Extraction of Brain Tumor in Coronal MRI Sliced Images by Implementing Active Contour and Different Segmentation Techniques

Rabab Saadoon Abdoon

University of Babylon,
College of Science,
Department of Physics
sr614@ymail.com

Abstract:

Many segmentation methods were proposed to process medical images for diagnosis purposes. In this work, two stages were achieved to extract tumor region of three MRI sliced brain images of coronal orientation. Active contour algorithm was implemented as first step to extract brain matter of T2W_FLAIR modality MRI images for the first time to avoid interference of tumor gray values with skull. The second stage involved implementing four segmentation techniques to extract tumor regions. First technique was utilizing contrast adjustment process after presenting analysis study of this operation to select an adequate gray level range to be stretched. Second method is an adaptive technique, which is contour based method, to isolate and extract tumor regions. The third and fourth methods were K-Means and FCM. The surface and relative surface area of the extracted tumor regions were calculated. The results of extracting brain matter proved high quality performance of active contour algorithm with its adaptive initialization element. The adequate gray level range that deduced from the proposed analysis of contrast adjusting process is [0.6 0.7]. In addition, the results of the proposed contour based technique present good isolation and extraction of tumor regions. The four implemented techniques are adequate to extract tumor regions correctly without overlapping with skull as declared from the results. This work was implemented by utilizing the facilities of Mat lab programing system.

Keywords: MRI; Brain tumor; Contrast adjusting; Active contour.

إستخلاص أورام الدماغ من شرائح صور الرنين المغناطيسي ذات الاتجاه الامامي بواسطة المنحني النشط وتقنيات تجزئة مختلفة

رباب سعدون عبدون

قسم الفيزياء- كلية العلوم- جامعة بابل- الحلة- العراق

الخلاصة:

لقد اقترح العديد من طرق التجزئة لمعالجة الصور الطبية لأغراض تشخيصية. في هذا العمل انجزت مرحلتين لغرض إستخلاص مناطق الورم لثلاث شرائح من صور الرنين المغناطيسي ذات الاتجاه الامامي. نفذت خوارزمية المنحني النشط كخطوة اولى لاستخلاص المادة الدماغية من صور الرنين المغناطيسي ذات النمط T2W_FLAIR للمرة الاولى لتجنب التداخل ما بين القيم الرمادية لمناطق الورم و الجمجمة والمرحلة الثانية تتضمن تنفيذ أربع تقنيات تجزئة

لغرض استخلاص مناطق الورم. التقنية الاولى إستخدام عملية تعديل التباين بعد تقديم دراسة تحليلية لغرض الحصول على أنسب مدى مستويات رمادية لغرض توسيعها. والطريقة الثانية هي طريقة مطورة مستندة على المنحني المغلق لغرض عزل واستخلاص مناطق الورم. أما الطريقتان الثالثة والرابعة فهما متوسطات كي و متوسط سي المضبب. كما حسبت المساحة السطحية والمساحة السطحية النسبية لمناطق الورم المستخلصة. وقد بينت النتائج الأداء عالي الجودة لخوارزمية المنحني النشط بعنصر تشغيله المطور لعزل المادة الدماغية. إن مدى المستويات الرمادية المناسب الذي توصل إليه هو[٠.٦-٠.٧]. إضافة الى ذلك، إن نتائج تقنية المنحني المغلق المقترحة أظهرت عزل وإستخلاص جيدين لمناطق الورم. إن التقنيات الأربعة المطبقة كانت سديدة في إستخلاص مناطق الورم وبشكل صحيح من دون تراكب مع الجمجمة وكما كشفت النتائج عن ذلك. وقد تم تنفيذ هذا العمل بالاستفادة من تسهيلات النظام البرمجي الماتلاب.

الكلمات المفتاحية: التصوير بالرنين المغناطيسي، أورام الدماغ، تعديل التباين، المنحني النشط.

