Swansea University
Prifysgol Abertawe

FACULTY OF SCIENCE AND ENGINEERING

POSTGRADUATE STUDENT HANDBOOK

MSC (FHEQ LEVEL 7)

DATA SCIENCE

DEGREE PROGRAMMES

SUBJECT SPECIFIC
PART TWO OF TWO
MODULE AND COURSE STRUCTURE
2022-23

Welcome to the Faculty of Science and Engineering!

Whether you are a new or a returning student, we could not be happier to be on this journey with you.

This has been a challenging period for everyone. The COVID-19 pandemic has prompted a huge change in society as well as how we deliver our programmes at Swansea University and the way in which you study, research, learn and collaborate. We have been working hard to make sure you will have or continue to having an excellent experience with us.

We have further developed some exciting new approaches that I know you will enjoy, both on campus and online, and we cannot wait to share these with you.

At Swansea University and in the Faculty of Science & Engineering, we believe in working in partnership with students. We work hard to break down barriers and value the contribution of everyone. Our goal is an inclusive community where everyone is respected, and everyone's contributions are valued. Always feel free to talk to academic staff, administrators, and your fellow students - I'm sure you will find many friendly helping hands ready to assist you.

We all know this period of change will continue and we will need to adapt and innovate to continue to be supportive and successful. At Swansea we are committed to making sure our students are fully involved in and informed about our response to challenges.

In the meantime, learn, create, collaborate, and most of all – enjoy yourself!

Professor Johann (Hans) Sienz
Interim Pro-Vice Chancellor/Interim Executive Dean
Faculty of Science and Engineering

Faculty of Science and Engineering	
Interim Pro-Vice Chancellor/Interim Executive Dean	Professor Johann Sienz
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School of Mathematics and Computer Science **Head of School: Professor Elaine Crooks**	
School Education Lead	Dr Neal Harman
Head of Computer Science	Professor Xianghua Xie
Computer Science Programme Director	Undergraduate: Dr Liam O'Reilly MSc: Dr Bertie Müller
Year Coordinators	MSc Cyber Security Course Coordinator: Dr Pardeep Kumar MSc Computer Science Course Coordinator: Dr Oliver Kullmann MSc Advanced Software Technology Course Coordinator: Dr Anton Setzer MSc Advanced Computer Science Course Coordinator: Dr Anton Setzer MSc Data Science Course Coordinator: Dr Alma Rahat

DISCLAIMER

The Faculty of Science and Engineering has made all reasonable efforts to ensure that the information contained within this publication is accurate and up-to-date when published but can accept no responsibility for any errors or omissions.

The Faculty of Science and Engineering reserves the right to revise, alter or discontinue degree programmes or modules and to amend regulations and procedures at any time, but every effort will be made to notify interested parties.

It should be noted that not every module listed in this handbook may be available every year, and changes may be made to the details of the modules. You are advised to contact the Faculty of Science and Engineering directly if you require further information.

The 22-23 academic year begins on 26 September 2022

Full term dates can be found here

DATES OF 22-23 TERMS

26 September 2022 – 16 December 2022

9 January 2023 – 31 March 2023

24 April 2023 – 09 June 2023

SEMESTER 1

26 September 2022 – 27 January 2023

SEMESTER 2

30 January 2023 – 09 June 2023

SUMMER

12 June 2023 – 22 September 2023

IMPORTANT

Swansea University and the Faculty of Science of Engineering takes any form of **academic misconduct** very seriously. In order to maintain academic integrity and ensure that the quality of an Award from Swansea University is not diminished, it is important to ensure that all students are judged on their ability. No student should have an unfair advantage over another as a result of academic misconduct - whether this is in the form of **Plagiarism**, **Collusion** or **Commissioning**.

It is important that you are aware of the **guidelines** governing Academic Misconduct within the University/Faculty of Science and Engineering and the possible implications. The Faculty of Science and Engineering will not take intent into consideration and in relation to an allegation of academic misconduct - there can be no defence that the offence was committed unintentionally or accidentally.

Please ensure that you read the University webpages covering the topic – procedural guidance here and further information here. You should also read the Faculty Part One handbook fully, in particular the pages that concern Academic Misconduct/Academic Integrity. You should also refer to the Faculty of Science and Engineering proof-reading policy and this can be found on the Community HUB on Canvas, under Course Documents.

STUDENT SUPPORT

The Faculty of Science and Engineering has two **Reception** areas - Engineering Central (Bay Campus) and Wallace 223c (Singleton Park Campus).

Standard Reception opening hours are Monday-Friday 9am-5pm.

