International Journal of Engineering (IJE)
Singaporean Journal of Scientific Research(SJSR)
Vol 6.No.2 2014 Pp. 111-118
available at:www.iaaet.org/sjsr
Paper Received :10-03-2014
Paper Accepted:20-03-2014
Paper Reviewed by: 1Prof.Dr.Kabilan 2. Chai Cheng Yue
Editor : Dr. Binod Kumar

A STUDY OF IMAGE SEGMENTATION TECHNIQUES ON BRAIN MRI IMAGES

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ABSTRACT

Automated brain tumor detection from MRI images is one of the most challenging task in today's modern Medical imaging research. Magnetic Resonance Images (MRI)are used to produce images of soft tissue of human body. It is used to analyze the human organs without the need for surgery. Automatic detection requires brain image segmentation, which is the process of partitioning the image into distinct regions, is one of the most important and challenging aspect of computer aided clinical diagnostic tools. Segmentation is used to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in MRI images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of MRI image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (edge detection). Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture, in this paper various (existing)segmentation algorithm has been studied a and implemented using MATLAB.

***Keywords**: MRI, Brain, Image segmentation,Thresholding, K-means clustering, Fuzzy c-means Clustering*

1. INTRODUCTION

Medical images play vital role in assisting health care providers to access patients for diagnosis and treatment. Studying medical images depends mainly on the visual interpretation of the radiologists. However, this consumes time and usually subjective, depending on the experience of the radiologist. Consequently the use of computer-aided systems becomes very necessary to overcome these limitations. Artificial Intelligence methods such as digital image processing when combined with others like machine learning, fuzzy logic and pattern recognition are so valuable in Image techniques can be grouped under a general framework; Image Engineering (IE). This is comprised of three layers: image processing (lower layer), image analysis (middle layer), and image understanding (high layer), as shown in Fig 1. Image segmentation is shown to be the first step and also one of the most critical tasks of MRI image analysis. Its objective is that of extracting information (represented by data) from an image via image segmentation, object representation, and feature measurement, as shown in Fig 1. Result of segmentation; obviously have considerable influence over the accuracy of feature measurement [2]. The computerization of medical image segmentation plays an important role in medical imaging applications. It has found wide application in different areas such as diagnosis, localization of pathology, study of anatomical structure, treatment planning, and computer-integrated surgery. However, the variability and the complexity of the anatomical structures in the human body have resulted in medical image segmentation remaining a hard problem [3].

2. IMAGE SEGMENTATION

Segmentation subdivides an image into its basic regions or objects. The level of detail to which the subdivision is carried depends on the problem being solved. That is interest in an application have been detected [4]. The goal of image segmentation is to cluster pixels into salient image regions, i.e., regions corresponding to individual surfaces, objects, or natural parts of objects [5]. Image is formed in the eye and in the camera by the amount of illumination reflected by an object [6].In computer vision, image processing is any form of signal processing for which the input is an image, such as photographs or frames of videos. The output of MRI image processing can be either an image or a set of characteristics or parameters related to image. The image processing techniques like image restoration, image enhancement, image segmentation etc. [7].

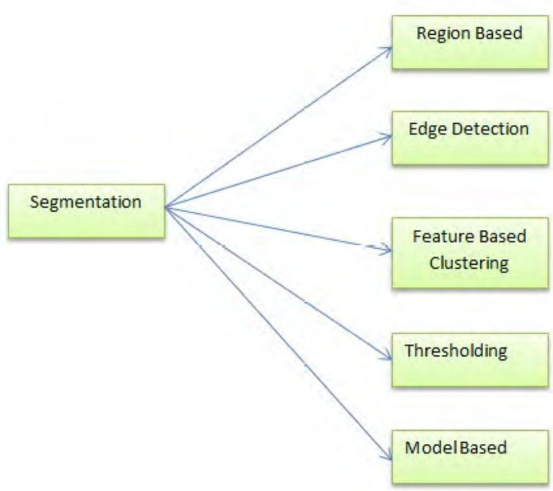

Figure 1. Various types of segmentation

Image segmentation is an important yet still challenging problem in computer vision and image processing. In specific, it is an essential process for many applications such as object recognition, target tracking, content-based image retrieval and medical image processing, etc. Generally speaking, the goal of image segmentation is to partition an image into a certain number of pieces which have coherent features (color, texture, etc.) and in the meanwhile to group the meaningful pieces together for the convenience of perceiving [8].