1. Introduction

Magnetic Resonance Imaging (MRI), is one of the most important examining medical techniques to investigate the physiological structures of the body especially the soft tissues as brain matter. One of more life threatening problems is brain tumor, so ease; fast and accurate isolating of the tumor regions is an urgent task needed to save patients life. Many medical image processing methods are presented by researchers to achieve this job. Some of these methods are thresholding based technique, boundary (contour) based technique, region based technique and combination of the last two methods [1].

In this work, active contour algorithm is implemented as boundary based technique to segment the adopted MRI of brain. There are three orientations of MRI sliced images, which are: axial, sagittal and coronal [2]. Coronal orientation images are selected to achieve the goal of this study. Active contour was implemented to extract brain matter in MRI sliced images of T2-weighted axial orientation for the first time in our previous work [3] and in the present work, active contour algorithm is utilized for the first time to extract brain matter in T2W_FLAIR MRI of coronal orientation images as a first step to avoid interference between the intensity values of the skull and the tumor regions. After that implementing three segmentation techniques on the resultant brain matter images to extract the tumor regions as a second step. The adapted initialization element of Active contour algorithm was created for the first time to be dynamic with the image. An analysis study of one of the enhancement techniques which is contrast adjusting is proposed to fulfill good isolating of the tumor regions. Besides, K-Means and Fuzzy C-Mean methods are proposed to segment and extract the tumor regions only from the adopted images.

2. Active Contour

Active contour was firstly proposed by Kass et. al. [4, 5]. It defines interfaces on the image domain. It moves according to internal and external forces. These forces are derived from the characteristics of the image. The internal forces incorporate regularizing constraints which give the contour its tension and stiffness, while the external forces are defined as the gradient of the gray-level of the image [4].

Active contour is represented by a vector, *v(s)*, which contains all of the *n* points of the contour that called also a snake. The net functional energy of this snake can be expressed as [4]:

$$E_{Snake} = \int_0^1 \left[E_{\text{int}}(v(s)) + E_{image}(v(s)) + E_{con}(v(s)) \right] ds$$

where, E_{int} is the internal energy which results from bending. E_{image} is the image forces that pushing the snake toward the features of the image like edges, and E_{con} is the external constraints which are responsible for putting the snake near the desired local minimum. For more details about each of these terms see [1]. Many researchers applied active contour algorithm and its modifications, to isolate region of interest, like: [6-10].

3. Contrast Adjustment

Contrast adjusting is one procedure of many involved in enhancement techniques to improve the appearance of images to make them suitable for a specific purpose. To know more about this technique see [1, 11].

4. Contour Based Segmentation Method

This adaptive technique is proposed for the first time to detect and isolate tumor region within MRI brain images of coronal orientation. The theoretical base of this technique is found in [1].

5. K-Means Segmentation Method

K-Means is a clustering algorithm implemented to segment digital images by partition data into certain number of clusters [12]. It is an iterative algorithm that is utilized to split an image into 'k' segments or clusters, and the number of clusters must be fixed priority. For more details of the followed procedure of this method see [1] as an example.

6. Fuzzy C-Mean Segmentation Method

Fuzzy C-Mean, FCM is a clustering algorithm too but it is of soft scheme. It owns robust characteristics for ambiguity. The data patterns in FCM algorithm may belong to many clusters, with different values of membership grade. The membership grade of processed data to some cluster indicates the similarity between the data pattern and this cluster [3]. For more details about this algorithm see [13].

7. Experimental Data

The experimental data of this work are three MRI sliced brain images of coronal orientation for a patient suffers from malignant brain tumor. These images are of T2W_FLAIR modality with a matrix of 256 rows and 256 columns. Fig.(1) shows these images, after removing the background, the white areas represent the tumor regions.

