IMPERIAL

Module Specification

Basic details

UID		Cohorts covered (Earliest cohort)	
Long title	Statistical Signal Processing and Inference		
New code	ELEC60002	New short title	

Brief description of module *(approx. 600 chars.)*

This module will introduce you to the fundamentals of statistical signal processing and statistical inference, with particular emphasis upon statistical estimation theory, parametric and nonparametric stochatic modelling, time series analysis and prediction, least squares methods, adaptive learning theory and learning machines, the concept of artificial neuron and its applications.

You will gain practical experience of utilising statistical signal processing as a foundation for Generative AI, for inference on real world random signals, such as your own speech and your own physiological recordings, through the provision of structured coursework assignments based upon using MATLAB.

Available as a standalone module/ short course? No

Statutory details

	ECTS	CATS	Non-credit	
Credit value	5	10	N	HECOS codes
FHEQ level	6			

Allocation of study hours

	Hours	
Lectures	20	
Group teaching	10	*Incl. seminars, tutorials, problem classes.*
Lab/ practical	0	
Other scheduled	0	*Incl. project supervision, fieldwork, external visits.*
Independent study	95	*Incl. wider reading/ practice, follow-up work, completion of assess*
Placement	0	*Incl. work-based learning and study that occurs overseas.*
Total hours	125	
ECTS ratio	25.00	

Project/placement activity

Is placement activity allowed? 0

Module delivery

Delivery mode	Taught/ Campus	Other	
Delivery term	Term 2	Other	

Ownership

Primary department: Department of Electrical and Electronic Engineering

Additional teaching departments	0
Delivery campus	South Kensington

Collaborative delivery

Collaborative delivery?	N

External institution	N/A
External department	N/A
External campus	N/A

Associated staff

Role	CID	Given name	Surname
Module leader		Danilo	Mandic
		0	0
		0	0
		0	0
		0	0
		0	0
		0	0
		0	0
		0	0
		0	0

Learning and teaching

Module description

Learning outcomes	Upon successful completion of this module, you will be able to: 1. Model, analyse and predict real world random processes using linear stochastic models 2. Identify time varying parameters of non-stationary signals using statistical estimation and inference 3. Derive theoretical and practical performance bounds for statistical signal processing and inference algorithms in practical settings such as in regression approaches for financial modelling 4. Understand and design adaptive learning systems for denoising and prediction of signals corrupted by noise 5. Estimate relevant physiological parameters from real life recordings (your own ECG data) and critically analyse and improve signal quality

Module content	Discrete random signals; statistical stationarity, strict sense and wide sense; Averages; mean, correlations and covariances. Bias-Variance dilemma; Curse of dimensionality; Linear stochastic models; ARMA modelling; Stability of linear stochastic models; Introduction to statistical estimation theory; Properties of estimators; bias and variance; Role of Cramer Rao lower bound; Minimum variance unbiased estimator; Best linear unbiased estimator (BLUE) and maximum likelihood estimation; Maximum likelihood estimator, links with Generative AI; Bayesian estimation; Least squares estimation: orthogonality principle, block and sequential forms; Wiener filtering, adaptive filtering and signal modelling; Concept of an artificial neuron; Applications: time series modelling (financial, biomedical), acoustic echo cancellation and signal enhancement, inverse system modelling and denoising.
Learning and Teaching Approach	The theory of the module will be taught in the lecture theatre. This will go hand-in-hand with in-class recording of your own physiological data (ECG) and the analysis of the signals obtained. You are expected to use MATLAB for the coursework to analyse these recorded signals. The analysis of the signal is supported by in class workshops with help from GTAs.
Assessment Strategy	The coursework comprises five assignments, whose individual scores yield 90% of the final mark. The remaining 10% accounts for presentation and organisation. You are allowed to discuss the coursework but must code your own MATLAB scripts, produce your own figures and tables, and provide your own discussion of the coursework assignments. The first assignment will introduce you to the generation and treatment of random signals in MATLAB. The second assignment involves linear stochastic (ARMA) modelling of random processes, inluding your own recorded real-world Electrocardiogram (ECG). In the third assignent, you will be introduced to the estimation of power spectral density (PSD) of a random signal, including your own ECG, time-frequency analysis using a dial-tone touch pad, and Maximum Likelihood Estimation (MLE) of the frequency of a signal. The fourth assignment looks at optimal adaptive filtering including the estimation of paremeters of your own speech.
Feedback	Coursework and Matlab implementations will regularly be discussed in class from the completion of the first coursework onwards.
Reading list	1) Kay, S: Fundamentals of Statistical signal Processing: estimation theory, Prentice Hall. 2) Box, G: & Jenkins, G.: Time Series Analysis: forecasting and control, Wiley, 4th ed, 2013. 3) Hayes, M.H.: Statistical Digital Signal Processing and Modelling, Wiley, 2006. 4) Mandic, D. & Chambers, J.: Recurrent Neural Networks for Prediction, Wiley, 2002

Quality assurance

Date of first approval	
Date of last revision	July 2025
Date of this approval	
Module leader	Prof Danilo Mandic

Office use only

QA Lead	
Department staff	
Date of collection	
Date exported	
Date imported	

Notes/ comments	updated 11 Sept 2026

Template version

Assessment details

Grading method	Numerical	Pass mark	40%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
Coursework	Matlab experiment 1: random signals and stochastic processes	20%	40%	N
Coursework	Matlab experiment 2: linear stochastic modelling	20%	40%	N
Coursework	Matlab experiment 3: spectral estimation and modelling	25%	40%	N
Coursework	Matlab experiment 4: optimal filtering - flxed and adaptive	25%	40%	N
Coursework	Laboratory report	10%	40%	N
		100%		