Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

The sections shown on this interface are based on the templates UG OBTL+ or PG OBTL+
If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to Data Transformation Status for more information.

Expected Implementation in Academic Year	AY2024-2025
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Pui Tze Sian
Course Author Email	tspui@ntu.edu.sg
Course Title	Biomedical Imaging
Course Code	BG3104
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

This course aims to support you in learning the fundamentals of medical imaging, and image processing techniques. Medical imaging techniques include X-ray projection imaging, X-ray Computed Tomography (CT), Nuclear imaging, Magnetic resonance imaging, Ultrasounds, and optical imaging shall be introduced.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Describe biomedical imaging and various imaging modalities
ILO 2	Analyse the mathematical functions used in biomedical imaging
ILO 3	Elaborate on how x-ray imaging is done
ILO 4	Describe how CT image acquisition works, and various types of image reconstruction used in CT.
ILO 5	Describe Nuclear Imaging. Explain how PET and SPECT is done
ILO 6	Explain basic principles of ultrasound imaging, various modes of ultrasound imaging
ILO 7	Summarize motivation behind optical imaging, explain the concept of Optical coherence tomography (OCT)
ILO 8	Explain the purpose of digital image processing and states examples of how digital image processing is used in biomedical imaging
ILO 9	Illustrate the basic of image sampling, quantization, spatial and intensity resolution and their effects on image appearance
ILO 10	Explain the mechanics of spatial filtering and how they are applied to enhance image.
ILO 11	Apply different approaches for image segmentation
ILO 12	Describe the key processes in generation of MR signals from the body, including precession, RF excitation and resonance
ILO 13	Describe the slice selection, phase encoding and frequency encoding in the creation of MR images.
ILO 14	Explain basic pulse sequence and describe how contrast (T1 weighted and T2 weighted) is achieved in MR imaging.

Course Content

This course introduces Biomedical Imaging at a fundamental level. Medical image processing techniques. X-ray imaging. CT scan. Magnetic resonance imaging. Ultrasounds and ultrasonic imaging. Nuclear imaging. Optical Imaging

Reading and References (if applicable)

1. Jerry L. Prince, Jonathan Links, Medical Imaging Signals and Systems, Pearson Prentice Hall, 2006
2. L. V. Wang, Biomedical Optics, Wiley, 2007.
3. Rafael C. Gonzalez and Richard e. Woods, Digital Image Processing, 3rd edition, Prentice Hall, 2008.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Introduction of Biomedical imaging	1	Reading list [1][2]	In-person	Face to face lecture Tutorial 1
2	Signals and Systems	2	Reading list [1][2]	In-person	Face to face lecture Tutorial 2
3	X-ray imaging	3	Reading list [1][2]	In-person	Face to face lecture Tutorial 3
4	CT	3,4	Reading list [1][2]	In-person	Face to face lecture Tutorial 4
5	Nuclear Imaging	5	Reading list [1][2]	In-person	Face to face lecture Tutorial 5
6	Ultrasound Imaging	5, 6	Reading list [1][2]	In-person	Face to face lecture Tutorial 6
7	Optical Imaging	7	Reading list [1][2]	In-person	Face to face lecture Tutorial 7
8	Fundamentals of image processing	8	Readling list [3]	In-person	Face to face lecture Tutorial 8
9	Image enhancement	9	Readling list [3]	In-person	Face to face lecture Tutorial 9
10	Image segmentation	10	Readling list [3]	In-person	Face to face lecture Tutorial 10
11	Magnetic resonance physics	11	Reading list [1]	In-person	Face to face lecture Tutorial 11
12	Creating images in MRI	12,13	Reading list [1]	In-person	Face to face lecture Tutorial 12
13	Spin echo sequence and image contrast	13,14	Reading list [1]	In-person	Face to face lecture Tutorial 13

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lecture	Demonstrate how to carry out a procedure such as working through a problem, use incomplete handouts which enabling students participating in class.
Tutorial	TBL classroom discussion sessions on tutorial questions and related topics

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Test/Quiz(Continuous Assessment 1 (Quiz))	1,2,3,4,5,6	EAB SLOs a, b	20	Individual	Analytic	Relational
2	Continuous Assessment (CA): Test/Quiz(Continuous Assessment 2 (Quiz))	8,9,10,11	EAB SLOs a, b, c	20	Individual	Analytic	Multistructural
3	Summative Assessment (EXAM): Final exam(Final Examination)	1,2,3,4,5,6,7,8,9,10,11,12,13,14	EAB SLOs a, b, c, d, f, i	60	Individual	Analytic	Relational

Description of Assessment Components (if applicable)

Formative Feedback

Examination results;
Marker's report on overall examination performance will be uploaded to NTUlearn;
Quiz answers will be discussed in class

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Critical Thinking	Intermediate
Design Thinking	Intermediate
Systems Thinking	Intermediate

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

(1) General

Students are expected to complete all online activities and take all scheduled assignments and tests by due dates. Students are expected to take responsibility to follow up with course notes, assignments and course related announcements. Students are expected to participate in all tutorial discussions and activities

Policy (Absenteeism)

(2) Absenteesim

Continuous assessments make up a significant portion of students' course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect students' overall course grade.

Policy (Others, if applicable)

Continuous assessments: Students are required to attend all continuous assessments

Last Updated Date: 27-03-2024 06:53:33

Last Updated By: Song Juha (Assoc Prof)

Appendix : Rubric/Assessment Criteria for Components listed in Assessment Table

Appendix 1: Assessment Criteria

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: > 90%
Knowledge Understanding of principles of biomedical imaging	• Lacks understanding of the principles of biomedical imaging. • Unable to apply the principles of biomedical imaging to solve engineering problems.	• Partial understanding of the principles of biomedical imaging. • Can apply the principles of biomedical imaging to solve simple engineering problems.	• Good understanding of the principles of biomedical imaging. • Can apply the principles of biomedical imaging to solve medium level engineering problems	• Good and comprehensive understanding of the principles of biomedical imaging. • Can apply the principles of biomedical imaging to solve engineering problems.	• Very good and comprehensive understanding of the principles of biomedical imaging. • Can apply the principles of biomedical imaging to solve engineering problems.
Evaluation Able to solve numerical problems in medical imaging	• Calculations are attempted but are both unsuccessful and are not comprehensive.	• Calculations are attempted but represent only a portion of the calculations required with some comprehensive to solve the problem.	• Calculations attempted are mostly successful and sufficiently comprehensive to solve the problem.	• Calculations attempted are all successful and sufficiently comprehensive to solve the problem.	• Calculations attempted are all successful and fully comprehensive to solve the problem; calculations are also presented elegantly

Appendix 2: Assessment Criterial for Final exam

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Knowledge & Comprehension Understanding of principles of biomedical imaging	• Lacks understanding of the principles of biomedical imaging. • Unable to apply the principles of biomedical imaging to solve engineering problems.	• Partial understanding of the principles of biomedical imaging. • Can apply the principles of biomedical imaging to solve simple engineering problems.	• Good understanding of the principles of biomedical imaging. • Can apply the principles of biomedical imaging to solve medium level engineering problems	• Good and comprehensive understanding of the principles of biomedical imaging. • Can apply the principles of biomedical imaging to solve engineering problems.	• Very good and comprehensive understanding of the principles of biomedical imaging. • Can apply the principles of biomedical imaging to solve engineering problems.
Application Applying imaging principles to solve problems	• Unable to understand theoretical concepts of biomedical imaging and apply the knowledge to design and optimize medical imaging systems	• Can read and partially understand theoretical concepts of biomedical imaging and apply the knowledge to design and optimize simple medical imaging systems	• Can read and understand theoretical concepts of biomedical imaging and apply the knowledge to design and optimize simple medical imaging systems	• Can read and understand theoretical concepts of biomedical imaging and apply the knowledge to design and optimize medium level medical imaging systems	• Can read and understand theoretical concepts of biomedical imaging and apply the knowledge to design and optimize medical imaging systems
Evaluation Able to solve numerical problems in medical imaging	• Calculations are attempted but are both unsuccessful and are not comprehensive.	• Calculations are attempted but represent only a portion of the calculations required with some comprehensive to solve the problem.	• Calculations attempted are mostly successful and sufficiently comprehensive to solve the problem.	• Calculations attempted are all successful and sufficiently comprehensive to solve the problem.	• Calculations attempted are all successful and fully comprehensive to solve the problem; calculations are also presented elegantly
Analysis Able to analyze problems, make reasonable assumptions, and choose appropriate methods.	• Unable to make reasonable assumptions and judgment according to the nature of the problems, uncertain about drawing any conclusions.	• Can make reasonable assumptions and judgment, but the choice of methods are not appropriate, uncertain about the accuracy of the outcome.	• Can make reasonable assumptions and judgment, can choose appropriate methods and predict the outcome mostly, but not necessarily the best choice.	• Can make reasonable assumptions and judgment, can choose appropriate methods and predict the outcome, can draw reasonable conclusions.	• Can make correct assumptions, can choose appropriate methods to solve the problem and draw conclusions. Can identify potential problems and tailor the process accordingly.

