ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

A COMBINED MEAN-SHIFT ALGORITHM FOR VERTEBRA IMAGE SEGMENTATION

[1]HAO WANG, [2] XIAO-DONG KANG, [3] LING-LING LIU

[1]Asstt Engineer, Department of Interventional Radiology

Affiliated Hospital of Hebei University, China

[2]Prof., School of Medical Imaging , Tianjin Medical University, China

[3]School of Medical Imaging, Tianjin Medical University, China

E-mail: [1]mouseking2008@163.com

ABSTRACT

This paper is in order to improve the efficiency of image segmentation and reduce the amount of user interaction, the mean shift algorithm is proposed with a combination of segmentation methods applied to the vertebra images. The image was pre-processed with the mean shift method and the region graph was obtained instead of pixel graph, which could reduce dozen times edge numbers in the graph. Furthermore, the edge-preserving property of mean shift algorithm was used. The experimental results show that the proposed method possesses nice properties of the mean shift and graph algorithm, so it is efficient and accurate, and it also reduces user interaction.

Keywords: *Vertebra Image; Image Segmentation; Mean-shift Algorithm*

1. INTRODUCTION

Medical image is a clinician and expert diagnosis important basis, medical image segmentation technology is a region of interest in the image of the object extracted [1], and also contributes to medical research and clinical diagnosis. While in the surgical operation of vertebra segmentation has important significance.

In spinal surgery before the operation, doctors need according to the patient image treatment plan, for example, can be obtained by measuring the spine geometry information to determine the angle of pedicle screw implantation, implant depth, due to the more intuitive 3-D surface mesh measurement, conveniently, it is easier for doctors to cure patients, so it is necessary to establish the 3-D model. Vertebra segmentation accuracy will directly affect the accuracy of 3-D surface model, thus affecting the doctor operation plan, and ultimately affect the operation effect. Due to vertebra CT(Computed Tomography)image of vertebral body relatively small proportion, using the expectation-maximization algorithm of semi-automatic segmentation [4], using thresholding and morphological methods combined to realize the segmentation of vertebra [5], these methods to a certain extent in the bone tissue segmentation, but the segmentation accuracy slightly there is a lack of. Aslan *et al.* [2] using the graph cut algorithm from volume data on spine vertebral segmentation, it has a optimal, user interactivity, combining boundary and region information and other features, to better handle the accuracy of segmentation problem, but the graph cut algorithm itself has a large amount of calculation shortcomings. For the problems are also proposed many solutions. The first is mainly using accelerated processing, such as Vineet *et al.* [3] using GPU(Graphic Processing Unit) accelerated to achieve graph cut algorithm, Delong *et al.* [6] using parallel computing to implement fast graph cut algorithm, and achieved good results; alternatively, mainly by reducing the graph segmentation algorithm operation with the number of vertices and arcs in the graph segmentation algorithm to improve the efficiency, in the Lazy Snapping method [7] using a watershed algorithm based on image segmentation processing, and the use of segmented regions map instead of pixel graph execution graph cut algorithm, can greatly reduce the number of arcs, improved algorithm efficiency. The watershed algorithm for image boundary structure to maintain efficiency is not high, makes for the more complex medical image result is not satisfied, and mean shift algorithm has better boundary structure [8-9].Therefore, this article will

Journal of Theoretical and Applied Information Technology
15th October 2012. Vol. 44 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

combine graph segmentation and mean shift algorithm, make full use of the advantages to achieve the spine image segmentation.

2. MEAN-SHIFT ALGORITHM

Mean shift algorithm is a simple non-parametric probability density gradient projection methods used to sample points within the feature space cluster analysis and statistical model type of the space. In image segmentation, object tracking has a wide range of applications. The basic principle [8]: Given a d space R_d in the n sample points x_i, $i=1, \cdots, n$, the basic form of the mean shift vector is defined as:

$$M_h(x) \equiv \frac{1}{k}\sum_{x_i \in S_h}(x_i - x) \quad (1)$$

In which, S_h is the radius h of a high-dimensional area, the following relations between the set of points y,

$$S_h(x) \equiv \left\{ y : (y-x)^T (y-x) \le h^2 \right\} \quad (2)$$

k represents the n sample points x_i , there are k-points fall into the S_h region .

