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Comparative Analysis of Atlas-Based and Manual Prefrontal Brain Parcellation in an Ageing Cohort

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Introduction
- Regions of interest (ROI) definition is an important step in the analysis of many MR images.
- Manual Definition of Region of Interest
  - Time Consuming
  - User Bias and Issues with Reproducibility
- Atlas based Method
  - Requires standardization to normalize variation in brain sizes and shapes
  - Non-linear registration matches boundaries better than linear
  - Single atlas cannot account for anatomical diversity
  - Multi-atlases1 performs well in young adults

Challenge
- Age-related changes pose a significant challenge to any automatic method2
  - E.g. Atrophy
  - Skull Thickening
  - Lessons
- Prefrontal brain
  - High degree of inter-subject sulcal pattern variation
  - Highly susceptible to age-related changes e.g. atrophy
- Performance of atlas based parcellation in ageing has not been investigated

Purpose
- To compare the performance of both single- and multi-atlas parcellation with manual segmentation using brain MRI of older men
- Also to investigate the choice of atlas(es) selection for both single- and multi-atlas approaches

Manual Segmentation
- Frontal gyri segmented anterior to the coronal appearance of precentral sulcus.

Single Atlas Parcellation
- Representative atlases selected based on:
  - Study-based ageing brains
  - Intracranial volume (ICV)
  - Total Brain volume (TBV)
  - Frontal lobe volume (lobe)
  - Non-study-based brain
    - Young male adult
  - Atlases transformation to target brain used ART5

Multi Atlas Parcellation
- Atlases selected based on
  - Normalised Mutual Information (mutual)
  - Normalised correlation coefficient (corr)
  - Cross validation based on leave-one-out method
  - Atlases transformation to target brain used ART5
  - Atlases combination used image fusion6
  - Post-processed to remove CSF

Results
- The atlas based on TBV performed best of the single atlases
  - For multi-atlas Correlation and mutual information gave equal performance
  - Multi-atlas performed better than single atlas
  - CSF removal improved performance

Conclusion
- Atlas-based parcellation method performed reasonably well in the ageing men. However, brain shape and particularly the effects of age-related atrophy could reduce its performance, hence there is need for visual assessment and some manual editing. The performance of any parcellation scheme should be assessed, not only by volumetrically, but also visually and by measure of spatial concordance. Future work should investigate incorporating atrophy metric into atlas selection

References
2. Cabacau M et al., Computer methods and programs in biomedicine 2011
3. Diary et al., BMC Genet 2007, 7(S2)
4. Wardlaw et al., Int. J. Stroke 2011
6. Ajibar et al. (2009), Neuroimage, 2009, 46(3), 726-738