift) [4]-[6]. Clustering methods are most promising technique for processing the medical images. Cluster analysis can be set out as a pre-processing stage for other methods, namely classifiers that would then run on selected clusters [7]. Therefore in our system, we have used clustering segmentation techniques for diagnosis of tumor and calculating tumor area in MRI images.

2. RELATED WORK

Exhaustive work has been done by several researchers in the area of image segmentation.Zaldeh (1965) introduced fuzzy set theory to clustering concept so it is named as fuzzy clustering. Matthew C. Clark et. al (1998) [4], proposed artificial intelligence techniques based on automated segmentation method using FCM and multispectral tool. Using a multi-layer Markov random field framework, Gering, et. al

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(2002) [5] proposed a method that identifies deviations from normal brains. M.N. Ahmed et. al (2002) [6], proposed a automatic segmentation technique using a new biascorrected FCM (BCFCM) algorithm for adaptive segmentation and intensity correction of MRI. Liang Liao et. al(2007) [7], proposed a method using more robust kernelized algorithm by joining Gibbs spatial constraints for the fuzzy segmentation of MRI data. J. J. Corso, et. al (2008) [8], proposed method used multichannel MRI volumes to detect and segment brain tumor. Fuzzy clustering is a very famous technique for detecting brain tumor. It has demonstrated the fuzzy clustering approach which provides better results for multi sequence data. Nikhil R. Pal et. al proposed the fuzzy-possibilistic c-means (FPCM) (2005) algorithm. Hathaway and Hu, (2009) have been proposed a new technique to improve the performance of standard FCM algorithm and to reduce its computational complexity. S.R. Kannanaet. al (2012), proposed a robust FCM algorithms with kernel functions for segmentation of brain and breast medical images. Vida HaratiRasoulKhayatiet. al (2011), proposed a fully automatic method for tumor region detection in brain MRI. Cai. Et Al. proposed the fast generalized FCM (FGFCM) algorithm, which can significantly reduce the execution time by clustering on the gray-level histogram rather than on pixels. It is less sensitive to noise to some extent because of the introduction of local spatial information. Maoguo Gong et. al (2012) proposed reformulated fuzzy local information C-means clustering algorithm (RFLICM) segmentation technique.

Many researchers have suggested several methodologies and procedures for medical image segmentation and techniques for tumor detection. These include region growing, thresholding, mean shift methods, clustering and statistical model. H. Suzuki and J. Torwaki [8], developed an algorithm for automatic segmentation of head MRI images using thresholding techniques. The algorithm consists of three incremental steps; histogram analysis to locate the brain and next step is to create a mask using nonlinear anisotropic diffusion and thresholding to segregate brain from detected head region. Finally active contour model is applied to detect intracranial boundary.

Bandhyopadhyay sk, paul proposed a segmentation technique based on k-mean clustering with dual localization that effectively segment tumor from brain MR images. After optimal segmentation, histogram and line scan method are applied to estimate breadth, length of tumor along xy-axis.

Shen, William sansharm designed a fuzzy brain tissue segmentation method by applying new extension to FCM. In segmentation, they considered two influential factors to address the issues in neighborhood attraction. Finally, proposed techniques were tested for simulated, square and hospital collected MR images, at different noise levels.

Lemieux, G. Hahemann et al. presented an automatic segmentation technique for brain in T1-weighted MR imaging data by applying thresholding and morphological operations. Their segmentation technique is independent of imaging scan orientation. They evaluated the performance by comparing results with semi-automated measurements.

3 WORK METHODOLOGY

The implemented system has mainly five modules asimage acquisition, image enhancement, segmentation of image using K-means algorithm, segmentation of image using RFLICM algorithm, feature extraction. The implemented method is a combinationof K-means and RFLICM algorithms. In the literature survey found that the conventional FCM algorithm is noise sensitive and complex [13,14]. In order to compensate this Maoguo Gong et. al [14] introduced RFLICM algorithm with weighted fuzzy factor local similarity measure. This method makes a tradeoff between image detail and noise. Fig. 1 shows system block diagram of implemented method.

A. Implemented System's Block Digram

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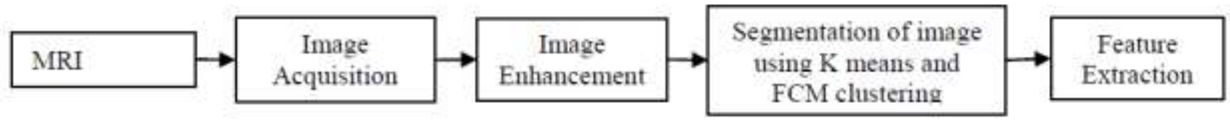

Fig. 1. System block digram

B. Image acquisition

MRI brain images for processing are obtained from internet database having featureT1-weighted (T1W), T2-weighted (T2W) and T2 Flair. The images contain soft brain tissues such as WM, GM and CSF are surrounded by bone structure. The WM, GM and CSF of the brain are represented by white, gray and black colors respectively except the background black color. These images are available in joint photo graphic (.jpg) format.

