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Image Segmentation

Image segmentation consists of two related operations, namely *recognition* and *delineation*. *Recognition* is the high level process of determining roughly the whereabouts of an object in the image. *Delineation* is the low-level process of determining the spatial extent (and composition) of the object in the image. Humans outperform computer algorithms in most recognition tasks especially involving anatomic objects, and this is vice versa for delineation. Segmentation is perhaps the most challenging of all image operations. Ironically most image operations depend on segmentation directly or indirectly. Approaches to segmentation may be broadly classified into three groups: *boundary-based*, *region-based*, and *hybrid*. *Boundary-based* methods recognize and delineate boundaries of objects in images. *Region-based* methods recognize and delineate the regions occupied by the objects in images. *Hybrid* methods attempt to exploit the relative strengths of boundary- and region-based methods in an attempt to overcome their respective weaknesses. In all these approaches, the actual delineation may be done in a *crisp* (hard) or *fuzzy* manner. Further, the method design in all approaches may be such that it may be *interactive* or *non-interactive*. If we consider all these sub-classifications, there are 12 possible strategies in all for image segmentation, starting from iterative, boundary-based, hard approaches to non-interactive, hybrid, fuzzy techniques. In this tutorial, I will present an overview of image segmentation methodologies along this disciplinary framework and discuss exemplary methods in each group in detail with illustrations from particular medical application areas.

A related issue in image segmentation is how to evaluate and compare methods. This has remained a challenge owing to a lack of commonly accepted and standard metrics, standard image data, true segmentations, and reference methods and their standard implementations. In the final part of this tutorial, I will outline a disciplinary framework for evaluating segmentation methods keeping these challenges in mind.