DELINEATION OF TARGET VOLUME FOR BRAIN TUMORS IN RADIOTHERAPY USING ACTIVE CONTOUR SEGMENTATION AND SIMPSON INTEGRATION

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DELINEATION OF TARGET VOLUME FOR BRAIN TUMORS IN RADIOTHERAPY USING ACTIVE CONTOUR SEGMENTATION AND SIMPSON INTEGRATION

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Abstract:
This research conducts the delineation process for a brain tumor on the radio therapy. Delineation means the imaging process of target volume that is conducted in the beginning of Treatment Planning System (TPS). Target volume consists of gross tumor volume (GTV), clinical target volume (CTV), planning target volume (PTV), and Organ at Risk (OAR). This research aims to delineate target volume and measure the target volume axial brain tumor. The images that are used are Magnetic Resonance Imaging (MRI) including axial, coronal, and sagittal slice. Evaluation is only done with one patient affected by a brain tumor. Delineation process is performed by the active contour segmentation method and volume calculations using Simpson integration method. The delineation of target volume is conducted by segmenting each slice of images moreover they are reconstructed until the three dimension of visualized target volume is obtained. Having done this process, target area and target volume calculations are conducted. This research results range error rate for target area is 0.0006 to 0.0059 and target volume is 0.0001 to 0.0013.

Keywords: Delineation; Brain Tumor; Target Volume; Active Contour; Simpson Integration.

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1. Introduction

Brain tumors are one of the tumors that are often suffered by people, especially in men. In the United States brain tumors cover about 85-90% of all central nervous system tumors. The incidence ranges from 6.6 per 100,000 population per year with a mortality rate of 4.7 per 100,000 population per year [1]. The presence of brain tumors can be known by using several modalities, one of which is MRI (Magnetic Resonance Imaging). MRI can see images of soft tissue more clearly.

Treatment of tumors with radiation is called radiotherapy. Because using high-dose radiation, radiotherapy must be carefully planned. To ascertain this, planning needs to be called the Treatment Planning System (TPS). In the TPS process, the first step to take is to know the description of the tumor. Therefore, it is necessary to do the delineation process of the tumor. The

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delineation process is a description of a tumor or volume target. From the results of this delineation, we will know the form of 3D target volume visualization and target volume values. Usually the delineation process is done manually and requires a considerable amount of time so a program is needed to accelerate the delineation process.

The delineation process uses image data that is already in Matlab and the tumor is homemade, not the original tumor. The study did not calculate the target volume. The results of the study obtained visualization forms from 4 types of volumes, namely GTV, CTV, PTV, and OAR and reconstructed in 3D [2].

Research on delineation of volume targets has been carried out using the active contour, and is only limited to the CTV delineation process. The results of the study showed a reasonable accuracy and showed that this algorithm has a great ability to determine CTV [3].

Volume calculation can be done using the integration method, another study calculates phantom volume from CT scan images using the trapezium integration method. The phantom is tubular which is assumed to be a tumor [4].

This study uses a delineation process with the active contour segmentation method and Simpson integration method. This segmentation is used to contour so that the volume target form is obtained. The result of this delineation will also be obtained the target volume value that can be calculated using Simpson integration. In this study the process of delineation of volume targets for MRI brain tumors. The volume target consists of GTV, CTV, PTV and OAR. This delineation process is important so that the optimal TPS results are obtained, namely that the dosage in the tumor is truly correct and the dangerous organs do not get high doses because the target shape and volume are obtained correctly.

2. Materials and Methods

2.1. Delineation

Delineation of accurate volume targets is an important element in the TPS process. To improve visualization and help in volume delineation during radiotherapy planning, CT images can be combined with MRI or even PET. This is a beneficial aspect of both imaging modalities. Using MRI results in accurate volume delineation while using CT excels in dosimetric calculations [5]. The DICOM protocol states that delineation of volume targets is carried out for each cancer. Delineation begins by defining GTV on the main pieces of primary cancer and then GTV is used as masking initialization to determine CTV, then CTV is used as masking to determine PTV [6]

2.2. Image Segmentation

Image segmentation in the planning of radiotherapy treatment is used for delineation of the anatomy of the volume target, the area of danger, external contours, normal critical structures, and others. Image segmentation is one of the most tiring but an important process in planning treatment [7].

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Segmentation divides the image into a number of regions or objects. The level for division depends on the problem being solved. So that segmentation should stop when the desired object in the application has been isolated [8]. Binary image segmentation aims to group pixels of objects into regions that represent objects.

