Modelling the Healthy Premature Infant Brain
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1. The Background

- 8% of infants in Canada are born prematurely [1].
- These infants are at high risk for developmental delays.
- Developmental delays likely due to white matter brain injuries at, or near, time of birth [2].
- Diffusion MRI can be used to assess white matter integrity.

2. The Goal

- Create a Diffusion MRI model of the preterm infant brain.
- Compare infants to the model to highlight abnormalities.

3. The Imaging → Diffusion MRI

- MRI measures the movement of water molecules (diffusion).
- Cell structure impedes that movement [3].
- Measure the rate of water molecule movement in many 3D directions [4].
- At each pixel, fit a 3D surface to our measurements of water molecule movement.
- These surfaces with be cigar-shaped for fibrous tissue such as white matter.
- Examining the shape & main direction of these surfaces give insight into white matter integrity and organization [4].

4. The Data

- 205 Infant Subjects born 8-16 weeks premature.
- Scanned soon after birth and again at term.
- Diffusion MRI scans examined by neurologists for presence of injury.
- Healthy infants are chosen to create model.

5. The Method

- Statistical model built using the above established protocol [5].
- Image Registration aligns the Diffusion MRI scans [6].
- Mean and Covariance are estimated at each pixel [7].
- Average inverse deformation transforms model to average brain shape & size.

- A new Diffusion MRI scan can be compared to the model by:
  1. Aligning the model to the new Diffusion MRI scan (i.e. image registration).
  2. Running basic statistical tests (e.g. t-tests) at each pixel.

6. The Results

Age-specific averages of Diffusion MRI scans:
- Colour encodes neuronal pathway direction (red = left-right, green = front-back, blue = top-bottom).
- Brightness encodes neuronal pathway integrity.

Statistical injury maps computed from comparing to model:
- Comparison for a severe white matter injury case shown.
- Highlighted areas show statistically significant abnormalities in white matter maturation.
- Abnormalities evidence of delayed brain development.

References & Acknowledgments

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