The **Student Support Team** provides dedicated and professional support to all studentsin the Faculty of Science and Engineering. Should you require assistance, have any questions, be unsure what to do or are experiencing difficulties with your studies or in your personal life, our team can offer direct help and advice, plus signpost you to further sources of support within the University. There are lots of ways to get information and contact the team:

Email: studentsupport-scienceengineering@swansea.ac.uk (Monday–Friday, 9am–5pm)

Call: +44 (0) 1792 295514 and 01792 6062522 (Monday-Friday, 10am–12pm, 2–4pm).

Zoom: By appointment. Students can email, and if appropriate we will share a link to our Zoom calendar for students to select a date/time to meet.

The current student **webpages** also contain useful information and links to otherresources:

https://myuni.swansea.ac.uk/fse/coe-student-info/

READING LISTS

Reading lists for each module are available on the course Canvas page and are also accessible via http://ifindreading.swan.ac.uk/. We've removed reading lists from the 22-23 handbooks to ensure that you have access to the most up-to-date versions. Access to print material in the library may be limited due to CV-19; your reading lists will link to on-line material whenever possible. We do not expect you to purchase textbooks, unless it is a specified key text for the course.

THE DIFFERENCE BETWEEN COMPULSORY AND CORE MODULES

Compulsory modules must be **pursued** by a student.

Core modules must not only be **pursued**, but also **passed** before a student can proceed to the next level of study or qualify for an award. Failures in core modules must be redeemed.

Further information can be found under "Modular Terminology" on the following link - https://myuni.swansea.ac.uk/academic-life/academic-regulations/taught-guidance/essential-info-taught-students/your-programme-explained/

MSc (FHEQ Level 7) 2022/23
Data Science
MSc Data Science

Coordinator: Dr AAM Rahat

Compulsory Modules

Semester 1 Modules	Semester 2 Modules
CSCM27 **Human-Centred Visual Analytics** **15 Credits** **Dr DW Archambault**	**CSCM10** **Computer Science Project Research Methods** **15 Credits** **Dr MJ Roach**
CSCM45 **Big Data and Machine Learning** **15 Credits** **Dr Z Li**	**CSCM35** **Big Data and Data Mining** **15 Credits** **Dr S Yang**
CSCM70 **Mathematical Skills for Data Scientists** **15 Credits** **Prof GG Powathil**	
Dissertation	
CS-M20 **MSc Project** **60 Credits** **Dr U Berger**	
Total 180 Credits	

Optional Modules

Choose exactly 15 credits

Graduates from our BSc programmes in Computer Science at Swansea University are usually not allowed to take modules of which they have already taken the level 3 version. The department aims to offer sufficient modules to allow a balanced choice of optional modules. In case of queries regarding the required modules for your scheme, please contact the course coordinator for the respective scheme.

Select one module.

CSCM72	Optimisation	Dr AAM Rahat	TB1	15
CSCM85	Modelling and Verification Techniques	Dr U Berger	TB1	15
CSCM98	Operating Systems and Architectures	Dr B Mora	TB1	15

And

Choose exactly 30 credits

Select two modules.

CSCM21	Abuses, Biases and Blessings of Data	Dr MJ Roach	TB2	15
CSCM37	Data Visualisation	Dr C Wacharamanotham/Dr B Mora	TB2	15
CSCM39	Human Computer Interaction	Dr MI Ahmad	TB2	15
CSCM77	Computer Vision and Deep Learning	Prof X Xie	TB2	15

CS-M20 MSc Project

Credits: 60 Session: 2022/23 Academic Year

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr U Berger

Format: Individual project supervision

Delivery Method: Individual project supervision

Module Aims: This module will provide students with the opportunity of exploring a particular topic in computer science in some considerable depth. It is only open to students studying MSc Computer Science, MSc Advanced Computer Science, MSc Advanced Software Technology, MSc in High Performance and Scientific Computing, and MSc Data Science.

Module Content: The student will carry out independent project under the guidance of their supervisor.
The dissertation may include the
following topics:
- Discussion of the subject area and its history;
- A literature survey;
- Formulation of scientific questions and the answers to them;
- Theoretical background;
- Description of the approach taken;
- Discussion of issues arising in the undertaking of the project;
- Evaluation of results;
- Progress and achievements of the project;
- Suggestions for further work.

Intended Learning Outcomes: Students will be able
to undertake independent research into appropriate areas of Computer Science;
plan and undertake a significant independent piece of project work;
critically evaluate their work in the context of current work in related areas.

Assessment: Project (100%)

Assessment Description: Project dissertation. The maximum word count for a Swansea University MSc is defined in the online Academic Guide:
http://www.swan.ac.uk/registry/academicguide/

Moderation approach to main assessment: Universal double-blind marking

Assessment Feedback: Students will receive guidance from their academic supervisor during individual supervision meetings. The minimum frequency of these is defined in University regulations; though it is expected that in practice they will be more frequent. Formal notification of the result of the MSc dissertation will be sent to the student via usual University processes. The student will receive individual feedback on their dissertation from their supervisor.

Failure Redemption: Resubmit dissertation in accordance with University regulations.

Additional Notes: Only available to students pursuing an MSc degree in Computer Science.

CSCM10 Computer Science Project Research Methods

Credits: 15 Session: 2022/23 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr MJ Roach

Format: 12 lectures and seminars plus 6 one-to-one project supervision meetings; 3 hours presentations

Delivery Method: On-campus/virtual lectures and lab sessions.

Module Aims: This module will introduce students to some fundamental research methodologies and good practice in research. They will undertake background research including a literature review and specify the aims of their MSc project.

Module Content: Seminars about selected scientific texts and research projects
Lectures on
• fundamental research methodologies
• good practice in research
• formulation of research questions and hypotheses
• logical reasoning
• literature research
• proper acknowledgement of sources
• principles of carrying out experimental research including ethical issues
• presentation of results
Individual guidance from project supervisors on
• identifying a research topic
• finding and reading related work
• report writing, citations and references
• using (digital) library services and search tools

Intended Learning Outcomes: Students will:-
- have gained a thorough understanding of fundamental research methodologies and good practice in research including:
• the formulation of research questions and hypotheses;
• techniques of valid and convincing argumentation;
• literature research methods;
• the proper acknowledgement of sources;
• the extraction of information from literature;
• project planning.

- be conversant with the principles of carrying out experimental research.
- have an understanding of how scientific research is conducted, reported, reasoned about and evaluated.
- be able to show their understanding of the requirements of a masters level project by writing a formal project proposal and specification which contains an outline solution to the problem and which clearly defines the scope of the MSc project, its goals, the methodology to be undertaken and the criteria of its evaluation
- have gained an in-depth knowledge in specific areas related to their project, and have critically assessed different methods to be used in their project and will have developed a detailed plan for carrying out their project.
have an understanding and appreciation of the importance of relevant legal, social, ethical and professional issues as they relate to their project.

Assessment: Presentation (30%)
Report (60%)
Class Test 1 - Coursework (10%)

Resit Assessment: Coursework reassessment instrument (100%)

Assessment Description: Report on background research in project area 15% (end February, Semester 2)
Careers Development exercise 10% (February/March, Semester 2)
Oral presentation on project aim/background research 25% (end March/April , Semester 2)
Detailed specification of proposed summer project 50% (May, Semester 2)

Moderation approach to main assessment: Universal double-blind marking

Assessment Feedback: Individual feedback will be given by markers (CSCM10 lecturers, supervisors and second markers) using marking pro-forma. The comments and marks of the detailed specification document will be discussed by the project supervisor at individual meetings.

Failure Redemption: Failure to be redeemed by submitting document addressing unsatisfactory aspects of initial submission(s).

Additional Notes:

Only available to students on MSc Computer Science, MSc Advanced Computer Science, MSc Advanced Software Technology.

CSCM21 Abuses, Biases and Blessings of Data

Credits: 15 Session: 2022/23 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr MJ Roach

Format: 2 hours per week lecture, 2 hours per week lab/debate.

Delivery Method: On-campus/virtual lectures and lab sessions.

Module Aims: This module will take a look at how Fair Machine Learning, Artificial Intelligence and data driven systems are applied in various real-world contexts. It will cover a variety of successful and unsuccessful case studies from academia and industry. Lectures will provide theoretical framework though which students will learn to construct their analysis and evaluate various forms of ML/ AI algorithms for their appropriateness to be deployed in society as decision support systems. Students will be expected to read published literature and contribute to seminars by preparing presentations on new material and take part in reasoned scientific debate on contemporary ethical issues in the design and deployment of data and Intelligent systems. This theoretical understanding and critical analysis will be complemented by honing practical implementation skills by empirically exploring bias in data, ML explanation and fair ML techniques.

Module Content: Introduction and Setting the Scene
- Data-driven intelligence systems use in society
- Contemporary Machine Learning approaches including representation learning,

Bias in Algorithms / Models
- Reducing, Detecting, Measuring, Mitigating.
- Types of Bias
* Representation, Measurement, Evaluation, Aggregation, Population, Sampling, Behavioural, Content publication, Linking, Temporal, Popularity, Social

Explaining Blackbox Algorithms
- Algorithms, use case, limitations, insights.
- Interpretability, Transparency, Meaningful explanations, Accountability, Safety, Industrial liability
- Permutation Importance, Partial Difference Plots, Salience Maps

Fair ML
- Concepts, Metrics, principles, frameworks.
* Fairness through Unawareness, Fairness through Awareness
* Group Fairness

