BMDE - 660

Advanced Magnetic Resonance Imaging and Spectroscopy of the Brain

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General Information

Term: Winter

Course Schedule: Twice per week, 1.5 hours

Number of credits: 3

Location: Lecture room in BME Department, Duff Medical Building 3775 University Street, Montreal, Quebec, H3A 2B4

Pre-requisites:

- PHYS 241 Signal Processing, ECSE 304 Signals and Systems 2 or ECSE 306 Fundamentals of Signals and Systems
- PHYS 242 Electricity and Magnetism or ECSE 251 Electric and Magnetic Fields

Estimated number of students: 10-15

Course Organizers

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Course Information

Course description

This course focuses on advanced magnetic resonance imaging and spectroscopy acquisition techniques to investigate the structure, connectivity, chemistry and physiology of the brain in vivo. It will provide students with an in-depth understanding of data acquisition and reconstruction techniques, scanner hardware, and contrast mechanisms. The course will focus on neuroscience applications.

Learning outcomes

By the end of this course, students will:

1. Know a variety of MRI/S data acquisition and reconstruction techniques.
2. Understand MRI/S contrast mechanisms and how they related to brain structure, function, connectivity and chemistry.
3. Understand the trade-offs between different MRI/S techniques in terms of data quality, acquisition efficiency and biological specificity.
4. Be able to evaluate data quality and identify sources of artifacts.
5. Be able to optimize an MRI/S protocol for a given study.
6. Be able to critically evaluate new imaging and spectroscopy techniques.

Course materials

Classes will mainly consist of powerpoint presentations.

PDFs of lecture slides will be available via *MyCourses*. Additional material, such as book chapters, journal articles or websites, may be recommended during class.

Evaluation Scheme (graded assessments)

Assignments: **55%**

There will be three (3) assignments worth 20%, 20% and 10% respectively.

Image artifact presentation in groups of 2-4 students: **10%**

Final project: **35%**

The final project will be a review on an MRI/S topic that will be selected by the student and approved in advance by the course organizers. The project will include:

- an oral presentation (15%)
- a written report (~6 page, 20%)

Course Content/Outline

Lecture 1	Classical and quantum description of NMR
Lecture 2	Excitation, relaxation and detection
Lecture 3	MRI/S equipment and safety, including magnets, gradients, and radio-frequency coils
Lecture 4	Fourier transform, spatial encoding, k-space
Lecture 5	Basic Sequences: gradient echo and spin-echo based approaches
Lecture 6	Introduction to coil design
Lecture 7	Advanced coil design
Lecture 8	MR Spectroscopy basics
Lecture 9	Advanced MR Spectroscopy
Lecture 10	Radiofrequency excitation pulse design
Lecture 11	Parallel transmit RF pulse design
Lecture 12	Fast image acquisition & reconstruction I: turbo and multiple echos, steady state imaging, trajectories, k-space regridding
Lecture 13	Fast image acquisition & reconstruction II: parallel imaging, Wave CAIPI
Lecture 14	Fast image acquisition & reconstruction III: SMS, compressed sensing
Lecture 15	Image quality and artifacts
Lecture 16	Diffusion imaging - part 1
Lecture 17	Diffusion imaging - part 2
Lecture 18	Quantitative MRI - part 1
Lecture 19	Quantitative MRI - part 2
Lecture 20	Biophysical models of brain tissue microstructure - part 1
Lecture 21	Biophysical models of brain tissue microstructure - part 2
Lecture 22	MRI of brain physiology