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PII: S0031-3203(18)30045-1
DOI: 10.1016/j.patcog.2018.01.032
Reference: PR 6441

To appear in: *Pattern Recognition*

Received date: 18 October 2016
Revised date: 1 September 2017
Accepted date: 28 January 2018

Please cite this article as: Annupan Rodtook , Khwunta Kirimasthong , Wanrudee Lohitvisate , Stanislav S. Makhanov , Automatic Initialization of Active Contours and Level Set Method in Ultrasound Images of Breast Abnormalities, *Pattern Recognition* (2018), doi: 10.1016/j.patcog.2018.01.032

Automatic Initialization of Active Contours and Level Set Method in Ultrasound Images of Breast Abnormalities

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Abstract.
We propose a novel initialization method designed for active contours (AC) and the level set method (LSM), based on walking particles. The algorithm defines the seeds at converging and diverging configurations of the corresponding vector field. Next, the seeds "explode", generating a set of walking particles designed to differentiate between the seeds located inside and outside the object. The exploding seeds method (ESM) has been tested against five state-of-the-art initialization methods on 180 ultrasound images from a database collected by Thammasat University Hospital of Thailand. The set of images was additionally partitioned into malignant tumors, fibroadenomas and cysts. The method has been tested for each of those cases using the ground truth hand-drawn by leading radiologists of the hospital. The competing methods were: the trial snake (TS), centers of divergence (CoD), force field segmentation (FFS), Poisson Inverse Gradient Vector Flow (PIG), and quasi-automated initialization (QAI). The numerical tests demonstrated that CoD and FFS failed on the selected test images, whereas the average accuracy of PIG and QAI were lower than that achieved by the proposed method for both AC and the LSM. The LSM combined with the ESM provides the best results.

1 Introduction

Since the seminal work [1] AC (snakes) have been applied to many segmentation problems derived from different applications. Further improvements are gradient vector flow (GVF) [2] and the generalized gradient vector flow field (GGVF) [3]. Some variations of these ideas are multidirectional GGVF [4] and the non-linear diffusion model [5]. Recent modifications of the GVF-type model are Normal Gradient Vector Flow [6], Infinity Laplacian [7], Harmonic Gradient Vector Flow [8], Convolution Vector Flow [9], Dynamic Directional Gradient Vector Flow [10], Adaptive Diffusion Flow [11], and Multi Feature Gradient Vector Flow [12]. A comparative study of AC methods in medical image segmentation is presented in [61].

The accuracy and the computational time of segmentation produced by the AC depend on their initial positions (seeds). The seeds must be initialized close to the desired object. Otherwise the AC attach to false boundaries created by noise and artifacts.

One of the popular solutions is analysis of the vector field generated by the GVF-type model. Since the noise and small artifacts generate star-like (divergent or convergent) configurations of the vector field, multiple AC generated around them avoid the false boundaries. For instance, [14] applies force field segmentation (FFS) to divide the image

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