Demographic Parity, Equalized Odds, Predictive Rate Parity
* Individual Fairness
* Counterfactual fairness

Human-ML interaction
- Trust, Autonomy, Efficacy, Responsibility
- Combining Human and Algorithm insight

Intended Learning Outcomes: - Evaluate and critique the impact of deployment of varied data driven and intelligent systems in real world contexts
- Analyse and compare approaches to explainability, interpretability and transparency in (so called) blackbox decision systems.
- Formulate and construct a reasoned scientific debate on the impact of deploying Artificial Intelligence / Machine learning systems in society.
- Assess the data ethics in contemporary data and intelligent driven systems
- Develop methodological approaches to ethical intelligent algorithmic design and deployment in the Digital Economy and Society

Assessment: Presentation (20%)
Laboratory work (20%)
Report (60%)

Resit Assessment: Coursework reassessment instrument (100%)

Assessment Description: Debates (Presentation and reasoning, Participating in discussion seminars and debates), 20%
Labs (Completion of lab tasks on various Practical experiments on explaining, bias, black box explanation algorithms and Fair ML), 20%
Project Report (This is a two part research paper on a module sub-topic of the students choice), 60%

Moderation approach to main assessment: Second marking as sampling or moderation
Assessment Feedback: Group (oral) feedback in lectures; debate-based discusion, individual written feedback. Labs will receive automated marking feedback from autograder and quizzes.
Failure Redemption: Presentation (in place of debate) Completed Labs Project Report
Additional Notes: Created April 2019. The module content will include a number of contributions from real-world deployments of data-driven intelligent systems in the form of case studies (delivered as lectures, through reading and discussions in seminars) and as such the content will vary based on the nature of the current state-of-the-art techniques and contemporary examples. Some of these case studies will be contributions will be from existing and new partners of the DTC in Enhancing Human Interactions and Collaboration with Data and Intelligent Systems and be related to the aims of this module.

CSCM27 Human-Centred Visual Analytics

Credits: 15 Session: 2022/23 September-January

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr DW Archambault

Format: 20 hours lectures,
10 hours practicals

Delivery Method: On campus lectures.

Module Aims: Visual analytics is a human-centred area of computing that studies systems to support exploration and explanation of features in data sets. The course will provide an introduction to visual analytics and supporting necessary concepts in information visualisation. Visual analytics is the combination of visualisation and data analytics, which includes machine learning, to create effective data analysis systems.

Module Content: History and goals of visual analytics.

Types of data and encodings.

Data processing and clustering.

Information visualisation techniques.

The analytics process and pipeline.

Intended Learning Outcomes: Students will be able to apply the principles of human perception to construct and evaluate visual interfaces of data;

Students will be able to apply human-centred techniques as related to visualisation (e.g. paper prototyping and human-centred design);

Students will be able to analyse and apply data processing for visual analytics purposes;

Students will be able to apply necessary concepts in information visualisation that support the analytics process;

Students will have experience with techniques in visual analytics and information visualisation;

Students will have experience in applying the right visual analytics technique to the right problem.

Assessment: Coursework 1 (25%)
Presentation (15%)
Report (40%)
Report 2 (20%)

Resit Assessment: Coursework reassessment instrument (100%)

Assessment Description: Coursework 1: Visual Analytics Individual Assignment

Students select a data set and design a small visual analytic system around that data set. The system will have an analysis and visualisation component that will work together.

Presentation and report (December):
Students will select a visual analytics problem and study it through the term. They will present their solution and implementation in the form of a report. This assessment will be evaluated in the form of a report and implementation of the desired technique. The project will be conducted in small groups.

Report 2: Paper Summary (January):
Students will summarise a paper from the state of the art and demonstrate that they can understand research contributions in the wider field. In particular, they will state the objective of the work, how it fits into the related work, and summarise the technical content. This understanding is commensurate with their experience with the material.

Moderation approach to main assessment: Second marking as sampling or moderation

Assessment Feedback: Outline solutions provided along with group and individual analytical feedback for courseworks.
Individual feedback for presentation and report for each pair.

Failure Redemption: Resubmit coursework(s) as appropriate.

Additional Notes:

Generated December 2016. Available to visiting and exchange students.

CSCM35 Big Data and Data Mining

Credits: 15 Session: 2022/23 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr S Yang

Format: 20 hours lectures, 10 hours lab

Delivery Method: Primarily on campus

Module Aims: This module introduces students to the fundamental topics of data mining, including data pre-processing techniques, applied probability and statistics, data mining algorithms (incl. associate rule, classification, clustering, outlier detection and probabilistic graphical model), and big data frameworks.

