Institut de Neurosciences de la Timone,
Aix-Marseille Université,
UMR CNRS 7289

Deep Learning methods for fetal cortical surfaces generation from MRI scans

Duration : 3-6 months
Level : M1/M2/Engineering school
Location : Institut de Neurosciences de la Timone, 13005, Marseille
Equipe : Methods and Computational Anatomy (MeCA research group)
Supervision : Olivier Coulon, olivier.coulon@univ-amu.fr
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Context

The human cerebral cortex undergoes dynamic and regionally heterogeneous development during gestation[1]. Cortical surface-based analysis is based on the reconstruction of topologically-correct and geometrically accurate surface representations of the folded, thin cerebral cortex, as illustrated on Figure 1. The fetal cerebral cortex is typically represented as a triangulated mesh with a spherical topology for each brain hemisphere, generated from a tissue segmentation of the structural MRI scan. Although various algorithmic solutions have been proposed in the past to propose such mesh meshes, deep learning approaches have now become state-of-the-art for cortical surface generation [2].The goal of this internship is to evaluate some of these methods. In particular we will evaluate their performance on fetal MR data, that are difficult to process with standard methods.

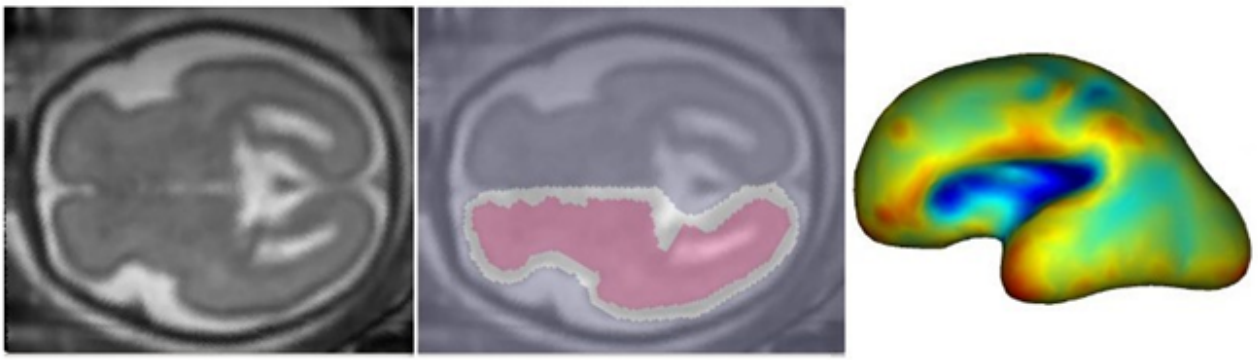

Figure 1: MRI scan of a fetal brain (left); 2 tissues (white matter, and cortex) segmentation (center), mesh representation of the cortex colored following the curvature (right)

Objectives

The intern will be in charge of:

1. Testing pre-selected deep-learning approaches from the literature (CortexODE [3] CorticalFlow++[4], DeepCSR[5], PialNN[6], Topofit[7]).
2. Comparing these methods on a large dataset of fetal MRI available in the team and containing normal and pathological scans

3. Perform an application study on the obtained surfaces representations to characterize normal and pathological fetal development (optional, depending on progress)

Required Skills

- Good knowledge of deep learning principles
- Experience with Python for Deep Learning (e.g. Pytorch)
- Git, GitHub and Linux based environment
- Previous professional or scholar project involving deep learning is a plus but not mandatory

Work Environment

The intern will integrate the MeCA research team of the Institut des Neurosciences de la Timone, in Marseille, France. The Meca team combines expertise in processing of large fetal MRI databases and surface based morphometry methods. Tools and data required for the internship will be provided by the team.

How to apply

Send your CV + motivation letter to olivier.coulon@univ-amu.fr and guillaume.auzias@univ-amu.fr

Bibliography

[1] I. Kostović, G. Sedmak, and M. Judaš, “Neural histology and neurogenesis of the human fetal and infant brain,” *NeuroImage*. 2019, doi: 10.1016/j.neuroimage.2018.12.043.
[2] F. Zhao, Z. Wu, and G. Li, “Deep learning in cortical surface-based neuroimage analysis: a systematic review,” *Intell. Med.*, 2023, doi: 10.1016/j.imed.2022.06.002.
[3] Q. Ma, L. Li, E. C. Robinson, B. Kainz, D. Rueckert, and A. Alansary, “CortexODE: Learning Cortical Surface Reconstruction by Neural ODEs.” arXiv, 2022 http://arxiv.org/abs/2202.08329
[4] R. Santa Cruz *et al.*, “CorticalFlow++: Boosting Cortical Surface Reconstruction Accuracy, Regularity, and Interoperability,” in *MICCAI 2022*, doi: 10.1007/978-3-031-16443-9_48.
[5] R. S. Cruz, L. Lebrat, P. Bourgeat, C. Fookes, J. Fripp, and O. Salvado, “DeepCSR: A 3D Deep Learning Approach for Cortical Surface Reconstruction,” IEEE/CVF, 2021, https://openaccess.thecvf.com/content/WACV2021/html/Santa_Cruz_DeepCSR_A_3D_Deep_Learning_Approach_for_Cortical_Surface_Reconstruction_WACV_2021_paper.html
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[7] A. Hoopes, J. E. Iglesias, B. Fischl, D. Greve, and A. V. Dalca, “TopoFit: Rapid Reconstruction of Topologically-Correct Cortical Surfaces,” MIDL, 2021, https://openreview.net/forum?id=-JiHeZNDY3a