3. IMAGE THRESHOLDING

Threshold is one of the widely methods used for image segmentation. It is useful in discriminating foreground from the background. By selecting an adequate threshold value T, the gray level image can be converted to binary image. The binary image should contain all of the essential information about the position and shape of the objects of interest (foreground). The benefit of obtaining first a binary image is that it decreases the complexity of the data and simplifies the process of recognition and classification. The most common way to change a gray-level image to a binary image is to select a single threshold value (T). Then all the gray level values below this T will be classified as black (0), and those above T will be white (1). The segmentation problem becomes one of selecting the correct value for the threshold T. A common method used to select T is by analyzing the histograms of the type of images that want to be segmented.

The ideal case is when the histogram presents only two dominant modes and a clear valley (bimodal). In this case the value of T is selected as the valley point between the two modes. In real applications histograms are more complex, with many peaks and not clear valleys, and it is not always easy to select the value of T [9].

A. Iterative Method for Finding T
1. Estimate value of T (start with mean)
2. Divide histogram into two regions, R1 and R2 using T
3. Calculate the mean intensity values µ1 and µ2 in regions R1 and R2
4. Select a new threshold T = (µ1 + µ2)/2
5. Repeat 2-4 until the mean values µ1 and µ2 do not change in successive iterations

$$G(x,y) = f(x) = \begin{cases} 1, & \text{if } f(x,y) > T \\ 0, & \text{if } f(x,y) \leq T \end{cases} \quad \text{---------} \quad (1)$$

Any point (x,y) in the image at which f(x,y)> T is called an object point; otherwise, the point is called a background point. In other words, the segmented image g(x,y), is given by [4].

4. FORMATION OF AN MRI IMAGE

In this first section we describe the process of formation of MRI to understand the model that will be used later and to be able to identify limitations. We were inspired by various documents explaining the physics of MRI, it seemed necessary to develop the implementation of the model we will use later in our paper.

This chapter introduces the basic concepts necessary to understand this work. At first we present some elements of the central nervous system anatomy, to clarify the vocabulary and concepts that are then used in a second step, we briefly introduce the physical principles of magnetic resonance imaging in emphasis particularly on the difficulties arising from this acquisition technique.

4.1. Elements of Cerebral Anatomy

This first section presents some basics of brain anatomy. It defines key terms and concepts to better understand what is seen with brain imaging. The central nervous system consists of the spinal cord located in the spinal canal, and brain. In what follows we describe the anatomy of the latter, including the components of interest in this study.

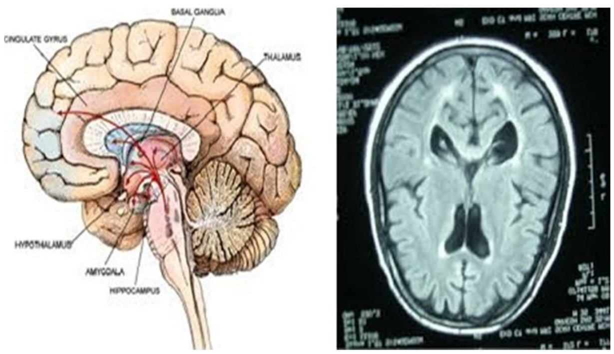

Figure 2. - The image (a) shows the brain consisting of the brain, cerebellum and brainstem. Image (b) shows a histological section of the brain showing the three main subjects of the brain.