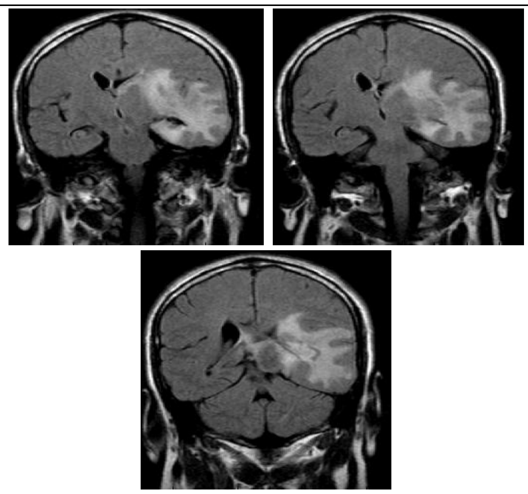

Fig.(1): The coronal orientation MRI adopted images

8. Implemented Methodologies and Results

In this work, two main steps were applied: firstly, the brain matter was extracted then three different methods were implemented to extract the tumor regions.

The procedure of this work is summarized in the block diagram of Fig.(2).

8.1. Active Contour to Extract Brain Matter

In this step, active contour algorithm was implemented on coronal MRI of brain to extract the brain matter only. In this study, the utilized initialization element of active contour algorithm *was created for the first time* to be dynamic with the image and with iterations ranged from 1250 to 2500. Fig.(3) demonstrates the steps of extracting the brain matter from the skull for one image as a sample. The resultant extracted brain matter of the experimental images are presented in Fig.(4).

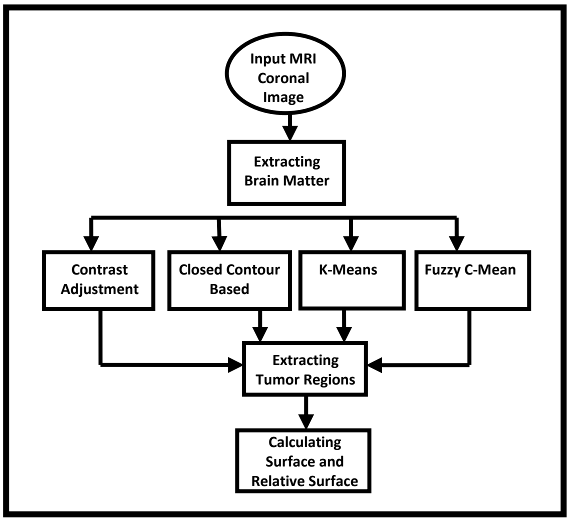

Fig.(2):Block diagram of the proposed work

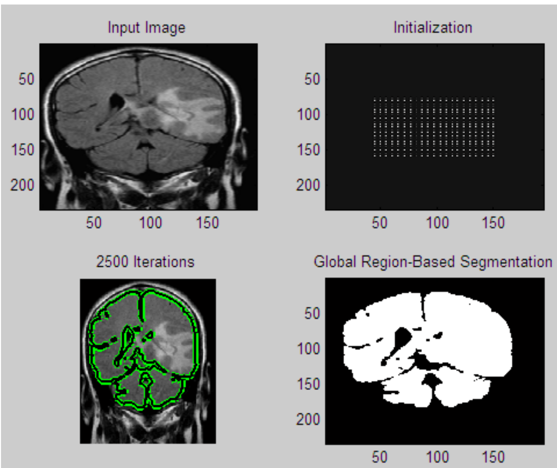

Fig.(3):The extracted brain matter of one experimental image by implementing active contour with dynamic initialization element.

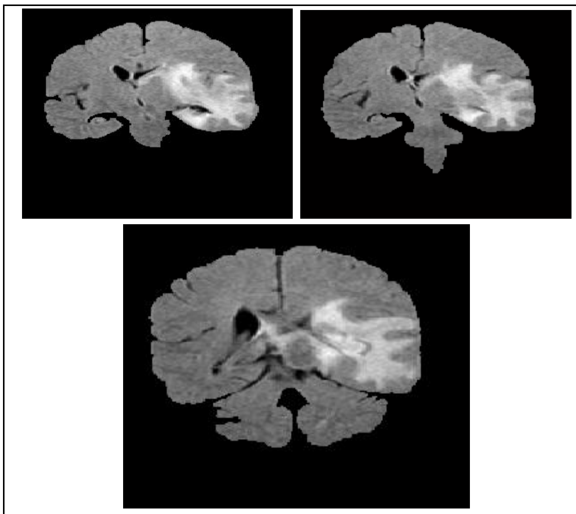

Fig.(4): The extracted brain matter of the experimental images

8.2. Extraction of Tumor Regions

In this step three methods were implemented to segment and extract the tumor regions.

