A NOVEL ALGORITHM FOR ACTIVE CONTOUR MODELS: ADAPTIVE SNAKES

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Abstract

We present a novel algorithm to optimize deformable contour models. It overcomes an inherent problem of traditional snakes using a dynamic intervention in the evolution of the curve so that leads to better fidelity in contour detection. In practice, the main difference from the traditional GVF snakes is the definition of a feature merit function. The proposed method solves the problem of points bunching together on strong portions of the contour and achieves fuller matching of concavities with external forces. We also show with a set of well-parameterized images that the proposed solution leads to better convergence and matching.

1. Introduction

The parametric active contour model known as snakes was first proposed by Kass et all [1] and has been widely used in image processing and computer vision. These models simulate elastic materials which can fit themselves dynamically to object shapes in response to internal forces, external image forces, and user-specified constraints. Grasping [2], and tracking [3] are illustrative application examples.

The snake was originally defined as a curve $X(s) = (x(s), y(s))$, $s \in [0,1]$ that evolves through the spatial domain of the image to minimize an energy function. The snake has been used widely but its original formulation is inadequate for images with deep concavities or a complex geometry and topology. These questions have been raised in recent publications and attempts made to improve these aspects of the original implementation [4], but they do not achieve a global analysis of the optimum inter-distance and the problem is only addressed by the insertion of severe constraints and essentially different formulations [5].

The solution proposed here is an adaptive algorithm that uniquely addresses the problem by a global analysis of the optimal inter-distance. The results generated show that this method greatly enhances the contour detection accuracy.

2. Proposed Solution

The proposed principle of adaptation is the definition of new optimal point positions along the snake that minimize a morphological energy function $\xi(X)$ shown in equation 1,

$$\xi(X) = \int u \left| \oint_X \frac{\partial}{\partial s} h(X) dX \right|^2 + vh(X) ds \quad (1)$$

where h(X) represents the merit function, and u and v are weighting factors specified by the user to balance the differential and the non-differential terms. The merit function is chosen to have local minima in the regions of interest such that the updated point positions improve the accuracy in the desired portions of the contour. Equation 2 shows a typical merit function example,

$$h(x) = \left(\frac{\|X(s_i) - X(s_i - \Delta s_i)\| + \|X(s_i + \Delta s_i) - X(s_i)\| - \|X(s_i + \Delta s_i) - X(s_i - \Delta s_i)\|}{\|X(s_i + \Delta s_i) - X(s_i - \Delta s_i)\|} \right)^2 \Bigg|_{i=1}^{np} \quad (2)$$

where np is the number of points, is shown in figure 1.

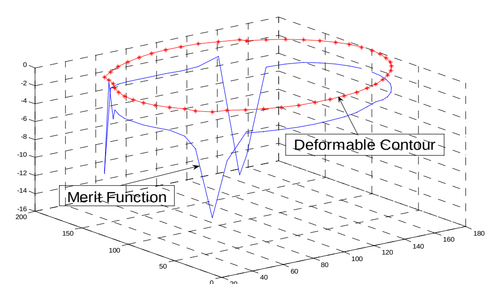

Figure 1 – Merit function (---) and deformable contour (-+-)

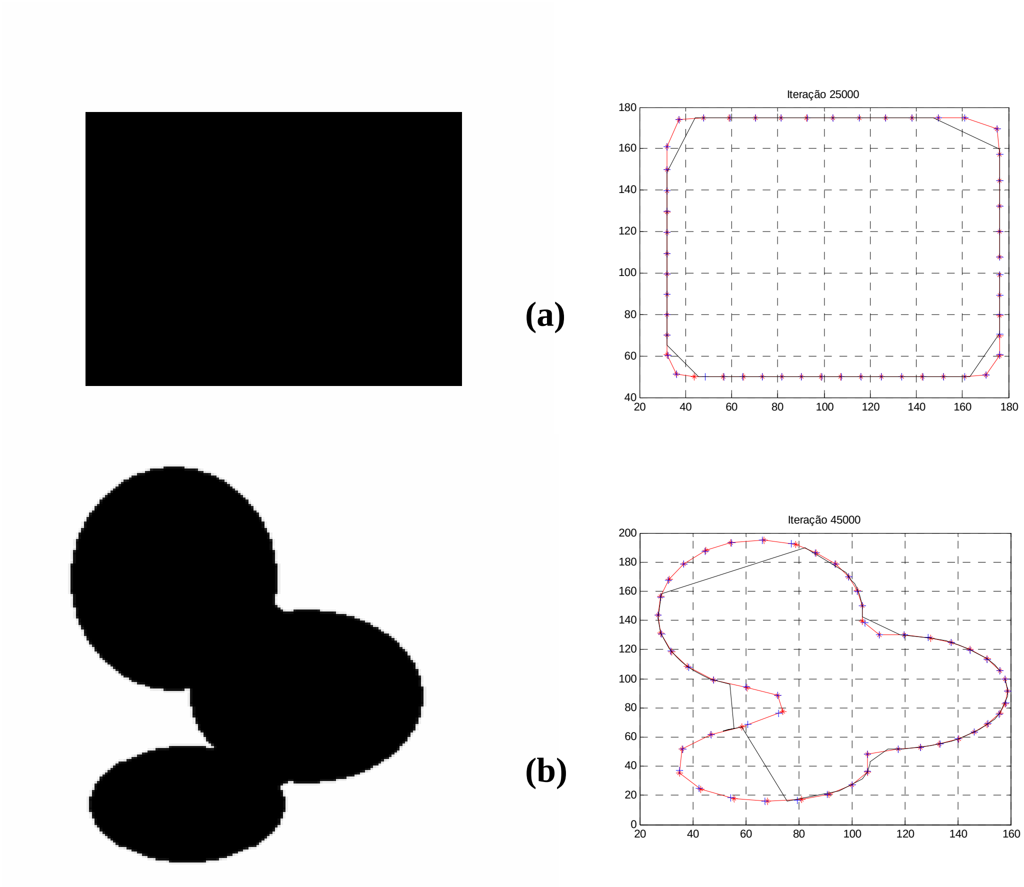

Figure 2- GVF snake (---) and adaptive snake (-+-): flat/flat image (a) and curve/curve image (b)

3. Experimental Results

For two well-parameterized synthetic images, figure 2 presents a comparison between the traditional GVF snakes formulation [6] and the proposed adaptive algorithm for a poor snake (both with 30 points). As we can see, the proposed algorithm significantly enhances the contour detection performance.

4. Conclusions

The experimental results show that the proposed algorithm needs fewer points then the traditional snake formulation and is uniquely able to address the extern force concavity achieving capability. Its low processing time is also an important aspect to be considered in image recognition scheme for vision systems.

5. References

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