4.2. The Main Substances in the Brain

Besides the presence of cerebral veins, tissues using walls, or many small structures such as glands, brain mainly contains three substances (Figure 2): a. The cerebrospinal fluid (CSF) (or cerebrospinal fluid, CSF) is the fluid that bathes the brain and cerebellum. It is a transparent substance made up of 99% water with an average volume of 150ml, it is absorbed by the cerebral venous system and continually renewed.b. Gray matter (GM) (or gray) corresponds to the cell bodies of neurons with their dense network of dendrites.c. White matter (WM) (or white matter) corresponds to the myelin sheath covering the axons of neurons to accelerate conduction. The myelinated axons are assembled into bundles to establish connections between groups of neurons.

4.3. Observation of the Brain

The observation of two-dimensional slices of the brain can be performed in several angles. Thus, there are three anatomical axes to make cuts(Figure 3). - Axial: These cuts are virtually identical to a horizontal plane. In magnetic resonance imaging, they correspond to a plane perpendicular to the axis of the main magnetic field. - Sagittal: These cuts are taken in planes parallel to the inter-hemispheric. These lateral views of the brain. - Coronal: These are cut perpendicular to the axial slices. They correspond to views from the front of the brain.

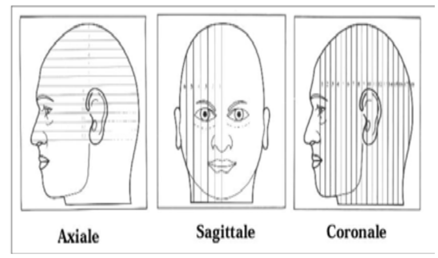

Figure.3 : three cutting axes for viewing of the brain.

4.4Organization of Paper

The rest of this paper is organized as follows. In section (3) we will give a brief view about Literature Review. In section (4), we will discuss concerning with the experimental results. In section (4) we have denoising approaches in medical images MRI we will deal with the segmentation of MRI images by the level set method in section (5). The complete results and their comments will be presented in section (6) followed by conclusion in Section (7).

5. LITERATURE REVIEW

Techniques such as thresholding, the region growing, statistical models, active control models and clustering have been used for image segmentation. Because of the complex intensity distribution in medical images, thresholding becomes a difficult task and often fails. [46]. In the region growing method, thresholding is combined with connectivity. [29].

Fuzzy C – means is a popular method for medical image segmentation but it only considers image intensity thereby producing unsatisfactory results in noisy images. [22]. A bunch of algorithms are proposed to make FCM robust against noise and in homogeneity but it's still not perfect. [1] [46].

Accurate estimation of the probability density function (PDF) is essential in probabilistic classification [46]. Nonparametric approach does not make any assumption in obtaining the parameters of PDF thereby making it accurate but expensive . In parametric approaches, a function is assumed to be a PDF function. It is easy to implement but sometimes lacks accuracy and does not match real data distribution [46].

Segmentation for brain with anatomical deviations: The main challenge lies in segmentation of brain with anatomical deviation like tumor with different shape, size, location and intensities. The tumor not only changes the part of brain which tumor exists but also sometimes it influences shape and intensities of other structures of the brain. Thus the existence of such anatomical deviation makes use of prior information about intensity and spatial distribution challenging. Segmentation of the tumor, its surrounding edema and other structures of the brain is very important for treatment and surgical planning. Some methods for brain tumor segmentation can be found in [44] and [45]. FFT based Segmentation for brain: Noises present in the medical images are multiplicative noises and reductions of these noises are difficult task. The anatomical details should not be destroyed by the denoising process from clinical point of view. Spectral leakage has the effect of the frequency analysis of finite-length signals or finite-length segments of infinite signals. In brain the tumor itself, comprising a necrotic (dead) part and an active part, the edema or swelling in the nearby brain. As all tumor do not have a clear boundary between active and necrotic parts there is need to define a clear boundary between edema and brain tissues. It shows that some energy has leaked out of the original signal spectrum into other frequencies. A radix-4 FFT recursively partitions a DFT into four quarter-length DFTs of groups of every fourth time sample. The total computational cost reduced by these shorter FFTs outputs which are reused for computing the output.