C. Image Enhancement

The enhancement method consists of two steps as median filter to reduce noise and unsharp mask (USM) filter for edge sharpening. This technique is applied to input data in order to remove noise and to sharpen edges.It"s necessary in order to assure that image satisfies certain assumptions for good segmentation according to Haralick and Shapiro [3]. Filtering can be utilized to take out undesirable components of noise.Median filtering is a prevalent technique of the image enhancement to remove salt and pepper noise without effectively reducing the image sharpness. Here, the median procedure was performed by sliding a 3x3 windowing operator over the image. Next step is USM is a classical tool for sharpening image [16, 17,18]. It is process that enhances edges and other high frequency parts in images. The USM improve the visual quality of images by emphasizing their high frequency portions that contain fine details. The two steps of unsharp mask filter [16] are mentioned equation(3.1) and (3.2) unsharp mask filter makes edges image g (x, y) from input images f (x, y).

$$g(x,y) = f(x,y) - fsmooth(x,y)$$

Where, f smooth (x, y) is a smoothed form of f (x, y) (gaussian blur algorithm) the edge images from the result of subtracting input images from low pass signal could be utilized for image sharpening by adding it into the input signal.

$$fsharp(x,y) = f(x,y) + \alpha * g(x,y)$$

Where, α is a scaling constant range 0-1.When α >1, the process is referred to as high boost filtering.The essential point of interest of the unsharp filtering over other sharpening filters is the control flexibleness on the grounds that a larger part of other sharpening filters does not supply any user-adjustable parameters.

D. K-means Segmentation method

K-means clustering applied to output images of USM technique. K-means clustering [13] is the unsupervised learning algorithm. Clustering the image is gathering the pixels as per some attributes. In the K-means algorithm first need the number of clusters k. Then centers of k-cluster are chosen randomly. The distance between each pixel to each cluster center is calculated. The distance may be about simple Euclidean function. A single pixel is compared to all cluster centers utilizing the separation equation. The pixel is moved to specific cluster, which has the shortest distance among all. At that point the centroid is re-estimated again each pixel is compared to all centroids. The methodology proceeds until the center converges. Segmentation task is performed using orthonormal operators. Images having the tumor are processed using K-means clustering and significant accuracy rate of 75% is obtained [19]. The K-means algorithm divided into eight steps as follows:

1) Give the number of cluster values as the k.
2) Centers of the k - cluster are chosen randomly (μ).

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3) Calculate mean or center of each cluster (μu (i)) given in (3.3).
4) If the distance is near, the center (μ==old μ) then moving to that cluster.
5) Calculate the distance between each pixel and each cluster center given in (3.4).
6) Otherwise, move to the next cluster.
7) Re-estimate the center.
8) Repeat the above process until the center does not move.

Mathematical representation to compute the cluster means μ

$$\mu = \frac{\sum_{i:c(i)=k} x_i}{N_k}, k = 1 \ldots\ldots K$$

E. Segmentation Using Improved Fuzzy C-Means

Improved FCM applied to the final segment image of K-means segmentation. Clustering procedures fabricate a panel of data into clusters with similar entities grouped in a cluster and dissimilar entities in different clusters. In clustering process, the dissimilarity between any two elements of the dataset can be computed using distance measures. The fuzzy logic is a way preparing the information by giving the partial membership value to each pixel in the image. The membership value of the fuzzy set is ranging from 0 to 1. Among the clustering methods, the FCM algorithm is a standout amongst the most well-known routines since it can retain more data from the original image and has vigorous qualities for ambiguity. However, the traditional FCM algorithm is very sensitive to noise so it does not consider any information about the spatial context. Recently, Krindis and Chatzis proposed a robust FLICM clustering algorithm to remedy the above shortcoming. The characteristic of FLICM is the use of a fuzzy local similarity measure which is aimed at guaranteeing noise insensitiveness and also the image detail preservation. A novel fuzzy factor is brought into the FLICM to improve the clustering execution [14]. The fuzzy factor can be defined mathematically as follows:

m = fuzzification factor (2),xi= Image, C=represents the prototype value of the ith cluster (Vk)

$$G_{ki} = \sum_{j \in N_i} \frac{1}{d_{ij}+1} \left(1-u_{kj}\right)^m \left\| x_i - v_k \right\|^2$$

Lobe classification and stage classification

Lobe classification is applied to output image of RFLICM to find the position of tumor.Firstly obtained the centroid of tumor using MATLAB function „regionprops ()‟‟ which gives position of centroid with respective x-axis and with respective y-axis. Then the size of tumor calculated using MATLAB command „size ()‟‟ and columns of the image are divided into two equal partsand then compared with the x-axis position of the tumor. After the compassion it detects the tumour presence in right or left lobe.Stage classification applied to output images of RFLICM to find the stage of tumor classified on local based staging on a single slice. SVM has been used for tissue classification into two classes, namely stage 1 and stage 2. It is based on the concept of hyper plane that depicts choice limits. The principle motivation behind SVM is a change of information into higher measurement space in such a way where hyper plane divides with maximal separation from the closest preparing data.

CONCLUSION

In this paper an algorithm using Matlab GUI has been developed for the segmentation and detection of brain tumor from MRI brain scanned images based on various operations like pre-processing, Fuzzy C- means and K-means segmentation, feature extraction. The two algorithms K-means and FCM algorithm were successfully implemented. Comparison of these algorithms is done on the basis of time, tumor area and reproducibility, PSNR, RI, GCE, and VOI. The proposed method gives 98% accuracy in detection and 96% and 89% accuracy in segmentation using FCM and K-means respectively. The results obtained conclude that

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the efficiency of FCM is comparatively better than K-means algorithm for overlapped datasets. In future, this system can be implemented with some other algorithm which will give more accuracy and save more time.

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