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Automatic Template-based Brain Extraction in Fetal MR Images

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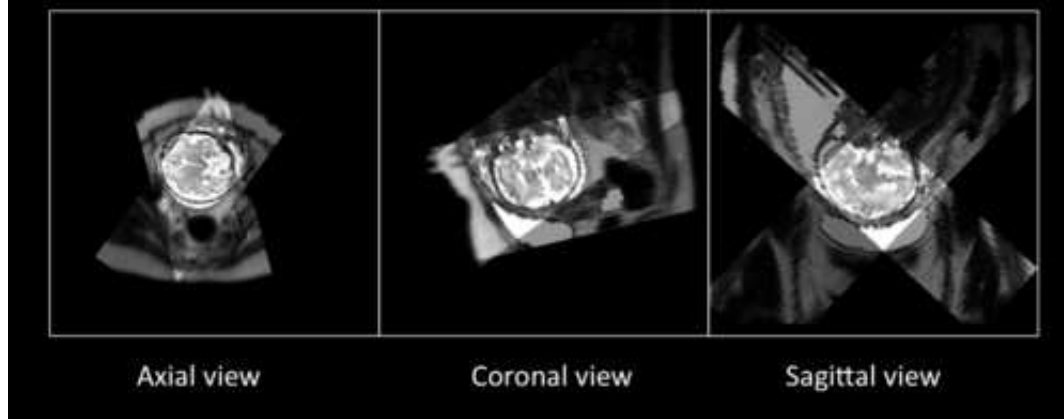
Introduction:

MRI is currently a very powerful imaging technique to study the human fetal brain in-utero. However, 3D MRI-based fetal brain studies remain challenging due to the low resolution of the images and the fetal motion that occurred during the acquisition. Although efficient image analysis algorithms have been developed to reconstruct 3D high-resolution fetal brain images [1,2,3], one of the first processing steps that consists in detecting the fetal brain in the images is usually manually performed. In [4], relying on priors such as image contrast, morphological and biometrical information, Anquez et al. have proposed a detection strategy that first estimates locations of eyes and then the fetal brain. More recently, Ison et al. [5] have presented a supervised method based on a random forest classifier, and an approximate high-order Markov random field solution. In [5], the complete brain lies inside the final bounding box in only 28% to 53% of cases. To develop a more robust fetal brain extraction algorithm, we investigate the use of a template-based technique that makes use of geometrical information of acquired scans to automatically create a mask of the brain in fetal MR images.

Methods:

The current image acquisition protocol used at the Hospital of Strasbourg consists in acquiring at least three orthogonal anatomical images in each direction (axial, coronal and sagittal) to provide to the radiologist an overview of the fetal brain. Figure 1 shows an overlay of two orthogonal (axial and coronal) images. In the same way as some image reconstruction methods [2,3], the proposed method relies on the fact that the images are acquired orthogonally to first define, as the intersection of the set of images, a 3D region of interest (ROI). Then, for each original image, the image portion corresponding to this 3D ROI is extracted and registered using FSL-FLIRT (<http://fsl.fmrib.ox.ac.uk>) to an age-specific template (<http://biomedic.doc.ic.ac.uk/brain-development>). As a result of the registration step, an estimation of the brain mask of each orthogonal image is obtained. Finally, to improve the robustness of the estimation, consistent brain mask estimates are fused. 3D consistency is estimated by computing a similarity measure (normalized correlation) between the estimated masked brains. By considering the number of similar brain masks, this fusion step provides feedback to the user on the quality (or variance) of the estimated brain mask.

Figure 1: Overlay of two (axial and coronal) fetal brain images



Results:

We have applied the algorithm to clinical fetal MR scans: T2 weighted HASTE sequence (TE/TR = 147/3190 ms) on a 1.5 T Siemens Avanto MRI Scanner (SIEMENS, Erlangen, Germany), resolution: $0.74 \times 0.74 \times 3.45\text{mm}$. The set of images consisted in 34 subjects, for a total of 163 images. The method has been evaluated by considering 2 cases (success and failure). Failure is detected if the complete brain does not lie in the estimated mask or if the mask is too large with respect to the brain. Figure 2 shows examples of correct and incorrect estimations.

Fetal brain masks have been successfully estimated for 134 images (82%). In 17% of subject cases, no brain masks have been correctly estimated for all the images of the subject. In such cases, the mask consistency criterion allows us to warn the user that manual intervention may be necessary for further processing of the images.



Conclusions:

We have presented a method for brain masking of in-utero fetal brain MR images. The method first makes use of the geometrical properties of the acquired images (i.e. orthogonality between images). Then, a registration step to an age-specific template is performed to provide a first estimate of the masks. Finally, a fusion step is done to improve the robustness of the brain mask estimates. This tool is freely available in Baby Brain Toolkit (BTK) [6].

Modeling and Analysis Methods:

Motion Correction and Preprocessing

- [1] Studholme, C. (2011), 'Mapping fetal brain development in utero using magnetic resonance imaging: the Big Bang of brain mapping', *Annu Rev Biomed Eng*, vol. 15, no.13, pp.345-68.
- [2] Rousseau, F. (2006), 'Registration-based approach for reconstruction of high-resolution in utero fetal MR brain images', *Academic Radiology*, vol. 13, no. 9, pp. 1072-1081.
- [3] Kim, K. (2010), 'Intersection based motion correction of multislice MRI for 3-D in utero fetal brain image formation', *IEEE Trans. Medical Imaging*, vol. 29, no. 1, pp. 146-158.
- [4] Anquez, J. (2009), 'Automatic segmentation of head structures on fetal MRI', *IEEE Int. Symp. Biomedical Imaging (ISBI)*, pp. 109-112.
- [5] Ison, M. (2012), 'Fully automated brain extraction and orientation in raw fetal MRI', *Perinatal and Paediatric Imaging (PaPI 2012)*, MICCAI workshop, pp. 17-24.
- [6] Rousseau, F. (2013), 'BTK: An open-source toolkit for fetal brain MR image processing', *Computer Methods and Programs in Biomedicine*, vol. 109, pp. 65-73.