2.3. Active Contour

Active contour, also called snake, is a segmentation method using a closed curve model that can move wide or narrow. This method works by minimizing energy related to the current contour as the amount of internal and external energy. Active contour can move wider or narrower by minimizing image energy using external power, and also influenced by the image characteristics such as lines or edges (edge), energy that affects formulated active contour as in equation 1.

$$E = \int_0^1 E_{\text{int}}(\vec{\gamma}(s))ds + \int_0^1 E_{ext}(\vec{\gamma}(s))ds \tag{1}$$

With E_{int} is internal energy that is influenced by the curve of the object, while E_{ext} is external energy that will attract contours either broadened or narrowed to the desired object. $\vec{\gamma}(s)$ is a curve in two-dimensional space, namely $\vec{\gamma}(s):[0,1] \rightarrow \Re^2$. Internal energy is written as a formula:

$$E_{\text{int}} = \left(\alpha(s)\left|\vec{\gamma}_s(s)\right|^2 + \beta(s)\left|\vec{\gamma}_{ss}(s)\right|^2 \right)/2 \tag{2}$$

Value $\alpha(s)$ and $\beta(s)$ determine the movement of the curve, that is, the first term causes the curve to move like a membrane and the second term causes the curve to move like a thin plate. Whereas external energy is formulated:

$$E_{ext} = \left|\nabla G(\vec{\gamma}(s))\right|^2 \tag{3}$$

with G is the image to be segmented. This system consists of a set of points that are interconnected and controlled by a straight line.

2.4. Simpson Integration

The way to get estimates with accurate accuracy is to use high order polynomials to connect data points. For example if there is one additional point between f (a) and f (b), then all three points can be related to the parabolic function (figure 1a). If there are two additional points with the same distance between f (a) and f (b), then all four points can be related to order 3 polynomials (Figure 1b). The method generated by the integral under the polynomial is known as the Simpson method.

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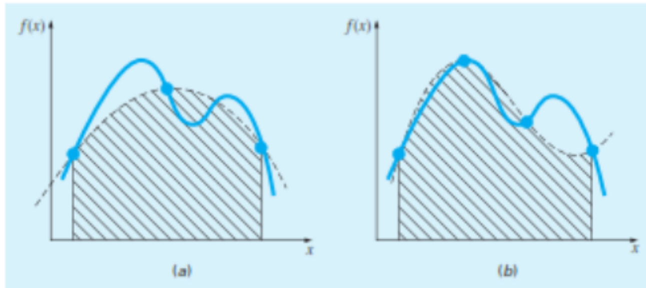

Figure 1: Simpson: a) Simpson rules 1/3 b) Simpson rules 3/8 [9]

The approach of the Simpson method will provide the most accurate results. This is the nature that causes this method to be widely used

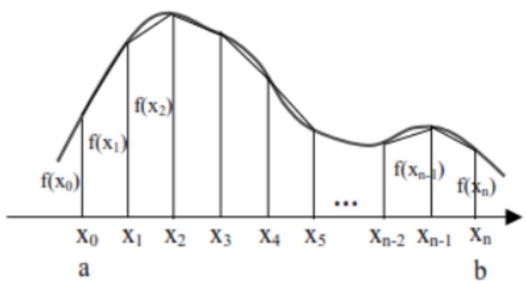

Figure 2: Simpson Integration [10]

Using the Simpson rule, the area of the area bounded by the function y = f (x) and the X axis can be calculated as follows:

$$L = \frac{h}{3}(f_0 + 2f_1) + \frac{h}{3}(2f_1 + f_2) + \frac{h}{3}(f_2 + 2f_3) + \frac{h}{3}(2f_3 + f_4) + \cdots + \frac{h}{3}(f_{n-2} + 2f_{n-1}) + \frac{h}{3}(2f_{n-1} + f_n) \quad (4)$$

Or it can be written with:

$$L = \frac{h}{3}\left(f_0 + 4\sum_{i\,odd} f_i + 2\sum_{i\,even} f_i + f_n\right) \quad (5)$$

data processing as shown in the flow diagram of Figure 3:

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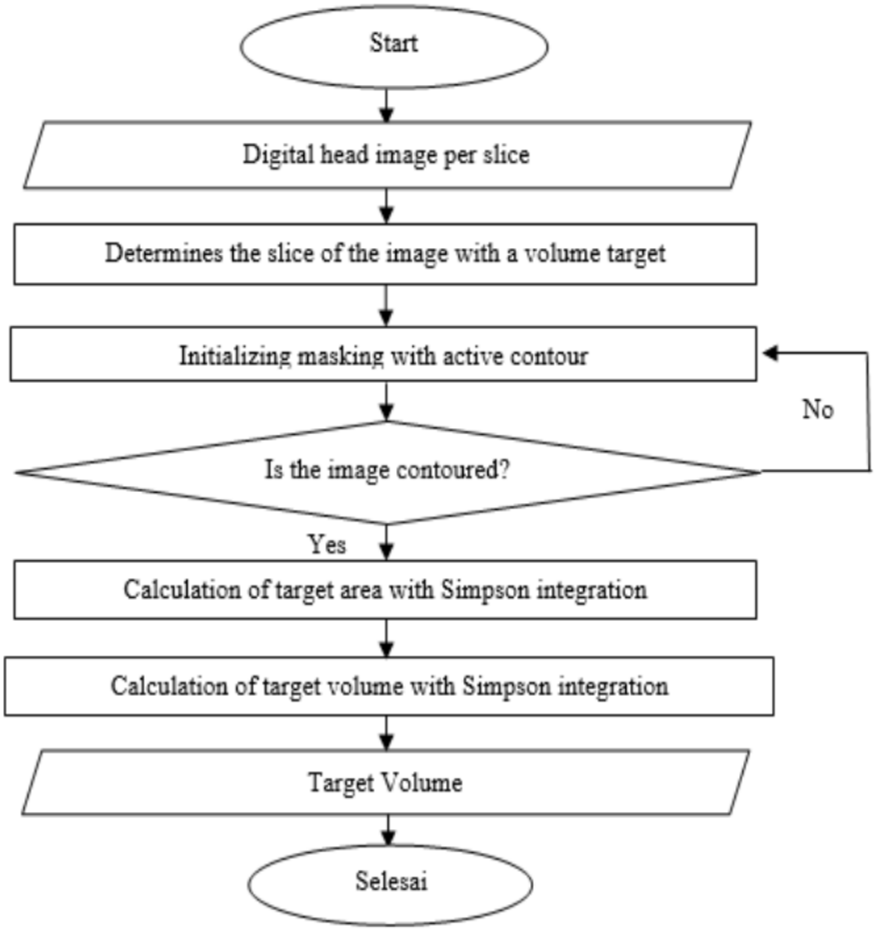

Figure 3: Flowchart of data processing

3. Results and Discussions

In this study, the results of the delineation process and the target volume of axial pieces were discussed. Axial images in this study were 256 x 192 pixels with 19 slices and 0.5 cm slice thickness. This image has a resolution of 10.24 pixels / cm. The image contained in the tumor is at the 12^{th}, 13^{th}, 14^{th}, 15^{th}, and 16^{th} slices. The images that have the right eye and left eye are in slices 4, 5, 6 and 7.

3.1. Image Contour

The image contour is the process of localizing the volume target. In this study, the contour process was carried out using segmentation of active contour. This contour process consists of determining volume targets, namely GTV, CTV, PTV, and OAR. Contoured OAR is the eye because it is the organ closest to the tumor. Some image contour processes are displaying original images, segmenting, displaying segmentation results, and visualizing contours in 3D.

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3.1.1. Image Contour 2D

The 2D image contour process begins with segmentation of GTV, namely the main volume target of the primary tumor at each slice axial image containing a tumor. After that, CTV segmentation then PTV segmentation. The samples from the contours of GTV, CTV, and PTV were carried out at the 16th slice shown in Figure 4

