Title of workshop: Extreme Motion: 3D Reconstruction From Fast Multi Slice Imaging

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Highlights

- Extreme Motion in MRI. Key motivation: in-utero Fetal brain imaging
- Retrospective Motion Estimation: why its still needed
- Modeling and Estimating Extreme Motion Trajectories between slices
- Examples of extreme motion trajectories in clinical imaging
- Localizing motion estimates to specific anatomy

Problem summary

Many conventional motion correction techniques in MRI have been developed for adult and pediatric studies of the head. Here absolute motion is often constrained by the head rest and coil and positioning information can be extracted using a variety of techniques as the object of interest (the head) is moving in air. In contrast, fetal imaging motion correction has been an active area of research that has been driven by the need to capture high quality images when almost fully unconstrained motion can occur within fluidly deforming structures. This unique application has motivated the development of a range of retrospective approaches over the last 10 years based on fast multi-slice imaging combined with retrospective between-slice motion estimation techniques.

Body

This talk will review the underlying challenges posed by extreme motion during fetal brain imaging studies and provide an overview of the different solutions that have been explored since the first work in this area in 2005. Initial approaches to conventional structural imaging will be examined looking at the two main components of the problem: Slice to slice motion estimation, and 3D reconstruction from scattered slice data. Alternative parametric and non-parametric motion trajectory estimation schemes will be examined. Developments in deconvolution based 3D reconstruction algorithms enabling isotropic image reconstruction from multiple thick slice planes will then be covered together with signal level standardization and robust signal estimation. The extension of these techniques to diffusion weighted imaging will then be described, comparing interpolation and robust iterative deconvolution approaches to ODF estimation from scattered diffusion slice data. Examples of applying these techniques to studies of early brain development will be included.

Summary/recap/follow-up:

1. The challenges of collecting MRI during extreme motion of the fetal head.

2. A solution: Fast Multi-slice imaging and retrospective motion estimation
3. Components: slice to slice motion estimation and 3D reconstruction from scattered slice data.
4. Slice to Volume vs Slice Intersection: 2D Image Mosaicing in 3D.
5. Deconvolution: resolution enhancement from multi-plane imaging.
6. Extension to DWI studies: interpolation vs model based approaches

REFERENCES

1. F. Rousseau, O. A. Glenn, B. Iordanova, C. E. Rodriguez-Carranza, D. Vigneron, A. J. Barkovich, and C. Studholme, "A novel approach to high resolution fetal brain MR imaging," in Medical Image Computing and Computer-Assisted Intervention, LNCS, vol. 3749, pp. 548-555, October 2005.
2. F. Rousseau, O. A. Glenn, B. Iordanova, C. E. Rodriguez-Carranza, D. B. Vigneron, A. J. Barkovich, and C. Studholme, "Registration-based approach for reconstruction of high-resolution in utero MR brain images," Acad. Radiol., vol. 13, no. 9, pp. 1072-1081, September 2006.
3. C. Studholme, "Mapping fetal brain development in utero using MRI: the big bang of brain mapping," Annu. Rev. Biomed. Eng., vol. 13, no. 1, pp. 345-368, August 2011.
4. M. Fogtmann, S. Seshamani, C. Kroenke, X. Cheng, T. Chapman, J. Wilm, F. Rousseau, M. Koob, J.-L. Dietemann, C. Studholme, "A unified approach to diffusion direction sensitive slice registration and 3D DTI reconstruction from moving fetal brain anatomy", IEEE Trans. Med. Imaging, Vol. 33, No. 2, February 2014
5. S. Seshamani, X. Cheng, M. Fogtmann, M. Thomason, C. Studholme, "A Method for Handling Intensity Inhomogenieties in fMRI Sequences of Moving Anatomy of the Early Developing Brain", Medical Image Analysis, Vol 18, Issue 2, February 2014, Pages 285-300
6. V. Rajagopalan, J. Scott, P.A. Habas, K. Kim, F. Rousseau, A.J. Barkovich, O.A. Glenn, C. Studholme, "Mapping directionality specific volume changes using tensor based morphometry: An application to the study of gryrogenesis and lateralization of the human fetal brain," NeuroImage, Volume 63, Issue 2, 1 November 2012, Pages 947-958
7. P. A. Habas, J. A. Scott, A. Roosta, V. Rajagopalan, K. Kim, F. Rousseau, A. J. Barkovich, O. A. Glenn, and C. Studholme, "Early folding patterns and asymmetries of the normal human brain detected from in utero MRI," Cereb. Cortex, vol. 22, no. 1, pp. 13-25, 2012.
8. E. Oubel, M. Koob, C. Studholme, J.-L. Dietemann, and F. Rousseau, "Reconstruction of scattered data in fetal diffusion MRI," Med. Image Anal., vol. 16, no. 1, pp. 28-37, January 2012.
9. K. Kim, P. A. Habas, V. Rajagopalan, J. A. Scott, J. M. Corbett-Detig, F. Rousseau , A. J. Barkovich, O A. Glenn, and C. Studholme, "Bias field inconsistency correction of motion-scattered multislice MRI for improved 3D image reconstruction," IEEE Trans. Med. Imaging, vol. 30, no. 9, pp. 1704-1712, September 2011.
10. K. Kim, P. A. Habas, F. Rousseau, O. A. Glenn, A. J. Barkovich, and C. Studholme, "Intersection based motion correction of multislice MRI for 3-D in utero fetal brain image formation," IEEE Trans. Med. Imaging, vol. 29, no. 1, pp. 146-158, January 2010