High-resolution Fetal Subplate Automatic Segmentation

Fetal Neonatal Neuroimaging and Developmental Science Center (FNNDSC) Symposium

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Introduction

Subplate (SP) in fetal brain is a **transitory** compartment [1-2] that lasts until 31 weeks of gestational age (GA) [3-4], and it is critical for **brain development** [5], **cortical circuitry** and **structure** [2,6].

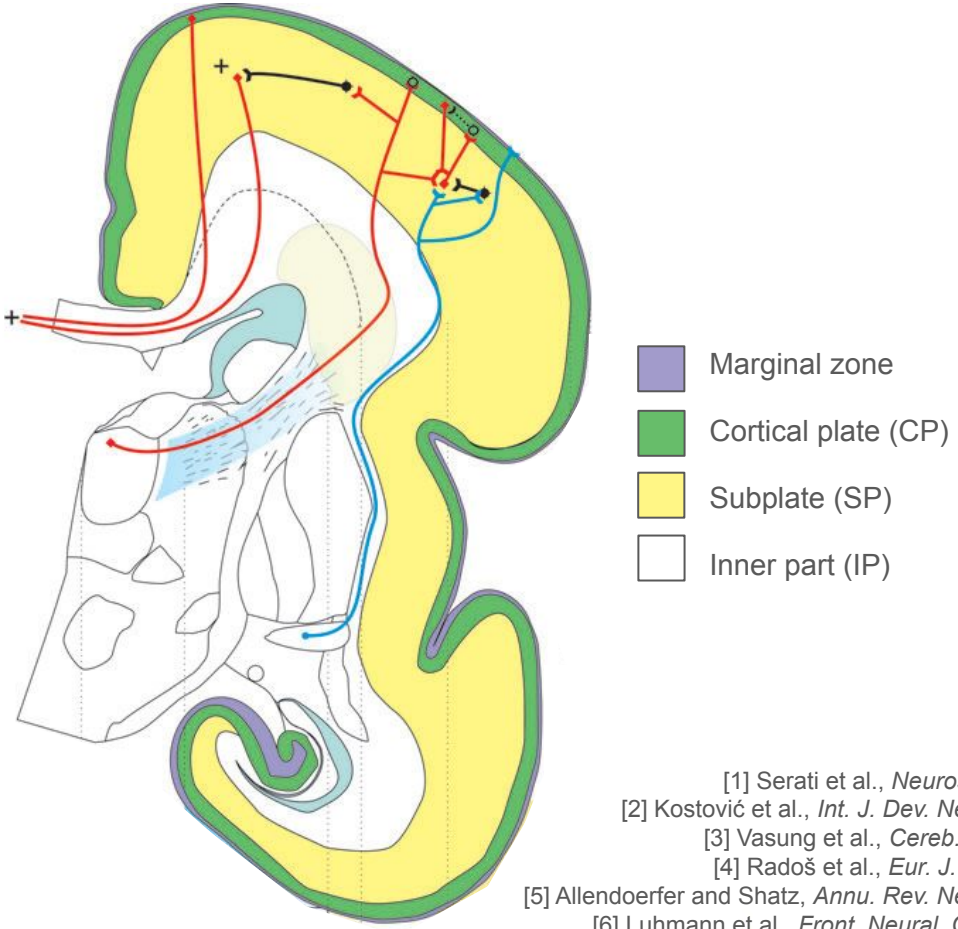
Objective:

- **Upsample** and **auto-smooth** existing low-resolution (0.86 mm) SP dataset to high-resolution (0.5 mm), via IRTK and **Bivariate Gaussian Smoothing (BGS)**
- **Train** a high-resolution **U-Net model** for **automatic** SP, cortical plate (CP), and inner part (IP) **segmentation**

Benefits:

- More **detailed delineation** of brain tissues such as the SP, CP, and IP
- More accurate SP **volume & thickness**