Let X be d dimension space overall, $\{x_i, 1 \le i \le n\}$ is derived from the overall X independent of the distribution of sample set, the X kernel density estimation for:

$$f(x) = \frac{1}{nh^d}\sum_{i=1}^{n} K\left(\frac{x-x_i}{h}\right) \quad (3)$$

Among them: h is bandwidth, $K(x) = ck(\|x\|^2)$ is kernel function, model point is located in the kernel density function extreme point, so it is necessary to calculate kernel density function gradient

$$\nabla f(x) = 0 \quad \nabla f(x) = \frac{2c}{nh^{d+2}}\sum_{i=1}^{n}(x_i - x)g\left(\left\|\frac{x-x_i}{h}\right\|^2\right) = \frac{2c}{nh^{d+2}}\sum_{i=1}^{n} g\left(\left\|\frac{x-x_i}{h}\right\|^2\right) \cdot \left[\frac{\sum_{i=1}^{n} x_i g\left(\left\|\frac{x-x_i}{h}\right\|^2\right)}{\sum_{i=1}^{n} g\left(\left\|\frac{x-x_i}{h}\right\|^2\right)} - x\right] \quad (4)$$

Among them $g(s) = -k'(s)$, the first term proportional to $G(x) = c_{gd}\, g(\|x\|^2)$, kernel density estimation, second:

$$m_h(x) = \left[\frac{\sum_{i=1}^{n} x_i g\left(\left\|\frac{x-x_i}{h}\right\|^2\right)}{\sum_{i=1}^{n} g\left(\left\|\frac{x-x_i}{h}\right\|^2\right)} - x\right] \quad (5)$$

Where $m_h(x)$ is the mean shift vector, the vector pointing to the intensity of the maximal growth direction, and the mean shift results will intensify gradient to zero point. The process iterates through the realization of $x^{t+1} = x^t + m_h(x^t)$.

3. GRAPH CUT ALGORITHM

Graph cut algorithm is as follows: the image as an undirected graph $G(V,E)$, each vertex is assigned a unique tag, i.e., the object and the background of the markers were x_i = 1 and x_i = 0.Let $A=(A_1 \ldots A_p \ldots A_P)$a two value vector, A_P may be the object or the background, in this way, the image segmentation problem is converted to divided A/B, $A \cup B = V$, $A \cap B = \varnothing$, A/B between the cut :

$$cut(A,B) = \sum_{\mu \in A, \nu \in B} w(\mu, \nu) \quad (6)$$

This E $(\boldsymbol{A})$ for vector $\boldsymbol{A}$ energy function, which represents the $\boldsymbol{A}$ edge and regional characteristics of soft constraints:

$$E(A) = \lambda \cdot R(A) + B(A) \quad (7)$$

In Eq.7 coefficient λ reflect between the regional mark R ($\boldsymbol{A}$) and edge mark B ($\boldsymbol{A}$) the relative importance. In which:

$$\begin{cases} R(\boldsymbol{A}) = \sum_{p \in P} R_p(\boldsymbol{A_p}) \\ B(\boldsymbol{A}) = \sum_{\{p,q\} \in N} B_{\{p,q\}} \cdot \delta(\boldsymbol{A_p}, \boldsymbol{A_q}) \end{cases} \quad (8)$$

$$\begin{cases} B_{(p,q)} \propto \exp\left(-\frac{(I_P - I_q)^2}{2\sigma^2}\right) \cdot \frac{1}{dist(p,q)} \\ R_p(\text{"}obj\text{"}) = -\ln \Pr(I_p | \text{"}obj\text{"}) \\ R_p(\text{"}bkg\text{"}) = -\ln \Pr(I_p | \text{"}bkg\text{"}) \end{cases} \quad (9)$$

$$\delta(\boldsymbol{A_p}, \boldsymbol{A_q}) = \begin{cases} 1 & if\ \boldsymbol{A_p} \ne \boldsymbol{A_q} \\ 0 & other \end{cases} \quad (10)$$

4. COMBINING MEAN-SHIFT ALGORITHM WITH GRAPH CUT

This paper will combine mean shift algorithm and graph cut algorithm together, a mean shift

Journal of Theoretical and Applied Information Technology
15th October 2012. Vol. 44 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

algorithm for segmentation, the calculation speed is improved; on the other hand, the mean shift algorithm for boundary good maintenance, has better boundary structure maintenance; in addition, the graph segmentation algorithm to obtain the foreground and background of the mean and standard deviation, the interactive segmentation method to automatic segmentation method.

Algorithm flow is as follows.

1) The input image using mean-shift algorithm for image over-segmentation mark. Set the reference point and the search radius using the iterative formula to move; on the similarities of each pixel region merging and tagging.

2) The use of over-segmentation mean shift algorithm for images, each of which area, calculated as the average gray value in the region. The area to get over-segmentation adjacency graph instead of a single pixel map, complete the transformation from the image into the map. Use experienced clinicians to manually obtain the foreground and background, to calculate the mean and standard deviation for each value of a region adjacency graph empowerment, the mean shift algorithm to obtain the over-segmentation image through its every pixel for 6 - o domain search, if there has two different pixel tag values, then the region has two adjacent pixels, and using Eq. 10 to judge.

