ES3H5-15 Biomedical Imaging and Medical Devices

22/23

Department
School of Engineering
Level
Undergraduate Level 3
Module leader
Joanna Collingwood
Credit value
15
Module duration
10 weeks
Assessment
100% coursework
Study location
University of Warwick main campus, Coventry

Description

Introductory description

ES3H5-15 Biomedical Imaging and Medical Devices

Module web page

Module aims

To introduce students to the fundamental principles and applications of medical imaging in the human body, and to imaging and sensing in the brain. Techniques include Magnetic Resonance Imaging (MRI), X-ray Computed Tomography (CT), Positron Emission Tomography (PET), Electroencephalography (EEG), Magnetoencephalography (MEG), and Ultrasound. The module will provide students with a firm grounding in the basic theory underpinning the core methods in clinical practice, as well as an awareness of emerging technologies and their applications.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Lectures and Seminars:

1. Introduction to Imaging and Sensing, to include a general introduction to the course. Introduction or revision of core concepts including statistics, vector calculus, k-space, Fourier transforms.

2. Magnetic Resonance Imaging (MRI), to include: the physical basis of MRI, sequences commonly used in the clinic and research, system interfaces, data formats and post-processing tools, quality control in image acquisition and interpretation, functional MRI and statistical approaches to data processing, instrumentation, safety.

3. Magnetic Resonance Spectroscopy (MRS), to include: the physical origin of the Nuclear Magnetic Resonance (NMR) spectrum, methods of spatial localisation and quantitative analysis, characteristic spectra in health and disease.

4. Electroencephalography (EEG), to include: the physical, electrophysiological, and technological principles underlying the generation and measurement of Electroencephalography (EEG) signals, spatio-temporal nature of EEG signals, and the link with Magnetoencephalography (MEG), Brain mapping using EEG and EMG.

5. Computed Tomography (CT) to include: the physical and mathematical basis for X-Ray Computed Tomography (CT), concept of a sinogram, Radon Transform for image reconstruction by back-projection, processing tools including 3D reconstruction, instrumentation, and safety. Production of X-ray images, attenuation coefficients, choice of suitable energy, contrast, hardware.

6. Radionuclide Imaging (RI) to include: the theory of radioactive decay and detectors, radiopharmaceuticals and their production, nuclear medicine imaging systems, clinical applications, instrumentation including Positron Emission Tomography (PET) and Single-Photon Emission Computed Tomography (SPECT) systems.

7. Ultrasound in Medicine to include: ultrasound imaging, generation and detection of ultrasound, ultrasound propagation, choice of frequency, A-scan, B-scan, M-mode imaging and echo cardiography. Use of Doppler techniques for blood flow etc. Use of ultrasound in therapy.

8. Introduction to Image Processing, to include: Segmentation, registration and fusion, and quantification; software including open-source packages.

9. Advanced Techniques and Applications, with topics including (but not exclusively): Transcranial Sonography, Multimodal imaging (PET-MRI), Dual-energy CT, Imaging for Current Applications (choice of topics might include Surgery, Spinal Cord Imaging, Dementia, Automated Segmentation, etc.).

Examples Classes (2 hours): Worked examples reflecting the level at which the module will be examined, and an opportunity for the students to raise questions about the course content.

Learning outcomes

By the end of the module, students should be able to:

- Illustrate how the underlying physics principles apply to modern medical imaging and sensing.
- Compare and contrast the primary methods in clinical practice for investigation of the human body and brain.
- Perform quantitative and qualitative assessments related to the theoretical and practical constraints on imaging and sensing technologies
- Analyse key applications of medical imaging and sensing for supporting diagnostics, surgery, and therapy.

Indicative reading list

Essentials of In Vivo Biomedical Imaging, Simon R. Cherry, Ramsey D. Badawi, Jinyi Qi, 2015 by CRC Press Textbook ISBN 9781439898741

MRI from Picture to Proton, Second edition, By Donald W. McRobbie, Elizabeth A. Moore, Martin J. Graves, Martin R. Prince, Publisher: Cambridge University Press, Online ISBN:9780511545405, Hardback ISBN:9780521865272, Paperback ISBN:9780521683845

View reading list on Talis Aspire

Research element

The coursework gives the student the opportunity to research a topic independently and in depth, using published sources, and to present their findings.

Interdisciplinary

This module integrates content from biomedical engineering, medical physics, and medicine.

Subject specific skills

Awareness of, and conceptual understanding of the core medical imaging technologies and applications in the clinical and research environment, combined with direct insights from - and an opportunity to interact with - radiology practitioners.

This module has a track record of equipping students to apply for clinical physics/engineering careers in the NHS, and/or to enter postgraduate taught and research degrees in the field of medical imaging.

Transferable skills

This module enables the student to develop their ability and confidence to assimilate and use conceptual-level understanding of an extensive technical syllabus in an unfamiliar area.

This module also supports the student to independently and competently find and collate information on a challenging topic, and to communicate this in an accessible way in a short video, encouraging development of organisational and presentation skills at a high level.

A guide to working with high-level technical resources such as peer-reviewed journal papers is embedded in the module, to support access to, and confidence in using, advanced imaging material in the main syllabus and independent research undertaken for the coursework. This is valuable as a long term skill, but also has immediate benefit for those using such sources in their independent project work.

Study

Study time

Type	Required
Lectures	10 sessions of 2 hours (13%)
Seminars	4 sessions of 2 hours (5%)
Other activity	2 hours (1%)
Private study	120 hours (80%)
Total	150 hours

Private study description

Guided independent learning 120 hours

Other activity description

Assessment Support Classes – 2 hours – giving guidance on how to approach preparation of the assessed work for the module, and an opportunity for the students to raise questions.

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group A1

	Weighting	Study time
Medical imaging technology video	30%	
Create a five-minute video that explains the fundamental principles of a core medical imaging method in a way that could be understood by a non-specialist.		
Essay - Compare and contrast medical imaging modalities	70%	

	Weighting	Study time
in current clinical practice		

Structured written coursework that tests all the stated learning objectives for this assessment.

Feedback on assessment

Assessments marked with detailed comments.
Face-to-face (including online) feedback in seminars.
Cohort-level feedback on main essay.

Availability

Courses

This module is Core for:

- Year 3 of UESA-H161 BEng Biomedical Systems Engineering
- Year 3 of UESA-H163 MEng Biomedical Systems Engineering

This module is Core optional for:

- Year 4 of UESA-H164 MEng Biomedical Systems Engineering with Intercalated Year
- Year 3 of UESA-H115 MEng Engineering with Intercalated Year

This module is Optional for:

- Year 3 of UESA-H113 BEng Engineering
- Year 3 of UESA-H114 MEng Engineering
- Year 4 of UESA-H115 MEng Engineering with Intercalated Year
- Year 4 of UESA-HH32 MEng Systems Engineering with Intercalated Year
- UESA-H11L Undergradaute Engineering (with Intercalated Year)
  - Year 3 of H11L Engineering (with Intercalated Year)
  - Year 4 of H11L Engineering (with Intercalated Year)

This module is Option list A for:

- Year 4 of UESA-H111 BEng Engineering with Intercalated Year
- Year 3 of UESA-HH35 BEng Systems Engineering
- Year 4 of UESA-HH34 BEng Systems Engineering with Intercalated Year
- UESA-H112 BSc Engineering
  - Year 3 of H112 Engineering
  - Year 3 of H112 Engineering
- UESA-HH31 MEng Systems Engineering
  - Year 3 of HH31 Systems Engineering
  - Year 3 of HH35 Systems Engineering