SAFIRA: A Statistically Assisted Fluid Image Registration Algorithm

Abstract No:

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Introduction:

As more image registration techniques are developed in computational anatomy, it is important to compare them to see which methods are most appropriate for different tasks. In [1], we developed a Statistically Assisted Fluid Registration Algorithm for brain images, which includes statistical information on empirical brain variability and uses Lagrangian mechanics. SAFIRA can be run in 4 different ways. When applied to a set of brain images from a population, vector fields and their corresponding deformation matrices are computed in a first round of registrations using a non-statistical implementation. Covariance matrices for both deformation matrices and the vector fields are then obtained and incorporated (separately or jointly) in the regularization terms expressed as non-conservative Lagrangian terms that govern the autocorrelations of the mappings. Here, we evaluate the accuracy of each algorithm variant using the manually labeled LPBA40 dataset, which provides ground segmentation

Methods:

We applied SAFIRA to the 3D structural brain MRI scans of 40 normal subjects in the LPBA atlas. Each MRI has manually delineations of 54 regions of interest, mostly on the cortex; 3D volumes of the labeled structures are also computed. Preprocessing details for the LPBA40 may be found at http://www.loni.ucla.edu/~shattuck/resources/lpba40/.

SAFIRA was primarily developed to study volume and shape differences between subjects and groups in studies using tensor based morphometry (TBM), a technique that has been successfully used to detect morphological brain differences between two groups of subjects [2][4].
Consequently, we estimated how the incorporation of different types of statistics in the registration algorithm influenced structure volumes measured by the deformation algorithm. We randomly chose a subject from the LPBA40 dataset as a template and registered all the other MRI scans to this template using the 3 independent versions of our algorithm (non-statistical, tensor- and vector-based). Then, we applied the vector field, obtained from each subject's registration to the template, to the corresponding labeled image. Each registered labeled image was compared to the manually segmented labeled template (ground truth segmentation). Volume differences between the template Tr and each subject Sr were reported for each region and averaged across the population. The volume similarity coefficient Vs was defined as [3]:
$Vs = 2\,\Sigma(|S_r| - |T_r|) / \Sigma\,(|S_r| + |T_r|)$.
For this measure, smaller values denote a lower segmentation error, i.e., a more accurate quantification of substructure volumes.

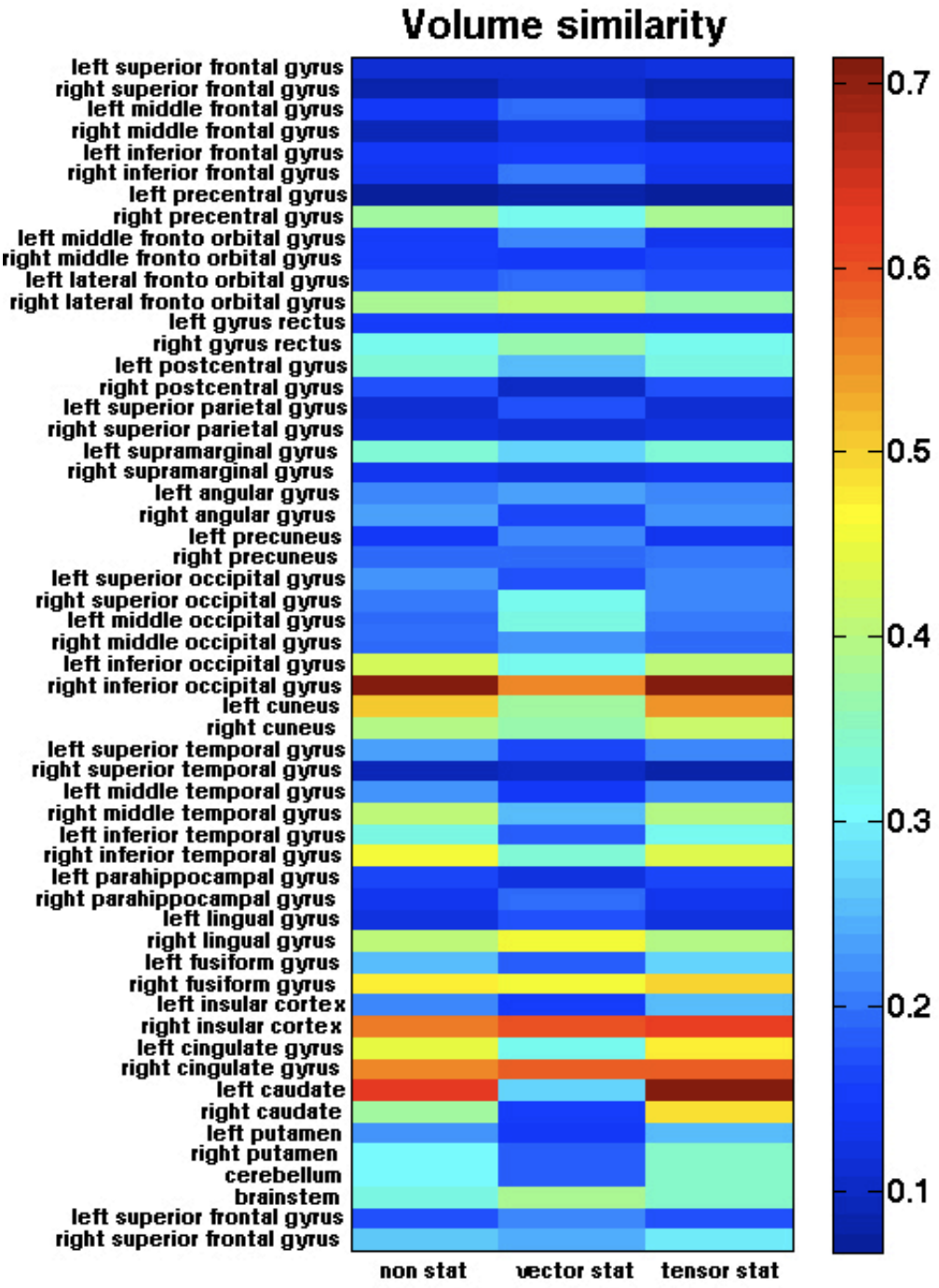
Results:

Figure 1 shows the volume quantification error, Vs, for all ROIs. Blue colors indicate small volume differences between the registered label (the deformed segmentation) and the manually defined ground

truth label, whereas red colors indicate large differences. Results are shown for the three independent versions of the algorithm (non-statistical, vector-based and tensor-based statistics). Overall, incorporating vector-based statistics on the deformation field during the registration improves volumetric matching, and makes volume quantification more accurate. This is the especially clear for subcortical gray matter structures, such as the caudate and putamen.

Conclusions:

Here we estimated the performance of our Statistically Assisted Fluid Image Registration Algorithm, which combines large-deformation fluid matching with empirical statistics on population variability in anatomy. Overall, the vector-based statistical method showed the greatest improvements in volume quantification versus the non-statistical version. This improve accuracy may be advantageous for studying groupwise morphological brain differences.



References:

Brun, C. (2009), 'A Lagrangian formulation for statistical fluid registration', *Proceedings of the IEEE International Symposium on Biomedical Imaging*, pp. 975-978.
Brun, C. (2009), 'Sex differences in brain structure in auditory and cingulate regions', *Neuroreport*, vol. 20, no. 10, pp. 930-935.
Klein, A. (2009), 'Evaluation of 14 nonlinear deformation algorithms applied to human brain MRI registration', *NeuroImage*, vol. 46, no. 3, pp. 786-802.
Lee, A. (2007), '3D Pattern of Brain Abnormalities in Fragile X Syndrome visualized using Tensor-Based Morphometry', *NeuroImage*, vol. 34, no. 3, pp. 924-938.

Categories

- Anatomical MRI (Imaging Techniques and Contrast Mechanism)
- Anatomical Studies (Neuroanatomy)