Module Content: Basic knowledge in machine learning and mathematics are required, where we students are strongly encouraged to take CSCM45 and CSCM70 in the first semester. For those who have not taken those two modules, we will revisit some key concepts in the first three weeks, i.e. probability and statistics. Practical work will be done through the medium level of Python programming. You will also get to discover key scientific libraries of Python, i.e. NumPy, SciPy, Scikit-Learn, Matplotlib, Tensorflow, Hadoop, Spark. Classes in the first 3 weeks will include support time for Python programming and the use of these libraries.

Course Overview and Python Programming for Data Science
Mathematics Background: Numerical Analysis, Applied Probability and Statistics
Frequent Pattern, Association, Correlations
Naïve Bayes Classifier, Quantitative Evaluation
Decision Tree, Random Forest, AdaBoost
Maximum Likelihood Estimation, Expectation Maximisation
Clustering, DBSCAN, High Dimensional Data Analysis
Text Data Analysis, Word2Vec, Skip-Through, CBOW
Time-Series Data Analysis, Regression, Hidden Markov Model
Scalability and Efficiency Big Data Analysis

Intended Learning Outcomes: After completing this module students will:
- be able to manipulate complex, large, heterogeneous datasets, from storage to processing
- be able to extract information from complex, large, heterogeneous datasets
- be able to critically evaluate and select data mining algorithms and techniques, and be able to apply them in real world applications.

Assessment: Laboratory 1 (15%)
Laboratory 2 (15%)
Examination (70%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: Lab 1 15% (February): Examination of Python programming in Data Science
Lab 2 15% (March): Examination of Data Mining and Machine Learning algorithm
Exam 70% (May/June): Standard Format Computer Science Exam

Moderation approach to main assessment: Second marking as sampling or moderation

Assessment Feedback: Grades, individual and collective written feedback for coursework.

Failure Redemption: Redemption of failure via resit instrument.

Additional Notes: Available to visiting and exchange students. Basic knowledge in machine learning and mathematics are required and Computer Science students are strongly encouraged to take CSCM45 and CSCM70 in the first semester. For those who have not taken those two modules, some key concepts will be revisited in the first three weeks, i.e. probability and statistics. NOTE: students on the MSc Applied Data Science will have covered the relevant material in MA-M06 and MA-M16

CSCM37 Data Visualisation

Credits: 15 Session: 2022/23 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr C Wacharamanotham, Dr B Mora

Format: 20 hours lectures,
10 hours practicals

Delivery Method: On-campus and lab sessions.

Module Aims: Data Visualisation is concerned with the automatic or semi-automatic generation of digital images that depict data in a meaningful way(s). It is a relatively new field of computer science that is rapidly evolving and expanding. It is also very application oriented, i.e., real tools are built in order to help scientists from other disciplines.

Module Content: Introductory topics include: purposes and goals of visualisation, applications, challenges, the visualisation pipeline, sources of data: data dimensionality, data types, and grid types.

Information visualisation topics include: abstract data, hierarchical data, tree maps, cone trees, focus and context techniques, hyperbolic trees graphs and graph layouts, multi-dimensional data, scatter plots, scatter plot matrices, icons, parallel coordinates, interaction techniques, linking and brushing.

Volume visualisation topics include: slicing, surface vs. volume rendering, transfer functions, interpolation schemes, direct volume visualisation, ray casting, shear-warp factorisation, image order vs. object order algorithms, gradients, filtering, interpolation, and isosurfacing.

Flow visualisation topics include: simulation, measured, and analytical data, steady and time-dependent (unsteady) flow, direct and indirect flow visualisation, applications, hedgehog plots, vector glyphs, numerical integration schemes, streamlines, streamline placement, geometric flow visualisation techniques, line integral convolution (LIC), texture-based techniques, feature-based flow visualisation.

Intended Learning Outcomes: Students will be able to:
- identify problems that can be addressed with visualisation.
- comprehensively explain data visualisation techniques and be able to critically appraise their suitability to particular situations.
- choose, evaluate and apply visualisation techniques to effectively reveal insights into complex and potentially-incomplete data.

Assessment: Examination 1 (60%)
Coursework 1 (20%)
Coursework 2 (20%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: Standard Computer Science format unseen examination, duration 2hrs.
Two practical courseworks.

Moderation approach to main assessment: Second marking as sampling or moderation

Assessment Feedback: Outline solutions provided along with group and individual analytical feedback for courseworks.
Examination feedback summarising strengths and weaknesses of the class.

Failure Redemption: Resit examination and/or resubmit coursework(s) as appropriate.

Additional Notes: Available to visiting and exchange students.

CSCM39 Human Computer Interaction

Credits: 15 Session: 2022/23 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr MI Ahmad

Format: 30 Lectures including presentations and consultation hours.

Delivery Method: On-campus/virtual lectures and lab sessions.

