Automated Segmentation of Brain Tissues based on Atlas-based Segmentation and AdaBoost Classification

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Proposed Segmentation Framework

We proposed a fully automated segmentation framework based on the atlas-based segmentation and AdaBoost classification for segmenting the MR images into three tissue types: white matter, gray matter and cerebrospinal fluid (CSF). A schematic diagram of the proposed framework is shown in Fig.1.

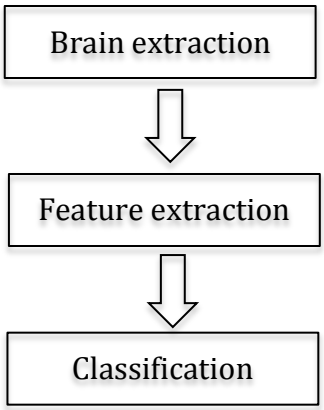

Figure 1. Schematic diagram of the proposed framework.

1. Brain Extraction

For each test image brain mask was extracted using Atlas-based segmentation. For this purpose ten T1-weighted images [1] were used as atlases, five of which were the training scans and the other five were the left-right-flipped version of these training scans. For each atlas, training multi-label (manual segmentation) image was also provided, which was transformed to a binary label image by setting the brain structure labels to 1. Each atlas was registered to the T1-weighted test image using IRTK tool [2] by computing the non-rigid transformation followed by rigid and affine transformations. The non-rigid transformation was also employed on the binary label image to align it to the test image. Finally the brain mask for the test image was extracted by fusion the all registered binary label images into a single binary image using the vote rule based decision fusion [3].

2. Feature Extraction

For each voxel of the MR scan, 9 features were extracted:

- The intensity

- The intensity with Gaussian filtering
- The magnitude of first derivative along x, y and z direction
- The magnitude of second derivative along x, y and z direction
- The gradient magnitude

This yielded a total of 27 features from the multi-sequence (T1-weighted (T1), T1-weighted inversion recovery (T1_IR) and FLAIR) MR images. All features were normalized to zero mean and unit standard deviation.

3. Classification

AdaBoost [4] was applied to classify each voxel into one of the seven tissue labels: Cortical gray matter, basal ganglia, white matter, white-matter lesions, CSF in the extracerebral space, ventricles and background. In AdaBoost, the decision tree was used as a week classifier and it was trained on a total of 12,000 samples from the multi-sequence training subject for the seven labels. The samples were selected randomly from the brain excluding the cerebellum and the brain stem. The output of the AdaBoost classifier was the seven tissue labels, which was reduced to four labels (Gray matter, white matter, CSF and background) by merging the voxels segmented as cortical gray matter and basal ganglia, white matter and white-matter lesions, and CSF in the extracerebral space and the ventricles.

For each test subject, the whole segmentation process takes approximately 45 minutes, using the IRTK tool for atlas-based brain segmentation and MATLAB for AdaBoost classification for brain tissues and running on a laptop with OS X 10.9.3 and equipped with an Intel Core i5 processor, at 2.5 GHz, and 4 GB of RAM.

References

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