Medical Image Segmentation using Modified Interactive Thresholding Technique

Asst. instructor **Noor Muwafak Abed Al Hadi***

Abstract

Medical image segmentation is one of the most actively studied fields in the past few decades, as the development of modern imaging modalities such as magnetic resonance imaging (MRI) and computed tomography (CT), physicians and technicians nowadays have to process the increasing number and size of medical images. Therefore, efficient and accurate computational segmentation algorithms become necessary to extract the desired information from these large data sets. Moreover, sophisticated segmentation algorithms can help the physicians delineate better the anatomical structures presented in the input images, enhance the accuracy of medical diagnosis and facilitate the best treatment planning.

Many of the proposed algorithms could perform well in certain medical image applications.The aim of this paper is to change the medical image into something that is more meaningful and easier to analyze and recognize features that helps the doctors to diagnoses the diseases .This paper views selected medical image and segmentation method that have been proposed, which are suitable for processing medical images by use the modification of the traditional interactive threshold technique. This method gave good results, and these results are tested according to the measure of quality (PSNR).

1 General Introduction

Diagnostic imaging is an invaluable tool in medicine. Magnetic resonance imaging (MRI), computed tomography (CT), digital mammography, and other imaging sodalities provide an effective means for non invasively mapping the anatomy of a subject. These technologies have greatly increased knowledge of normal and diseased anatomy for medical research and are a critical component in diagnosis and treatment planning. The growing size and number of these medical images have necessitated the use of computers to facilitate processing and analysis. In particular, computer algorithms for the delineation of anatomical structures and other regions of interest are becoming increasingly important in assisting and automating specific radiological tasks. These algorithms, called image segmentation algorithms, play a vital role in numerous biomedical-imaging applications, such as (1) the quantification of tissue volumes,(2) diagnosis, (3) localization of pathology,(4)study of anatomical structure,(5)treatment planning, and (6) computer-integrated surgery. **[Dzung,2000]**

This paper provides an overview of current method for computer-assisted or computer-automated segmentation of anatomical medical images.

* Dept. of computer science-College of science for women - Baghdad university

2 Medical image processing and visualization

Medical image, such as CT, MRI, shows the information inside the patient body by non-invasive method, so that it is much helpful for doctor diagnoses and less painful for patients,

However the raw data can only give the material to doctor, the doctor as to decide by himself what is important and what is not. The computer-aided diagnoses is to use computer to process the medical to extract the useful information so that the doctor can make a diagnoses decision easier and quicker, and the pipeline that declare the stages that helps the doctors to diagnoses the status of medical image was shown in figure(1). In this research a segmentation method is proposed to segment medical image and visualize the segmented object, further more give the doctors the means of measurement and analysis of interested object. **[Jan,2005]**

- **Medical imaging pipeline**

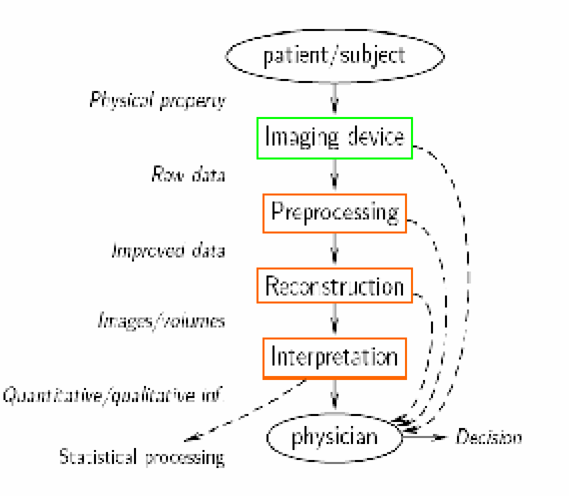


Fig.1 Medical imaging pipeline

There are four stages that enable doctors to diagnose and analyze the medical image.

- **Stage one:** This stage declare the imaging device as shown in figure (2) with the examples of this device.

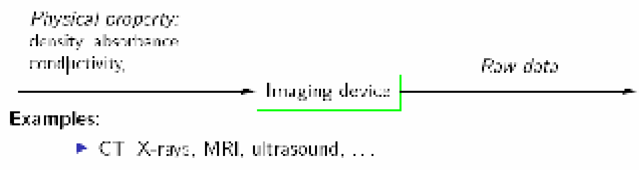


Fig.2 imaging device

- **Stage two:** This stage corresponding to preprocessing the medical image and the removal of any noise, to be ready for the reconstruction as shown in figure (3).

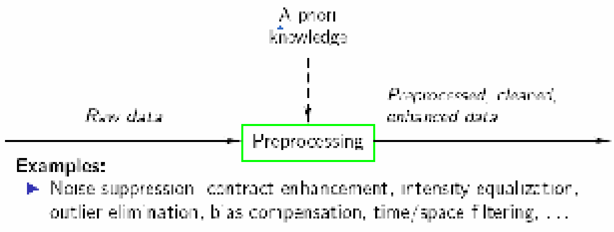


Fig.3 Preprocessing

- **Stage three:** This stage represent the reconstruction of medical image as shown in figure (4).

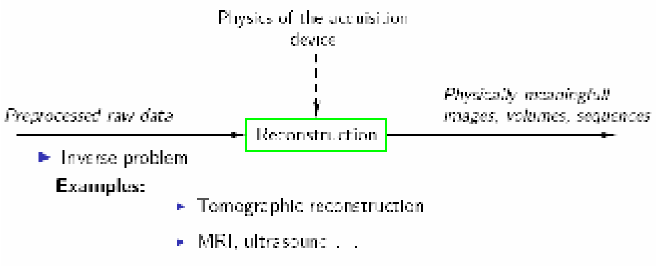


Fig.4 Reconstruction

- **Stage four:** this stage corresponding to the interpretation methods as shown in figure (5).

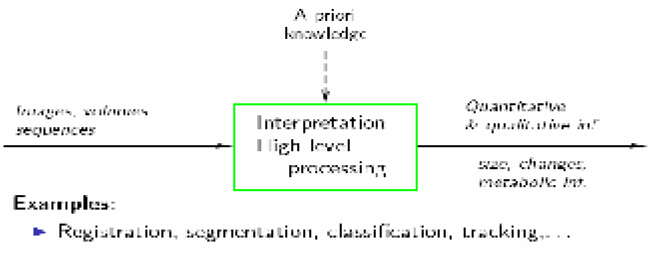


Fig.5 Interpretation

3 Medical Imaging Technology

Among biomedical imaging technologies, image information processing applicable to computer assisted diagnosis and ultra high resolution MRI are focused in this research. Medical image data obtained from such as CT ,X_Ray and MRI becomes larger so as to provide medical staff with higher quality images. One major objective is to develop image information processing algorithm and systems to assist doctors in extracting necessary information from the huge data by more precise and more effective way. **[Lionel,2003]**

4 Medical imaging

Medical imaging refers to the techniques and processes used to create images of the human body (or parts thereof) for clinical purposes (medical procedures seeking to reveal, diagnose or examine disease) or medical science (including the study of normal anatomy and function). As a discipline and in its widest sense, it is part of biological imaging and incorporates radiology (in the wider sense), radiological sciences, endoscopy, (medical) thermography, medical photography and microscopy (e.g. for human pathological investigations). Measurement and recording techniques which are not primarily designed to produce images, such as electroencephalography (EEG) and magneto-encephalography (MEG) and others, but which produce data susceptible to be represented as maps (i.e. containing positional information), can be seen as forms of medical imaging. In the clinical context, medical imaging is generally equated to radiology or "clinical imaging" and the medical practitioner responsible for interpreting (and sometimes acquiring) the images is a radiologist. Diagnostic radiography designates the technical aspects of medical imaging and in particular the acquisition of medical images. The radiographer or radiologic technologist is usually responsible for acquiring medical images of diagnostic quality, although some radiological interventions are performed by radiologists. As a field of scientific investigation, medical imaging constitutes a sub-discipline of biomedical engineering, medical physics or medicine depending on the context: Research and development in the area of instrumentation, image acquisition (e.g. radiography), modeling and quantification are usually the preserve of biomedical engineering, medical physics and computer science; Research into the application and interpretation of medical images is usually the preserve of radiology and the medical sub-discipline relevant to medical condition or area of medical science (neuroscience, cardiology, psychiatry, psychology, etc) under investigation. Many of the techniques developed for medical imaging also have scientific and industrial applications. Medical imaging is often perceived to designate the set of techniques that noninvasively produce images of the internal aspect of the body. In this restricted sense, medical imaging can be seen as the solution of mathematical inverse problems. This means that cause (the properties of living tissue) is inferred from effect (the observed signal). In the case of ultrasonography the probe consists of ultrasonic pressure waves and echoes inside the tissue show the internal structure. In the case of projection radiography, the probe is X-ray radiation which is absorbed at different rates in different tissue types such as bone, muscle and fat**. [Naozo,2001]**

5 Segmentation

In computer vision, segmentation refers to the process of partitioning a digital image into multiple regions (sets of pixels) as shown in figure (6). The goal of segmentation is 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 images. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s). **[Vasant,2009]**

Fig.6 example of segmentation

7 Thresholding Techniques

In a digital image processing, thresholding is a well-known technique for segmentation gray level images(it is a technique for converting a grayscale or color image to a binary image based upon a threshold value). Because of its wide applicability to other area of the digital image processing, a variety of techniques have been proposed over the years for determining thresholds at which to segment an image in extract objects from their background. Thresholding in its simplest form means to classify the pixels of a given image into two regions objects and background one including those pixels with their gray value above certain threshold. If the gray level ranges occupied by objects and background are sufficiently well separated (e.g., the image light objects on a dark background or vice versa) there will be a valley in the gray level histogram between the two peaks segment at a threshold the located at the bottom of this valley .Let f(x , y) be an image composed of a light object on a dark background and t be a threshold. the separation of light and dark regions. Thresholding creates binary images from gray-level ones by turning all pixels below some threshold to zero and all pixels above that threshold to one ,that's mean if a pixel in the image has intensity less than the threshold value, the corresponding pixel in the resultant image is set to black. Otherwise, if the pixel is greater than or equal to the threshold intensity, the resulting pixel is set to white. **[Wu,1999]**

The result is an image function f(x , y) at gray level 't' is a binary image function g(x , y) , such that in eq.(1)

$$g(x,y) = \begin{cases} 0 \text{ if } f(x,y) < t \\ 1 \text{ if } f(x,y) > t \end{cases} \quad (1)$$

A single threshold will be able to detect all or most of the object boundaries at the object-background discontinuity. However, those boundaries which correspond to object discontinuity or to internal structure if the object may not exhibit a clear foreground-background distinction (such as images of natural outdoor scenes).One cannot expect a single threshold to detect all or even most of the object boundaries in the scene. In order to detect most of the interesting boundaries of an image, some alternative or additional processing must be done to obtain clearer result. One alternative is to use multiple thresholds or threshold that varies across an image. **[Wu,1999]**
selection the following two points should be considered:
* If the threshold level is too high, there will be a loss of information.
* If the threshold too low then it will cause noise to be falsely detected as an image edge.

Thresholding techniques are divided mainly into four types: **[Wu,1999]**

1.Global thresholding.
2.Local thresholding:
3.Adaptive thresholding
4.Interactive thresholding

8 Interactive threshold: this technique uses two values of threshold to define the threshold range. The threshold are adjusted interactively by showing all pixel within the rang in one color and all pixel outside the rang to a different color, the threshold rang can be defined locally and varied from slice to slice. All pixels within rang are segmented to generate the final boundaries. The threshold values as follows: **[Wu,1999]**

t1
t2

9 Grayscale Segmentation Methods

There are a variety of grayscale segmentation methods such as thresholding-based segmentation methods (difficulty in determining the value of thresholds because of variability of anatomy and MR data as well as image artifacts), edge-based segmentation methods (suffers from incorrect detection of edges due to noise, over- and under-segmentation, and variability in threshold selection in the edge image), seed growing segmentation methods (only ambiguous boundaries between homogenous regions are detected and results are generally dependent on the operator settings), etc. We have other techniques that can be categorized as grayscale segmentation methods, but almost all of them are constrained with a limitation. For instance, an associative memory technique was employed and was found to be very promising. But it involves extensive work making it computationally very intensive which may prohibit their practical use.

