Supplementary material
for
« Automated Template-based Brain Localization and Extraction for Fetal Brain MRI Reconstruction »

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1. Low-resolution stack corrupted by severe motion

We excluded stacks and cases with severe motion and significant motion-induced intensity artifacts, as clinically acquired images of comparable quality are typically unused or skipped by the reading radiologist in favor of higher quality images. An example of a stack with such severe motion excluded from our study is presented here.

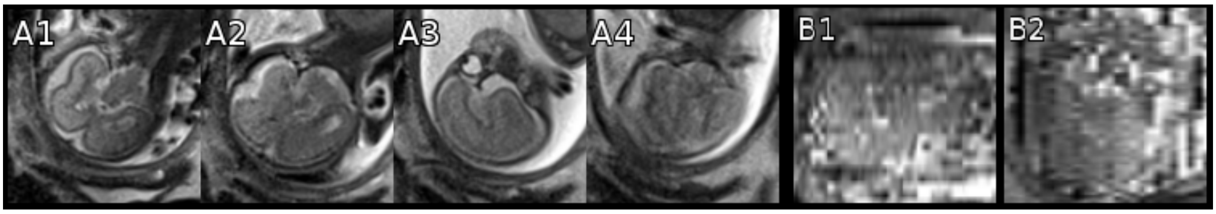

Figure 1. Example of severe motion that was not included in our study. Panels A1-A4 show inter-slice motion in slices of one stack in which the fetal head changed orientation from coronal to sagittal. Panel A4 shows intra-slice motion which corrupted the image. Panels B1 and B2 show the out-of-plane views and stack misalignment due to motion.

2. Parallelization effectiveness of the brain localization algorithm

To evaluate the effectiveness of our parallelized brain localization algorithm, we performed brain localization with $\Delta\theta$=45°, on three orthogonal stacks from case F6 with *4mm* slice thickness and three orthogonal stacks with *2mm* slice thickness, where *c*= {1,2,4,8} cores were used. Computational times are plotted in Figure 1 here after. We observe that computational time decreased as the number of cores increased. This confirms the effectiveness of the CPU-based parallelization at the level of the rotation sampling. The part of the algorithm that estimated the optimal translation was still sequential as CPU-based parallelization aimed to parallelize the computations for the most computationally expensive part of the algorithm, that is estimating the optimal translation at each sampled rotation angle.

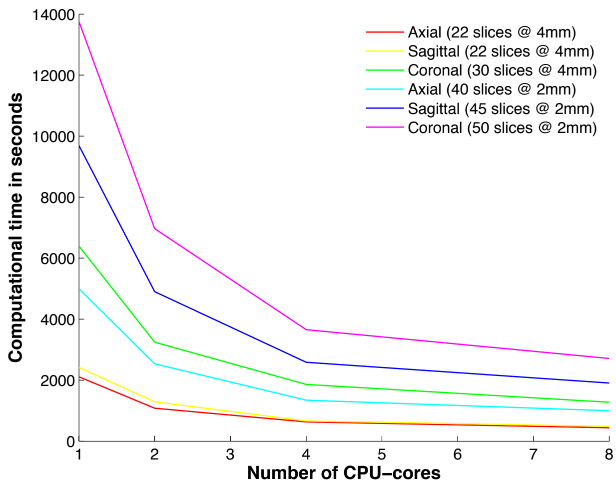

Figure 2. CPU-parallelization effectiveness of the proposed block matching brain localization algorithm. Computational times for six orthogonal stacks (axial, sagittal, coronal) of case F6 with *2mm* and *4mm* slice thickness are plotted where the brain localization algorithm was tested with *c*={1,2,4,8} CPU cores.

3. Atlas-based segmentation of brain tissues

With the developed template-based brain localization and extraction algorithm, high-resolution volumetric images of the fetal brain are readily reconstructed in the atlas space. This enables automatic atlas-based tissue segmentation using fetal brain MRI atlases [1] and probabilistic label fusion [2] algorithms. We present here after estimated volumes (in mL) for different brain structures. Volumes are estimated for 26 fetuses ranging from 23 to 38 weeks of gestational age (GA). Cases depicted with filled symbols are pathological cases.

