Analyzing the Developing Brain by Quantifying Curvature Measures

Rudolph Pienaar\(^1,2\), Bruce Fischl\(^1\), Nikos Makris\(^2\), P Ellen Grant\(^1\)

\(^1\): MGH/MIT/HMS Athinoula A. Martinos Center for Biomedical Imaging; \(^2\): MGH Center for Morphometric Analysis

Introduction

- Analyzing functions of curvature on brain surfaces can be a more sensitive marker for developmental disorders than volume/surface measurements;
- Study considers functions of principal curvature across:
  - cohort of normal neonate, pediatric, and adult subjects
  - normal and abnormal (polymicrogyria) pediatric subjects
  - principal Gaussian curvature is used to flag areas of interest on cortical surface.

Data Acquisition

- \(T1\) weighted axial 3D SPGR images were collected on a 1.5T (GE, Milwaukee), a 1.5T Siemens and 3.0T Siemens (Siemens, Erlangen, Germany) scanners:
  - TR/TE = 30/8
  - flip angle = 25 to 30\(^\circ\)
  - Matrix size = 256x192
  - FOV = 200x150mm
  - slice thickness = 1.2 to 1.4mm

Curvature functions

- In this paper we analyzed the gray-white junction for:
  - Maximum curvature, \(k_1\)
  - Minimum curvature, \(k_2\)
  - Gaussian curvature, \(K = k_1 k_2\)
  - Sharpness curvature, \(S = (k_1 - k_2)^2\)

Adaptive filtering based on Gaussian curvature:

- Gaussian curvatures thresholded at curvature values between different sulcal scales between 3mm\(^{-1}\) and 7mm\(^{-1}\)
- Sharpness of curvature (Willmore Bending) normalized per area at each threshold.

Results

- A curvature analysis showed age-related clustering in normals across several functions.
- For abnormal cases, the curvature analysis demonstrated marked differentiation between matched control and experiment cohorts.
- Normalized Bending Energy as function of surface Gaussian showed measurably higher energy in early neonate folding surfaces.

Conclusion

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