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

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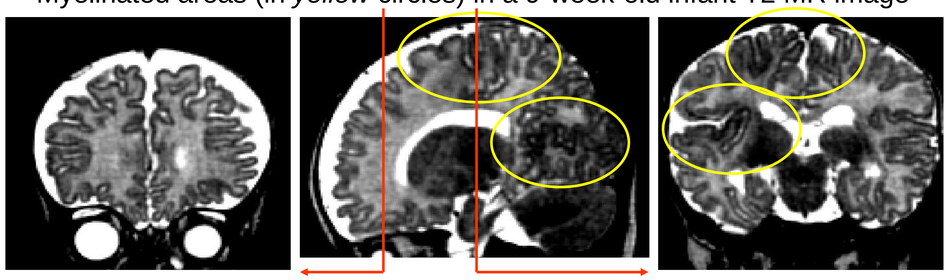
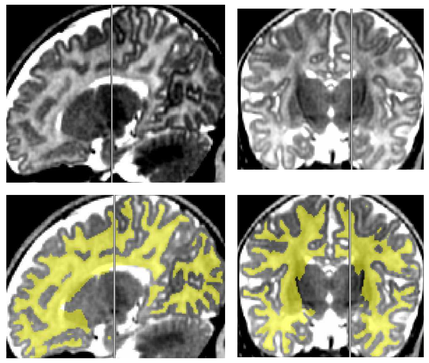
Myelinated areas (in *yellow* circles) in a 9-week-old infant T2 MR image





WM segmentation in a 9-week-old infant

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

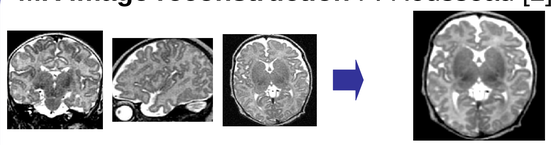
Infant database

- 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

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*

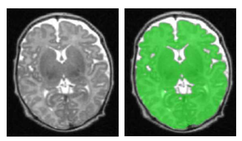
MR image reconstruction F. Rousseau [2]



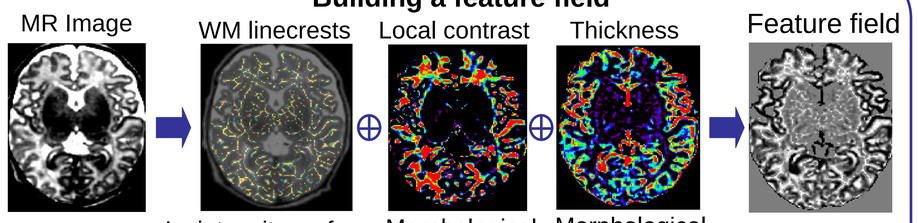
3 MR Images 0.8 x 0.8 x 2mm

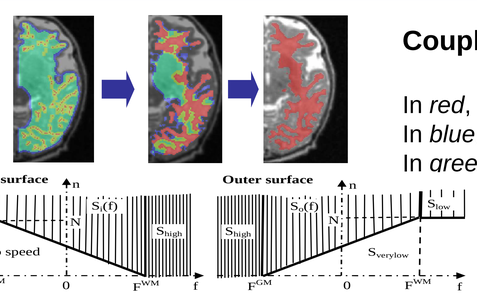
1 isotropic MRI 0.8 x 0.8 x 0.8 mm

Removal of skull, cerebellum and CSF



Building a feature field





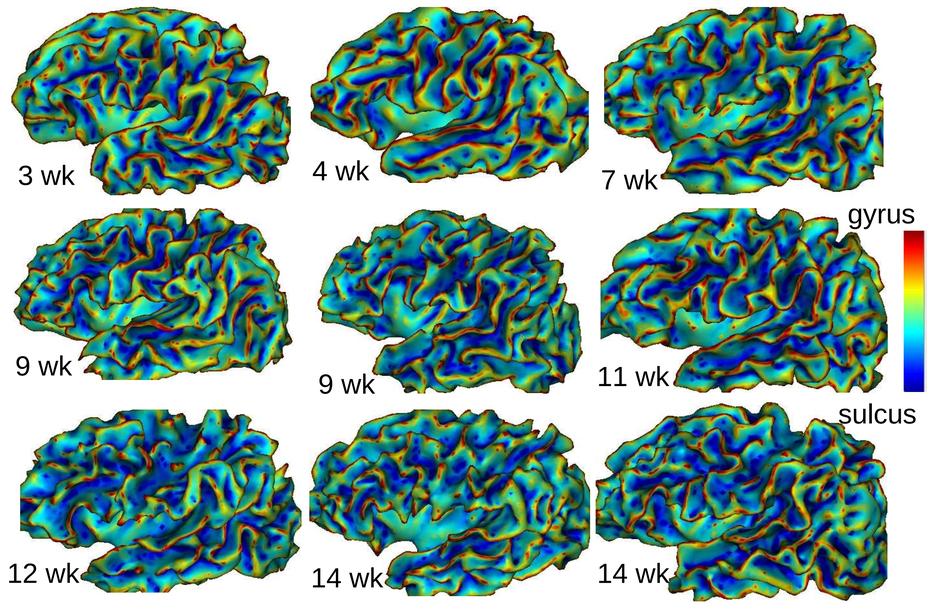
Coupled surfaces deformation

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

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

Results

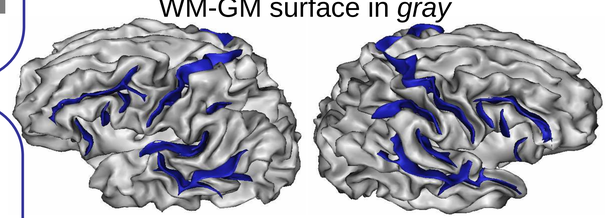
GM-WM surface meshes of 9 infants brains



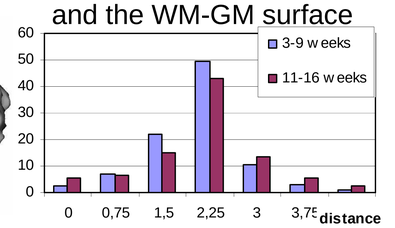
Evaluation

- 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

Sulcal landmarks in *blue*
WM-GM surface in *gray*



Distance histograms between sulcal voxels and the WM-GM surface



References

- Xue, Srinivasan, Jiang, Rutherford, Edwards, Rueckert, Hajnal: Automatic Segmentation and Reconstruction of the Cortex from Neonatal MRI. NeuroImage, 2007
- Rousseau, Glenn, Iordanova, Rodriguez-Carranza, Vigneron, Barkovitch, Studholme: A Novel Approach to High Resolution Fetal Brain MR Imaging. MICCAI, 2005