P.O.Box 8718, Beijing 100080, China	Journal of Software, April 2007,18(4):842-849
E-mail: jos@iscas.ac.cn	ISSN 1000-9825, CODEN RUXUEW, CN 11-2560/TP
http://www.jos.org.cn	Copyright © 2007 by *Journal of Software*

多速度函数水平集算法及在医学分割中的应用

陈 健, 田 捷, 薛 健, 戴亚康

陈 健1,2, 田 捷1,2, 薛 健1,2, 戴亚康1,2
1(中国科学院 自动化研究所 复杂系统与智能科学重点实验室 医学影像研究室,北京 100080)
2(中国科学院 研究生院,北京 100049)
作者简介: 陈健(1981－),男,重庆合川人,博士生,主要研究领域为医学图像分割与配准.田捷(1960－),男,博士,教授,博士生导师,主要研究领域为医学影像处理,生物特征识别.薛健(1979－),男,博士生,主要研究领域为三维可视化.戴亚康(1982－),男,博士生,主要研究领域为三维可视化.
联系人: 田 捷 Phn: +86-10-82618465, Fax: +86-10-62527995, E-mail: tian@doctor.com, http://www.mitk.net

Received 2006-04-18; Accepted 2006-05-30

Abstract
All of the former level set algorithms have only one level set function and only one speed function, and it is a complex procedure to minimize the energy function during the evolvement of the zero-level-set. Furthermore, there are a lot of problems in this single speed function. In this paper, a new multi-level-set algorithm with multiplicate speed functions is proposed according to the different properties of different objects: Different level set functions are constructed in different regions, and so are different speed functions accordingly; many zero-level-sets are evolved at the same time and act on one another in order to segment. This method not only enhances the accuracy of segmentation, but also solves the bounder gap problem well, which is quite a puzzle for single level set algorithm. Perfect results are achieved when this method is applied to segment the MR and CT images.

Chen J, Tian J, Xue J, Dai YK. Levelset method with multi-speed-function and its application in segmentation of medical images. *Journal of Software*, 2007,18(4):842-849.
DOI: 10.1360/jos180842
http://www.jos.org.cn/1000-9825/18/842.htm

摘要
以往的水平集算法都只有一个单一的速度函数,在零水平集的演化过程中,能量函数最小化是一个很复杂的过程,而单一的速度函数存在很多问题.在此基础上,根据不同分割区域属性的异同,提出了一种具有多个速度函数的多水平集分割算法:以不同的待分割区域构造多个不同的水平集函数,相应地构造多个不同的速度函数.多个零水平集同时演化,相互作用,以达到分割的目的.该方法不但提高了分割的精度,而且能够很好地解

决单一速度函数水平集算法难以处理的边界缺口问题.将此算法应用于医学MRI和CT的图像分割,得到了很好的分割结果.

基金项目：Supported by the National Natural Science Foundation of China under Grant Nos.30600151, 30500131, 60532050 (国家自然科学基金); the National Grand Fundamental Research 973 Program of China under Grant No.2006CB705700 (国家重点基础研究发展计划); the National High-Tech Research and Development Plan of China under Grant No.2006AA04Z216 (国家高技术研究发展计划(863)); the National Science and Technology Support Program of China under Grant No.2006BAH02A25 (国家科技支撑计划); the Joint Research Fund for Overseas Chinese Young Scholars under Grant No.30528027 (海外青年学者合作研究基金); the Beijing Natural Science Foundation of China under Grant Nos.4051002, 4071003 (北京市自然科学基金)

References:

[1] Hadziavdic V. A comparative study of active contour models for boundary detection in brain images [Ph.D. Thesis]. University of Tromso, 2000.

[2] Osher S, Sethian JA. Fronts propagating with curvature dependent speed: Algorithms based on the Hamilton-Jacobi formulation. Journal of Computational Physics, 1988,79(1):12-49.

[3] Malladi R, Sethian JA, Vemuri BC. Shape modeling with front propagation: A level set approach. IEEE Trans. on Pattern Analysis and Machine Intelligence, 1995,17(2):158-174.

[4] Garcia JN, Kutalik Z, Cho KH, Wolkenhaue O. Level sets and minimum volume sets of probability density functions. Int'l Journal of Approximate Reasoning, 2003,34(1):25-47.

[5] Engquist B, Tornberg AK, Tsai R. Discretization of Dirac delta functions in level set methods. Journal of Computational Physics, 2005,207 (1):28-51.

[6] Cadre B. Kernel estimation of density level sets. Journal of Multivariate Analysis, 2006,97(4):999-1023.

[7] Cecil TC, Osher SJ, Qian JL. Simplex free adaptive tree fast sweeping and evolution methods for solving level set equations in arbitrary dimension. Journal of Computational Physics, 2006,213(2):458-473.

[8] Bertalmio M, Sapiro G, Randall G. Region tracking on level-set methods. IEEE Trans. on Medical Imaging, 1999,18(5):448-451.

[9] Masouri AR, Sirivong B, Konrad J. Multiple motion segmentation with level sets. In: Proc. of the SPIE, Vol 3974. 2000. 584-595.

[10] Paragios N, Deriche R. Geodesic active contours and level sets for the detection and tracking of moving objects. IEEE Trans. on Pattern Analysis and Machine Intelligence, 2000,22(3):266-280.

[11] Samon, C, Blanc-Feraud L, Aubert G, Zerubia J. Level set model for image classification. Int'l Journal of Computer Vision, 2000,40(3): 187-197.

[12] Loncaric S, Subasic M, Sorantin E. 3-D deformable model for aortic aneurysm segmentation from CT images. In: Proc. of the 22nd Annual EMBS Int'l Conf. Chicago, 2000. 398-401. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp-arnumber=900759&fromcon

[13] Chenoune Y, Deléchelle E, Petit E, Goissen T, Garot J, Rahmouni A. Segmentation of cardiac cine-MR images and myocardial deformation assessment using level set methods. Computerized Medical Imaging and Graphics, 2005,29(8):607-616.

[14] Drapaca CS, Cardenas V, Studholme C. Segmentation of tissue boundary evolution from brain MR image sequences using multi-phase level sets. Computer Vision and Image Understanding, 2005,100(3):312-329.

[15] Dydenko I, Jamal F, Bernard O, D'hooge J, Magnin IE, Friboulet D. A level set framework with a shape and motion prior for segmentation and region tracking in echocardiography. Medical Image Analysis, 2006,10(2):162-177.

[16] Manniesing R, Velthuis BK, van Leeuwen MS, van der Schaaf IC, van Laar PJ, Niessen WJ. Level set based cerebral vasculature segmentation and diameter quantification in CT angiography. Medical Image Analysis, 2006,10(2):200-214.

[17] Suri JS, Singh S, Liu K, Laxminarayan S, Zeng XL, Reden L. Shape recovery algorithms using level sets in 2-D/3-D medical imagery: A state-of-art review. IEEE Trans. on Information Technology in Biomedicine, 2002,6(1):8-28.

[18] Wang MY, Wang X. "Color" level sets: A multi-phase method for structural topology optimization with multiple materials. Computer Methods in Applied Mechanics and Engineering, 2004,193(6-8):469-496.

[19] Chan TF, Vese LA. Active contours without edges. IEEE Trans. on Image Processing, 2001,10(2):266-277.