Reproduced from Vasung et al., *J. Anat.*, 2010



[1] Serati et al., *Neuroscience*, 2019
[2] Kostović et al., *Int. J. Dev. Neurosci.*, 2010
[3] Vasung et al., *Cereb. Cortex*, 2020
[4] Radoš et al., *Eur. J. Radiol.*, 2006
[5] Allendoerfer and Shatz, *Annu. Rev. Neurosci.*, 1994
[6] Luhmann et al., *Front. Neural. Circuits.*, 2016

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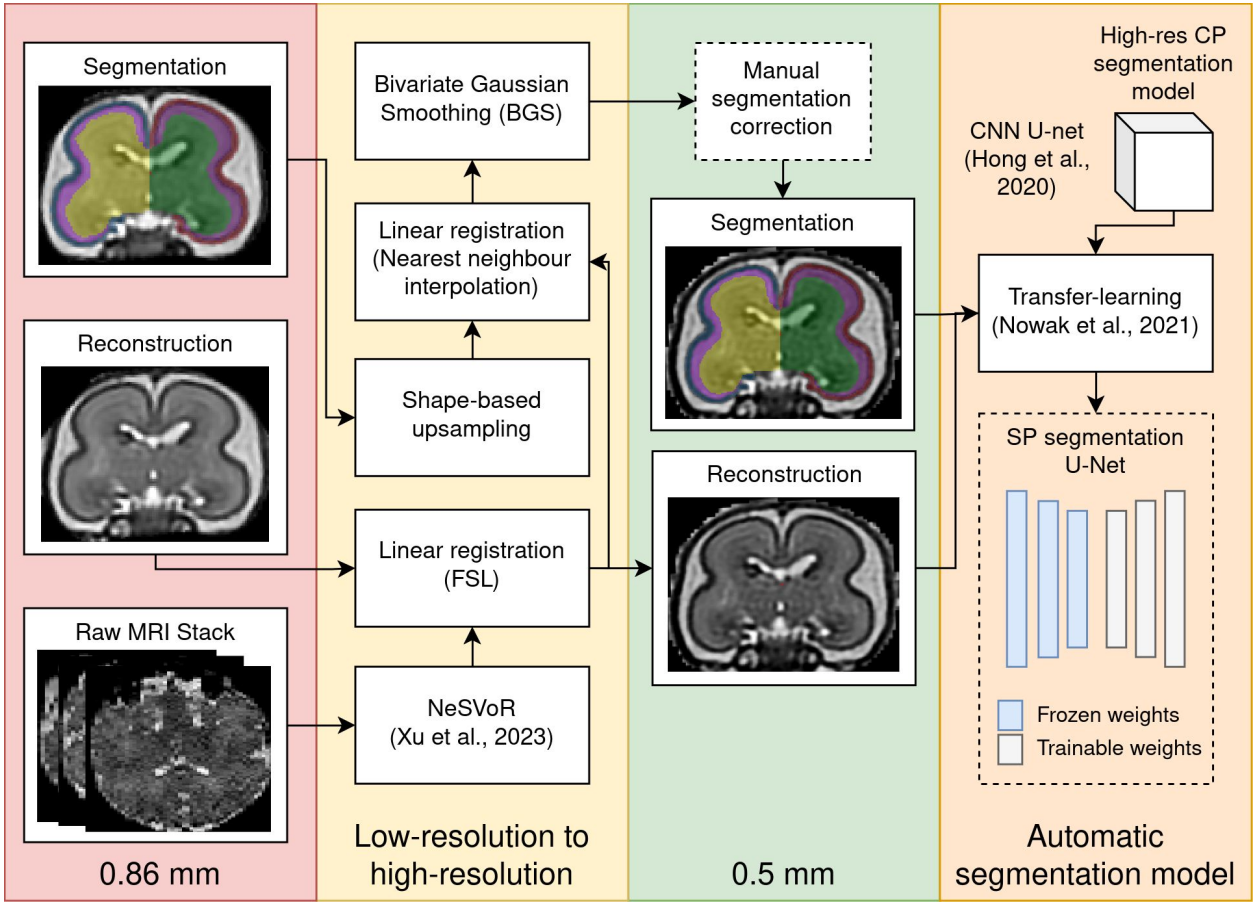
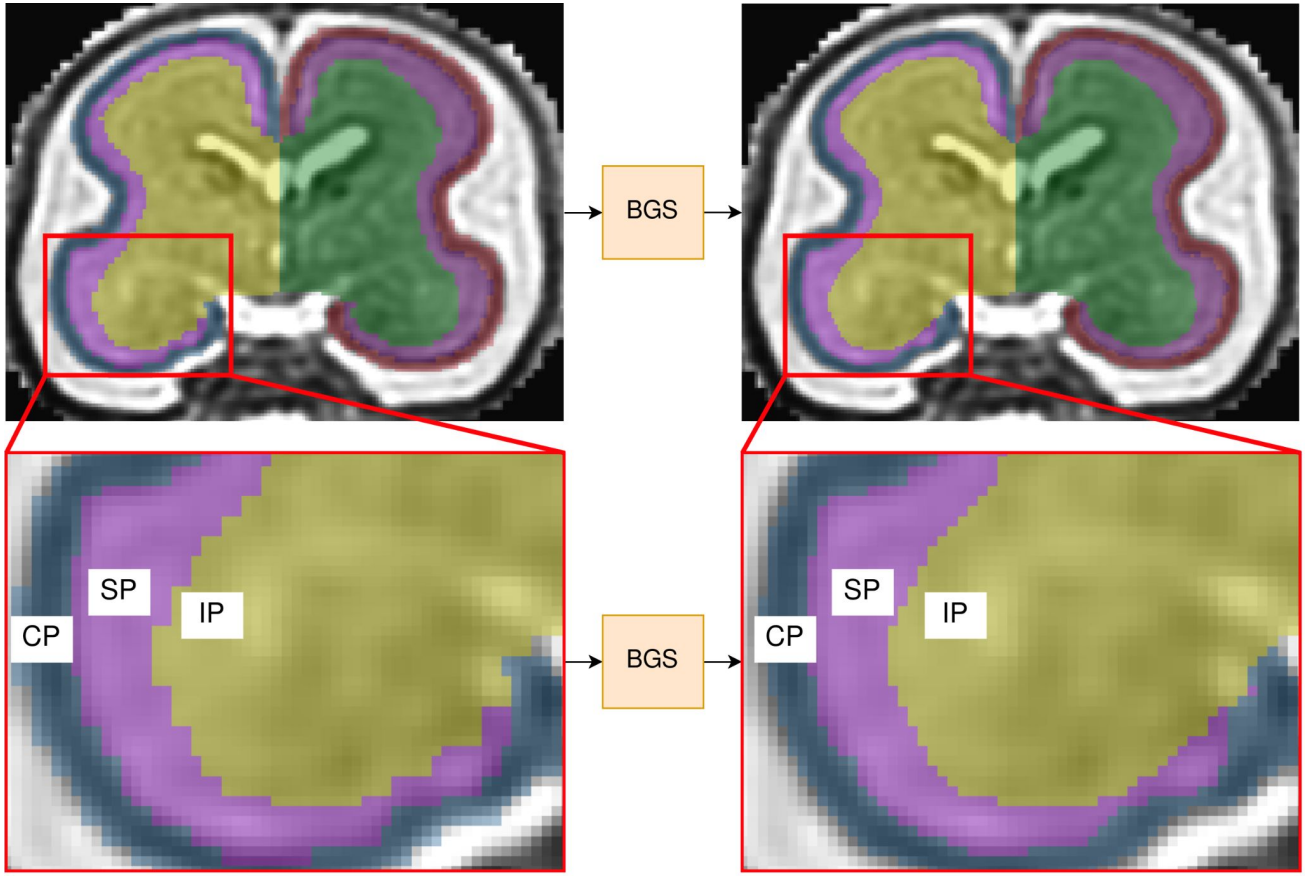
Methodology



Bivariate Gaussian Smoothing (BGS)