8.2.1 Contrast Adjustment Method

In this method, the range of gray levels of the tumor region was emphasized by applying many steps depending on contrast adjustment process followed by thresholding process. Contrast adjustment process was applied here to stretch the range of gray levels of the brain matter image from some range to be in the range [0 1] to perform extracting tumor regions only. To analyze the performance of this operation. Many image ranges: [0.2 0.7]; [0.3 0.7]; [0.4 0.7] and [0.5 0.7] were stretched to be in [0 1] range, and the results of this process are presented in Fig.(5).

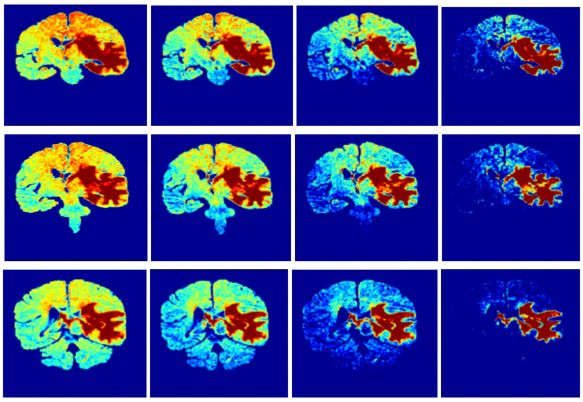

Fig.(5): Results of the analysis study of Contrast adjustment process for the three images from first to last line respectively (tumor regions in brown).

It is clear from inspecting of Fig.(5) that, the tumor regions are refined from other brain tissues step by step depending on the selected gray level range of the brain matter images. The last and adequate selective range of this analysis study was [0.6 0.7] and the results of this process are demonstrated in the first line of Fig.(6). After contrast adjustment process of this adopted range, thresholding process was implemented. The adopted threshold value is depending on the processed image intensity.

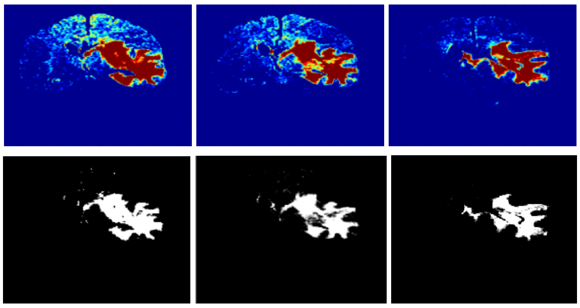

Fig.(6): Results of Contrast adjustment method

The images in first line of Fig.(6) present the highlighted tumor regions gray values (in brown) within the brain matter and the images of second line represent the corresponding extracted tumor regions of the three images respectively.

8.2.2 Closed Contour based method

The results of proposed closed contours based segmentation method, with two number selected close contours, to segment the adopted images are demonstrated in Fig.(7).

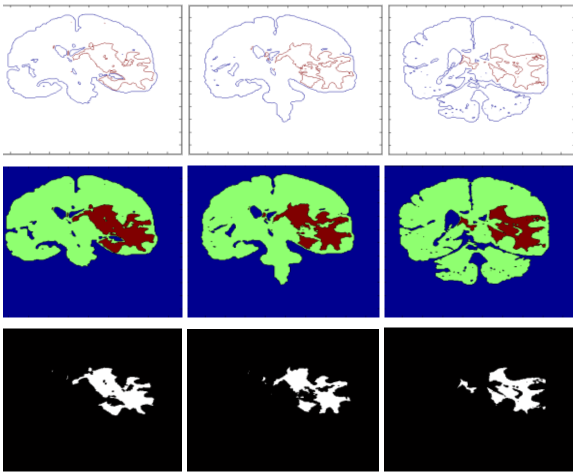

Fig.(7): Closed Contour based segmentation results, (tumor regions are in brown)