Module Aims: This module gives an overview on the main topics in Human Computer Interaction and helps students understand research and research processes in Human Computer Interaction. Students explore the advanced literature and research results underpinning the field of HCI. Classic papers and controversies are covered, as well as recent work from the leading figures. Students achieve a clear view of the 'cutting edge' and issues in the field and where things are happening. The module is very interactive, and students will be expected to give presentations.

Module Content: Advanced topics in Human Computer Interaction including:
- Interface design.
- Usability.
- Evaluation.
- Human factors.
- Human error.
- Cognitive science, and their role in the field.
- User models.
- User experience.
- Larger systems, ethics, design principles.

Research topics: Classic literature and personalities
Research Methods in HCI.

Intended Learning Outcomes: The ability to demonstrate detailed understanding of advanced topics in HCI including topics such as interface design, human factors, human error, cognitive science, etc, and their role in the field.

The ability to review and critically assess the literature on specific topics at the current limits of theoretical and research understanding.

The ability to analyse and present the results of a literature review both as a scientific report (paper, poster, etc) and as an oral presentation.

Assessment: Coursework 1 (30%)
Coursework 2 (70%)

Resit Assessment: Coursework reassessment instrument (100%)

Assessment Description: 3 courseworks.

Moderation approach to main assessment: Second marking as sampling or moderation

Assessment Feedback: Individual written feedback.

Failure Redemption: Resubmit coursework as appropriate.

Additional Notes:

Created April 2015. Available to visiting and exchange students

CSCM45 Big Data and Machine Learning

Credits: 15 Session: 2022/23 September-January

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr Z Li

Format: 20 hours lectures, 10 hours lab.

Delivery Method: On campus lectures.

Module Aims: This module will discuss in-depth some of the most widely used and state-of-the-art artificical intelligence and machine learning techniques and their applications to big data problems. The students will gain both theoretical understanding of learning and practical know-how in applying those theories to real world problems. Topics include big data concept, data mining, learning theories, supervised and unsupervised learning, and reinforcement learning.

Module Content: This module covers three parts: introduction to big data and learning, data analysis techniques, and learning concepts and methods.

Introduction to big data and data mining;
Data clustering;
Dimensionality reduction: linear techniques;
Dimensionality reduction: nonlinear techniques;
Discriminative analysis;
Learning theory, including bias and variance theory, innovation process in machine learning;
Expert systems;
Unsupervised learning;
Supervised learning, including parametric and nonparametric methods, neural network, kernels, support vector machine, randomised decision trees;
Reinforcement and adaptive control;
Example applications to bioinformatics, health informatics, and web data processing.

Intended Learning Outcomes: Upon completion of this module students will be able to:
- Describe, explain, and critique the fundamental techniques of analysing complex and heterogeneous data.
- Describe and explain machine learning techniques and their applications to big data problems.
- Discuss and contrast both conventional and state-of-the-art machine learning techniques.
- Implement and apply machine learning techniques to synthesise solutions.
- Analyse big data problems and evaluate and devise potential solutions.

Assessment: Examination 1 (60%)
Coursework 1 (20%)
Coursework 2 (20%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: Standard format Computer Science exam.
Essay based practical programming assignment.
Lab work with smaller tasks to complete.

Moderation approach to main assessment: Second marking as sampling or moderation

Assessment Feedback: Outline solutions provided along with analytical individual feedback for assignment.
Examination feedback summarising strengths and weaknesses of the class.

Failure Redemption: Redemption of failure via resit instrument.

Additional Notes: Created March 2015; updated July 2016. Available to visiting and exchange students.

CSCM70 Mathematical Skills for Data Scientists

Credits: 15 Session: 2022/23 September-January

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Prof GG Powathil

Format: 20 hours lectures,
10 hours practicals

Delivery Method: On campus lectures.

Module Aims: This course is an introductory course to the mathematical methods needed by a data scientist. It covers the basics of algebra, optimisation techniques, statistics, and Fourier analysis. The main goal of the class is for students to gain practical experience of the mathematical methods and tools that are essential in data science and that will be used in the other modules of this programme. The module is aimed at students with basic experience in mathematics.

Module Content: Vectors and matrices
Derivatives and partial derivatives
Variational calculus (fundamentals)
Gradient descent
Least Squares
Fundamentals of probability
Standard deviation, Variance and covariance
Bayesian Theorem
Eigenvalues and eigenvectors, PCA
Gaussian distribution, T-distribution
Cross correlation, Chi-square, mahalanobis distance
Fourier analysis

Intended Learning Outcomes: After studying this module, students will:
- be able to apply a range of mathematical and statistical methods in the context of data science
- be able to use mathematics tools for data analysis
- be able to choose the suitable mathematical tools for their data analysis needs
- have experience with using mathematics tools for data science, and be able to apply them in real world applications

Assessment: Coursework 1 (10%)
Coursework 2 (10%)
Laboratory work (30%)
Examination (50%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: The lab work is continuous assessment: programming exercises, exercises in class, coursework.