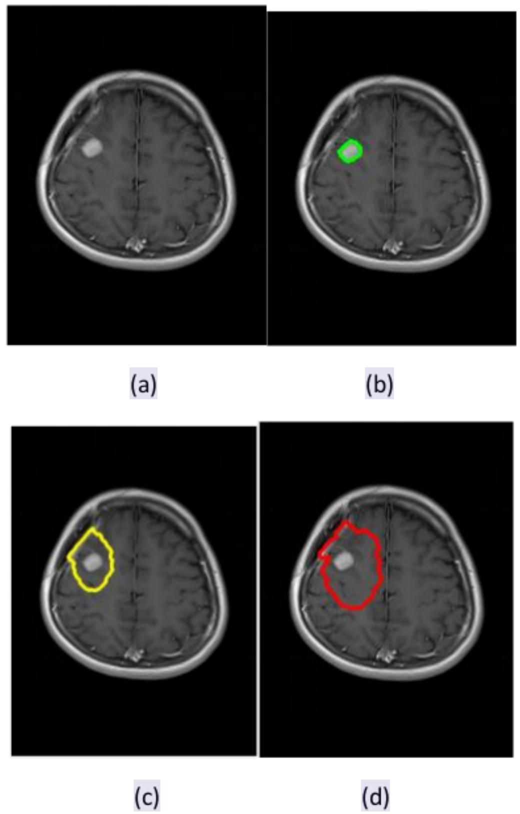

Figure 4: Results of axial image contours on 16th slice (a) original image (b) GTV contour results (c) CTV contour results (d) PTV contour results

Figure 4 shows the contour process of axial imagery performed at slice 16. The GTV contour is carried out precisely in the primary tumor which can be seen then contoured CTV with a margin of 1 cm from GTV or CTV = GTV + 1 cm. The GTV area is used as masking initialization for the CTV contour. After that, contour PTV with a margin of 1 cm from CTV, namely PTV = CTV + 1 cm or PTV = GTV + 2 cm. The CTV area is used as masking initialization for the PTV contour. The image has a pixel unit, so that the unit of cm is obtained, the pixel value is divided by the value of resolution. This axial image has a resolution of 10.24 pixels / cm. After carrying out the contours of GTV, CTV, and PTV, the next process is to contour OAR1 and OAR 2. In this axial piece, OAR 1 and OAR 2 are in the same slice, ie at slices 4, 5, 6, and 7. Samples OAR contour results are shown in Figure 5.

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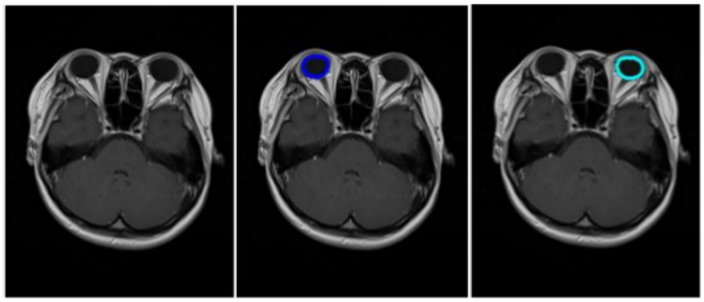

Figure 5: The results of the axial image contour at the 6th slice (a) original image (b) OAR 1 (c) OAR 2 contour results

Figure 5 shows an example of the OAR 1 and OAR 2 contour processes in the 6th slice. OAR 1 is the right eye which is marked with a blue contour while OAR 2 is the left eye which is characterized by Tosca color contour. The OAR 1 contour process starts at the 4th slice, which is calling the original image followed by contouring the right eye part. Then do the same for slices 5, 6, and 7. Likewise with the OAR 2 contour process also starts at slice 4, which is calling the original image followed by contouring the left eye part. Then do the same for slices 5, 6, and 7.

3.1.2. Konturcitra 3D

The 3D image contour process begins by calling previously stored 2D contour data, where the contour data is the result of segmentation using active contour. The form of visualization of the target volume in 3D is shown in Figure 6.

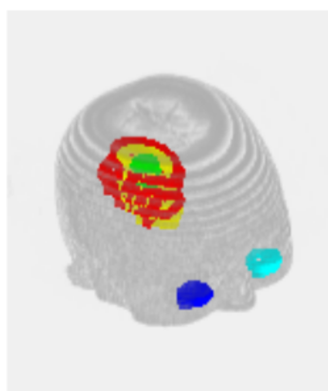

Figure 6: Display the 3D visualization form on the target volume

Figure 6 shows a display of the 3D visualization form of the overall volume target in axial pieces. Green shows GTV, yellow shows CTV, red indicates PTV, blue indicates OAR 1 (right eye), and Tosca color shows OAR 2 (left eye).

3.2. Target Volume

Volume calculation starts with calculating the target area at each slice first

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3.2.1. Target Area

The target area is calculated using the Simpson integration formula (6):

$$L\ (piksel) = \frac{h}{3}\left(f_0 + 4\sum_{i\ odd} f_i + 2\sum_{i\ even} f_i + f_n\right) \quad (6)$$

h is a valuable step size 1. Extensive calculation results with Simpson integration compared to the results of manual target area calculations. The overall calculation of the target area is shown in Table 1.

