Modelling the Healthy Premature Infant Brain

Brian G. Booth[1] Steven P. Miller[2] Vann Chau[2] Ken Poskitt[2] Ghassan Hamarneh[1]

[1] Medical Image Analysis Lab, School of Computing Science, Simon Fraser University

[2] Division of Neurology, BC Children's Hospital

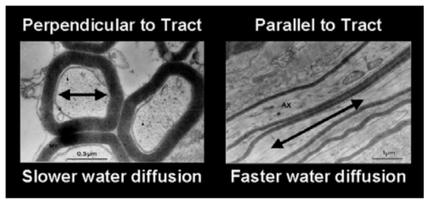
1. The Background

- 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

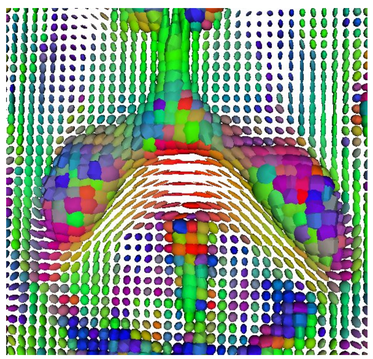
- **Create a Diffusion MRI model of the preterm infant brain.**
- **Compare infants to the model to highlight abnormalities.**

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].

References & Acknowledgments

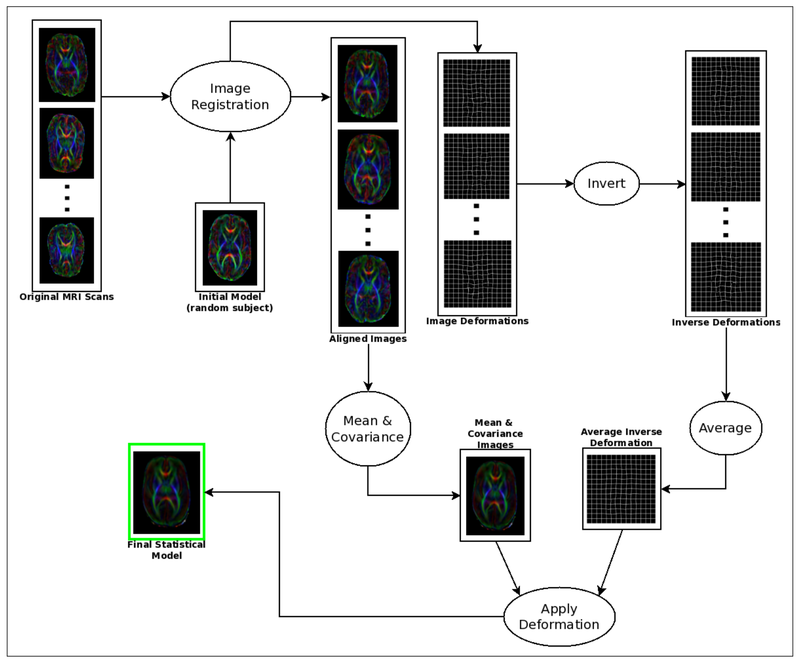
1. CIHI, *"Too early, too small"*, 2009.
2. Dudink *et al.*, Early Human Devel., vol.84, pp. 777–782, 2008.
3. Beaulieu, In proceedings of ISBI, pp. 347–350, 2006
4. Jones, Cortex, vol. 44, pp. 936–952, 2008.
5. Guimond *et al.*, Comp. Vis. Image Und., vol. 77, pp. 192–210, 2000.
6. Yeo *et al.*, IEEE Trans. Med. Imag., vol. 28, pp. 1914–1928, 2009.
7. Arsigny *et al.*, Mag. Res. Med., vol. 56, pp. 411–421, 2006.

This research is undertaken in collaboration with BC Children's Hospital and is partially funded by NSERC.

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



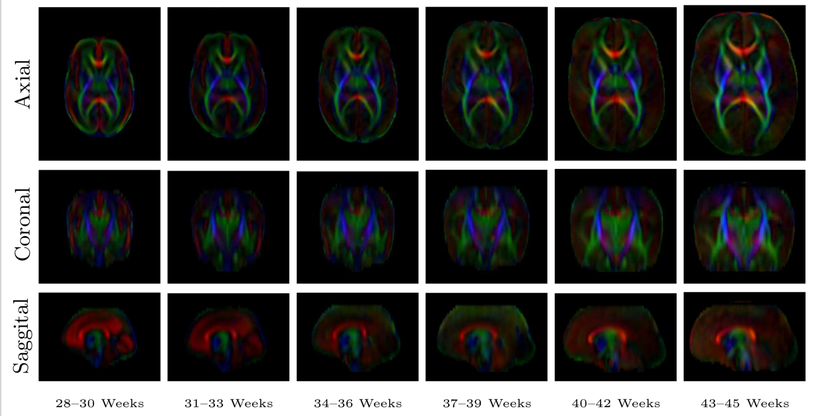
- Statistical model built using the above established protocol [5].
- Image Registration aligns the Diffusion MRI scans [6].
- Mean and Covariance are estimated at each pixel [7].
- Average inverse deformation transforms model to average brain shape & size.

- 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

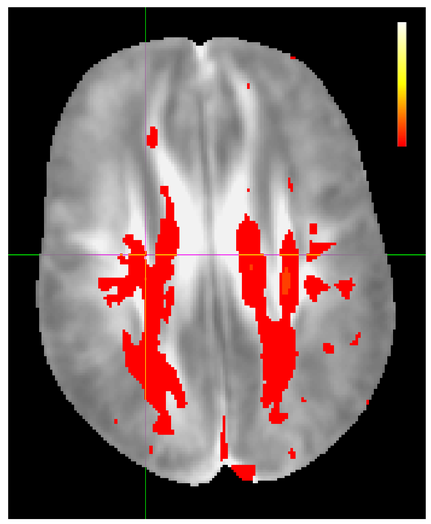
Age-specific averages of Diffusion MRI scans:

- Colour encodes neuronal pathway direction (red = left-right, green = front-back, blue = top-bottom).
- Brightness encodes neuronal pathway integrity.

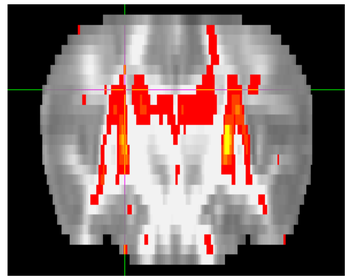


Statistical injury maps computed from comparing to model:

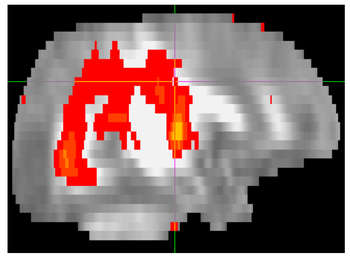
- Comparison for a severe white matter injury case shown.
- Highlighted areas show statistically significant abnormalities in white matter maturation.
- Abnormalities evidence of delayed brain development.



Axial View



Coronal View



Saggital View