6. EXPERIMENTAL RESULTS

This section presents the results obtained from Global Thresholding(GT) using Iterative algorithm which was carried out for the study. This type of image segmentation was implemented using MATLAB software on a MRI image with pixel size of 325x140 which was taken brain MRI image. The figures show the experimental results.

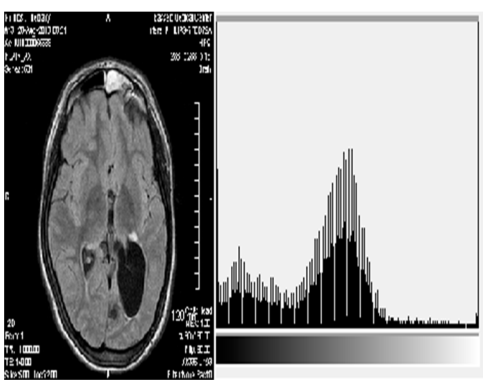

Figure 4. (a) Showing Original Colored Image (b) Histogram of the Original Image

The above figure 4(a) shows a natural color image and figure 4(b),shows the histogram representation of the MRI image. From the above figures, it was observed that, the histogram has reasonably clear valley between the modes related to objects and the background.

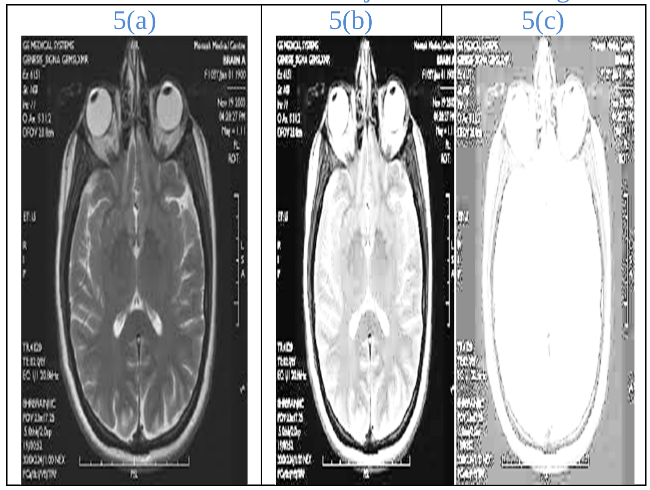

Figure 5. (a). Image without noise (b) Image after applying Gaussian Noise (c) Image after applying Salt and Pepper Noise

In figure 5 (b), it can be observed that, Gaussian noise was added to the original brain MRI image and in figure 5(c) Salt and Pepper was added to the original image,

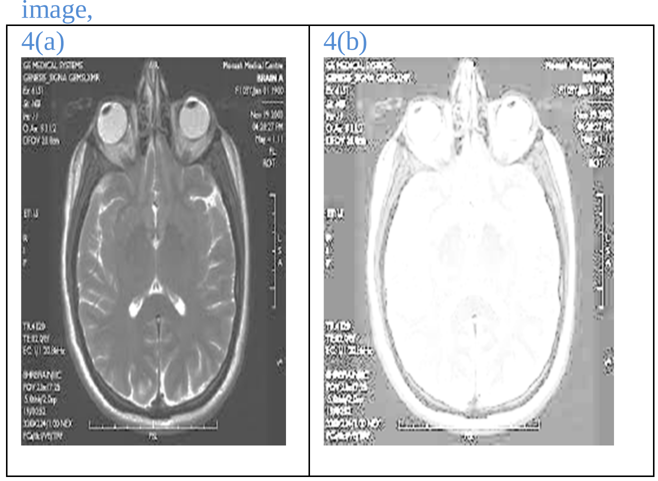

Figure 6. (a). Shows grayscale Image with Gaussian noise (b) Thresholded Image with Gaussian Noise

For the figure 6(a) above, the image with Gaussian Noise was first converted to grayscale then global thresholding using iterative algorithm was performed on the image. The object was successfully separated from its background (Background and Foreground). In figure 6(b), it can be observed that the white (1) represents the foreground and black (0) represents the background.

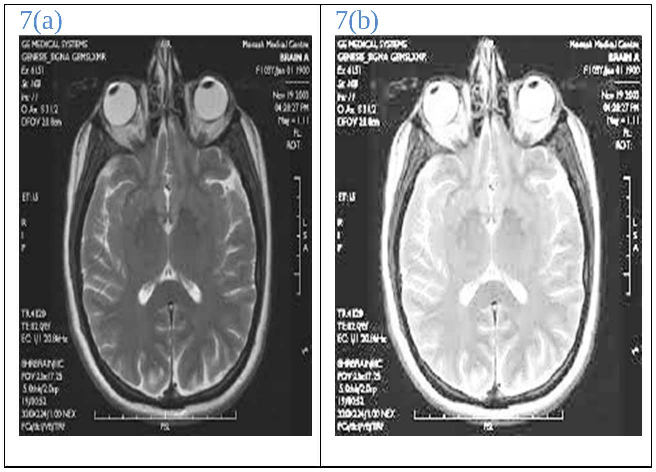

Figure 7. (a). Grayscale Image with Salt and Pepper Noise (b) Thresholded Image with Salt and Pepper Noise

For the figure 7(a) above, the image with Salt and Pepper Noise was first converted to grayscale and global thresholding using iterative algorithm was performed on the image. The object was successfully separated from its background. In figure 7(b), it can be observed that the white (1) represents the foreground and black (0) represents the background.

Image segmentation is often used to differentiate the foreground from the background. The focus of this paper is an attempt to study and achieve Image Segmentation using Thresholding Techniques on images with Gaussian Noise as well as Salt and Pepper Noise using MATLAB software. The study made use of the Iterative algorithm for the purpose of Image Thresholding on an image with pixel size 325x140 and the results obtained in the experiment were studied thereby highlight the performance of this image segmentation technique.

From the results obtained, figure 2 (a) shows a colored image and figure 2 (b), the histogram representation of the colored image. It was observed that, the histogram has reasonably clear valley between the modes related to objects and background. In the Figure 6(a), the image with Gaussian Noise was first converted to grayscale and global thresholding using iterative algorithm was performed on the image. The object was successfully separated from its background. In figure 6(b), it was observed that the white (1) represents the foreground and black (0) represents the background. In the Figure 7(a), the image with Salt and Pepper Noise was first converted to grayscale and global thresholding using iterative algorithm was performed on the image. The object was successfully separated from its background. In figure 7(b), it can be observed that the white (1) represents the foreground and black (0) represents the background. This technique of image segmentation by using Image Thresholding performed on an image corrupted with two different kinds of noise successfully separated the object from the background. Thus the background of the image is represented as black and the object represented as white (1) as seen in the figures above.

7. COMPARATIVE ANALYSIS

The implementation of the various methods starts with the identification of all the adjustable parameters for each method. We have implemented and tested real images with and without noise. It starts in all cases by a simple and closed curve (circle or rectangle).

Before the segmentation is activated, one needs to initialize the contour that will be shown in the first frame of the subsequent results. In general, six experiments will be conducted, and three methods are employed in this paper for performance comparison, 1.original level set by Caselles-Kimmel-Sapiro ,2. level set by Chan & Vese, 3. level set by Yezzi, 4.e level set by Lankton 5. level set by Bernard et al. and 6. Proposed level set by Sivakumar et. al., The whole implementation (MATLAB coding) is run on a PC with a 3GHz Intel system.

Table 1 summarizes the performance comparison of these six methods in different circumstances, where in general the our scheme is superior to the others in terms of location accuracy and computational time. The details follow.

