Magnetic Resonance Imaging and Spectroscopy: From Methods to Functional Brain Imaging

Short Title: ECE595 - Magnetic Resonance Imaging

Lecturers:
Stefan Posse, PhD (Psychiatry and ECE)
Guest lecturers are Charles Gasparovic, PhD, Paul Mullins, PhD, Arvind Caprihan, PhD, and Rohit Sood, MD PhD, and possibly other guest lecturers.

Goals:
This course introduces the physics and engineering aspects of MR imaging and spectroscopy. Applications in Neuroscience and clinical research are shown. This course is held jointly with a corresponding course in the Department of Psychology on applications of functional MR imaging in cognitive neuroscience (Psychology 650 - MRI/S METHODS & APPL), offered by Vincent Clark, PhD, a faculty member in Psychology and Neuroscience. This joint course will be of interest for students and fellows in engineering, physics, computer science, psychology, neuroscience, psychiatry, etc.

Objectives:
To be able to assess the power and limitations of MR techniques for studying normal and diseased brain function. This course provides a basis for students who want to choose MR as a field of research.

Prerequisites:
Standard engineering, physics and mathematics core courses. The following would be useful but are not mandatory: differential equations, complex variables, Fourier analysis, statistics, electronics laboratory, and electromagnetism.

Class/laboratory schedule:
Fall 2004
Tuesday 9:30-10:45am (this course)
Thursday 9:30-10:45am (Psychology 650)

Location:
Dane Smith Hall and MIND Imaging Center

Topics:

1. History, introduction to magnetic moments, precession, Bloch equations, and relaxation (T1, T2) (1 lecture)
2. Free Induction Decay, Steady State, Inversion Recovery, Spin Echo, Gradient Echo (1 lecture).
3. Visit to the MIND Imaging Center (1 lecture)

4. Principles of imaging: Slice selection, Projection, Phase encoding, Fourier imaging in multi-dimensions (2 lectures)
5. Signal, contrast, and noise (1 lecture)
6. Motion and MR angiography (1 lecture)
7. Diffusion and Perfusion (1 lecture)
8. Fast imaging and image distortion (2 lectures)
9. Functional MRI of the brain (1 lecture)
10. Basics of MR spectroscopy (1 lecture)
11. Spectroscopic localization and imaging (2 lectures)
12. Spectroscopic quantification (1 lecture)
13. Functional MRI and spectroscopy experiments at the MIND imaging center (1 lecture)

Textbooks

Lecture series A:

- *NMR and its applications to living systems*, D.G. Gadian, Oxford University Press (1995)
- *Magnetic Resonance Imaging: Physical Principles and Sequence Design*, E. M. Haacke, R.W. Brown, M.R. Thompson and R. Venkatesan, 1st edition, Wiley, 1999.

Additional reading:

Lecture series A:

- *Principles of Nuclear Magnetism*, A.Abragam, Oxford University Press (1996)
- *Principles of Nuclear Magnetic Resonance in One and Two Dimensions*, R.R. Ernst, G. Bodenhausen and A. Wokaun, Clarendon Press (1990)
- *High Resolution NMR - Theory and Chemical Applications*, E.D. Becker, Academic Press (1980)
- *Principles of Magnetic Resonance*, C. P. Slichter, Harper (1963)
- *Nuclear Magnetic Resonance Spectroscopy - A Physicochemical View*, R.K. Harris, Longman Scientific & Technical (1994)
- *NMR Imaging in Biomedicine*, P. Mansfield, P.G. Morris, Academic Press (1982)
- *Biomedical Magnetic Resonance Imaging: Princliples, Methodology and Applications*, F.W. Wehrli, D. Shaw, J.B. Kneeland, VCH Publishers, Inc. (1988)