3.1 Brain parenchyma (WM and GM only, without considering cerebellum area)

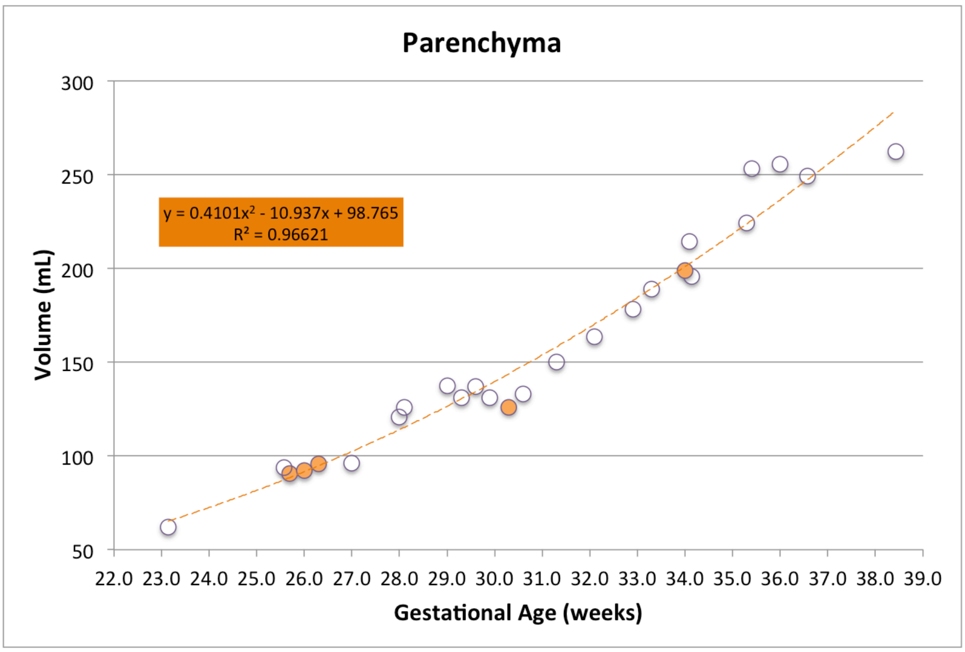

Figure 3 Brain parenchyma volume as function of the gestational age. Volumes are in mL.

3.2 Cerebellum

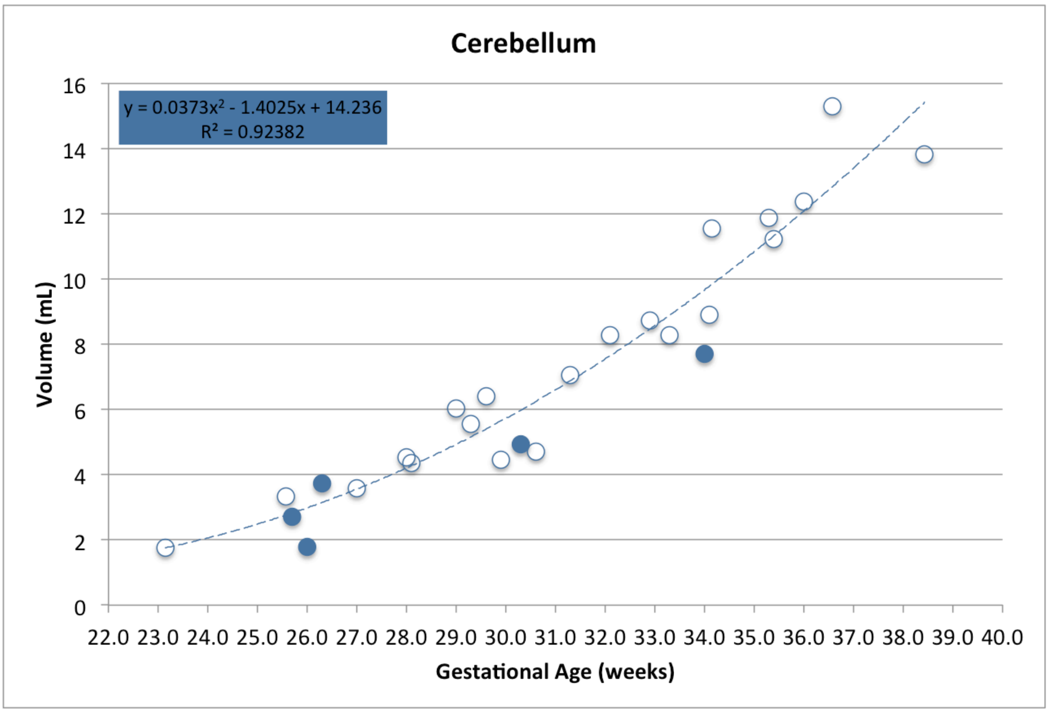

Figure 4 Cerebellum volume as function of the gestational age. Volumes are in mL.

