Automatic Nonlinear Transformation to Talairach Stereotaxic Space with Quality Assurance

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Target Audience: People who are doing MRI research projects involving multiple subjects.

Purpose: Transforming MR brain images into Talairach space will greatly facilitate the comparison of neuroimaging research results across subjects and applications of atlas to research subjects and clinical patients. The original Talairach transformation used manually identified landmarks and piece-wise linear transformations[1]. Revised Talairach transformations were developed to automatically identify landmarks and to apply improved transformation for better accuracy[2,3]. An alternative solution has also been invented to transform brain images from MNI space to Talairach space[4,5]. The methods mentioned above are all linear based and their limited degree of freedom restricts the accurate matching of brains from multiple subjects in the Talairach space. Nonlinear methods provide much higher degree of freedom and thus have the potential to make a better matching in the Talairach space. However, on the other hand, the exact same freedom can potentially lead to bigger mismatch. To take the advantage and avoid the pitfall, we developed an automatic processing pipeline based on nonlinear registration to transform brain images to Talairach space. The pipeline depended on matching scores derived from brain parcellation for quality assurance (QA). The pipeline was tested on subjects including five controls, eleven patients with high EDSS score. Among the eleven patients, three had severe brain atrophy. The results showed the new method had significant improvement on the matching accuracy for both control and patients over the manual Talairach method and the automatic method provided by AFNI[6].

Methods: Data Collection: Five healthy controls and eleven patients with high EDSS scores were scanned under an IRB-approved protocol on a 3T Siemens Tim-Trio scanner (Erlangen, Germany). T1W images were acquired using a 3D MPRAGE sequence with the following scan parameters, FOV=256x256, voxel size=1x1x1.2mm and reconstructed matrix size=256x256x120, TE/TR/TI=1.75/1900/900ms.

Data Analysis: Data was processed through the pipeline in four steps. In step 1), Subject's brain image was registered to a Talairach template using symmetric image normalization (Syn) in Advanced Normalizaiton Tools (ANTS) [7] after brain extraction by FSL[8]. The Talairach template was generated by manually transforming one of the base templates, TT_N27 provided by AFNI, using the manual Talairach procedure in AFNI. In step 2), we used FreeSurfer[9] to segment the subject's brain into 35 ROIs in cortical gray matter, 36 ROIs in white matter and 8 ROIs in subcortical gray matter for both hemispheres. Brain parcellation was also applied to the Talairach template. In step 3), The ROIs in each of the above sections are converted into Talairach space by using the registration transformation obtained in step 1). In step 4), we computed Dice coefficient and volume ratio to measure the volume overlapping of the registered ROIs to the Talairach template ROIs. The above matching indexes were used as the scores to judge the quality of the registration.

Method Comparison: The parcellated brains generated in step 2) are also transformed into Talairach space by manual Talairach conversion and the auto Talairach conversion in AFNI and overlapping scores were calculated respectively.

Results: The QA scores are shown in figure 1. The new nonlinear pipeline is substantially better than the other two methods. (The range of Dice index is from 0 to 1 and closer to 1 means better matching. The volume ratio is from 0 to +∞ and closer to 1 means better matching.)

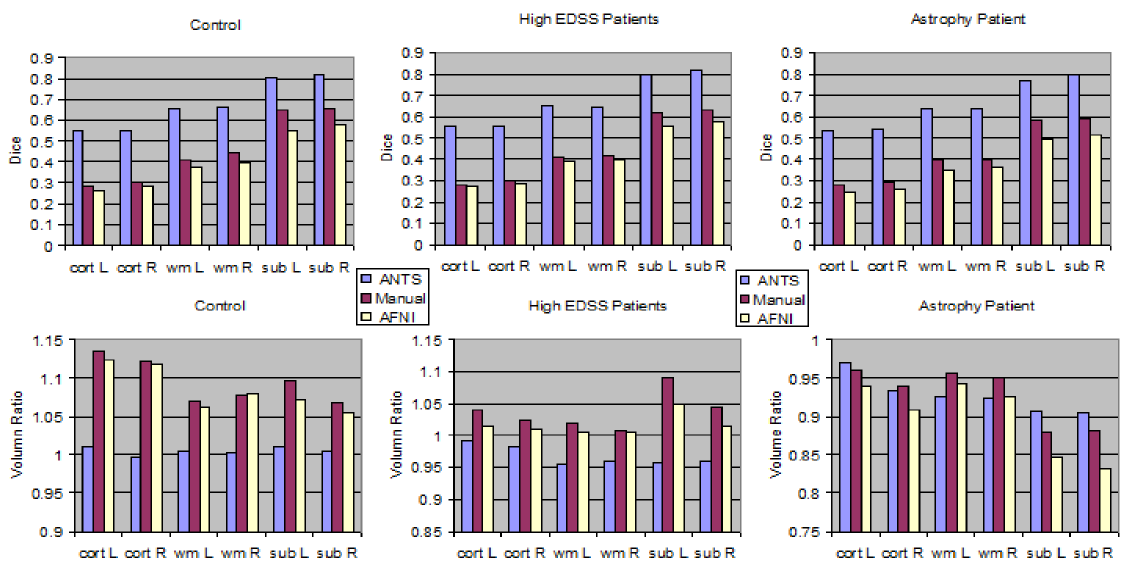

Figure 1 QA scores for control and patients

Discussion: We considered the brain parcellation result from FreeSurfer as the "gold standard" and relied on it to compute QA scores. In the future work, we will inspect the accuracy of the parcellation results and investigate the influence of parcellation error on the QA scores.

Conclusion: We have presented a processing pipeline to automatically transform brain images from individual subjects into Talairach space with automatically generated quality assurance scores. Results on five normal controls and eleven patients with high EDSS all showed the new pipeline was substantially better than the manual Talairach method and automatic Talairach method provided by AFNI.

References:

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