Disjunctive Normal Parametric Level Set With Application to Image Segmentation

Abstract:

Level set methods are widely used for image segmentation because of their convenient shape representation for numerical computations and capability to handle topological changes. However, in spite of the numerous works in the literature, the use of level set methods in image segmentation still has several drawbacks. These shortcomings include formation of irregularities of the signed distance function, sensitivity to initialization, lack of locality, and expensive computational cost, which increases dramatically as the number of objects to be simultaneously segmented grows. In this paper, we propose a novel parametric level set method called disjunctive normal level set (DNLS), and apply it to both two-phase (single object) and multiphase (multiobject) image segmentations. DNLS is a differentiable model formed by the union of polytopes, which themselves are created by intersections of half-spaces. We formulate the segmentation algorithm in a Bayesian framework and use a variational approach to minimize the energy with respect to the parameters of the model. The proposed DNLS can be considered as an open framework that allows the use of different appearance models and shape priors. Compared with the conventional level sets available in the literature, the proposed DNLS has the following major advantages: it requires significantly less computational time and memory, it naturally keeps the level set function regular during the evolution, it is more suitable for multiphase and local region-based image segmentations, and it is less sensitive to noise and initialization. The experimental results show the potential of the proposed method.