IMPERIAL

Module Specification

Basic details

UID		Cohorts covered (Earliest cohort)	
Long title	Machine Intelligence for Finance		
New code	ELEC70103	New short title	

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

This module is driven by time series perspectives and short term statistical behaviour, underpinned by digital signal processing and machine learning, which is appropriate for cash assets (stocks, bonds, currencies, portfolios) and futures. It therefore answers the needs of the rapidly changing global financial system which requires financial models to be adaptively inferred from the data.
You will gain hands-on experience through structured Python assignments based upon time series models, robust estimators, subspace techniques, portfolio optimisation, and data analytics on graphs.
There are no particular prerequisites, although knowledge of estimation theory and statistics would be useful.

Available as a standalone module/ short course? N

Statutory details

	ECTS	CATS	Non-credit
Credit value	5	10	N

HECOS codes

FHEQ level: 7

Allocation of study hours

	Hours	
Lectures	20	
Group teaching		*Incl. seminars, tutorials, problem classes.*
Lab/ practical		
Other scheduled		*Incl. project supervision, fieldwork, external visits.*
Independent study	105	*Incl. wider reading/ practice, follow-up work, completion of assess*
Placement		*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	Electrical and electronic engineering
Additional teaching departments	None

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Delivery campus: South Kensington

Collaborative delivery

Collaborative delivery? N

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

Associated staff

Role	CID	Given name	Surname
Module Leader		Danilo	Mandic

Learning and teaching

Module description

Learning outcomes

By the end of the module, you will be able to:
(i) apply qualitative and quantitative principles and methodologies for financial modelling,
(ii) describe the fundamental economic drivers of the financial markets and behavioural economics, and explain their relevance to successful trading algorithms,
(iii) assess risk issues with current financial models and apply portfolio optimisation methods,
(iv) employ advanced methods, such as reinforcement learning and robust optimisation, to portfolio optimisation,
(v) develop insights and hands-on experience into big data methods for financial modelling, and expoit limit order book through big data strategies,
(vi) perform financial modelling through market graphs, and use machine learning on graphs for portfolio optimisation and diversification.

Module content	Commonalities and differences of econometrics and financial engineering with signal processing and machine learning, definition and operation on stocks (S&P500, NASDAQ, FTSE500), classic behavioural finance theory (Efficient Market Theory), its limitations and modern theories (Adaptive Market Hypothesis). Dealing with nonstationarity, asset trends, cyclicality and seasonality, tests for stationarity, multivariate nonstationarity and cointegration. Time series approaches, from univariate regression to Big Data regression, role of memory in modelling, ARIMA(p,d,q) for directional models, vector autoregressive (VAR) models for cointegration, volatility extraction and following. Robust and nonlinear models, latency and anomaly detection, nonlinearities in the market signals, non-Gaussian distributions and fat tails, robust statistics, M-estimation. Statistical factor analysis, cross-sectional regression, conditional volatility models, ARCH and GARCH, NPV (net present value). Portfolio selection and optimisation, asset pricing, measures of asset risk, capital asset pricing model (CAPM) and arbitrage pricing theory (APT), efficient frontier and return-risk relationship, robust principal component analysis, techniques for portfolio optimisation. Machine intelligence in finance, predictive machine learning technique, penalised regression models (LASSO, ridge, elastic net), constrained models, kernel based methods and clustering, curse of dimensionality. Advanced asset tracking, why deep models matter, from shallow assets to deep portfolios, maximum margin estimation, augmenting financial decisions through text mining, reinforcement learning in order execution, Q-learning, neural network models. Big data in finance, dimensionality reduction and latent component analysis, multi-way data structures, from support vector machine (SVM) to support tensor machine, from a (small data) asset to a (big data) portfolio, cross-portfolio modelling. Financial data analytics on graphs, concept of a market graph,information propagation on a graph, diffusion on a graph and graph shift operator, graph cut, graph approaches to asset clutering and segmentation, dynamical graph-based portfolio optimisation.
Learning and Teaching Approach	This module provides a rigorous theoretical grounding in machine intelligence for financial modelling. Particular emphasis will be on the temporal and multivariate aspects, finding structure in data, dimensionality reduction, modelling on irregular market graph domains, and real-world applications. You will also learn about various aspects of dealing with uncertainty in data, risk and robust portfolio optimisation, reinforcement learning for finance, data analytics on graphs and Big Data for finance. The lecture material is supported by a number of worked-out Case Studies, incuding 1) APT and risk modelling as multivariate regressions, 2) interpreting latent components in S&P500, 3) choosing factors for a risk model with PCA, 4) mean-variance optimisation vs variance-constrained optimisation, 5) the efficient frontier of different portfolio constructions, 6) support vector and kernel based prediction, 7) reinforcement learning in order execution, 8) Q-learning for portfolio construction, 9)tensor-variate nature of financial data (fixed income, forward and futures curves), factors in Big Data models, 10) graph data analytics for portfolio selection and diverstification, will AI make you rich?
Assessment Strategy	The course is assessed 100% by coursework. There are five coursework assignments, whose individual scores yield 80% of the final mark. The remaining 20% is awarded for innovation, clarity of presentation and organisation. The assignments will be performed in Python, and are based on real world financial data. You are allowed to discuss the coursework with fellow students; but must code your own Python scripts, produce your own figures and tables, and provide your own discussion of coursework assignments.
Feedback	You will first submit Assignment 1, and will be given deailed feedback as a guideline for the rest of the Coursework.
Reading list	R. C. Grinold nd R. N. Kahn, "Active portfolio management", McGraw-Hill, 1999. R. A. Brealey, S. C. Myers and F. Allen, "Principles of corporate finance", McGraw-Hill, 2017. Y. Fend and D. Palomar, "A signal processing perspective of financial engineering", Foundations & Trends in Machine Learning, vol. 9, no. 1-2, pp. 10213, 2015 L. Stankovic, D, Mandic et al. "Graph data analytics. Part 3: Machine learning on graphs", Foundations and Trends in Machine Learning, vol. 13, no. 4, pp. 332–530, 2020. A. Cichocki, D. Mandic et al. "Tensor networks for dimensionaloity reduction and large scale optimisation", Now Publishers, 2017.

Quality assurance

Date of first approval	February 2022
Date of last revision	March 2023
Date of this approval	
Module leader	Danilo Mandic
Notes/ comments	

Office use only

QA Lead	
Department staff	
Date of collection	
Date exported	
Date imported	

Template version

Assessment details

Grading method	Numeric	Pass mark	50%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
Coursework	Coursework 1 (implementation of multiple versions of periodgram using Matlab)	20%	50%	N
Coursework	Coursework 2 (performing practical spectrum estimation using parametric models using Matlab)	20%	50%	N
Coursework	Coursework 3 (Apative signal processing using Matlab)	20%	50%	N
Coursework	Coursework 4 (Implement widely linear adaptive filtering for estimation of noncircular signals in Matlab)	20%	50%	N
Coursework	Report and Matlab codes (for all four assignments)	20%	50%	N
		100%		