3) The use of the above established minimum cut-maximum flow diagram method to obtain the value of the graph structure of the two results, thus completing the objectives and background of the original image segmentation.

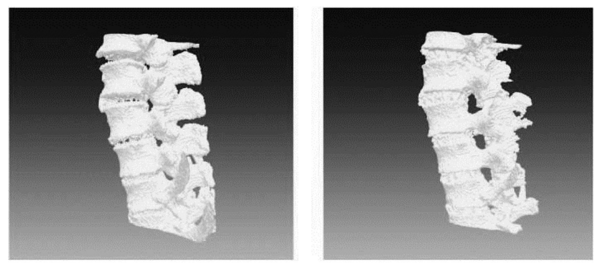
5. EXPERIMENTAL RESULTS AND ANALYSIS

This experimental compiler for MATLAB 2010, Inter dual-core processor, clocked at 3.00G Hz, the memory of 2GB. The experimental data for the two sets of 3D CT vertebral image.

From Table 1 we can see, the number of this algorithm's nodes is less than the single standard algorithm, radians about reduced to 1/35, the running time is about 1/4 of the original, so this algorithm is more efficient, and has better inhibition effect on noise. Fig. 1 (a) for the algorithm results, Fig.1 (b) for the results combined with standard algorithm and watershed algorithm. From the results of segmentation, the algorithm can better retain the vertebral of the foramen, processus spinous, transverse process and other details, and achieved good results, and combining watershed algorithm compared in the boundary structure retention has more advantages.

Table 1 The Algorithm with the Standard Algorithm Performance Comparison

Data No.	Node No.		Time(s)	
	Standard	Algorithm	Standard	Algorithm
1	3514335	1739	150	49
2	5818293	1572	256	69
3	6460332	2466	300	79



(a)The Algorithm (b) Watershed Algorithm

Figuer. 1 The Algorithm and Watershed Algorithm Combined 3D Vertebral Comparison Results

6. CONCLUSION AND DISCUSSION

In this paper, the combination of the mean shift algorithm, the effective use of the mean shift algorithm to maintain the good boundary structure, and to overcome the graph cut algorithm for computing the large of this shortcoming, effectively select two of the vertebral image authentication algorithm. To some extent reduce the error caused by user interaction, which can be used to improve spinal surgical planning. Next is to verify more collected 3-D image data, in order to better improve the robustness of segmentation results.

REFRENCES:

[1] Zhang YJ, "Image Segmentation", *Science Press, Beijing*, 2001, pp. 30-35.

[2] Melih Aslan, Asem Ali, Ham Rara *et al*., "A Novel 3D Segmentation of Vertebral Bones from Volumetric CT Images Using Graph Cuts", *Proceedings of the 5th International Symposium on Advances in Visual Computing*, *Las Vegas, Nevada*, 2009, pp. 519-528.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[3] Vu N and Manjunath B, "Shape Prior Segmentation of Multiple Objects with Connectivity Priors", *IEEE Computer Society Conference on Computer Vision and Pattern Reconnition. Alaska, USA.*2008.

[4] Austin.Ramme, Nicole. DeVries, Nicole. Kallemyn, "Semi-automated Phalanx Bone Segmentation Using the Expectation Maximization Algorithm", *Journal of Digital Imaging.* 2009,22(5):483-491

[5] Yao Peiyan,Zhao Honga,Zhou Mingquan,Hao Dingjun, Segmentation of Vertebra Based on CT Image. *Computer Engineering and Applications,* 2009, 45(27):237-239.

[6] Andrew Delong , Yuri Boykov. "A Scalable Graph-Cut Algorithm for N-D Grids". *In IEEE Conference on Computer Vision and Pattern Recognition, Anchorage*, 2008, pp. 1-8.

[7] Li,Y,Sun J,Tang C.K Shum, H Y. "Lazy Snapping". *In SIGGRAPH (ACM Transactions on Graphics), Los Angeles, USA,* 2004.

[8] Li Hua, Zhang Mingxin, Zheng Jinglong. "Color Image Segmentation Based on Mean Shift and Multi-feature Fusion". *Computer Applications.* 2009, 29(8) pp. 2074-2076..

[9] Dorin Comaniciu, Peter Meer. "Mean Shift: A Robust Approach Toward Feature Space Analysis". *IEEE Transactions on Pattern Analysis and Machine Intelligence,* 2002, 24(5), pp.1-18.

[10] Tobias Heimann, Bramvan Ginneken, Martin A. "Comparison and Evaluation of Methods for Liver Segmentation from CT Datasets". *IEEE Transactions on Medical Imaging.* 2009, 28(8), pp. 1251-1265.