modeling early development and maturation of human cortical folding

1. DESCRIPTION OF THE PHD THESIS PROJECT

1.1 OBJECTIVES OF THE PROJECT BASED ON THE CURRENT STATE OF THE ART

The project SulcalGRIDS (Dynamics of cortical morphology during childhood development) is funded by the French National Research Agency (ANR) for four years, starting on January 2020. SulcalGRIDS aims at elaborating a new model of cortical morphogenesis that could explain how the human cerebral cortex shape complexity emerges during development. Such a model would be instrumental to develop novel biomarkers of early atypical development and to better understand the pathophysiology of neurodevelopmental disorders. It is based on our recent works on specific cortical points, the sulcal pits (illustrated on Fig.1), that correspond to singularities from which sulci emerge during in utero and early post-natal cortical maturation phases. We have developed a method for automatic extraction of these points from anatomical MRI scans [1], and published several applications [2-5].

The objective of this PhD thesis is to extend this work both in terms of methodological developments and large-scale applications.

Methods: The recruited PhD candidate will propose, implement and evaluate new techniques dedicated to the quantitative analysis of the organization of sulcal pits and its dynamics during brain maturation. One option is to pursue our effort on graph representation of sulcal pits patterns as introduced in [2], but other avenues of research might be investigated.

Applications: The methods will be validated through several applications aiming at characterizing early brain maturation. Two types of data will be used: 1- publicly available MRI data acquired shortly after birth https://www.developingconnectome.org/ and 2- fetal MRI data (acquired before birth) with appropriate clinical description, thanks to our collaboration with the neuroradiology unit of CHU Timone.

For references, see the publications from our team below.

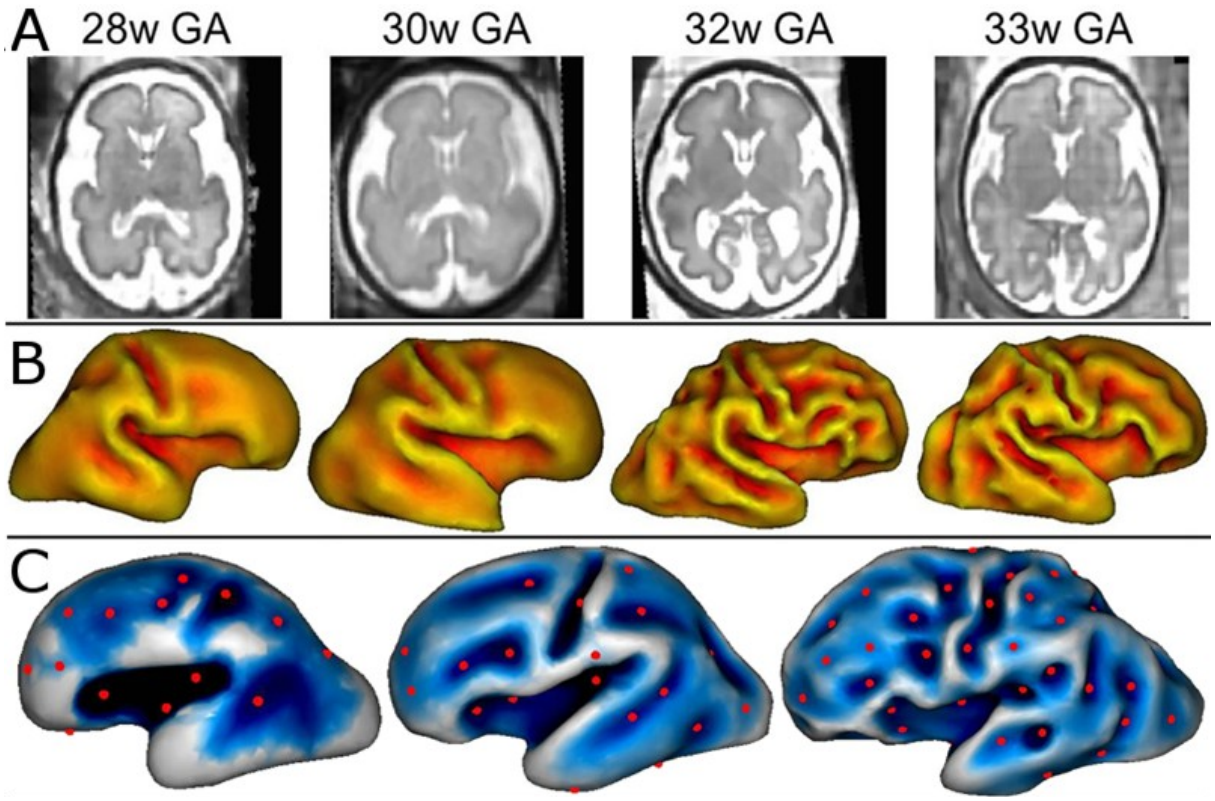

Fig.1. A) Anatomical MRI of fetuses at different gestational ages. B) Corresponding 3D cortical surfaces reconstruction. C) The sulcal pits shown as red dots indicating the deepest point of each cortical fold.

