

Introduction

- **Fetal brain atlases**
 - Contains **prior knowledge** on the dynamic developmental pattern of prenatal brain structure and function.
 - Can serve as **reference** for various clinical and scientific applications.
- **Challenges**
 - Highly **dynamic** gyrification process.
 - **Non-uniform** temporal distribution of fetal brain images in a dataset.
 - Spatiotemporally **non-uniform** and **low** tissue contrast.

Contribution

- **Surface-Guided Anatomical Constraint (SGAC)**
 - Incorporates guidance from both **tissue segmentation maps (TSMs)** and **cortical surfaces** to supervise the atlas-generating process.
 - Enables the model to better capture the anatomical appearance of the highly dynamic fetal brains.

Experiments

- **Dataset:** 72 healthy fetuses, gestational age (GA) from 22 to 32 weeks.
- **Preprocessing**
 - Brain localization, extraction [1], and super-resolution volume reconstruction [2] were performed to generate 3D fetal brain volume at 0.8 mm iso.
 - Volumes were segmented into white matter (WM), cortical gray matter (GM), and cerebrospinal fluid (CSF) [3].
 - Cortical surfaces were reconstructed using iBEAT V2.0 [4].
 - Inner surfaces were inflated to a sphere [5] and aligned to the 4D fetal cortical surface atlases [6, 7] based on cortical geometric features [8] and resampled with the same surface mesh tessellation, resulting in **vertex-wise correspondence**.
- **Comparison:** Atlas-GAN [9].
- **Evaluation Metric:** Pearson's correlation coefficient (PCC), Dice similarity coefficient, 95th percentile of the Hausdorff distance (HD95), average symmetric surface distance (ASSD).

Method

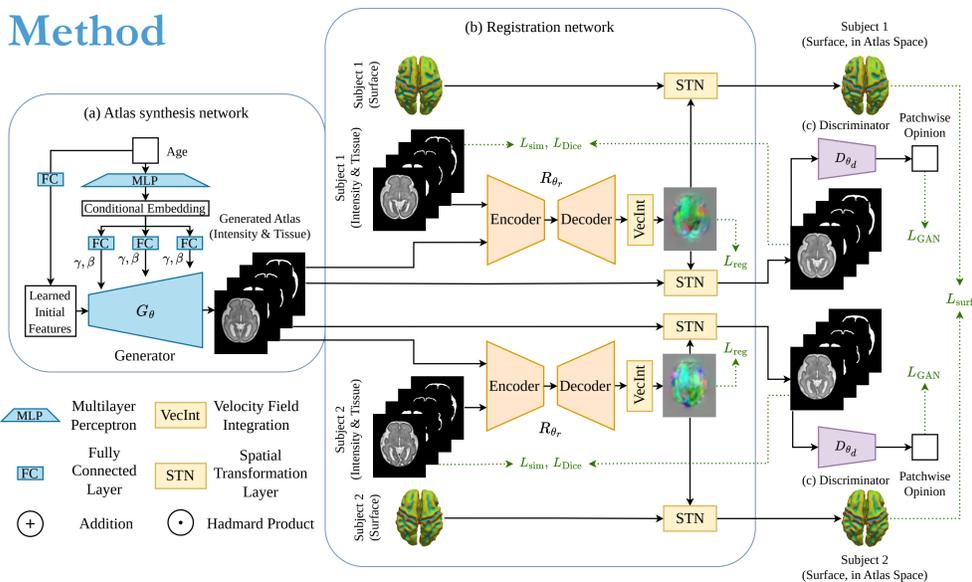


Fig. 1. An overview of the proposed surface-guided atlas construction framework.

Results

Table 1. Comparison of the atlases generated by the proposed framework (Ours) and its ablated variant without surface guidance (Ours w/o SG) with Atlas-GAN [9]. *: $p < 0.05$.

	Atlas-GAN [9]	Ours w/o SG	Ours
PCC (\uparrow)	0.985 (0.010)	0.986 (0.005)	0.982 (0.011)
Dice (%) (\uparrow)			
WM	93.4 (1.9)	96.6 (0.6)	97.3 (0.6)*
Cortical GM	68.3 (7.5)	71.9 (1.2)*	70.4 (1.1)
CSF	73.6 (2.2)	79.0 (1.6)	80.5 (1.4)*
HD95 (mm) (\downarrow)	2.056 (0.251)	1.785 (0.217)	1.579 (0.145)*
ASSD (mm) (\downarrow)	0.793(0.065)	0.712 (0.053)	0.619 (0.046)*

Results

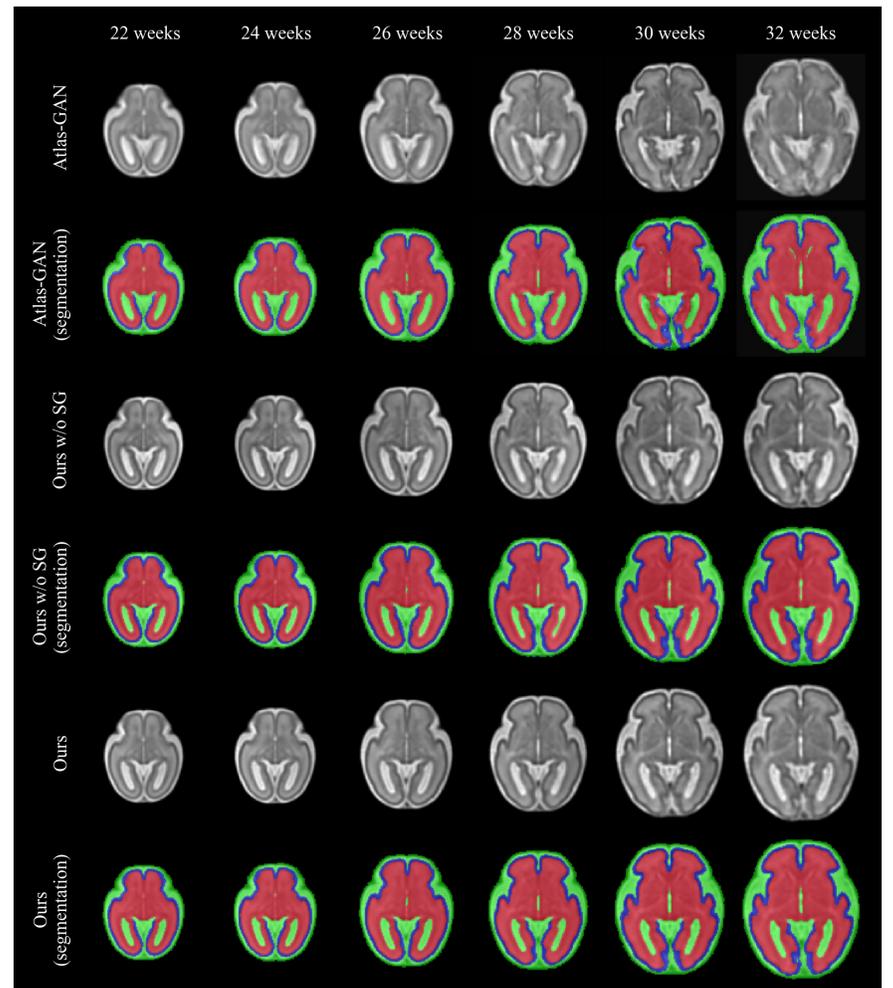


Fig. 2. Visual comparison of the generated atlases and the corresponding tissue maps at representative ages by our proposed method (Ours), its ablated variant without surface guidance (Ours w/o SG), and Atlas-GAN [9].

Acknowledgments

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