Cortical localization by surface parameterization: a gyrus-based approach

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Goals:
Automatic and reproducible surface-based coordinates system associated to any parcel of a gyrus parcellation.
Application: cortical localization for surface based functional data analysis, morphometry on gyri or generally on cortical ROI, visualization purposes (e.g. surface-flattening, sphertizing)...

Results:
Parcels by [Cachia et al., 2003]

All visualization made with free package Brainvisa / Anatomist (http://brainvisa.info)

Somatotopy protocol experiment (J.-L. Anton et al.):
13 subjects, 6 right motor tasks: foot, elbow, auricular, index, thumb, tongue
Individual SPM maps are projected onto individual cortical surfaces. Maximum activation foci are localized on each individual gyrus-based coordinate system, and plotted onto a generic atlas.

Method:

On a given parcellation [Cachia et al., 2003], the method processes each gyri after another,
– Association of four border segments to the edges of the coordinate domain (fig. A). A flexible description model of neighborhood relationships between gyri makes these associations invariant.
– Integration of user-defined constraints imposing the values of certain gyral intersections.
– Propagation of the coordinates system over the whole gyrus surface (fig. B) using the Heat equation. Latitude and longitude are propagated from the constraints using a heat diffusion process [Clouchoux et al., 2004]. Constraints are used as heat sources with constant temperature.

User-defined constraints:
The coordinates of selected gyral intersections can be manually defined by user:
– after a first constraint-less propagation (fig. A1), the method finds a path connecting the marker from one border (cross-marked) to the point (circle-marked) which carries the user-specified value on the opposite border (fig. A2). This value is then imposed along the path (fig. A3) and the propagation is run once again with this constraint on (fig. B).
– Additional anatomical information is integrated to the system
– Interest of constraining coordinates of functional foci as well

Discussion - conclusions:
– Automatic construction of surface-based system based on stable anatomical landmarks
– Reproducibility and anatomical sense depends strongly on the quality of the parcellation
– The method herein is applied to gyri but can be adapted to other ROI, such as sulci [Coulon et al., 2006] or any other user-defined areas
– A 2D coordinate system opens the way to cortical-based activation detection

References: