UNIVERSITY OF WARWICK

Proposal Form for New or Revised Modules (MA1 - version 7 - April 2014)

Approval information	
Approval Type	☒ Revised module
Date of Introduction/Change	1/10/2018
If new, does this module replace another? If so, enter module code and title:	N/A
If revised/discontinued, please outline the rationale for the changes:	A minor change to the assessment to better reflect briefing requirements
Confirmation that affected departments have been consulted:	Dr Nigel Williams, Head of Nuclear Medicine at UHCW has confirmed with the module leader, and with staff at UHCW that the proposed involvement of UHCW in the module will be supported.

Module Summary	
1. Module Code (if known)	ES97D
2. Module Title	Imaging & Sensing in Body & Brain
3a. Lead department:	School of Engineering
3b. Teaching Split (if known):	N/A
4. Name of module leader	Dr Joanna Collingwood
5. Level	UG: ☐ Level 4 (Certificate) ☐ Level 5 (Intermediate) ☐ Level 6 (Honours) PG: ☒ Level 7 (Masters) ☐ Level 8 (Doctoral) See Guidance Notes for relationship to years of study
6. Credit value(s) (CATS)	15 credits

Module Summary	
7. Principal 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.
8. Principal Learning Outcomes	At the end of the module, students will be able to: • Demonstrate an advanced understanding of the complex underlying principles of modern medical imaging and sensing. • Critically evaluate, 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 state-of-the-art imaging and sensing technologies, including spatial and temporal resolution, sensitivity, and specificity for the structural or functional properties to be detected. • Understand key drivers for the development of advanced applications, including an appreciation of how medical imaging and sensing support areas of diagnostics, surgery, and therapy. • Understand how recent developments, e.g. in multimodal imaging, are advancing progress at the frontiers of medical research and delivered healthcare.
9. Timetabled Teaching Activities (summary)	20 lectures, 6*1hr seminars, 2*3hr practical classes, 1*2hr site visit, 2*1hr examples classes.
10. Departmental Web-link	http://www2.warwick.ac.uk/fac/sci/eng/eso/modules/year3/es97d
11. Other essential notes	Advice and feedback hours are available for answering questions on the module
12. Assessment methods (summary)	Written examination 70% Assignment (2000 words, excluding glossary, appendices, references, table and figure content, and captions) 30%

For use by Strategic Planning and Analytics Office only - Do not fill in this section			
Level	**JACS3 Code**		**Teaching Split**
			If not provided in 3b above
External Credit Level		**Scheme**	

Module Context

13. Please list all departments involved in the teaching of this module. If taught by more than one department, please indicate percentage split.

School of Engineering
(with guest lectures from UHCW)

14. Availability of module

Degree Code	Title	Study Year	C/OC/ A/B/C	Credits
Example **H800**	Accounting and Finance **MSc Biomedical Engineering**	1 **1**	C **C**	12 **15**

15. Minimum number of registered students required for module to run

1

16. Pre- and Post-Requisite Modules

N/A

Module Content and Teaching

17. Teaching and Learning Activities *(totals for module – please see guidance)*

Module duration (weeks)	**10**
Lectures	**20**
Seminars	**6*1hr**
Tutorials	
Project Supervision	
Demonstration	
Practical Class/Workshops	2*3hr
Supervised time in studio/workshop	
Fieldwork	
External visits	1*2hr
Work based learning	
Placement	
Year abroad	
Other activity *(please describe): e.g. distance-learning, intensive weekend teaching etc.*	**Examples Classes 2*1 hr** **Guided independent learning 114 hr**

18. Assessment Method (Standard)

Module Content and Teaching		
Type of assessment	**Length**	**% weighting**
Written Examinations	3 Hours	**70**
Practical Examinations	Hours	
Assessed essays/coursework	1 Assignment (2000 words, excluding glossary, appendices, references, table and figure content, and captions)	**30**
18a. Final chronological assessment *(please see guidance*)	**Exam**	

19. Methods for providing feedback on assessment.

Coursework marked with detailed comments.
Face-to-face feedback in seminars.
Cohort level feedback on examinations

20. Outline Syllabus

Lectures and Seminars:

1. **Introduction to Imaging and Sensing**, to include a general introduction to the course. Revision of core concepts including statistics, vector calculus, k-space, Fourier transforms [*1 lecture*]

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. [4 lectures + 1 practical class, MRI facilities to be included in UHCW site visit]

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. [1 lecture + 1 seminar]

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. [2 lectures + Neurophysiology facilities to be included in UHCW site visit]

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. [3 lectures + CT facilities to be included in UHCW site visit]

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. [3 lectures + PET facilities to be included in UHCW site visit]

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. [3 lectures + Ultrasound facilities to be included in UHCW site visit]

8. **Advanced Techniques and Applications**, with topics including (but not exclusively): Transcranial Sonography, Multimodal imaging (PET-MRI), Dual-energy CT, Imaging and Robotics in Surgery. [6 seminars, with 'Imaging and Robotics' on site at UHCW]

9. **Introduction to Image Processing**, to include: Segmentation, registration and fusion, and quantification; software including open-source packages. [3 lectures + 1 practical class]

Proposed Site visit to UHCW – opportunity to tour the clinical imaging technologies that are in mainstream use, and to put questions to the experts. Target group size: up to 6 students per tour.

Practical Session 1 – Magnetic Resonance Imaging – utilizing the MRI Science Cities imaging probe to obtain real datasets from non-hazardous material, using basic sequences and student-selected parameter values. 3 hour practical session for a cohort of up to 8 students.

Practical Session 2 – Image Analysis – processing the datasets acquired in Practical Session 1 utilizing tools in ImageJ, image segmentation and analysis, and a subsequent exercise with an anonymized MRI dataset from the human brain involving segmentation and quantification. 3 hour practical session followed by a coursework assignment to be completed and submitted for credit.

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.

21. Illustrative Bibliography

Anthony B. Wolbarst, Medical Imaging: Essentials for Physicians, Wiley 2014 (E-Book)
Troy Farncombe, Krzysztof Iniewski [Editors]: Medical imaging : technology and applications, CRC Press, Taylor & Francis Group 2014 [E-Book]
S. Webb (Ed), The Physics of Medical Imaging, Hilger
B.H. Brown et. al., Medical Physics and Biomedical Engineering IOPP
G. Steele, Basic Clinical Radiobiology, Arnold
Bomford et. al., Walter and Miller's textbook of radiotherapy, Churchill

22. Learning outcomes

Successful completion of the module leads to the learning outcomes. The learning outcomes identify the knowledge, skills and attributes developed by the module.

Learning Outcomes should be presented in the format "By the end of the module students should be able to..." using the table at the end of the module approval form:

Resources

23. List any additional requirements and indicate the outcome of any discussions about these.
Practical Session 1 – Magnetic Resonance Imaging – utilization of the MRI Science Cities probe [School of Engineering] requires access to the 400 MHz wide-bore spectrometer for a 3 hour practical session for a cohort of up to 8 students.
Practical Session 2 – Requires each student to have access to a networked computer for the 3 hour session.

Approval

24. Module leader's signature	Dr Joanna Collingwood
25. Date of approval	Meeting of 17 January 2018
26. Name of Approving Committee (include minute reference if applicable)	Course and Module Approval Committee Minute 24-17/18
27. Chair of Committee's signature	Professor Gillian Cooke
28. Head of Department(s) signature	Professor David Towers

Examination Information		
A1. Name of examiner (if different from module leader)		
A2. Indicate all available methods of assessment in the table below		
% Examined	**% Assessed by other methods**	**Length of examination paper**
70	**30**	**3hr**
A3. Will this module be examined together with any other module (sectioned paper)? If so, please give details below.		
No		
A4. How many papers will the module be examined by?	☒ 1 paper	☐ 2 papers
A5. When would you wish the exam take place (e.g. Jan, April, Summer)?	**Summer**	
A6. Is reading time required?	☐ Yes	☒ No
A7. Please specify any special exam timetable arrangements.		
A8. Stationery requirements		
No. of Answer books?	**1**	
Graph paper?	**Y**	
Calculator?	**Y**	
Any other special stationery requirements (e.g. Data books, tables etc)?	**Engineering Data Book**	
A9. Type of examination paper		
Seen?	☐ Yes	☒ No
Open Book?	☐ Yes	☒ No
Restricted?	☐ Yes	☒ No
If restricted, please provide a list of permitted texts:		

LEARNING OUTCOMES		
(By the end of the module the student should be able to....)	**Which teaching and learning methods enable students to achieve this learning outcome? (reference activities in section 15)**	**Which summative assessment method(s) will measure the achievement of this learning outcome? (reference activities in section 16)**
Demonstrate an advanced understanding of the complex underlying principles of medical imaging and sensing.	Formal lectures and examples classes	Examination/Assignment
Critically evaluate, compare and contrast the primary methods in modern clinical practice for investigation of the human body and brain.	Formal lectures and UHCW visit	Examination/Assignment
Perform quantitative and qualitative assessments related to the theoretical and practical constraints on state-of-the-art imaging and sensing technologies, including spatial and temporal resolution, sensitivity, and specificity for the structural or functional properties to be detected.	Formal lectures, seminars, practical classes, and UHCW visit	Examination/Assignment
Understand key drivers for the development of advanced applications, including an appreciation of how modern advances in medical imaging and sensing are supporting diagnostics, surgery, and therapy.	Formal lectures, seminars, and UHCW visit	Examination/Assignment
Understand how recent developments, e.g. in multimodal imaging, are advancing progress at the frontiers of medical research and delivered healthcare.	Formal lectures, seminars, practical classes, and UHCW visit	Examination/Assignment