Mapping of Course ILOs to EAB Graduate Attributes

Course Code & Title	BG3104 & Biomedical Imaging
Course Type	Core

Overview											
(a)	●	(b)	◐	(c)	◐	(d)	○	(e)		(f) ○	
(g)		(h)	○	(i)	◐	(j)		(k)	○		

Legend:

●	Fully consistent (contributes to more than 75% of Student Learning Outcome)
◐	Partially consistent (contributes to about 50% of Student Learning Outcome)
○	Weakly consistent (contributes to about 25% of Student Learning Outcome)
Blank	Not related to Student Learning Outcome

Course ILOs		**EAB Graduate Attributes**
1)	Describe biomedical imaging and various imaging modalities	a, f, i, k
2)	Analyze the mathematical functions used in biomedical imaging	a, b, d
3)	Elaborate on how x-ray imaging is done	a, i
4)	Describe how CT image acquisition works, and various types of image reconstruction used in CT.	a, b, c
5)	Describe Nuclear Imaging. Explain how PET and SPECT is done	a, i
6)	Explain basic principles of ultrasound imaging, various modes of ultrasound imaging	a, b, c, i
7)	Summarize motivation behind optical imaging, explain the concept of Optical coherence tomography (OCT)	a, i
8)	Explain the purpose of digital image processing and states examples of how digital image processing is used in biomedical imaging	a, d, k
9)	Illustrate the basic of image sampling, quantization, spatial and intensity resolution and their effects on image appearance	a, b, i

10)	Explain the mechanics of spatial filtering and how they are applied to enhance image.	a, b, i
11)	Apply different approaches for image segmentation	a, b, c
12)	Describe the key processes in generation of MR signals from the body, including precession, RF excitation and resonance	a, i
13)	Describe the slice selection, phase encoding and frequency encoding in the creation of MR images.	a, b, i
14)	Explain basic pulse sequence and describe how contrast (T1 weighted and T2 weighted) is achieved in MR imaging.	a, d, i

EAB Graduate Attributes

a) **Engineering Knowledge**: Apply the knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialisation as specified in WK1 to WK4 respectively to the solution of complex engineering problems.

b) **Problem Analysis**: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences with holistic considerations for sustainable development. (WK1 to WK4)

c) **Design / Development of Solutions**: Design creative solutions for complex engineering problems and design systems, components or processes that meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required. (WK5)

d) **Investigation**: Conduct investigations of complex problems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e) **Modern Tool Usage**: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering problems, with an understanding of the limitations. (WK2 and WK6)

f) **The Engineer and the World**: When solving complex engineering problems, analyse and evaluate sustainable development impacts to: society, the economy, sustainability, health and safety, legal frameworks and the environment (WK1, WK5, and WK7).

g) **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (WK9).

h) **Individual and Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multidisciplinary, face-to-face, remote and distributed settings (WK9).

i) **Communication**: Communicate effectively and inclusively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions, taking into account cultural, language, and learning differences.

j) **Project Management and Finance**: Demonstrate knowledge and understanding of engineering management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

k) **Life-long Learning**: Recognise the need for, and have the preparation and ability to (i) engage in independent and life-long learning, and (ii) adapt to new and emerging technologies, and (iii) think critically, in the broadest context of technological change (WK8).

No	Knowledge Profile
WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline
WK5	Knowledge including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts that supports engineering design and operations in a practice area
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues
WK9	Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc with mutual understanding and respect, and of inclusive attitudes

Reference: EAB Accreditation Manual