Using deep learning to develop a fully automated, real-time 3D-ultrasound segmentation tool to estimate placental volume in the first trimester.

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Abstract

Image analysis tools to estimate organ volume do exist but are too time consuming and operator-dependant. Fully automating the segmentation process would potentially allow the use of placental volume to screen for increased risk of pregnancy complications.

Previously Looney et al. [2017] trained Deepmedic [Kamnitsas et al., 2017] on 300 ultrasound volumes and obtained a Dice similarity coefficient (DSC) of 0.73. Yang et al. [2017] used 104 cases and obtained a DSC of 0.64 for the placenta. In this work a new technique [Looney et al., 2018] to fully automate the segmentation of an organ from 3D ultrasound (3D-US) volumes is presented, using the placenta as the target organ. The architecture of the CNN is a modified version of U-Net for 3D [Ronneberger et al., 2015].

The placenta was segmented from 2393 first trimester 3D-US volumes using a semi-automated technique. This was quality controlled by three operators to produce the 'ground-truth' dataset. A fully convolutional neural network (OxNNet) was trained using this 'ground-truth' dataset to automatically segment the placenta.

OxNNet delivered state of the art automatic segmentation (median Dice similarity coefficient of 0.84). The effect of training set size on the performance of OxNNet demonstrated the need for large datasets (n=1200, median DSC (inter-quartile range) 0.81 (0.15)). By looking at prediction of small-for-gestational-age (SGA) babies at term the clinical utility of placental volume was tested. The receiver-operating characteristics curves demonstrated almost identical results (OxNNet 0.65 (95% CI; 0.61-0.69) and 'ground-truth' 0.65 (95% CI; 0.61-0.69)).

Our results demonstrated good similarity to the 'ground-truth' and almost identical clinical results for the prediction of SGA. The software used to obtain these results is available online [Looney, 2018].

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