Table 1: Target Area on Axial Cuts

Target Volume	Manually calculated total target area (cm^2)	Extensive calculation with Simpson integration (cm^2)	Error rate
GTV	12.9413	12.9445	0.0029
CTV	57.7068	577037	0.0014
PTV	97.4369	97.4655	0.0006
OAR 1	7.4673	7.4768	0.0059
OAR 2	7.6199	7.6103	0.0039

From these results it can be seen that Simpson integration can be used to calculate the target area whose results are close to the results of manual area calculations. The range error rate obtained is an area of 0.0006 to 0.0059.

3.2.2. Target Volume

After calculating the target area, then calculate the volume by summing the target area multiplied by the slicthickness. It is known that the slice thickness is 0.5 cm. Calculation of target volume is obtained from equation (7).

$$V = S \times \sum L \quad (7)$$

V is the target volume (cc), L is the target area (cm2) and S is the slice thickness (cm).

The results of calculation of volume with Simpson integration are also compared with the results of manual volume calculations and shown in table 2.

Table 2: Target Volume in Axial Cuts

Target volume	Volume calculation manually (cc)	Volume calculation with Simpson integration (cc)	Error rate
GTV	6.4707	6.4723	0.0002
CTV	28.8534	28.8518	0.0001
PTV	48.7185	48.7328	0.0003
OAR 1	3.7337	3.7384	0.0013
OAR 2	3.8100	3.8052	0.0013

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From table 2, it can be seen that the target volume error rate at the axial pieces is 0.0001 to 0.0013. So, it can be concluded that the bias target volume is generated from calculations manually and by using Simpson integration.

4. Conclusions and Recommendations

The process of delineating volume targets can be done using segmentation of active contour. This segmentation was successfully acquired for GTV, CTV, PTV, and OAR. The target volume can be displayed in the form of 3D visualization.

Simpson integration can be used to calculate the target area whose results are close to the results of manual target area calculations. The range error rate obtained is an area of 0.0006 to 0.0059, and also for the target volume with a range of error rates for axials of 0.0001 to 0.0013.

Image data used should have the same resolution, contrast, and sequence in order to obtain optimal results.This delineation process can be developed on images of other modalities, for example PET images and can be done for other cancer cases, such as the lungs, uterus, breast, and others.

References

[1] KPKN, 2015, Panduan Nasional Penanganan Kanker: Tumor Otak Versi 1.0, BaktiHusada: Kementriankesehatan Republik Indonesia.
[2] Basyid, F. danKusworo A. 2014, Segmentasi Citra Medisuntuk Pengenalan Objek Kankermenggunakan Metode Active Contour, Youngster Physics Journal, Vol.3, No.3, Fakultas Sains danMatematika, UniversitasDiponegoro, Semarang.
[3] Aslian, H., Mahdi, S., Seied, R.M., Farshid, B., M., Mahdi, A., Navid, K., and Pedram, F., 2013, Magnetic Resonance Imaging-Based Target Volume Delineation in Radiation Therapy Treatment Planning for Brain Tumors Using Localized Region-Based Active Contour, Vol. 87, Issue 1, Pages 195-201, Int J RadiatOncolBiolPhys, America. .
[4] Sari, R.T.D., Kusworo, A., danChoirul, A., 2014, PengukurandanPenghitungan Volume Phantom dari Citra Computed Tomography (CT) Scan, Youngster Physics Journal, Vol.3, No.4, Fakultas Sainsdan Matematika Universitas Diponegoro, Semarang.
[5] Cherry, P. and Angela, D., 2009, Practical Radiotherapy, Physics and Equipment, 2rd Edition, Wiley-Black Well, Singapore.
[6] Barret, A., Dobbs, J., Morris, S., and Roques, T., 2009, Practical Radiotherapy Planning, Hodder Arnold, an imprint of Hodder Education, an Hachette UK Company.
[7] Khan, F. M. and Gibbons, J.P., 2014, Physics of Radiation Therapy Fifth Edition, Lippincott Williams & Wilkin, USA.
[8] Prasetyo, E., 2011, Pengolahan Citra Digital Dan AplikasinyaMenggunakan MATLAB, Andi, Yogyakarta.
[9] Chapra, S.C., 2012, Applied Numerical Methods with MATLAB, 3rd Edition, McGraw-Hill, New York.
[10] Sutanta, E., 2004, Algoritma Teknik Penyelesaian Permasalahanuntuk Komputasi, GrahaIlmu, Yogyakarta

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GENERAL COMMENTS

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