Moderation approach to main assessment: Second marking as sampling or moderation

Assessment Feedback: Outline solutions provided along with group and individual analytical feedback for courseworks.
Examination feedback summarising strengths and weaknesses of the class.

Failure Redemption: Resit examination and/or resubmit coursework(s) as appropriate.

Additional Notes:

Generated December 2016. Available to visiting and exchange students.

CSCM72 Optimisation

Credits: 15 Session: 2022/23 September-January

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr AAM Rahat

Format: 30 hours (20 lectures, 10 laboratory hours)

Delivery Method: On Campus Lectures and Labs.

Module Aims: Optimisation is at the core of many disciplines. Whether we want to improve the performance of a machine learning model,
increase the efficiency of an aircraft design, or simply reduce the costs of productions in a business operation, we must deploy computational optimisation methods for achieving the best results. In this module, we will cover mathematical and
algorithmic fundamentals of optimisation, including derivative and derivative-free approaches for both linear and non-linear
problems. We will also discuss advanced topics, such as multi-objective optimisation, handling uncertainty, principled methods when problem evaluations are computationally expensive, and performance comparison between stochastic optimisers, in the context of real-world problems.

Module Content: Lectures:
* Introduction to optimisation.
* Derivatives and related gradient descent methods.
* Bracketing methods.
* Direct methods.
* Stochastic and evolutionary methods.
* Constrained problems.
* Multi-objective optimisation and decision making.
* Model-based methods.
* Optimisation under uncertainty.
* Performance comparison for stochastic optimisers.

Labs programmatically explore optimisation problems and algorithms.

Intended Learning Outcomes: On completion of this module, students will be able to:
* Demonstrate systematic understanding of fundamental concepts of optimisation problems and algorithms.
* Analyse an unseen optimisation problem, and formulate a mathematical description.
* Propose an appropriate method to solve an optimisation problem, and justify their selection.
* Develop appropriate software for solving optimisation problems.
* Critically evaluate performance of multiple competing optimisers, and communicate analysis to specialist and nonspecialist
audiences
* Critically review a relevant topic from the literature.

Assessment: Examination (60%)
Coursework 1 (20%)
Report (20%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: Examination. Standard unseen 2 hour Computer Science examination.
Coursework. A practical programming assignment on solving an optimisation problem.
Report. A short critical review on a relevant topic from the literature. [1000-1200 words]
Quiz. A range of multiple choice questions. [Non assessed]

Moderation approach to main assessment: Second marking as sampling or moderation

Assessment Feedback: Individual feedback on coursework and report..

Failure Redemption: 100% Examination Resit Instrument.

Additional Notes:

Available for visiting and exchange students.

CSCM77 Computer Vision and Deep Learning

Credits: 15 Session: 2022/23 January-June

Pre-requisite Modules: CSC345; CSCM45

Co-requisite Modules:

Lecturer(s): Prof X Xie

Format: 20 hours lectures, 10 hours practicals.

Delivery Method: Primarily on campus

Module Aims: This module introduces students to the important and modern topics and concepts of computer vision and deep learning, including image processing, feature extraction, camera calibration, stereo vision, motion and tracking, recognition, deep neural network and its application to vision problems. It teaches techniques that are used to understand and interpret the contents of images and videos and dissects state-of-the-art vision systems, such as Microsoft Kinect. Practical examples in Matlab are provided throughout the lectures.

Module Content: This course is composed of following parts: Introduction, Image Processing and Video Analysis, Neural networks and Deep Learning.

Introduction: The first part of the lectures gives an overview of Computer Vision and Deep Learning (CVDL) and a roadshow of this course. It also provides a brief revision of basic and important mathematical techniques frequently used in CVDL.

Image processing: filtering, object extraction, segmentation, texture analysis.

Video analysis: camera models and calibration, stereo vision, depth estimation, motion estimation and tracking, local features for tracking.

Neural networks and Deep Learning: feedforward neural networks, back propagation, convolutional neural network, recurrent neural network, and applications.

The module is also accompanied with practical examples in Matlab.

Intended Learning Outcomes: Students will gain an in-depth understanding of the important concepts of computer vision and deep learning, acquire a detailed knowledge of how the analysis of digital images and videos may be performed, and develop the skills necessary to program a basic computer vision system using both conventional and deep learning approaches.

Assessment: Examination 1 (60%)
Coursework 1 (20%)
Coursework 2 (20%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: The coursework is designed to test the students ability to synthesise a computer vision system to solve a practical real work problem using all the techniques and methods discussed and provided in the module.

