Cortical Surface Segmentation in Infants by Coupled Surfaces Deformation across Feature Field

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Motivation

- Immature brain segmentation is challenging because of:
  - low WM-GM contrast in T2-MR imaging
  - fluctuations of tissue intensity due to rapid, intense and asynchronous myelination patterns across brain compartments
  - inverted CSF/GM T2 contrast compared with T1 contrast
  - small and folded brain
- Thus, T1-MR segmentation methods of adult brains are not optimal
- Furthermore, multiple templates would be required to capture the anatomical variability of infant brains
- Only one template-free automatic method (Xue et al. [1])
  - based on local estimates of tissue intensity
  - applied to younger subjects, i.e., preterms and newborns

Method

- We propose using additional geometrical properties of tissues
- The discrimination of the WM-GM interface from the CSF-GM interface is improved by the deformation of two surfaces with coupled speeds

Evaluation

- Sulcal landmarks were drawn manually and validated by a neuroanatomist
- We have measured the distance between these landmarks and the GM-WM surface
- The distance matches estimates of cortex thickness (2-3mm) to a large extent: 76% of all sulcal voxels

Results

GM-WM surface meshes of 9 infants brains
3 wk 4 wk 7 wk 9 wk 11 wk 14 wk 12 wk
 gyrus sulcus

Infant database

- 11 infants from 3 to 16 weeks of age
- T2 fast spin-echo sequence
- 1.5 T MRI system
- Axial + coronal + sagittal scans
- Slice resolution: 0.8 x 0.8 x 2mm

Coupled surfaces deformation

In red, inner surface (inflating)
In blue, outer surface (deflating)
In green, deformation domain

Coupled speed variations
f: feature value
n: number of neighbors

References

- Xue, Srinivasan, Jiang, Rutherford, Edwards, Rueckert, Hajnal: Automatic Segmentation and Reconstruction of the Cortex from Neonatal MRI. Neuroimage. 2007