ADNI Alzheimer's Disease Neuroimaging Initiative

Automated Brain Delineation using Multi-Atlas Propagation and Segmentation (MAPS)

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Contents

Summary

We describe the processing methods of multi-atlas propagation and segmentation (MAPS) for automated brain delineation (Leung *et al.* 2011). First, the target image is compared to all the atlases in a template library of >600 scans. Multiple (19) best-matched atlases are then selected, and the brain regions in the selected atlases are propagated to the target image after image registration. Shape based averaging is then used to combine the brain regions from different atlases to create an accurate brain region in the target image.

Methods

We now describe each step in MAPS in more details.

Template library preparation

Our template library consisted of 682 1.5 T MRI scans from the ADNI-1 data set and corresponding semi-automated brain regions (Freeborough *et al.* 1997). To facilitate the matching of the target image to the atlases in the template library, all the atlases were put into the same reference space by affinely registering to a subject (ADNI-1 subject ID=021_S_0231, MCI male aged 60 with MMSE 29/30). The affine registration algorithm used in all our methods was based on maximising the normalised cross-correlation between the source and target images using a conjugate gradient descent optimization scheme.

Template selection

The target image was affinely registered to the subject to which all the template library scans were registered. Best matches from the template library were ranked as to their similarity using the cross-correlation (R^2) between the target image and the template library over the two-voxel dilated whole brain segmentations. Once a rank of best to worst matches was established, the highest ranking 19 matches were used to propagate the undilated whole brain segmentations onto the target image.

Label propagation

The best-matched atlases were registered to the target image using affine registration and non-rigid registration based on free form deformation (Rueckert *et al.* 1999; Modat *et al.* 2010).

Multiple control point spacings (16 mm→8mm→4 mm) were used in the non-rigid registration to model increasingly local deformations. The whole brain regions in the best-matched atlases were then propagated to the target image using the results of the registrations. The mean and SD of CSF, GM and WM intensity of the brain were estimated using *k*-means clustering. The grey level whole brain region in the target image was thresholded between two thresholds (T_{GM}: cut-off between CSF and GM and T_{WM}: cut-off between WM and other bright noise/artifact/fat). , where T_{GM} was determined by the mean and SD of CSF and GM, and T_{WM} was determined by the mean and SD of the WM. Specifically,

$$TGM=IGM- 0.9*\sigma GM\sigma GM+\sigma CSF*IGM-ICSF,$$

$$TWM=IWM+4.42*\sigma WM,$$

where $I_{\{CSF, GM, WM\}}$ are the mean intensity of CSF, GM and WM, and $\sigma_{\{CSF, GM, WM\}}$ are the standard deviation of CSF, GM and WM. This was followed by a two-voxel conditional dilation within T_{GM} and T_{WM}.

Label fusion

Multiple brain regions in the target image were combined using shape based averaging (Rohlfing and Maurer, Jr. 2007). We used the 50% trimmed mean instead of the simple mean when calculating the average distance of a voxel to the labels in order to increase the robustness to outliers.

Manual editing

The final segmentation was checked and edited if necessary by an expert rater.

Version Information

This is the first version.

Dataset Information

This methods document applies to the following dataset(s) available from the ADNI repository:

Dataset Name	Date Submitted
UCL – Brain-MAPS brain regions [ADNI GO/2]	31 October 2012

References

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