These values were normalized to facilitate their comparisons.

• Visual criterion: This criterion allows you to plot the results of the selected algorithms on the image to compare them with the reference you have selected.

• Computation time.

• Similarity criterion: Four similarity criteria can be computed between the result of the algorithms and the reference :

i. Dice criterion
ii. peak signal-to-noise ratio(PSNR)
iii. Hausdor_ distance
iv. Mean Sum of Square Distance

Table 1. Criteria values for each of the methods for segmentation of image.

	Geodesi Cactive Countour	Chan and Yese Method	Yezzi Method	Lanktn Method	Bernad Method	Proposed
Visual Criterion	1	1	1	0	1	1
Dice	0.69	0.69	0.28	0.6	0.7	0.70
PSNR	10.63	8.86	8.31	7.19	9.01	7.10
Computa tion Time	1.28	0.85	2.60	1.1	1.26	0.75
Hausdor Distance	21.35	31.98	21.54	16.97	20.1 0	28.0 1
MSSD	54.65	153.35	119.09	59.85	49.6 4	135. 01

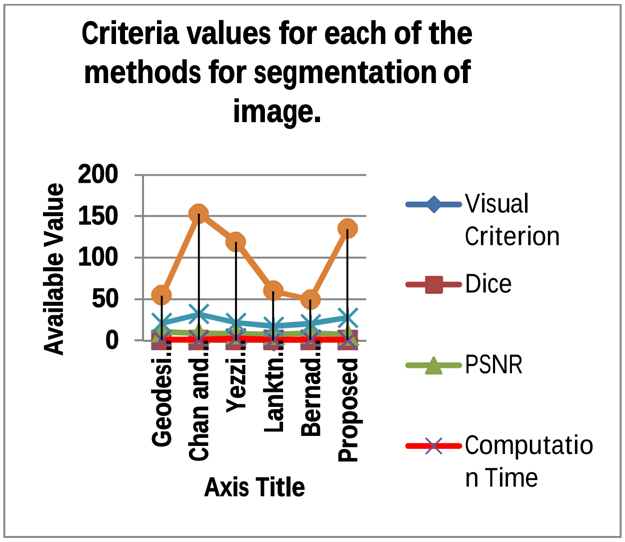

Figure 8. Performance of different Criteria values for each of the methods for segmentation of image.

According to our tests, our segmentation method seems to be the best. It depends on the nature of the image, and other parameters.

8. CONCLUSION

In spite of the availability of a large variety of state-of art methods for brain MRI segmentation, but still, brain MRI segmentation is a challenging task and there is a need and huge scope for future research to improve the accuracy, precision and speed of segmentation methods. In this study, the overview of various segmentation methodologies applied for digital image processing is explained briefly. The study also reviews the research on various research methodologies applied for image segmentation and various research issues in this field of study. This study aims to provide a simple guide to the researcher for those carried out their research study in the image segmentation. Image segmentation has a promising future as the universal segmentation algorithm and has become the focus of contemporary research. In spite of several decades of research up to now to the knowledge of authors, there is no universally accepted method for image segmentation, as the result of image segmentation is affected by lots of factors, such as: homogeneity of images, spatial characteristics of the image continuity, texture, image content. Thus there is no single method which can be considered good for neither all type of images nor all methods equally good for a particular type of image. Due to all above factors, image segmentation remains a challenging problem in image processing and computer vision and is still a pending problem in the world.

The document image under test is attempted to the help of global Thresholding approach while estimating most likely background information using iterative algorithm. In each iteration the average intensity of the document image is adopted as midpoint between the pixels. In the next step the remaining pixels are equalized. The number of iterations depends on the sensitivity of successive thresholds. This algorithm is found to be effective on historical document images as well as camera captured stone carvings. However it is observed that further improvement is necessary on palm leave manuscripts.

Acknowledgements

The authors would like to thank the Management and Staff Members of Andal Azhagar Engineering College for his help and his thoughtful comments.

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