First row in Fig.(7) represents the contour map of brain matter images after adopting number of contours equals two, contours of brown color belong to tumor regions. The second row shows the images of filled area of the brain matter and tumor regions, brown areas represent tumor regions. It is clear from the figure that, this technique has good ability for isolating and extracting tumor regions.

8.2.3 K-Means Method

K-Means method, with four clusters, was implemented on the resultant brain matter images and the results are in Fig.(8).

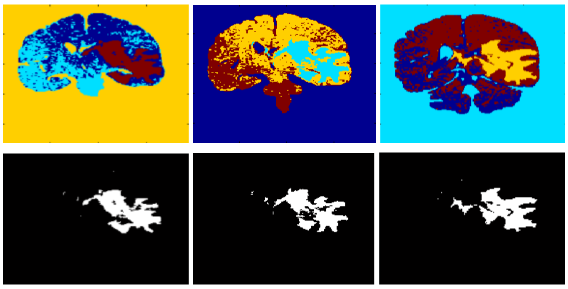

Fig.(8): Results of K-Means method

In Fig.(8), first line of images represents the brain matter segmented images and the images of second line represent the extracted tumor regions.

8.2.4 Fuzzy C-Mean Method

Fuzzy C-Mean algorithm of four clusters was applied on the brain matter images that are deduced from first step to cluster these images and extract the tumor regions only. Fig.(9) presents the results

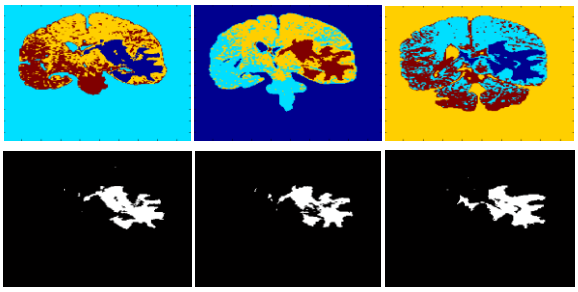

Fig.(9): Results of Fuzzy C-Means algorithm

The first line of images in Fig.(9) represents the brain matter clustered images and the second one shows the extracted tumor regions.

The surface area of the extracted tumor regions by implementing the proposed methods were calculated depending on the spatial resolution of the experimental images (which equals 0.8984375 x 0.8984375 mm^2/pixel). The values of the calculated area in mm^2 are presented in Table (1).

Table (1): Calculated surface area of the extracted tumor regions by different methods

Image	Tumor area (mm^2)			
	Contrast Adjustment	Contour based	K-Means	Fuzzy C-Mean
first	2137.5	1920.3	2011.5	1986.5
second	1875.9	1637.0	1861.4	1825.1
third	1816.2	1488.5	1988.9	1965.5

The relative surface area of the extracted tumor regions was calculated depending on the surface area of the brain matter. The surface area of the brain matter of the experimental images were calculated depending on the extracted brain matter by implementing active contour algorithm and their values are: 15512, 16198 and 18845 in pixels for the three images respectively. Fig.(10) shows the extracted brain matter mask of the images and Table (2) presents the relative surface area of the extracted tumor regions. From Table (1) and (2), it is clear that, there is an agreement of calculated area by contrast adjusting, K-Means and FCM, but the results of closed contour based method is less than them due to the neglecting of this technique to the very small portions of the fragments of tumor regions.

Table (2): Relative surface area of the extracted tumor regions.