Thus, gray scale segmentation methods though might provide useful information, are limited to relatively simple structures. For complex pathology, more information is often required, which is usually available in multi-spectral MRI data, which is used in the research, so that the original image is converted from the RGB color image to gray scale image. **[Y.Ted,2001]**

In this paper the described method is modified interactive threshold technique with its implementation to represent the segmentation of medical image.

10 Proposed System paper

This paper reviews selected medical image and segmentation method that have been proposed and which are suitable for the processing of volume images. The focus is on classification methods. The anatomical structures presented in the input images, enhance the accuracy of medical diagnosis and facilitate the best treatment planning. However, due to the specific and complex requirements of biomedical image, the proposed method was modified according to the requirements of medical image processing field.

11 Modified Interactive Thresholding Technique

This technique is the modification of the traditional method of interactive thresholding technique. It was suggested to enhance the segmentation of the medical image. It works by adding a specific factor to the minimum value of all the pixels in the image and subtract the same factor value from the maximum value. The selected factor was found experimentally, and applied on a large number of images. It's found that this approach gave good results more than the traditional approach.

11.1 Modified Interactive Thresholding Algorithm

The algorithm steps are:

1- Convert the image to gray scale image.
2- Find the minimum and the maximum of the pixels in the image.
3- Add the factor to the minimum value and subtract the same factor from the maximum value to generate the thresholing values T1 and T2.
4- Assign each point inside the range of threshold value to the value 255, otherwise set the value to 100 (this value of color distinguished clearly between the anatomical structures of image).
5- Represent these steps for all pixels in the image.

The proposed formula of this technique with factor equal to 50 (this factor were choose among many factors by try and error) as follows: T1= MIN + 50
T2=MAX - 50

The resulted image g(x,y) of the original image f(x,y) at gray level T1 and T2 is a binary image such as in eq.(2) and eq.(3):

$$g(x,y) = 100 \quad \text{when} \quad T1 > f(x,y) > T2 \qquad (2)$$

$$g(x,y) = 255 \quad \text{when} \quad T1 <= f(x,y) <= T2 \qquad (3)$$

12 System Performance Measures

System performance could be investigated with several parameters. In this paper is a set of parameters is taken into consideration to evaluate the performance of the suggested medical image segmentation method (modified interactive thresholding technique).

12.1 Mean Square Error

Mean square error (MSE) is an old proven measure of control and quality. In the literature of statistical process control (SPC) it is often referred to as the mean square deviation (MSD). MSD is the mean of the squares of the deviations from target. It is used to measure the error between the original image and the reconstructed image. It is calculated by the following equation :

$$MSE = \frac{1}{N} \sum_{i=0}^{N-1} (wi - ri)^2 \quad (4)$$

Where:

wi is the value of the ith sample in the original data.

ri is the value of the ith sample in the target or intended data, (i.e. reconstructed wave after encoding phase).

N is the number of sample (i.e.size of image).

12.2 Signal To Noise Ratio

Signal to noise ratio is an engineering term for the power ratio between a signal (meaningful information) and the background noise:

$$SNR = \left[\frac{\sum_{i=0}^{N-1} wi^2}{MSE} \right] \quad (5)$$

Since signals may have a very wide dynamic range , SNRs are usually expressed in terms of the logarithmic decibel scale. In decibels, the SNR is 10 times the logarithm of the power ratio:

$$SNR\,(dB) = 10 \log_{10} \left[\frac{\sum_{i=0}^{N-1} wi^2}{MSE} \right] \quad (6)$$

Most of the time, the quality of signal is expressed by using the peak signal to noise ratio (PSNR), which represent the ratio between the peak value of the signal and the mean square error (MSE) , and it is calculated by the following equation

$$PSNR\,(dB) = 10 \log_{10} \left[\frac{255^2}{MSE} \right] \quad (7)$$

Where, the value 255 represents the dynamic range of the image (for the case of sample resolution equal to 8 bit).

