Master or Semester project

Location: EPFL AVP-CP CIBM-AIT, Bâtiment CH F.
EPFL STI-IEM LTS5 Bâtiment EL (ELD244).

Dates/Duration: Autumn 2024/Spring 2025 - 4-6 months.

Multimodal connectivity mapping: Combining structural and metabolic connectomics to understand neurodegenerative pathologies

Background:

Brain structure and function spans multiple spatial and temporal scales. A complete picture of neuronal architecture and interactions across these hierarchical scales is crucial to comprehensively understand the brain, as well as numerous damaging brain diseases**.** MRI has proven a valuable, non-invasive way of proving both the architecture and activity of the brain in-vivo, with sufficient spatial and temporal resolution.

Diffusion MRI (dMRI) is sensitive to the microscopic movement of water molecules (Brownian motion), allowing to infer at the macroscopic level the major axonal pathways of the brain by means of tractography algorithms (structural connectivity). On the other hand, [18F]-fluorodeoxyglucose positron emission tomography (FDG-PET) enables 3D mapping of brain energy metabolism based on cerebral glucose uptake (metabolic connectivity), whereas proton magnetic resonance spectroscopy imaging (1H-MRSI) provides mapping of steady-state brain metabolites from multiple spatial positions simultaneously. For these last two approaches, the metabolic connectivity between the cerebral subregions that these modalities characterize remains to be explored. Each of these techniques provides a unique, region-specific and highly sensitive characterization of the brain. MRI measurements are highly indirect and spatio-temporally uncertain, and are often confounded by other sources of MRI signal as noise. In addition, **no single modality can fully capture brain structure and function as a whole, but only sub-domains of its spatial and temporal scales**. Combining these techniques (high-resolution MRI, MRSI and PET) in a multimodal approach may provide new biomarkers to bridge this gap.

Project description:

Within this project, we aim at implementing a multimodal connectomics framework to explore the link between structural and metabolic connectivity. The final goal is to identify novel biomarkers using this multiparametric connectome-based analysis for the detection and prediction of neurodegenerative disorder in a pre-clinical setting.

The student will be part of the CIBM Center for Biomedical Imaging. CIBM MRI EPFL has high-end multimodal imaging infrastructure allowing the development of cutting-edge acquisition and processing techniques in preclinical imaging, being thus an international leader in preclinical magnetic resonance imaging (MRI) and magnetic resonance spectroscopy (MRS) at ultra-high magnetic fields (UHF) and combining it with novel quantitative metabolic mapping approaches using FDG-PET.

Supervisors:

- Dr. Cristina Cudalbu, CIBM MRI EPFL AIT, https://cibm.ch/people/, https://www.epfl.ch/labs/mrs4brain/, cristina.cudalbu@epfl.ch

- Dr. Elda Fischi-Gomez, CIBM SP CHUV EPFL, elda.fischi@epfl.ch
- Dr. Bernard Lanz, CIBM MRI EPFL AIT, bernard.lanz@epfl.ch
- Dr. Maria Giulia Preti, CIBM SP EPFL UNIGE, maria.preti@epfl.ch

Skills

Qualifications, previous experience and background: This project is suitable for students with a background/knowledge in physics or biomedical physics, signal processing, machine learning or computer science who are interested in biomedical applications of magnetic resonance imaging (MRI), positron emission tomography (PET) and related metabolic modelling, and image processing. Experience in programming (Matlab and/or Python), machine learning & image processing is desirable. Previous knowledge in medical imaging analysis and medical imaging software (FSL, Freesurfer, etc) is welcomed. Students should be enrolled in one of the partner institutions (EPFL, UNIGE, UNIL).

How to apply: Please send your CV and motivation letter: cristina.cudalbu@epfl.ch, elda.fischi@epfl.ch

About CIBM

The CIBM Center for Biomedical Imaging was founded in 2004 and is the result of a major research and teaching initiative of the partners in the Science-Vie-Société (SVS) project between the Ecole Polytechnique Fédérale de Lausanne (EPFL), the Université de Lausanne (UNIL), Université de Genève (UNIGE), the Hôpitaux Universitaires de Genève (HUG) and the Centre Hospitalier Universitaire Vaudois (CHUV), with the generous support from the Fondation Leenaards and Fondation Louis-Jeantet.
CIBM brings together highly qualified, diverse, complementary and multidisciplinary groups of people with common interest in biomedical imaging.

We welcome you in joining the CIBM Community.

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