Image	Relative surface area of the tumor regions			
	Contrast Adjustment	Contour based	K-Means	Fuzzy C-Mean
first	0.1707	0.1534	0.1606	0.1587
second	0.1435	0.1252	0.1424	0.1396
third	0.1194	0.0979	0.1308	0.1292

Fig.(10): Extracted brain matter mask of the experimental images

9. Conclusions

In this study, an adaptive initialization element of active contour algorithm is proposed to extract the brain matter of MRI sliced images of coronal orientation for the first time. The results of extracting brain matter proved high quality performance of active contour algorithm with its adaptive initialization element. The adequate gray level range that deduced from the proposed analysis of contrast adjusting process is [0.6 0.7]. In addition, the results of the proposed contour based technique present good isolation and extraction of tumor regions. The four implemented techniques are adequate to isolate tumor regions correctly without overlapping with skull as shown from the results, and the values of calculated surface area and relative surface area for the proposed methods are of good agreement.

10. Reference

[1] Rabab Saadoon Abdoon, Loay K. Abood and Ali S. M., 2015, "Adaptive Techniques for Brain Tumor Detection in MRI", Lap LAMBERT Academic Publishing, Germany.

[2] Stuart Clare, 1997, "Functional MRI: Methods and Applications", Ph.D. Thesis, University of Nottingham.

[3] Ali S.M., Loay K. Abood and Rabab S. Abdoon, 2014, "Brain Tumor Detection of Skull Stripped MR Images Utilizing Clustering and Region Growing", Iraqi Journal of Science, Vol. 55, No.3A, pp:1108-1119.

[4] Kass M., Witkin A., and Terzopoulos D. 1987, "Snakes: Active Contour models", Proceedings of First International Conference on Computer Vision, London. Vol. 1, No. 4, pp: 259-269.

[5] Kass M., Witkin A., and Terzopoulos D. 1988, "Snakes: Active Contour Models," International Journal of Computer Vision, Vol. 1, No. 4, pp: 321-331.

[6] Kyeong- Jun Mun, Hyeon Tae Kang, Hwa-Seok Lee, Yoo-Sool Yoon, Chang-Moon Lee, and June Ho Park, 2004, "Active Contour Model Based Object Contour Detection Using Genetic Algorithm with Wavelet Based Image Processing", International Journal of Control, Automation, and Systems, Vol. 4, No. 1, pp:100-106.

[7] Tao Wang, Irene Cheng and Anup Basu, 2009, "Fluuid Vector Flow and Applications in Brain Tumor Segmentation", IEEE Transactions on Biomedical Engineering, Vol. 56, No. 3, pp:781-789.

[8] Amarjot Singh, Shivesh Bajpai, Srikrishna Karanam, Akash Choubey and Thaluru Raviteja, 2012, "Malignant Brain Tumor Detection", International Journal of Computer Theory and Engineering, Vol. 4, No. 6, pp:1002-1006.

[9] Li Ma and Tianzhen Su, 2013, "Contour Extraction of Skin Tumors Using Visual Attention and GVF-Snake Model", Engineering, Scientific Research, pp:482-486. (http://www.scrip.org/journal/eng).

[10] Aman Chandra Kaushik and Vandana Sharma, 2013, "Brain Tumor Segmentation from MRI Images and Volume Calculation of Tumor", International Journal of Pharmaceutical, Vol. 2, Issue 7, pp:23-26.

[11] Gonzalez R.C, Woods R.E and Eddins S.L. 2004. Digital Image Processing Using MATLAB. Pearson Prentice-Hall.

[12] Chen C.W., LuoJ., and Parker K.J., 1998 , "Image Segmentation via Adaptive K-Mean Clustering and Knowledge-based Morphological Operations with Biomedical Applications", IEEE Trans. on Medical Imaging, Vol. 7, pp:1673–1683.

[13] Rabab Saadoon Abdoon, Loay Kadom Abood and S.M. Ali, 2015, "Analysis Study of Fuzzy C-Mean Algorithm Implemented on Abnormal MR Brain Images", IOSR Journal of Applied Physics (IOSR-JAP), Vol. 7, Issue 3, pp: 42-49.