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Adaptive Segmentation Model for Images with Intensity Inhomogeneity based on Local Neighborhood Contrast

WANG Yan[1,2], XIANG Yongjia[2], ZHANG Xuyuan[3,*], and WU Dan[1]

[1] *College of Biomedical Engineering & Instrument Science, Zhejiang University, Hangzhou 310027, China.*

[2] *School of Mathematical Sciences, Chongqing Normal University, Chongqing 401331, China.*

[3] *College of Electronics and Information Engineering, Shenzhen University, Shenzhen 518060, China.*

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Abstract. Segmentation of images with intensity inhomogeneity is a significant task in the field of image processing, especially in medical image processing and analysis. Some local region-based models work well on handling intensity inhomogeneity, but they are always sensitive to contour initialization and high noise. In this paper, we present an adaptive segmentation model for images with intensity inhomogeneity in the form of partial differential equation. Firstly, a global intensity fitting term and a local intensity fitting term are constructed by employing the global and local image information, respectively. Secondly, a tradeoff function is defined to adjust adaptively the weight between two fitting terms, which is based on the neighborhood contrast of image pixel. Finally, a weighted regularization term related to local entropy is used to ensure the smoothness of evolution curve. Meanwhile, a distance regularization term is added for stable level set evolution. Experimental results show that the proposed model without initial contour can segment inhomogeneous images stably and effectively, which thereby avoiding the influence of contour initialization on segmentation results. Besides, the proposed model works better on noise images comparing with two relevant segmentation models.

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*Corresponding author. *Email addresses:* `pmfxyz@163.com` (X. Y. Zhang), `wycq2006@sina.com` (Y. Wang), `549205356@qq.com` (Y. J. Xiang), `danwu.bme@zju.edu.cn` (D. Wu)

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1 Introduction

Image segmentation is a basic but significant problem in the field of computer vision and image processing, the goal of which is to separate the target from background. There are various kinds of images in the world, and they are always susceptible to some contaminations, such as inhomogeneity, noise, blur and so on, which make accurate segmentation still a challenging task. In this paper, we focus on images with intensity inhomogeneity.

Intensity inhomogeneity always occurs in medical images, especially in X-ray radiography, computed tomography (CT) and magnetic resonance (MR) images [1-3]. It often appears as intensity variation across an image, which results from technical limitations or artifacts introduced by the object being imaged. Popular global region-based models, such as Chan-Vese model [4], generally assume that image intensities are statistically homogeneous, i.e., roughly a constant [2]. Thus, these piecewise constant (PC) models have difficulty to deal with intensity inhomogeneity. Segmentation of such inhomogeneous medical images usually requires intensity inhomogeneity correction as a preprocessing step [5].

In order to handle directly intensity inhomogeneity, some more sophisticated models than PC model are developed. Vese and Chan [6] and Tsai et al. [7] independently proposed two similar models, which are called piecewise smooth (PS) model. These methods can segment more general images, but they are computationally inefficient. To this issue, some local region-based models have been proposed [1, 2, 8-12]. For example, Li et al. [2] proposed a region-scalable fitting (RSF) active contour model (originally termed as local binary fitting (LBF) model [1]), which employs local region information and can deal with intensity inhomogeneity. However, the RSF model is computationally expensive since four convolutions need to be computed at each iteration for implementation. For more efficient segmentation, Zhang et al. [8] presented a local image fitting (LIF) model based on a constraint of the differences between the fitting image and the original image. Both models are only based on region mean information without considering region variance and thereby may lead to inaccurate segmentation. In [9], Zhang et al. exploited the local image region statistics and obtained a local statistical active contour (LSAC) model. The LSAC model can be directly applied to simultaneous segmentation and bias correction for 3T and 7T magnetic resonance images. For accurate medical image segmentation, an adaptive local-fitting-based active contour model is proposed in [10].

Local region-based models, however, to some extent, are sensitive to contour initialization. Dissimilar initial contours may lead to dissimilar segmentation results, even false results. This means they may be up against the problems of how and where to