IMPERIAL

Module Specification

Basic details

			Earliest cohort	Latest c
UID		Cohorts covered		

Long title	Wavelets, representation learning and their appllications

New code	ELEC70039	New short title	

Brief description of module
(approx. 600 chars.)

Finding useful information in a huge amount of data is as difficult as finding a needle in a haystack. The key insight of wavelet theory is that by finding alternative representations of signals, it is possible to extract the essential information in a fast and effective way. Wavelet theory provides the tools to find alternative representations of a signal and then to choose the representation which is more appropriate for the task at hand. Because of this flexibility, the wavelet transform plays a pivotal role in many modern data-driven applications such as time-series analysis, multimedia processing and applications in the bio-medical domain.

The main aim of the module is to introduce you to wavelet theory. You will learn about Hilbert spaces and the notions of signal approximation and projection. You will learn about orthogonal, biorthogonal and redundant representations and how to obtain some of these representations using filter banks. You will learn how to design perfect-reconstruction filter banks and how to relate these constructions to the multi-resolution properties inherent to wavelets. The module will also cover some applications in which wavelets have been successful like image compression, image super-resolution and in neuroscience.

1268 characters

Available as a standalone module/ short course?	No

Statutory details

	ECTS	CATS	Non-credit		
Credit value	5	10	N	HECOS codes	
FHEQ level	L7				

Allocation of study hours

	Hours	
Lectures	20	
Group teaching	0	*Incl. seminars, tutorials, problem classes.*
Lab/ practical	0	
Other scheduled	0	*Incl. project supervision, fieldwork, external visits.*
Independent study	105	*Incl. wider reading/ practice, follow-up work, completion of assessments*
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?	No

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?	0
External institution	
External department	
External campus	

Associated staff

Role	CID	Given name	Surname
Lecturer		Pier Luigi	Dragotti
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Learning and teaching

Module description

Learning outcomes	On successful completion of this module, you'll be able to : -Analyse natural signals and images like for example biomedical signals, speech, audio, medical images, video sequences -Analyse the efficacity of a signal representation and develop new signal representations -Design perfect reconstruction filter banks; -Design filter banks and construction of discrete and continuous-time bases for efficient signal analysis; - Apply basic image and video compression principles.

Module content	**Part 1** - Introduction and Background: Motivation: Why wavelets, subband coding and multiresolution analysis?; Mathematical background; Hilbert spaces; Unitary operators; Review of Fourier theory; Continuous and discrete time signal processing;Time-frequency analysis; Multirate signal processing; Projections and approximations. **Part 2** - Discrete-Time Bases and Filter Banks: Elementary filter banks; Analysis and design of filter banks; Spectral Factorization; Daubechies filters; Orthogonal and biorthogonal filter banks; Tree structured filter banks; Discrete wavelet transform; Multidimensional filter banks. **Part 3** - Continuous-Time Bases and Wavelets: Iterated filter banks; The Haar and Sinc cases; The limit of iterated filter banks; Wavelets from Filters; Construction of compactly supported wavelet bases; Regularity; Approximation properties; Localization; The idea of multiresolution; Multiresolution analysis. **Part 4** - Applications: Fundamentals of compression; Analysis and design of transform coding systems; Image Compression, the new compression standard (JPEG200) and the old standard; Why is the wavelet transform better than the discrete cosine transform?; **Advanced topics:** Beyond JPEG2000; Non-linear approximation and compression; Modern sampling theory: Shannon sampling theorem revisited;Sampling parametric not bandlimited signals;
Learning and Teaching Approach	Lectures. You are provided with lectures slides and lecture notes. The learning esperience is enriched with several examples of applications of the theory presented during the lectures as well as numerical examples presented through simulations. You are provided with the Matllab routines used in these simulations so that you can run them by yourself during the self-study period to further digest the theory. Blackboard and Ed discussion allow you to access the course material and to ask questions to the GTAs.
Assessment Strategy	3-hour written exam consisting of four compulsory questions carring equal marks (75%) and mini project in Python (25%). This is an invidual project. You have to produce a report and to write some matlab code to adress the questions in the project. The goal is to make you use wavelet theory to produce an image at a resolution much higher than the resolution of the various images provided by us as part of this mini-project.
Feedback	You will be provided with formative and summative written feedback two weeks after coursework submission. This will be in the form of a short document. You can also request a one-to-one meeting with the module leader. The feedback on the exam will be provided in the form of annotated model solutions after resit exams have taken place. The annotation represents a form of cohort level feedback and focuses on those areas of the exam where common mistakes appeared.
Reading list	Core: Vetterli, M. & Kovacevic, J: Wavelets and Subband Coding, Prentice Hall, 1995. Recommended 1) M. Vetterli, J. Kovacevic and V.Goyal,Foundations of Signal Processing http://www.fourierandwavelets.org/, 2) M.Vetterli, J. Kovacevic and V. Goyal, Fourier and Wavelet Signal Processing http://www.fourierandwavelets.org/. 3) S. Mallat, A Wavelet Tour of Signal Processing, Academic Press, Second Edition, 1999. 4) G. Strang and T. Q. Nguyen, Wavelets and Filter Banks, Wellesley-Cambridge Press, Revised Edition, 1998. 5) I. Daubechies, Ten Lectures on Wavelets, SIAM, 1992

Quality assurance

Date of first approval	February 2022
Date of last revision	May 2023
Date of this approval	

Office use only

QA Lead	
Department staff	
Date of collection	
Date exported	

Module leader	Pier Luigi Dragotti	Date imported	
Notes/ comments			

Template version #####

Assessment details

			Pass mark
Grading method	Numerical		50%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
Examination	3 hour written examination	75%	50%	N
Coursework	Python mini project: Sampling Signals with Finite Rate of Innovation with an Application to Image Super-Resolution	25%	50%	N
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		100%		