A rat brain template of class distribution maps based on diffeomorphic image registration

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Introduction:

Brain tissue segmentation of MR images is an important step for detecting morphological changes within and across different subject populations as well as for quantifying the tissue contents of MR spectroscopy voxel for absolute quantification. The open source software SPM[1] allows automatic tissue segmentation using templates and prior probability maps for different tissue types. Since SPM is designed for human data and uses human templates accordingly, we set up a procedure for easy creation of population and scanner specific templates for segmenting rat MR-images using SPM5 and FSL[2].

Methods:

In a pilot study 21 in-vivo rat brains were measured in a 9.4T animal scanner (Bruker, Rheinstetten, Germany) using a 4 Element PAT-coil. All 21 animals were investigated under 2.3% isolfurane anesthesia with a T1-weighted FISP 3D-Sequence (MTX 256x256x128, FOV = 3cm). The measured 3D data were then resized by a factor of 10 to be more suited for the SPM algorithms optimized for the scale of the human brain.

Compared to the human data, the rat data involve more head tissue in the volume. For convenience, all of the data were realigned to each other, so that only one bounding box was used to roughly crop the region of interest for all of the brains. Then the FSL Brain Extraction Tool (BET) was used to estimate the brain regions in a more accurate way. For about 15% of our data, FSL BET algorithm returned brains with a small part of the head tissue. In these cases, a polishing procedure including thresholding, morphological closing and distance transform was applied to remove the residual tissue.

The extracted brains were then debiased to correct the non-uniformity of the acquisition. Then the FSL Automated Segmentation Tool (FAST) was used to do a pre-segmentation for each data on the voxel level. All of the FSL FAST results were eventually collected together to prepare the templates for different kind of materials in the brain using the SPM Diffeomorphic Anatomical Registration through Exponentiated Lie Algebra (DARTEL) [3].

Results:

Individual rat data sets were segmented with SPM5 on the sub-voxel level using the described templates for gray matter, white matter and cerebrospinal fluid as prior probability images.

Discussion:

With the created templates, SPM offers the possibility to segment rat brain images fully automatically. Due to the small object size, rat brain images are usually acquired using surface receive coils with resulting in strongly biased data which poses a problem to the segmentation. Nevertheless the bias correction incorporated in SPM and FSL seems to be sufficient enough for a robust segmentation of most acquired data.

Comparing to the existing templates[4,5] generated based on the affine transform, our template gets the benefit of nonlinear registration provided by DARTEL algorithm.

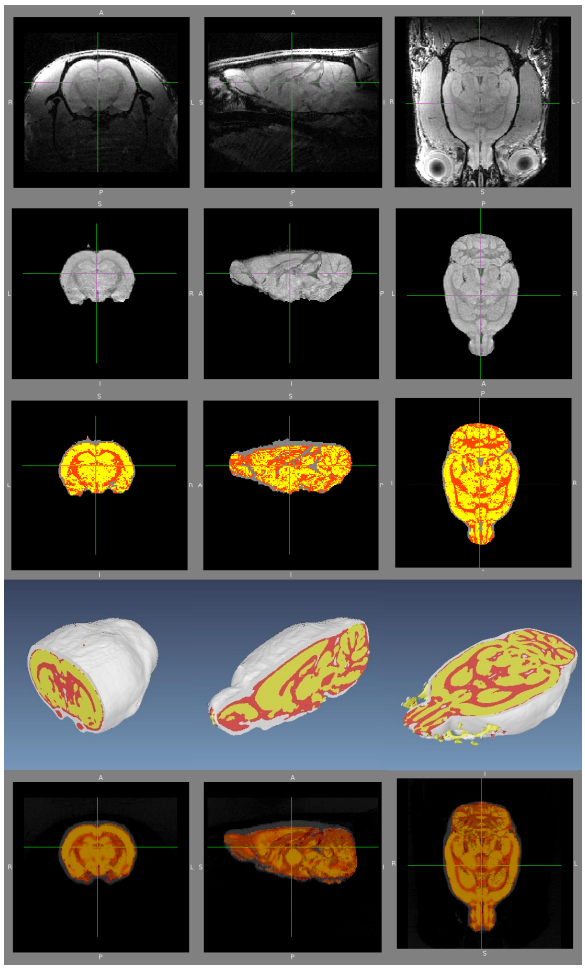

Fig. 1.From top to bottom: original images; debiased images; pre-segmentation results using FLS FAST; templates in 3D isosurface view; overlaid segmentation results using SPM5 with templates

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