Thesis subject, University of Strasbourg: Level sets for object detection

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Subject

An image may be described from its level sets, which contain the set of points above or below a given value. This representation possesses two advantages : on the one hand, being invariant under contrast changes, it allows to define an equivalence class between images ; on the other hand, level sets generally coincide with visually significant structures in the image. Several recent studies suggest that level sets play a fundamental role in visual perception [1, 2].

Gestalt approaches consider, for instance, remarkable structures formed by level lines in the image (alignment, contrasted regions, etc.) [3].

Within the framework of mathematical morphology, several hierarchical structures rest on level sets of an image : the component tree [4, 5], the binary partition tree [6] or the tree of shapes [7]. These structures are generally used for filtering purposes, as they allow an algorithmically efficient implementation of "connected operators", operators that have the property of not changing image contours.

Recently, these structures were used for fast identification of objects [8, 9]. However, these methods analyse individually the different connected components of level sets for recognition purposes. In complex scenes, a visually significant object will be potentially formed by several level sets, possibly disjoint ones. These methods can thus fail in such cases.

The purpose of this thesis is to be able to generalize approaches based on level sets towards detecting objects in complex images. It should lead to original methodologies for object recognition, as well as efficient algorithms for processing them.

For this goal, works will tie up around three axes :

1. Study of alternate connectivities

Hierarchical structures based on level sets generally store connected components of level sets. However, considered individually, level sets do not necessarily correspond to objects of interest. In order to solve these problems, alternate connectivities could be envisaged [10, 11], allowing to extend tree-like hierarchical structures to hyper-tree-type structures [12]. Multi-scale approaches can also be put to work in order to bypass problems of contour changes that lead to local connection or deconnection of objects.

2. Spatial relations between nodes

Actual hierarchical methods do not use informations pertaining spatial relations between components. This axis of work consists in studying the contribution of spatial relations between the nodes of a hierarchical structure for the purpose of image analysis. The description of spatial relations could notably rest on the notion of force histogram [13], allowing to represent, for each object, the spatial influence of other objects.

3. Object detection

Shape descriptors allow the characterization of an object shape in a perspective of recognition [14, 15]. Preliminary works have shown the interest of combining structural approaches with shape descriptors for the purpose of recognition [8]. Similarly, some recognition methods rest on detectors of interest zones having a very strong link with the notion of component tree (Maximally Stable Extremal Region [16]). This axis of work will lead to a comparative study of existing descriptors and should allow the development of shape descriptors specifically adapted to object detection from structural approaches.

Moreover, from two structural representations (with a tree-like, or more generally, graph-type structure), a crucial point concerns putting all or part of their contents into correspondence [19]. This putting

into correspondence requires developing a metric that can rest notably on the search for the greatest common sub-tree maximizing a similarity measure (Maximum Similarity Subtree Isomorphism [17, 18]).

Finally, these object descriptors will be used and combined withing learning methods in order to implement object classification.

Applications

Methods developed in this work will be applied to object analysis in biomedical images (medical or biological imaging).

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