Investigating Cortical Variability Using a Generic Gyral Model

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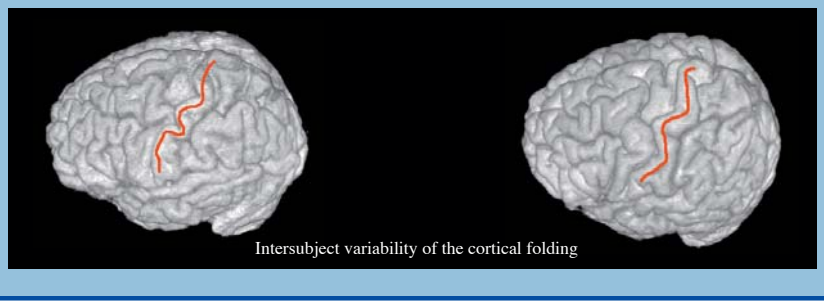
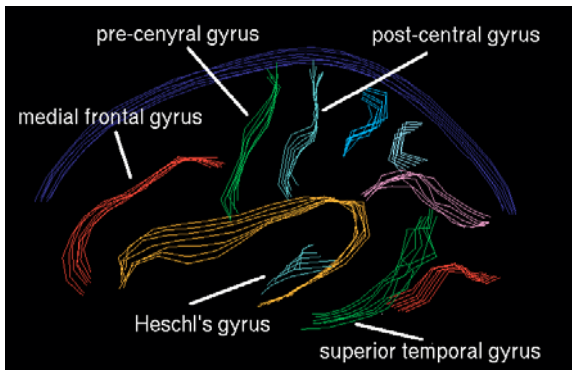
Introduction

Human cortical folding shows a high degree of inter-individual variability which makes inter subject comparisons very difficult.



Intersubject variability of the cortical folding

We investigate inter-subject variability using a set of cortical landmarks. These landmarks are derived from a generic gyral model (GGM) that was introduced at MICCAI 2005. The GGM resulted from gyral maps of 96 subjects. The vertices of the GGM serve as landmarks that can be easily identified across a large population of subjects using non-linear registration techniques. Their variances and covariances can then be analyzed and used in a regionalized way.

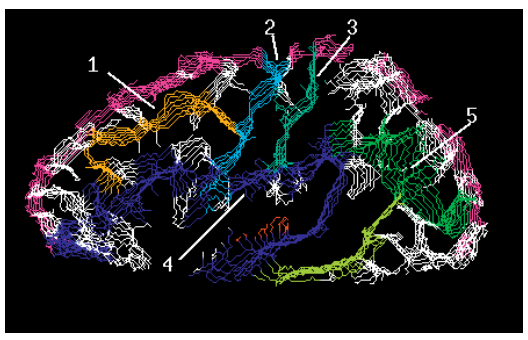


Generic Gyral Model (GGM) - MICCAI 2005

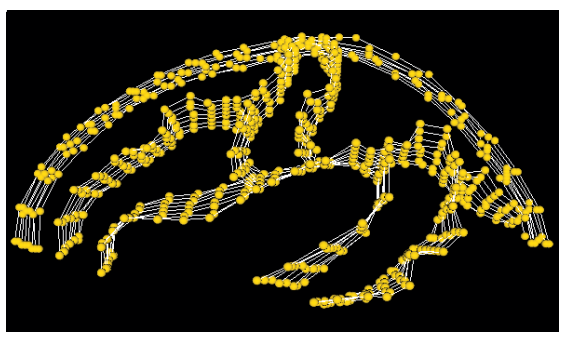
Obtaining landmarks

The generic gyral model (GGM) consists of an averaged line representation for some major gyri at eight depth levels. Each depth level contains about 85 vertices so that the entire model has about 700 vertices.

We used these vertices as landmarks for inter-subject registration. These landmarks can be identified in each individual via non-linear registration. An initial rough match is obtained via a cubic polynomial, a refined match via thinplate splines.



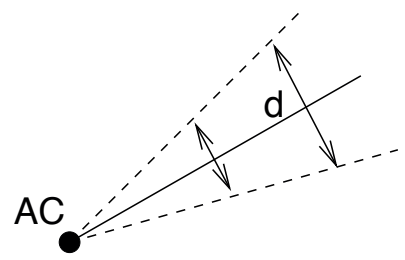
single subject gyral lines



GGM-landmarks to be matched

Correcting for AC/PC bias

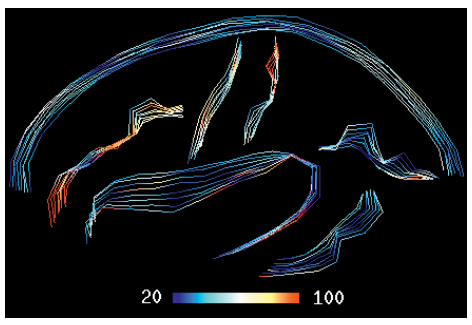
Landmarks that are closer to AC/PC will tend to be less variable than those that are further away. To correct for this problem, we divided the displacement magnitude of each vertex by its distance from AC/PC.



AC/PC bias

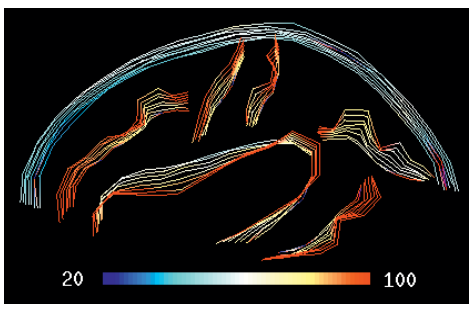
Results

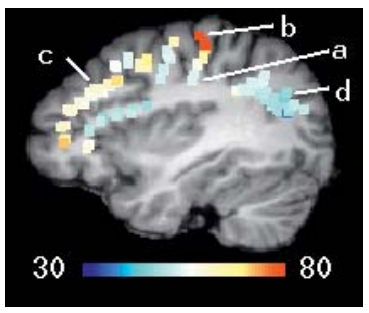
1. Variability maps



A displacement map of one individual data set.

The displacement is corrected for the bias introduced by the AC/PC-alignment by dividing the displacement magnitude by the distance from AC/PC. The color-coded values correspond to corrected displacement magnitudes.





Variability map computed as an average of displacement maps of 96 subjects.

The right-hand image shows the vertices of the GGM superimposed onto a T1-weighted structural image. The ventral region of the post-central gyrus (a) is less variable than the dorsal region (b). The parietal gyrus (d) is less variable than the middle frontal gyrus (c). The color coding is based on the AC/PC-corrected variability measure described above.

2. Variability decreases with depth

	perisylvian	precentral	postcentral	parietal	temporal	middle frontal
deep	6.890	2.689	1.811	2.435	6.054	5.399
shallow	8.892	3.837	1.995	2.128	6.085	5.578

The decrease in variance with depth.

The table shows the decrease in variance with depth. The estimates correspond to standard deviations averaged across the landmarks within a gyrus and summed over x,y,z. Note that in all but one case, the standard deviations are less at the deeper level.

Discussion

The novelty of our approach lies the usage of the generic gyral model which provides a set of well-defined landmarks that can be identified across may subjects using non-linear registration. These landmarks are particularly useful because they are located on main gyri that can be easily detected in most healthy subjects. Also, these landmarks are separated into different strata of depth so that variability can be investigated as a function of depth.

Reference:

G. Lohmann,D.Y. von Cramon, A.C.F. Colchester:
A construction of an averaged representation of human cortical gyri using non-linear principal component analysis. MICCAI 2005, Palm Springs, CA.

MICCAAI, Kopenhagen, 2006