fMRI Guided Personalization of Cortical Parcellation Maps

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PURPOSE

To personalize the 3D cortical parcellation of T1w MRI volumes to increase intra-parcel functional homogeneity by means of co-registered fMRI guidance.

METHOD AND MATERIALS

Inspired by the Demons Algorithm (Med. Image Anal., 2(3), pp 243-260,1998), we propose an iterative 3D deformation of the cortical parcellation map of a given subject, constrained to the cortex, to maximize the pairwise intra-parcel correlation coefficients (CCs) of fMRI BOLD signals (**B**). The co-registered T1w MRI, fMRI and (148 parcel, P) Destrieux cortical parcellation map are the inputs. The iterations are driven by a vector-field, $\mathbf{F}(r_{ij})$, normal to boundary (r_{ij}) of P_i and P_j, and zero elsewhere. **F** is computed according to a local cost that takes into account the change in intra-parcel functional homogeneity and parcel volume change (ΔV). The former uses the CCs between the local signal, $\mathbf{B}(r_{ij})$, and the parcel representative signals ($\mathbf{B}_i$, $\mathbf{B}_j$) defined as the in-parcel **B** that is closest to the left principal singular vector of the matrix composed of parcel's **B**'s. The latter is added with a multiplicative factor λ. We used FreeSurfer and FSL for all co-registration and parcellation steps. We tested the algorithm on 5 normal subjects for $\lambda=0$ and 0.25, by measuring the mean of pairwise CCs between in-parcel **B**'s and the mean **B** per parcel, before and after the algorithm, for each subject. Statistical significance is assessed with paired t-test of CCs per parcel per subject and mean values over subjects is reported. The mean of subject-wise minimum and maximum parcel volumes (V_{min}, V_{max}) are reported together with the percentage of parcels with $\Delta V > 20\%$.

RESULTS

The initial mean intra-parcel CC of 0.43±0.04 was increased to 0.52±0.04 (0.51±0.04) with mean p-value 1.21e-5 (4.50e- 5) for $\lambda=0$ (0.25). The mean [V_{min}/V_{max}] (mm^3) was changed from [282.8/15747.1] to [592.7/10467.9] ([582.5/11136.8]) with 64% (57%) of parcels having $\Delta V > 20\%$ for $\lambda=0$ (0.25).

CONCLUSION

The proposed functionally homogeneizing personalization of cortical parcellations showed a statistically significant improvement in intra-parcel correlations accompanied by a decrease in parcel volume variation. Volume constraint with $\lambda=0.25$ does not affect the final intra-parcel CCs while limiting the volume change