Brain structures segmentation in fetal MRI

Background
The radiological diagnosis and follow-up of fetal developmental disorders consists of assessing the brain development and gestational age of the fetus on longitudinal studies. Currently, this assessment is obtained by performing various linear measurements on ultrasound images. The linear nature of the measurements, coupled with the low contrast, limited field of view, and specular noise of the ultrasound images hampers the quality of the assessment. Prenatal MR imaging has the potential to significantly improve this by providing clinicians with accurate volumetric measurements of fetal brain structures and pathologies. However, volumetry is rarely used because of the long MRI scan times and the time-consuming delineation of the brain structures on the scan.

Purpose
A semi-automatic method for the segmentation of the fetus brain on MRI scans to support the assessment of fetal developmental disorders.

Methods
We have developed a new semi-automatic method for obtaining accurate volumetric measurement of the fetal brain based on the new FIESTA (Fast Imaging Employing Steady sTate Acquisition) MR rapid imaging protocol. Our method for fetal brain segmentation consists of five steps: 1) manual selection of the Region of Interest enclosing the fetus brain; 2) automatic generation of geometric constraints to bound the segmentation process; 3) Seeded region-growing segmentation within those constraints; 4) automatic out-of-skull segmentation leaks removal by ray propagation, and; 5) user-guided corrections of the resulting segmentation.

Results
We evaluated our method on eight clinical fetal FIESTA MRI scans. An expert radiologist produced ground-truth delineations of the fetal skull and brain. Our method yields volumetric fetal brain measurements with a mean volume error of 4.8% and mean volume overlap error of 18% and requires on average 2 minutes from the user. The accuracy of the volumetric measurements was considered clinically acceptable and far superior to ultrasound-based estimates.


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