# Segmentation and Visualization of Brain and Lung volumes in fetal MRI using Active Contours and Morphological Operators

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**Purpose:** Prenatal survival critically depends on a sufficiently sized and functionally well-developed brain and cardiopulmonary system [1]. Computation of fetal brain volume can be used as a biometric measure to monitor the fetal development for diagnosis and/or prognosis of fetal pathologies. The diseases related to abnormal development of the brain such as: Occipital Encephalocele (0-85/1000 cases) [2], Occipital Meningocele (0-28/1000 cases) [2], Sacral Meningocele and Lumbar Meningocele. In the case of lung development, biochemical and structural maturity of the fetal lung are the significant determinants for survival of the fetus [1]. Pulmonary Hypoplasia range from 9-14 per 10000 births globally [3] and 50% of the premature babies are prone to Infant Respiratory Distress syndrome (IRDS) [4]. The goal of the current work is to determine volumes of fetal brain and lungs that can aid in illustrating biometric measures required to determine fetal developmental rates for characterization of pathology.

**Methods:** Six volumes of $T_2$ weighted fetal data were acquired with following specifications**:** single shot fast spin echo **(**ssFSE), TR-1750ms, TE-92ms, slice thickness-4mm and slice gap-5mm**.** Brain was visible in all the six volumes and lungs were completely visible in three datasets. The datasets were 2D multi-slice and hence scattered data interpolation was carried out in order to obtain the 3D dataset for volume segmentation. The first step in brain segmentation was the application of active contours, and the seed region was selected automatically as described further, and the parameters required for the active contours were optimized as 800 iterations and alpha value 0.07. Morphological processing was carried out in order to remove spurious areas in segmented regions. The seed region was automated based on the assumption that the object of focus in an imaging experiment will be at the centre of the slice. Lung segmentation was carried out using active contour method, working prominently with optimized smoothening factor as 0.06 and number of iterations as 200. Segmentation was followed by morphological operations to remove spurious regions to allow for further calculations. After interpolation, stripe/banding artefacts were observed in image slices. The banding artefact was removed through wavelet and Fourier transform filtering [5]. For removal of banding artefact, a level 7 Haar wavelet was used. The semi-automatic segmentation of the lung was carried out using Active Contour region based segmentation technique and the segmented lung images were used to obtain 3D model of the lung. Calculation of means and standard deviations was not performed due to difference in gestational weeks of the volumes. Hence, plots of results of segmentation performed through the algorithm as well as manually were graphed for all the data sets.

**Results:** The results of a representative fetal brain segmentation are shown in figure 1 where (A) shows a slice of the fetal data with the brain depicted by the yellow arrow; (B) shows the segmented fetal brain of mid-sagittal slice; (C) shows the 3D view of the segmented fetal brain post interpolation and (D) depicts the quantification results of the automated segmented and manual segmentation of the fetal brain. Figure 2: (A) depicts the fetal MR image with the ROI marked in red, while (B) shows the segmented output of lungs; (C) shows the 3D visualization of the lungs after interpolation. Figure (D) shows the difference between manual and semi-automated segmentation of the three volumes.

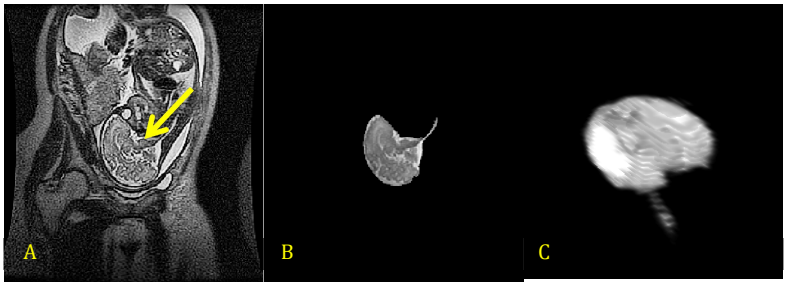


*Figure 1: (A) Representative fetal MRI. (B) shows the segmented brain in mid slice. (C) shows the 3D view of the segmented brain. (D) Graph showing the results of comparison between manual and automated segmentation.*

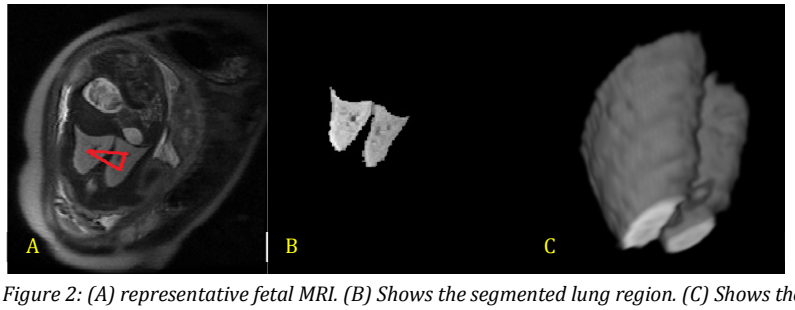


*Figure 2: (A) representative fetal MRI. (B) Shows the segmented lung region. (C) Shows the 3D view of segmented lung. (D) Graph shows the results of comparison between manual and semi- automated segmentation.*

**Discussion:** The results show that the algorithm is capable of segmenting fetal brain automatically and fetal lung semi-automatically, as can be validated by comparison with manual segmentation. The brain segmentation surface is not uniform due to slice gaps introduced during acquisition. The lung appears to be truncated, as certain parts of the lungs are not visible in the acquired data, as validated by manual segmentation. The volumes V5 and V6 in brain data have lesser number of segmented pixels because the fetuses were of early gestational weeks. The volumes V2 and V3 in lung data have less segmented volume because the fetal dataset were acquired in earlier gestational week as compared to V1.

**Conclusion/ Future work:** The datasets worked on have low Signal-to-Noise Ratio (SNR), on which our algorithm has been tested and has able to segment significantly similar to manual segmentation. Current work involves extending the algorithm for $T_1$ data as the segmentation does not rely on apriori information of the image based on hyper or hypo-intensities and the visualization of brain and lungs. The future work includes to derive the bio-metric markers in-order to distinguish between healthy and unhealthy fetus. **References:** 1) Daniela Prayer et al., Medical Radiology Diagnostic imaging-Fetal MRI (2011), 2) M L Kulkarni et al., Archives of Disease in Childhood (1989). 3) Praveen Kumar et al., Congenital Malformations (2007). 4) Beena D. Kamath et al, Paediatrics, (2011). 5) Beat Munch et al, OSA (2009).