Methods of fMRI segmentation

Image segmentation plays a vital role in a medical imaging applications. Many image segmentation methods have been proposed for the process of successive image analysis tasks in the last decades.

In general, MRI segmentation is not a trivial task, because acquired MR images are imperfect and are often corrupted by noise and other image artifacts. The diversity of image processing applications has led to development of various techniques for image segmentation. This is because there is no single method that can be suitable for all images, nor are all methods equally good for a particular type of image.

The segmentation methods, with application to brain MRI, may be grouped as follows:

1. manual segmentation
2. intensity-based methods (incuding thresholding, region growing, classification, clustering)
3. atlas-based methods
4. surface-based methods
5. hybrid segmentation methods

Intensity-based segmentation methods classify individual pixels/voxels based on their intensity. In the case of the brain MRI, three main tissue classes, WM, GM, and CSF, can be distinguished based on intensity.

Thresholding is the simplest image segmentation method. A thresholding procedure uses the intensity histogram and attempts to determine intensity values, called thresholds τ, which separates the desired classes. The segmentation is then achieved by grouping all pixels between thresholds into one class. In brain MRI segmentation, thresholding can be used to separate background voxels from the brain tissue or to initialize the tissue classes in iterative segmentation methods such as fuzzy -means clustering.

Classification methods use data with known labels to partition image feature space. Image features are typically intensity values but can be also related to texture or other image properties. Classification methods can be both supervised and unsupervised. Supervised classification requires training images, which are manually segmented and then used as references for automatic segmentation of new images. One of the simplest classifiers is the nearest-neighbor classifier, where each pixel/voxel is classified in the same class as the training datum with the closest intensity.

Clustering methods are unsupervised segmentation methods that partition an image into clusters of pixels/voxels with similar intensities without using training images. In fact, clustering methods use the available image data to train themselves. The segmentation and training are done in parallel by iterating between two steps: data clustering and estimating the properties of each tissue class.

Due to the rapid development of medical image modalities, new application-specific segmentation problems are emerging and new methods are continuously explored and introduced. As a consequence, the segmentation process often becomes more complex and time-consuming. The likely future research will still focus not only on developing more accurate and noise-robust methods, but also on improving the computational speed of segmentation methods.