Dual-Snake Model in the Framework of Simplicial Domain Decomposition

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Abstract. The original proposal of Active Contour Models, also called snakes, in the field of image segmentation and computer vision, suffers from the strong sensitivity to the initial contour position. The Dual-Snake model is an approach to relieve this problem by using two contours: one contour which contracts from outside the target and another one which expands from inside as a balanced technique with the ability to reject local minima. In this work we propose to embed the dual contour approach in a simplicial domain decomposition framework to generalize and to extend it to 3D images.

Snake Model

Contour Model: Closed Curve c.
$E(c)$ =*(Internal Energy) +(Image Energy).*
Problem: Minimize $E(c)$.

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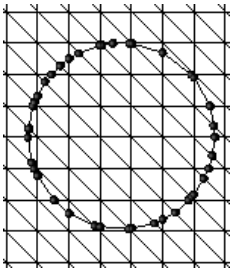
Discrete Model:

$$c = \{v_i = (x_i, y_i), i = 0, ..., N-1\},$$
$$v_i^{(t+\Delta t)} = v_i^{(t)} + h_i\left(\alpha_i^{(t)} + \beta_i^{(t)} + \gamma_i^{(t)} + f_i^{(t)}\right).$$

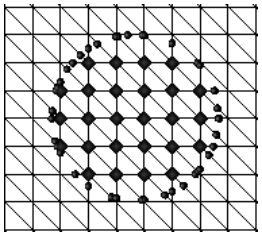
Simplicial Domain Decomposition Framework

Fig. a) Snake is projected over a triangulation of the image domain.
Fig. b) Characteristic Function to distinguish the interior from exterior of a curve: $\chi(p) = 1$ if $p \in interior$ and $\chi(p) = 0$, otherwise, where p is a node of the simplicial grid.

a) Curve Projected.

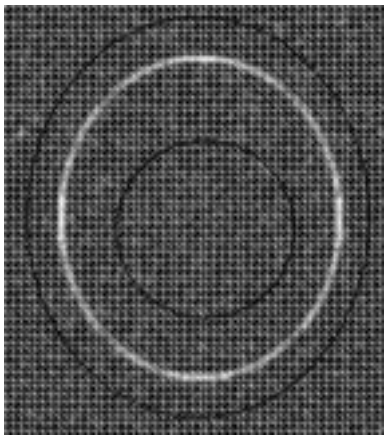


b) Characteristic Function.



Dual-Snake Algorithm

Initialization: Image Triangulation and Dual Snakes (dark curves).



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1. Select contour with highest energy;
2. If snake motion is below a threshold, add a normal force to accelerate it;
3. When snake energy starts decreasing, remove the added normal force liberating the curve to reach equilibrium;
4. Repeat this procedure until the characteristic functions of the two snakes are similar.

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Final Result.