Univariate GS for IP mask **(dilatation)**

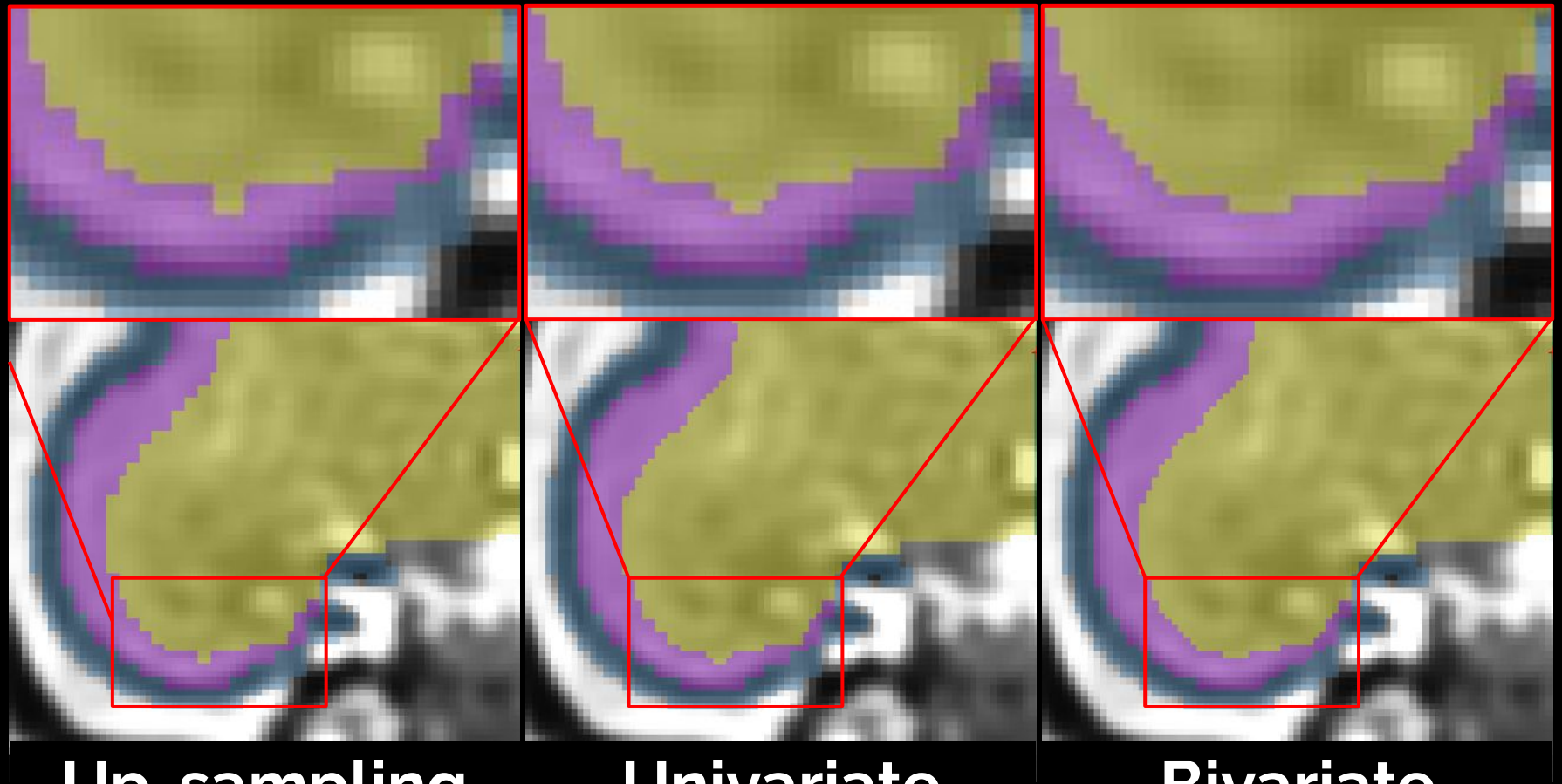
$$G(x, y, \sigma)_{ip} = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Univariate GS for neg IP mask **(erosion)**

