PROC C4601: Biomedical Signal Processing

Module Title:	Biomedical Signal Processing
Language of Instruction:	English

Credits:	5

NFQ Level:	8

Module Delivered In	1 programme(s)

Teaching & Learning Strategies:	(a) Teaching will be conducted using lectures, tutorials, and practical laboratory sessions. (b) The Institute's VLE will be used to evaluate the students' understanding of the basic concepts during each section using online quizzes. (c) At the end of each section, self-test tutorial question sheets will be issued to the students. They will have one week to complete these questions. Any difficulties arising from the self-test question sheets will be addressed in class or laboratory sessions. (d) At various stages of the module, students will be directed to online materials and resources and will also have to conduct independent research on specific topics for purpose of completing practical exercises and assignments. (e) The practical laboratory sessions will offer the students hands-on laboratory experience using real measurement and test equipment, experimental instruments, and apparatus along with computational software environments. These applied experiments will serve to reinforce the theoretical knowledge and understanding of real-world systems.

Module Aim:	The aim of this module is to provide the student with knowledge and understanding in relation to core signal processing methods and machine learning approaches for biomedical signals and images. This module focuses specifically on different analogue to digital conversion (ADC) methods, statistical analysis, feature engineering and characterisation, medical imaging systems and image processing, and finally, machine learning and artificial intelligence algorithms for different biomedical applications.

Learning Outcomes	
On successful completion of this module the learner should be able to:	
LO1	Examine the different digital conversion methods (ADCs and DACs).
LO2	Apply feature engineering, statistical analysis, and characterisation to biomedical signals.
LO3	Examine medical imaging systems and image processing.
LO4	Appraise different machine learning and artificial intelligence algorithms for biomedical applications.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is recommended before enrolment in this module.*
No recommendations listed
Incompatible Modules *These are modules which have learning outcomes that are too similar to the learning outcomes of this module.*
No incompatible modules listed
Co-requisite Modules
No Co-requisite modules listed
Requirements *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed.*
No requirements listed

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Module Content & Assessment

Indicative Content
Analogue to digital conversion (ADC) methods: (i) Sampling and Quantisation, (ii) Multiplexed vs. single ADC per channel, (iii) Successive Approximation (SAR), (iv) Delta-sigma (ΔΣ), (v) Dual Slope, (vi) Pipelined, (vii) Flash.
Digital to analogue conversion (DAC) methods: (i) Pulse Width Modulator, (ii) Delta Sigma Modulator, (iii) Binary-weighted, (iv) Successive Approximation (Cyclic).
Feature engineering and signal characterisation: (i) Signal representations and time and frequency domain transformations, (ii) Fourier Analysis, (iii) Wavelet Analysis, (iv) Hilbert-Huang Transform.
Statistical analysis (i) Principal Component Analysis, (ii) Linear Discriminant Analysis, (iii) Application of methods to ECG, EMG, EEG, MEG, SpO2, acoustic/speech, fMRI signals/data.
Medical imaging systems: (i) Computed Radiography, (ii) Computed Tomography (CT or CAT), (iii) Magnetic Resonance Imaging (MRI), (iv) Nuclear Medicine, (v) Single-Photon Emission Computed Tomography, (vi) Positron Emission Tomography, (vii) Ultrasonography, (viii) Contrast agents.
Image processing: (i) Image sensors, (ii) Image compression, (iii) Discrete cosine transform (DCT).
Machine learning and artificial intelligence: (i) Biomedical and diagnostic applications, (ii) Dimensionality Reduction, (iii) Clustering, (iv) Supervised Learning (Regression and Classification), (v) K-Nearest Neighbour (k-NN), (vi) Support Vector Machines (SVM), (vii) Convolutional Neural Network (CNN).

Assessment Breakdown	%
Continuous Assessment	20.00%
Practical	20.00%
End of Module Formal Examination	60.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome addressed*	*% of total*	*Assessment Date*
Examination	Class Assessment	1,2	10.00	Week 7
Project	Research Assignment/Exercise.	2,3,4	10.00	Week 14

No Project

Practical

Assessment Type	*Assessment Description*	*Outcome addressed*	*% of total*	*Assessment Date*
Practical/Skills Evaluation	Lab Reports – Formative Assessments.	1,2,3,4	20.00	Week 14

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome addressed*	*% of total*	*Assessment Date*
Formal Exam	Summative Assessment – Formal Examination.	1,2,3,4	60.00	End-of-Semester

SETU Carlow Campus reserves the right to alter the nature and timings of assessment

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Module Workload

Workload: Full Time		
Workload Type	*Frequency*	*Average Weekly Learner Workload*
Lecture	Every Week	3.00
Laboratory	Every Week	2.00
Independent Learning	Every Week	3.00
	Total Hours	8.00

Module Delivered In

Programme Code	Programme	Semester	Delivery
CW_EEBEE_B	Bachelor of Engineering (Honours) in Biomedical Electronics	8	Mandatory