3.3 Cortical plate

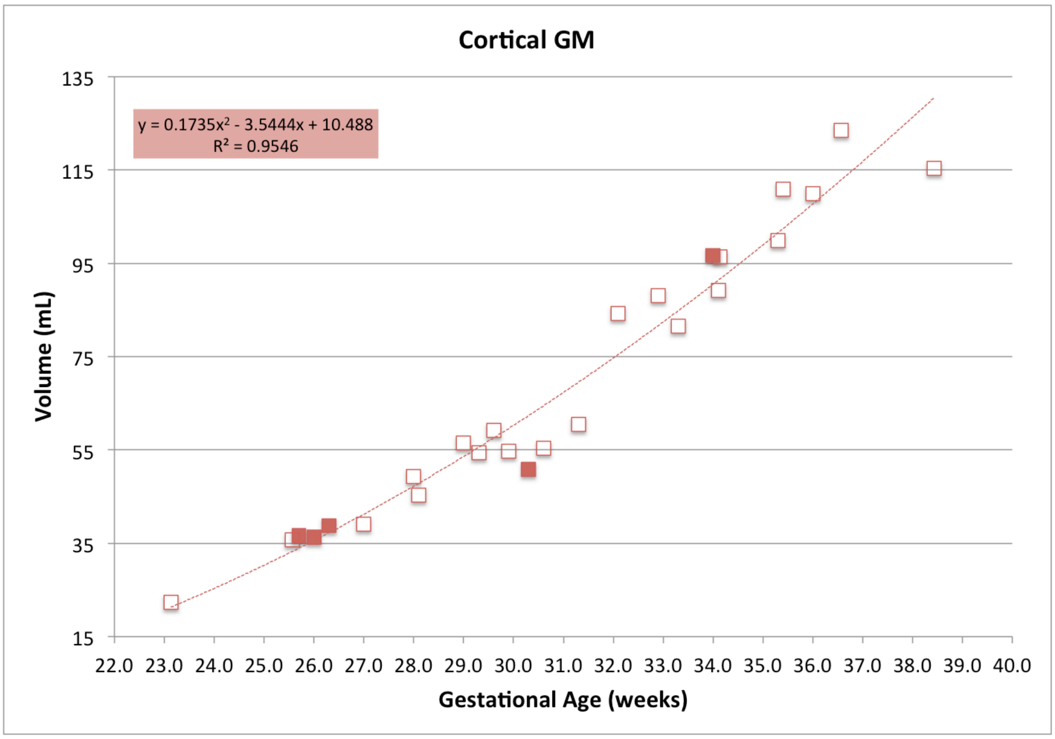

Figure 5 Cortical plate volume (GM) as function of the gestational age. Volumes are in mL.