PSNR is the most commonly used measure to evaluate the objective quality of the reconstructed signal after image segmentation. Typically, PSNR value range between 20 to 40 . They are usually reported up to two decimal points. The actual value is not meaningful , but the image segmentation between the two value for different reconstructed image gives more indications about the quality. **[Waseem,2007]**

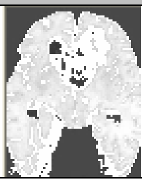
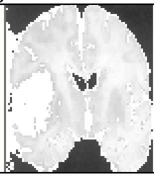
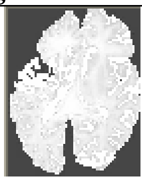
13 Results and Analysis

A wide variety of methods are used for medical image segmentation, Medical image segmentation is the basic for organs visualization and operation simulation. The precise of the segmented object is critical for doctors diagnosis and disease treatment. The application is medical image process that includes image segmentation, object visualization, furthermore aiding diagnosis.

The results will show how the medical image segmentation method (modified interactive thresholding technique)are applied to the image. The benefit of this resulted picture is to give the doctors the means of measurement and analysis of interested object by the differentiation between the anatomical structures.

The fig.7, shows example images taken by different devices such as (CT Scan , X_Ray, MRI) devices with there measure of MSE and PSNR.

Figure 7 show the results of the proposed method:

Original image	processed image
	
image 1	
	
Image 2	
	
Image 3	

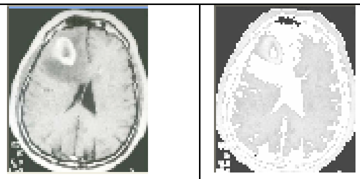


Image 4

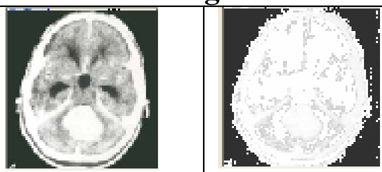


Image5

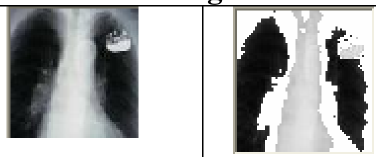


Image 6

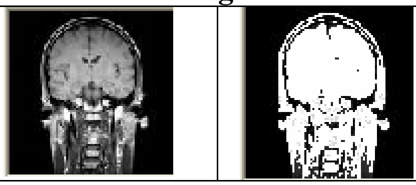


Image 7

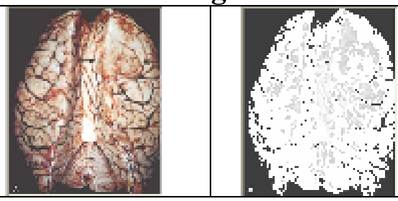


Image 8

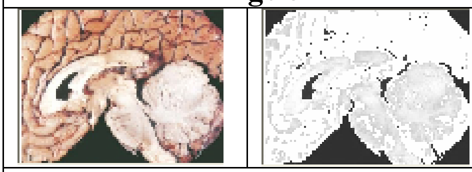


Image 9

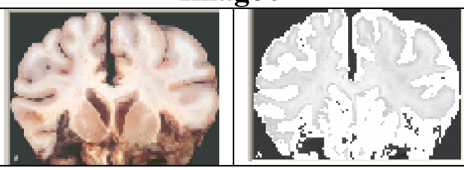


Image 10

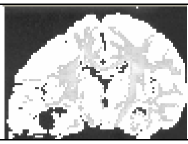



Image 11

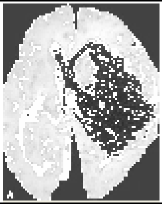



Image 12

Fig 7 Original and resulted image

The table below shows MSE and PSNR results obtained .

Image	MSE	PSNR
Image 1	10.20693092329	38.0418518523038
Image 2	18.13650713025	35.5452670990328
Image 3	7.718272530478	39.2556025152067
Image 4	12.33143471949	37.2206675268175
Image 5	16.64150879439	35.9188766202781
Image 6	42.02338498362	31.8958932896885
Image 7	29.55616192769	33.424323236294
Image 8	27.0278378124681	33.812690567353
Image 9	29.2104152612107	33.475426298317
Image 10	25.7070223922902	34.030285850219
Image 11	27.984554505356	33.6616196323622
Image 12	9.53021001528121	38.3397788966581

The table above shows the quality measure for the segmented medical images using the proposed method, and it founds that this method gave good quality measure.