$$G(x, y, \tau)_{-ip} = \frac{1}{2\pi\tau^2} e^{-\frac{x^2+y^2}{2\tau^2}}$$

BGS for image I **(dilatation & erosion)**

$$BGS(I, \sigma, \tau) = G(G(I, \sigma)_{ip}, \tau)_{-ip}$$


Up-sampling
Univariate
Bivariate

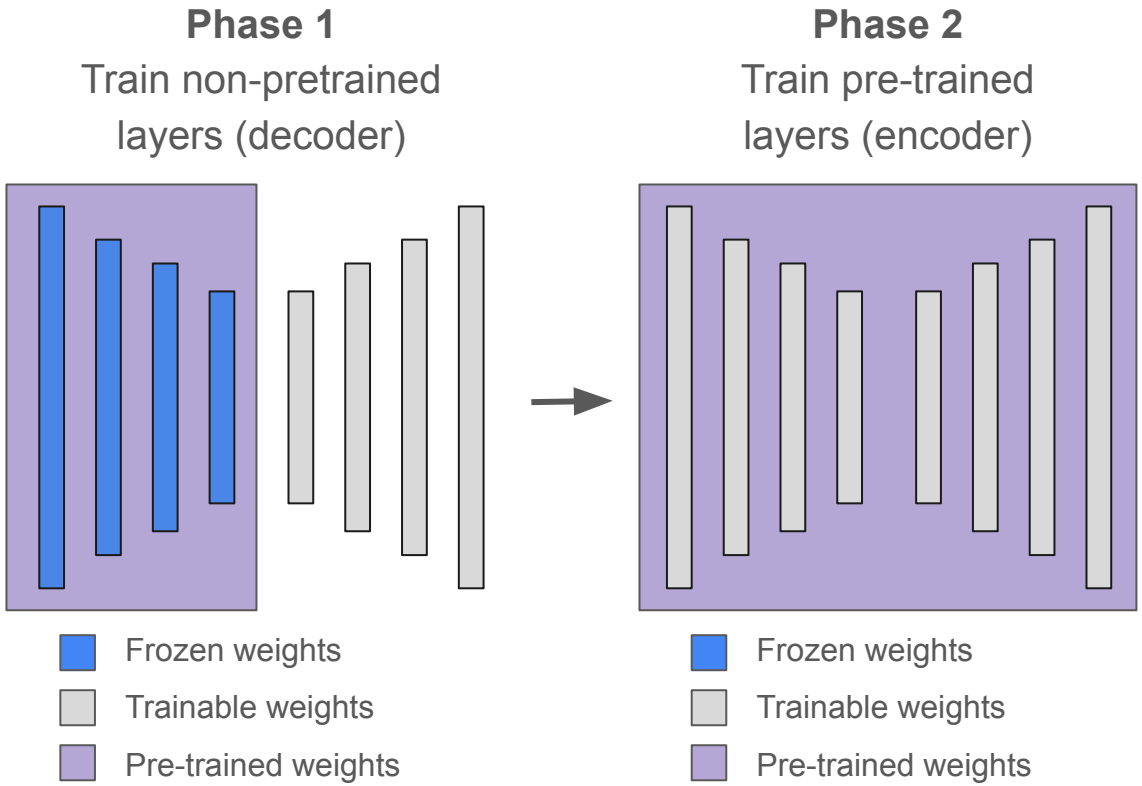
Conclusions and Future Work

Conclusions:

- **High-quality** (voxel size=0.5 mm) **segmentation** upsampling
- **Fast** construction of a new high-resolution **training dataset**
- **Reduced manual** tasks for segmentation correction

Future work:

- Finish **segmentation correction** (14 out of 68 are now reviewed)
- **Phased** U-Net model **training**; leveraged by high-resolution CP model [1] (~200 subjects) via **deep transfer-learning** [2]



[1] Hong et al., *Front. Neurosci.*, 2020
[2] Nowak et al., *Eur. Radiol.*, 2021