1.2 SUPERVISOR AND RESEARCH GROUP DESCRIPTION

This PhD project will be supervised by Guillaume Auzias, within the MeCA team of the Institute for Neurosciences of La Timone (INT, http://www.int.univ-amu.fr/?lang=en). As further described in section 4 and visible in the publication list below, this project lies at the crossroad between several domains of expertise. The candidate will benefit from the support of the members of the SulcalGRIDS project consortium.

MeCA is a computational anatomy and methods team with a solid experience in developing methods for surface-based analysis of cortical morphometry. In addition, you will receive the support of the SCALP team, which is a neuroscience team with a long experience in neurodevelopmental disorders, at both cognitive psychology and neuroimaging levels. The team embeds clinicians from the Child, the Adolescence and the Adult Psychiatry Units (CHU Timone). Both teams have a strong partnership with the Neuroradiology Unit of CHU Timone (Prof. N Girard) where all clinical MR protocols are performed with specific guidelines. Fetal MRI data has been acquired in this unit for clinical purpose since more than 20 years. The INT is one of the top French neuroscience research institutes with 150 staff members gathered in 12 inter-disciplinary teams examining different aspects of the cerebral organization. It is

located on the medical campus of Aix-Marseille University. The candidate will have access to the INT Neurocomputing Center, with a large-scale cluster (548 cores, 170To storage) and computing engineers specialized in neuroimaging.

2. RECENT PUBLICATIONS

[1] G. Auzias, L. Brun, C. Deruelle, and O. Coulon, 'Deep sulcal landmarks: Algorithmic and conceptual improvements in the definition and extraction of sulcal pits', NeuroImage, vol. 111, pp. 12–25, May 2015.

[2] S. Takerkart, G. Auzias, L. Brun, and O. Coulon, 'Structural graph-based morphometry: A multiscale searchlight framework based on sulcal pits', Medical Image Analysis, vol. 35, pp. 32–45, Jan. 2017.

[3] L. Brun, G. Auzias et al., 2016. Localized Misfolding Within Broca's Area as a Distinctive Feature of Autistic Disorder. Biological Psychiatry: Cognitive Neuroscience and Neuroimaging, 1(2), pp.160–168.

[4] Y. Le Guen, G. Auzias et al., 2017. Genetic Influence on the Sulcal Pits: On the Origin of the First Cortical Folds. Cerebral Cortex, (2015), pp.1–12

[5] I. Kaltenmark, al. and & Auzias, G. (2020). Group-level cortical surface parcellation with sulcal pits labeling. Medical Image Analysis, 66, 101749. https://doi.org/10.1016/j.media.2020.101749

3. EXPECTED PROFILE OF THE CANDIDATE

We are seeking a PhD candidate who meets the following requirements:

1) Master degree in data science, electrical engineering or a similar field;

2) Proficient with computer programming (python will be our language of choice);

3) Good knowledge and/or experience in signal and image processing,

4) Good knowledge and/or experience in machine learning / data science / multivariate statistics.

Experience with graph structures would be a plus. Prior experience in neuroscience is not a requirement, but interest in the field and high motivation are of course necessary. Good reading/writing/communication skills in English are also essential.

4. SUPERVISORS' PROFILE

Guillaume Auzias was recruited as a CNRS researcher on November 2017, He supervised more than 20 master fellows and research engineers, and is currently co-supervisor of two PhD theses.

Characterizing cortical folding pattern both locally and globally is at the center of the research program of Guillaume Auzias from his PhD on spatial alignment across individuals (Auzias et al. 2008; Auzias et al. 2011; Mangin et al. 2016) to his post-doctoral work on folds organization and alignment (Auzias et al. 2013), and sulcal pits in adults (Auzias, Brun, et al. 2015; Takerkart et al. 2017). He has an interdisciplinary training in neuroimaging with a background in both Applied Mathematics and Computer Sciences (PhD) and neurosciences (post-doctoral training). He published research articles in both fields with new methods for neuroimaging (IEEE TMI) and applications in neurosciences and clinical neuroimaging (J Neurosci, Biol Psychiatry, Am J Psychiatry).

He created the Marseille Young Autism Database (MYAD: http://www.int.univ-amu.fr/MYAD) through collaborations between INT and the Neuroradiology and Pediatric Psychiatry Departments of CHU Timone. MYAD led to several publications from the team (Auzias et al. 2014; Brun et al. 2016) and as well as from the large international consortium ENIGMA using both our dataset and analysis methods (van Rooij et al. 2018; Postema et al. 2019). G Auzias is one of the main contributors of the cortical surface toolbox developed by MeCA team (https://meca-brain.org/software/, https://gauzias.github.io/slam/). This free and open source toolbox is distributed in the BrainVISA software (http://brainvisa.info). It has been used by several research group outside the team such as in (Le Guen et al. 2018; Le Guen et al. 2017).

Th starting date can be as early as November 2020 and can be postponed until the position is fulfilled. If you are interested, please send your CV and a cover letter to:

guillaume_DOT_auzias_AT_univ-amu_DOT_fr