Master or Semester project

Location: EPFL AVP-CP CIBM-AIT, Bâtiment CH F. / Campus Biotech, Geneva
Dates/Duration: Spring/Autumn 2022/4 – 6 months.

An innovative and interoperable toolbox for multimodal preclinical image processing: Part 2

Worldwide there is an **urgent need for accessible, innovative and interoperable toolboxes for multimodal biomedical data processing to improve harmonization in data analysis and accelerate the uptake of new techniques.** This is a universal challenge with whom several research centers are confronted all over the world. Expert consensus recommendations have recognized the need for processing harmonization, especially in the era of *big data* that we are witnessing, where the amount of data produced is such that procedures of automated pre-processing and data analysis become essential for a maximum gain of information.
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 MRI and MRS at UHF. Among the acquired images at CIBM MRI EPFL, we deal with **classical type of images or spectra** (like anatomical images or parameter (T1 and T2) mapping for brain volume assessment and tissue characterization, respectively; and proton localized spectroscopy in different brain regions for an overall characterization of regional metabolic changes) and **more complex ones** (i.e. advanced DWI and DW-MRS for the characterization of brain microstructure[1–4]; dynamic proton, carbon, phosphorus magnetic resonance spectroscopy used for metabolic studies an additional determination of biochemical fluxes far beyond glucose phosphorylation, e.g. glycolytic rate, tricarboxylic cycle flux, exchange of glutamate and glutamine through neurotransmission[5–9]; FDG-PET for measuring glucose metabolism[10], electron paramagnetic resonance spectroscopy used for the study of oxidative stress[11], fast proton spectroscopic imaging for tissue regional information on metabolism[12,13]; functional MRI and MRS for brain activation response[14], etc) requiring **a more complicated processing**. In addition, different organs are investigated i.e. brain, liver, heart, abdomen, lungs. Analyzing and processing this extended and diversified amount of data is **challenging**, and requires the input from specialized researchers.
Therefore, **we aim to advance the state-of-the-art methodology in the field of preclinical image processing by proposing a holistic, interoperable toolbox for multimodal biomedical data processing.** In addition to tissue characterization or simple metabolic modelling, the **incorporation of diversified information from multimodal data** acquired at CIBM (MRI, MRS, DWI, PET, EPR, cellular information from histological data) would represent a **major advance in research,** something **novel** that we wish to implement in the current project. Finally, **powerful machine learning / deep learning techniques** will be integrated in our toolbox, creating a multimodal framework which exploits all available information to implement tasks such as data quality assessment, classification, quantification, advanced fast reconstruction techniques, and eventually disease response prediction.

The overall project is divided in three parts, with the second part being described below:

Combine diversified information from multimodal data acquired at CIBM MRI EPFL (MRI, MRS, FDG-PET, EPR, cellular information from histological data).
The creation of this toolbox will also represent a unique occasion to integrate multimodal data, such as:

- Oxidative stress measures from: 1H-MRS, 31P-MRS and EPR with spin trapping
- brain metabolism measures from: 1H-MRS, 13C-MRS, 31P-MRS and PET
- microstructural information measures: DWI for water molecules, DW-MRS for metabolites and histological measure for cell specific information
- structural information from volumetry, providing details in changes of tissue volume which could be related to DWI and histology

In this way, the created toolbox will offer the unique opportunity to collect multidimensional and multimodal data in the same framework, easing the combination of these different sources for the next steps of the analysis, such as group comparisons, disease or outcome prediction.

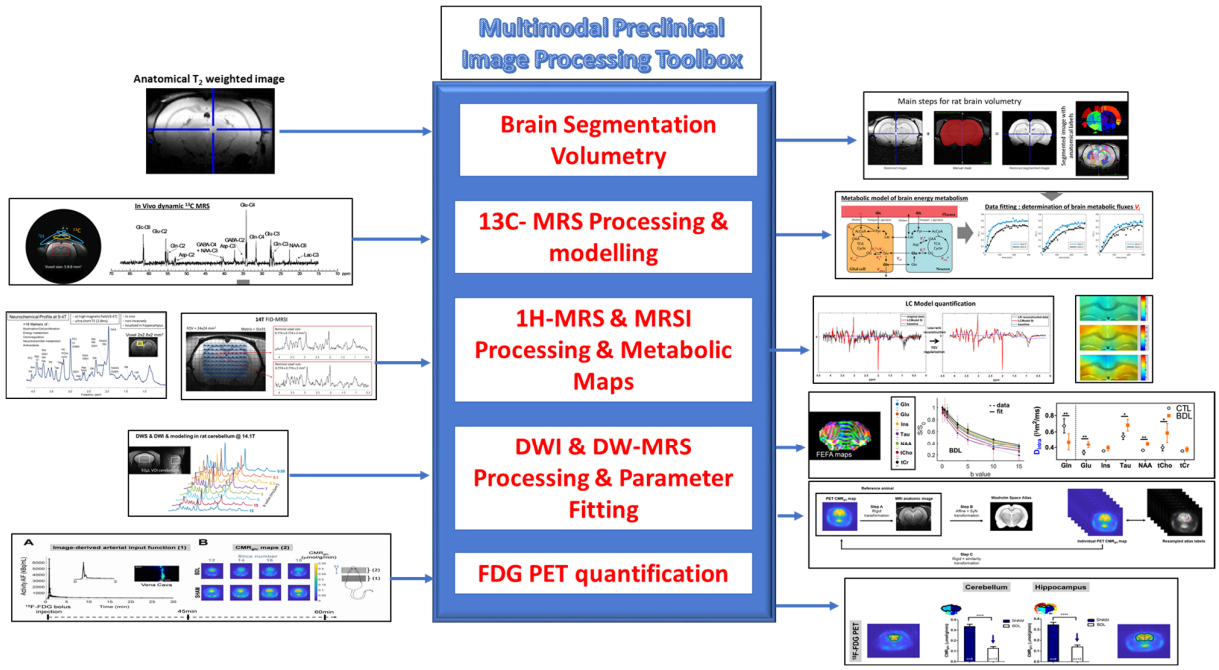

Figure 1: Schematic view of our innovative and interoperable toolbox for multimodal preclinical image processing with some detailed examples of acquired data and their processing

References

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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), and image processing. Experience in programming (Matlab and/or Python), machine learning & image processing is desirable.

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