The exam is a comprehensive assessment of bookwork, understanding of the computer vision and pattern recognition methods, and the ability to propose solutions to vision problems.

Moderation approach to main assessment: Second marking as sampling or moderation

Assessment Feedback: Outline solutions provided along with group and individual analytical feedback for courseworks.
Examination feedback summarising strengths and weaknesses of the class.
Individual feedback on submissions from lecturer and/or demonstrators in laboratory sessions.

Failure Redemption: Resit exam or resubmit coursework as appropriate.

Additional Notes:

Updated April 2018. This module is available to students studying
MSc Data Science, MSc Advanced Computer Science, MSc Computer Science, and MEng Computing/MSci Computer Science.

Prerequisite: CSCM45/345 Big Data and Machine Learning

CSCM85 Modelling and Verification Techniques

Credits: 15 Session: 2022/23 September-January

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr U Berger

Format: 20 hours lectures;
2 x 3 practicals;
4 problem consultation hours.

Delivery Method: primarily on campus

Module Aims: This module will give an overview of the landscape and the state of the art of current modelling and verification techniques. One particular tool for software verification will be studied in depth. Students will gain hands-on experience in using that tool.

Module Content: Overview of techniques for formal verification.
Interactive theorem proving, automated theorem proving and model checking.
Introduction to one specific logic for modelling and verification.
Techniques for modelling of software using verification tools.
Practical verification of software examples.

Intended Learning Outcomes: The students will have
- gained an thorough overview of the landscape and the state of the art of current modelling and verification techniques
- acquired a deep understanding of one particular verification tool and know how to translate practical and mathematical problems into its notation
- obtained hands-on experience in practical verification.

Assessment: Examination 1 (70%)
Coursework 1 (15%)
Laboratory work (15%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: Standard format Computer Science exam (2 hours), and coursework:

Assignment 1: Mathematical and logical foundations of concurrent processes.
Assignment 2: Advanced modelling and verification in the process language CSP.
Lab: Modelling and verification in CSP using the process tools ProBE and FDR.

Moderation approach to main assessment: Second marking as sampling or moderation

Assessment Feedback: Outline solutions provided along with group and individual analytical feedback for courseworks.
Examination feedback summarising strengths and weaknesses of the class.
Individual feedback on submissions from lecturer and/or demonstrators in laboratory sessions.

Failure Redemption: Resit examination and/or resubmit coursework(s) as appropriate

Additional Notes:

Available to visiting students

CSCM98 Operating Systems and Architectures

Credits: 15 Session: 2022/23 September-January

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr B Mora

Format: 20 hours lectures, 10 hours lab.

Delivery Method: On-campus/virtual lectures and lab sessions.

Module Aims: This module gives an overview of current and future processor architectures, operating systems and basic concurrency problems. It intends to teach most details of the developing environment that must be taken into consideration when developing efficient software

Module Content: * Operating Systems in general (Scheduler, Virtual Memory, Multi-tasking).
- Kernel calls.
- Resource management.
- Memory management.
- Paging and virtual memory.
- File Systems
- Processes and threads management

* Architectures
- Registers+ALU
- Caches, cache lines and cache levels.
- Cache trashing.
- MMU
- TLB
- RAM Latency and throughput
- SIMD units
- SIMD Programming SSE,AVX, AVX-512
- Dedicated processor instructions.

* Concurrency and issues
- Definition of core concepts including race conditions, deadlocks, starvation, critical sections.
- Standard concurrency problems and solutions
- Some standard techniques including software based locks, mutexes and semaphores, atomic instructions, barriers.

* Distributed systems
- Distributed locks.
- Distributed file systems.
- Distributed clocks and time stamping.
- Cloud computing.
- Map/reduce algorithm.

* Security aspects of OS, including:
- Principles of memory protection (virtual memory, randomised stack address, non-executable bit, hypervisor rings).
- Spectre and Meltdown attacks

Intended Learning Outcomes: Students will have a thorough understanding of:
- Current and future processor architectures.
- The role of an Operating System, especially on the multithreading and memory management aspects.
- The issues associated with parallel programming and know some standard solutions.
- How to produce better code when programming parallel architectures.
- Cloud and distributed systems.

Assessment: Examination 1 (70%)
Assignment 1 (30%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: Standard Computer Science format unseen examination, duration 2hrs.
Practical assignment.

Moderation approach to main assessment: Second marking as sampling or moderation

Assessment Feedback: Outline solutions provided along with group and individual analytical feedback for courseworks. Examination feedback summarising strengths and weaknesses of the class. Individual feedback on submissions from lecturer and/or demonstrators in laboratory sessions.
Failure Redemption: Resit exam and/or resubmit assignment as appropriate.
Additional Notes: Available to visiting and exchange students.