Module Title	**Machine Learning**
Level	7
Reference No. *(showing level)*	CSI_7_MAL
Credit Value	20
Student Study Hours	Total: 200 Contact hours: 52 Student managed learning hours: 148 Requirements for Self-Managed Learning Hours: • Read research papers and make notes for seminar presentations. • Undertake research work, complete and write up lab exercises and assessments. • Maintain a journal on contemporary research and technical work.
Pre-requisite learning	Foundations of calculus, statistics and optimization Python programming for AI and Visualization
Co-requisites	None
Excluded combinations	None
Module co-ordinator	TBC
School/Division	Engineering/Computer Science and Informatics
Short Description	The module introduces you to the basic theory, concepts, and techniques of machine learning using Python. It will cover the main topics and essential theory in the area. The module also focuses on developing practical skills in designing and developing machine learning systems using suitable software and algorithms in order to solve real-world problems.
Aims	To develop an in-depth, critically evaluative knowledge of the essential fundamentals of machine learning and sufficient hands-on experience to build your understanding and knowledge of the basic concepts, approaches, and algorithms of machine learning and practical programming skills for the design, implementation and test of machine learning systems.
Learning Outcomes	**Knowledge and Understanding:** On successful completion of this module, you will have knowledge and understanding of: • Demonstrating a systematic understanding of the domain of machine learning algorithms including the importance of research, methodologies, driving innovation and contribution; (covers course outcomes: a1, a2; BCS requirements: 7.1.1 - 7.1.4; 8.1.1 - 8.1.2; 8.2.1; 9.1.1, 9.1.2, 9.2.2; 10.1.1, 10.1.2, 10.2.1) • consistently producing and reviewing research informed work which applies and is at the forefront of the developments in the domain; (covers course outcomes: a3; BCS requirements: 7.1.1, 7.1.4, 7.1.6; 8.1.1 - 8.2.1; 9.1.1 - 9.1.3) • study and management of associated projects including timescales, risk identification/management, cost and quality constraints, as well as ethics working within professional frameworks and social/legal constraints (covers course outcomes: a4; BCS requirements: 7.1.5 - 7.1.9; 8.1.1 - 8.2.2 9.1.3 - 9.2.3; 10.1.1 - 10.2.3) **Intellectual Skills:** • Conduct a critically evaluative analysis of a case-based domain using appropriate analytic and quantitative methods; also developing the in-depth knowledge necessary to identify and apply suitable techniques in order to synthesize advanced theory/practical concepts. (covers course outcomes: b1, b2; BCS requirements: 8.1.1 - 8.1.3; 9.1.1 - 9.1.3; 10.1.1 - 10.1.3) • Specify/critically evaluate a project applying appropriate techniques, life-cycle/methodology; conducting effective independent research

	(covers course outcomes: b3, b4; BCS requirements: 8.1.1 - 8.1.3; 9.1.1 - 9.1.3; 10.1.1 - 10.1.3) **Practical Skills:** • Develop the in-depth knowledge necessary to identify machine learning project domains and apply suitable techniques in order to synthesize advanced (theory/practical) concepts to design, develop, deploy, and maintain bespoke/innovative machine learning solutions using suitable tools e.g: Python; as well as being able to specify, manage, critically evaluate a project applying appropriate technology, techniques, life-cycle/methodology (covers course outcomes: c2, c4; BCS requirements: 8.2.1, 8.2.1; 9.2.1 - 9.2.3; 10.2.1 - 10.2.3) • Be able to make concise, engaging and well-structured oral presentations, arguments and explanations; Communication /presentation of advanced machine learning algorithm-based projects and concepts to a wide range of audiences. (covers course outcomes: c1, c3; BCS requirements: 8.2.1, 8.2.1; 9.1.1 - 9.2.3; 10.2.1 - 10.2.2) **Transferable Skills:** • Critically evaluate existing/emerging machine learning technology and techniques, carrying out independent research, recognize and contribute to opportunities for innovation, deal with uncertainty, evaluate and manage risks, synthesise ideas/theories/solutions and report back appropriately to your peers, also conducting effective peer reviews. (covers course outcomes: d2, d3; BCS requirements: 7.1.1 - 7.1.4) • Self-manage your study time and work effectively to meet deadlines, select and evaluate appropriate knowledge, skills, etc...; also select and evaluate supporting resources/tools for a particular purpose, as well as being able to make effective contributions as team member/leader when required. (covers course outcomes: d1, d4; BCS requirements: 7.1.5 - 7.1.9)
Employability skills	In the age of Big Data, enterprises in almost every business sector have started to adopt machine learning-based systems to analyse massive data sets across the enterprise and its environment in order to generate insight from these data sets. Having an in-depth knowledge of machine learning along with strong programming skill for systems implementation will potentially enhance your employability within the IT marketplace.
Teaching and learning pattern	The module will be delivered using a combination of lectures, tutorials and lab sessions. Teaching takes place over 15 weeks of the semester when there will be 4 hours of direct class contact. You will also be expected to undertake appropriate follow-up private study. Developing programming skills in the lab work for machine learning systems development is an important part of the module.
Supporting Tutorials	Each lecture will be followed by appropriate lab work to help the student understand and apply the principles and theories taught in order to design, implement, test, and evaluate machine learning systems.
Indicative content	The module syllabus includes: • Basic concepts in machine learning, What leaning means, Learning process, global and local optimals, convergence of a learning process. • Supervised methods - Classification and regression. Bayesian classification, density estimation, different type of error metrics. Generalization: train, validation, test, cross validation, bootstrapping, bagging. Nearest neighbours. Linear classification, linear regression for classification. Logistic regression. Feature selection and regularization. Generalization of linear boundaries: the kernel trick and SVM. Decision trees. Ensamble methods: voting methods, random forests, boosting. • Unsupervised methods – Density estimation. Clustering, data approximation with PCA and ICA, sparse methods and dictionary learning. Python fundamentals • Build machine learning systems with Python

Assessment Elements and weightings	**100% Coursework (Summative Assessment)** The coursework will entail conducting research on a assigned topic, providing the mathematical formalization, the computational implementation, and the critical assessment of the results. This research will culminate in the production of an academic journal style paper on the chosen area, demonstrating a focussed, clear and critically evaluative understanding of the subject domain The coursework consists of two major components: (covers BCS requirements: 7.1.1 - 7.1.9; 8.2.1, 8.2.1; 9.1.1 - 9.2.3; 10.2.1 - 10.2.2) (Formative Assessments: The students will usually be given a range of weekly tutorial-based tasks (both individual/group work) comprised of formative exercises imparting the knowledge and skills required to satisfy the learning outcomes)
Indicative Sources *(Reading lists)*	**Core materials**: • Trevor Hastie; Robert Tibshirani; J. H. Friedman, The elements of statistical learning: data mining, inference, and prediction, 2nd Edition, Springer 2009. • Konstantinos Koutroumbas and Sergios Theodoridis, Pattern Recognition, 4th Edition, Elsevier 2008 • Raschka, S. and Mirajalili, V. (2017) Python machine learning: machine learning and deep learning with Python, scikit-learn, and TensorFlow. Second edition. 2017 Birmingham, UK: Packt Publishing. **Optional materials:** • Sergios Theodoridis (2020), Machine Learning-A Bayesian and Optimization Perspective, 2nd Edition, Elsevier. • Bishop, C. M. (2007) Pattern recognition and machine learning. Vol. Information science and statistics. New York: Springer