14 Conclusions

The main difficult task of any image is the segmentation of it. So the algorithm is one of the most important algorithms that check the accuracy and efficiency as an essential request for doctors in the diagnosis of contemporary conditions. The proposed method can be used in self-diagnosis by find the infected areas in order to assist physicians in diagnostic accuracy and avoid mistakes.

15 Reference

[Dzung,2000] Dzung L. Pham, Chenyang Xu, and Jerry L. Prince,medical imaging,2000,Department of Electrical and Computer Engineering,The Johns Hopkins University,3Laboratory of Personality and Cognition, National Institute on Aging,

[Jan,2005] Jan Kybic, Medical Imaging , 2005.

http://www.hpi.unipotsdam.de/meinel/research/telemedicine/former_topics/3d_medical_image_processing.html

[Lionel,2003] Lionel Carminati /Image segmentation/ 2003 / labri cnrs umr 800/351/cours de la libration33405 talence france.
[Naozo,2001] Naozo Sugimoto, Information Technology and Medical Engineering 2001,PhD(inEng.)Professor,Graduate School of Medicine Kyoto University.
http://www.med.kyotou.ac.jp/E/grad_school/introduction/5253/ Information Technology and Medical Engineering/copyright 2006.
[Vasant,2009] Vasant Manohar, Yuhua Gu ,MRI Segmentation Using Fuzzy C-Means and Finite Gaussian Mixture Model,2009,Computer Science
& Engineering Department ,University of South Florida,Email:
{vmanohar, yuhua}@csee.usf.edu
[Waseem,2007] Waseem Mudhafar Aziz /Fast fractal audio compression using DCT description/2007.
[Wu,1999] Wu . Ted.Y/3-Dimage segmentation/first step in imaging/for Ph. D. Able Software Corp/1999.
http://www.ablesoftware.com/seg.html.
[Y.Ted,2001] Y. Ted Wu / New Partnerships in Medical Diagnostic Imaging/2001/Ph.D. Able Software Corp /Prepared for presentation at the NAS Advanced Technology Workshop/ Greenbelt/ MD.
http://www.ablesoftware.com/3ddoctor/3dseg.htm

تقطيع الصور الطبية باستخدام حد العتبة التفاعلي المعدل

م.م.نور موفق عبد الهادي
قسم علوم الحاسبات- كلية العلوم للبنات- جامعة بغداد

الملخص:
ان تقطيع الصور الطبية من اهم واكثر الحقول الفعالة في البحث العلمي المعاصر في العقود القليلة المنصرمة . فالصور الطبية المنتجة حاليا من قبل النماذج المختلفة لاجهزة التصوير الطبي : كاجهزة التصوير بالرنين المغناطيسي وجهاز المفراس جعلت الفسلجيون او علماء وظائف الاعضاء والتقنيون يفكرون في زيادة عدد واحجام هذه الصور لتلبية اغراضهم.

لذا اصبح من الضروري التفكير بخوارزميات التقطيع الصوري الكفوءة والدقيقة لانها ستكون الوسيلة التي تساعد في استخلاص المعلومة المطلوبة من بين مجاميع وحزم المعلوملت المعروضة من خلال المدخلات ، وكذلك من الممكن لهذه الخوارزميات ان تساعد الفسلجيين في تحديد افضل التراكيب التشريحية او العضوية المدخلة ابتداء،وايضا من الممكن لهذه الخوارزميات ان تحسن دقة التشخيص الطبي والذي من شانه ان يسهل عملية وصف العلاج للمريض.

في الحقيقة هناك خوارزميات متعددة ومقترحة من الممكن ان تحقق ماقدمناه ومنها خوارزمية حد العتبة التفاعلي ، وهذه الورقة تهدف الى استعراض التعديل الذي اجريناه على هذه الخوارزمية كي تعطي الصورة الطبية التقليدية معان جديدة وكثيرة وهي التي استعرضناها سابقا_ من شانها ان تسهل عملية تحليل المعلومة وتحسن خواص التشخيص للكادر الطبي المتخصص.

هذه الورقة تستعرض الطريقة المختارة في التصوير الطبي ومن ثم طريقة التقطيع المقترحة والتي اعطت نتائج جدا مرضية وكذلك من خلال تطابق هذه النتائج لمعايير الجودة القياسية (psnr).