**UNIVERSIDAD CATÓLICA DE CHILE**

**DEPARTMENTENT OF ELECTRICAL ENGINEERING**

**Image Formation (Formación de Imágenes)**

2022 -1st Term

COURSE : **Image Formation**

MODULE CODE : IEE3764

CREDITS : 10

LECTURERS : R.M. Botnar ([rebotnar@uc.cl](mailto:rebotnar@uc.cl))

TEACHING ASSISTANTS : TBA

SCHEDULE : Mondays and Wednesdays 11:30-12:50

WEBSITE : https://cursos.canvas.uc.cl/

**I. Module aims**

This series of lectures will provide an understanding of the theory of image formation and applications of ionizing and non-ionizing medical imaging systems. Frequently used modalities, such as x-ray computed tomography (CT), positron emission tomography (PET) and optical imaging will be discussed. Special emphasis will be given to the physics of magnetic resonance imaging (MRI) and its applications. Prerequisites for this class include calculus, linear systems, Fourier transforms and MATLAB programming.

**II. Course objectives**

On completion of the course the students should be able to:

* describe the major components of frequently used medical imaging modalities such as MRI, X-ray, CT, PET and optical imaging.
* understand the characteristics, advantages and limitations of frequently used medical imaging modalities.
* describe applications of frequently used medical imaging modalities.

**III. Prerequisites:**

* + Linear algebra (linear systems of equations in matrix-vector form)
  + Signal and systems theory (Fourier transforms, sampling theorem, convolution, filtering)
  + Basic statistics (Gaussian and Poisson probability distributions)
  + MATLAB programming (laptop with Matlab)

**IV. Contents**

* Magnetic resonance imaging: principles of NMR, MR image acquisition (B0, B1 and gradient magnetic fields, signal equation, spatial encoding, relaxation, Bloch simulations), basic MR reconstruction, tissue contrast, basic imaging sequences, fast imaging sequences, image quality and artefacts, clinical applications of MRI.
* X-ray: x-ray production, interaction with matter and detectors.
* Computed tomography: CT systems design, modes of CT acquisition, basic CT reconstruction, CT image artefacts, clinical applications of CT.
* Nuclear medicine: radioactivity and radiotracers, the gamma camera, radiation detection and measurement, image characteristics, SPECT, clinical applications of SPECT, PET, radiotracers for PET, instrumentation for PET, clinical applications of PET.
* Optical imaging: wave propagation, interactions of waves with matter, tomographic image reconstruction, in-vivo applications of optical imaging.
* Paper presentation of writing of a review article.
* Research examples: lectures introducing state-of-the-art medical imaging research will provide real world examples how the material taught in this class can lead to new imaging solutions.

**V. Methodology**

* Zoom/in person lectures
* Zoom/in person tutorials/Matlab Labs
* Coursework
* Scientific paper presentation
* Final Project (review paper)
* Textbook, scientific articles and complementary reading

**VI. Administrative aspects**

* **Participation.** Attendance to lectures and tutorials, as well as your participation during the class is very important, thus 10% of the final mark will depend on your class participation.
* **Coursework.** There will be 4 coursework related to the labs. The assignments are individual. Late coursework **will not be accepted** at least there are reasonable justifications for the delay communicated to the Professor before the deadline.
* **Scientific paper presentation.** Each student will present once in the semester, individually, a scientific publication (paper) related to the topics of the course. The titles of the publications will be agreed with the professor at the beginning of May. After each presentation there will be a critical analysis of aspects of content and form by the whole class, with the aim of giving feedback and suggestions to the presenter.
* **Final Project:** There will be one final project which will consist of 10% outline presentation, 60% report and 30% final presentation. The report should be written in review paper style, e.g. IEEE or Frontiers style (examples will be provided).
* **Assessment**

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| --- | --- |
| Coursework  Article presentation  Final project  Class participation | 40%  10%  40%  10% |

**VII. Recommended Text Books**

* Zhi-Pei Liang & Paul C. Lauterbur, *“Principles of Magnetic Resonance Imaging: A Signal Processing Perspective”*, IEEE Press Series on Biomedical Engineering (Book 4), Wiley-IEEE Press; 1 edition (November 1, 1999).
* Andreas Maier, Stefan Steidl, Vincent Christlein, Joachim Hornegger (Eds.). “Medical Imaging Systems: An Introductory Guide”.

**VIII. Complementary reading**

* Bushberg J.T., Seibert J.A., Leidholdt E.M. & Boone, J. "The Essential Physics of Medical Imaging", 3rd Edition, Lippincott Williams and Wilkins
* Thorsten M. Buzug. *“Computed Tomography: From Photon Statistics to Modern Cone-Beam CT”.* ISBN 978-3-540-39408-2.
* Bahaa E. A. Saleh, Malvin Carl Teich. *Fundamentals of Photonics*, 2 Volume Set, 3rd Edition. ISBN: 978-1-119-75081-9
* Dwight G Nishimura. “*Principles of magnetic resonance imaging”*. Publisher: Stanford, Calif. : Stanford Univ., 1996.

**IX. Schedule** (subject to minor changes in content)