3.4 Basal ganglia (inlc. caudate, lentiform and thalamus)

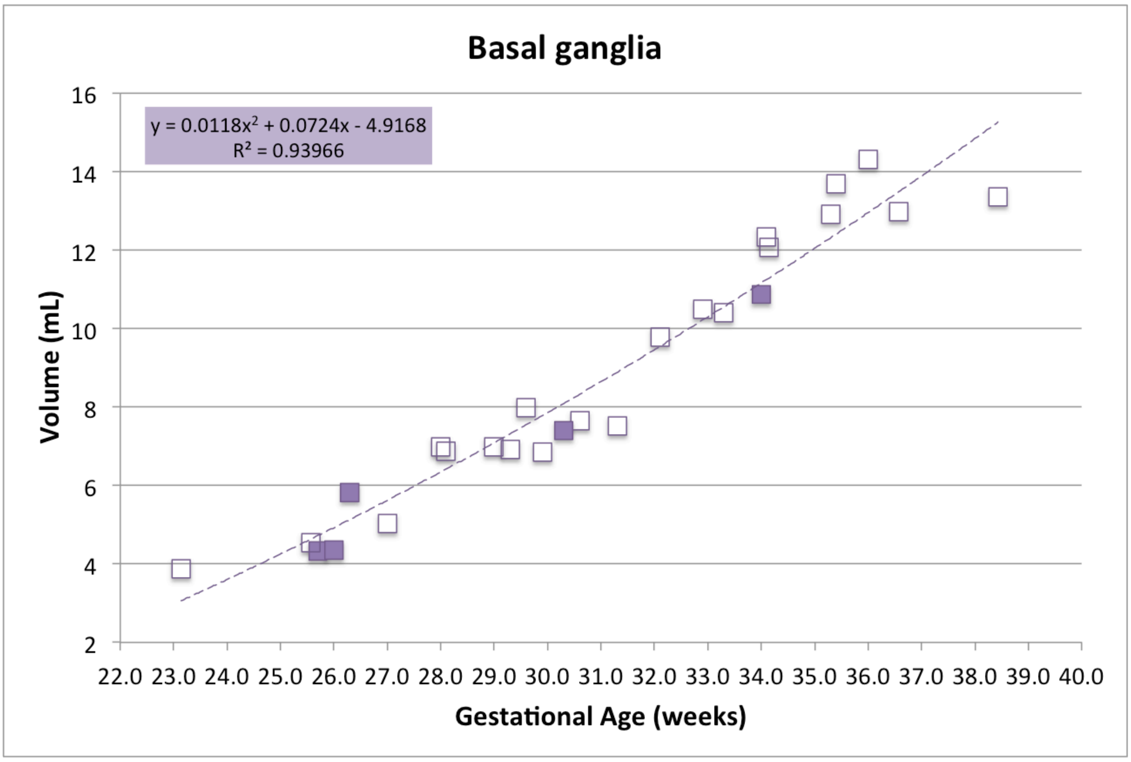

Figure 6 Volume of basal ganglia as function of the gestational age. Volumes are in mL.

3.4 Ventricles

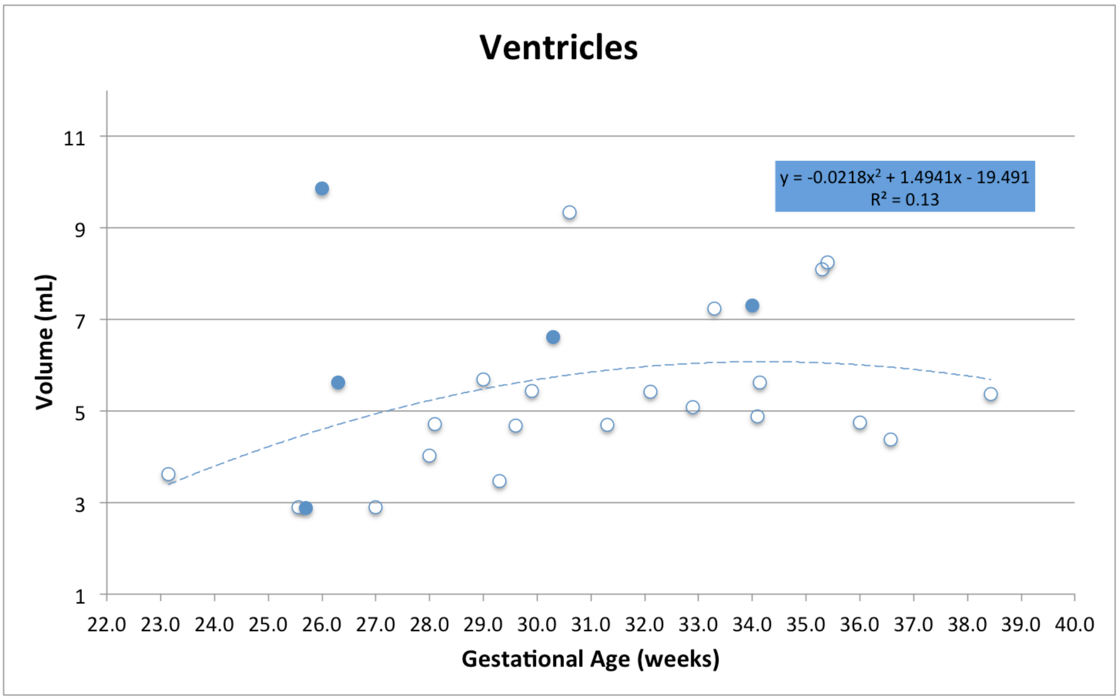

Figure 7 Volume of ventricles as function of the gestational age. Volumes are in mL.

4. References

[1] A. Gholipour, C. K. Rollins, C. Velasco-Annis, A. Ouaalam, A. Akhondi-Asl, O. Afacan, C. M. Ortinau, S. R. Clancy, C. Limperopoulos, E. Yang, J. A. Estroff, S. K.Warfield, « A normative spatiotemporal MRI atlas of the fetal brain for automatic segmentation and analysis of early brain growth », Scientific Reports in-press.

[2] A. Akhondi-Asl, S. K. Warfield, « Simultaneous truth and performance level estimation through fusion of probabilistic segmentations », IEEE transactions on medical imaging 32 (10) (2013) 1840–1852.