PHYS-473

MRI Practicals on CIBM preclinical imaging systems

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Cursus	Sem.	Type
Biomedical technologies minor	H	Opt.
Ing.-phys	MA1, MA3	Opt.
Minor in Imaging	H	Opt.
Neuro-X	MA1, MA3	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Withdrawal	Unauthorized
Session	Winter
Semester	Fall
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Project	2 weekly
Number of positions	**20**

It is not allowed to withdraw from this subject after the registration deadline.

Summary

The goal of this course is to teach students how to perform basic MRI and MRS experiments in-vivo and ex-vivo directly on preclinical horizontal ultra-high field MRI systems.

Content

Main topics addressed in the course:
1. Introduction to MRI: Nuclear spin and magnetic moment, nmr-active nuclei/isotopes, macroscopic magnetization, classical description of magnetic resonance, FID, spin echo, gradient echo signal acquisition.
2. Basic anatomical imaging and contrast: T1, T2 and T2* weighted images, impact of acquisition parameters on image contrast
3. Introduction to advanced MRI and contrast : fast MRI, 3D imaging, volumetry, diffusion MRI, *in vivo* vs *ex vivo* imaging, volume vs surface RF coils properties
4. Introduction to Magnetic Resonance Spectroscopy (MRS), data acquisition and processing using MRS4Brain toolbox : 1H metabolites resonance patterns, chemical shift, J-coupling, shimming, MRS localization approaches, water signal suppression, outer volume signal suppression, metabolites quantification.
5. Introduction to Magnetic Resonance Spectroscopic Imaging (MRSI), reconstruction, data acquisition and processing using MRS4Brain toolbox : Basics of spectroscopic imaging, signal encoding for localization, 2D and 3D MRSI, FID vs echo-based MRSI
6. Basic artifacts in MRS and MRI and how to avoid them
7. Data processing: volumetry, DTI, metabolic imaging

Keywords

Magnetic Resonance Imaging (MRI), Magnetic Resonance Spectroscopy (MRS), Brain, ultra high magnetic field, metabolic imaging, brain metabolites, spin physics, processing/quantification,

Learning Prerequisites

Required courses

General Physics
Electromagnetism
Basic signal processing
Important concepts: Fourier transformation

Recommended courses

Fundamentals of biomedical imaging - PHYS-438
Neural signals and signal processing - Fiche de cours - NX-421
Quantum physics
Signaux et systèmes

Important concepts to start the course

NMR, MRI basics

Learning Outcomes

By the end of the course, the student must be able to:

- Understand the physical principles of MRI and MRS during hands on exercises on MRI scanners
- Perform basic MRI and MRS experiments
- Establish MRI and MRS acquisition protocols and understand the impact of the acquisition parameters on image contrast or spectral pattern
- Analyze the results for the acquired data
- Explain the basics of organizing a successful MRS experiment, processing/quantification, image processing, using MRS4Brain toolbox
- Read, analyze and discuss representative scientific papers
- Discover the power of interdisciplinary interaction by working on questions and hands on exercises in groups

Transversal skills

- Use both general and domain specific IT resources and tools
- Communicate effectively with professionals from other disciplines.
- Write a literature review which assesses the state of the art.
- Write a scientific or technical report.

Teaching methods

In general the course will be organized as follows:
- 2h theoretical
- 2h practical at the scanner

Expected student activities

Active participation in the theoretical courses with questions
Discussions/questions during the live demos
Supervised experimental manipulation of the MRI scanner
Processing of the acquired data
Work in teams for a joint report/project

Assessment methods

Report/mini project and oral presentation of this Report.
MCQ exam primarily based on the practical sessions.

Supervision

Office hours	Yes
Assistant.e.s	Yes

Resources

Bibliography

In Vivo NMR Spectroscopy: Principles and Techniques (Robin de Graaf); Principles of Magnetic Resonance Imaging: A Signal Processing Perspective (Zhi-Pei Liang & Paul C. Lauterbur)
1. Nuclear Magnetization (youtube.com)
magritek - YouTube

Ressources en bibliothèque

- Find the references at the Library

Références suggérées par la bibliothèque

- Magitrek (Youtube) /Magitrek
- Basics of In Vivo NMR (Youtube) / Robin de Graaf

Websites

- https://cibm.ch/
- https://www.epfl.ch/labs/mrs4brain/

Moodle Link

- https://go.epfl.ch/PHYS-473

Videos

- https://www.epfl.ch/labs/mrs4brain/links/live-demos/